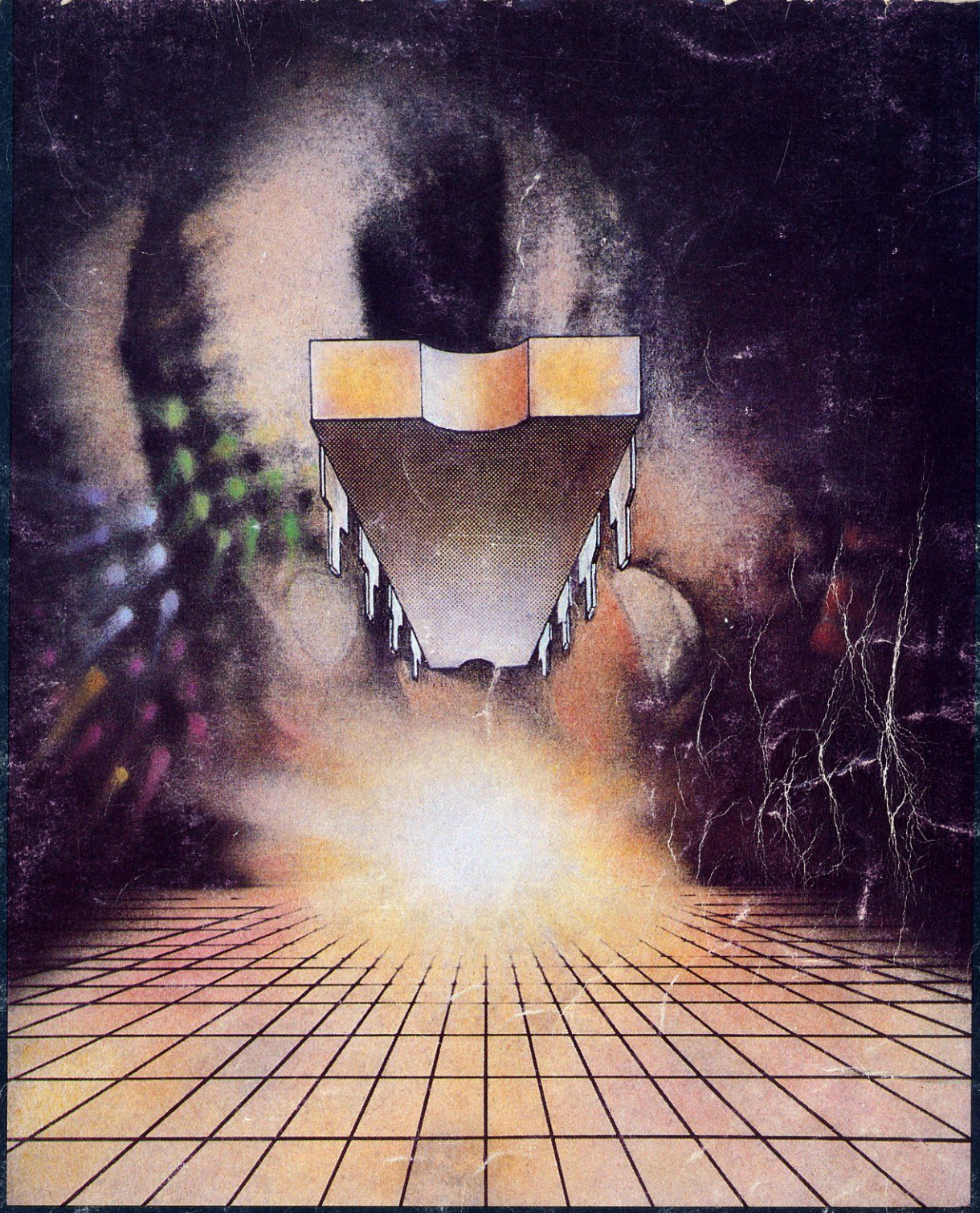

Semiconductor Reference Guide

~~INCLUDES OVER 100,000 SEMICONDUCTOR SUBSTITUTIONS~~

1985 EDITION

ARCHER®

Cat. No. 276-4008

INTEGRATED CIRCUITS INDEX BY GENERIC NUMBER

INTEGRATED CIRCUITS INDEX BY CATALOG NUMBER

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INTRODUCTION

This SEMICONDUCTOR REFERENCE HANDBOOK is intended to be just that—a reference handbook. It is not a definitive text book on semiconductors. It is a compilation of data on Radio Shack's line of prime-quality ARCHER semiconductors. Every ARCHER device covered in this Handbook is guaranteed prime—they are not "fall-outs" or "seconds"; all are top-quality, with known JEDEC, EIA or manufacturer's numbers.

At the back of the book is a cross-reference listing for replacement of Transistors, Diodes and other interchangeable semiconductor devices. The total number of cross-referenced devices exceeds 100,000. These cross-reference/replacement listings are computer-selected and are based on careful analysis of important parameters of the listed devices.

NOTE: If you can't find a replacement listing for a device you require, refer to the specification listings of the appropriate ARCHER family device. Often you will be able to make suitable replacements based on the information presented.

Each ARCHER replacement should meet or exceed the required parameters. However, due to differences in Quality Control and Manufacturing procedures (which often allow for or result in broad parameter variations), and because many of the ARCHER devices are capable of better performance than the original, Radio Shack does not guarantee, nor does it imply, that the listed items will provide an exact replacement in **every** instance. Therefore we recommend that you check the voltage and current requirements of the circuit (and other pertinent specifications) before replacement and compare with the specifications listed for that particular ARCHER device.

HOW TO USE THIS BOOK

This book has been prepared to aid in BOTH replacement and original applications of Semiconductor devices. The information included will be invaluable for the service technician as well as the circuit designer (whether he be an engineer, hobbyist, student or electronics experimeter).

We have included hints on handling Semiconductor devices, operating considerations, and some simple tests to aid you in evaluating the quality of the device in existing equipment (and thus the need for replacement). Also, a complete section on the specifications for each of the ARCHER devices is included; if there is any question in your mind about replacement equivalents or original use, refer to the appropriate category in the book. You will find the important characteristics specified there.

The next to last section is an extensive listing of replacement and cross reference between other manufacturer's numbers (both JEDEC/EIA 2N—numbers and in-house designations) and the ARCHER devices. This listing provides for the substitution of over 82,000 semiconductors with ARCHER devices.

The final section includes case style drawings and some handy reference notes, a comprehensive glossary of commonly used words, plus symbols and abbreviations.

CARE AND HANDLING OF TRANSISTORS

Most modern transistors are somewhat immune from mechanical shock; however, it is always a good idea to keep them from excessive mechanical shocks, especially the metal-case type (avoid dropping, etc).

When cutting transistor leads, use scissor-type cutting tools (rather than diagonal cutting tools which use a crimping action). Crimp-type cutting tools produce a mechanical shock along the lead which when transmitted to the semiconductor chip or material can cause fracture. Consider the force with which the cut lead flies off the crimp-type cutting tool and you have a good idea of the intensity of the equal and opposite force which acts on the lead going into the device.

It is always a good practice to use a heat-sink tool on a transistor lead when soldering (use a low-wattage iron—30-watts or less). Heat from soldering can cause problems (especially with certain types of semiconductor devices). Thus, to be sure, always use a heat-sink on the lead when soldering. Gripping the lead with long nose pliers between the solder connection and the case of the device makes a good heat-sink; or use a tool designed for such use.

SILICON OR GERMANIUM?

The quickest way to determine if a transistor is germanium or silicon type, is to check the normal emitter-base voltage drop. With NPN devices, if the base is approximately 0.25 volts positive with respect to the emitter, it is a germanium type. If the voltage is about 0.65 volts, it is a silicon type. For PNP devices, the voltage will be the same value, but opposite in polarity (0.25 volts for germanium and 0.65 for silicon).

OPERATING CONSIDERATIONS

Before replacing an original-equipment device with the recommended Archer Type:

(A) Compare the lead or terminal arrangement of the Archer replacement device with the lead or ter-

minal arrangement of the original device. If these arrangements are different, and the original transistor is a "plug in" type, bend the leads of the ARCHER device so that the base, emitter and collector leads will mate with the original transistor leads. Trim the leads after soldering in place.

CAUTION: Be particularly careful about "pin-circle" and "in-line" lead break-out type transistors. Often one manufacturer makes a type with "in-line" leads, while another may make the same type with "pin-circle" configuration. **Doublecheck both the original and the replacement device before soldering or plugging in transistors.**

BOTTOM VIEW

PIN-CIRCLE IN-LINE

(B) Certain considerations are involved whenever an original equipment transistor is replaced by one having a different type designation. When an ARCHER series transistor is used to replace an original equipment device in an untuned amplifier stage operating at a low signal level such as the untuned RF-amplifier (antenna) stage of a radio receiver, or a low-level AF amplifier stage, it is generally unnecessary to make any circuit adjustment to assure proper performance of the equipment. However, when a replacement is made in a turned RF amplifier stage, it is always advisable to check the alignment of the associated tuned circuits to assure proper tracking and to achieve the required gain without loss of stability.

(C) When replacements are made in stages operating at relatively high power levels, such as Class A and Class B AF output stages of automobile radio receivers, phonographs and AF-amplifier systems, the transistor bias should be checked and adjusted, if necessary, to protect the ARCHER replacement transistors against excessive dissipation and to minimize distortion. Means for making adjustments are generally provided in the equipment, and the necessary instructions are usually given in the equipment manufacturer's service data.

(D) When installing an ARCHER transistor as a substitute for an original equipment type in an FM tuner, TV tuner, or other circuits operating at frequencies in the VHF or UHF regions, it is extremely important not to change any of the lead lengths or position of the original circuit. Before removing the original transistor, carefully note its position with respect to other circuit components as well as the lengths and placement of the transistor leads, and duplicate these details as closely as possible with the ARCHER replacement transistor. Failure to observe this precaution can result in improper tuning or circuit instability. The same holds true for any replacement of Integrated Circuits, specially in FM radios and TV Receivers. Failure to observe this precaution can result in damage in the device. Transistor substitution in tuned circuits will often require realignment of the circuit.

SILICON VS SELENIUM RECTIFIERS

Silicon rectifiers are inherently more efficient than selenium or other metallic-oxide type rectifiers. When a silicon rectifier is used to replace a selenium rectifier in the power supply of a typical line-operated radio or TV receiver, the silicon rectifier will frequently deliver higher DC output voltage than the original device.

In some cases, this higher supply voltage may improve the performance of the equipment. However, in many other cases, it may immediately or eventually damage filter capacitors and/or other components which were designed to withstand only the voltage delivered by the original selenium rectifier. To prevent such damage, it is generally advisable to insert a power type resistor in series with the silicon rectifier either on the input side, between the AC supply and the rectifier, or on the output side between the rectifier and the first filter capacitor. The value of this resistor will depend on the required reduction in the DC output voltage and on the DC load current of the equipment. This value may be determined experimentally or calculated from the equation:

$$R = \frac{E}{I}$$

where R is the required resistance in ohms, E the required reduction in DC output voltage in volts and I the DC load current in amperes.

The wattage rating of the resistor should be at least 2 X EI (in no case less than 10 watts).

SOLDERING PRECAUTIONS

Extreme care should always be used in making solder connections to semiconductors. Momentary application of excessive heat, or even prolonged application of a properly heated soldering tool to a semiconductor lead or terminal, can permanently damage the device. Observe the following precautions in soldering a semiconductor lead or terminal:

1. Solder as far as possible from the body of the semiconductor.
2. Never, apply heat or molten solder to a lead or terminal for longer than 10 seconds or at a point closer than 1/16 inch to the body of the device.
3. Use a low voltage iron (30 watts or less) specifically intended for use with transistors or miniature circuit components.
4. Keep the surfaces to be soldered clean and the tip of the soldering tool adequately tinned so that the connection can be made as quickly as possible.
5. Always use a heat sink on the lead when soldering. Gripping the lead or terminal with longnose pliers between the solder connection and case or body allows the pliers to act as a heat sink, conducting heat away from the internal elements of the device.

ABOUT CASE DIMENSIONS

In some instances, the case of an ARCHER Semi-

conductor may be slightly taller or thicker than that of the original device or have a slightly different shape, particularly if the original device is a foreign type not made to U.S.A. EIA (JEDEC) standards. These mechanical differences should not affect the performance of the equipment in which the replacement is made and normally will not prevent or complicate the installation of the ARCHER replacement device.

You should realize that cross-reference substitution listings are created based **on electrical parameters (not necessarily on mechanical size or type).** Thus, when you make substitutions based on our listings, check for physical/mechanical compatibility. If space is limited, it would be a good idea to check physical dimensions as well as electrical specs before making substitution.

GENERAL PRECAUTIONS

ARCHER transistor and ARCHER semiconductors should not be inserted or withdrawn from circuits with the power on, because transient currents may cause permanent damage to the device. In some cases ARCHER semiconductors are in metal cans and thus could possibly become shock hazards if they are allowed to operate at a voltage appreciably above or below ground potential.

For the most effective protection, a power transistor should be operated with an adequate heat sink and with the lowest value of resistance or impedance in the emitter-to-base circuit consistent with driving signal considerations. The transistor should be protected against extremely high collector voltage pulses which may be generated when the device is operated with inductive loads particularly when current transients are present.

When replacing a power transistor or rectifier which is attached to the equipment chassis, or to a special heat sink, observe the following precautions:

A. In the case of oxide coated metal washers or wafers, which are frequently used as electrical insulators between the cases of power transistors and the chassis or heat sink, it is important not to scratch, chip or otherwise damage the oxide surface.

B. When installing an ARCHER power transistor, where a mica or oxide coated metal washer was used to insulate the case of the original device electrically from the case, apply a thin coating of Heat Sink Compound (Radio Shack Number 276-1372) between the washer and the chassis or heat sink.

TESTING A TRANSISTOR

Before replacing a transistor you want to be sure it needs to be replaced. Always check the entire circuitry to be sure the transistor requires replacement.

The best method for checking transistors is to use a good transistor checker (dynamic in-circuit and out-of-circuit type). However, a sensitive VOM can give you a good indication of the quality of the device.

I. In-Circuit Testing

A. First, check to see if the emitter-base junction is forward-biased. An NPN transistor should show the base 0.2 to 0.65 volts positive with respect to the emitter (approximately 0.25 volts for a germanium type and 0.6 volts for silicon). A PNP transistor should show the base 0.2 to 0.65 volts negative with respect to the emitter (0.25 volts for germanium and 0.6 volts for silicon).

B. Check to see if the device is functioning as an amplifier. Short the emitter-base junction to remove forward bias. Voltage at the collector lead should rise to approximately the potential of the collector supply buss line. Any difference is caused by I_{CES} (collector-to-base leakage current). The closer the collector voltage approaches the buss line, the lower I_{CES} is and the better the transistor.

II. Out-of-Circuit Testing

Again, for the best indication of transistor quality, use a good transistor checker. However, an ohmmeter can be used as described here.

Before using the ohmmeter, find out which polarity of the internal ohmmeter battery is connected to which test lead (not all ohmmeters have the + battery polarity connected to the red lead and the − battery polarity connected to the black lead). To determine the polarity of the leads when using the ohmmeter function, use an external voltmeter or study the schematic of your VOM.

Also, remember that in most transistor circuits you are dealing with low voltages and currents (in some cases, very low). Therefore, **NEVER** use RX1 scale (extensive currents can flow through a junction, permanently damaging the transistor). It is best to determine the maximum amount of current available in each resistance range before using an ohmmeter for testing semiconductor junctions.

After you have evaluated your VOM for the above and are sure you will not damage a transistor (with excessive current or voltage in any given ohmmeter range), proceed as follows:

A. Small Signal PNP Germanium Transistors
   1. Connect the positive lead of your ohmmeter to the emitter. Connect the negative lead to the base. You should read 200-500 ohms.
   2. Connect the negative lead to the collector. You should read 10K-100K. Shorting collector base, the resistance should decrease.

B. Small Signal NPN Germanium Transistors
   Reverse the polarity of the leads; the readings should be approximately the same.

C. Power PNP Germanium Transistors
   1. Connect the positive lead to the emitter. Connect the negative lead to the base. The reading should be 35-50 ohms.
   2. Connect the negative lead to the collector The reading should be several hundred ohms. Shorting collector to base, the resistance should decrease.

D. Power NPN Germanium Transistors
   Reverse the polarity of the leads; the reading should be approximately the same.

E. Small Signal PNP Silicon Transistors
   1. Connect the positive lead to the emitter. Connect the negative lead to the base. The reading should be 1K-3K.
   2. Connect the negative lead to the collector. The reading should be very high (may show as an "open").

F. Small Signal NPN Silicon Transistors
   Reverse the polarity of the leads; the readings should be approximately the same.

G. Power PNP Silicon Transistors
   1. Connect the positive lead to the emitter. Connect the negative lead to the base. The reading should be 200-1K.
   2. Connect the negative lead to the collector. The reading should be about 1 megohm or more.

H. Power NPN Silicon Transistors
   Reverse the polarity of the leads; the readings should be approximately the same.

The resistance readings noted above can only be approximate; as long as you obtain somewhat **proportionate** readings (emitter-base readings as compared to emitter-collector), you can safely assume the transistor is OK.

HANDLING OF INTEGRATED CIRCUITS

Because MOS devices have extremely high input resistance, they are susceptible to damage when exposed to static electrical charges (even electrical charges that normally build up on the human body can cause damage). To avoid possible damage to the devices during handling, testing, or actual operation, the following procedures should be observed:

1. Except when being tested or in actual operation, the leads of devices should be in contact with a conductive material, to avoid build-up of static charge.
2. Soldering iron tips, tools, metal parts of fixtures and handling facilities should be grounded.
3. Transient voltages may cause permanent damage to the device if it is removed or inserted with the power on.
4. Do not apply signals to the input with the power supply off.
5. All unused input leads must be connected to either V_{SS} or V_{DD} (whichever is appropriate for the logic circuit involved).

DIODES AND RECTIFIERS

GENERAL PURPOSE DIODES RATINGS @ 25°C

Catalog Number	PIV (min) V	If A	Ir (max) @ Vr μA	Vf (max) @ If V	Case Style
276-1101	50	1.000	10	1.6	DO41
276-1102	200	1.000	10	1.6	DO41
276-1103	400	1.000	10	1.6	DO41
276-1104	600	1.000	10	1.6	DO41
276-1114	1000	2.500	200	1.0	A1vm
276-1122	75	0.010	250nA	1.0	A1
276-1123	60	0.085	15	1.0	A1
276-1124	5	0.010	100nA	0.340	A4
276-1141	50	3.000	500	1.2	A3q
276-1143	200	3.000	500	1.2	A3q
276-1144	400	3.000	500	1.2	A3q

ZENER DIODES—1 Watt

Catalog Number	Vz Volts ±10%	Iz @ mA	Zz @ Iz ohms max	Case Style
276-561	6.2	41	2	DO41
276-562	9.1	25	7	DO41
276-563	12.0	21	9	DO41
276-564	15.0	17	14	DO41
276-565	5.1	49	7	DO41

BRIDGE RECTIFIERS

Catalog Number	PIV (min) V	If (max) A	Case Style
276-1146	50	4	M532a
276-1151	50	1.4	M548
276-1152	100	1.4	M548
276-1161	50	1	Y1
276-1171	100	4	M532a
276-1173	400	4	M532a
276-1180	50	6	M532a
276-1185	50	25	—

BIPOLAR TRANSISTORS

Catalog Number	Direct Commercial Equivalent	Mat.	Appli.	Polarity	Power Diss. @25°C Free Air	f_T Typical MHz	V_{CBO} V	V_{CEO} V	V_{EBO} V	I_C Max	I_B Max	h_{FE}	@V_{CE} V	@I_C mA	I_{CBO} at max V_{CB}	Case Style
276-2007	2N1305	G	S	PNP	150mW	5	30	—	25	300mA	—	40	1	10	6μA	TO5
276-2009	MPS2222A	S	G.P.	NPN	500mW	300	75	40	6	800mA	—	50	10	1	10nA	TO92
276-2010	PN2484	S	LL	NPN	360mW	15	60	60	6	50mA	—	250	5	1	10nA	TO92
276-2016	MPS3904	S	S	NPN	350mW	300	60	40	6	200mA	—	100	10	1	50nA	TO92
276-2017	TIP31	S	P	NPN	40W‡	3	40	40	5	3A	1A	10-50	4	3A	300μA	TO220AB-2
276-2020	TIP3055	S	P	NPN	90W‡	3	100	70	7	15A	7A	20	4	4A	1mA	TO220
276-2023	MPS2907	S	S	PNP	400mW	200	60	40	5	600mA	—	50	10	1	20nA	TO92
276-2027	MJE34	S	P	PNP	90W‡	3	40	40	5	10A	3A	20-100	4	3A	220μA	TO220
276-2030	2N3053	S	P	NPN	1W	100	60	40	5	700mA	—	50	10	150	—	TO5
276-2032	MPS3638	S	RF/IF	PNP	350mW	100	25	25	4	500mA	—	30	3	10	10nA	TO92
276-2041	2N3055	S	P	NPN	115W‡	2.5	100	60	7	15A	7A	50	4	1A	—	TO3
276-2043	MJ2955	S	P	PNP	150W‡	4	100	60	7	15A	7A	70	10	0.5	—	TO3
276-2044	MRF901	S	UHF	NPN	300mW	2500	25	15	2	30mA	—	80	5	5	50nA	MACRO-X
276-2048	2SD313	S	P	NPN	30W‡	8	60	60	5	3A	—	40-320	2	1	100μA	TO220
276-2051	2SC945	S	G.P.	NPN	250mW	250	60	50	5	100mA	—	60-600	6	1	100nA	TO92J
276-2055	2SC1308	S	SW	NPN	50W‡	—	1400	400	6	7A	0.8A	3	2	4A	5mA	TO3
276-2058	2N4401	S	G.P.	NPN	350mW	250 min.	40	60	6	600mA	—	500	10	1	0.1μA	TO92
276-2059	MPSA06	S	P	NPN	625mW	100	80	80	4	500mA	—	50 min.	1	100	0.1μA	TO92
276-2060	MPSA13	S	P*	NPN	625mW	2	30	30	10	500mA	—	10,000	5	100	100nA	TO92
276-2061	MPSA42	S	G.P.	NPN	625mW	50	300	300	6	500mA	—	40 min.	10	30	0.1μA	TO92
276-2068	TIP120	S	P	NPN	65W‡	0.1	60	60	5	5A	120mA	2500	3	500	0.2mA	TO220AB-2

NOTE: All ratings given are for 25°C except where otherwise noted. ‡With heat sink.

MATERIAL:
S—Silicon; G—Germanium

APPLICATION:
S—Switch
G.P.—General purpose
P—Power amp/switch
RF/IF—RF/IF frequency
*—High Gain Darlington
UHF—Ultrahigh frequency
LL—Low Level
SW—TV Sweep

SPECIAL TRANSISTORS (FET)

MPF102
276-2062

SILICON N-CHANNEL JUNCTION FIELD EFFECT TRANSISTOR

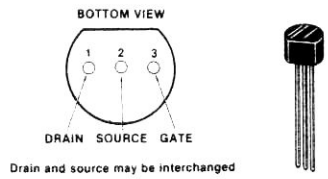
GENERAL DESCRIPTION

The MPF102 is designed for small signal applications. These include VHF amplifiers and mixers.

ABSOLUTE MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Drain-Source Voltage ..... 25 V
Drain-Gate Voltage ..... 25 V
Gate-Source Voltage ..... 25 V
Gate Current ..... 10 mA
Total Device Dissipation ..... 310 mW
Operating Junction Temperature ..... 125°C
Storage Temperature Range ..... −65 to +150°C

PIN CONNECTION



Drain and source may be interchanged

N-CHANNEL LOW POWER HEXFET

IRFD1Z3
276-2073

GENERAL DESCRIPTION

This device combines automatic insertion efficiency, a 1 watt heat sink tab with the HEXFET high performance, quality, and reliability. These space saving HEXDIPs are end-stackable in rows of any length on 100 mil centers. The low profile N-Channel HEXDIPs can be used on boards for cages with 0.5" board spacing.

PIN CONNECTION

ABSOLUTE MAXIMUM RATINGS

Drain-to-Source Voltage, V_{DS} 60V
On-State Resistance, $R_{DS(ON)}$ 3.2Ω
Continuous Drain Current, I_D (25°C Case) 0.4A
Pulsed Drain Current, I_{DM} 1.5A
Maximum Power Dissipation, P_D 1.0W

N-CHANNEL MOSFET TRANSISTOR

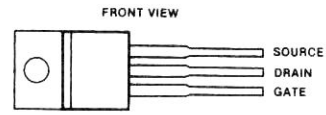
IRF511
276-2072

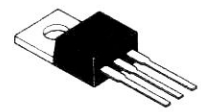
GENERAL DESCRIPTION

The efficient geometry and unique processing of the HEXFET design achieve very low on-state resistance combined with high transconductance and great device ruggedness.

This transistor also features all of the well established advantages of MOSFETs such as voltage control, freedom from second breakdown, very fast switching, ease of paralleling, and temperature stability of the electrical parameters.

PIN CONNECTION





FEATURES

- Fast switching
- Low drive current
- Ease of paralleling
- No second breakdown
- Excellent temperature stability

APPLICATIONS

- Switching power supplies
- Motor controls
- Inverters
- Choppers
- Audio amplifiers
- High energy pulse circuits

ABSOLUTE MAXIMUM RATINGS

Drain-Source Voltage, V_{DS} 60V
Drain-Gate Voltage (R_{GS} = 1 MΩ), V_{DGR} 60V
Gate-Source Voltage, V_{GS} ..... ±20V
Continuous Drain Current, I_D @ $T_C \cong 86°C$ 3A
Pulsed Drain Current, I_{DM} 8A
Maximum Power Dissipation, P_D 20W
Linear Derating Factor 0.16W/K
Inductive Current, Clamped, I_{LM} (See Fig. 1) L = 100 μH 8A
Operating Temperature Range, T_J ..... −55 to +150°C
Storage Temperature Range, T_{stg} ..... −55 to +150°C

IRF511 276-2072

TEST CIRCUITS

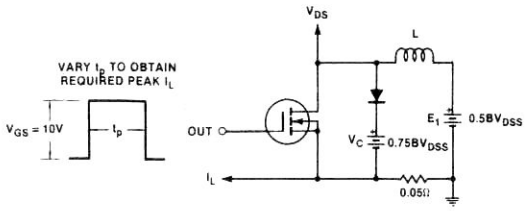


Figure 1—Clamped Inductive Test Circuit and Waveform

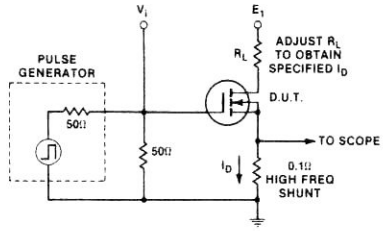
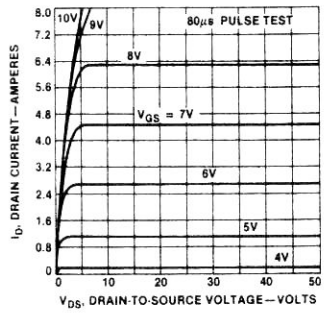
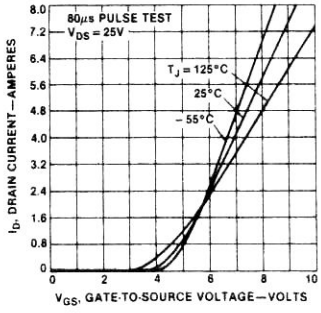


Figure 2—Switching Time Test Circuit

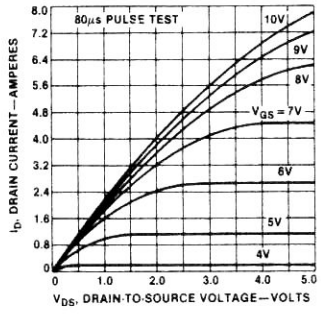
TYPICAL CHARACTERISTICS



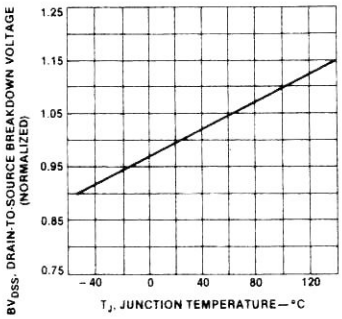
Output Characteristics



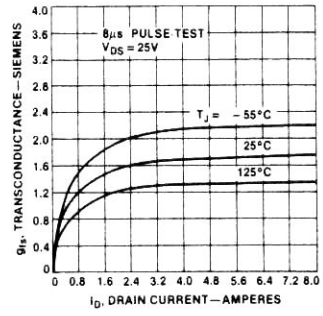
Transfer Characteristics



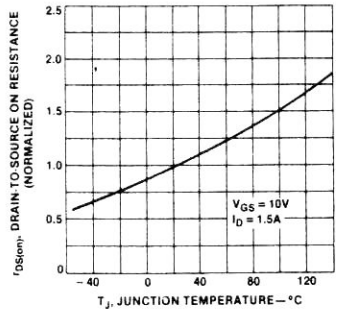
Saturation Characteristics



Breakdown Voltage vs Temperature



Transconductance vs Drain Current



Normalized On-Resistance vs Temperature

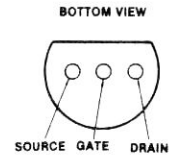
SILICON N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR

2N3819
276-2035

GENERAL DESCRIPTION

The 2N3819 is designed for general purpose small-signal applications. It features low capacitance between drain and gate terminals and an excellent high-frequency figure of merit. It achieves a low noise figure and good power gain with low crossmodulation and intermodulation.

PIN CONNECTION



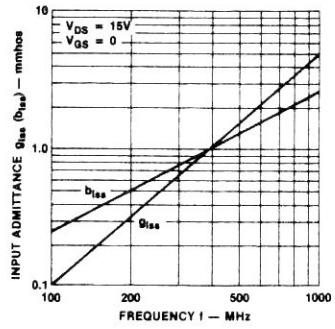
TO92

ABSOLUTE MAXIMUM RATING
(T_A = 25°C unless otherwise noted)

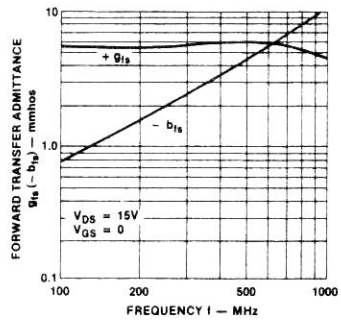
Gate-Source Breakdown Voltage BV_{GSS}	−40 V
Zero Gate Voltage Drain Current I_{DSS}	20 mA
Forward Transconductance g_{fs}	7.0− mmhos
Reverse Gate Leakage I_{GSS}	−100 pA
"ON" Resistance r_{DS}	500 ohms
Pinch Off Voltage $V_{GS(OFF)}$	−6.0 V
Output Conductance g_{os}	10 μmhos
Feedback Capacitance C_{rss}	0.9 pF
Input Capacitance C_{iss}	4.0 pF
Power Gain G_{PS}	12 dB
Power Dissipation	360 mW

TYPICAL CHARACTERISTICS

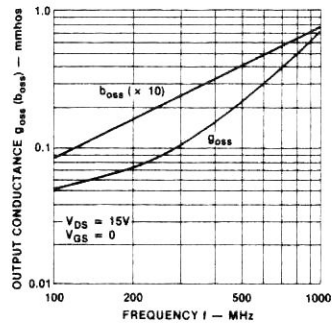
COMMON SOURCE



Input Admittance vs Frequency

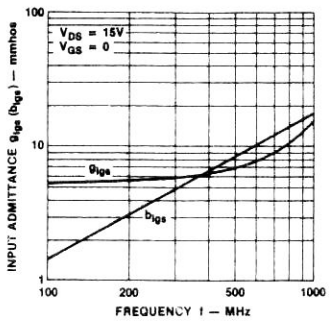


Forward Transfer Admittance vs Frequency

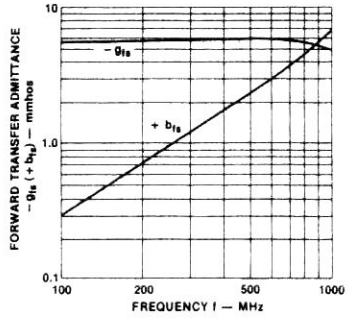


Output Conductance vs Frequency

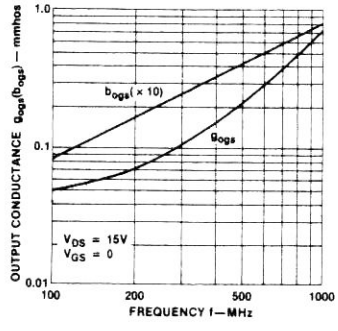
COMMON GATE



Input Admittance vs Frequency

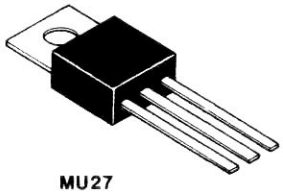


Forward Transfer Admittance vs Frequency

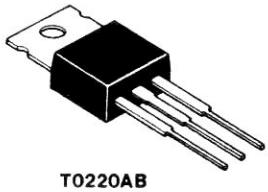


Output Conductance vs Frequency

276-1000 276-1001 276-1020 276-1067 THYRISTORS



MU27



TO220AB

GENERAL DESCRIPTION

Thyristors and their trigger devices can take numerous forms, but they share these characteristics:

- They are "open circuits," capable of withstanding rated voltage until triggered.
- They become low-impedance current paths when triggered, and remain so, even after the trigger source is removed, until current through that path stops, or is reduced below a minimum "holding" level.

SCRs

Silicon-Controlled Rectifiers (SCRs) are Thyristors intended to switch load currents in one direction only, making them useful for DC and half-wave AC applications as well as full-wave applications, in which bidirectional current is routed in one direction through the SCR via a bridge rectifier.

TRIACs

Triacs are bidirectional Thyristors, in which a single trigger source turns the device on for load current in either direction. Because they do not require a bridge rectifier in order to handle full-wave AC, Triacs are useful in AC power applications that require full source power control capability to be applied to the load.

Catalog Number	Imax A	Vmax V	I_{GT} (max) mA	V_{GT} (max) V	Case Style
276-1067	6	200	25	1.5	MU27
276-1020	6	400	25	1.5	MU27

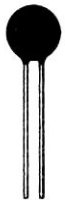
Catalog Number	Imax A	Vmax V	I_{GT} (max) mA	V_{GT} (max) V	Case Style
276-1001	6	200	50	2.5	TO220AB
276-1000	6	400	50	2.5	MU27

V130LA1 276-571 METAL OXIDE VARISTOR

GENERAL DESCRIPTION

This is a metal oxide varistor and the end of lifetime for the device is defined as a degradation failure which occurs when the device exhibits a shift in the Varistor Voltage at one (1) milliampere exceeding ± (10% + 1V) of the initial value. This type of failure is normally a result of a decreasing V−I value, but does not prevent the device from continuing to function. However, the device will no longer meet the original specifications.

PIN CONNECTION

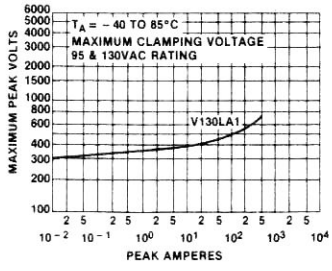


ABSOLUTE MAXIMUM RATINGS

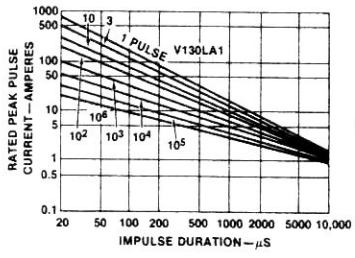
Voltage (DC) Continuous ..... 175 V
Voltage (RMS) Continuous ..... 130 V
Energy (W_{TM} Joules (10/1000 μs) Transient ..... 7 W_{TM}
Peak Current (I_{TM}) Amperes (8/20 μs) Transient ..... 800 A

TYPICAL CHARACTERISTICS

Varistor Voltage (@ 1 mA DC Test Current) ..... 255 V
Maximum Clamping Voltage (V_C @ Test Current) (8/20 μs) ..... 390 V_C
10 A_{IP}
Typical Capacitance (f = 0.1 To 1 MHz) ..... 180 pF



Transient V-I Characteristics



Pulse Lifetime Ratings

METAL OXIDE VARISTOR

SNR-20A130K
276-568
SNR-14A130K
276-570

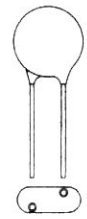
GENERAL DESCRIPTION

SNR Varistors for transient voltage suppression are metal oxide devices with industry standard. Their impedance is a nonlinear inverse function of applied voltage. At rated voltage their impedance is high. When a higher voltage transient appears across the varistor, its impedance sharply decreases to a low value. This transient voltage is clamped to a safe level and the energy in the transient is dissipated in the varistor. Characteristics are bi-directional.

ABSOLUTE MAXIMUM RATING

Varistor Voltage (V-I @ 1mA DC) (184V ~ 225V)	205 V
Applied Voltage (AC_{RMS})	130 V
(DC)	175 V
Energy (J) (276-568)	70 J
(276-570)	35 J
Power (276-568)	1 W
(276-570)	0.60 W
Capacitance (PF @ 1 MHz) (276-568)	1900 PF
(276-570)	940 PF
Peak Pulse Current (8 X 20 μs) 2 Times (276-568)	4000 A
(276-570)	2500 A
Storage Temperature	−40° +125°C
Operating Ambient Temperature	−40° +85°C

PIN CONNECTION



CHARACTERISTICS

MAXIMUM APPLIED VOLTAGE

The maximum RMS of commercial line voltage or sine wave, or the maximum DC voltage which can be applied to the device continuously.

ENERGY

The maximum allowable energy for a single square wave of 2 ms. Its ratings are based on a shift of VARISTOR VOLTAGE of less than ±10% of initial value.

AVERAGE POWER DISSIPATION

The maximum value of average pulse power dissipation for repetitive surge current.

VARISTOR VOLTAGE

The varistor terminal voltage which will be measured with 1mA DC applied.

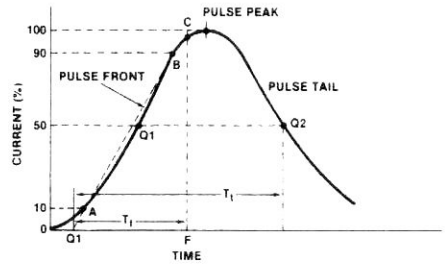
STANDARD IMPULSE CURRENT WAVEFORM

The impulse of 8x20μs current waveform is applied as standard impulse current when PEAK PULSE CURRENT and VOLT-AMPERE CHARACTERISTICS are measured.

PEAK PULSE CURRENT

The maximum allowable pulse current for 2 impulses of 8x20μs current waveform with 5 minutes interval. Its ratings are based on a shift of VARISTOR VOLTAGE of less than ±10% of initial value. When impulses are applied more than 2 times the current should be reduced.

TYPICAL CHARACTERISTICS



T_f : Virtual time of pulse front
T_1 : Virtual time of pulse tail
Q1 : Virtual origin
Q1,Q2 : Half points of pulse peak
CF : Value of pulse peak

Impulse current waveform is conventionally expressed by $T_f \times T_1 \mu S$

SNR-20A130K 276-568 SNR-14A130K 276-570

CHARACTERISTICS (Cont'd)

VOLTAGE-TEMPERATURE COEFFICIENT

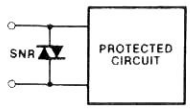
The shift of varistor voltage at ambient temperature between 20°C and 70°C is expressed by √(%/°C)

$$\sqrt{(\%/°C)} = \frac{V_1mA\ (at\ 70°C) - V_1mA\ (at\ 20°C)}{V_1mA\ (at\ 20°C)} \times \frac{1}{50} \times 100$$

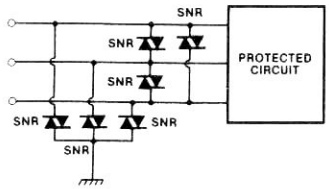
MAXIMUM CLAMPING VOLTAGE

The maximum voltage that will appear across the varistor when an 8X20us current pulse in the current range indicated is applied to the varistor.

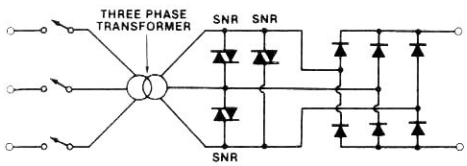
TYPICAL APPLICATIONS



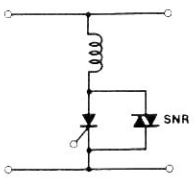
Single Phase Line Surge



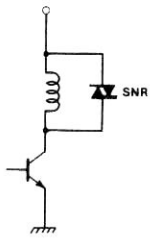
Three Phase Line Surge



Transformer Inductive Surge
by Primary Switch Off



Solenoid Inductive Surge
by Thyristor Switching



Solenoid Inductive Surge
by Transistor Switching

LED INDICATORS

Catalog Number	Direct Commercial Equivalent	Peak Wave Length nM	Color	Forward Voltage V_F (V)	Reverse Voltage V_R (V)	Max DC Forward Current I_F (MA)	Max Pwr Diss P_D (MW)	Fig. No.
276-018	PR5534S	700	RED	2.5	4	100	75	5
276-021	SLP-236B	565	YELLOW	2.8	3	30	70	6
276-022	SLP-236B	565	GREEN	2.8	3	30	70	6
276-025	R9-56	—	RED/GREEN	2.0	3.0	10	—	8
276-026	—	650	RED	—	3	50	100	3
276-033	TLR-147	700	RED	2.1	4	35	100	2
276-037	SLP-235B	565	GREEN	2.8	3	30	70	5
276-041	—	700	RED	1.75	3	70	140	4
276-068	—	700	RED	1.9	—	30	—	7
276-069	—	560	GREEN	2.1	—	30	—	7
276-070	SEL-1120R	700	RED	2.5	3	30	—	1
276-073	—	—	YELLOW	2.1	—	30	—	7

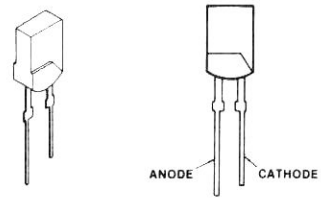


FIGURE 1
Miniature LED with diffused lens. Its features include high brightness—ideal for bar graph display—can be arranged horizontally or vertically.

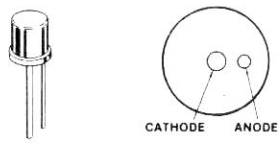


FIGURE 2
Miniature LED with diffused lens. This LED is compatible with most TTL and transistor circuits. It features a Fresnel lens design.

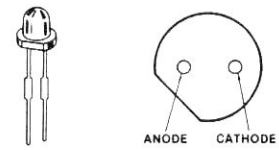


FIGURE 3
This LED features a frosted diffused lens in a plastic encapsulant. When the device is on, it appears as a large, soft light source, making it ideally suited for front panel applications.

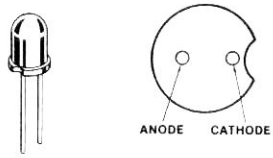


FIGURE 4
This device is a jumbo LED with a diffused lens. It can be used in applications such as pilot and indicator lamps.

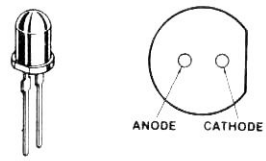


FIGURE 5
Subminiature LED with diffused lens. This device has solid state reliability and is compatible with most TTL and transistor circuits.

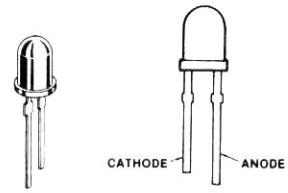


FIGURE 6
This is a frame type solid state LED with a diffused lens.

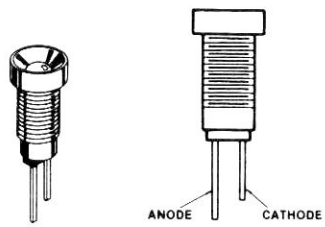


FIGURE 7
This is a subminiature LED indicator with polished chrome reflective holder.

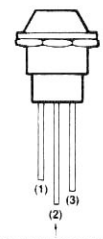


FIGURE 8
This is a three terminal LED. The light color radiates "red" when terminals 2 and 3 are used. Green light radiates when terminals 1 and 2 are used.

CQX21
276-036B

BLINKING LED

GENERAL DESCRIPTION

Blinking Frequency

In all types of blinking LEDs the blinking frequency with a supply voltage of 5 V and a temperature of 25 °C is typically about 3 Hz, varying between 1.3 and 5.2 Hz. It can be measured using a photodiode mounted on the lens of the diode being measured and connected to the high resistance input of a frequency meter. When the measurements are to be made in a temperature enclosure, of course, it is simpler to introduce a small measuring resistance in the supply lead and to take the signal for the counter from this.

Dependence on Supply Voltage

Throughout the range of supply voltage from 4.75 to 7.0 V, the blinking frequency increases with voltage on average of 0.5 Hz, that is at the rate of about 0.2 Hz/V or 7%/V (See Fig. 1). In individual cases the frequency may even remain constant, in others it may increase by more than 1 Hz/V (see the limits of scatter).

If the supply voltage goes below the lower limit of 4.75 V, the oscillator can no longer be relied upon to commence oscillation, especially at low temperatures. This is why when the supply voltage rises slowly the point of commencement of blinking is higher than when switched on normally.

Effect of a Series Resistance

The current through a blinking LED swings back and forth between typically 20 mA in the ON-state and about 0.9 mA in the OFF-state. This circumstance must be kept in mind if it is intended to connect a resistance in series with the diode, whether this is to drive it at a voltage higher than 7 V or to be able to derive an electrical signal. The fluctuating current causes a fluctuating voltage drop across the resistor and thereby a varying voltage on the blinking LED. The frequency and duty cycle of the blinking are both affected by this. It must be ensured that the actual supply voltage does not fall below the minimum level of 4.75 V otherwise there is a possibility that the AFI-circuit of the IC may come into operation.

Fig. 2 shows the blinking frequency as a function of the series resistance. As the value of resistance R_s was increased, so was that of the supply voltage, so as to keep the diode voltage in the ON-state at 5 V and thus also to maintain the current constant. The supply voltage to the circuit can be calculated as

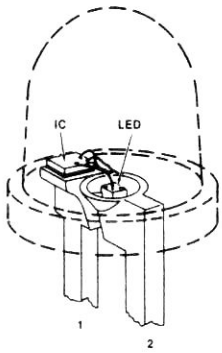
$$V_s = 5\ V + (20\ mA \bullet R_s/k\Omega).$$

Blinking-on Voltage

By "blinking-on voltage" is meant that supply voltage to the blinking LED at which the transition from continuous to blinking emission occurs. With a slowly rising supply voltage this voltage threshold is higher than with a quickly rising one, such as occurs when the blinking LED is inserted into a socket with an already established voltage. The minimum supply voltage of 4.75 V quoted in the data sheet was chosen to ensure reliable commencement of oscillation of the blinking LED at the lowest permissible temperature of −40C and with a slowly-rising supply voltage. The component is not guaranteed to function correctly when operated with a supply voltage below this limit.

The actual blinking-on voltage for slowly-rising voltage supply at 25 °C is typically 3.3 V, varying about 2.3 and 4.3 V. The blinking-on voltage is also temperature-dependent, falling with increasing temperature (Fig. 4). A typical blinking LED with a blinking-on voltage of about 3.3 V at 25 °C needs about 3.45 V at 40 °C and 3.2 V at +70 °C. The temperature-coefficient of the blinking-on voltage is thus about −2.3 mV/K or −0.07%/K.

PIN CONNECTION



TYPICAL CHARACTERISTICS

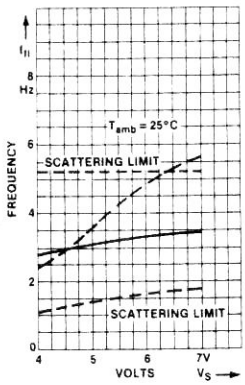


Figure 1

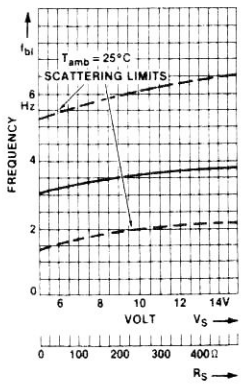


Figure 2

CQX21 276-036B

Blinking-on Voltage (Cont'd)

If the supply voltage of an already blinking LED is slowly reduced, at a certain level the opposite transition from blinking to steady light occurs. This "blinking-off voltage" is from 0.1 V to almost 1 V lower than the blinking-on voltage for slowly rising supply. Blinking starts again at this same voltage if the rise is sudden, as when plugged into a socket. In the transition region, an irregular flickering may occasionally be observed.

Dependence on Supply Voltage

The duty cycle or ON/OFF ratio for all types of blinking LEDs at 5 V is almost exactly 1:1, or otherwise expressed: pulse-duration/period $t_p/T = 0.5$. According to the data sheet a tolerance bandwidth from 0.33 to 0.67 must be allowed for, but this, however, is required for only a few individual cases.

As shown by Fig. 5, the duty cycle ratio rises only gradually with increasing supply voltage, on the average between 0.51 and 0.53 at 7 V. In some individual example the ratio is higher at low voltages, falling with increasing voltage (see scatter limit curves).

Effect of Series Resistance

The duty cycle ratio is more strongly affected by resistance than the blinking frequency. From Fig. 6 it can be seen that the ratio, with a supply voltage between 5 and 15 V, increases typically from 0.50 to 0.61 as the resistance increases from 0 to 500Ω. The limit curves show an even greater increase, which means that in individual cases the lengthening of the light phase and shortening of the dark is clearly visible.

The reason for this increase is the characteristic of blinking LEDs described in the section called Dependence on Supply Voltage, namely that with increasing supply voltage the frequency also increases, i.e. both light and dark phases become shorter. With resistance connected in series the voltage in the ON-state is lower, i.e. the light phase becomes longer. In the OFF-state the voltage increases, i.e. the dark phase becomes shorter. Lengthening of the light phase and shortening of the dark, however, means that the duty cycle ratio (= light phase/period) increases with increasing resistance and voltage.

Dependence on Temperature

Of all the parameters of blinking LEDs the duty cycle ratio is the least affected by temperature. The temperature-coefficient of duty cycle can actually be determined only by instrumental measurement (Fig. 7). In a typical blinking LED with a duty cycle ratio of 0.5 at 5 V and 25°C, the value increase from about 0.497 o 0.502 in the temperature range from −40 to +70°C, i.e. overall by 0.01%K.

Table 1 gives a review of all temperature-coefficients of the CQX21.

Parameter	Temp.Coef.in%/K
Current, ON-state	−0.35
Current, OFF-state	−0.38
Light intensity	−1.0 . . . −1.8
Blinking frequency	−0.40
BLinking-on voltage	−0.07
Duty cycle	+0.01

Table 1: Temperature-Coefficients of blinking LEDs

As Fig. 3 shows, the blinking frequency falls with increasing temperature. A typical blinking LED with a frequency of 3.0 Hz at 5 V and 25°C blinks at −40°C with a frequency of about 3.8 Hz and at +70°C of 2.5 Hz. In the region around 25°C the temperature-coefficient of frequency is about 0.012 Hz/K or −0.40%/K.

TYPICAL CHARACTERISTICS (Cont'd)

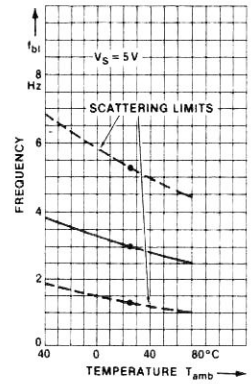


Figure 3

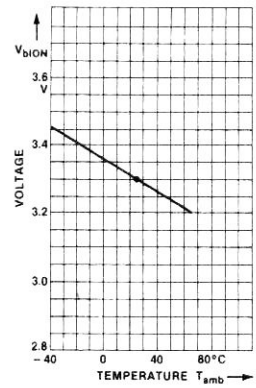


Figure 4

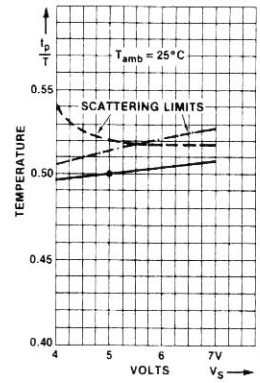


Figure 5

CQX21 276-036B

TYPICAL CHARACTERISTICS (Cont'd)

TYPICAL APPLICATION	MEANING OF THE BLINKING SIGNAL
Domestic apparatus	
Electric drill	Motor overloaded
Steam iron	Distilled water needed
Ventilating-fan hood	Change filter
Electric oven	Hot-plate overheated
Gas oven	Gas flame extinguished
Freezer	Internal temperature too high
Hand mixer	Motor overloaded
Coffee percolator	Water compartment empty
Coffee grinder	Hopper empty
Oil-fired central heating	Fault
Vacuum cleaner	Bag too full
Telephone	Extension in use
Auto	
Light system	Bulb out of order
Petrol gauge	Tank almost empty (continuous light—refill immediately)
Theft alarm	Set out of operation
Hand-brake	Brake applied
Cooling system gauge	Motor overheated
Oil pressure	Oil level too low
Safety belt	Not engaged
Throttle (choke)	Out
Radio/Audio/Television/Video	
TV-receiver	Remote-control unit operating
Cassette-recorder	Tape jammed or at the end Ready to record continuous light—recording in progress
UHF-HiFi-receiver	Interference due to multi-channel reception
Electronic Instrument	
Functional check	Fault in apparatus or incorrect operation
Calibration	Re-calibration needed
Data-handing	
Computer	Loss of data due to short-term mains break
Printer	No paper
Machines	
Work-piece	Jammed or in wrong position
Adjustment	Machine incorrectly adjusted
Monitoring	Danger of overheating
Others	
Buildings	Direction signs

Table 2: Application Examples for Blinking LEDs

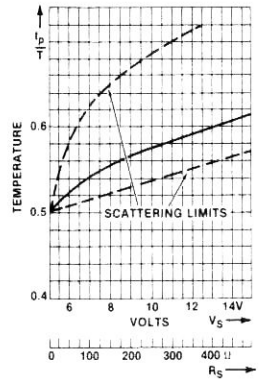


Figure 6

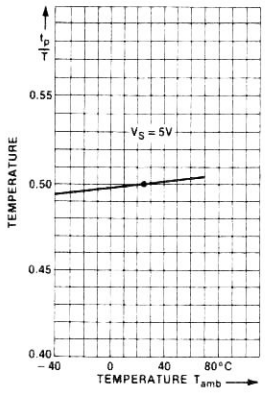
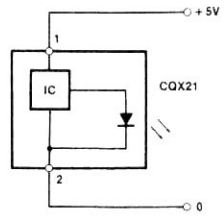


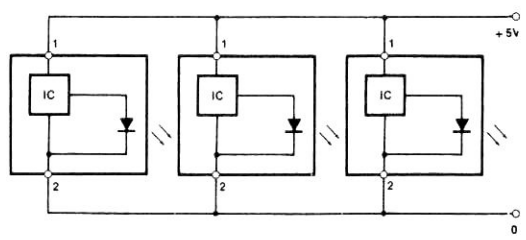
Figure 7

ABSOLUTE MAXIMUM RATING

Supply Voltage (V_S) ..... 7 V
ON-State Forward Current (I_F) ..... 56 mA
Thermal Resistance, Junction Ambient (Z_{THP}) ..... 130 K/W
Power Dissipation (V_S ● I_F) ..... 390 mW
Junction Temperature (T_j) ..... 100°C
Ambient Temperature (T_{Amb}) ..... 70°C
Wavelength (RED) (Ga As on Ga AS) ..... 660 NM

TYPICAL APPLICATION





P-N GALLIUM ALUMINUM ARSENIDE INFRARED- EMITTING DIODE

TIL906-1
276-143

GENERAL DESCRIPTION

This is a P-N Gallium Aluminum Arsenide Infrared-Emitting diode designed to emit near infrared radiation when forward biased. Its output is spectrally compatible with silicon sensors and has a high power output with a 20° beam angle.

ABSOLUTE MAXIMUM RATINGS

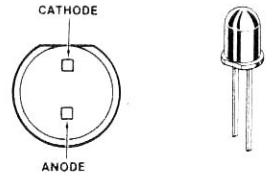
Forward Voltage (Static) (VF) ..... 1.75 V
Reverse Voltage (VA) ..... 3 V
Continuous Forward Current at (Or Below)
25°C Free-Air Temperature ..... 100 mA
Peak Forward Current (See Note 1) ..... 2 A
Reverse Current (V_R = 3 V) ..... 100 μA
Radiant Power Output (P_O) (IF = 20 mA) ..... 1.5 MW
Emission Beam Angle Between
Half-Intensity Points ..... 20°
Wave Length at Peak Emission (IF = 20 mA) ..... 880 nM
Operating Temperature Range ..... −40°C To 80°C
Storage Temperature Range ..... −40°C to 100°C

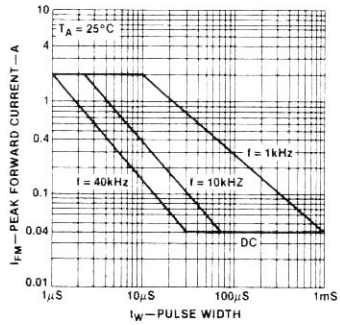
NOTE: 1. This value applies for $t_w \leq 10\ \mu s$, $f \leq 1$ kHz. See Figure 1.

FEATURES

- High power output With a 20° beam angle
- Output spectrally compatible with silicon sensors

PIN CONNECTION

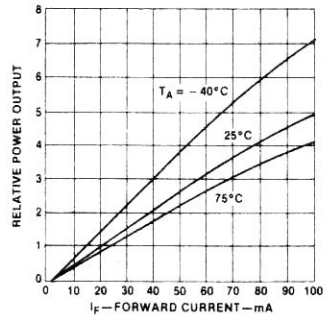




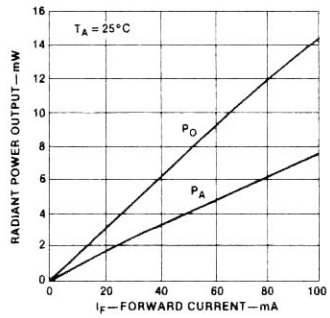
Peak Forward Current vs Pulse Width

Figure 1

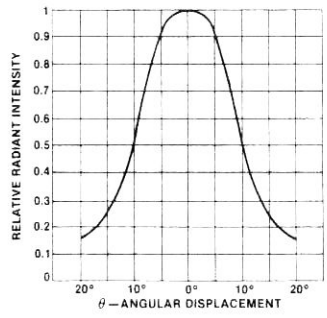
TYPICAL CHARACTERISTICS



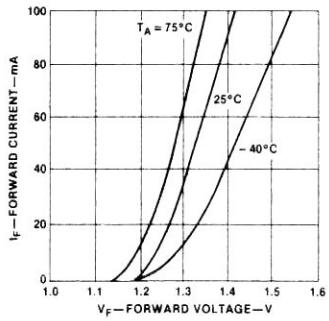
Relative Power Output vs Forward Current



Radiant Power Output vs Forward Current



Relative Radiant Intensity vs Angular Displacement



Forward Conduction Characteristics

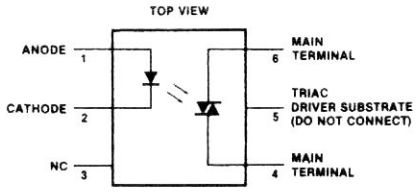
MOC3010
276-134

OPTOCOUPLER TRIAC DRIVER

GENERAL DESCRIPTION

This device consists of a gallium-arsenide infrared emitting diode, optically coupled to a silicon bilateral switch and is designed for applications requiring isolated triac triggering, low-current isolated ac switching, high electrical isolation (to 7500 V peak), high detector standoff voltage, small size, and low cost.

PIN CONNECTION



INFRARED EMITTING DIODE MAXIMUM RATINGS

Reverse Voltage ..... 3.0 volts
Forward Current—Continuous ..... 50 mA
Total Power Dissipation @ TA = 25°C ..... 100 mW

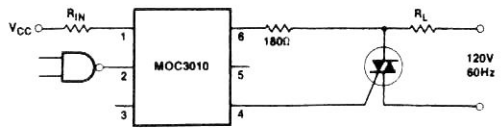
OUTPUT DRIVER MAXIMUM RATINGS

Off-State Output Terminal Voltage ..... 250 Volts
On-State RMS Current TA = 25°C ..... 100 mA
(Full Cycle, 50 to 60 Hz TA = 70°C) ..... 50 mA
Peak Nonrepetive Surge Current ..... 1.2 A
(PW = 10ms, DC = 10%)
Total Power Dissipation @ TA = 25°C ..... 300 mW
Derate above 25°C ..... 4.0 mW/°C

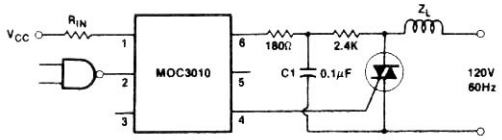
TOTAL DEVICE MAXIMUM RATINGS

Isolation Surge Voltage (1s) ..... 7500 Vac
(Peak ac Voltage, 60 Hz, 5 Second Duration)
Total Power Dissipation ..... 330 mW
Junction Temperature Range ..... −40 to +100°C
Ambient Operating Temperature Range ..... −40 to +70°C
Storage Temperature Range ..... −40 to +150°C
Soldering Temperature (10s) ..... 260°C

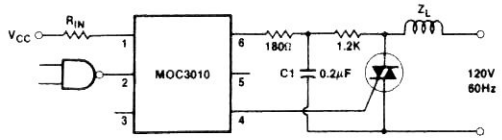
APPLICATIONS



Resistive Load

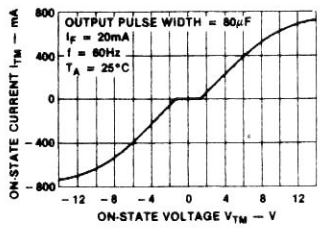


Inductive Load with Sensitive Gate Triac
($I_{GT} \leq 15mA$)

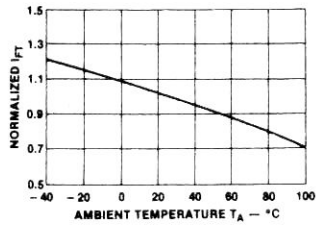


Inductive Load with Non-Sensitive Gate Triac
($15mA < I_{GT} < 50mA$)

TYPICAL CHARACTERISTICS



On-State Current vs On-State Voltage



Trigger Current vs Temperature

HIGH EFFICIENCY RED BAR GRAPH DISPLAY

MV57164
276-081

GENERAL DESCRIPTION

The MV57164 is a 10 segment bar graph display with separate anodes and cathodes for each light segment. The packages are end stackable.

FEATURES

- Large segments, closely spaced
- End stackable
- Fast switching, excellent for multiplexing
- Low power consumption
- Directly compatible with IC's
- Wide viewing angle
- Standard .3" DIP leading spacing

ABSOLUTE MAXIMUM RATINGS
(25°C Free Air Temperature Unless Otherwise Specified)

Power dissipation	750mW
Continuous forward current	
Total	300 mA
Per segment	30 mA
Reverse voltage	
Per segment	6.0 V
Storage and operating temperature	−40 to +85°C
Solder time 5 sec.	260°C

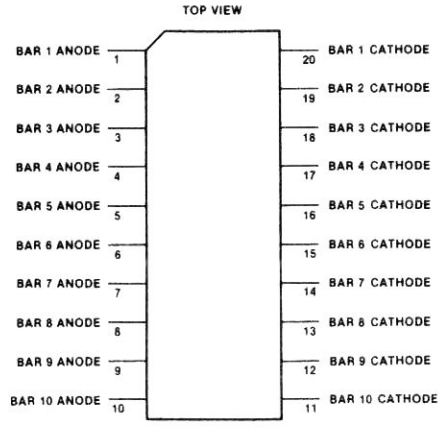
TYPICAL THERMAL CHARACTERISTICS

Thermal resistance junction to free air Φ JA	160° C/W
Wavelength temperature coefficient (case temp)	1.0 A/°C
Forward voltage temperature coefficient	−2.0 mV/°C

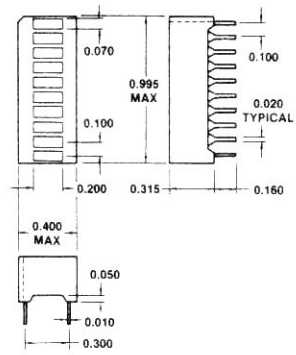
ELECTRO-OPTICAL CHARACTERISTICS

Forward Voltage	2.5 V
Peak emission wavelength	630nm
Spectral line half width	40nm
Dynamic resistance	
Segment	26 ohms
Capacitance	35 pF
Switching Time	400 ns
Reverse Voltage	6.0 V

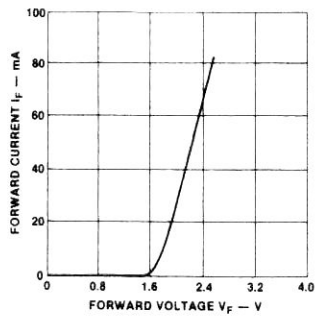
PIN CONNECTION



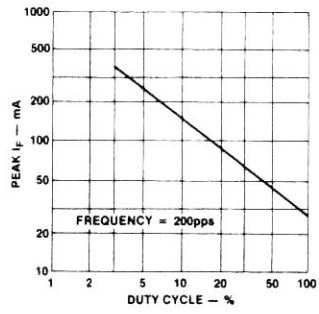
DIMENSIONAL DIAGRAM



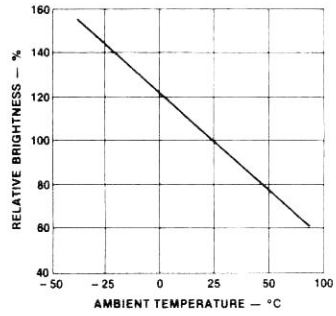
TYPICAL CHARACTERISTICS



Forward Current vs Forward Voltage



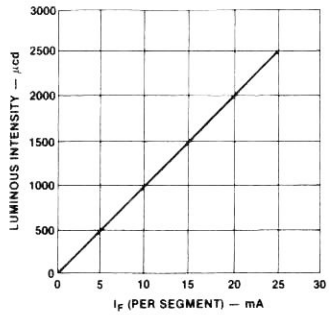
Luminous Intensity vs Forward Current



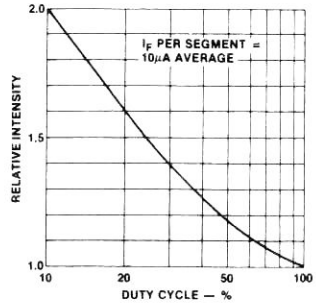
Luminous Intensity vs Ambient Temperature

MV57164 276-081

TYPICAL CHARACTERISTICS (Cont'd)



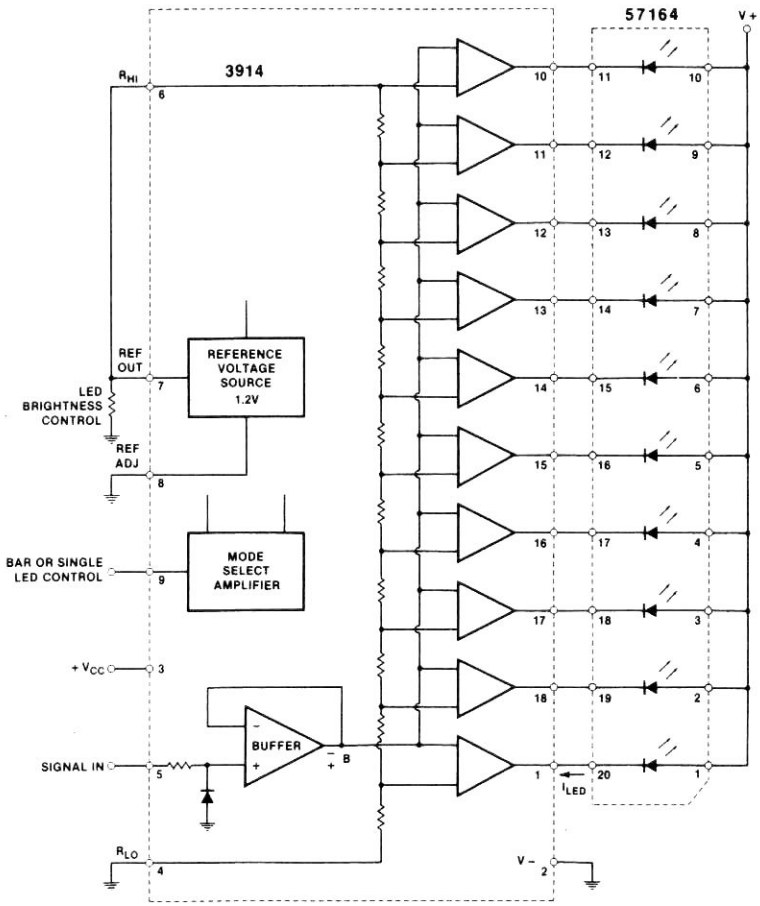
Maximum Peak Current vs Duty Cycle

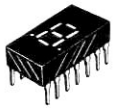


Luminous Intensity vs Duty Cycle

TYPICAL APPLICATION

Typical Drive Circuit





COMMON CATHODE DISPLAY

MAN74
276-075

GENERAL DESCRIPTION

This is a red .3 inch common cathode RHDP Display device with a brightness or luminous intensity (Per Seq. MIN) of 125 μcd @ 10mA.

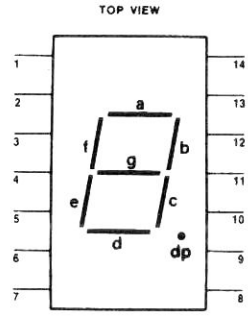
APPLICATIONS

- Instruments
- Test Equipment
- Office Machines
- Computers
- Automobiles
- Clocks/Radios
- Communication Equipment
- Calculators
- CB Radios

ABSOLUTE MAXIMUM RATINGS

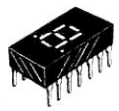
Forward Voltage ..... 2 V
Forward Current ..... 20 mA
Power (P_D) ..... 700 mW
Wave Length ..... 660 nM
Brightness/Luminous Intensity @ 10mA ..... 125 μcd

PIN CONNECTION



OPTOELECTRONIC INDEX BY FUNCTION

276-053 0.3" SOLID STATE SEVEN SEGMENT DISPLAY



GENERAL DESCRIPTION

The 276-053 is a common anode LED numeric display. The large 0.3" high character size generates a bright, continuously uniform 7 segment display. Designed for viewing distances of up to 10 feet, this single digit display has been human engineered to provide a high contrast ratio and wide viewing angle.

FEATURES

- Fits 14 pin DIP socket
- Excellent character appearance—continuous uniform segments; wide viewing angle; high contrast
- IC compatible—1.6 V per segment
- Standard 0.3" DIP lead configuration; PC board or standard socket mountable
- Both left and right decimal points

APPLICATIONS

- Electronic calculators
- TVs
- Radios
- Frequency counters
- Digital clocks

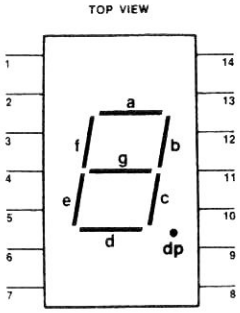
RADIANT CHARACTERISTICS (IF=20mA) T_A=25°C

Luminous Intensity ..... 250 mcd
Wavelength (Peak) ..... 655 nM

ABSOLUTE MAXIMUM RATINGS

Power Dissipation T_A=25°C ..... 400 mW
Average Forward Current/Segment or Decimal Pt. T_A =25°C ..... 25 mA
Peak Forward Current/Segment or Decimal Pt. T_A=12°C
(Pulse Duration 500μs) ..... 150 mA
Reverse Voltage per Segment or Decimal Pt. ..... 6 V
Operating Temperature Range ..... −20 to +85°C
Storage Temperature Range ..... −20 to +85°C
Max Solder Temperature 1/16" Below Seating Plane (t ≤ 5 sec.) ..... 230°C

PIN CONNECTION



COMMON ANODE

PIN	FUNCTION
1	CATHODE a
2	CATHODE f
3	ANODE
4	NO PIN
5	NO PIN
6	CATHODE dp
7	CATHODE e
8	CATHODE d
9	NO CONNECTION
10	CATHODE c
11	CATHODE g
12	NO PIN
13	CATHODE b
14	ANODE

ALTERNATE CONNECTION

PIN	FUNCTION
1	NO PIN
2	ANODE
3	CATHODE-f
4	CATHODE-g
5	CATHODE-e
6	CATHODE-d
7	NO PIN
8	NO PIN
9	ANODE
10	CATHODE-dp
11	CATHODE-c
12	CATHODE-b
13	CATHODE-a
14	NO PIN

276-116 CADMIUM SULPHIDE PHOTOCELL

GENERAL DESCRIPTION

A cadmium sulphide photo cell is a light variable resistor which is most sensitive in the green to yellow portion of the light spectrum. With it you can use light to control many electronic devices. Max. resistance .5 meg., min. resistance 100 ohms, max. voltage 170 V, max. wattage .2 watts, rugged epoxy case.

APPLICATIONS

- Night light
- Light control
- Burglar alarm
- Relay

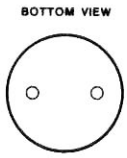
SPECIFICATIONS

- Shape ..... Round
- Sensitive Area ..... .07 sq. in.
- Weight ..... 1.56 gms.
- Resistance at 1 Ftc (2870°K) ..... 1.7k Ohms . 40%
- Typical Resistance 100 Ftc (2870°K) ..... 100 Ohms
- Resistance Dark Minimum (1 Minute) ..... 0.5 Megohms

ABSOLUTE MAXIMUM RATINGS

Max. Applied Voltage (ac or dc) ..... 170 V peak
Max. Power Dissipation at 25°C ..... 2 watts
Power Derating ..... Linearly to 0 @ 75°C
Operating Temp. Range ..... −40 to +75°C

CONNECTIONS



TRI-COLOR LIGHT EMITTING DIODE

XC-5491
276-035

GENERAL DESCRIPTION

The XC-5491 tri-state LED provides red, green, and yellow emission in the same package. This LED is a popular .200 diameter, two-leaded package containing a red and green LED chip in inverse parallel. By reversing the polarity of the applied current, the LED will emit red or green light while an AC voltage results in yellow light. The chips used in the XC-5491 are brightness matched so that the light output is uniform. This eliminates the necessity for the special drive circuits previously required with tri-state lamps.

These lamps provide the designer with the capability of efficiently displaying three functions with one indicator. This reduces the number of front panel indicators and simplifies design.

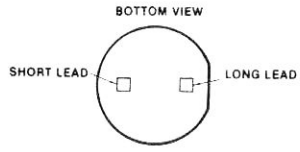
FEATURES

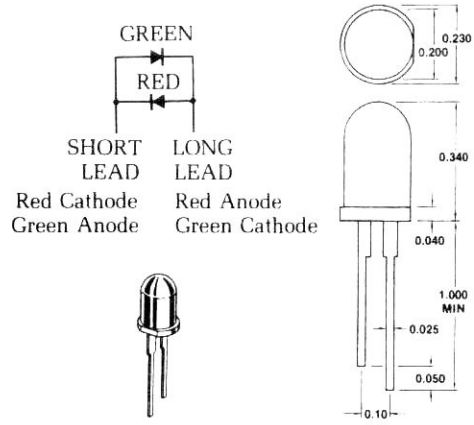
- 3 States—red, green, and yellow
- Equal brightness in all three colors
- Popular T 1¾ size package
- Wire wrappable leads

ABSOLUTE MAXIMUM RATINGS

Forward Current	25 mA
Peak Reverse Voltage	5V
Power Dissipation	100 mW
Operating Temperature Range	−55 to +85°C
Lead Solder Temperature	260°C

PIN CONNECTION





INFRARED PHOTOTRANSISTOR

TIL414
276-145

GENERAL DESCRIPTION

The TIL414 is an NPN silicon phototransistor in A T-1 3/4 style case. It provides high speed and high photosensitivity, suitable for IR switching applications.

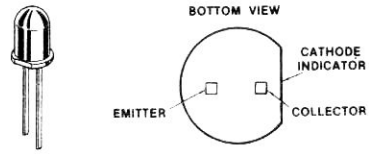
ABSOLUTE MAXIMUM RATINGS

Collector-Emitter Voltage	50 V
Emitter-Collector Voltage	7 V
Power Dissipation	50 mW
Operating Temperature	−40° to +100°C

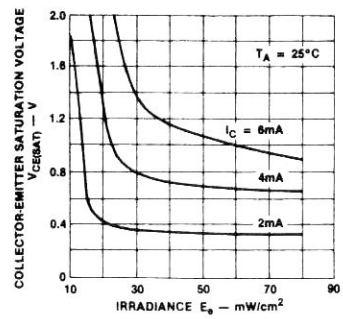
ELECTRICAL CHARACTERISTICS (Typical)

Dark Current (V_{CE} = 30 V)	25 nA
Light Current (V_{CE} = 5 V●E_e = 20mW/cm²)	7 mA
Collector-Emitter Saturation	0.4 V
Rise Time	8 μs
Fall Time	6 μs

PIN CONNECTION



TYPICAL CHARACTERISTICS



Collector-Emitter Saturation Voltage vs Irradiance

276-142 INFRARED EMITTER AND DETECTOR

GENERAL DESCRIPTION

The 276-142 is a pair consisting of an infrared photodetector and an infrared-emitting diode. The diode is capable of emitting radiant energy in the infrared region of the spectrum.

FEATURES

- Spectrally and mechanically matched
- High power efficiency . . . typically 5 percent at 25°C

ABSOLUTE MAXIMUM RATINGS

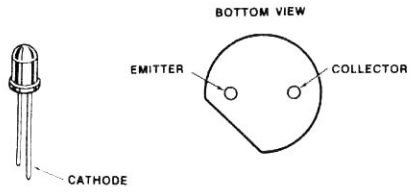
Photodetector

Collector-Emitter Voltage 20V
Collector Current 25mA
Continuous Device Dissipation at (or below) 25°C Free-Air Temperature 50mW
Operating Free-Air Temperature Range ..... −40 to +80°C
Storage Temperature Range ..... −40 to +85°C
Lead Temperature 1/16 Inch from Case for 5 Seconds ..... 240°C

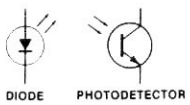
Infrared-Emitting Diode

Reverse Voltage 2V
Continuous Forward Current 40mA
Radiant Power Output 0.5mW
Wavelength at Peak Emission 915mm

PIN CONNECTION



GRAPHIC SYMBOL



276-124 2.5×5cm SILICON SOLAR CELL

GENERAL DESCRIPTION

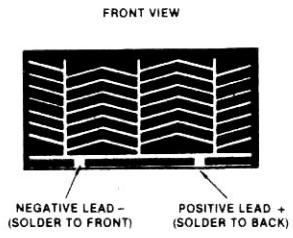
A solar cell is a silicon semiconductor device which converts light energy directly to electricity. A typical 2.5×5cm cell will produce 0.42 volt and up to .18 amp of usable current. The power generated is affected by the load resistance (circuit powered by cell) strength of sunlight and temperature.

Be extremely careful when soldering leads. Use only a very fine wire (#26 or thinner) and use a small soldering iron (less than 50 watts). Solar cells may be connected in series to produce more voltage and in parallel for more current.

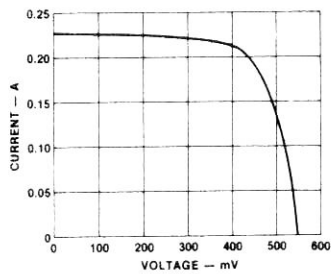
ABSOLUTE MAXIMUM RATINGS

Voltage (Open Circuit): 0.55V
Current (short circuit): 0.2A
(Test conditions: Full sunlight at noon on a clear day at 25°C (76°F))

CONNECTIONS



TYPICAL CHARACTERISTICS



Current vs Voltage

RING DETECTOR/DRIVER TCM1512A

276-1302

GENERAL DESCRIPTION

The TCM1512A integrated circuit is designed for use as an alerting device in the line powered telephone. The IC (with a minimum of external components) is powered and activated by the telephone line's AC "ring" voltage to generate a signal suitable for driving piezo-electric "sound disc" transducers. In a typical telephone application this AC ring voltage can vary from 40 to 150 V_{RMS} over a frequency range of 14 to 68 Hz. The output signal is a square wave alternating between two frequencies in a ratio 1.14:1; and with the average of these two frequencies set at 1250 Hz, a "warble" rate or shift rate of approximately 10 Hz.

During standby (prior to activation) the ringer presents an impedance of 100K or greater to prevent any interference with parallel "offhook" telephones transmitting DTMF or voice frequencies. The IC is designed to handle lightning strikes on the line of 1500 V, 200 μsec duration. In addition, dial pulses from parallel phones are ignored so a false ringing of the bell (tapping) won't occur.

FEATURES

- On-chip full-wave rectifier
- High standby impedance
- Built-in lightning protection circuitry
- Built-in anti-"tapping" circuitry
- Built-in regulators
- Built-in static protection
- 0.8 through 2 kHz output frequency range
- Low external component count
- Push-pull drive of piezo transducers

ABSOLUTE MAXIMUM RATINGS

Continuous Input Voltage (Pin 1 ref. to Pin 8) (See note) ..... 70 V
Continuous V_{CC} Supply (Pin 6 ref. to Pin 7) (See note) ..... 63 V
Package Power Capability @25°C ..... 1 W
Surge SCR On-STate Current (On-Time ≤ 200 μsec) ..... 0.9 A.
Continuous Input Current (with SCR Triggered) (See note) ..... 0.5 A_{RMS}.
Operating Ambient Temperature ..... −20 to +70°C
Storage Ambient Temperature ..... −40 to +150°C

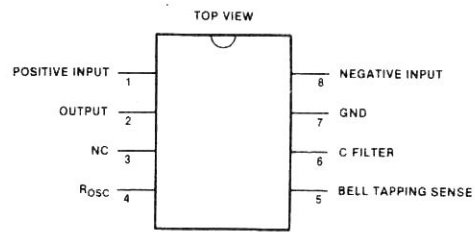
NOTE: Normally the IC is fed with an AC signal through a 2.2K resistor to guarantee compliance with these maximum ratings. Care should be taken when connecting a DC power supply to the IC to prevent the internal SCR from being fired which could result in damage to the IC.

TEST CIRCUIT

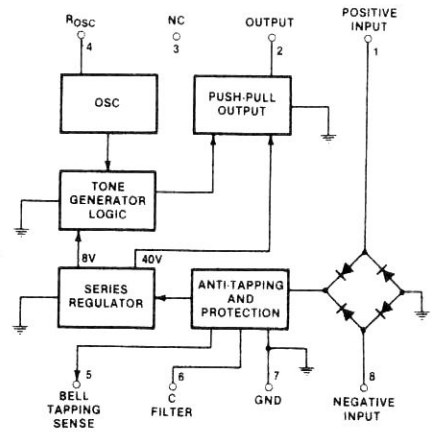
An oscilloscope can be used as the output "test equipment" for all the electrical measurements except output frequency, where a frequency counter should be used.

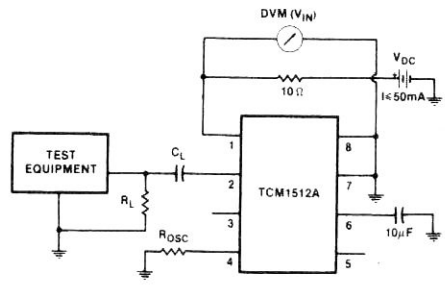
1. V_{IN} is the voltage measured across Pins 1 & 8 of the integrated circuit.
2. Threshold voltage is the input voltage V_{IN} measured the instant before the output (Pin 2) starts oscillating.
3. Care must be taken in attempting to measure SCR characteristics of the integrated circuit so as not to exceed absolute maximum. It is suggested that a curve tracer be used across Pins 1 & 8 with capacitor connection Pin 6 shorted to Pin 7 to simulate a standby transient effect of a discharged 10 μF filter capacitor.
4. DC output currents are measured in the steady state. Peak output current would normally be greater than specified.
5. The output frequency is measured across R_L using a frequency counter. The frequency counter measures and displays the average frequency of the output tones F_{AVG} (where F_{AVG} = the average of the high frequency of the low frequency which is integrated by the counter over a long period of time).
6. Oscillator drift is the deviation in output frequency due to change in temperature T_A or input voltage V_{IN} compared to the output frequency at T_A = 25°C and V_{IN} = 30 V. R_{OSC} is varied until the average output frequency F_{AVG} = 1250 Hz.
7. For most tests, Pin 5 is left open. Where specified, Pin 5 is activated by connecting a 2.2K resistor across Pins 5 & 6.

PIN CONNECTION



BLOCK DIAGRAM





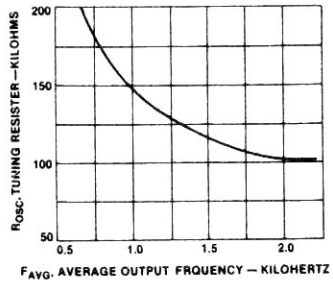
Test Circuit

TCM1512A 276-1302

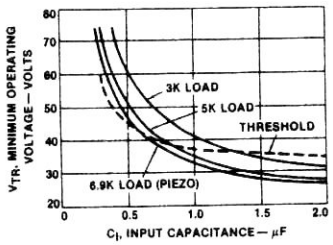
TYPICAL CHARACTERISTICS

This first graph shows the typical average output frequency vs. oscillator tuning resistor (R_{OSC}). The curve shows the general trend that the IC's follow; however, the values will differ from IC to IC. The curve should not be used as an accurate design tool since IC's could vary more than ± 10% from the values given in this graph.

The second graph shows the minimum operating voltage at tip and ring (20 Hz) vs. input capacitance C1 as a function of load resistance. The dashed curve marked "threshold" shows the voltage necessary at tip and ring to produce a voltage between pin 6 and 7 large enough to trip an internal switch and start the output oscillating. However, depending on the load and input capacitance, the minimum operating voltage could be larger than the threshold voltage. The threshold voltage can turn the IC on for an instant until the load drains the 10 μF capacitor across pins 6 and 7 and then the IC would turn off again. Depending on R_{LOAD} and C1, the minimum operating voltage could be the true threshold voltage.



Tuning Resistor vs Average Output Frequency



Minimum Operating Voltage vs Input Capacitance

TYPICAL APPLICATIONS

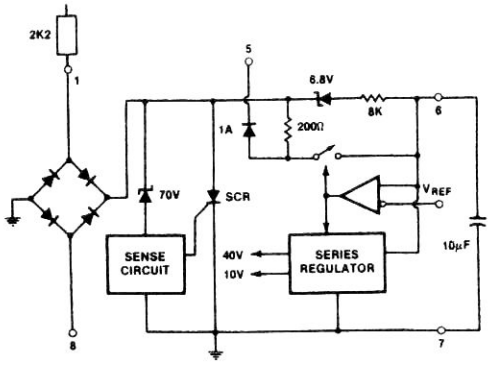
Input Circuitry

The TCM1512A has built-in circuitry to avoid "tapping," a false triggering due to transients. The IC is kept "OFF" (in standby) until the incoming signal has charged the capacitor on pins 6 and 7 to a threshold of approximately 8 volts through an internal zener and 8K resistor.

Connecting pin 5 and pin 6 bypasses the internal zener and thus reduces the threshold voltage, (V_{IN}). The connection, if made, should be with a resistor of not less than 2K.

The ring detector/driver IC has built-in transient protection circuitry which (with appropriate external circuitry) is designed to handle lightning strikes (1500 V/200 μsec) on a phone line. The IC is made up of a high current SCR triggered by a circuit that senses current (typically 70 mA) through the 70 V on-chip zener. The external 2.2K resistor is a necessary component to dissipate the energy when the SCR is turned on. Therefore, with an external resistor of 2.2K, a voltage transient of 224 V (peak) from tip to ring, will fire the SCR. (2200 Ω × 0.07 A Pk) + 70 V = 224 V (Pk), Note: Caution is required when a DC power supply is connected to the input pins (1 and 8). If the IC is subjected to a transient, it could possibly fire the SCR and would not turn off until the current supplied to it falls below the holding current I_H. The DC power supply provides constant current and would result in IC destruction.

The ring detector/driver IC has a standby impedance of greater than 100K. The IC achieves such a high impedance due to an on-chip series zener which presents a high impedance until its turn-on voltage (6.8V) is reached. However, when the IC reaches its threshold voltage (8V) across pins 6 and 7, an internal switch is closed which bypasses the 6.8 V zener. This allows for more efficient power transfer to the load when the IC is in the operating mode. In the operating mode the IC has an AC impedance determined largely from the output load.

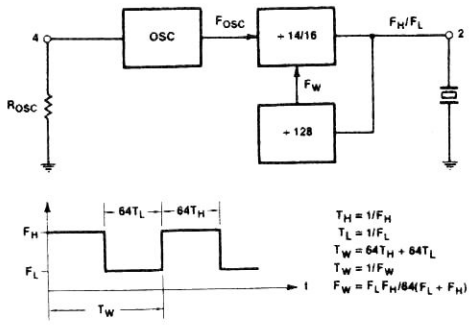


Input Circuitry

Output Tone Operation

The external resistor R_{OSC} sets the frequency of the IC's oscillator. The oscillator frequency F_{OSC} is then divided by a divide-by-14 counter for the high frequency F_H and a divide-by-16 counter for the low frequency F_L. The output frequencies are then divided by a divide-by-128 counter to establish the "warble rate." The warble rate is the alternation between the high frequency F_H and the low frequency F_L. Therefore, by changing the oscillator resistor R_{OSC}, the pitch of the output tones (F_H/F_L) and the warble rate between the tones can be set to the desired value. Oscillator drift is kept to a minimum (−1% to ±0.5%) during varying input voltages and operating temperatures due to an on-chip 10 V regulator and circuit design techniques. Tolerance of the output frequencies (F_H/F_L) from IC to IC are dependent upon IC tolerances and R_{OSC} tolerance and is normally in excess of ± 10%.

Oscillator Stability: It is recommended that on PCB's, R_{OSC} be located close to pin 4 (short lead) and be surrounded by ground plane. Also, pin 3 (N/C) should be grounded. These measures will prevent capacitive coupling from the output to the master oscillator, which may cause oscillator instability.



Output Tone Operation

TCM1512A 276-1302

TYPICAL APPLICATIONS (Cont'd)

Telephone Application

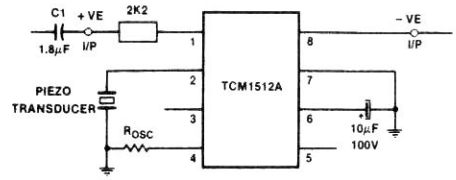
The primary application for the TCM1512A ring detector/driver IC is in the telephone set.

This TCM1512A ring detector/driver IC is designed for use in telephone sets to detect ring voltages and to drive a piezo-ceramic disc transducer, thus replacing the electromechanical bell. It can produce sound with efficiency comparable to that obtainable from a type 500 set. The typical output signal produces a pleasant but attention drawing sound with an average frequency of 1250 Hz. It is modulated between 1172 Hz and 1339 Hz at a 9.8 Hz warble rate. These output frequencies and the warble rate are adjustable by varying the value of the external R_{OSC}.

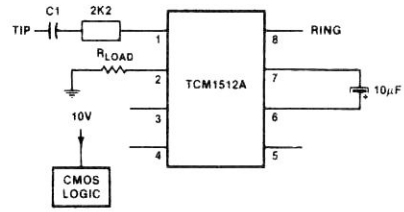
The network formed by the 1.8 μF DC blocking capacitor, the 2.2K current limiting resistor, and the diode full wave bridge supply the IC power from the phone lines. The 1.8 μF capacitor is "standard" with U.K. mechanical telephones and normally part of the hybrid network. The value of the capacitor (C1) affects turn-on time and the minimum input voltage. The incoming rectified AC signal is filtered by an external 10 μF/100 V capacitor connected between pin 6 and 7. The value of this filter capacitor affects the turn-on time of the IC. More significantly, it is used with internal IC circuitry to suppress "tapping." Tapping is a false ringing of the bell due to pulses on the phone line from rotary dials or pulse dialing IC's.

The TCM1512A incorporates a high standby input impedance to assure that "on-hook" telephones will not interfere with parallel (extension) "off-hook" telephones transmitting DTMF or voice frequency signals. Industry standards specify < 100K for voice frequencies (700 Hz - 1.6 kHz) for input voltages up to 3 V_{RMS}. The impedance for operating voltages (during ring) is specified to be < 8K. The TCM1512A meets both of these requirements. The DC blocking capacitor (C1) and the filter capacitor could modify the value of the ringer input impedances. The more closely the load and IC impedance match the line impedance, the greater the power transfer to the load. A potentiometer in series with the piezo load could be useful as a volume control.

The minimum operating voltage at tip and ring can be altered by changing the value of two external components, C1 and R_{LOAD}. C1 is the DC blocking capacitor at tip and ring and R_{LOAD} is the equivalent resistance of the load which may be a piezo transducer or the primary winding of a transformer. In the electromechanical telephone, C1 is fixed at 1.8 μF. However, if one is designing an all electronic telephone C1 and R_{LOAD} could be selected to achieve the desired minimum operating voltage.



Telephone Application of Ring Detector/Driver

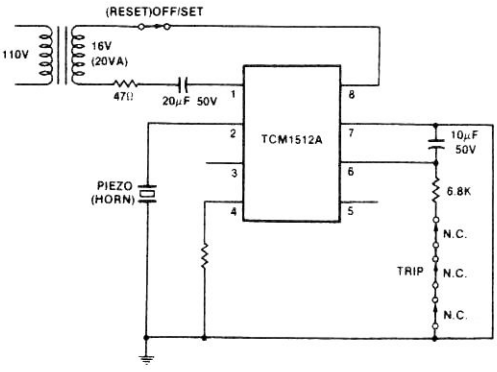


Input/Output Circuitry

Alarm Circuit

This device contains all the active components necessary to build a security alarm system. A few external capacitors and resistors are required, along with a 16 V or 24 V transformer. The external 20 μF capacitor stores voltage during alternate half-cycles that is added to the next half-cycle's voltage to generate 30 V (Pk) across pins 6 and 7. The voltage doubler allows the IC to turn on with lower supply voltages than are normally required.

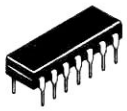
The IC is in standby (Off) when the "trip" switches are in their normally closed position. The 6.8K resistor doesn't allow the 10 μF capacitor (pins 6 and 7) to charge up to its 11.5 V threshold voltage. The instant the trip switch is opened, the capacitor charges and the alarm sounds. Even if the trip switch is closed, the alarm will continue to sound. This is due to a latch circuit internal to the IC. The alarm is disarmed by opening the reset/set switch. when using a "piezo horn" for a transducer, sound pressure levels of 105 dB or greater can be achieved with as little as 10 mA supply current.



Alarm Circuit

4001
276-2401

QUAD TWO-INPUT NOR GATE



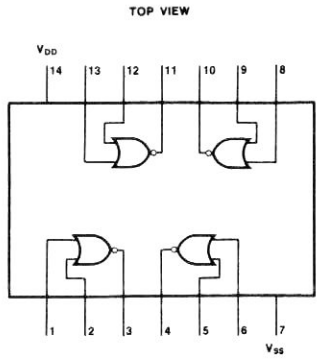
GENERAL DESCRIPTION

The 4001 quad 2-Input NOR gate is constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. These complementary MOS logic gates find primary use where low power dissipation and/or high noise immunity is desired.

This device contains circuitry to protect the inputs against damage due to high static voltages or electric fields; however, it is advised that normal precautions be taken to avoid application of any voltage higher than maximum rated voltages to this high impedance circuit. For proper operation it is recommended that V_{in} and V_{out} be constrained to the range $V_{SS} \leq (V_{in}$ or $V_{out}) \leq V_{DD}$.

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V_{SS} or V_{DD}).

PIN CONNECTION



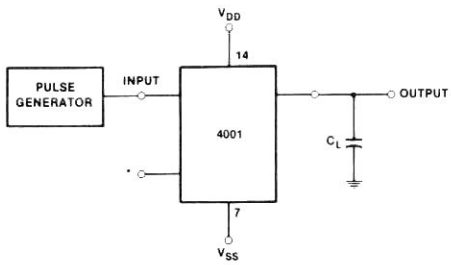
FEATURES

- Quiescent current = 0.5 nA typ/pkg @ 5 Vdc
- Noise immunity = 45% of V_{DD} typical
- Diode protection on all inputs
- Supply voltage range = 3.0 Vdc to 16 Vdc
- Single supply operation—positive or negative
- High fanout > 50
- Input impedance = 10^{12} ohms typical
- Logic swing independent of fanout

ABSOLUTE MAXIMUM RATINGS
(Voltages referenced to V_{SS})

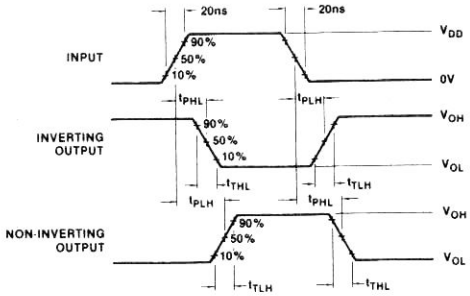
DC Supply Voltage	−0.5 to +16 Vdc
Input Voltage, All Inputs	−0.5 to V_{DD} +0.5 Vdc
DC Current Drain per Pin	10 mAdc
Operating Temperature Range	−40 to +85°C
Storage Temperature Range	−65 to +150°C

SWITCH TIME TEST CIRCUIT

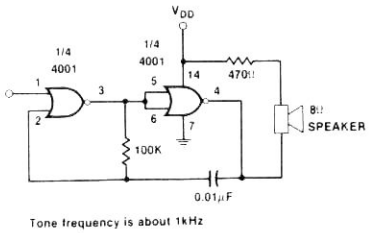


*All unused inputs of OR, NOR gates must be connected to V_{SS}.

SYNC TIMING WAVEFORMS

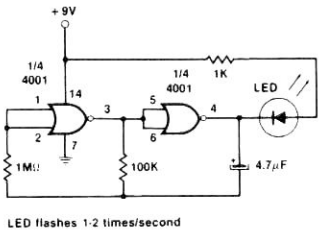


TYPICAL APPLICATIONS



Tone frequency is about 1kHz

Gated Tone Source



LED flashes 1-2 times/second

LED Flasher

QUAD TWO-INPUT NAND GATE

4011
276-2411

GENERAL DESCRIPTION

The 4011 is constructed with P and N channel enhancement mode devices in a single monolithic structure (Complementary MOS). Their primary use is where low power dissipation and/or high noise immunity is desired.

This device contains circuitry to protect the inputs against damage due to high static voltages or electric fields; however, it is advised that normal precautions be taken to avoid application of any voltage higher than maximum rated voltages to this high impedance circuit. For proper operation it is recommended that V_{in} and V_{out} be constrained to the range $V_{SS} \leq (V_{in}$ or $V_{out}) \leq V_{DD}$

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V_{SS} or V_{DD}).

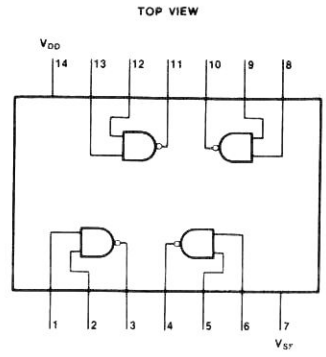
FEATURES

- Quiescent current = 0.5 nA typ/pkg @ 5 Vdc
- Noise immunity = 45% of V_{DD} typical
- Supply voltage range = 3.0 Vdc to 16 Vdc
- Double diode protection on all inputs

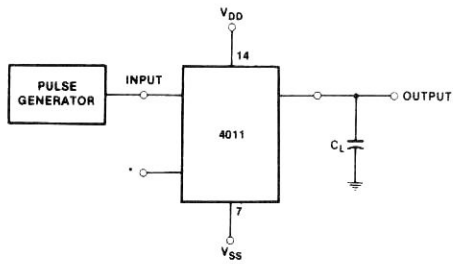
ABSOLUTE MAXIMUM RATINGS
(Voltages referenced to V_{SS})

DC Supply ..... −0.5 to +16 Vdc
Input voltage, All Inputs ..... − 0.5 to V_{DD} +0.5 Vdc
DC Current Drain per Pin ..... 10 mAdc
Operating Temperature Range ..... −40 to +85°C
Storage Temperature Range ..... −65 to +150°C

PIN CONNECTION

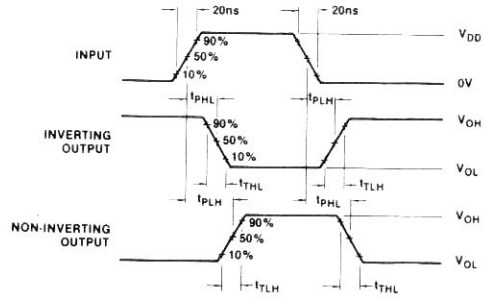


SWITCH TIME TEST CIRCUIT

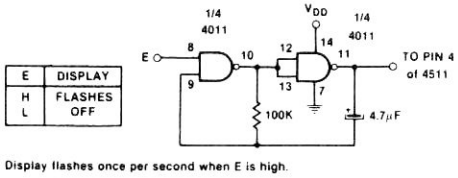


*All unused inputs of AND, NAND gates must be connected to V_{DD}.

SYNC TIMING WAVEFORMS



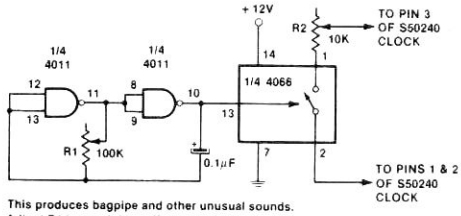
TYPICAL APPLICATIONS



E	DISPLAY
H	FLASHES
L	OFF

Display flashes once per second when E is high.

Display Flasher

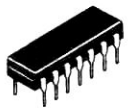


This produces bagpipe and other unusual sounds. Adjust R1 to vary interruption rate.

Special Effects

4013
276-2413

DUAL TYPE D FLIP-FLOP



GENERAL DESCRIPTION

The 4013 dual type D flip-flop is constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. Each flip-flop has independent Data, (D), Direct Set, (S), Direct Reset, (R), and Clock (C) inputs and complementary outputs (Q and $\overline{Q}$). These devices may be used as shift register elements or as type T flip-flops for counter and toggle applications.

This device contains circuitry to protect the inputs against damage due to high static voltages or electric fields; however, it is advised that normal precautions be taken to avoid application of any voltage higher than maximum rated voltages to this high impedance circuit. For proper operation it is recommended that V_{in} and V_{out} be constrained to the range $V_{SS} \leq (V_{in}$ or $V_{out}) \leq V_{DD}$.

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V_{SS} or V_{DD}).

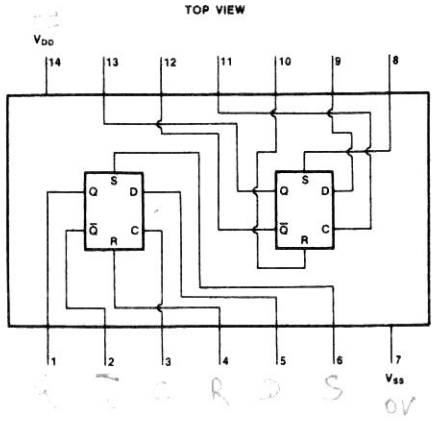
FEATURES

- Static operation
- Quiescent current = 2.0 nA/package typical @ 5 Vdc
- Noise immunity = 45% of V_{DD} typical
- Diode protection on all inputs
- Supply voltage range = 3.0 Vdc to 16 Vdc
- Single supply operation
- Toggle rate = 4 MHz typical @ 5 Vdc
- Logic edge-clocked flip-flop design—logic state is retained indefinitely with clock level either high or low; information is transferred to the output only on the positive-going edge of the clock pulse.
- Capable of driving two-low-power TTL loads, one low-power schottky TTL load or two HTL loads over the rated temperature range.

ABSOLUTE MAXIMUM RATINGS
(Voltages referenced to V_{SS})

DC Supply Voltage ..... −0.5 to +16 Vdc
Input Voltage, All Inputs ..... −0.5 to V_{DD} +0.5 Vdc
DC Current Drain per Pin ..... 10 mAdc
Operating Temperature Range ..... −40 to +85°C
Storage Temperature Range ..... −65 to +150°C

PIN CONNECTION

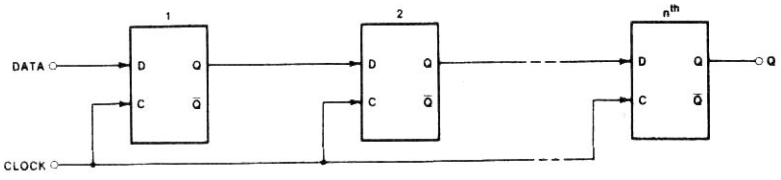


TRUTH TABLE

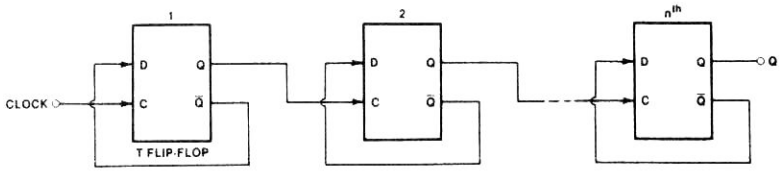
INPUTS				OUTPUTS	
Clock†	Data	Reset	Set	Q	$\overline{Q}$
—	L	L	L	L	H
—	H	L	L	H	L
—	X	L	L	No Change	
X	X	H	L	L	H
X	X	L	H	H	L
X	X	H	H	H	H

X = Don't Care
L = Low Level
H = High Level
† = Level Change

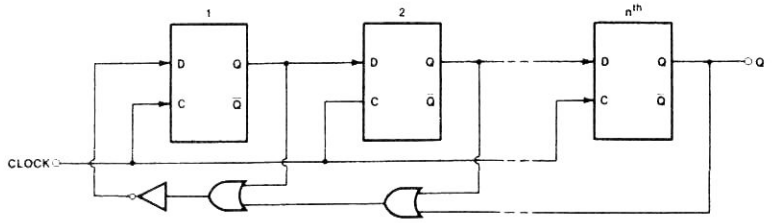
TYPICAL APPLICATIONS



n-Stage Shift Register

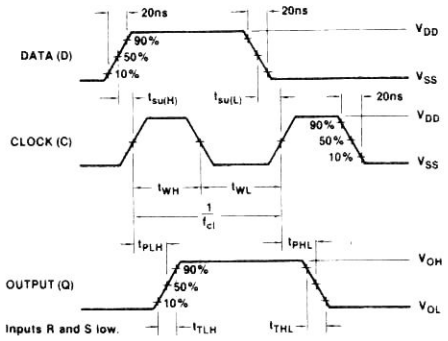


Binary Ripple Up-Counter (Divide-by-2^n)

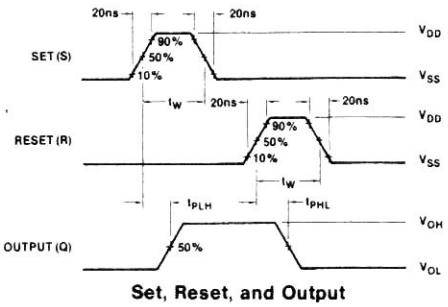


Modified Ring Counter (Divide-by-(n+1))

SYNC TIMING WAVEFORMS



Data, Clock, and Output



Set, Reset, and Output

DECADE COUNTER/DIVIDER

4017
276-2417

GENERAL DESCRIPTION

The 4017 is a five-stage Johnson decade counter with built-in code converter. High-speed operation and spike-free outputs are obtained by use of a Johnson decade counter design. The ten decoded outputs are normally low, and go high only at their appropriate decimal time period. The output changes occur on the positive-going edge of the clock pulse. This part can be used in frequency division applications as well as decade counter or decimal decode display applications.

This device contains circuitry to protect the inputs against damage due to high static voltages or electric fields; however, it is advised that normal precautions be taken to avoid application of any voltage higher than maximum rated voltages to this high impedance circuit. For proper operation it is recommended that V_{in} and V_{out} be constrained to the range $V_{SS} \leq (V_{in}$ or $V_{out}) \leq V_{DD}$.

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V_{SS} or V_{DD}.

FEATURES

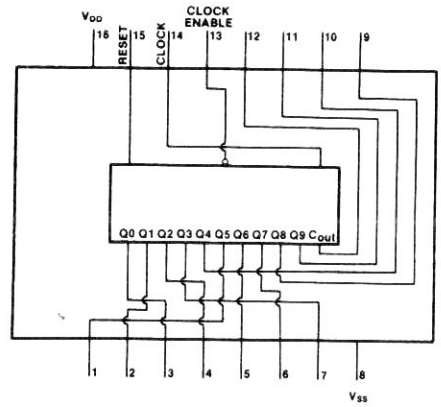
- Fully static operation
- DC clock input circuit allows slow rise times
- Carry out output for cascading
- 12 MHz (typical) operation @ V_{DD} = 10 Vdc
- Quiescent current = 5.0 nA/package typical @ 5 Vdc
- Supply voltage range = 3.0 Vdc to 16 Vdc
- Capable of driving two low-power TTL loads, one low-power schottky TTL load or two HTL loads over the rated temperature range

ABSOLUTE MAXIMUM RATINGS (Voltages referenced to V_{SS})

DC Supply Voltage	−0.5 to +16 Vdc
Input Voltage, All Inputs	−0.5 to V_{DD} +0.5 Vdc
DC Current Drain per Pin	10 mAdc
Operating Temperature Range	−40 to +85°C
Storage Temperature Range	−65 to +150°C

PIN CONNECTION

TOP VIEW

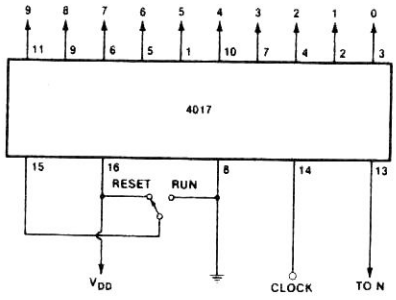


TRUTH TABLE (Positive Logic)

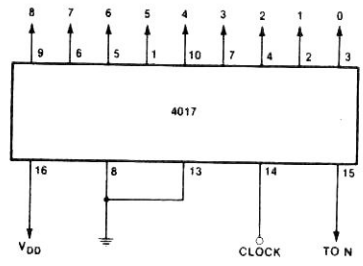
Clock	Clock Enable	Reset	Decode Output = n
L	X	L	n
X	H	L	n
X	X	H	QL
⎍	L	L	n + 1
⎍	X	L	n
X	⎍	L	n
1	⎍	L	n + 1

X = Don't Care If n <5 Carry = "H", Otherwise = "L"
L = Low Level H = High Level

TYPICAL APPLICATIONS



Count to N and Halt

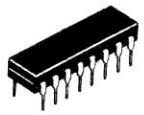


For N = 9, ground pin 15.

Count to N and Recycle

4049
276-2449

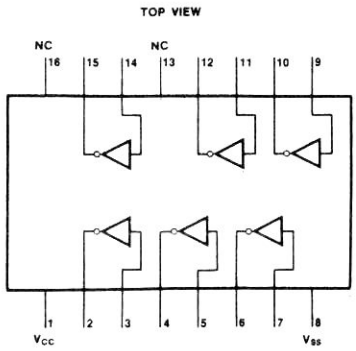
INVERTING HEX BUFFER



GENERAL DESCRIPTION

The 4049 hex inverter/buffer is constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. These complementary MOS devices find primary use where low power dissipation and/or high noise immunity is desired. These devices provide logic-level conversion using only one supply voltage, V_{CC}. The input-signal high level (V_{IH}) can exceed the V_{CC} supply voltage for logic-level conversions. Two TTL/DTL loads can be driven when the devices are used as CMOS-to-TTL/DTL converters (V_{CC} = 5.0 V, $V_{OL} \leq$ 0.4 V, $I_{OL} \geq$ 3.2 mA). Note that pin 16 is not connected internally on this device; consequently connections to this terminal will not affect circuit operation.

PIN CONNECTIONS



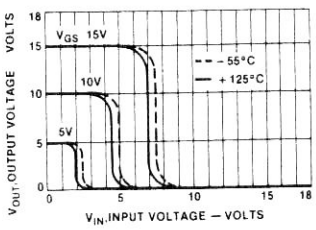
FEATURES

- High source and sink currents
- High-to-low level converter
- Quiescent current = 2.0 nA/package typical @ 5 Vdc
- Supply voltage range = 3.0 Vdc to 16 Vdc

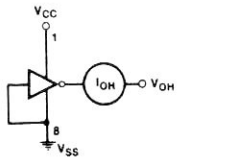
ABSOLUTE MAXIMUM RATINGS
(Voltages referenced to V_{SS}, Pin 8)

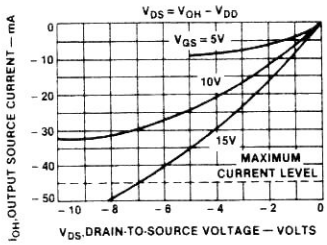
DC Supply Voltage	−0.5 to +16 Vdc
Input Voltage. All Inputs	−0.5 to V_{DD} +0.5 Vdc
DC Current Drain per Input Pin	10 mAdc
DC Current Drain per Output Pin	45 mAdc
Operating Temperature Range	−40 to +85°C
Storage Temperature Range	−65 to +150°C

TYPICAL CHARACTERISTICS

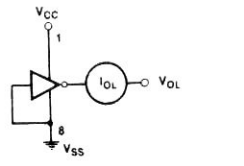


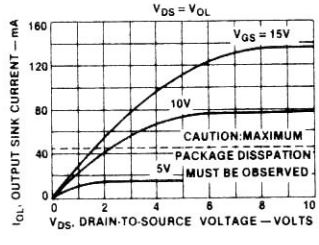
Output Voltage vs Input Voltage





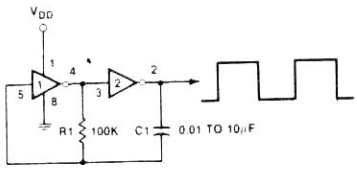
Output Source Current vs Drain-To-Source Voltage





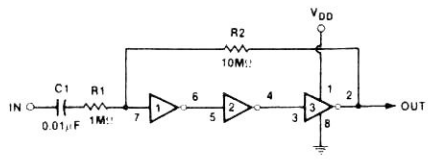
Output Sink Current vs Drain-To-Source Voltage

TYPICAL APPLICATIONS



1,2 = 1/3 4049
Pulse Rate = 1/1.4R1C1

Clock Pulse Generator



1,2,3 = 1/2 4049
Note that the inverters are used in a LINEAR mode.
Gain = R2/R1

Linear IOX Amplifier

QUAD BILATERAL SWITCH

4066
276-2466

GENERAL DESCRIPTION

The 4066 consists of four independent switches capable of controlling either digital or analog signals. This Quad Bilateral Switch is useful in signal gating, chopper, modulator, demodulator, and CMOS logic implementation.

This device contains circuitry to protect the inputs against damage due to high static voltages or electrical fields; however, it is advised that normal precautions be taken to avoid applications of any voltage higher than maximum rated voltages to this high impedance circuit.

For proper operation it is recommended that V_{IN} and V_{OUT} be constrained to the range $V_{SS} \leq (V_{IN}$ or $V_{OUT}) \leq V_{DD}$.

Unused inputs must always be tied to the appropriate logic voltage level (e.g., either V_{SS} or V_{DD}).

FEATURES

- Wide supply voltage range—3V to 15V
- High noise immunity—0.45 V_{DD} typ
- Wide range of digital and analog switching—± 7.5 V_{PEAK}
- "ON" resistance for 15V operation—80Ω typ
- Matched "ON" resistance over 15V signal input—$\Delta R_{ON} = 5\Omega$ typ
- "ON" resistance flat over peak-to-peak signal range
- High "ON"/"OFF" output voltage ratio—65 dB typ
- High degree of linearity—<0.4% distortion typ
- Extremely low "OFF" switch leakage—0.1 nA typ
- Extremely high control input impedance—$10^{12}\Omega$ typ
- Low crosstalk between switches—−50 dB typ
- Frequency response, switch "ON"—40 MHz typ

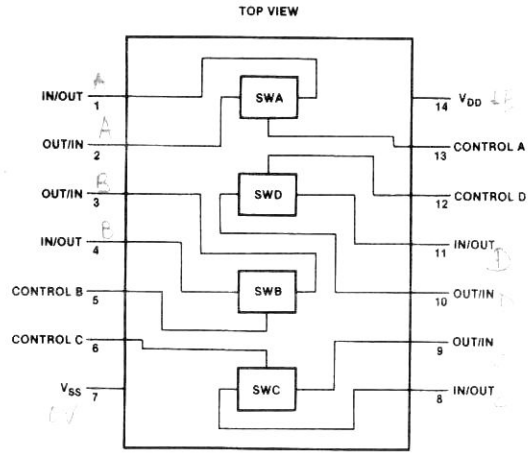
APPLICATIONS

- Analog signal switching/multiplexing
  - Signal gating
  - Squelch control
  - Chopper
  - Modulator/Demodulator
  - Commutating switch
- Digital signal switching/multiplexing
- CMOS logic implementation
- Analog-to-digital/digital-to-analog conversion
- Digital control of frequency, impedance, phase, and analog-signal gain

ABSOLUTE MAXIMUM RATINGS

Supply Voltage	−0.5V to +18V
Input Voltage	−0.5 to V_{DD} +0.5V
Package Dissipation	500 mW
Operating Temperature Range	−40 to +85°C
Storage Temperature Range	−65 to +150°C
Lead Temperature (Soldering, 10 seconds)	300°C

PIN CONNECTION

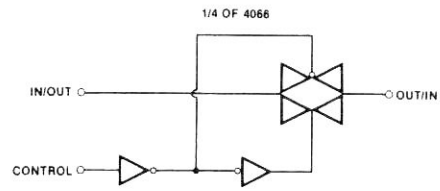


TRUTH TABLES

CONTROL	SWITCH
0	OFF
1	ON

$V_{CONTROL}$	V_{IN} TO V_{OUT} RESISTANCE
V_{SS}	$>10^9$ ohms typical
V_{DD}	3×10^2 ohms typical

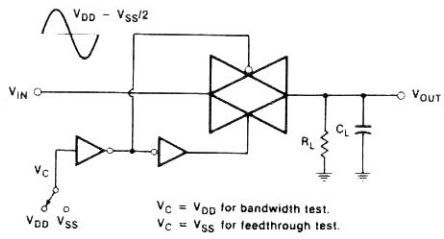
LOGIC DIAGRAM



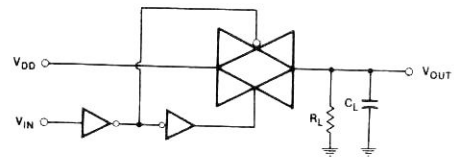
LOGIC DIAGRAM RESTRICTIONS

$V_{SS} \leq V_{IN} \leq V_{DD}$
$V_{SS} \leq V_{OUT} \leq V_{DD}$

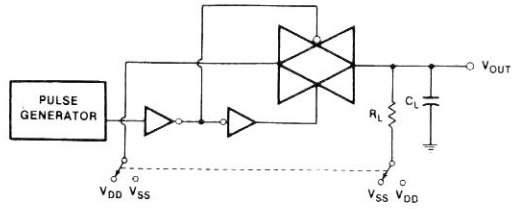
TYPICAL APPLICATIONS



Bandwidth and Feedthrough Attenuation



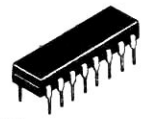
Input Voltage



Propagation Delay Time, Control to Output

4116
276-2505

16K DYNAMIC RAM



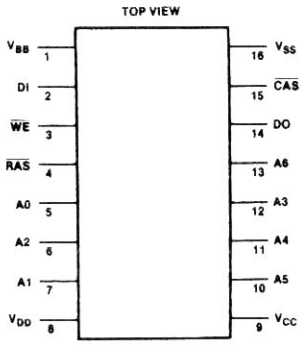
GENERAL DESCRIPTION

The 4116 is a 16,384 × 1 bit dynamic RAM. It features a multiplexed address input with separate row and column strobes. This added flexibility allows the 4116 to be used in page mode operation.

The 4116 must be refreshed every 2 ms. This can be accomplished by performing any cycle which brings the Row Address Strobe active including an RAS-only cycle at each of the 128 row addresses.

N-channel double-poly silicon gate technology is used in the manufacture of the 4116. This process combines high density and performance with reliability. Greater system densities are achievable by the use of a 16-pin dual-in-line package for the 4116.

PIN CONNECTION



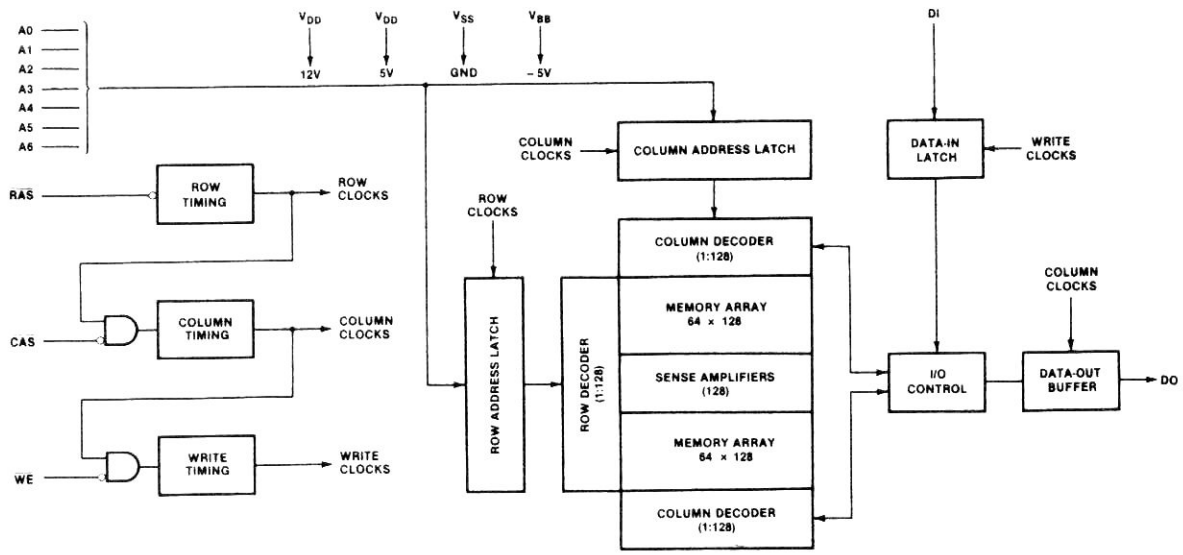
FEATURES

- Access times: 150 ns, 200 ns, 300 ns
- Low power: 462mW max
- TTL compatible: all inputs and output
- Gated CAS—noncritical timing
- Read, write, read-modify-write and RAS-only refresh cycles
- Page mode operation

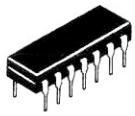
ABSOLUTE MAXIMUM RATINGS

Power Dissipation 1W
Supply Voltage V_{DD} 13.2V
Supply Voltage V_{CC} 5.5V
Voltage on Any Pin Relative to V_{BB} ..... −0.3 to +20V
($V_{SS} - V_{BB} \geq 4.5V$)
Operating Temperature Range ..... 0 to +70°C
Storage Temperature ..... −65 to +150°C
Lead Temperature (Soldering, 10 seconds) ..... 300°C

INTERNAL CIRCUIT



Note: All voltages referenced to V_{SS}. When applying voltages to the devices, V_{DD}, V_{CC}, or V_{SS} should never be 0.3V more negative than V_{BB}.



QUAD TWO-INPUT NAND GATE

7400
276-1801

GENERAL DESCRIPTION

This device employs TTL logic to achieve high speed at moderate power dissipiation. It provides the basic functions used in the implementation of digital integrated circuit systems.

For best noise immunity and switching speed, unused inputs should not be left floating, but should be held between 2.4 V and the absolute maximum input voltage.

Two possible ways at handling unused inputs are:

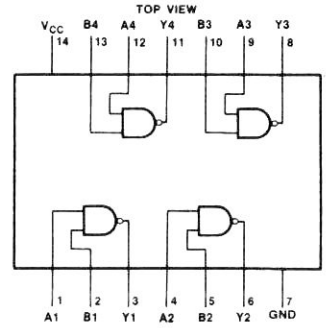
(1) Connect unused inputs to V_{CC}. For all multi-emitter conventional TTL inputs, A 1 to 10K ohm current limiting series resistor is recommended, to protect against V_{CC} transients that exceed 5.5 V.

(2) Connect the unused input to the output of an unused gate that is forced high.

ABSOLUTE MAXIMUM RATINGS

Supply Voltage V_{CC}	5.25 V
Input High Voltage	2.0 V
Input Low Voltage	0.8 V
Input Clamp Diode Voltage (V_{CC} = 5.0 V, I_{IN} = − 12 mA)	− 1.5 V
Input High CUrrent (V_{CC} = Max., V_{IN} = 2.4 V)	40 μA
Input Low Current (V_{CC} = Max., V_{IN} = 0.4 V)	− 1.6 mA
Operating Temperature	0 to + 70°C

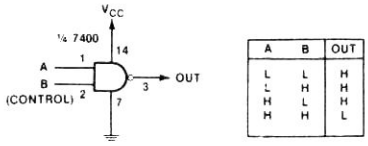
PIN CONNECTION



TRUTH TABLE

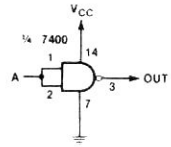
$Y = \overline{AB}$

TYPICAL APPLICATIONS



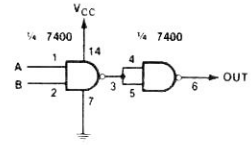
A	B	OUT
L	L	H
L	H	H
H	L	H
H	H	L

Control Gate



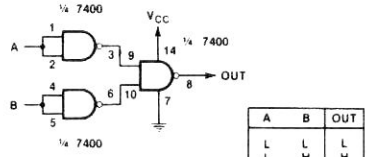
A	OUT
L	H
H	L

Inverter



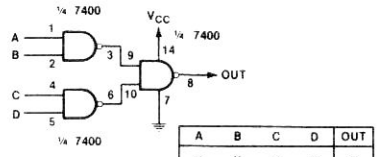
A	B	OUT
L	L	L
L	H	L
H	L	L
H	H	H

AND Gate



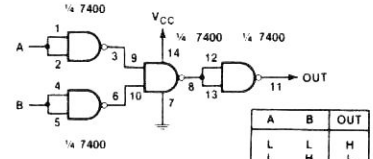
A	B	OUT
L	L	L
L	H	H
H	L	H
H	H	H

OR Gate



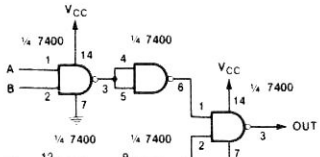
A	B	C	D	OUT
X	X	H	H	H
H	H	X	X	H
H	H	H	H	H

AND-OR Gate



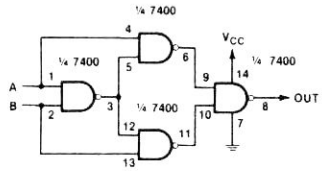
A	B	OUT
L	L	H
L	H	L
H	L	L
H	H	L

NOR Gate



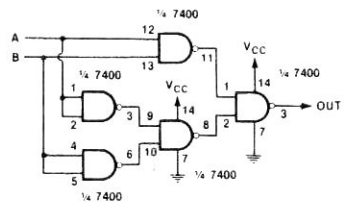
A	B	C	D	OUT
L	X	X	X	H
X	L	X	X	H
X	X	L	X	H
X	X	X	L	H
H	H	H	H	L

4-Input NAND Gate



A	B	OUT
L	L	L
L	H	H
H	L	H
H	H	L

Exclusive-OR Gate

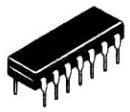


A	B	OUT
L	L	H
L	H	L
H	L	L
H	H	H

Exclusive-NOR Gate

7404
276-1802

HEX INVERTER



GENERAL DESCRIPTION

This device employs TTL logic to achieve high speed at moderate power dissipation. This hex inverter provides the basic functions used in the implementation of digital integrated circuit systems.

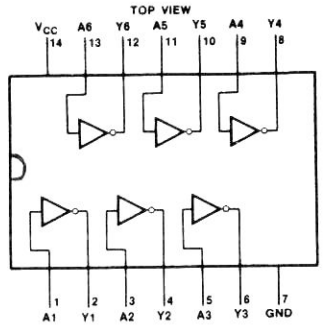
For best noise immunity and switching speed, unused inputs should not be left floating, but should be held between 2.4 V and the absolute maximum input voltage.

Two possible ways of handling unused inputs are:

(1) Connect unused inputs to V_{CC}. For all multi-emitter conventional TTL inputs, A 1 to 10K ohm current limiting series resistor is recommended, to protect against V_{CC} transients that exceed 5.5 V.

(2) Connect the unused input to the output of an unused gate that is forced high.

PIN CONNECTION



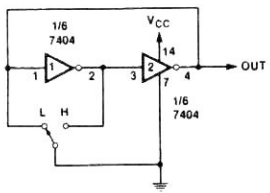
ABSOLUTE MAXIMUM RATINGS

Supply Voltage V_{CC}	5.25 V
Input High Voltage	2.0 V
Input Low Voltage	0.8 V
Input Clamp Diode Voltage (V_{CC} = 5.0 V, I_{IN} = − 12 mA)	− 1.5 V
Input High Current (V_{CC} = Max., V_{IN} = 2.4 V)	40 μA
Input Low Current (V_{CC} = Max., V_{IN} = 0.4 V)	− 1.6 mA
Operating Temperature	0 to + 70°C

TRUTH TABLE

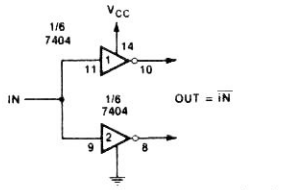
$Y = \overline{A}$

TYPICAL APPLICATIONS



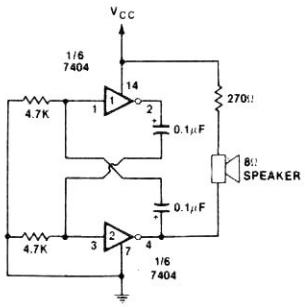
Output follows switch position.

Bouncefree Switch



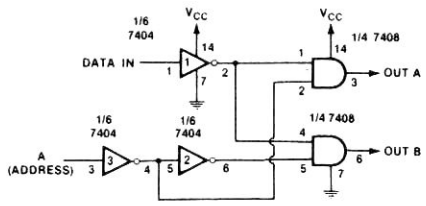
Allows one signal to control two or more inputs.

Universal Expander



Output tone is 4kHz.

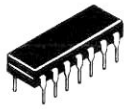
Audio Oscillator



This circuit steers the input bit to the output selected by the address.

DATA	ADDRESS	OUT A	OUT B
L	L	L	H
H	L	H	H
L	H	H	L
H	H	H	H

1-of-2 Demultiplexer



QUAD TWO-INPUT AND GATE

7408
276-1822

GENERAL DESCRIPTION

This device employs TTL logic to achieve high speed at moderate power dissipation. These gates provide the basic functions used in the implementation of digital integrated circuit systems.

For best noise immunity and switching speed, unused inputs should not be left floating, but should be held between 2.4 V and the absolute maximum input voltage.

Two possible ways at handling unused inputs are:

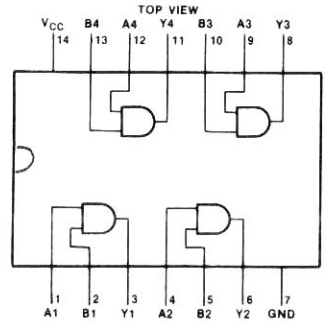
(1) Connect unused inputs to V_{CC}. For all multi-emitter conventional TTL inputs, a 1 to 10K ohm current limiting series resistor is recommended, to protect against V_{CC} transients that exceed 5.5 V.

(2) Connect the unused input to the output of an unused gate that is forced high.

ABSOLUTE MAXIMUM RATINGS

Supply Voltage V_{CC} ..... 5.25 V
Input High Voltage ..... 2.0 V
Input Low Voltage ..... 0.8 V
Input Clamp Diode Voltage (V_{CC} = 5.0 V, I_{IN} = − 12 mA) ..... − 1.5 V
Input High Current (V_{CC} = Max., V_{IN} = 2.4 V) ..... 40 μA
Input Low Current (V_{CC} = Max., V_{IN} = 0.4 V) ..... − 1.6 mA
Operating Temperature ..... 0 to + 70°C

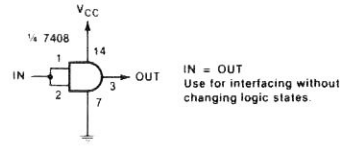
PIN CONNECTION



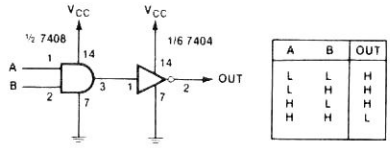
TRUTH TABLE

Y=AB

TYPICAL APPLICATIONS

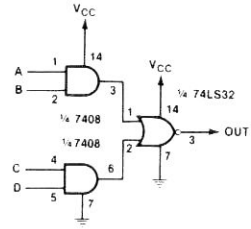


AND Gate Buffer



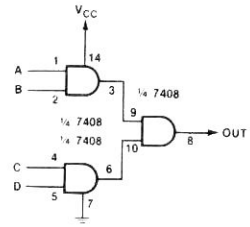
A	B	OUT
L	L	H
L	H	H
H	L	H
H	H	L

NAND Gate



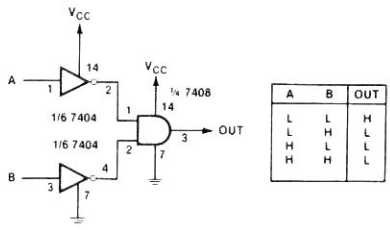
A	B	C	D	OUT
X	X	X	X	H
L	L	X	X	H
L	L	L	L	L

AND-OR-Invert Gate



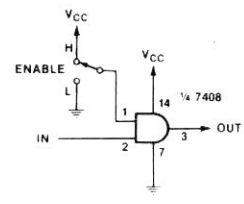
A	B	C	D	OUT
H	H	H	H	H
X	X	X	X	L

4-Input AND Gate



A	B	OUT
L	L	H
L	H	L
H	L	L
H	H	L

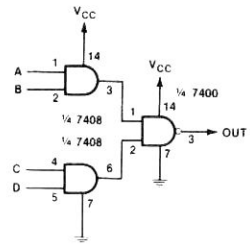
NOR Gate



IN	E	OUT
L	L	L
L	H	L
H	L	L
H	H	H

E = ENABLE

Digital Transmission Gate

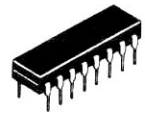


A	B	C	D	OUT
H	H	H	H	L
X	X	X	X	H

4-Input NAND Gate

7447
276-1805

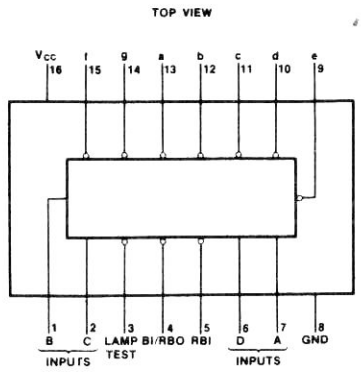
BCD TO SEVEN-SEGMENT DECODER/DRIVER



GENERAL DESCRIPTION

This versatile binary-coded-decimal 7-segment display driver fulfills a wide variety of requirements for most active high (common cathode) and active low (common anode) light emitting diodes (LED) or lamp displays. It fully decodes a 4-bit BCD input into a number from 0 through 9 in the standard 7-segment display format, and BCD numbers above 9 into unique patterns that verify operation. All circuits operate off of a single 5.0V supply. The output will withstand 15 Volts at a maximum leakage current of 250μA.

PIN CONNECTION



FEATURES

- Lamp-test input
- Leading trailing zero suppression (RBI and RBO)
- Blanking input that may be used to modulate lamp intensity or inhibit output
- TTL and DTL compatible
- Input clamping diodes
- Open collector outputs drive indicators directly

ABSOLUTE MAXIMUM RATINGS

Supply Voltage V_{CC} ..... 4.75 — 5.25 V
Continuous Voltage at Outputs a-g ..... Max. 15 V
Logic 1 Input Voltage ..... Min. 2 V
Logic 0 Input Voltage ..... Max. 0.8 V
Logic 0 Output Voltage BI/RBO ..... Max. 0.4 V
Logic 1 Output Voltage at BI/RBO ..... Min. 2.4 V
Power ..... 320 mW

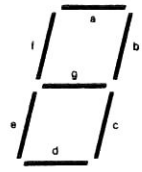
TRUTH TABLE

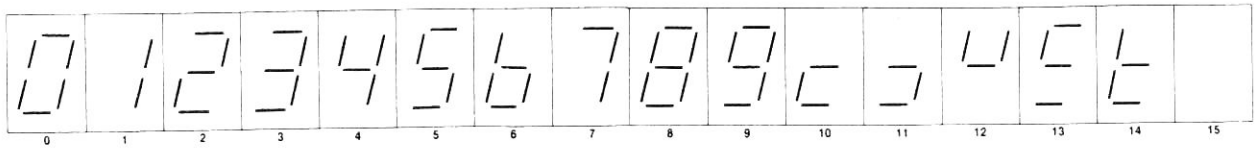
DECIMAL OR FUNCTION	INPUTS						BI/RBO†	OUTPUTS							NOTE
	LT	RBI	D	C	B	A		a	b	c	d	e	f	g	
0	H	H	L	L	L	L	H	L	L	L	L	L	L	H	
1	H	X	L	L	L	H	H	H	L	L	H	H	H	H	
2	H	X	L	L	H	L	H	L	L	H	L	L	H	L	
3	H	X	L	L	H	H	H	L	L	L	L	H	H	L	
4	H	X	L	H	L	L	H	H	L	L	H	H	L	L	
5	H	X	L	H	L	H	H	L	H	L	L	H	L	L	
6	H	X	L	H	H	L	H	H	H	L	L	L	L	L	
7	H	X	L	H	H	H	H	L	L	L	H	H	H	H	
8	H	X	H	L	L	L	H	L	L	L	L	L	L	L	1
9	H	X	H	L	L	H	H	L	L	L	H	H	L	L	
10	H	X	H	L	H	L	H	H	H	H	L	L	H	L	
11	H	X	H	L	H	H	H	H	H	L	L	H	H	L	
12	H	X	H	H	L	L	H	H	L	H	H	H	L	L	
13	H	X	H	H	L	H	H	L	H	H	L	H	L	L	
14	H	X	H	H	H	L	H	H	H	H	L	L	L	L	
15	H	X	H	H	H	H	H	H	H	H	H	H	H	H	
BI	X	X	X	X	X	X	L	H	H	H	H	H	H	H	2
RBI	H	L	L	L	L	L	L	H	H	H	H	H	H	H	3
LT	L	X	X	X	X	X	H	L	L	L	L	L	L	L	4

H = High Level. L = Low Level. X = Irrelevant

Notes: 1. The blanking input (BI) must be open or held at a high logic level when output functions 0 thru 15 are desired. The ripple-blanking input (RBI) must be open or high, if blanking of a decimal zero is not desired.
2. When a low logic level is applied directly to the blanking input (BI), all segment outputs are H regardless of the level of any other input.
3. When ripple-blanking input (RBI) and inputs A, B, C, and D are at a low level with the lamp-test input high, all segment outputs go H and the ripple-blanking output (RBO) goes to a low level (response condition).
4. When the blanking input/ripple blanking output (BI/RBO) is open or held high and a low is applied to the lamp test input, all segment outputs are L.

† BI/RBO is wire-AND logic serving as blanking input (BI) and/or ripple-blanking output (RBO).

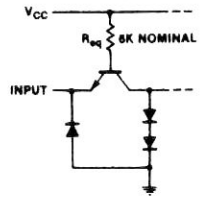




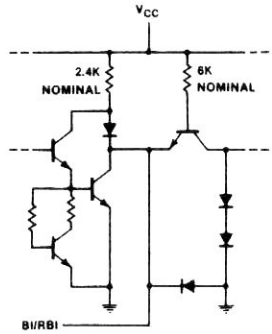
Numerical Designations and Resultant Displays

7447 276-1805

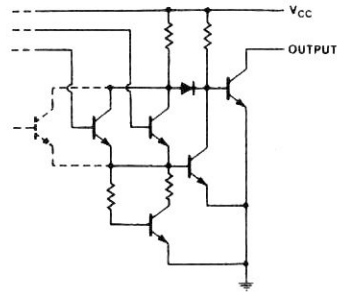
INPUT/OUTPUT EQUIVALENTS



Each Input Except BI/RBO

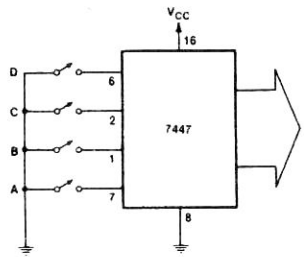


BI/RBO Input

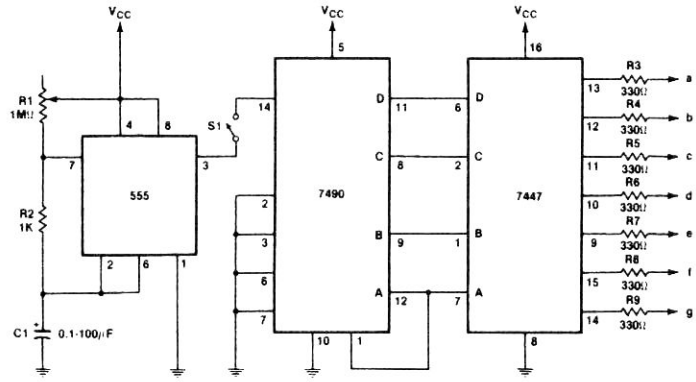


Typical of Outputs a Thru g

TYPICAL APPLICATIONS



Manually Switched Display

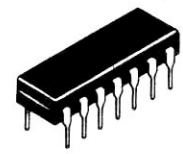


Close S1 to start timing cycle.
Calibrate 555 for 1 pulse (count) per second or 1 count per minute by adjusting R1.

0-9 Second/Minute Timer

7490
276-1808

DIVIDE BY 2 OR 5, BCD COUNTER



GENERAL DESCRIPTION

This monolithic BCD counter contains four master-slave flip-flops and additional gating to provide a divide-by-two counter and a three-stage binary counter for which the count cycle length is divide-by-five.

This counter has a gated zero reset and gated set-to-nine inputs for use in BCD nine's complement applications.

To use maximum count length, the B input is connected to the Q_A output. The input count pulses are applied to input A and the outputs are as described in the appropriate truth table. A symmetrical divide-by-ten count can be obtained from the 90 counter by connecting the Q_D output to the A input and applying the input count to the B input which gives a divide-by-ten square wave at output Q_A.

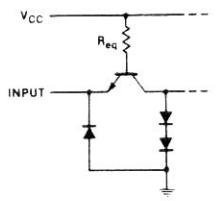
FEATURES

- Low power consumption
- High count rates . . . typically 50MHz
- Choice of counting modes
- Fully TTL and CMOS compatible

ABSOLUTE MAXIMUM RATINGS

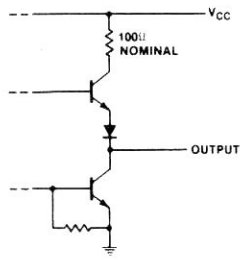
Typical Power Dissipation	145 mW
Count Frequency	42 MHz
High Level Input Voltage (Min)	2 V
Low Level Input Voltage (Max)	0.8 V
High Level Input Current	800 μA
Low Level Output Current (Max)	16 mA
V_{CC} to Ground	− 0.5 to + 7.0 V
Voltage Applied to Outputs (Output High)	− 0.5 to + 5.5 V

INPUT/OUTPUT EQUIVALENTS



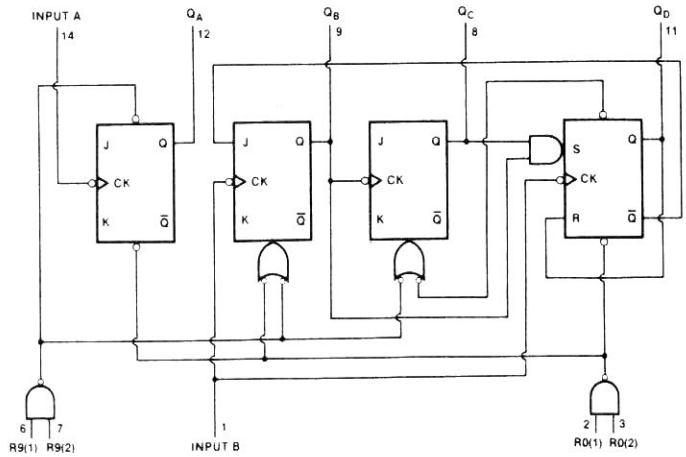
INPUT	R_{eq} NOMINAL
A	2.5K
B	1.25K
ALL RESETS	6K

Each Input

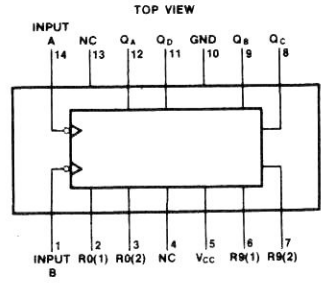


Typical of all Outputs

BLOCK DIAGRAM



PIN CONNECTION



TRUTH TABLES

RESET/COUNT

RESET INPUTS				OUTPUTS			
R0(1)	R0(2)	R9(1)	R9(2)	Q_D	Q_C	Q_B	Q_A
H	H	L	X	L	L	L	L
H	H	X	L	L	L	L	L
X	X	H	H	H	L	L	H
X	L	X	L	COUNT			
L	X	L	X	COUNT			
L	X	X	L	COUNT			
X	L	L	X	COUNT			

BCD COUNT SEQUENCE (See Note A)

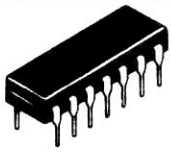
COUNT	OUTPUTS			
	Q_D	Q_C	Q_B	Q_A
0	L	L	L	L
1	L	L	L	H
2	L	L	H	L
3	L	L	H	H
4	L	H	L	L
5	L	H	L	H
6	L	H	H	L
7	L	H	H	H
8	H	L	L	L
9	H	L	L	H

BI-QUINARY (5-2) (See Note B)

COUNT	OUTPUTS			
	Q_A	Q_D	Q_C	Q_B
0	L	L	L	L
1	L	L	L	H
2	L	L	H	L
3	L	L	H	H
4	L	H	L	L
5	H	L	L	L
6	H	L	L	H
7	H	L	H	L
8	H	L	H	H
9	H	H	L	L

L = Low Level
H = High Level

Notes:
(A) Output Q_A is connected to input B for BCD count.
(B) Output Q_D is connected to input A for bi-quinary count.



QUAD LINE DRIVER

MC1488
276-2520

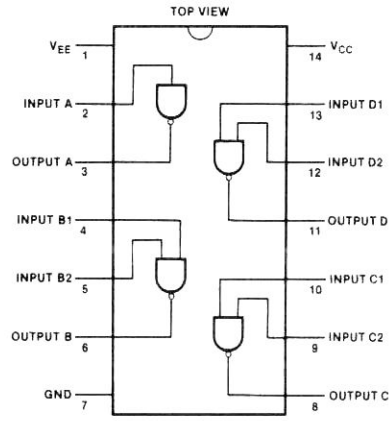
GENERAL DESCRIPTION

The 1488 is a monolithic quad line driver designed to interface data terminal equipment with data communications equipment in conformance with the specifications of EIA Standard No. RS-232C.

FEATURES

- Current Limited Output
  ±10 MA typ
- Power-Off Source Impedance
  300 Ohms min
- Simple Slew Rate Control with External Capacitor
- Flexible Operating Supply Range

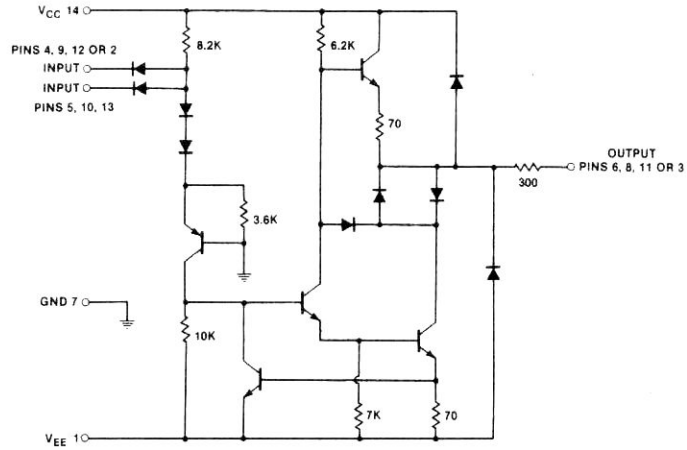
PIN CONNECTION



ABSOLUTE MAXIMUM RATINGS

Supply Voltage (V_{CC})	15 V
(V_{EE})	− 15 V
Output Signal Voltage (VO)	±15 V
Power (PD)	1 W
Input Current-Low Logic State (V_{IL} = 0) (See Fig. 8)	1.6 mA
Input Current-High Logic State (V_{IH} = 5.0V) (See Fig. 8)	10 μA
Output Resistance (V_{CC} = V_{EE} = 0/Vol = ±2.0V (See Fig. 11)	300Ω
Operating Temperature Range (TA)	0°C To + 75°C
Storage Temperature Range (T_{stg})	−65°C To +175°C

INTERNAL CIRCUIT
(¼ of Circuit Shown)



TYPICAL CHARACTERISTICS

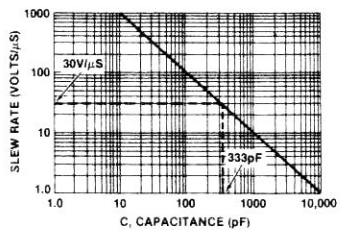


Figure 1—Slew Rate vs Capacitance for I_{SC} = 10mA

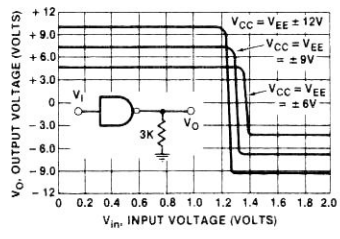


Figure 3—Transfer Characteristics vs Power-Supply Voltage

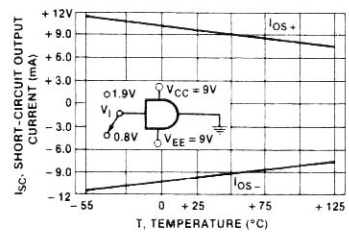


Figure 4—Short-Circuit Output Current vs Temperature

MC1488 276-2520

TYPICAL CHARACTERISTICS (Cont'd)

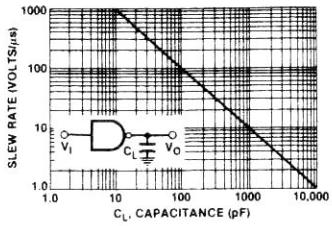


Figure 5—Output Slew Rate vs Load Capacitance

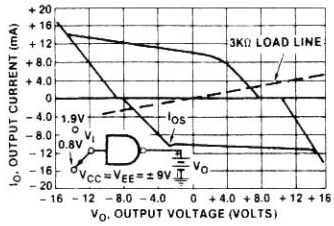


Figure 6—Output Voltage and Current-Limiting Characteristics

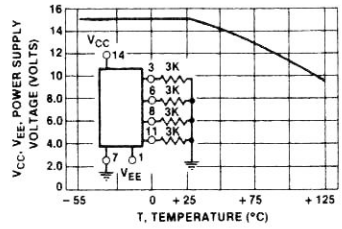
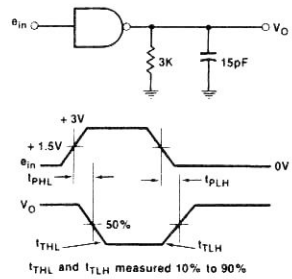


Figure 7—Maximum Operating Temperature vs Power-Supply Voltage



Switching Response

TEST CIRCUITS

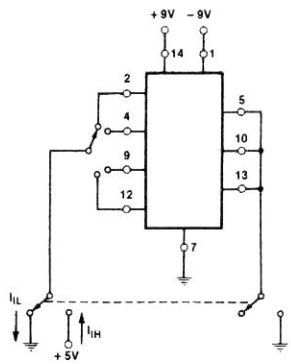


Figure 8— Input Current

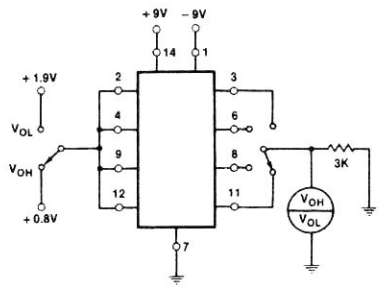


Figure 9— Output Voltage

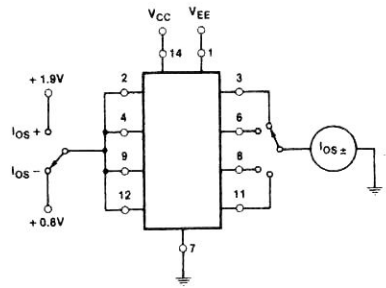


Figure 10— Output Short-Circuit Current

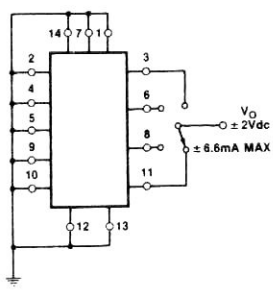


Figure 11— Output Resistance (Power-Off)

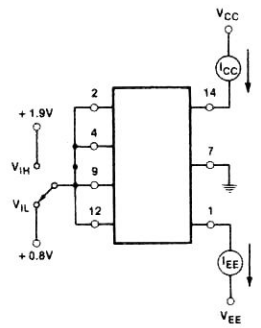


Figure 12— Power-Supply Currents

MC1488 276-2520

APPLICATIONS INFORMATION

The Electronic Industries Association (EIA) RS232C specification detail the requirements for the interface between data processing equipment and data communications equipment. This standard specifies not only the number and type of interface leads, but also the voltage levels to be used. The 1488 quad driver and its companion circuit, the 1489 quad receiver, provide a complete interface system between DTL or TTL logic levels and the RS232C defined levels. The RS232C requirements as applied to drivers are discussed herein.

The required driver voltages are defined as between 5 and 15-volts in magnitude and are positive for a logic "O" and negative for a logic "1". These voltages are so defined when the drivers are terminated with a 3000 to 7000-ohm resistor. The 1488 meets this voltage requirement by converting a DTL/TTL logic level into RS232C levels with one stage of inversion.

The RS232C specification further requires that during transitions, the driver output slew rate must not exceed 30 volts per microsecond. The inherent slew rate of the 1488 is much too fast for this requirement. The current limited output of the device can be used to control this slew rate by connecting a capacitor to each drive output. The required capacitor can be easily determined by using the relationship $C = I_{OS} \times \Delta T/\Delta V$ from which Figure 1 is derived. Accordingly, a 330-pF capacitor on each output will guarantee a worst case slew rate of 30 volts per microsecond.

The interface driver is also required to withstand an accidental short to any other conductor in an interconnecting cable. The worst possible signal on any conductor would be another driver using a plus or minus 15-volt, 500-mA source. The 1488 is designed to indefinitely withstand such a short to all four outputs in a package as long as the power-supply voltages are greater than 9.0 volts (i.e., $V_{CC} \geq 9.0$ V; $V_{EE} \leq -9.0$ V). In some power-supply designs, a loss of system power causes a low impedance on the power-supply outputs. When this occurs, a low impedance to ground would exist at the power inputs to the 1488 effectively shorting the 300-ohm output resistors to ground. If *all four outputs* were then shorted to plus or minus 15 volts, the power dissipation in these resistors would be excessive. Therefore, if the system is designed to permit low impedances to ground at the power-supplies of the drivers, a diode should be placed in each power-supply lead to prevent overheating in this fault condition. These two diodes, as shown in Figure 2, could be used to decouple all the driver packages in a system. (These same diodes will allow the 1488 to withstand momentary shorts to the ±25-volt limits specified in the earlier Standard RS232B.) The addition of the diodes also permits the 1488 to withstand faults with power-supplies of less than the 9.0 volts stated above.

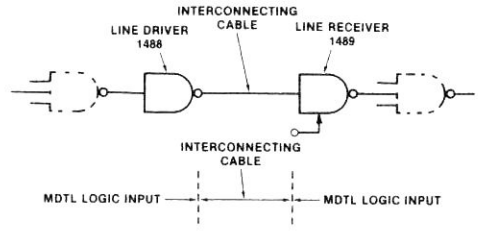
The maximum short-circuit current allowable under fault conditions is more than guaranteed by the previously mentioned 10 mA output current limiting.

OTHER APPLICATIONS

The 1488 is an extremely versatile line driver with a myriad of possible applications. Several features of the drivers enhance this versatility:

1. Output Current Limiting—this enables the circuit designer to define the output voltage levels independing of power-supplies and can be accomplished by diode clamping of the output pins. Figure 14 shows the 1488 used as a DTL to MOS translator where the high-level voltage output is clamped one diode above ground. The resistor divider shown is used to reduce the output voltage below the 300 mV above ground MOS input level limit.
2. Power-Supply Range—as can be seen from the schematic drawing of the drivers, the postive and negative driving elements of the device are essentially independent and do not require matching power-supplies. In fact, the positive supply can vary from a minimum seven volts (required for driving the negative pulldown section) to the maximum specified 15 volts. The negative supply can vary from approximately −2.5 volts to the minimum specified −15 volts. The 1488 will drive the output to within 2 volts of the postive or negative supplies as long as the current output limits are not exceeded. The combination of the current-limiting and supply-voltage features allow a wide combination of possible outputs within the same quad package. Thus if only a portion of the four drivers are used for driving RS232C lines, the remainder could be used for DTL to MOS or even DTL or DTL translation. Figure 15 shows one such combination.

TYPICAL APPLICATIONS



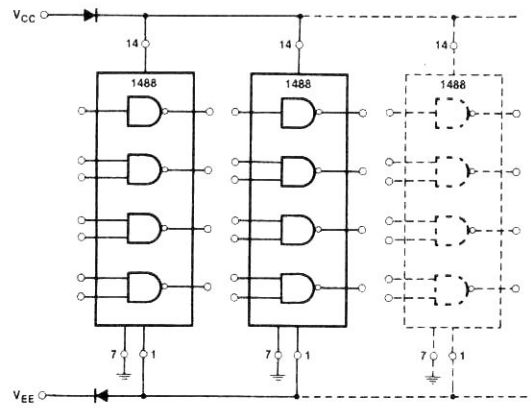


Figure 2—Power Supply Protection to Meet Power-Off Fault Conditions

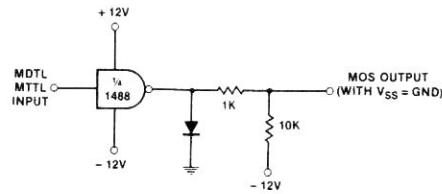


Figure 14—MDTL/MTTL-to-MOS Translator

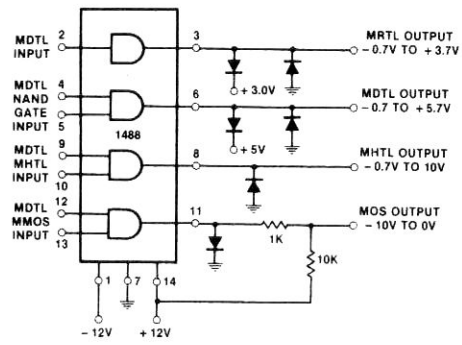
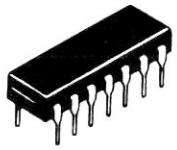


Figure 15—Logic Translator Applications

MC1489
276-2521

QUAD LINE RECEIVER



GENERAL DESCRIPTION

The 1489 monolithic quad line receiver is designed to interface data terminal equipment with data communications equipment in conformance with specificiations of EIA Standard No. RS-232C.

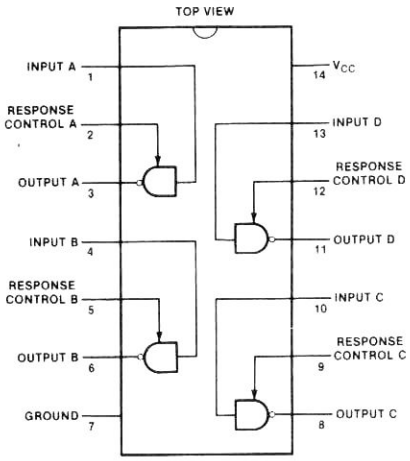
FEATURES

- Input Resistance—3.0 k to 7.0 K ohms
- Input Signal Range—±30 Volts
- Input Threshold Hysteresis Built In
- Response Control
  - a) Logic Threshold Shifting
  - b) Input Noise Filtering

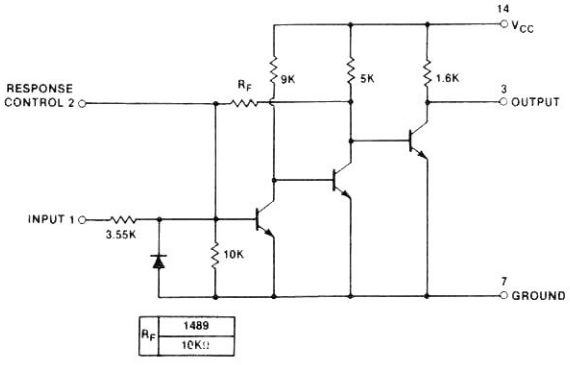
ABSOLUTE MAXIMUM RATINGS

Supply Voltage (V_{CC})	10 V
Input Voltage Range (V_{IR})	±30 V
Output Load Current (I_L)	20 mA
Power Dissipation (P_D)	1 W
Operating Temperature Range (TA)	0°C To +75°C
Storage Temperature Range (T_{stg})	−65°C To +175°C

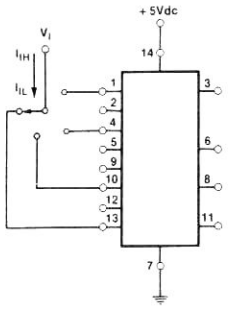
PIN CONNECTION



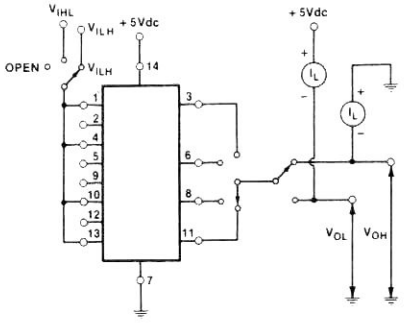
INTERNAL CIRCUIT
(¼ of Circuit Shown)



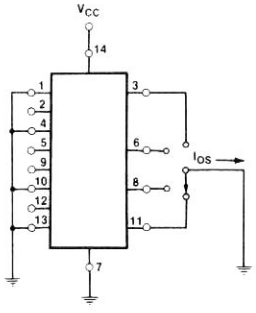
TEST CIRCUITS



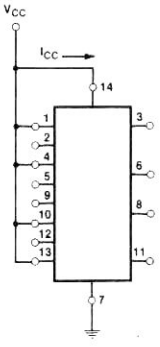
Input Current



Output Voltage and Input Threshold Voltage

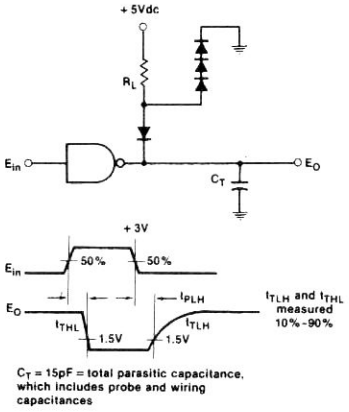


Output Short-Circuit Current



Power-Supply Current

TYPICAL CHARACTERISTICS



Switching Response

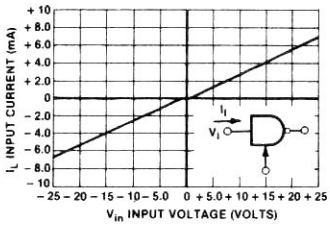


Figure 1—Input Current

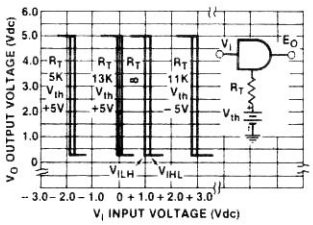


Figure 2—Input Threshold Voltage Adjustment

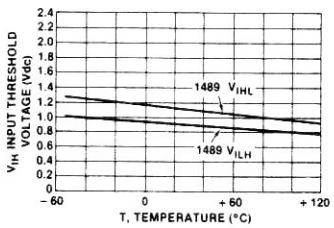


Figure 3—Input Threshold Voltage vs Temperature

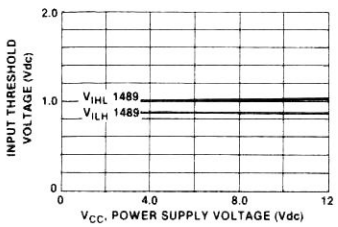


Figure 4—Input Threshold vs Power—Supply Voltage

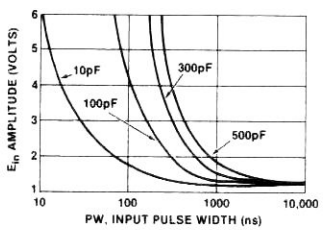


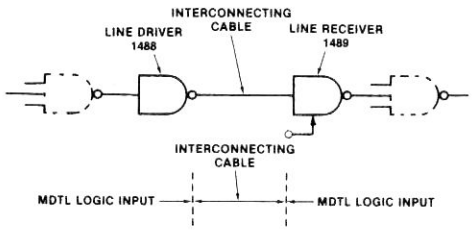
Figure 5—Turn-on Threshold vs Capacitance from Response Control Pin to Gnd

APPLICATIONS INFORMATION

The Electronic Industries Association (EIA) has released the RS-232C specification detailing the requirements for the interface between data processing equipment and data communications equipment. This standard specifies not only the number and type of interface leads, but also the voltage levels to be used. The 1488 quad driver and its companion circuit, the 1489 quad receiver, provide a complete interface system between DTL or TTL logic levels and the RS-232C defined levels. The RS-232C requirements as applied to receivers are discussed here. The required input impedance is defined as between 3000 ohms and 7000 ohms for input voltages between 3.0 and 25 volts in magnitude; and any voltage on the receiver input in an open circuit condition must be less than 2.0 volts in magnitude. The 1489 circuits meet these requirements with a maximum open circuit voltage of one V_{BE}.

The receiver shall detect a voltage between −3.0 and −25 volts as a logic "1" and input between +3.0 and +25 volts as a logic "0". On some interchange leads, an open circuit or power "OFF" condition (300 ohms or more to ground) shall be decoded as an "OFF" condition or logic "1". For this reason, the input hysteresis thresholds of the 1489 circuits are all above ground. Thus an open or grounded input will cause the same output as a negative of logic "1" input.

TYPICAL APPLICATIONS



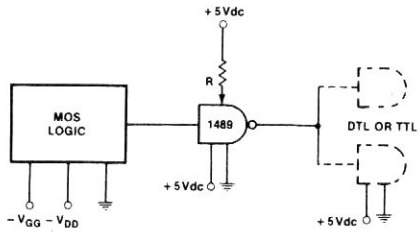
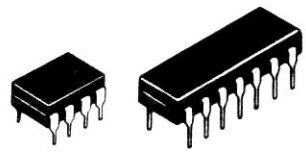


Figure 7—Typical Translator Application—MOS to DTL or TTL

TLC27M2 276-1749
TLC27M4 276-1750

DUAL OPERATIONAL AMPLIFIERS
QUAD OPERATIONAL AMPLIFIERS

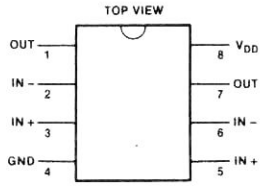


GENERAL DESCRIPTION

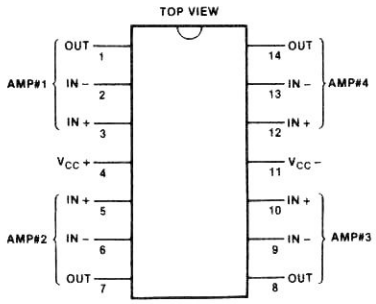
The TLC27M4 and TLC27M2 consist of low-cost low-power quad and dual operational amplifiers designed to operate with single or dual supplies. These devices utilize the silicon-gate LinCMOS™ process, giving them stable input offset voltage that is available with a 2 mV maximum, very high input impedances, and extremely low input offset and bias currents. Because the input common-mode range extends to the negative rail and the power consumption is extremely low, these devices are ideally suited for battery-powered or energy-conserving applications.

Because of the extremely high input impedance and low input bias and offset currents, applications for these devices include many areas that have previously been limited to BIFET and NFET product types. Any circuit using high-impedance elements and requiring small offset errors is a good candidate for cost-effective use of these devices. Many features associated with bipolar technology are available with LinCMOS™ operational amplifiers without the power penalties of traditional bipolar devices.

PIN CONNECTIONS



TLC27M2



TLC27M4

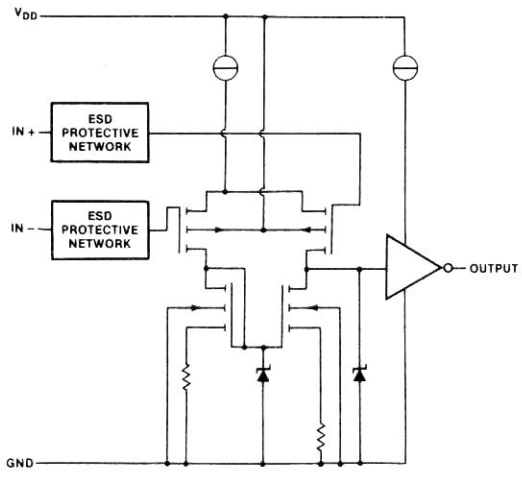
FEATURES

- Wide range of supply voltages (4 V To 16 V)
- True single supply operation
- Common-mode input voltage includes the negative rail
- Supply current range (150 μA/Amp Typical)
- Slew-rate performance (0.6 V/μs Typical
- Extremely low input bias and offset currents
  Input bias current (1 pA Typical)
  Input offset current (1 pA Typical)
- Low input offset voltage (2 mV Maximum)
- Low noise—30 nV $\sqrt{\text{Hz}}$ Typical at f = 1 KHZ
  (High bias versions)

APPLICATIONS

- Transducer Interfacing
- Analog Calculations
- Amplifier Blocks
- Active Filters
- Signal Buffering

INTERNAL CIRCUIT (Each Amplifier)



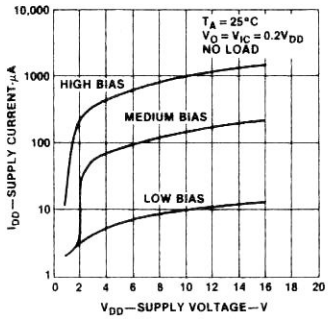
ABSOLUTE MAXIMUM RATINGS

Supply Voltage (V_{DD}) (See Note 1) . . . . . 18 V
Differential Input Voltage (See Note 2) . . . . . ±18 V
Input Voltage Range (Any Input) . . . . . −0.3 V To 18 V
Power Dissipation . . . . . 950 mW
Operating Temperature Range . . . . . 0°C To 70°C
Storage Temperature Range . . . . . −65°C To +150°C
Duration of Short-Circuit at (Or Below) 25°C
Free-Air Temperature (See Note 3) . . . . . Unlimited

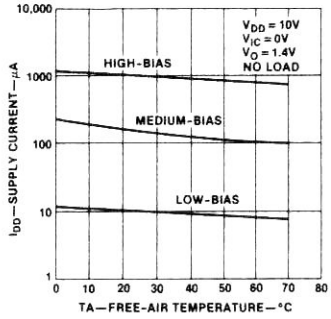
NOTES: 1. All voltage values, except differential voltages, are with respect to network ground terminal.
2. Differential voltages are at the noninverting input terminal with respect to the inverting input terminal.
3. The output may be shorted to either supply. Temperature and/or supply voltages must be limited to ensure the maximum dissipation rating is not exceeded.

TLC27M2 276-1749 TLC274 276-1750

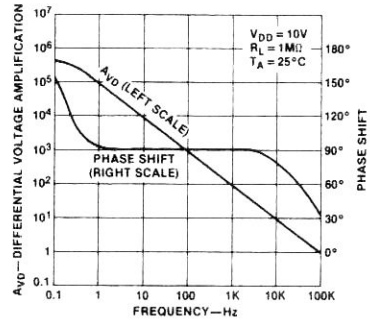
TYPICAL CHARACTERISTICS



Supply Current vs Supply Voltage



Supply Current vs Free-Air Temperature



Low-Bias Versions Large-Signal Differential Voltage Amplification and Phase Shift vs Frequency

TYPICAL APPLICATION INFORMATION

static protection

The inputs of this device are protected by series resistors and clamp diodes. As with any integrated circuit, ESD handling precautions should be used to avoid damage from strong electrostatic fields.

latchup avoidance

Junction-isolated CMOS circuits have an inherent parasitic PNPN structure that can function as an SCR. Under certain conditions, this SCR may be triggered into a low-impedance state, resulting in excessive supply current. To avoid such conditions, no voltage greater than 0.3 V beyond the supply rails should be applied to any pin. In general, the op amp supplies should be established simultaneously with, or before, any input signals are applied.

output stage considerations

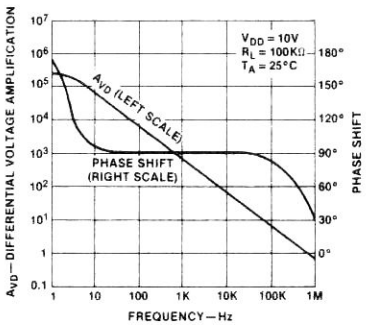
The amplifier's output stage consists of a source-follower-connected pullup transistor and an open-drain pulldown transistor. The high-level output voltage (V_{OH}) is virtually independent of the I_{DD} selection, and increases with high values of V_{DD} and reduced output loading. The low-level output voltage (V_{OL}) decreases with reduced output current and high input common-mode voltage. With no load, V_{OL} is essentially equal to the GND pin potential.

supply configuration

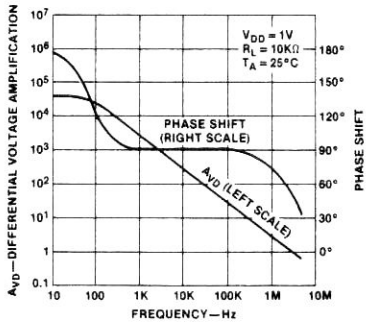
Even though this device is characterized for single-supply operation, it can be used effectively in a split-supply configuration if the input common-mode voltage (V_{ICR}), output swing (V_{OL} and V_{OH}), and supply voltage limits are not exceeded.

circuit layout precautions

The user is cautioned that whenever extremely high circuit impedances are used, care must be exercised in layout, construction, board cleanliness, and supply filtering to avoid hum and noise pickup, as well as excessive DC leakages.

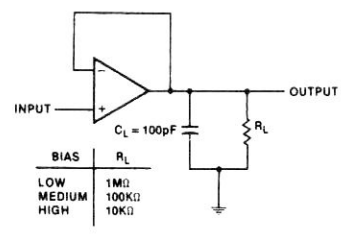


Medium-Bias Versions Large-Signal Differential Voltage Amplification and Phase Shift vs Frequency



High-Bias Versions Large-Signal Differential Voltage Amplification and Phase Shift vs Frequency

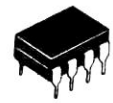
TYPICAL APPLICATION



Unity Gain Amplifier

TLC271
276-1748

PROGRAMMABLE LOW-POWER OPERATIONAL AMPLIFIER

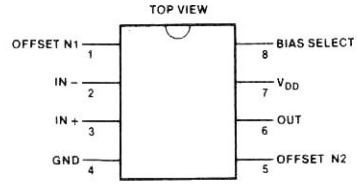


GENERAL DESCRIPTION

The TLC271 consists of low-cost, low-power programmable operational amplifiers designed to operate with single or dual supplies. Unlike tradition metal-gate CMOS op amps, the device utilizes the silicon-gate LinCMOS™ process, giving it stable input offset voltages without sacrificing the advantages of metal-gate CMOS. The TLC271 can be nulled with one external potentiometer. Because the input common-mode range extends to the negative rail and the power consumption is extremely low, this device is ideally suited for battery-powered or energy-conserving applications. A bias-select pin can be used to program one of three ac performance and power-dissipation levels, from a high bias level (slew rate of 4.5 V/us, 10 V) to a low level (slew rate of 0.04 V/μs, dissipation of only 100 μW at 10 volts) to suit the application.

Because of the extremely high input impedance and low input bias and offset currents, applications for the TLC271 include many areas that have previously been limited to BIFET and NFET product types. Any circuit using high-impedance elements and requiring small offset errors is a good candidate for cost-effective us of these devices. Many features associated with bipolar technology are available with LinCMOS operational amplifiers without the lower penalties of traditional bipolar devices. In addition, by driving the bias-select input with a logic signal from a microprocessor, these operational amplifiers can have software-controlled performance and power consumption.

PIN CONNECTION



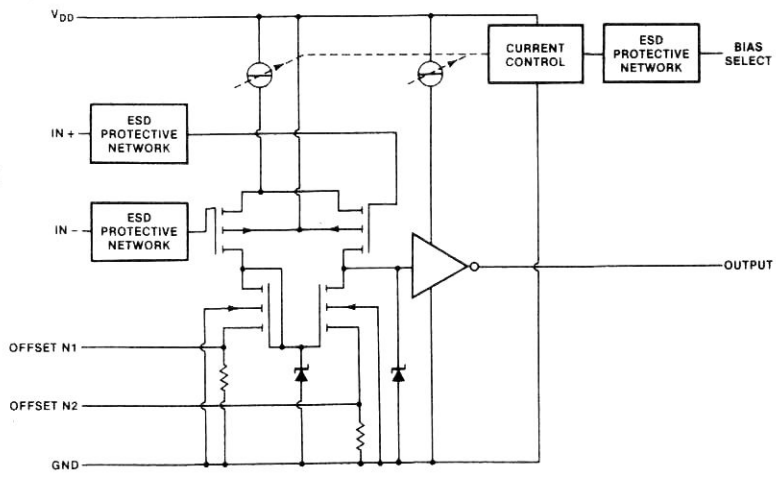
FEATURES

- Wide range of supply voltages
- True single supply operation
- Common-mode input voltage range includes the negative rail
- Selectable supply current
  Low = 100 μA typical
  Medium = 150 μA typical
  High = 1000 μA typical
- Extremely low input bias and offset currents
  I_{IB}—1 PA typical
  I_{IO}—1 PA typical
- Low input offset voltage

Low noise—30 nV $\sqrt{\ }$ H z typical at 1 kHz (High Bias)

- High slew rate
  High bias 4.5 V/μs typical
  Medius bias 0.6 V/μs typical
  Low bias 0.4 V/μs typical

INTERNAL CIRCUIT



APPLICATIONS

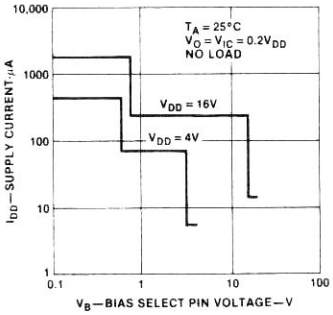
- Transducer interfacing
- Analog calculations
- Amplifier blocks
- Active filters
- Signal buffering

ABSOLUTE MAXIMUM RATINGS

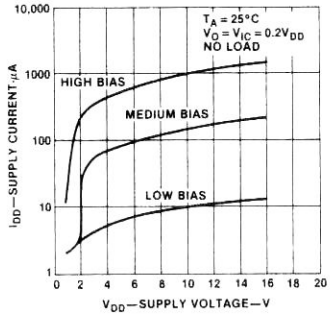
Supply Voltage (V_{DD}) (See Note 1) ..... 18 V
Differential Input Voltage (See Note 2) ..... ± 18 V
Input Voltage Range (Any Input) ..... −0.3 V To 18 V
Power Dissipation 725mW
Duration of Short-Circuit at (Or Below)
25°C Free Air Temperature (See Note 3) ..... Unlimited
Operating Temperature Range ..... 0°C To 70°C
Storage Temperature Range ..... −65°C To 150°C

NOTES: 1. All voltage values, except differential voltages, are with respect to network ground terminal.
2. Differential voltages are at the noniverting input terminal with respect to the inverting input terminal.
3. The output may be shorted to either supply. Temperature and/or supply voltages must be limited to ensure the maximum dissipation rating is not exceeded.

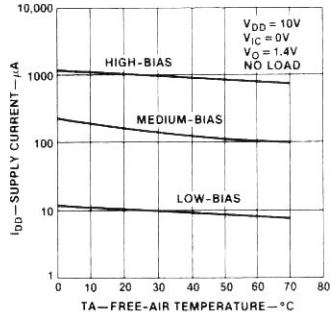
TYPICAL CHARACTERISTICS



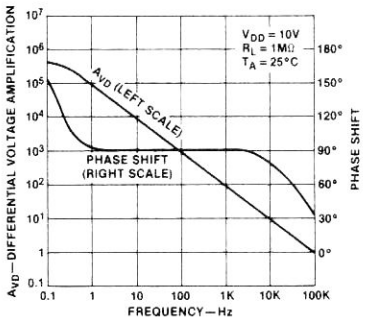
Supply Current
vs
Bias Select Pin Voltage



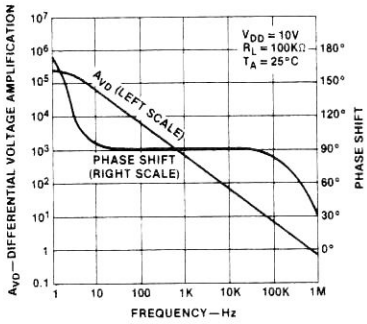
Supply Current
vs
Supply Voltage



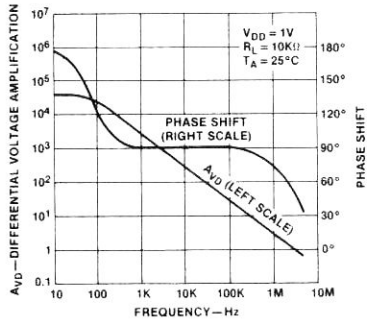
Supply Current
vs
Free-Air Temperature



Low-Bias Versions
Large-Signal
Differential Voltage Amplification
and Phase Shift
vs
Frequency

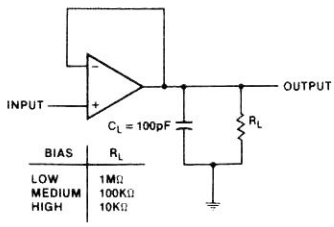


Medium-Bias
Large-Signal
Differential Voltage Amplification
and Phase Shift
vs
Frequency

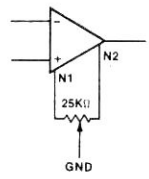


High-Bias
Large-Signal
Differential Voltage Amplification
and Phase Shift
vs
Frequency

TYPICAL APPLICATIONS



Unity-Gain Amplifier



Input Offset Voltage Null Circuit

TLC555 TIMER

276-1718

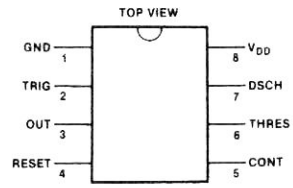
GENERAL DESCRIPTION

The TLC555 is a monolithic timing circuit fabricated using the Lin CMOS™ process. Due to its high-impedance inputs (typically $10^{12}\Omega$), it is capable of producing accurate time delays and oscillations while using less expensive, smaller timing capacitors. The TLC555 achieves both monostable (using one resistor and one capacitor) and astable (using two resistors and one capacitor) operation. In addition, 50% duty cycle astable operation is possible using only a single resistor and one capacitor. The Lin CMOS™ process allows the TLC555 to operate at frequencies up to 2 MHz and be fully compatible with CMOS, TTL, and MOS logic. It also provides very low power consumption (typically 1 mW at V_{DD} = 5V) over a wide range of supply voltages ranging from 2 volts to 18 volts.

Threshold and trigger levels are normally two-thirds and one-third respectively of V_{DD}. These levels can be altered by use of the control voltage terminal. When the trigger input falls below trigger level, the flip-flop is set and the output goes high. If the trigger input is above the trigger level and the threshold input is above the threshold level, the flip-flop is reset and the output is low. The reset input can override all other inputs and can be used to initiate a new timing cycle. When the reset input goes low, the flip-flop is reset and the output goes low. Whenever the output is low, a low impedance path is provided between the discharge terminal and ground.

While the complementary CMOS OUTPUT is capable of sinking over 100 mA and sourcing over 10 mA, the TLC555 exhibits greatly reduced supply current spikes during output transitions.

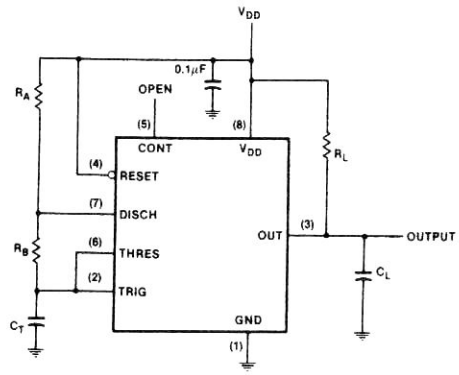
PIN CONNECTION



FEATURES

- Very low power consumption (1 mW typical at V_{DD} = 5 V)
- Capable of very high-speed operation (2 mHz in a stable operation)
- Complementary CMOS output capable of swinging rail to rail
- High output-current capability (sink 100 mA typical) (soucre 10 mA typical)
- Output fully CMOS, TTL, and MOS-compatible
- Low supply current reduces spikes during output transitions
- High impedance input $10^{12}\Omega$ typical)
- Single supply operation from 2 to 18 volts

TYPICAL APPLICATION



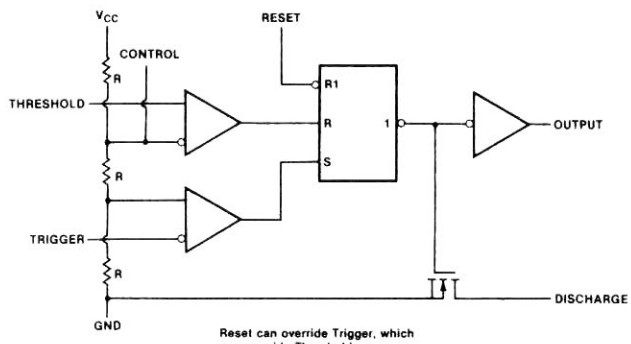
Circuit for Astable Operation

ABSOLUTE MAXIMUM RATINGS

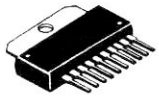
Supply Voltage (V_{DD}) (See Note 1) ..... 18 V
Input Voltage Range (Any Input) ..... −03 V To 18 V
Power Dissipation (mW) 600mW
Operating Temperature Range ..... 0°C To 70°C
Storage Temperature Range ..... −65°C To 150°C

NOTES: 1. All voltage values are with respect to network ground terminal.

BLOCK DIAGRAM



Reset can override Trigger, which can override Threshold.



5.8W AUDIO POWER AMPLIFIER

TA7205AP
276-705

GENERAL DESCRIPTION

The TA7205AP is a monolithic audio power amplifier with a built in thermal shut-down circuit designed for car radio and stereo applications.

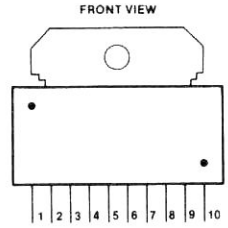
FEATURES

- Low distortion
  THD=0.15% (Typ.) (@ P_{OUT}=1W, G_V=55dB)
  THD=0.07% (Typ.) (@ P_{OUT}=1W, G_V=44dB)
- Operating supply voltage range: V_{CC}=9~18V
- 'PCT' process to insure low noise characteristic
- Current limiting for short-circuit protection
- Built in thermal shut-down circuit
- Built in surge voltage protection circuit

ABSOLUTE MAXIMUM RATINGS

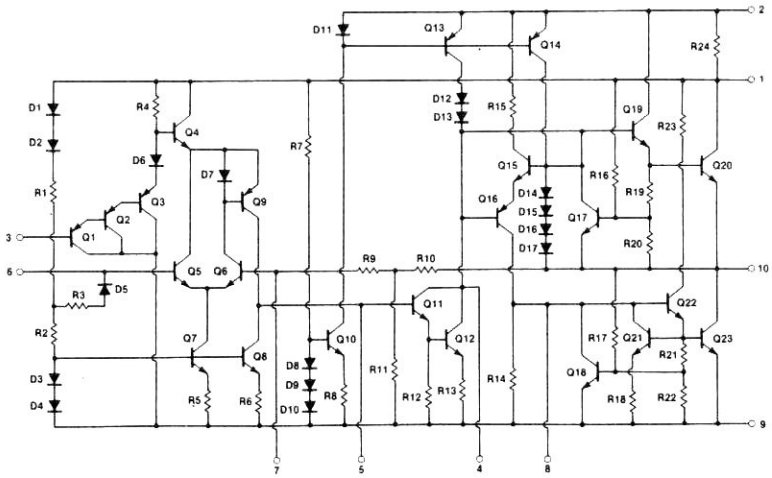
Operating Supply Voltage(V_{CC})	18V
Quiescent Supply Voltage (V_{CCQ})	25V
Output Peak Current (I_O)	4.5A
Quiescent Current (I_{CCQ})	80mA
Operating Temperature	−20 to +75°C
Storage Temperature	−55 to +150°C

PIN CONNECTION

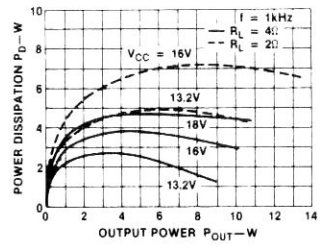


PIN	FUNCTION
1	V+
2	BOOTSTRAP
3	DECOUPLING
4	PHASE COMPENSATION
5	PHASE COMPENSATION
6	INPUT
7	NEGATIVE FEEDBACK
8	PHASE COMPENSATION
9	GROUND
10	OUTPUT

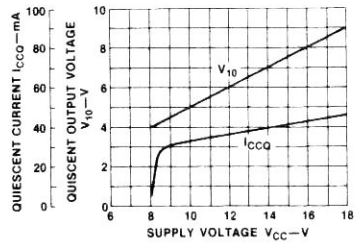
INTERNAL CIRCUIT



TYPICAL CHARACTERISTICS

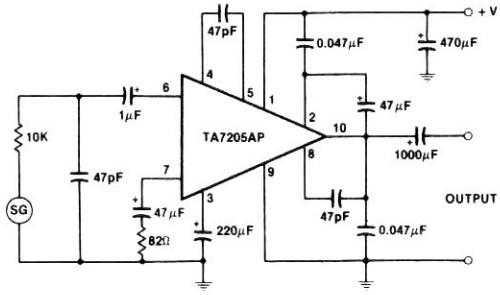


Power Dissipation vs Output Power

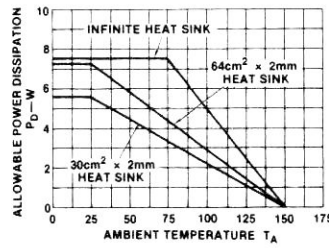


Quiescent Current and Output Voltage vs Supply Voltage

TYPICAL APPLICATION



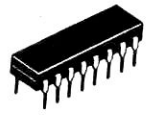
5 Watt Audio Amplifier



Allowable Power Dissipation vs Ambient Temperature

SN76495
276-1764

COMPLEX SOUND GENERATOR



GENERAL DESCRIPTION

The SN76495 complex sound generator is a monolithic chip combining both analog (bipolar) and digital (I2L) circuitry. It includes a noise generator, a voltage-controlled oscillator (VCO), and a super-low-frequency oscillator (SLF) together with a noise filter, mixer, audio amplifier, and control circuitry to provide noise, tone, or low-frequency sounds and any combinations of these. Programming is accomplished via control inputs and user-defined external components, which allows a wide variety of sound to be created and tailored for particular applications. This device may be used in a variety of applications requiring audio feedback to the operator.

Operation is from a 7.5 volts to 10.5 volt supply applied to a built-in regulator through the V_{CC} terminal, in which case a regulated five volts is available from the Vreg terminal to power a small amount of external circuitry, or to provide a high-logic-level voltage to logic inputs.

FEATURES

- Generates noise, tone, or low frequency based sounds, or combinations of these
- Sounds are defined by user via external components
- Allows custom sounds to be created easily
- Low power requirements
- Allows multiple sound system
- Compatible with microprocessor systems
- On board 125 mW audio amplifier

APPLICATIONS

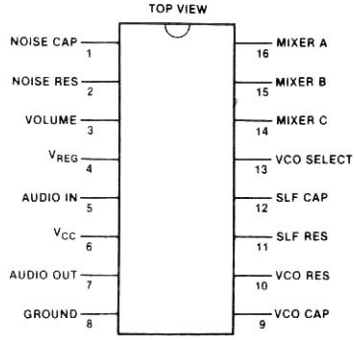
- Arcade Games
- Video Games
- Pinball Games
- Toys
- Timers
- Alarms

ABSOLUTE MAXIMUM RATINGS

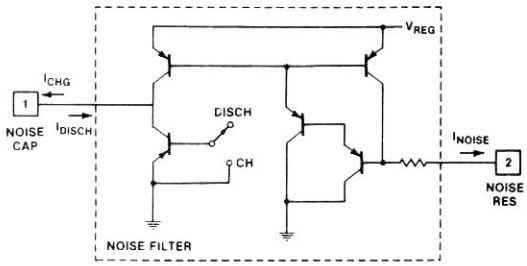
Supply Voltage (V_{CC}	12 V
Input Voltage: Logic Input	12 V
Capacitor Input	5.0 V
Resistor Input	5.0 V
Operating Temperature Range	0°C To 70°C
Storage Temperature Range	−65°C To +150°C

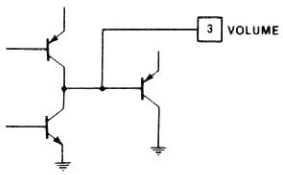
NOTE 1: All voltage values are with respect to package ground terminal.

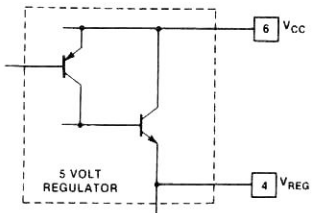
PIN CONNECTION

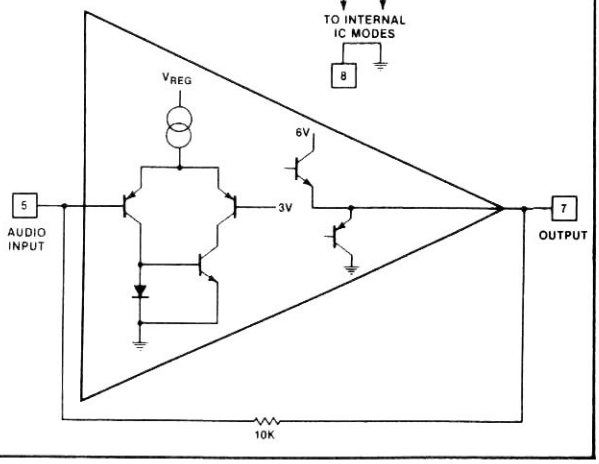


INTERNAL CIRCUITS

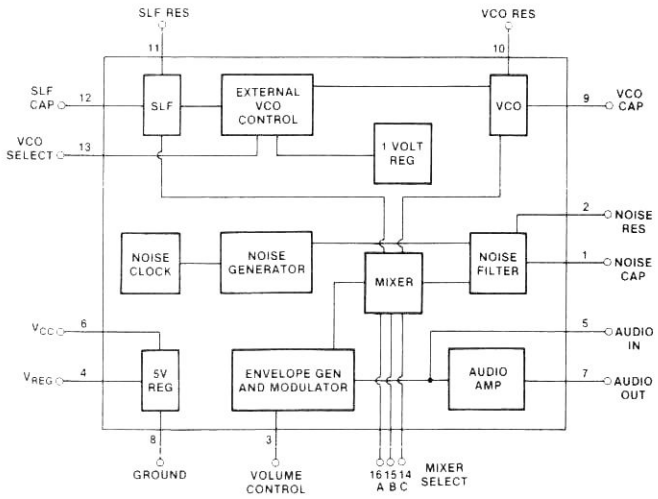








BLOCK DIAGRAM



SN76495 276-1764

OPERATION

Super Low Frequency Oscillator (SLF)

The SLF is normally operated in the range of 0.1 Hz to 30 hertz, but will operate up to 20 kHz. The frequency is determined by two external components, the SLF control resistor (Rslf) at pin 11 at ground and the SLF control capacitor (Cslf) at pin 12 at ground according to the following equation:

Equation 1: SLF Frequency (Hz) ≈ .66/(9Kohm+Rslf)xCslf at Vreg=5V

The SLF supplies two signals to other parts of the device. It feeds a 50% duty cycle square wave to the mixer, and it feeds a triangular wave to the external VCO of SLF select logic, where, if VCO select (pin 13) is at a low logic level, it is fed through to the VCO to modulate the frequency of that oscillator.

Voltage Controlled Oscillator (VCO)

The VCO produces a tone output whose frequency is dependent upon the voltage at the input of the VCO. This controlling voltage may be either the SLF output described above, an internal voltage producing a constant tone, or externally by placing a voltage on the SLF capacitor pin. The higher the voltage applied to the VCO, the lower the frequency of the VCO output.

The first mode, VCO controlled by SLF, is selected by placing the VCO select pin low and supplying both the VCO capacitor (CVCO) at pin 9 at ground the the VCO resistor (RVCO) at pin 10 at ground. Minimum frequency of the VCO is determined by the following equation:

Equation 2: Minimum VCO Frequency (Hz) ≈ 0.60/(9Kohm+RVCO) × CVCO

The frequency range of the VCO is internally determined at an approximate ratio of 10:1, so that maximum frequency of the VCO will be approximately ten times the minimum frequency determined by the external components RVCO and CVCO.

The second method of supplying a control voltage for the VCO is to use an internal voltage preset at 1 volt. This mode is selected by taking VCO select to a high level. In this mode, the VCO puts out a constant tone determined by CVCO and RVCO in this relationship:

Equation 3: fVCO ≈ 1.45/(RVCO + 9Kohn) × CVCO × 0.9V) Hz

A third method of controlling the voltage to the VCO is to apply the controlling voltage (Vext) to the SLF capacitor pin. This voltage level (0 to 2.30 volts) will determine the output frequency of the VCO. Output frequency in this mode is determined by this relationship:

Equation 4: fVCO ≈ 1.45/(RVCO + 9Kohn) × CVCO × (Vext − .1V) Hz

Mixer

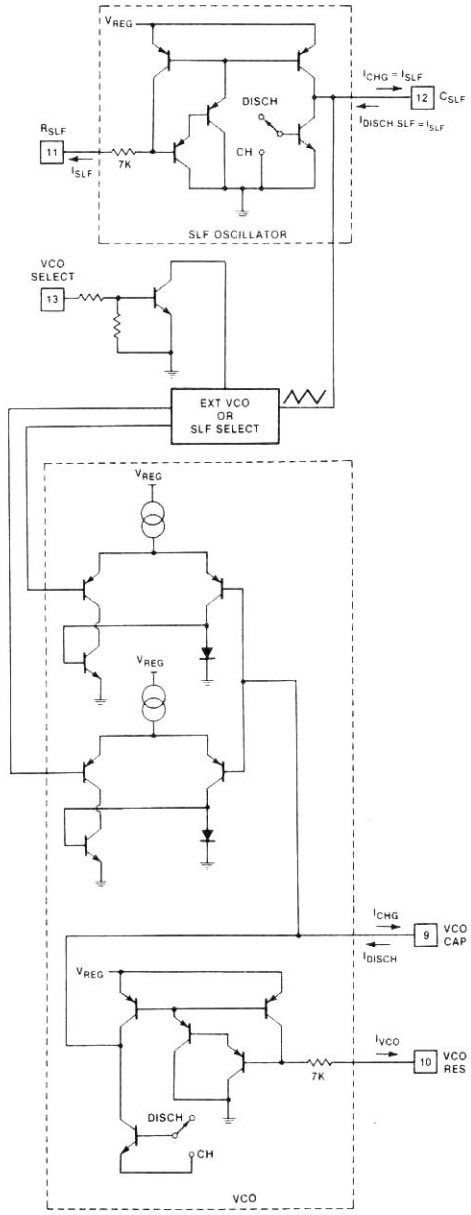
The mixer logic selects one or a combination of the inputs from the generators and feeds the output to the amplifier. The mixer performs a logical AND function on these sounds; therefore, the output of the mixer is not a combination of simultaneous sounds. The output of the mixer is determined by the logic levels at the mixer select inputs as shown in Table 1.

TABLE 1

MIXER SELECTS INPUTS			
A (PIN 16)	B (PIN 15)	C (PIN 14)	MIXER OUTPUT
L	L	L	VCO
H	L	L	SLF
L	H	L	NOISE
H	H	L	VCO/NOISE
L	L	H	SLF/NOISE
H	L	H	SLF/VCO/NOISE
L	H	H	SLF/VCO
H	H	H	INHIBIT

H = HIGH LEVEL L = LOW LEVEL OR OPEN

INTERNAL CIRCUITS (Cont'd)



SN76495 276-1764

Mixer (Cont'd)

Figure 1 is an example of how two signals would be combined by the mixer according to the logical AND function with the mixer select times set for SLF/noise (C input high, A and B inputs low).

To obtain two sounds occurring simultaneously (e.g., car engine and siren or steam engine and whistle), multiplexing is required. The multiplexing is accomplished by switching the mixer select lines at a sufficiently rapid rate that the two sounds seem to occur at the same time. The frequency of the multiplexing should be above the human hearing range. A multiplexing drive signal with a 50% duty cycle is required to provide equal amplitudes for both sound functions.

Volume

Output volume from the SN76495 can be controlled by varying a voltage level on pin 3. This voltage level should range from 3.5 volts, for maximum volume, to .4 volts or below for no output. Under no circumstances should this pin be taken above 5 volts or below 0 volts. Voltages outside of this range could damage the unit.

Noise Generator/Filter

The noise generator produces pseudo-random white noise that passes through the noise filter before being applied to the mixer. The variable-bandwidth low-pass filter has its cutoff point defined by the noise filter control resister (Rnf) at pin 2 and the noise filter control capacitor (Cnf) at pin 1 according to the following equation:

Equation 5: $fCutoff\ (Hz) = .43/(9Kohm + Rnf) \times Cnf$

Output Amplifier

The output amplifier is contained entirely on chip. The amplifier operates in a transimpedance mode and has a push-pull output capable of delivering 125 mA into a capacitively coupled 8 ohm load. This produces a two volt peak to peak output signal. The amplifier input (pin 5) can be used to sum several external current signals. If the signals are composed of a varying voltage they must first be converted to current signals. This can be accomplished by using a resistor in series between the external source and the input (pin 5). The relationship of this resistor value (R series) to the external signal voltage (V max) is given by the following equation:

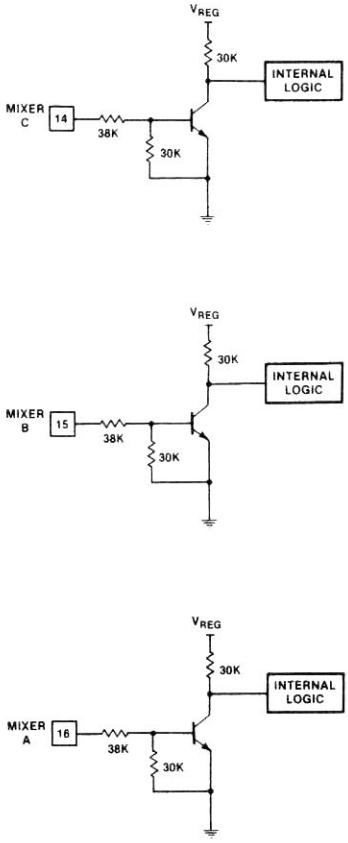
Equation 6: $100\ \mu A < Vmax - 3V/Rseries < 100\ \mu A$

Gain of the amplifier can be controlled by adding a resistor in parallel to the internal 10 Kohm feedback resistor. This will decrease gain and allow a larger input current.

Regulator

The circuit will operate from a singe supply (pin 6). An internal 5 volt regulator allows the use of a 7.5 volt to 10.5 volt unregulated supply applied to V_{CC} (pin 6) and in addition to supplying power for the chip, the internal regulator will provide a 5 volt regulated supply of up to 5 mA from Vreg (pin 4) for use outside the integrated circuit.

INTERNAL CIRCUITS (Cont'd)



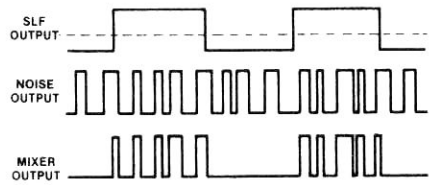
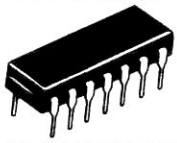


Figure 1



AUDIO POWER AMPLIFIER

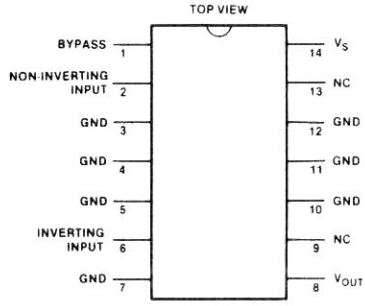
380
276-706

GENERAL DESCRIPTION

The 380 is a power audio amplifier for consumer application. In order to hold system cost to a minimum, gain is internally fixed at 34 dB. A unique input stage allows inputs to be ground referenced. The output is automatically self centering to one half the supply voltage.

The output is short circuit proof with internal thermal limiting. The package outline is standard dual-in-line. A copper lead frame is used with the center three pins on either side comprising a heat sink. This makes the device easy to use in standard p-c layout.

PIN CONNECTION



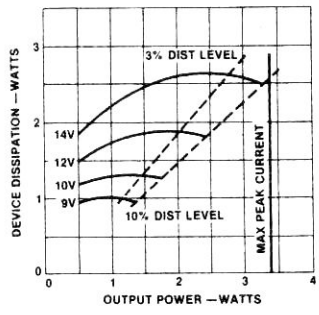
FEATURES

- Wide supply voltage range
- Low quiescent power drain
- High peak current capability
- Input referenced to GND
- High input impedance
- Low distortion
- Quiescent output voltage is at one-half of the supply voltage

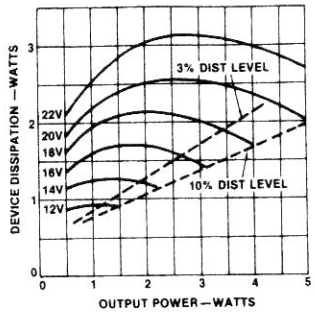
ABSOLUTE MAXIMUM RATINGS

Supply Voltage	22 V
Peak Current	1.3 A
Package Dissipation 14-Pin DIP	10 W
Input Voltage	±0.5 V
Storage Temperature	– 65 to + 150°C
Operating Temperature	0 to + 70°C
Junction Temperature	+ 150°C
Lead Temperature (Soldering, 10 sec)	+ 300°

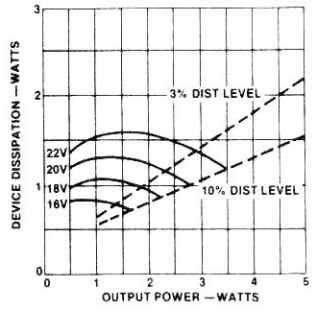
TYPICAL CHARACTERISTICS



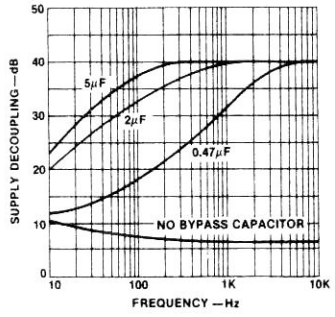
Device Dissipation vs Output Power — 4Ω Load



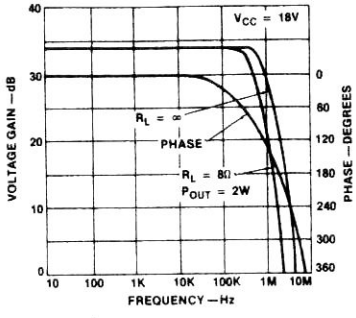
Device Dissipation vs Output Power — 8Ω Load



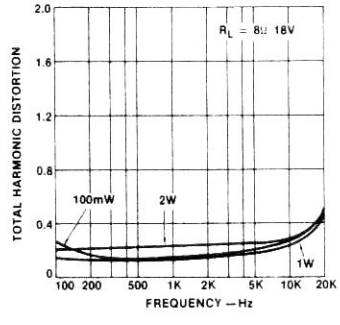
Device Dissipation vs Output Power — 16Ω Load



Supply Decoupling vs Frequency



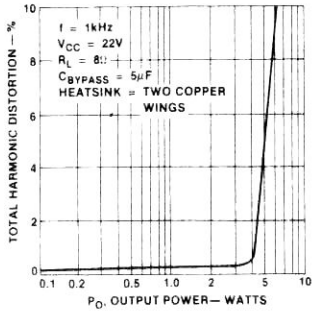
Output Voltage Gain and Phase vs Frequency



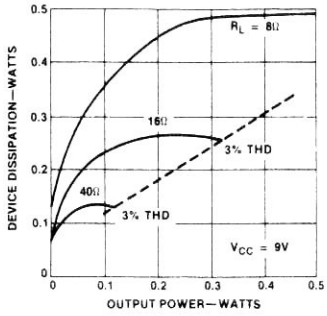
Total Harmonic Distortion vs Frequency

380 276-706

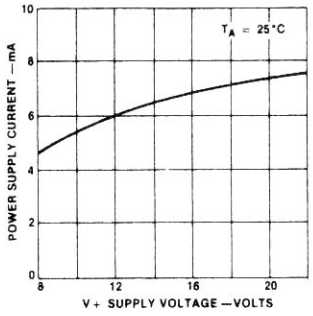
TYPICAL CHARACTERISTICS (Cont'd)



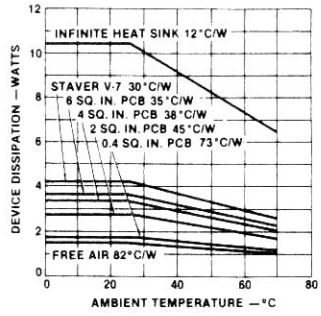
Total Harmonic Distortion vs Output Power



Device Dissipation vs Output Power

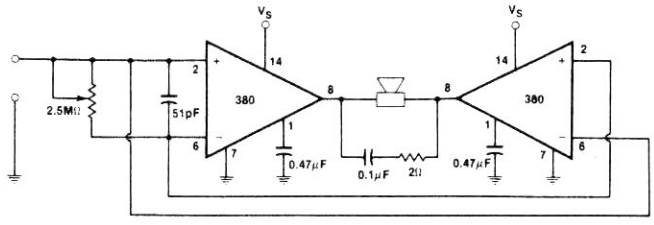


Power Supply Current vs Supply Voltage

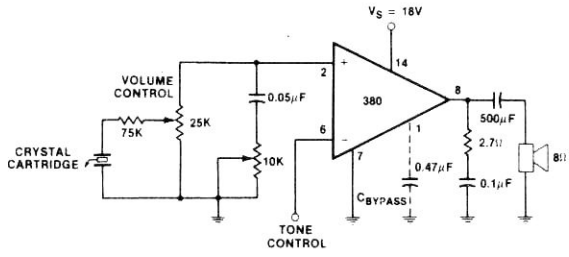


Device Dissipation vs Ambient Temperature

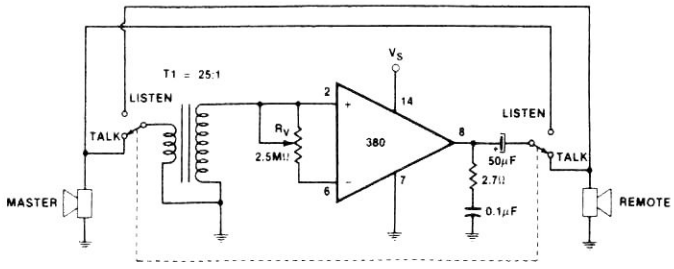
TYPICAL APPLICATIONS



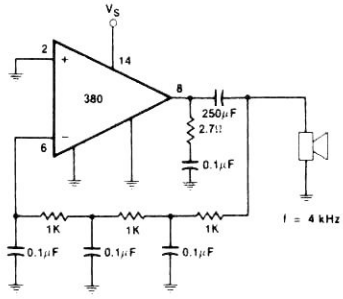
Bridge Amplifier



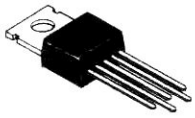
Phono Amplifier



Intercom



Phase Shift Oscillator



8 WATT AUDIO POWER AMPLIFIER

383
276-703

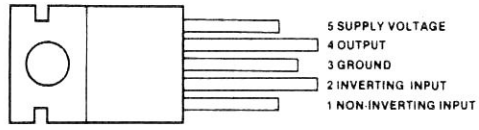
GENERAL DESCRIPTION

The 383 is a cost effective, high power amplifier suited for automotive applications. High current capability (3.5A) enables the device to drive low impedance loads with low distortion. The 383 is current limited and thermally protected. The 383 comes in a 5-pin TO-220 package.

FEATURES

- High peak current capability (3.5A)
- Large output voltage swing
- Externally programmable gain
- Wide supply voltage range (5V–20V)
- Few external parts required
- Pin for pin compatible with TDA2002
- Low distortion
- High input impedance
- No turn-on transients
- Low noise
- Short circuit protected

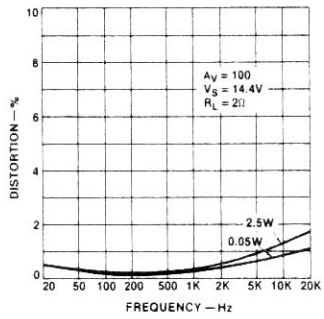
PIN CONNECTION



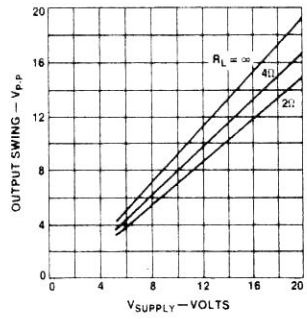
ABSOLUTE MAXIMUM RATINGS

Peak Supply Voltage (50 ms)	25V
Operating Supply Voltage	20V
Output Current	
Repetitive	3.5A
Non-repetitive	4.5A
Input Voltage	±0.5V
Power Dissipation	15W
Operating Temperature	0 to +70°C
Storage Temperature	−60 to +150°C
Lead Temperature (Soldering, 10 seconds)	300°C

TYPICAL CHARACTERISTICS

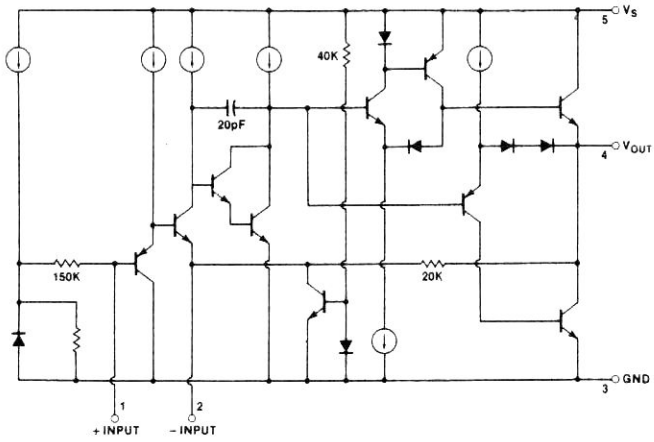


Distortion vs Frequency

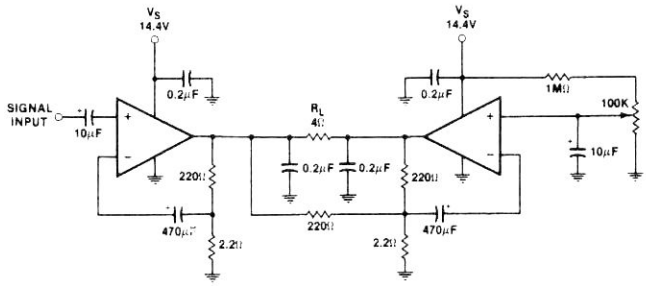


Output Swing vs Supply Voltage

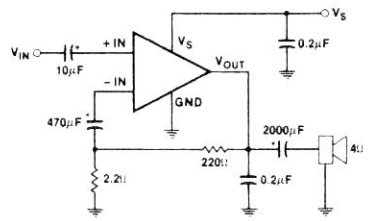
INTERNAL CIRCUIT



TYPICAL APPLICATIONS



16W Bridge Amplifier



Basic Audio Amp

386
276-1731

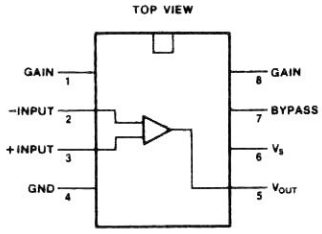
LOW VOLTAGE AUDIO POWER AMPLIFIER

GENERAL DESCRIPTION

The 386 is a power amplifier designed for use in low voltage consumer applications. The gain is internally set to 20 to keep external part count low, but the addition of an external resistor and capacitor between pins 1 and 8 will increase the gain to any value up to 200.

The inputs are ground referenced while the output is automatically biased to one half the supply voltage. The quiescent power drain is only 18 milli-watts when operating from a 6 volt supply, making the 386 ideal for battery operation.

PIN CONNECTION



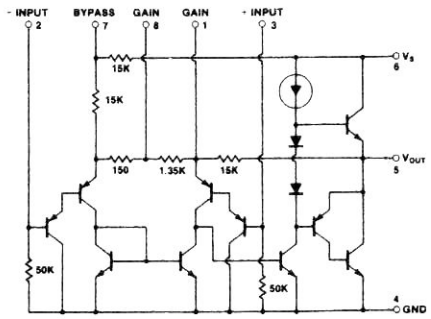
FEATURES

- Battery operation
- Minimum external parts
- Wide supply voltage range 4-12 volts
- Low quiescent current drain 3 mA
- Voltage gains from 20 to 200
- Ground referenced input
- Self-centering output quiescent voltage
- Low distortion
- Eight pin dual-in-line package

APPLICATIONS

- AM-FM radio amplifiers
- Portable tape player amplifiers
- Intercoms
- TV sound systems
- Line drivers
- Ultrasonic drivers
- Small servo drivers
- Power converters

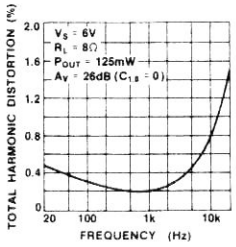
INTERNAL CIRCUIT



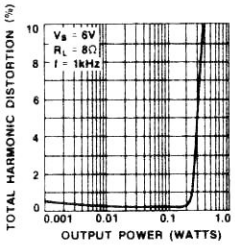
ABSOLUTE MAXIMUM RATINGS

Supply Voltage	15V
Package Dissipation 8 Pin DIP	660 mW
Input Voltage	±0.4V
Junction Temperature	+150°C
Operating Temperature	0 to +70°C
Storage Temperature	−65 to +150°C
Lead Temperature (Soldering, 10 seconds)	+300°C

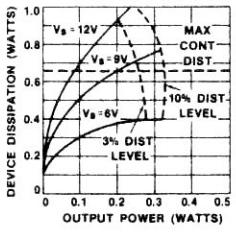
TYPICAL CHARACTERISTICS



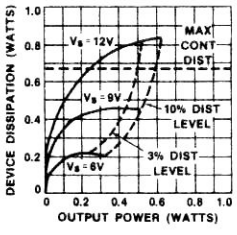
Distortion vs Frequency



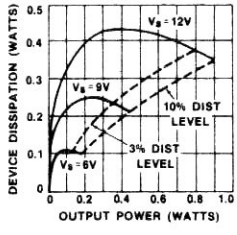
Distortion vs Output Power



Device Dissipation vs Output Power—4Ω Load

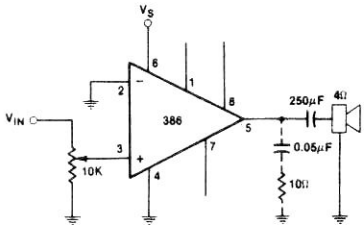


Device Dissipation vs Output Power—8Ω Load

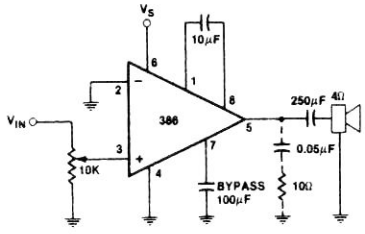


Device Dissipation vs Output Power—16Ω Load

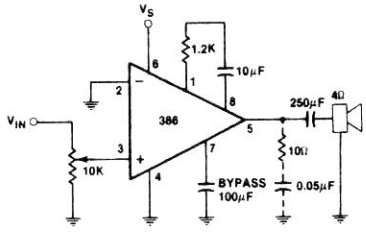
TYPICAL APPLICATIONS



Amplifier with Gain = 20 (Minimum Parts)



Amplifier with Gain = 50



Amplifier with Gain = 200

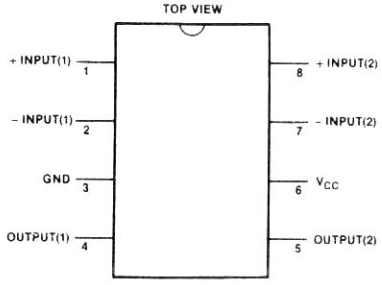
LOW NOISE DUAL PREAMPLIFIER

387
276-1737

GENERAL DESCRIPTION

The 387 is a dual preamplifier for the amplification of low level signals in applications requiring optimum noise performance. Each of the two amplifiers is completely independent, with an internal power supply decoupler-regulator, providing 110 dB supply rejection and 60 dB channel separation. Other outstanding features include high gain (104 dB), large output voltage swing (V_{CC} – 2 V) $_{p\text{-}p}$, and wide power band width (75 kHz, 20 $V_{p\text{-}p}$). The 387 operates from a single supply across the wide range of 9 to 30 V.

PIN CONNECTION



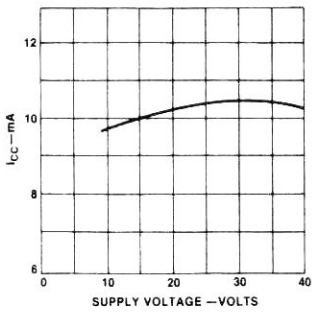
FEATURES

- Low noise — 0.8 μV total input noise
- High gain — 104 dB open loop
- Wide supply range — 9 to 30 V
- Power supply rejection — 110 dB
- Large output voltage swing (V_{CC} – 2 V) $_{p\text{-}p}$
- Wide band width 15 MHz unity gain
- Power band width 75 kHz, 20 $V_{p\text{-}p}$
- Internally compensated
- Short circuit protected

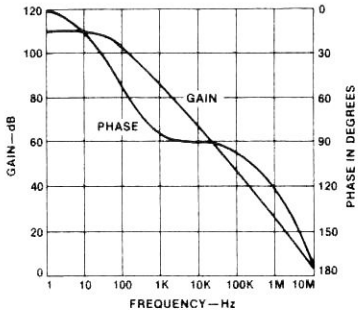
ABSOLUTE MAXIMUM RATINGS

Supply Voltage ..... + 30 V
Operating Temperature Range ..... 0 to + 70°C
Storage Temperature Range ..... – 65 to + 150°C
Lead Temperature (Soldering, 10 seconds) ..... 300°C

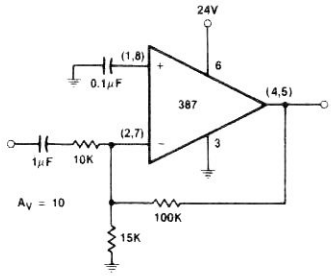
TYPICAL CHARACTERISTICS



Supply Current vs Supply Voltage

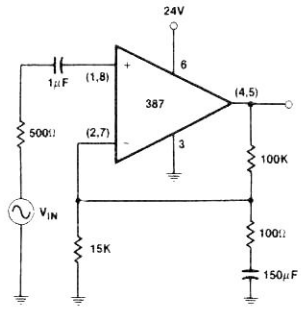


Gain and Phase Response vs Frequency

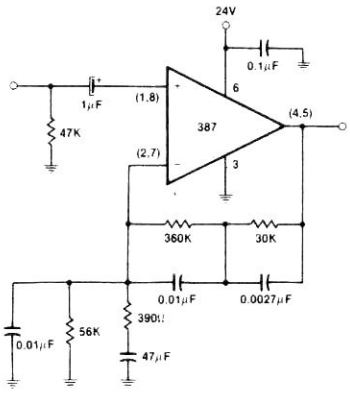


Ultra-Low Distortion Inverting Amplifier

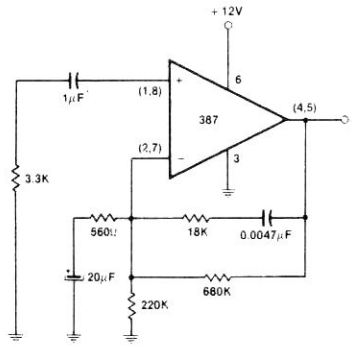
TYPICAL APPLICATIONS



Flat Gain Circuit (A_V = 1000)



Magnetic Phono Preamplifier



NAB Tape Circuit

3914
276-1707
3915
276-1708

DOT/BAR DISPLAY DRIVER

GENERAL DESCRIPTION

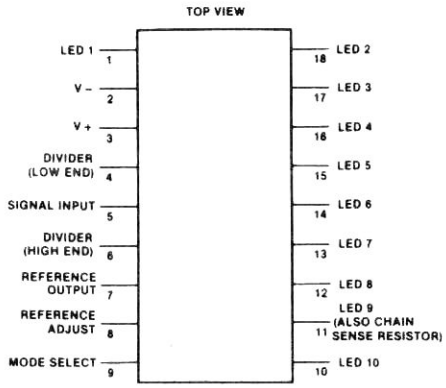
The 3914 is a monolithic integrated circuit that senses analog voltage levels and drives 10 LEDs, providing a linear analog display. A single pin changes the display from a moving dot to a bar graph. Current drive to the LEDs is regulated and programmable, eliminating resistors. This feature allows operation of the system from less then 3V. Controller, visual alarm, and expanded scale functions are easily added on to the display system. The circuit can drive LEDs of many colors, or low-current incandescent lamps. Many 3914s can be "chained" to form displays of segments. Both ends of the voltage divider are externally available so that 2 drivers can be made into a zero-center meter.

Individual DC regulated currents provide flexibility and various effects can be achieved by modulating these currents. Outputs can drive a transistor and a LED so controller functions including "staging" control can be performed.

The 3915 Bar/Graph Display Driver is different by a − 3db per segment logarithmic scaling compared to the linear scaling of the 3914.

The 3915 can be used with AC or DC signals. With AC (audio) inputs, the display will be quite eye-catching and informative, especially in the Dot mode. Connecting an audio signal to the signal input direct is all that is required.

PIN CONNECTION



FEATURES

- Bar or dot display mode externally selectable by user
- Expandable to displays of 20 steps (3915)
- Expandable to displays of 100 steps (3914)
- Internal voltage reference from 1.2V to 12V
- Operates with single supply of less than 3V
- Inputs operate down to ground
- Output current programmable from 2 to 3 mA
- No multiplex switching or interaction between outputs
- Input withstands ±35V without damage or false outputs
- LED driver outputs are current regulated, open-collectors
- Outputs can interface with TTL or CMOS logic. The internal 10-step divider is floating and can be reference to a wide range of voltages

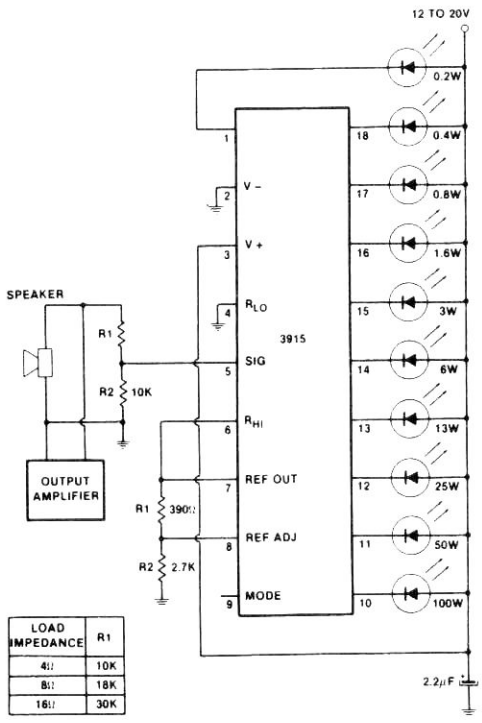
APPLICATIONS

- "Slow"—fade bar or dot display (doubles resolution)
- 20 step meter with single pot brightness control
- 10-step (nor multiples) programmer
- Multi-step or "staging" controller
- Combined controller and process deviation meter
- Exclamation point display for power savings
- Power Meters in stereo systems
- VU Meters in tape recorders
- S meters in Ham and CB radios
- Direction and rate indicator (to add to DVMs)

ABSOLUTE MAXIMUM RATINGS

Power Dissipation	660 mW
V + Voltage	25V
LED Collector Output Voltage	25V
Input Signal Overvoltage	±35V
Voltage on Resistor String	−100 MV to V+
Reference Load Current	10 mA
Signal Input Current (With Overvoltage Applied)	±3 mA

TYPICAL APPLICATIONS

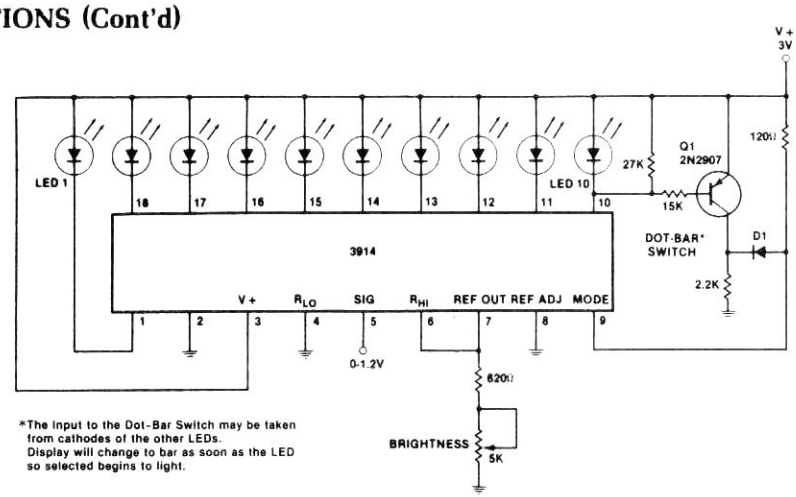


LOAD IMPEDANCE	R1
4Ω	10K
8Ω	18K
16Ω	30K

Audio Power Meter

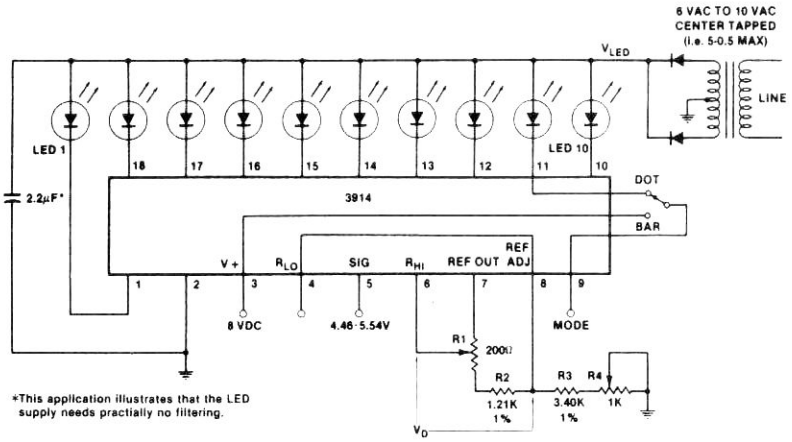
3914 276-1707 **3915** 276-1708

TYPICAL APPLICATIONS (Cont'd)



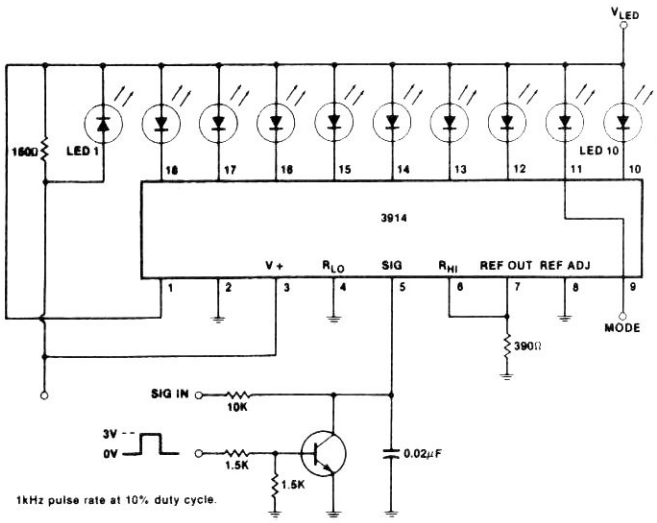
*The input to the Dot-Bar Switch may be taken from cathodes of the other LEDs. Display will change to bar as soon as the LED so selected begins to light.

Indicator and Alarm



*This application illustrates that the LED supply needs practially no filtering.

Expanded Scale Meter, Dot or Bar

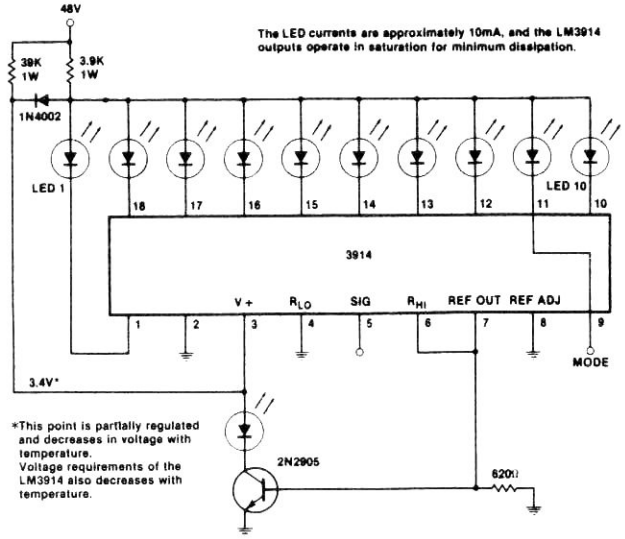


1kHz pulse rate at 10% duty cycle.

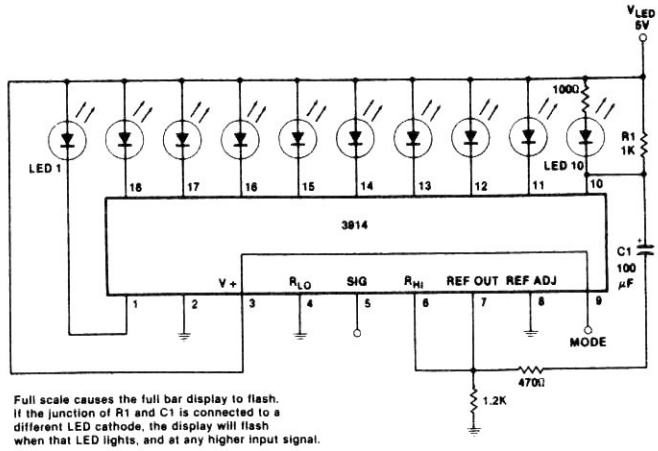
Exclamation Point Display

3914 276-1707 3915 276-1708

TYPICAL APPLICATIONS (Cont'd)

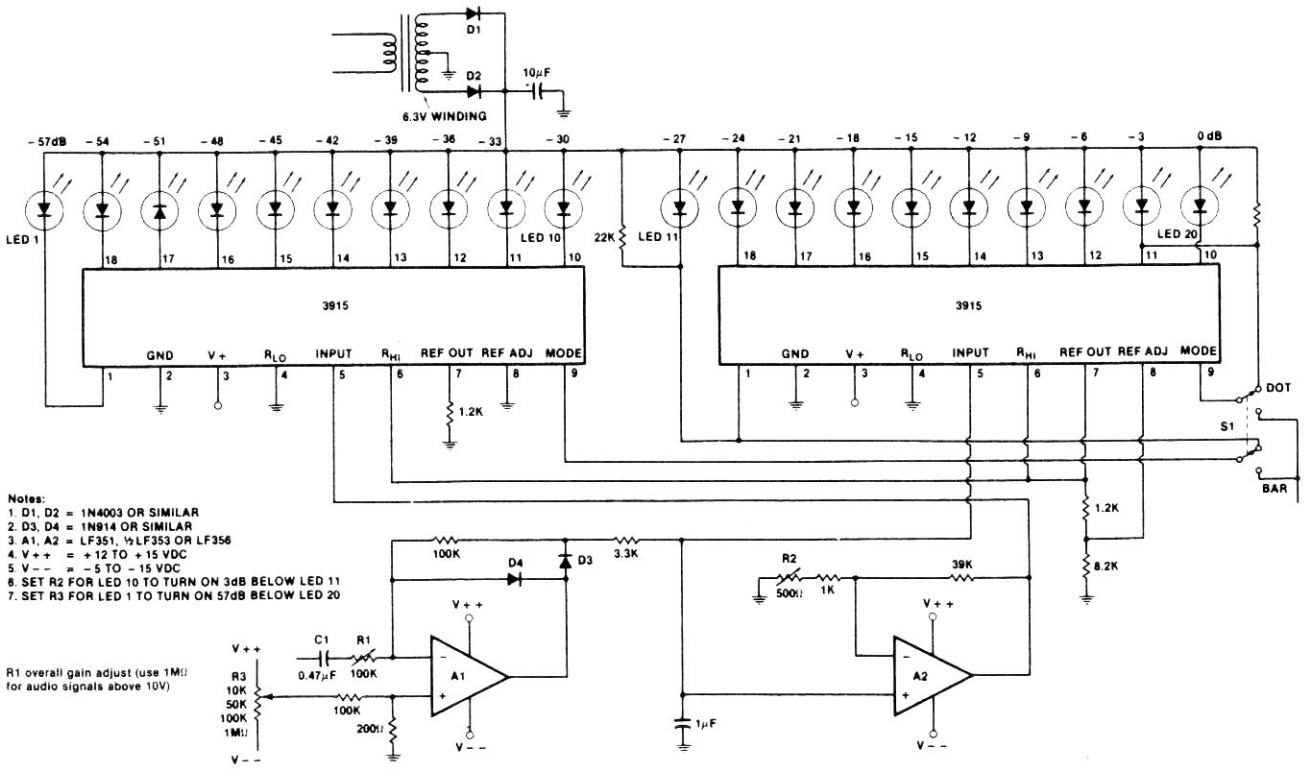


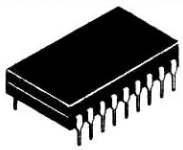
Operating with a High Voltage Supply



Bar Display with Alarm Flasher

Bar Graph Display





DOT/BAR DISPLAY DRIVER

3916
276-1709

GENERAL DESCRIPTION

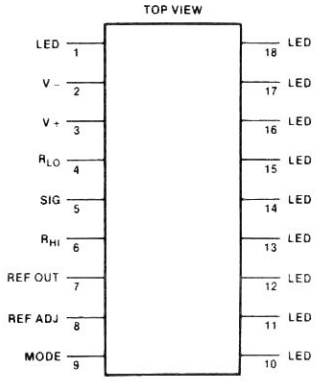
The 3916 is a monolithic integrated circuit that senses analog voltage levels and drives ten LEDs, LCDs or vacuum fluorescent displays, providing an electronic version of the popular VU meter. One pin changes the display from a bar graph to a moving dot display. LED current drive is regulated and programmable, eliminating the need for current limiting resistors. The whole display system can operate from a single supply as low as 3V or as high as 25V.

The IC contains an adjustable voltage reference and an accurate ten-step voltage divider. The high-impedance input buffer accepts signals down to ground and up to within 1.5V of the positive supply. Further, it needs no protection against inputs of ±35V. The input buffer drives 10 individual comparators referenced to the precision divider. Accuracy is typically better than 0.2 dB.

Audio applications include average or peak level indicators, and power meters. Replacing conventional meters with an LED bar graph results in a faster responding, more rugged display with high visibility that retains the ease of interpretation of an analog display.

The 3916 is extremely easy to apply. A 1.2V full-scale meter requires only one resistor in addition to the ten LEDs. One more resistor programs the full-scale anywhere from 1.2V to 12V independent of supply voltage. LED brightness is easily controlled with a single pot.

PIN CONNECTION



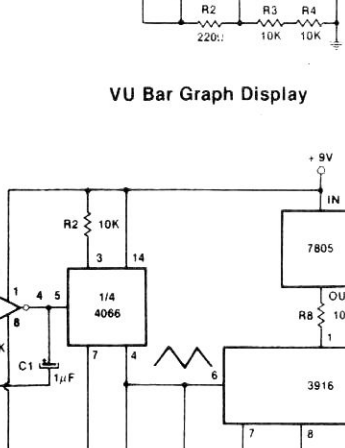
FEATURES

- Fast responding electronic VU meter
- Drives LEDs, LCDs, or vacuum fluorescents
- Bar or dot display mode externally selectable by user
- Expandable to displays of 70 dB
- Internal voltage reference from 1.2V to 12V
- Inputs operate down to ground
- Output current programmable from 1 mA to 30 mA
- Input withstands ±35V without damage or false outputs
- Outputs are current regulated, open collectors
- Directly drives TTL or CMOS
- The internal 10-step divider is floating and can be referenced to a wide range of voltages

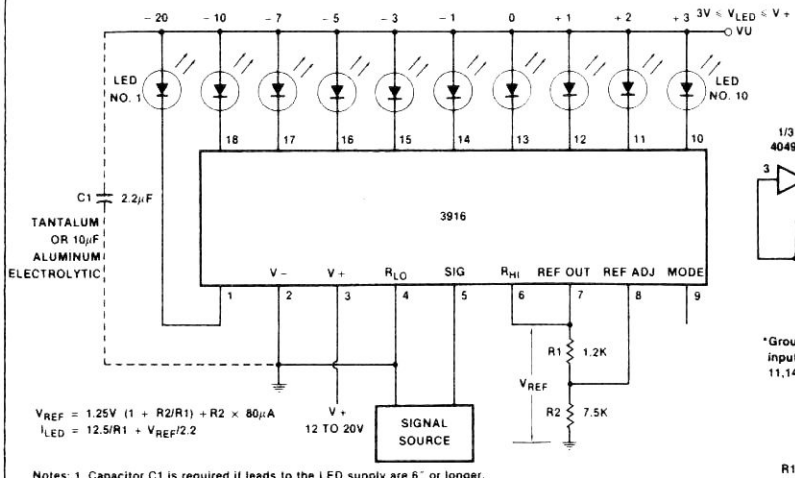
ABSOLUTE MAXIMUM RATINGS

Supply Voltage ..... 3 to 25 V
Input Signal Over Voltage ..... ± 35 V
Storage Temperature ..... 0 to 70°C

TYPICAL APPLICATIONS



VU Bar Graph Display



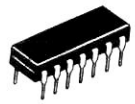
Notes: 1. Capacitor C1 is required if leads to the LED supply are 6" or longer.
2. Circuit as shown is wired for dot anode. For bar mode, connect pin 9 to pin 3.
L_{LED} must be kept below 7V or dropping resistor should be used to limit IC power dissipation.

0V to 10V VU Meter

R1 controls cycle rate.
R4 controls range.
Two gate oscillator switches 4066 on and off.
C2 is charged via R2 and discharged by R3 to give voltage ramp.

Back and Forth Flasher

TL084CN 276-1714 QUAD BI-FET OPERATIONAL AMPLIFIER



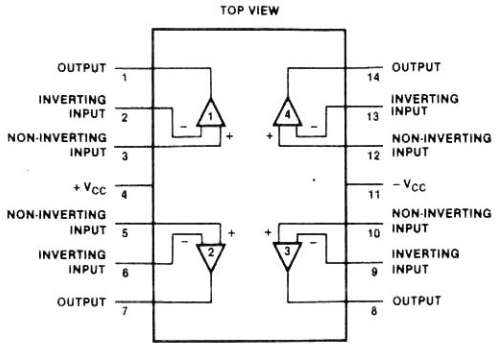
GENERAL DESCRIPTION

The TL084 JFET-input operational amplifier is designed to offer better performance than any previously developed quad-operational amplifier. Each of these JFET-input operational amplifiers incorporates well-matched, high-voltage JFET and bipolar transistors in a monolithic integrated circuit. The devices feature high slew rates, low input bias and offset currents, and low offset voltage temperature coefficient.

FEATURES

- Low power consumption
- Wide common-mode and differential voltage ranges
- Low input bias and offset currents
- Output short-circuit protection
- High input impedance—JFET-input stage
- Internal frequency compensation
- Latch-up-free operation
- High slew rate—13 V/μs Typ

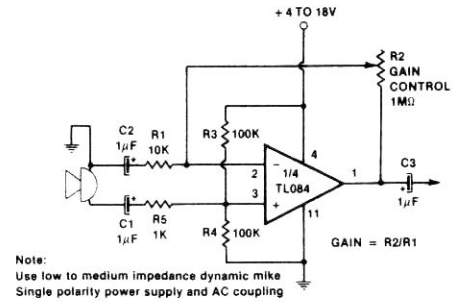
PIN CONNECTION



ABSOLUTE MAXIMUM RATINGS

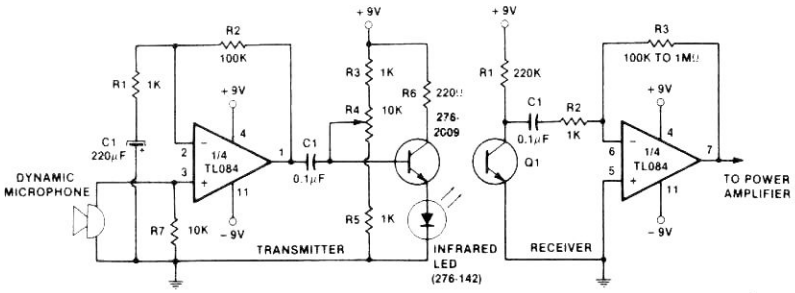
Supply Voltage, $V_{CC}+$	18V
Supply Voltage, $V_{CC}-$	−18V
Differential Input Voltage	±30V
Input Voltage	±15V
Duration of Output Short Circuit	Unlimited
Continuous Total Dissipation at (or Below)	
25°C Free-Air Temperature	680 mW
Operating Free-Air Temperature Range	0 to +70°C
Storage Temperature Range	−65 to +150°C
Lead Temperature 1/16 inch from Case for 10 Seconds	260°C

TYPICAL APPLICATIONS



Note:
Use low to medium impedance dynamic mike
Single polarity power supply and AC coupling

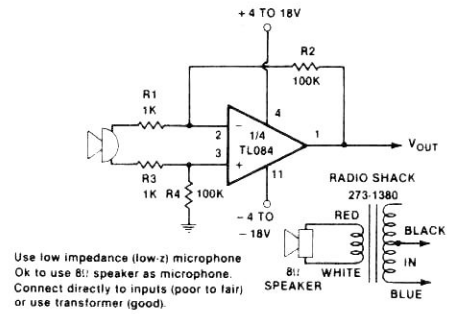
Microphone Preamplifier



Point the led at Q1 and adjust R4 until best voice quality is obtained. (R4 applies prebias to LED.) R6 limits maximum led current to a safe 40mA.

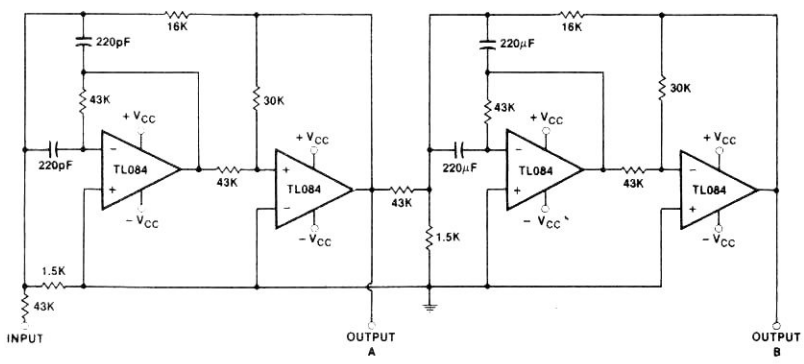
Use RADIO SHACK 276-130 phototransistor for Q1. Maximum range: Hundreds of feet at night with lenses at Q1 and LED.
Power amp: See LM386

Infrared Voice Communicator

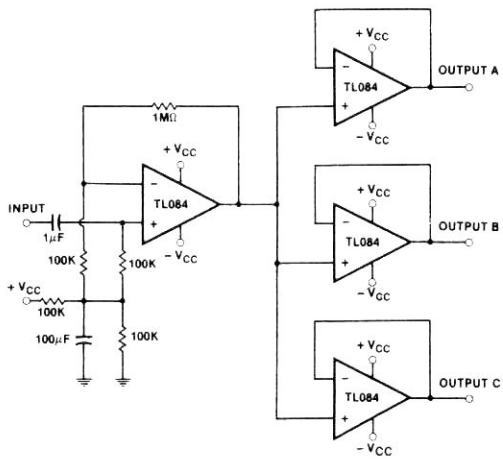


Use low impedance (low-z) microphone
Ok to use 8Ω speaker as microphone.
Connect directly to inputs (poor to fair)
or use transformer (good).

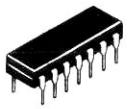
Low-Z Preamplifier



Positive—Feedback Bandpass Filter



Audio Distribution Amplifier



QUAD OP AMP

324
276-1711

GENERAL DESCRIPTION

The 324 series consists of four independent, high gain, internally frequency compensated operational amplifiers which were designed specifically to operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage.

Application areas include transducer amplifiers, dc gain blocks and all the conventional op amp circuits which now can be more easily implemented in single power supply systems. For example, the 324 series can be directly operated off of the standard +5 V_{DC} power supply voltage which is used in digital systems and will easily provide the required interface electronics without requiring the additional +15 V_{DC} power supplies.

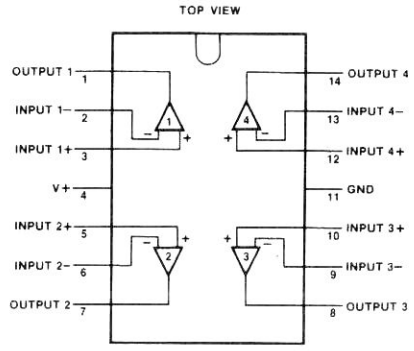
FEATURES

- Internally frequency compensated for unity gain
- Large dc voltage gain 100 dB
- Wide bandwidth (unity gain) 1 MHz (temperature compensated)
- Wide power supply range:
  Single supply 3 V_{DC} to 30 V_{DC}
  or dual supplies ±1.5 V_{DC} to ±15 V_{DC}
- Very low supply current drain (800 μA)—essentially independent of supply voltage (1 mW/op amp at +5 V_{DC})
- Low input biasing current 45 nA_{DC} (temperature compensated)
- Low input offset voltage 2 mV_{DC} and offset current 5 nA_{DC}
- Input common-mode voltage range includes ground
- Differential input voltage range equal to the power supply voltage
- Large output voltage swing 0 V_{DC} to V^+ − 1.5 V_{DC}

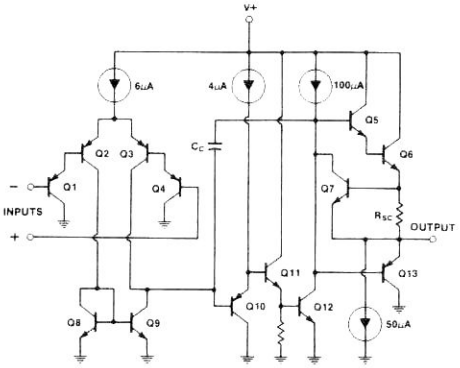
ABSOLUTE MAXIMUM RATINGS

Supply Voltage, V^+	32 V_{DC} or ±16 V_{DC}
Differential Input Voltage	32 V_{DC}
Input Voltage	−0.3 V_{DC} to +32 V_{DC}
Power Dissipation	
Molded DIP	570 mW
Cavity DIP	900 nW
Output Short-Circuit to GND (One Amplifier)	Continuous
$V^+ \leq 15$ V_{DC} and $T_A = 25°C$	
Input Current ($V_{IN} < -0.3$ V_{DC})	50 mA
Operating Temperature Range	0 to +70°C
Storage Temperature Range	−65 to +150°C
Lead Temperature (Soldering, 10 seconds)	300°C

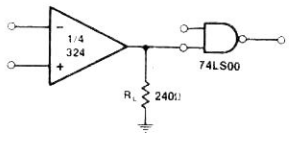
PIN CONNECTION



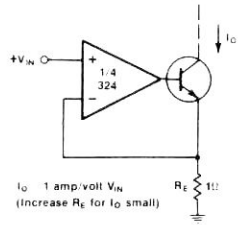
INTERNAL CIRCUIT
(Each Amplifier)



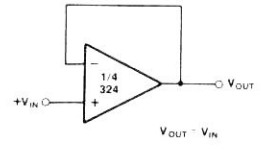
TYPICAL APPLICATIONS



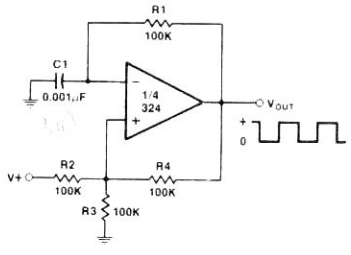
Driving TTL



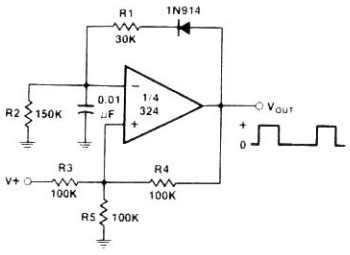
High Compliance Current Sink



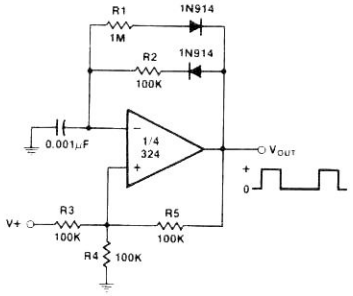
Voltage Follower



Squarewave Oscillator



Pulse Generator



Pulse Generator

353
276-1715

WIDE BANDWIDTH DUAL JFET INPUT OPERATIONAL AMPLIFIER

GENERAL DESCRIPTION

These devices are low cost, high speed, dual JFET input operational amplifiers with an internally trimmed input offset voltage (BI-FET II™) technology). They require low supply current yet maintain a large gain bandwidth product and fast slew rate. In addition, well matched high voltage JFET input devices provide very low input bias and offset currents.

These amplifers may be used in applications such as high speed integrators, fast D/A converters, sample and hold circuits and many other circuits requiring low input offset voltage, low input bias current, high input impedance, high slew rate and wide bandwidth. The devices also exhibit low noise and offset voltage drift.

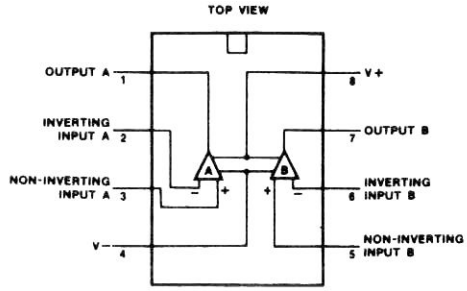
FEATURES

- Internally trimmed offset voltage = 2 mV
- Low input bias current = 50pA
- Low input noise voltage = 16nV/√Hz
- Low input noise current = 0.01 pA/√Hz
- Wide gain bandwidth = 4 MHz
- High slew rate = 13 V/μs
- Low supply current = 3.6 mA
- High input impedance = $10^{12}\Omega$
- Low total harmonic distortion A_V = 10, R_L = 10k, V_O = 20 Vp-p, BW = 20 Hz—20kHz = <0.02%
- Low 1/f noise corner = 50 Hz
- fast settling time to 0.0% = 2μs

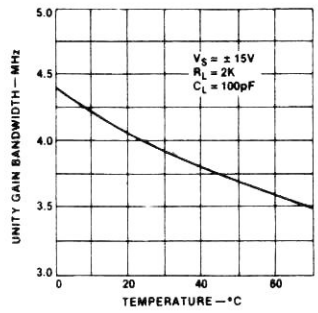
ABSOLUTE MAXIMUM RATINGS

Supply Voltage	±18V
Power Dissipation	500 mW
Differnetial Input Voltage	±30V
Input Voltage Range	±15V
Output Short Circuit Duration	Continuous
$T_{j(MAX)}$	115°C
Operating Temperature Range	0 to 70°C
Storage Temperature Range	−65 to +150°C
Lead Temperature (Soldering, 10 seconds)	300°C

PIN CONNECTION

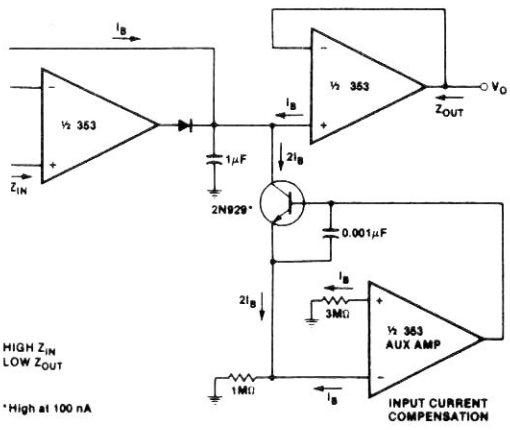


TYPICAL CHARACTERISTICS

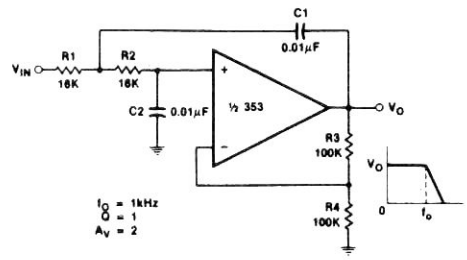


Unity Gain Bandwidth vs Temperature

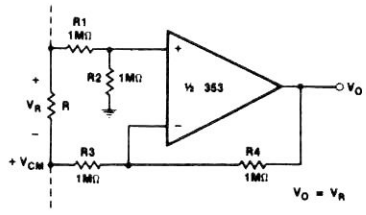
TYPICAL APPLICATIONS



Low Drift Peak Detector



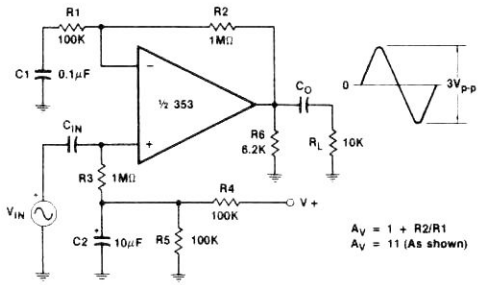
DC Coupled Low-Pass RC Active Filter



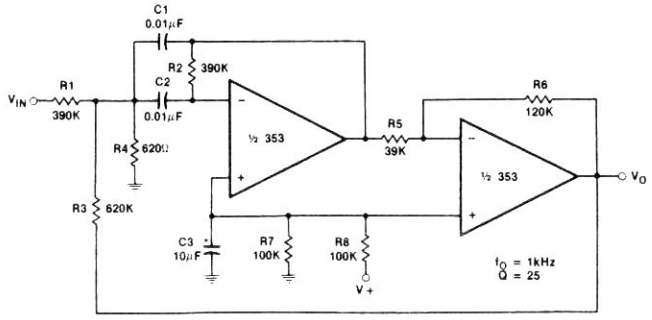
Ground Referencing A Differential Input Signal

353 276-1715

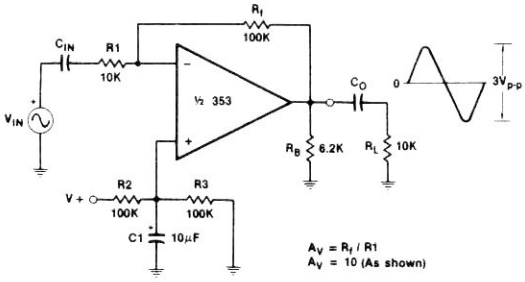
TYPICAL APPLICATIONS (Cont'd)



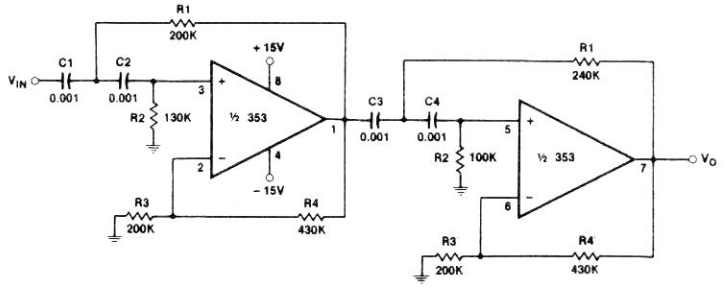
AC Coupled Non-Inverting Amplifier



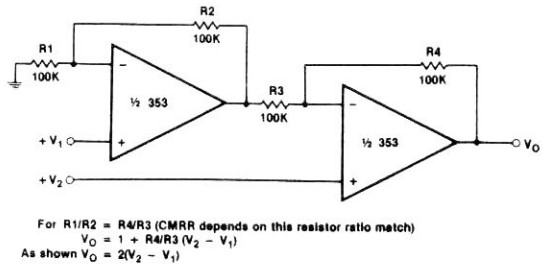
Bandpass Active Filter



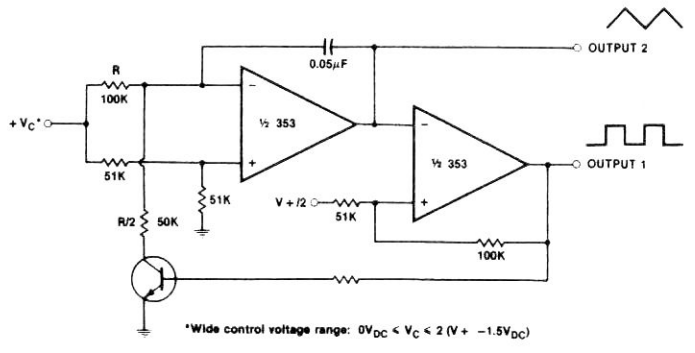
AC Coupled Inverting Amplifier



Fourth Order High Pass Butterworth Filter



High Input Z, DC Differential Amplifier



Voltage Controlled Oscillator (VCO)

741
276-007

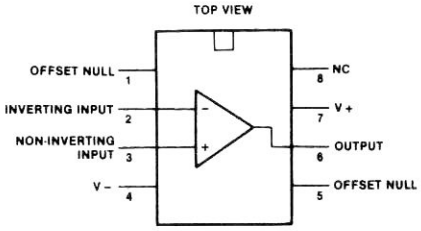
OPERATIONAL AMPLIFIER

GENERAL DESCRIPTION

The 741 series are general purpose operational amplifiers which feature improved performance over industry standards.

The amplifiers offer many features which make their application nearly foolproof: overload protection on the input and output, no latch-up when the common mode range is exceeded, as well as freedom from oscillations.

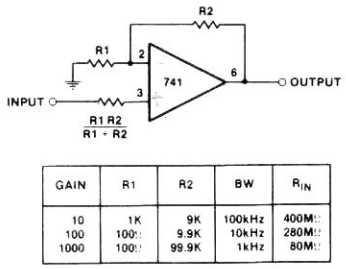
PIN CONNECTION



ABSOLUTE MAXIMUM RATINGS

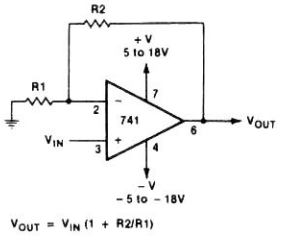
Supply Voltage	±16V
Power Dissipation	500 mW
Differential Input Voltage	±30V
Input Voltage	±15V
Output Short Circuit Duration	Indefinite
Operating Temperature Range	0 to +70°C
Storage Temperature Range	−65 to +150°C
Lead Temperature (Soldering, 10 seconds)	300°C

TYPICAL APPLICATIONS

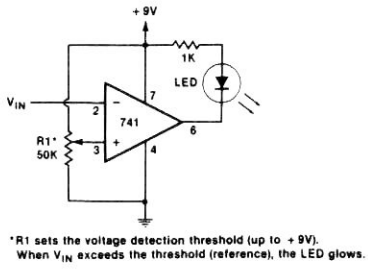


GAIN	R1	R2	BW	R_{IN}
10	1K	9K	100kHz	400MΩ
100	100Ω	9.9K	10kHz	280MΩ
1000	100Ω	99.9K	1kHz	80MΩ

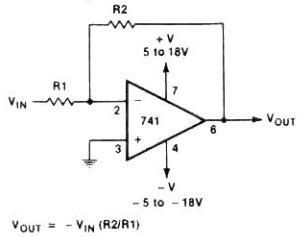
Non-Inverting Amplifier



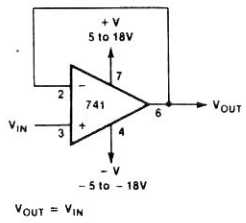
Non-Inverting Amplifier



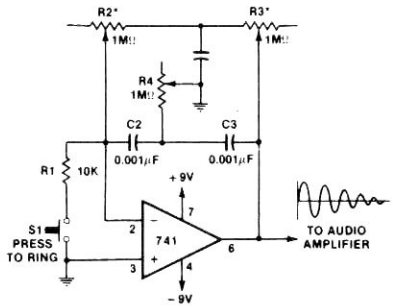
Level Detector



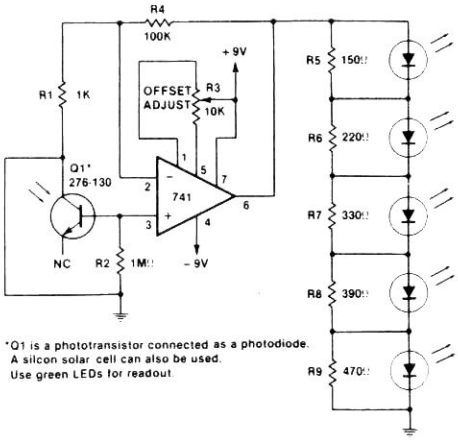
Inverting Amplifier



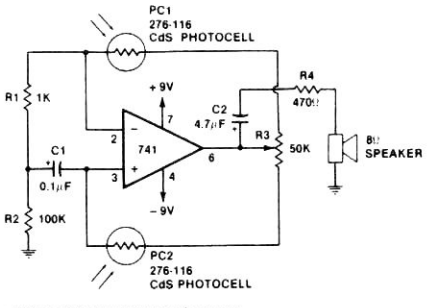
Unity Gain Follower



Electronic Bell



Bargraph Light Meter



Audible Light Sensor

DUAL OPERATIONAL AMPLIFIER

1458
276-038

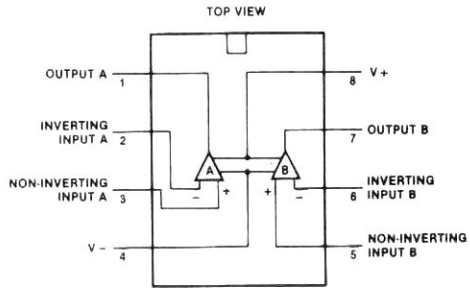
GENERAL DESCRIPTION

The 1458 is a general purpose dual operational amplifier. The two amplifiers share a common bias network and power supply leads. Otherwise, their operation is completely independent.

FEATURES

- No frequency compensation required.
- Short-circuit protection
- Wide common-mode and differential voltage ranges
- Low-power consumption
- No latch up when input common mode range is exceeded

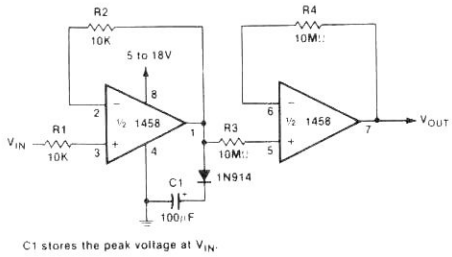
PIN CONNECTION



ABSOLUTE MAXIMUM RATINGS

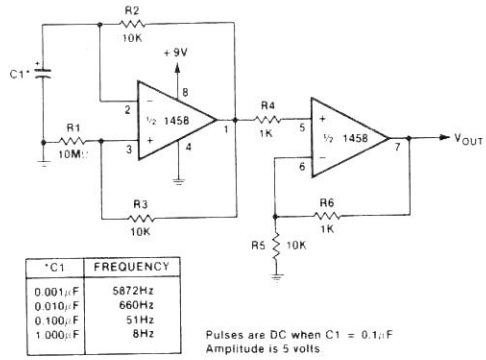
Supply Voltage	±16V
Power Dissipation	400 mW
Differential Input Voltage	±30V
Input Voltage	±15V
Output Short-Circuit Duration	Indefinite
Operating Temperature Range	0 to +70°C
Storage Temperature Range	−65 to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

TYPICAL APPLICATIONS



C1 stores the peak voltage at V_{IN}.

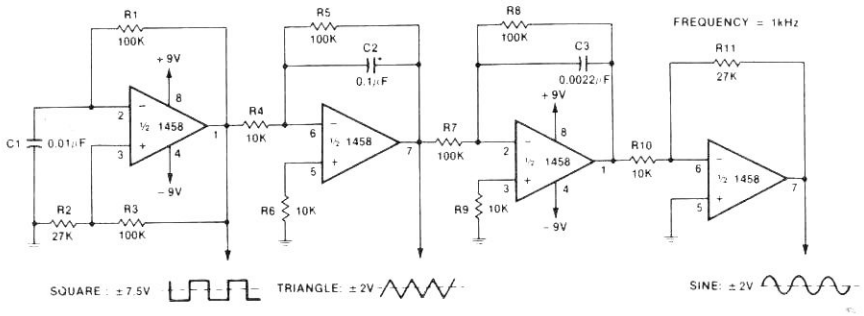
Peak Detector



*C1	FREQUENCY
0.001μF	5872Hz
0.010μF	660Hz
0.100μF	51Hz
1.000μF	8Hz

Pulses are DC when C1 = 0.1μF
Amplitude is 5 volts

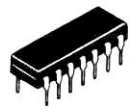
Pulse Generator



Function Generator

3900
276-1713

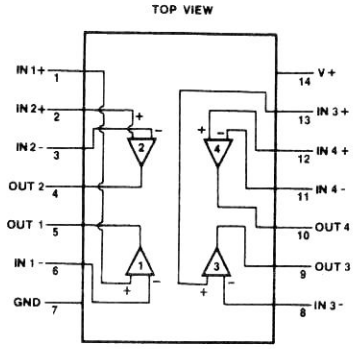
QUAD OPERATIONAL NORTON AMPLIFIER



GENERAL DESCRIPTION

The 3900 series consists of four independent, dual input, internally compensated amplifiers which were designed specifically to operate off of a single power supply voltage and to provide a large output voltage swing. These amplifiers make use of a current mirror to achieve the non-inverting input function. Application areas include: ac amplifiers, RC active filters, low frequency triangle, squarewave and pulse waveform generation circuits, tachometers and low speed, high voltage digital logic gates.

PIN CONNECTION



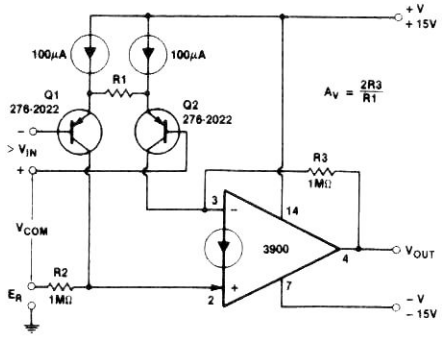
FEATURES

- Wide single supply voltage 4 V_{DC} to 36 V_{DC} range or dual supplies ±2 V_{DC} to ±18 V_{DC}
- Supply current drain independent of supply voltage
- Low input biasing current 30 nA
- High open-loop gain 70 dB
- Wide bandwidth 2.5 MHz (Unity Gain)
- Large output voltage swing $(V^+ - 1)$ $V_{p\text{-}p}$
- Internally frequency compensated for unity gain
- Output short-circuit protection

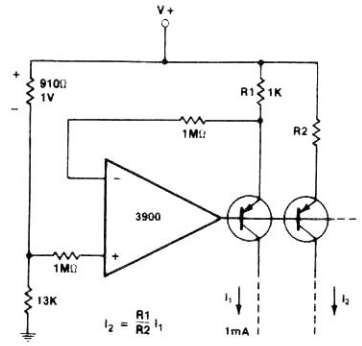
ABSOLUTE MAXIMUM RATINGS

Supply Voltage (Wide Range, Single Supply) ..... 32 V_{DC}
Supply Voltage (Wide Range, Dual Supply) ..... ±16 V_{DC}
Power Dissipation (T_A = 25°C)
Flat Pack ..... 570 mW
Input Currents, I_{IN}^+ or I_{IN}^- ..... 20 mA_{DC}
Output Short-Circuit Duration—One Amplifier ..... Continuous
T_A = 25°C (See Application Hints)
Operating Temperature Range ..... 0 to +70°C
Storage Temperature Range ..... −65 to +150°C
Lead Temperature (Soldering, 10 seconds) ..... 300°C

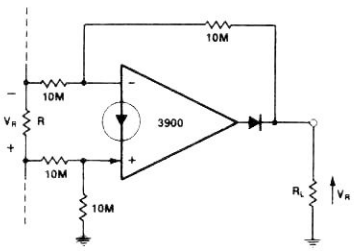
TYPICAL APPLICATIONS



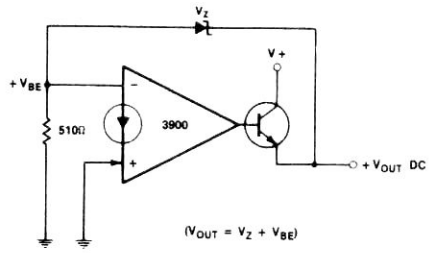
Basic Instrumentation Amplifier



Fixed Current Sources



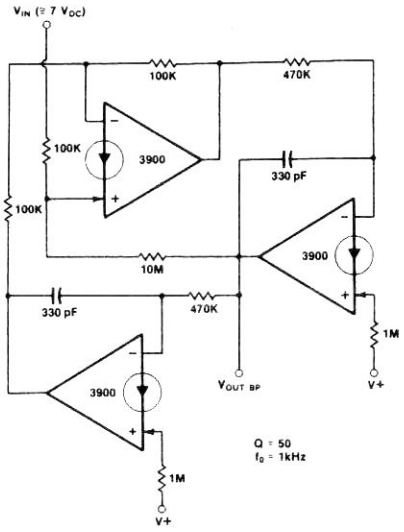
Ground-Referencing a Differential Input Signal



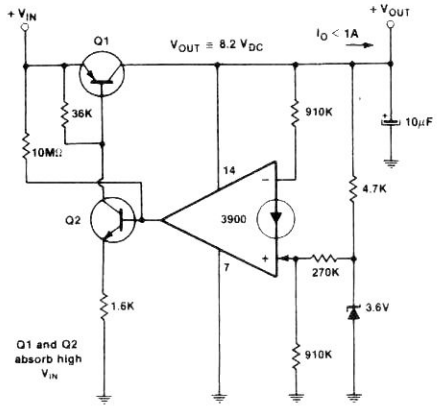
Voltage Regulator

3900 276-1713

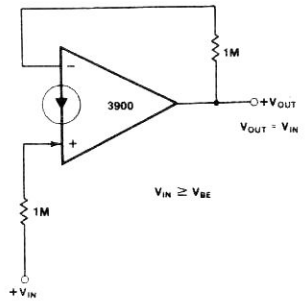
TYPICAL APPLICATIONS (Con't)



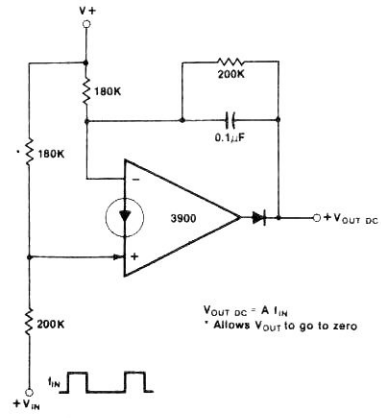
Bi-Quad Active Filter
(2nd Degree State-Variable Network)



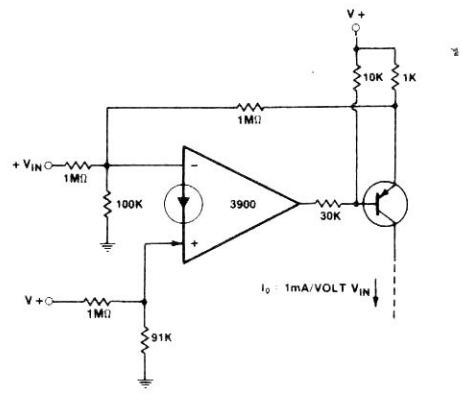
High V_{IN}, Low (V_{IN} − V_{OUT}) Self Regulator



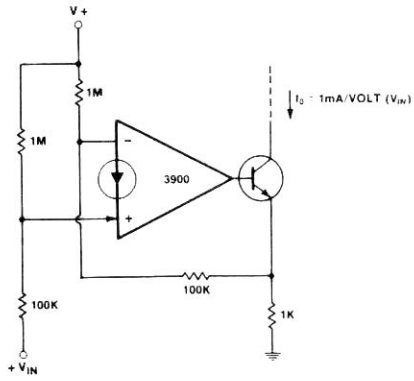
Buffer Amplifier



Tachometer



Voltage Controlled Current Source
(Transconductance Amplifier)



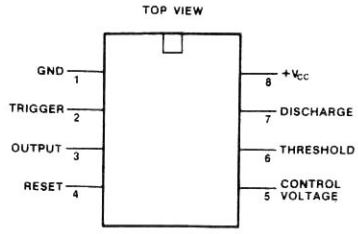
Voltage-Controlled Current Sink
(Transconductance Amplifier)

555 TIMER
276-1723

GENERAL DESCRIPTION

The 555 is a highly stable device for generating accurate time delays or oscillation. Additional terminals are provided for triggering or resetting if desired. In the time delay mode of operation, the time is precisely controlled by one external resistor and capacitor. For astable operation as an oscillator, the free running frequency and duty cycle are accurately controlled with two external resistors and one capacitor. The circuit may be triggered and reset on falling waveforms, and the output circuit can source or sink up to 200 mA or drive TTL circuits.

PIN CONNECTION



FEATURES

- Timing from microseconds through hours
- Operates in both astable and monostable modes
- Adjustable duty cycle
- Output can source or sink 200 mA
- Output and supply TTL compatible
- Temperature stability better than 0.005% per °C
- Normally on and normally off output

APPLICATIONS

- Precision timing
- Pulse generation
- Sequential timing
- Time delay generation
- Pulse width modulation
- Pulse position modulation
- Linear ramp generator

TRUTH TABLE

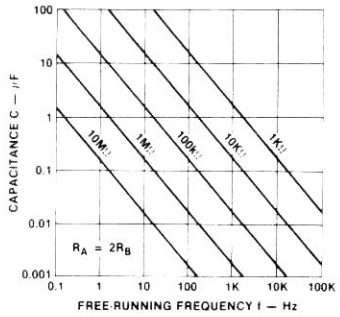
PIN 2 TRIGGER	PIN 6 THRESHOLD	PIN 4 RESET	PIN 3 OUTPUT
H	X	H	L
L	X	H	H
H	L	H	L
X	X	L	L

X = Don't Care L = Low Level H = High Level

ABSOLUTE MAXIMUM RATINGS

Supply Voltage	+16V
Power Dissipation	600 mW
Operating Temperature Range	0 to +70°C
Storage Temperature Range	−65 to +150°C
Lead Temperature (Soldering, 10 seconds)	300°C

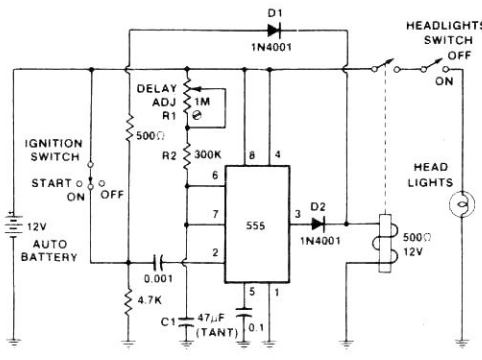
TYPICAL CHARACTERISTICS



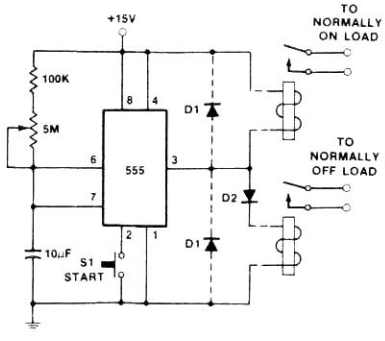
Capacitance vs Free-Running Frequency

The charge time (output high) is given by: $t_1 = 0.693 (R_A + R_B) C$
The discharge time (output low) is given by: $t_2 = 0.693 (R_B) C$
Thus the total period is: $T = t_1 + t_2 = 0.693 (R_A + 2R_B) C$
The frequency of oscillation is: $f = 1/T = 1.44 / (R_A + 2R_B) C$

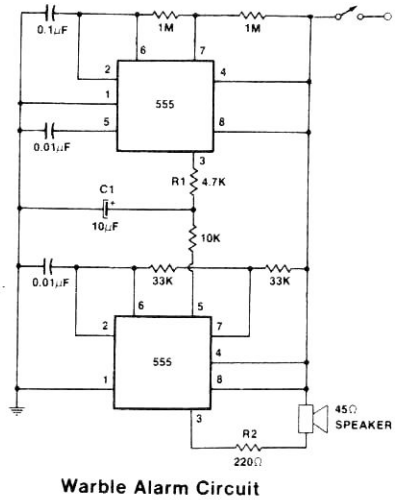
TYPICAL APPLICATIONS



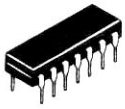
Automatic Headlight Turn-Off Circuit



Relay Timer



Warble Alarm Circuit



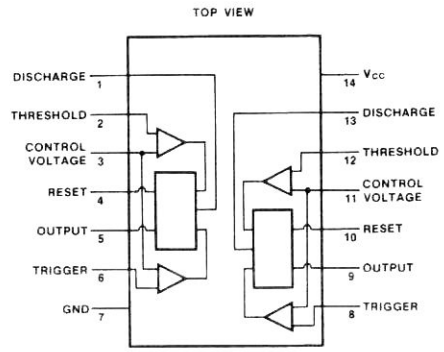
DUAL TIMER

556
276-1728

GENERAL DESCRIPTION

The 556 dual timing circuit is a highly stable controller capable of producing accurate time delays or oscillation. The 556 is a dual 555. Timing is provided by an external resistor and capacitor for each timing function. The two timers operate independently of each other sharing only V_{CC} and ground. The circuits may be triggered and reset on falling waveforms. The output structures may sink or source 200 mA.

PIN CONNECTION



FEATURES

- Timing from microseconds through hours
- Operates in both astable and monostable modes
- Replaces two 555 timers
- Adjustable duty cycle
- Output can source or sink 200 mA
- Output and supply TTL compatible
- Temperature stability better than 0.005% per °C
- Normally on and normally off output

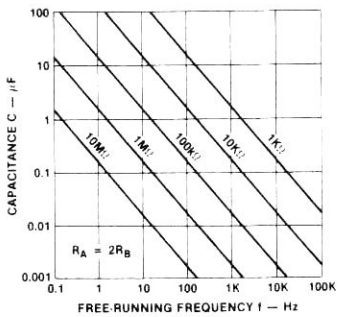
APPLICATIONS

- Precision timing
- Pulse generation
- Sequential timing
- Time delay generation
- Pulse width modulation
- Pulse position modulation
- Linear ramp generator

ABSOLUTE MAXIMUM RATINGS

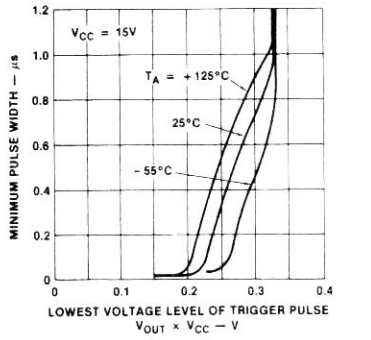
Supply Voltage	+16V
Power Dissipation	600 mW
Operating Temperature Range	0 to +70°C
Storage Temperature Range	−65 to +150°C
Lead Temperature (Soldering, 10 seconds)	300°C

TYPICAL CHARACTERISTICS

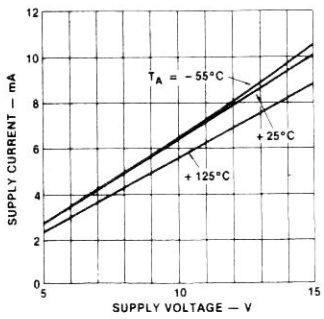


The charge time (output high) is given by:
$t_1 = 0.693 (R_A + R_B) C$
The discharge time (output low) is given by:
$t_2 = 0.693 (R_B) C$
Thus the total period is:
$T = t_1 + t_2 = 0.693 (R_A + 2R_B) C$
The frequency of oscillation is:
$f = 1/T = 1.44 / (R_A + 2R_B) C$

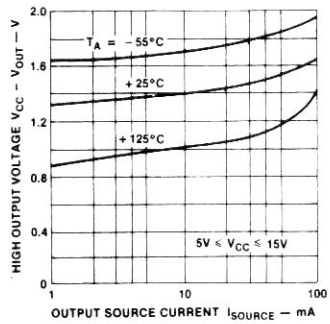
Capacitance vs Free-Running Frequency



Minimum Pulse Width vs Lowest Voltage Level of Trigger Pulse



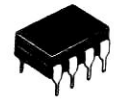
Supply Current vs Supply Voltage



High Output Voltage vs Output Source Current

MC1330
276-1757

LOW-LEVEL VIDEO DETECTOR



GENERAL DESCRIPTION

This is an integrated circuit featuring very linear video characteristics and wide bandwidth. Designed for color and monochrome television receivers, replacing the third IF, detector, video buffer and AFC buffer.

The MC1330A video detector is a fully balanced multiplier detector circuit that has linear amplitude and phase characteristics. The signal is divided into two channels, one a linear amplifier and the other a limiting amplifier that provides the switching carrier for the detector.

The switching carrier has a buffered output for use in providing the AFT function.

The video amplifier output is an improved design that reduces the differential gain and phase distortion associated with previous video output systems. The output is wide band, >8.0 MHz, with normal negative polarity. A separate narrow bandwidth, positive video output is also provided.

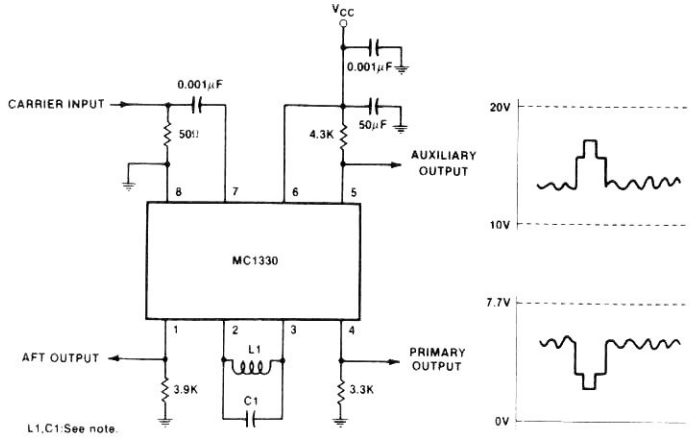
FEATURES

- Conversion gain—33 dB typical
- Excellent differential phase and gain
- High rejection of IF carrier feedthrough
- High video output—8.0 V p-p
- Fully balanced detector
- Output temperature compensated

ABSOLUTE MAXIMUM RATINGS

Power Supply Voltage	24 Vdc
DC Video Output Current	5mAdc
DC AFT Output Current	2mAdc
Zero Signal dc Output Voltage (V_{CC}=+20 Vdc, Q=40, f_c=45.75 MHz)	
MC1330A1P	8.2 Vdc
MC1330A2P	9.0 Vdc
Supply Current	20mA
Maximum Signal dc Output Voltage (Pin 4)	0.5 Vdc
Conversion Gain for 1Vp-p Output (30% Modulation)	65mVrms
AFT Buffer Output at Carrier Frequency	650mVp-p
Junction Temperature	150°C
Operating Temperature Range (Ambient)	0 to +75°C
Storage Temperature Range	−65 to +150°C

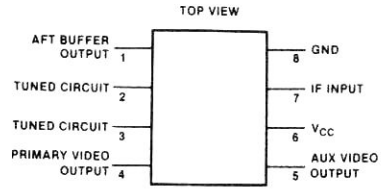
TYPICAL APPLICATIONS



NOTE: The choice of Q for the tuned circuit of pins 2 and 3 is not critical. The higher the Q, the better the rejection of 920 kHz products but the more critical the tuning accuracy required. See Figure 3. Values of Q from 20 to 50 recommended. (Note the internal resistance.)

Test Fixture Circuit

PIN CONNECTION



TYPICAL CHARACTERISTICS (V_{CC}=+20 Vdc)

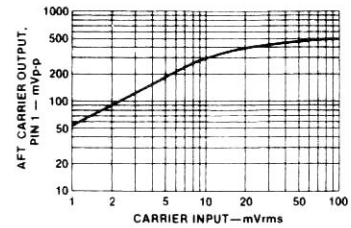


Figure 1

AFT Carrier Output vs Carrier Input

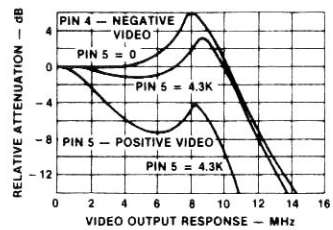
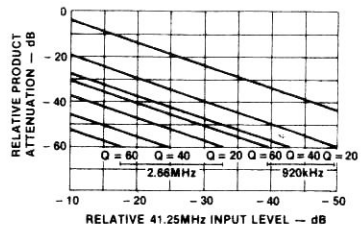


Figure 2

Relative Attenuation vs Video Output Response



REFERENCE = 3.58MHz OUTPUT
45.75MHz INPUT = 25mVrms
42.17MHz INPUT = 12.5mVrms
41.25MHz INPUT — RELATIVE TO 45.75 MHz INPUT = 4.5MHz

Figure 3

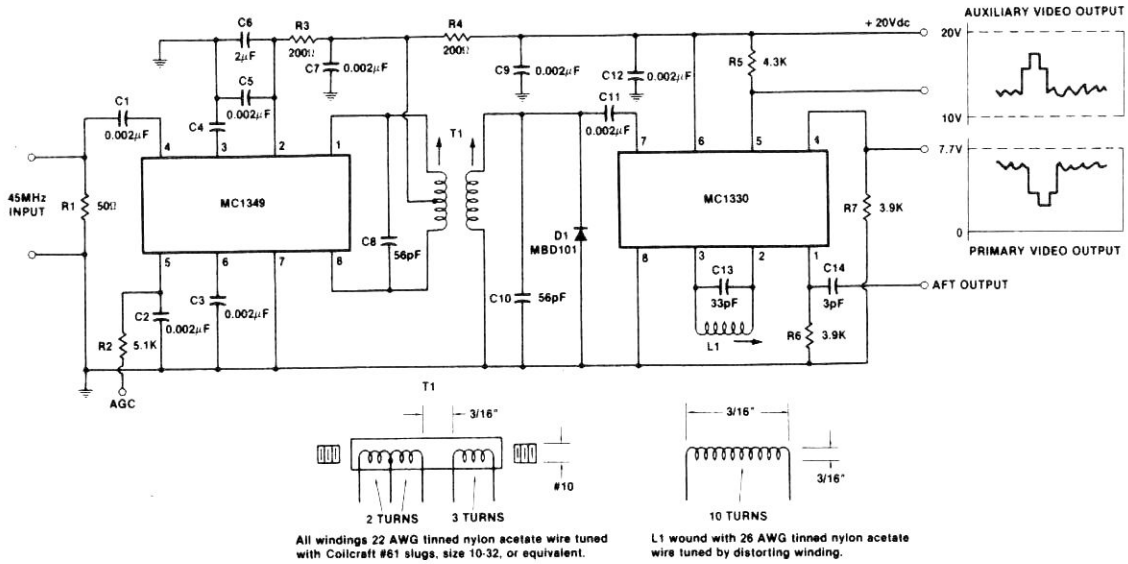
Relative Product Attenuation vs Relative 41.25 MHz Input Level

TYPICAL APPLICATIONS (Cont'd)

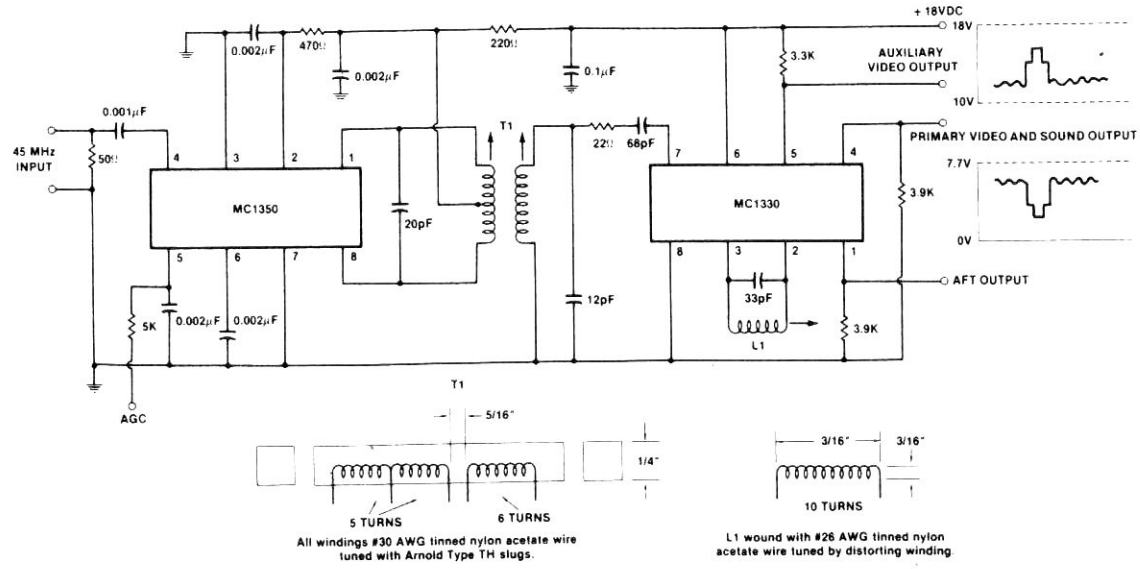
Alignment is most easily accomplished with an AM generator, set at a carrier frequency of 45.75 MHz, modulated with a video frequency sweep. This provides the proper realistic conditions necessary to operate to low-level detector (LLD). The detector tank is first adjusted for maximum detected dc (with a CW input), next, the video sweep modulation is applied and the interstage and input circuits aligned, step by step, as in a standard IF amplifier.

Note: A normal IF sweep generator, essentially an FM generator, will not serve properly without modification. The LLD tank attempts to "follow" the sweep input frequency, and results in variations of switching amplitude in the detector. Hence, the apparent overall response becomes modified by the response of the LLD tank, which a real signal doesn't do.

This effect can be prevented by resistively adding a 45.75 MHz CW signal to the output of the sweep generator approximately 3 dB greater than the sweep amplitude.



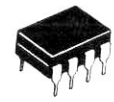
Video IF Amplifier and Low-Level Detector



Typical MC1350 Video IF Amplifier and MC1330 Low-Level Video Detector Circuit

MC1350
276-1758

IF AMPLIFIER



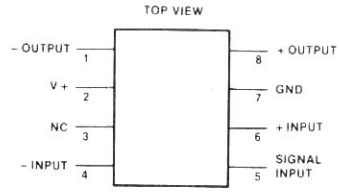
GENERAL DESCRIPTION

This monolithic IF amplifier is an integrated circuit featuring wide range AGC for use as an IF amplifier in radio and TV.

The input amplifiers (Q1 and Q2) operate at constant emitter currents so that input impedance remains independent of AGC action. Input signals may be applied single-ended or differentially (for ac) with identical results. Terminals 4 and 6 may be driven from a transformer, but a dc path from either terminal to ground is not permitted.

AGC action occurs as a result of an increasing voltage on the base of Q4 and Q5 causing these transistors to conduct more heavily thereby shunting signal current from the interstage amplifiers Q3 and Q6. The output amplifiers are supplied from an active current source to maintain constant quiescent bias thereby holding output admittance nearly constant. Collector voltage for the output amplifier must be supplied through a center-tapped tuning coil to Pins 1 and 8. The 12-volt supply (V^+) at Pin 2 may be used for this purpose, but output admittance remains more nearly constant if a separate 15-volt supply (V^{++}) is used, because the base voltage on the output amplifier varies with AGC bias.

PIN CONNECTION



FEATURES

- Power gain — 50 dB typ at 45 MHz,
  — 48 dB typ at 58 MHz
- AGC range — 60 dB min. dc to 45 MHz
- Nearly constant input and output admittance over the entire AGC range
- y_{21} constant (−3.0 dB) to 90 MHz
- Low reverse transfer admittance — ≪ 1.0 μmho typ
- 12-volt operation, single-polarity-power supply

ABSOLUTE MAXIMUM RATINGS

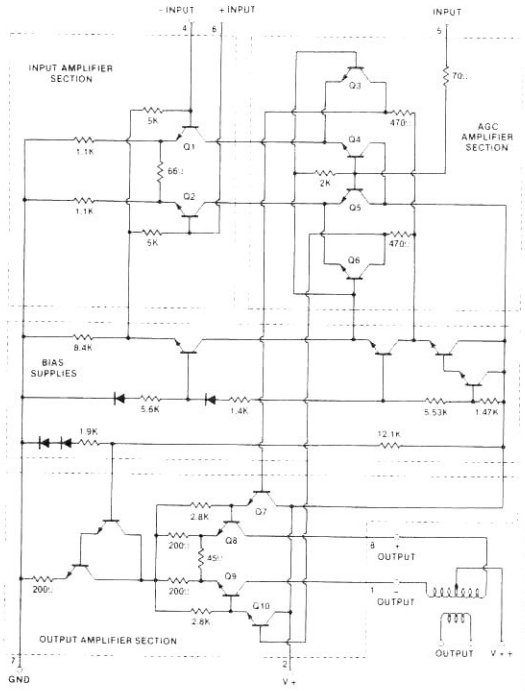
Power Supply Voltage	18Vdc
Power Dissipation	625mW
Operating Temperature Range	0 to +75°C

ELECTRICAL CHARACTERISTICS

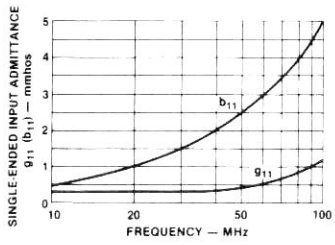
($V+ = +12$ Vdc; $T_A = +25°C$ unless otherwise noted)

Power Gain (Pin 5 grounded via a 5.1k resistor)	
f = 58 MHz, BW = 4.5 MHz	48dB
f = 45 MHz, BW = 4.5 MHz	50dB
f = 10.7 MHz, BW = 350 kHz	58dB
f = 455 kHz, BW = 20 kHz	62dB
Power Dissipation	204mW

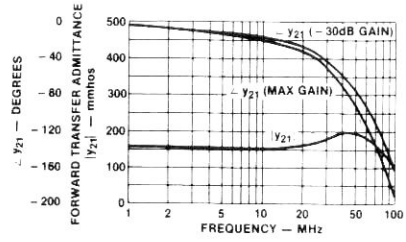
INTERNAL CIRCUIT



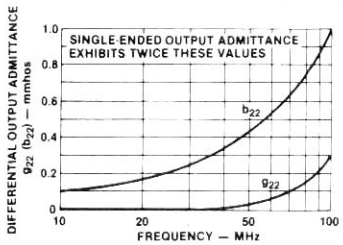
TYPICAL CHARACTERISTICS ($V+=12V$, $T_A=+25°C$)



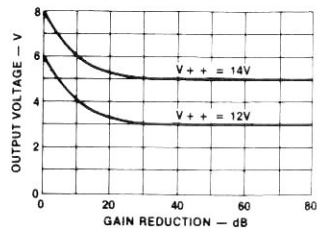
Input Admittance vs Frequency



Forward Transfer Admittance and Phase vs Frequency



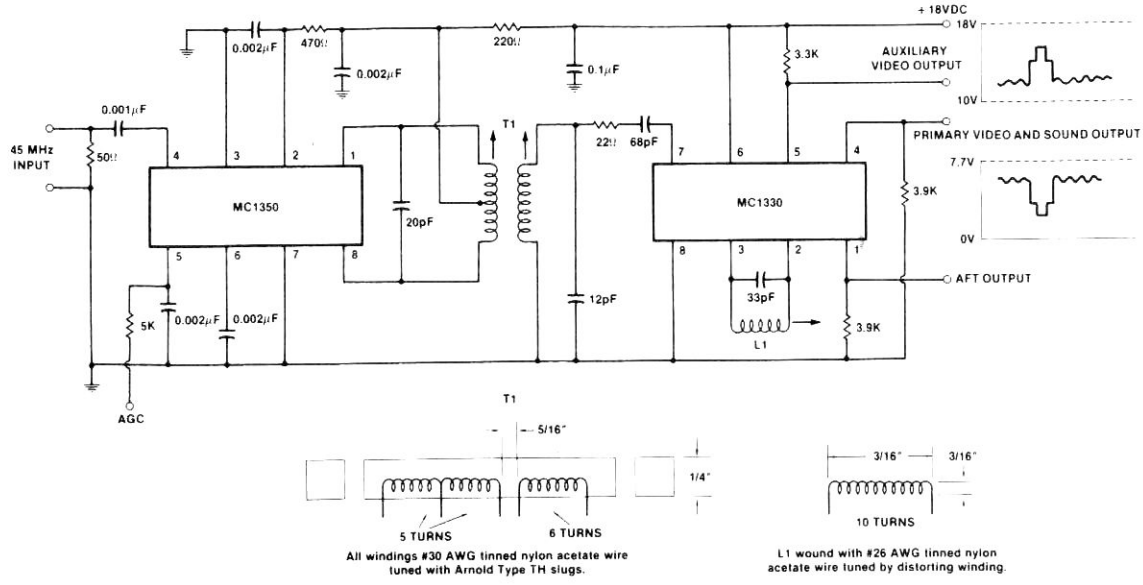
Differential Output Admittance vs Frequency



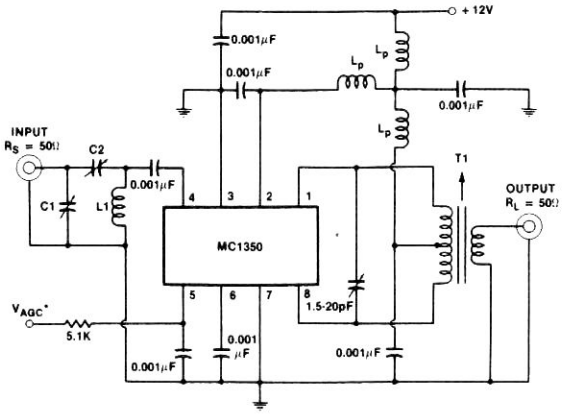
Differential Output Voltage vs Gain Reduction

MC1350 276-1758

TYPICAL APPLICATIONS



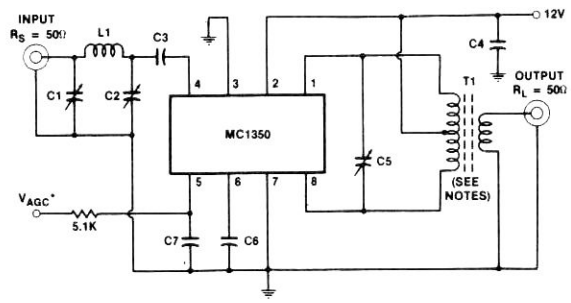
Typical MC1350 Video IF Amplifier and MC1330 Low-Level Video Detector Circuit



*Connect to ground for maximum power gain test.
All power-supply chokes (L_p), are self-resonate at input frequency. $L_p \geq 20K$
L1 @ 45 MHz = 7¼ turns on a ¼" coil form.
@ 58 MHz = 6 turns on a ¼" coil form.
T1 primary winding = 18 turns on a ¼" coil form, center-tapped.
secondary winding = 2 turns centered over primary winding @ 45MHz
= 1 turn @ 58MHz
Core = Arnold TH material ½" long.

	45MHz		58MHz	
L1	0.4μH	Q ≥ 100	0.3μH	Q ≥ 100
T1	1.3-3.4μH	Q ≥ 100 @ 2μH	1.2-3.8μH	Q ≥ 100 @ 2μH
C1	50-160pF		8-60pF	
C2	8-60pF		3-35pF	

Power Gain, AGC, and Noise Figure Test Circuit (45 MHz and 58 MHz)



*Grounded for maximum power gain.

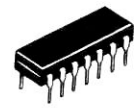
Note 1. Primary = 120μH, center-tapped.
Q_u = 140 at 455kHz.
Primary : Secondary turns ratio = 13
2. Primary = 6.0μH
Primary winding = 24 turns #36 AWG, close wound on ¼" diameter form.
Secondary winding = 1½ turns #36 AWG, ¼" diameter, wound over center-tap.
Core = Arnold type TH, or equivalent.

COMPONENT	FREQUENCY	
	455kHz	10.7MHz
C1	—	80-450pF
C2	—	5-80pF
C3	0.05μF	0.001μF
C4	0.05μF	0.05μF
C5	0.001μF	36pF
C6	0.05μF	0.05μF
C7	0.05μF	0.05μF
L1	—	4.6μH
T1	NOTE 1	NOTE 2

Power Gain and AGC Test Circuit (455 kHz and 10.7 MHz)

MC1358
276-1759

IF AMPLIFIER, LIMITER, FM DETECTOR AUDIO DRIVER, ELECTRONIC ATTENUATOR



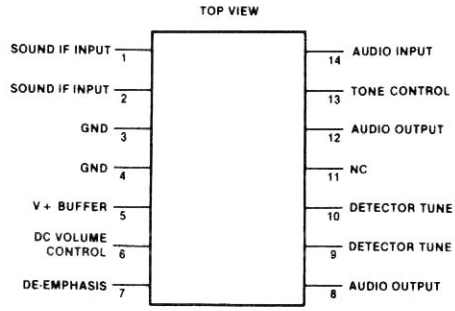
GENERAL DESCRIPTION

This TV sound IF amplifier is a versatile monolithic device incorporating IF limiting, detection, electronic attenuation, audio amplifier, and audio driver capabilities.

FEATURES

- Differential peak detector requiring a single tuned circuit
- Electronic attenuator replaces conventional ac volume control — Range > 60 dB
- Excellent AM rejection at 4.5 and 5.5 MHz
- High stability
- Low harmonic distortion
- Audio drive capability — 6.0 mAp-p
- Minimum undesirable output signal @ maximum attenuation

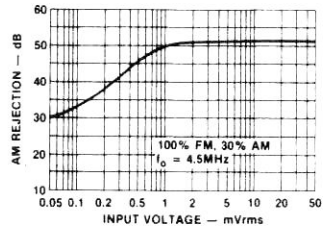
PIN CONNECTION



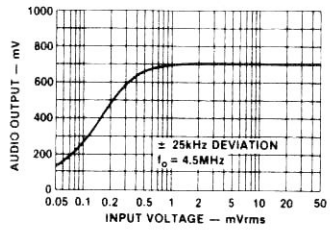
ABSOLUTE MAXIMUM RATINGS

Input Signal Voltage (Pins 1 and 2)	±3.0Vdc
Power Supply Current	50mA
Power Dissipation	625mW
Operating Temperature Range (Ambient)	−20 to +75°C
Storage Temperature Range	−65 to +150°C

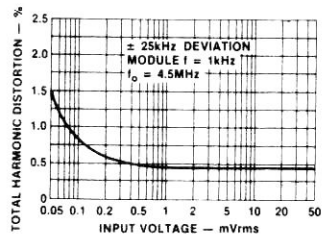
TYPICAL CHARACTERISTICS



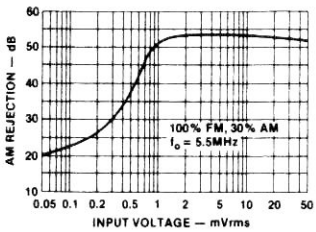
AM Rejection vs Input Voltage



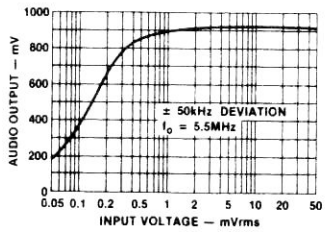
Audio Output vs Input Voltage



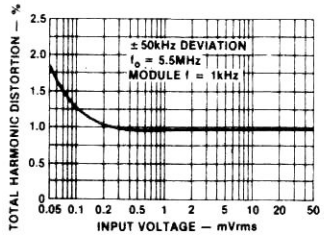
Total Harmonic Distortion vs Input Voltage



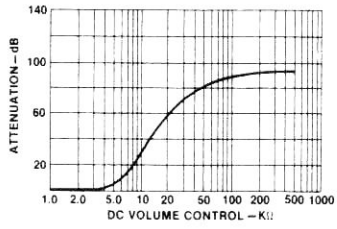
AM Rejection vs Input Voltage



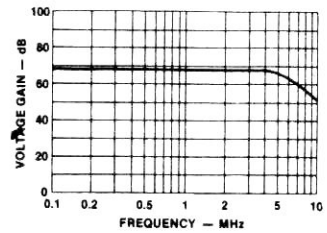
Audio Output vs Input Voltage



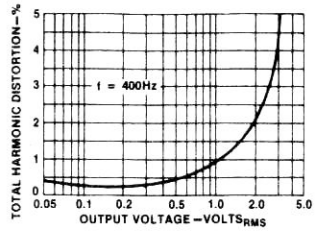
Total Harmonic Distortion vs Input Voltage



Attenuation vs DC Volume Control



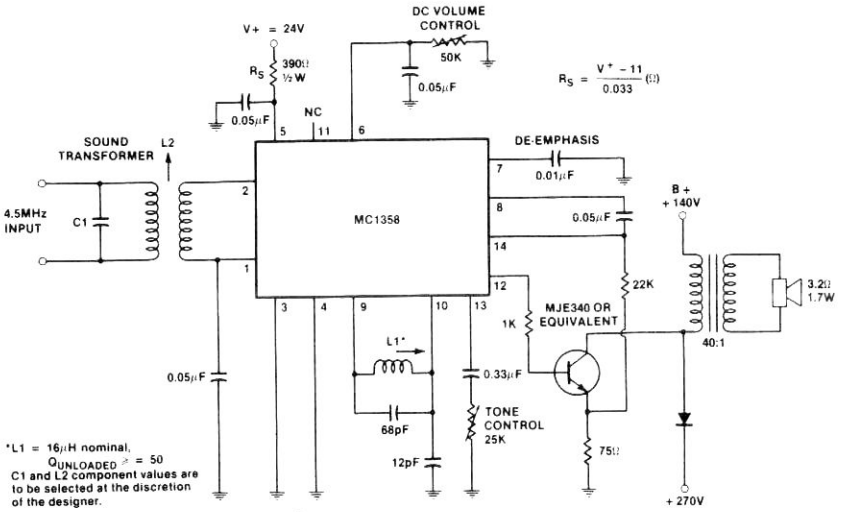
Voltage Gain vs IF Frequency



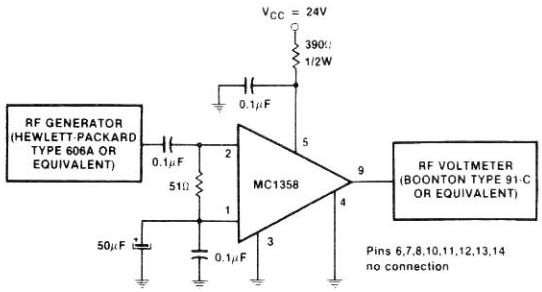
Total Harmonic Distortion vs Output Voltage

MC1358 276-1759

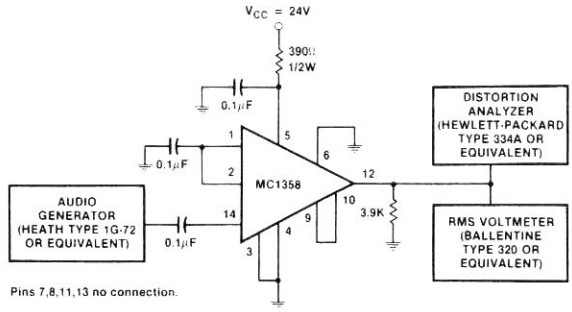
TYPICAL APPLICATIONS



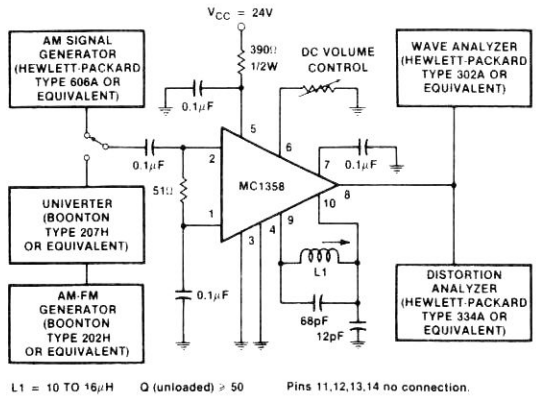
TV Application



IF Frequency Response Test Circuit



Audio Voltage Gain, Audio THD Test Circuit



AM Rejection, Detected Audio, THD, Attenuation Test Circuit

317T
276-1778

3-TERMINAL ADJUSTABLE POSITIVE REGULATOR

GENERAL DESCRIPTION

The 317T is an adjustable 3-terminal positive voltage regulator capable of supplying in excess of 1.5 A over a 1.2 V to 37 V output range. This device is exceptionally easy to use and requires only two external resistors to set the output voltage.

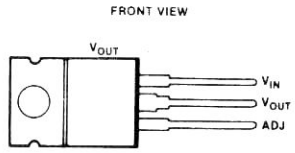
In addition to higher performance than fixed regulators, the 317T offers full overload protection available only in IC's. Included on the chip are current limit, thermal overload protection and safe area protection. All overload protection circuitry remains fully functional even if the adjustment terminal is disconnected.

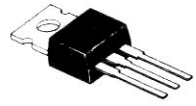
Normally, no capacitors are needed unless the device is situated far from the input filter capacitors in which case an input bypass is needed. An optional output capacitor can be added to improve transient response. The adjustment terminal can be bypassed to achieve very high ripple rejection ratios which are difficult to achieve with standard 3-terminal regulators.

Besides replacing fixed regulators, the 317T is useful in a wide variety of other applications. Since the regulator is "floating" and sees only the input-to-output differential voltage, supplies of several hundred volts can be regulated as long as the maximum input to output differential is not exceeded.

It will also serve as a simple adjustable switching regulator, programmable output regulator, or by connecting a fixed resistor between the adjustment and output, the 317T can be used as a precision current regulator. Supplies with electronic shutdown can be achieved by clamping the adjustment terminal to ground which programs the output to 1.2 V where most loads draw little current.

PIN CONNECTIONS





317T

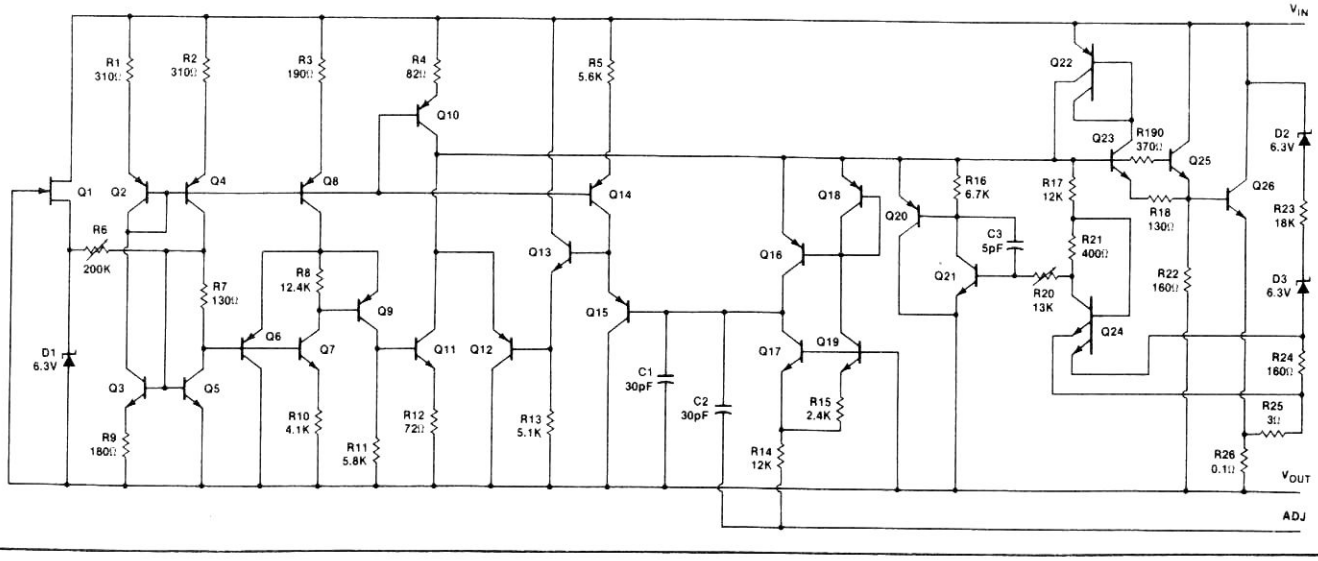
FEATURES

- Adjustable output down to 1.2V
- Guaranteed 1.5A outpput current
- Line regulation typically 0.01%/V
- Load regulation typically 0.1%
- Current limit constant with temperature
- 100% electrical burn-in
- Eliminates the need to stock many voltages
- Standard 3-lead transistor package
- 80 dB ripple rejection

ABSOLUTE MAXIMUM RATINGS

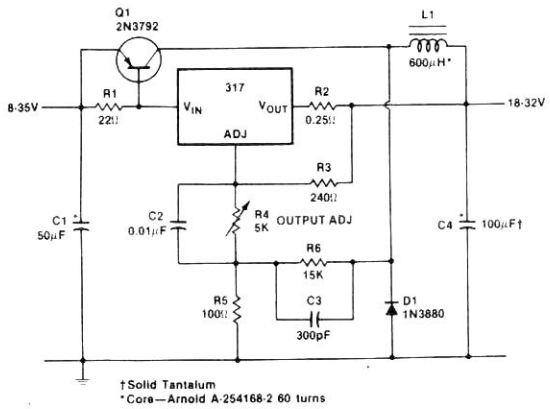
Power Dissipation	Internally limited
Input-Output Voltage Differential	40V
Operating Junction Temperature Range	0 to +125°C
Storage Temperature	−65 to +150°C
Lead Temperature (Soldering, 10 seconds)	300°C

INTERNAL CIRCUIT

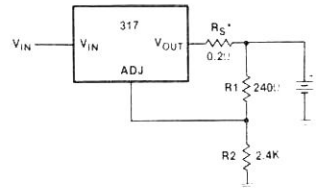


317T 276-1778

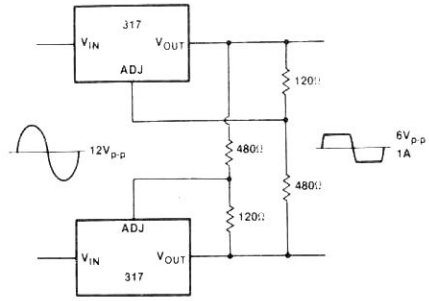
TYPICAL APPLICATIONS



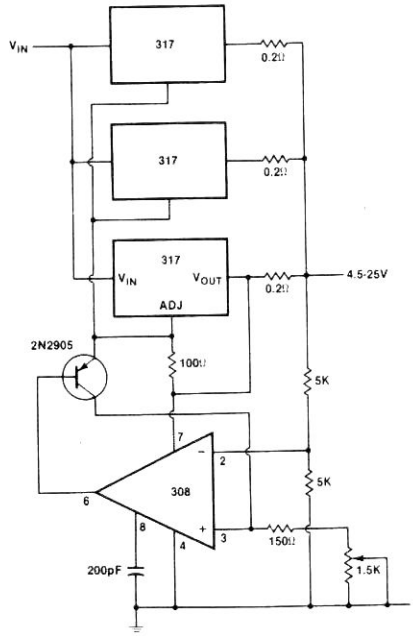
Low Cost 3A Switching Regulator



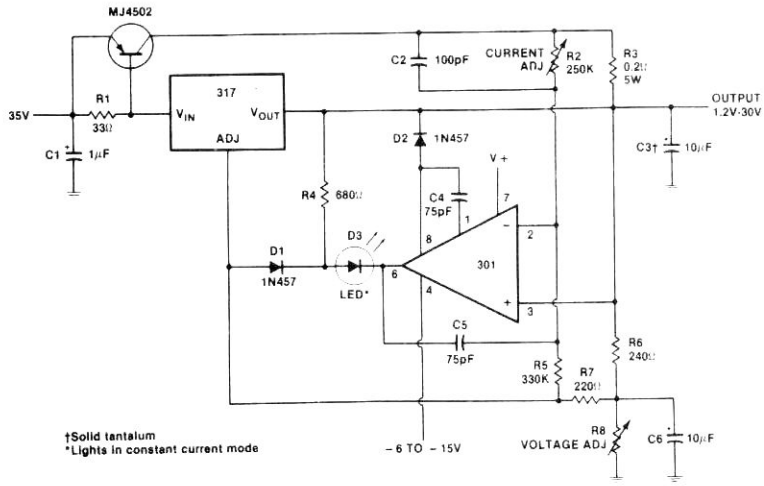
12V Battery Charger



AC Voltage Regulator



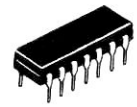
Adjustable 4A Regulator



5A Constant Voltage/Constant Current Regulator

723
276-1740

ADJUSTABLE VOLTAGE REGULATOR



GENERAL DESCRIPTION

The 723 is a voltage regulator designed primarily for series regulator applications. By itself, it will supply output currents up to 150 mA; but external transistors can be added to provide any desired load current. The circuit features extremely low standby current drain, and provision is made for either linear or foldback current limiting.

FEATURES

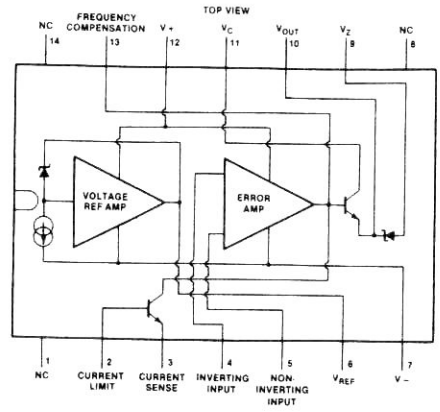
- 150 mA output current without external pass transistor
- Output currents in excess of 10A possible by adding external transistors
- Input voltage 40V max
- Output voltage adjustable from 2V to 37V
- Can be used as either a linear or a switching regulator

The 723 is also useful in a wide range of other applications such as a shunt regulator, a current regulator or a temperature controller.

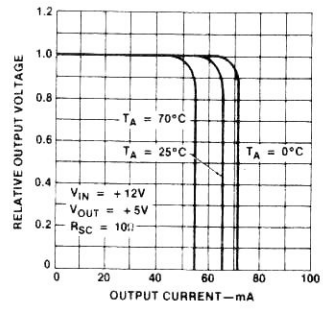
ABSOLUTE MAXIMUM RATINGS

Pulse Voltage from V+ to V− (50 ms)	50V
Continuous Voltage from V+ to V−	40V
Input-Output Voltage Differential	40V
Maximum Amplifier Input Voltage (Either Input)	7.5V
Maximum Amplifier Input Voltage (Differential)	5V
Current from V_Z	25 mA
Current from V_{REF}	15 mA
Internal Power Dissipation Metal Can	800 mW
Cavity DIP	900 mW
Molded DIP	660 mW
Operating Temperature Range	0 to +70°C
Storage Temperature Range Metal Can	−65 to +150°C
DIP	−55 to +125°C
Lead Temperature (Soldering, 10 sec)	300°C

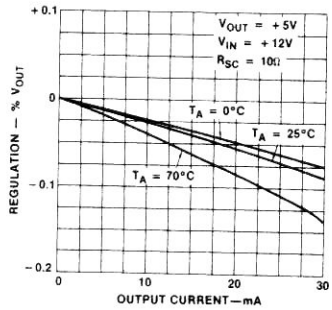
PIN CONNECTION



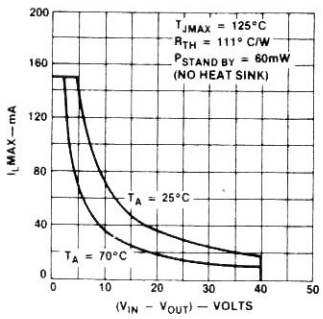
TYPICAL CHARACTERISTICS



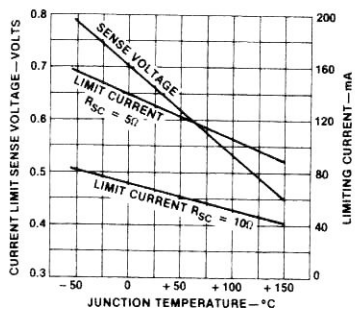
Relative Output Voltage vs Output Current



Load Regulation vs Output Current

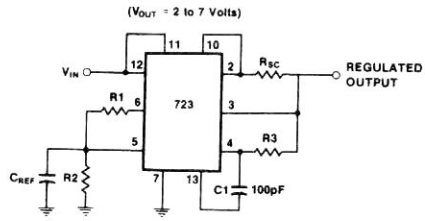


Maximum Load Current vs Input-Output Voltage Differential



Current Limit Sense Voltage vs Junction Temperature

TYPICAL APPLICATIONS

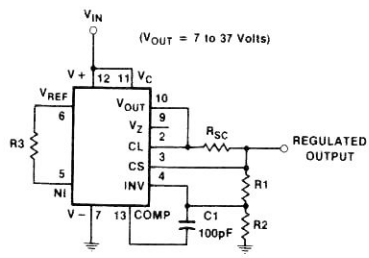


TYPICAL PERFORMANCE

Regulated Output Voltage	5V
Line Regulation (ΔV_{IN} = 3V)	0.5mV
Load Regulation (ΔI_L = 50mA)	1.5mV

Note: R3 = $\frac{R1\,R2}{R1 + R2}$ for minimum temperature drift.

Basic Low Voltage Regulator



TYPICAL PERFORMANCE

Regulated Output Voltage	15V
Line Regulation (ΔV_{IN} = 3V)	1.5mV
Load Regulation (ΔI_L = 50mA)	4.5mV

Note: R3 = $\frac{R1R2}{R1 + R2}$ for minimum temperature drift.

Basic High Voltage Regulator

5V VOLTAGE REGULATOR
12V VOLTAGE REGULATOR
15V VOLTAGE REGULATOR

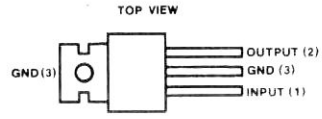
7805 276-1770
7812 276-1771
7815 276-1772

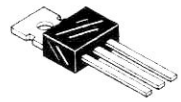
GENERAL DESCRIPTION

This series of three terminal regulators is available with several fixed output voltages making them useful in a wide range of applications. One of these is local on card regulation, eliminating the distribution problems associated with single point regulation. The voltages available allow these regulators to be used in logic systems, instrumentation, HiFi, and other solid state electronic equipment. Although designed primarily as fixed voltage regulators these devices can be used with external components to obtain adjustable voltages and currents.

This series will allow over 1.5A load current if adequate heat sinking is provided. Current limiting is included to limit the peak output current to a safe value. Safe area protection for the output transistor is provided to limit internal power dissipation. If internal power dissipation becomes too high for the heat sinking provided, the thermal shutdown circuit takes over preventing the IC from overheating.

PIN CONNECTION





FEATURES

- Internal thermal overload protection
- No external components required
- Output transistor safe area protection
- Internal short circuit current limit

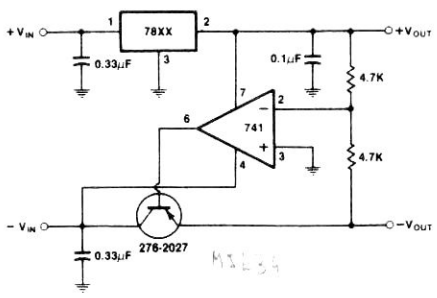
VOLTAGE RANGE

7805	5V
7812	12V
7815	15V

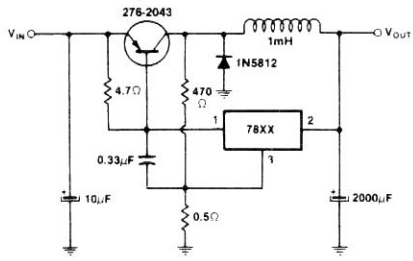
ABSOLUTE MAXIMUM RATINGS

Input Voltage	
(Output Voltage Options 5V through 18V)	35V
(Output Voltage Option 24V)	40V
Internal Power Dissipation	Internally Limited
Maximum Junction Temperature	150°C
Operating Temperature Range	0 to +70°C
Storage Temperature Range	−65 to +150°C
Lead Temperature (Soldering, 10 seconds)	300°C

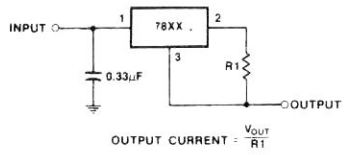
TYPICAL APPLICATIONS



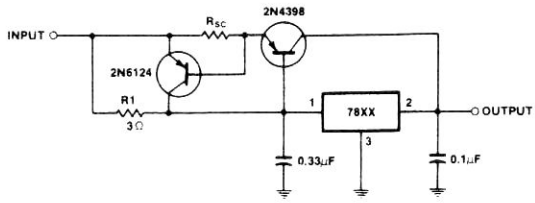
±Tracking Voltage Regulator



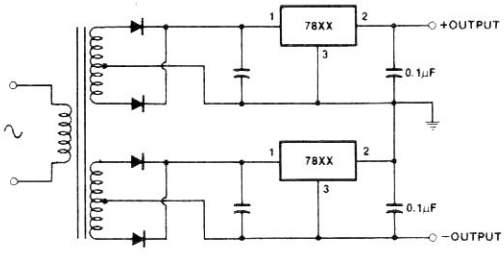
Switching Regulator



Current Regulator



High Output Current, Short Circuit Protected



Positive and Negative Regulator

7905
276-1773

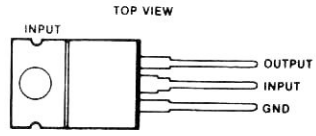
3-TERMINAL NEGATIVE REGULATOR

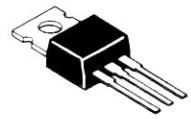
GENERAL DESCRIPTION

This regulator employs internal current limiting, safe area protection and thermal shutdown for protection against virtually all overload conditions.

Low ground pin current of the 7905 allows output voltage to be easily boosted above the preset value with a resistor divider. The low quiescent current drain of this device ensures good regulation in the voltage boosted mode.

PIN CONNECTION





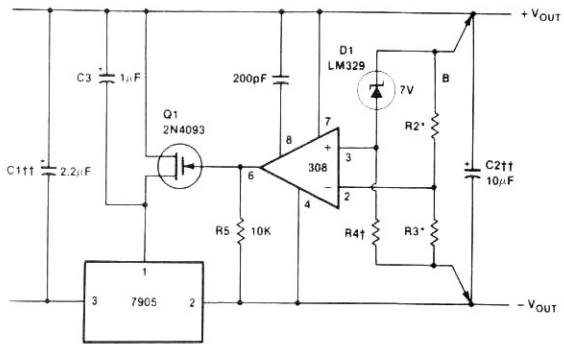
FEATURES

- Thermal, short circuit and safe area protection
- High ripple rejection
- 1.5A output current
- 4% preset output voltage

ABSOLUTE MAXIMUM RATINGS

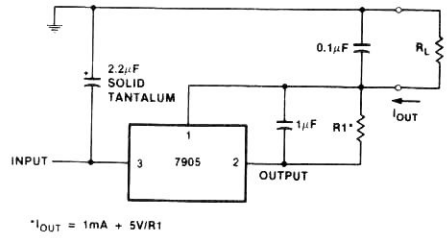
Input Voltage (V_O = 5V)	−35 V
Input/Output Differential (V_O = 5V)	25 V
Power Dissipation	Internally Limited
Operating Temperature Range	0 to +125°C
Storage Temperature Range	−65 to +150°C
Lead Temperature (Soldering, 10 seconds)	230°C

TYPICAL APPLICATIONS



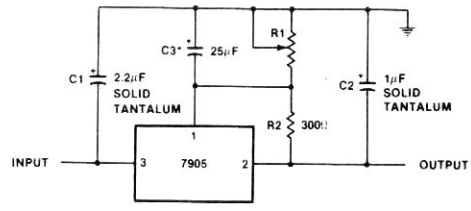
Load and line regulation < 0.01%, temperature stability ≤ 0.2%
† Determines zener current.
†† Solid tantalum
*Select resistors to set output voltage. 2ppm/°C tracking suggested.

High Stability 1 Amp Regulator



*I_{OUT} = 1mA + 5V/R1

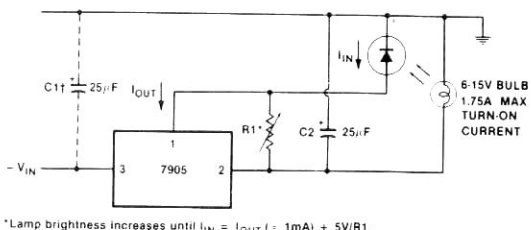
Current Source



*Improves transient response and ripple rejection. Do not increase beyond 50μF.

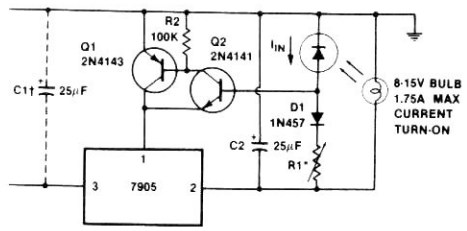
$V_{OUT} = V_{SET}(\frac{R1+R2}{R2})$

Variable Output



*Lamp brightness increases until $I_{IN} = I_{OUT}$ (≈ 1mA) + 5V/R1.
† Necessary only if raw supply filter capacitor is more than 2" from LM7905CT

Light Controller Using a Silicon Photo Cell



*Lamp brightness increases until I_{IN} = 5V/R1 (I_{IN} can be set as low as 1μA).
† Necessary only if raw supply filter capacitor is more than 2" from LM7905CT.

Light Controller Using a Silicon Photo Cell

3-TERMINAL NEGATIVE REGULATOR

7912
276-1774

GENERAL DESCRIPTION

This negative 12 V regulator employs current limiting, thermal shutdown, and safe-area compensation—making it remarkably rugged under most operating conditions with adequate heat-sinking it can deliver output currents in excess of 1.0 ampere.

FEATURES

- No external components required
- Internal thermal overload protection
- Internal short-circuit current limiting
- Output transistor safe-area compensation

ABSOLUTE MAXIMUM RATINGS

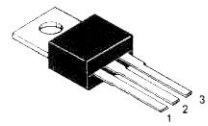
Input Voltage (V_O = −12 V)	−40 V
Input-Output Differential (V_O = −12 V)	30 V
Dropout Voltage (T_j = 25°C, I_{out} = 1A	1.1 V
Output Voltage (T_j = 25°C)	−12.5 V
Line Regulation Voltage	80 mV
Quiescent Current (T_j = 25°C)	3 mA
Power Dissipation	Internally Limited
Operating Temperature Range	0°C To +125°C
Storage Temperature Range	−65°C To +150°C

DESIGN CONSIDERATIONS

This device is designed with Thermal Overload Protection that shuts down the circuit when subjected to an excessive power overload condition, Internal Short-Circuit Protection that limits the maximum current the circuit will pass, and Output Transistor Safe-Area Compensation that reduces the output short circuit current as the voltage across the pass transistor is increased.

In many low current applications, compensation capacitors are not required. However, it is recommended that the regulator input be bypassed with a capacitor if the regulator is connected to the power supply filter with long wire lengths, or if the output load capacitance is large. An input bypass capacitator should be selected to provide good high-frequence characteristics to insure stable operation under all load conditions. A 0.33 uF or larger tantalum, mylar or other capacitor having low internal impedance at high frequencies should be chosen. The bypass capacitor should be mounted with the shortest possible leads directly across the regulators inputs terminals. Normally good construction techniques should be used to minimize ground loops and lead resistance drops since the regulator has no external sense lead. Bypassing the output is also recommended.

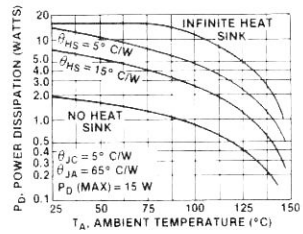
PIN CONNECTION

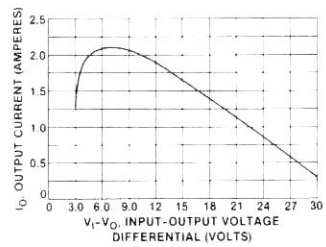


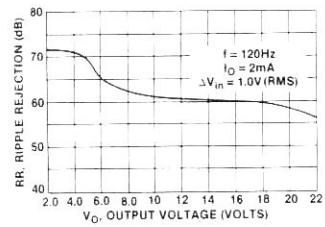
(Heat sink surface connected to Pin 2)

PIN 1. Ground
2. Input
3. Output

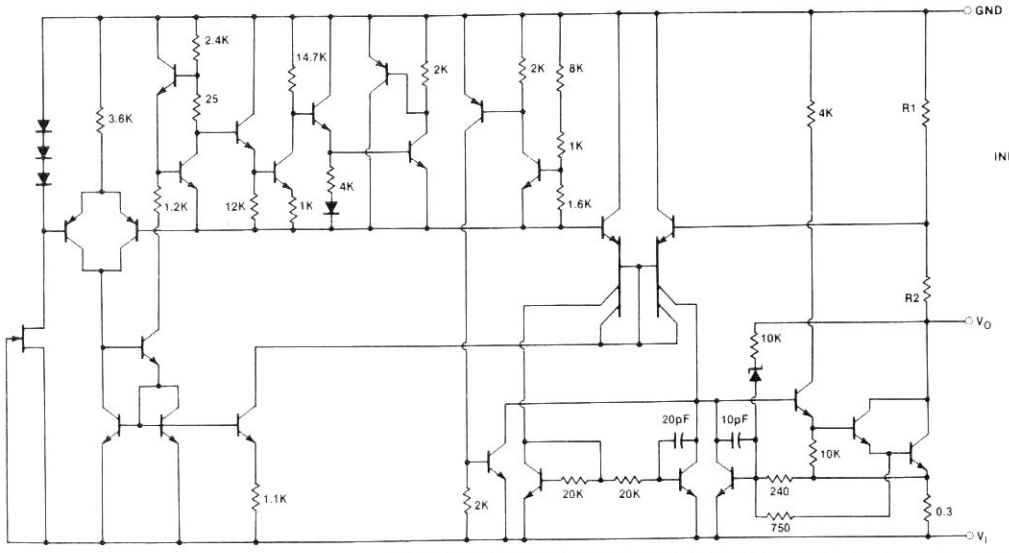
TYPICAL CHARACTERISTICS



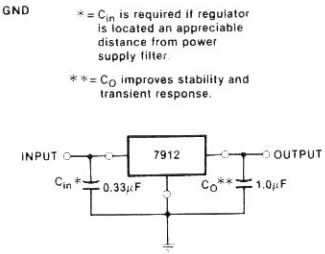




INTERNAL CIRCUIT

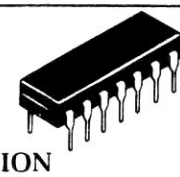


TYPICAL APPLICATION



ICL8038
276-2334

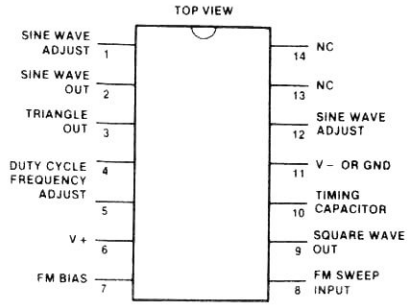
PRECISION WAVEFORM GENERATOR/ VOLTAGE CONTROLLED OSCILLATOR



GENERAL DESCRIPTION

The ICL8038 waveform generator is a monolithic integrated circuit capable of producing high accuracy sine, square, triangular, sawtooth and pulse waveforms with a minimum of external components. The frequency (or repetition rate) can be selected externally from 0.001Hz to more than 300kHz using either resistors or capacitors, and frequency modulation and sweeping can be accomplished with an external voltage. The ICL8038 is fabricated with advanced monolithic technology, using Schottky-barrier diodes and thin film resistors, and the output is stable over a wide range of temperature and supply variations.

PIN CONNECTION

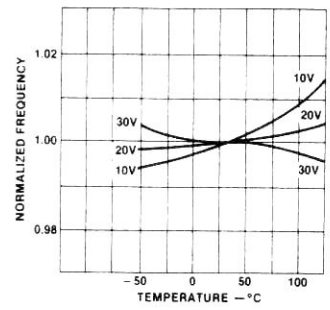


FEATURES

- Low frequency drift with temperature — 50ppm/°C
- Simultaneous sine, square, and triangle wave outputs
- Low distortion — 1% (sine wave output)
- High linearity — 0.1% (triangle wave output)
- Wide operating frequency range — 0.001Hz to 0.3MHz
- Variable duty cycle — 2% to 98%
- High level outputs — TTL to 28 V
- Easy to use — just a handful of external components required

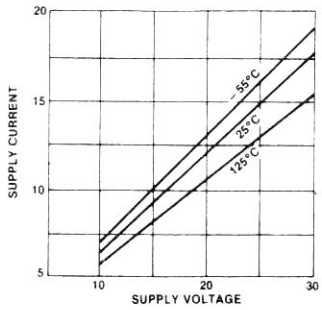
ABSOLUTE MAXIMUM RATINGS

Supply Voltage ..... ±18 V or 36 V Total
Power Dissipation ..... 750 mW
Input Voltage (any pin) ..... Not To Exceed Supply Voltages
Input Current (Pins 4 and 5) ..... 25 mA
Output Sink Current (Pins 3 and 9) ..... 25 mA
Storage Temperature Range ..... −65°C to +125°C
Lead Temperature (Soldering, 10 sec.) ..... 300°C

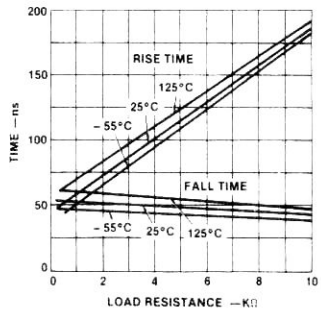


Normalized Frequency vs Temperature

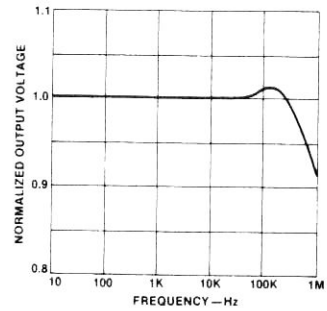
TYPICAL CHARACTERISTICS



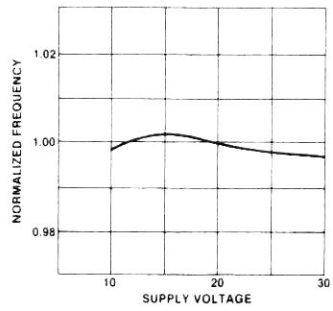
Supply Current vs Supply Voltage



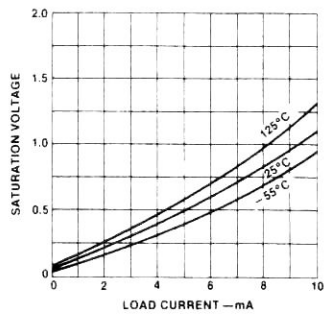
Time vs Load Resistance



Normalized Output Voltage vs Frequency

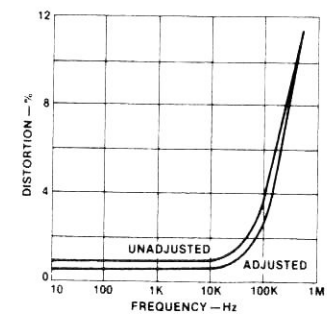


Normalized Frequency vs Supply Voltage



Saturation Voltage vs Load Current

Performance of the Square-Wave Output



Distortion vs Frequency

Performance of the Sine-Wave Output

ICL8038 276-2334

TEST CIRCUIT

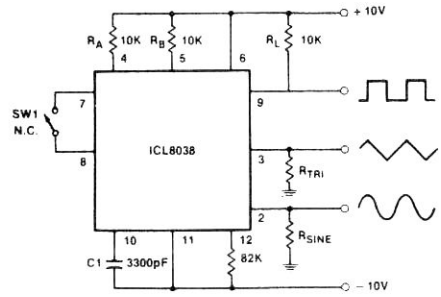
Selecting R_A, R_B AND C

For any given output frequency, there is a wide range of RC combinations that will work, however certain constraints are placed upon the magnitude of the charging current for optimum performance. At the low end, currents of less than 1μA are undesirable because circuit leakages will contribute significant errors at high temperatures. At higher currents (I > 5mA), transistor betas and saturation voltages will contribute increasingly larger errors. Optimum performance will, therefore, be obtained with charging currents of 10μA to 1mA. If pins 7 and 8 are shorted together, the magnitude of the charging current due to R_A can be calculated from:

$$I = \frac{R1 \times V_{SUPPLY}}{(R1 + R2)} \times \frac{1}{R_A} = \frac{V_{SUPPLY}}{5R_A}$$

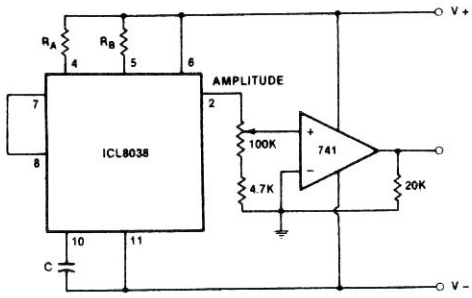
A similar calculation holds for R_B.

The capacitor value should be chosen at the upper end of its possible range.



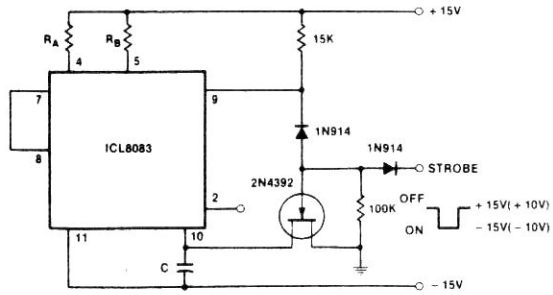
Test Circuit

TYPICAL APPLICATIONS



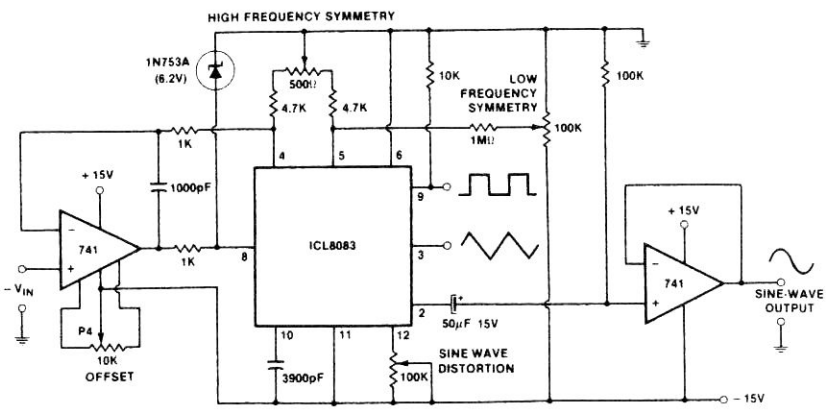
The sine wave output has a relatively high output impedance (1kΩ typical). This circuit provides buffering, gain and amplitude adjustment. A simple op amp follower could also be used.

Sine Wave Output Buffer Amplifier



With a dual supply voltage the external capacitor on pin 10 can be shorted to ground to halt the 8083 oscillation. This application uses a FET switch, diode ANDed with an input strobe signal to allow the output to always start on the same slope.

Strobe-Tone Burst Generator



Linear Voltage Controlled Oscillator

XR-2206
276-2336

MONOLITHIC FUNCTION GENERATOR

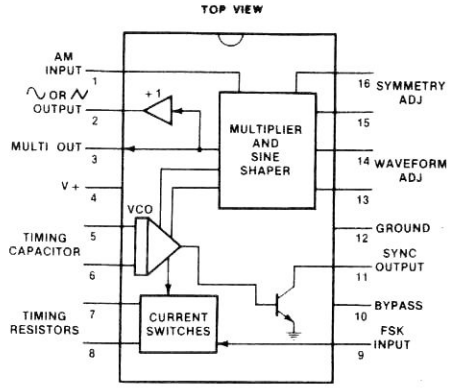
GENERAL DESCRIPTION

The XR-2206 is a monolithic function generator integrated circuit capable of producing high quality sine, square, triangle, ramp and pulse waveforms of high stability and accuracy. The output waveforms can be both amplitude and frequency modulated by an external voltage. Frequency of operation can be selected externally over a range of 0.01 Hz to more than 1MHz.

The XR-2206 is ideally suited for communications, instrumentation, and function generator applications requiring sinusoidal tone, AM, FM or FSK generation. It has a typical drift specification of 20 ppm/°C. The oscillator frequency can be linearly swept over a 2000: 1 frequency range with an external control voltage with very little affect on distortion.

The monolithic circuit is comprised of four functional blocks: a voltage-controlled oscillator (VCO); an analog multiplier and sine-shaper, a unity gain buffer amplifier; and a set of current switches. The internal current switches transfer the oscillator current to any one of the two external timing resistors to produce two discrete frequencies selected by the logic level at the FSK input terminal (pin 9).

PIN CONNECTION



FEATURES

- Low Sinewave Distortion (THD .5%—insensitive to signal sweep
- Excellent Stability (20 ppm/°C, typ)
- Wide Sweep Range (2000:1, typ)
- Low Supply Sensitivity (0.01%/V, typ)
- Linear Amplitude Modulation
- Adjustable Duty-Cycle (1% to 99T)
- TTL Compatible FSK Controls
- Wide Supply Range (10V To 26V)

TEST CIRCUIT

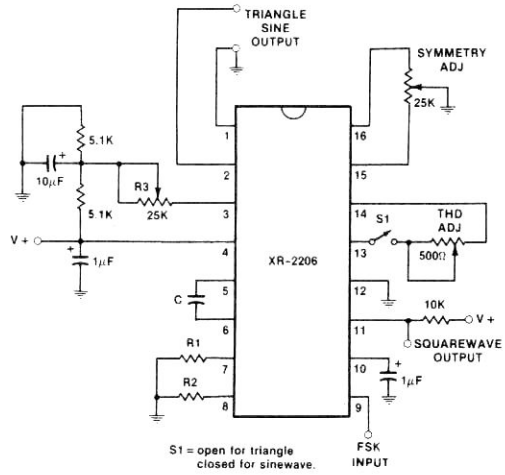


Figure 1

APPLICATIONS

- Waveform Generation Sine, Square, Triangle, Ramp
- Sweep Generation
- AM/FM Generation
- FSK and PSK Generation
- Voltage-to-Frequency Conversion
- Tone Generation
- Phase-Locked Loops

ABSOLUTE MAXIMUM RATINGS

Supply Voltage Single Supply	26 V
Split Supply	±13 V
Supply Current ($R_1 \geq 10K\Omega$)	20 mA
Power Dissipation	625 mW
Operating Temperature Range	0°C To +75°C
Storage Temperature Range	−65°C To + 150°C

TYPICAL CHARACTERISTICS

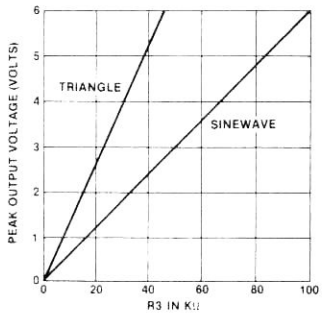


Figure 2—Output Amplitude as a Function of Resistor R3 at Pin 3.

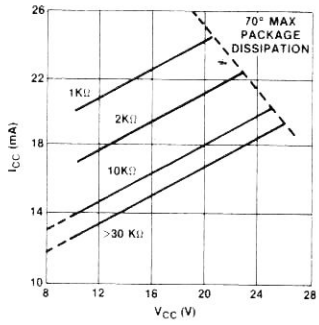


Figure 3—Supply Current vs Supply Voltage, Timing R

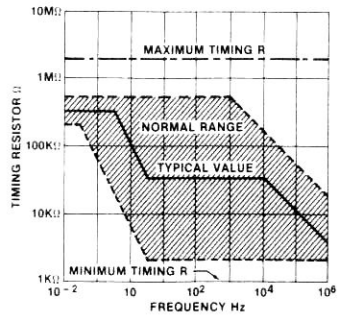


Figure 4—R vs Oscillation Frequency

TYPICAL CHARACTERISTICS (Cont'd)

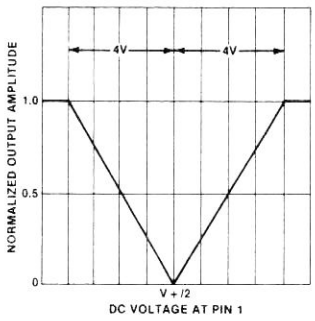


Figure 5—Normalized Output Amplitude vs DC Bias at AM Input (Pin 1).

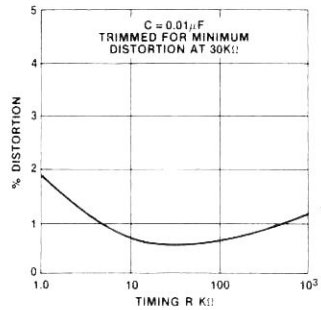


Figure 6—Trimmed Distortion vs Timing Resistor

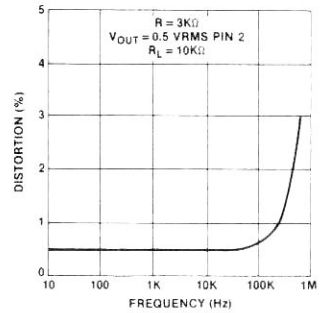


Figure 7—Signwave Distortion vs Operating Frequency With Timing Capacitors Varied

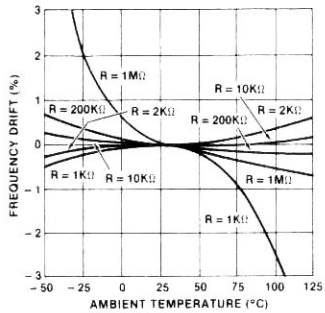


Figure 8—Frequency Drift vs Temperature

TYPICAL APPLICATIONS

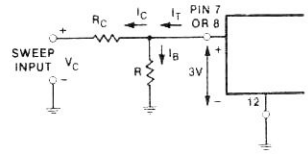


Figure 9—Circuit Connection for Frequency Sweep

DESCRIPTION OF CIRCUIT CONTROLS

FREQUENCY OF OPERATION

The frequency of oscillation, f_o, is determined by the external timing capacitor C across pins 5 and 6, and by the timing resistor R connected to either pin 7 or pin 8. The frequency is given as:

$$f_O = \frac{1}{RC} \text{ Hz}$$

and can be adjusted by varying either R or C. The recommended values of R for a given frequency range are shown in Figure 4. Temperature-stability is optimum for $4K\Omega < R < 200\ K\Omega$. Recommended values of C are from 1000 pF to 100 μF.

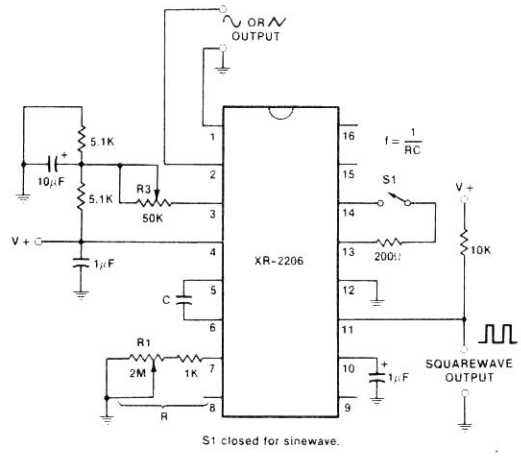


Figure 10—Circuit for Sinewave Generation Without External Adjustment (See Fig. 2 for choice of R3)

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FREQUENCY SWEEP AND MODULATION

Frequency of oscillation is proportional to the total timing current I_T drawn from pin 7 or 8

$$f = \frac{320 I_T\,(mA)}{C\,(\mu F)}\ Hz$$

Timing terminals (pins 7 or 8) are low impedance points and are internally biased at +3V, with respect to pin 12. Frequency varies linearly with I_T over a wide range of current values, from 1 μA to 3mA. The frequency can be controlled by applying a control voltage, V_C, to the activated timing pin as shown in Figure 9. The frequency of oscillation is related to V_C as:

$$f = \frac{1}{RC}\left[1 + \frac{R}{RC}\left(1 - \frac{V_C}{3}\right)\right] Hz$$

where V_C is in volts. The voltage-to-frequency conversion gain, K, is given as:

$$K = \partial f/\partial V_C = -\frac{0.32}{R_C C}\ Hz/V$$

NOTE: For safe operation of the circuit, I_T should be limited to < 3 mA.

TYPICAL APPLICATIONS (Cont'd)

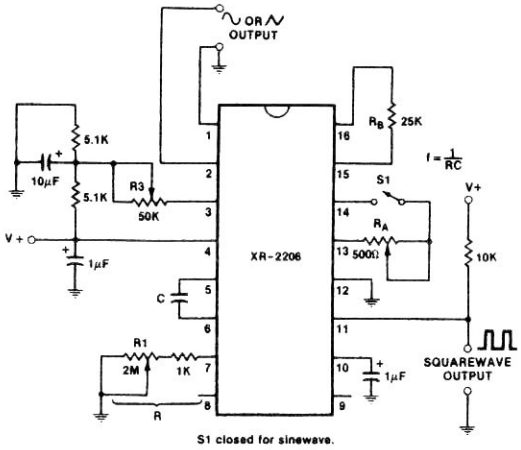

Figure 11—Circuit for Sinewave General With Minimum Harmonic Distortion (R3 Determines Output Swing—See Fig. 2)

OUTPUT CHARACTERISTICS

Output Amplitude

Maximum output amplitude is directly proportional to external resistor R_3 connected to pin 3 (See Fig. 2). For sinewave output, amplitude is approximately 60 mV peak per KΩ of R_3. For triangle, the peak amplitude is approximately 160 mV peak per KΩ of R_3. Thus, for example, R_3 = 50 KΩ would produce approximately ±3V sinusoidal output amplitude.

Amplitude Modulation

Output amplitude can be modulated by applying a dc bias and a modulating signal to pin 1. The internal impedance at pin 1 is approximately 100 kΩ. Output amplitude varies linearly with the applied voltage at pin 1, for values of dc bias at this pin, within ±4 volts of $V^+/2$, as shown in Fig. 5. As this bias level approaches $V^+/2$, the phase of the output signal is reversed; and the amplitude goes through zero. This property is suitable for phase-shift keying and suppressed-carrier AM generation. Total dynamic range of amplitude modulation is approximately 55 dB.

NOTE: AM control must be used in conjunction with a well-regulated supply since the output amplitude now becomes a function of V^+.

FREQUENCY-SHIFT KEYING

The XR-2206 can be operated with two separate timing resistors, R_1 and R_2, connected to the timing pins 7 and 8, respectively, as shown in Figure 12. Depending on the polarity of the logic signal at pin 9, either one or the other of these timing resistors is activated. If pin 9 is open-circuited or connected to a bias voltage ≥ 2V, only R_1 is active. Similarly, if the voltage level at pin 9 is ≤ 1V, only R_2 is activated. Thus, the output frequency can be keyed between two levels, f_1 and f_2 as:

$$f_1 = 1/R_1C \text{ and } f_2 = 1/R_2C$$

For split-supply operation, the keying voltage at pin 9 is referenced to V^-.

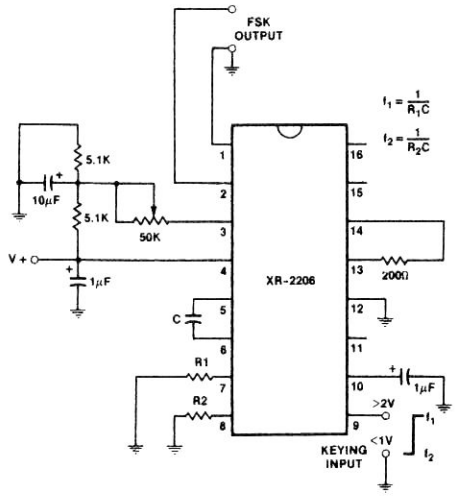

Figure 12—Sinusoidal FSK Generator

OUTPUT DC LEVEL CONTROL

The dc level at the output (pin 2) is approximately the same as the dc bias at pin 3. In figures 10, 11 and 12, pin 3 is biased mid-way between V^+ and ground, to give an output dc level of $\approx V^+/2$.

APPLICATIONS INFORMATION

SINEWAVE GENERATION

A) Without External Adjustment

Figure 10 shows the circuit connection for generating a sinusoidal output from the XR-2206. The potentiometer R_1 at pin 7 provides the desired frequency tuning. The maximum output swing is greater than $V^+/2$ and the typical distortion (THD) is < 2.5%. If lower sinewave distortion is desired, additional adjustments can be provided as described in the following section.

The circuit of Figure 10 can be converted to split supply operation simply by replacing all ground connections with V^-. For split supply operation, R_3 can be directly connected to ground.

B) With External Adjustment

The harmonic content of sinusoidal output can be reduced to ≈ 0.5% by additional adjustments as shown in Figure 11. The potentiometer R_A adjusts the sine-shaping resistor; and R_B provides the fine-adjustment for the waveform synmetry. The adjustment procedure is as follows:

1. Set R_B at mid-point and adjust R_A for minimum distortion.
2. With R_A set as above, adjust R_B to further reduce distortion.

TRIANGLE WAVE GENERATION

The circuits of Figures 10 and 11 can be converted to triangle wave generation by simply open circuiting pins 13 and 14 (i.e., S_1 open). Amplitude of the triangle is approximately twice the sinewave output.

FSK GENERATION

Figure 12 shows the circuit connection for sinusoidal FSK signal generation. Mark and space frequencies can be independently adjusted by the choice of timing resistors R_1 and R_2; and the output is phase-continuous during transitions. The keying signal is applied to pin 9. The circuit can be converted to split-supply operation by simply replacing ground with V^-.

PULSE AND RAMP GENERATION

Figure 13 shows the circuit for pulse and ramp waveform generation. In this mode of operation, the FSK keying terminal (pin 9) is shorted to the square-wave output (pin 11); and the circuit automatically frequency-shift keys itself between two separate frequencies during the positive and negative going output waveforms. The pulse-width and the duty cycle can be adjusted from 1% to 99% by the choice of R_1 and R_2. The values of R_1 and R_2 sould be in the range of 1 KΩ to 2 MΩ.

TYPICAL APPLICATIONS (Cont'd)

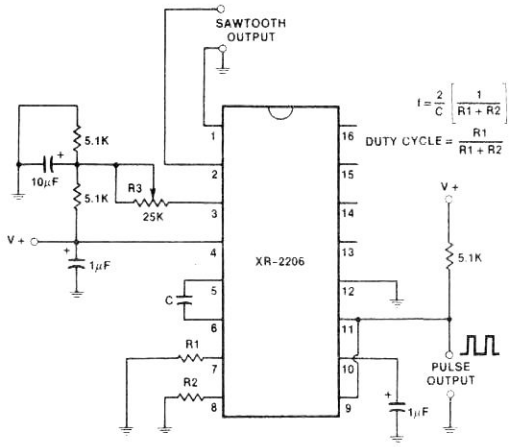

Figure 13—Circuit for Pulse and Ramp Generation

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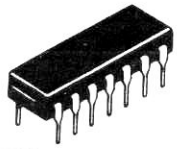
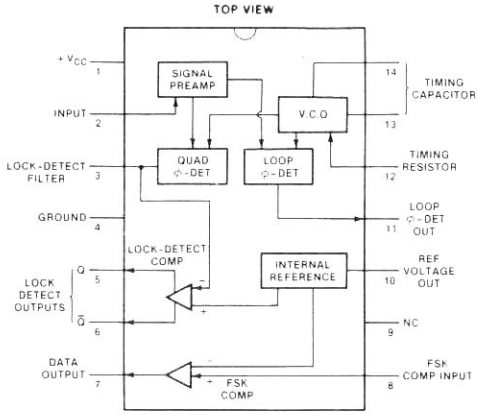
FSK DEMODULATOR/TONE DECODER



GENERAL DESCRIPTION

The XR-2211 is a monolithic phase-locked loop (PLL) system especially designed for data communications. It is particularly well suited for FSK modem applications. It operates over a wide supply voltage range of 4.5 to 20V and a wide frequency range of 0.01 Hz to 300 kHz. It can accommodate analog signals between 2mV and 3V, and can interface with conventional DTL, TTL and ECL logic families. The circuit consists of a basic PLL for tracking an input signal within the pass band. It also has a quadrature phase detector which provides carrier detection, and an FSK voltage comparator which provides FSK demodulation. External components are used to independently set center frequency, bandwidth, and output delay.

PIN CONNECTION



FEATURES

- Wide Frequency Range (0.01 Hz To 300 kHz)
- Wide Supply Voltage Range (4.5 V To 20 V)
- DTL/TTL/ECL Logic Compatibility
- FSK Demodulation, with Carrier-Detection
- Wide Dynamic Range (2 mV To 3 Vrms)
- Adjustable Tracking Range (±1% To ±80%)
- Excellent Temp. Stability (20ppm/°C, typ.)

APPLICATIONS

- FSK Demodulation
- Data Synchronization
- Tone Decoding
- FM Detection
- Carrier Detection

ABSOLUTE MAXIMUM RATINGS

Supply Voltage ..... 20 V
Supply current ($R_O \geq 10$ KΩ See Figure 4) ..... 9 mA
Input Signal Level ..... 3 V_{RMS}
Power Dissipation ..... 625 mW
Operating Temperature Range ..... 0°C To 75°C

BLOCK DIAGRAMS

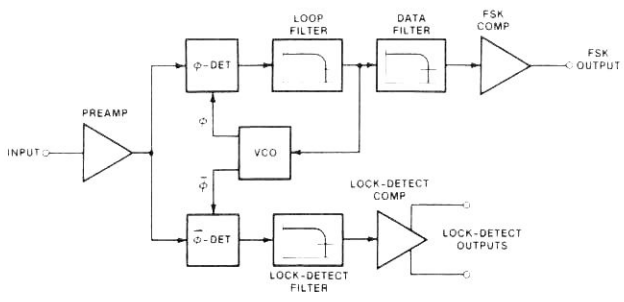


Figure 1—Functional Block Diagram of a Tone and FSK Decoding System Using XR-2211

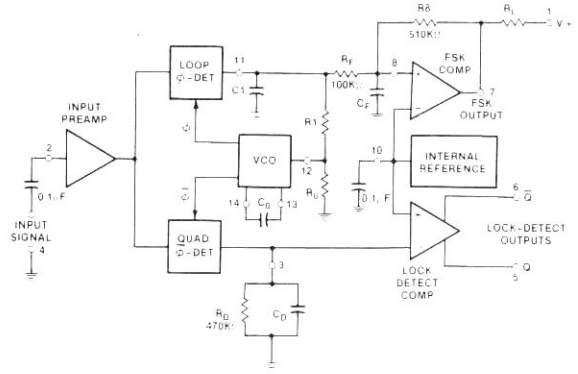


Figure 2—Generalized Circuit Connection for FSK and Tone Detection

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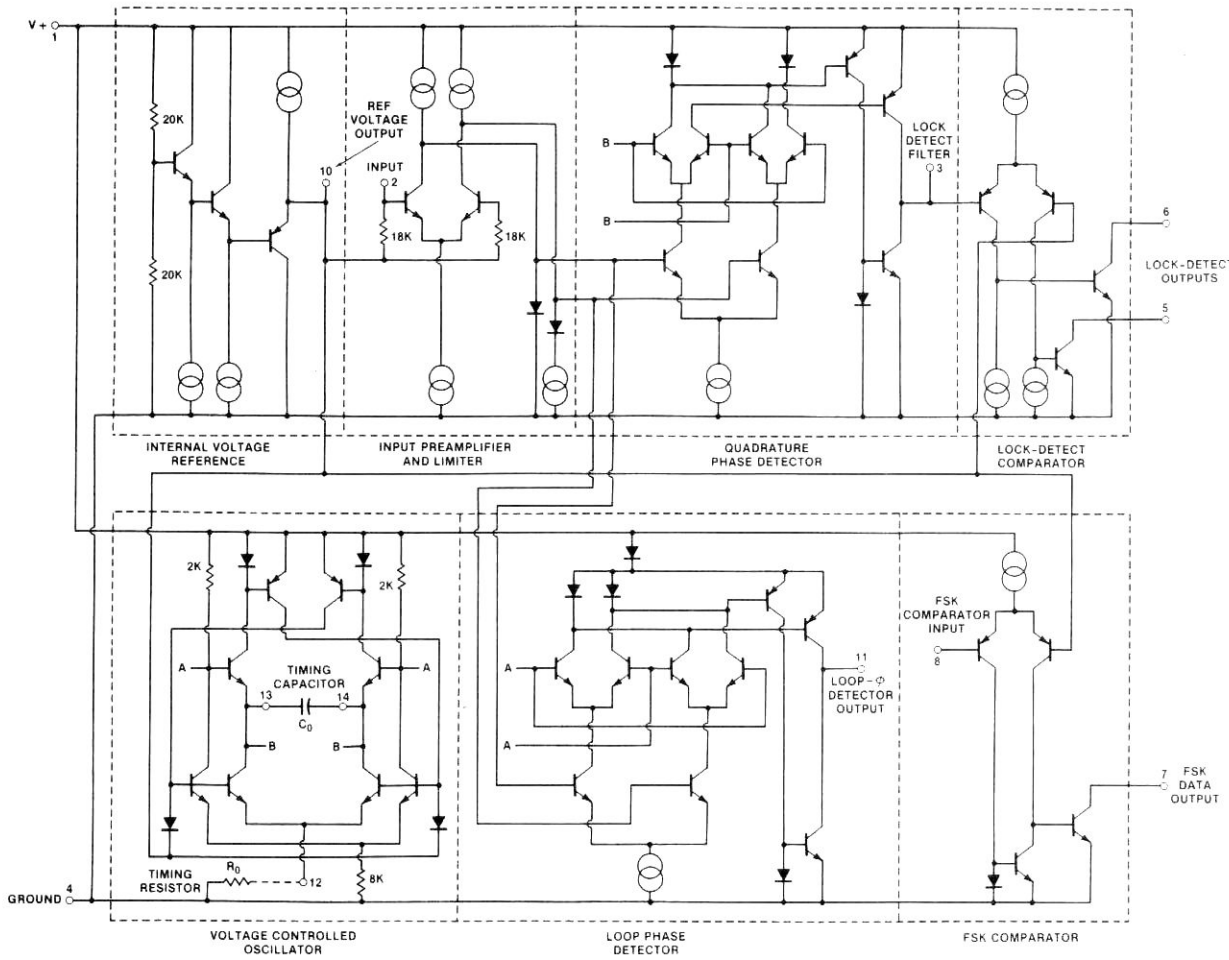
INTERNAL CIRCUIT



TYPICAL CHARACTERISTICS

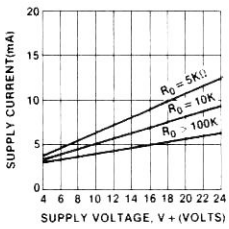


Figure 4—Typical Supply Current vs V+ (Logic Outputs Open Circuited)

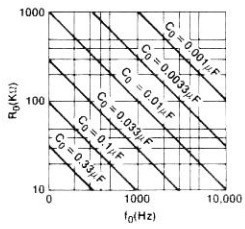


Figure 5—VCO Frequency vs Timing Resistor

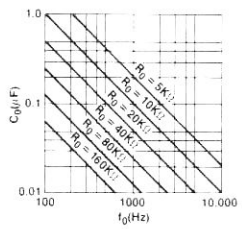


Figure 6—VCO Frequency vs Timing Capacitor

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TYPICAL CHARACTERISTICS (Cont'd)

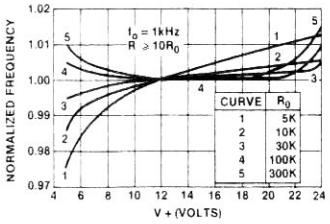

Figure 7—Typical f_0 vs Power Supply Characteristics

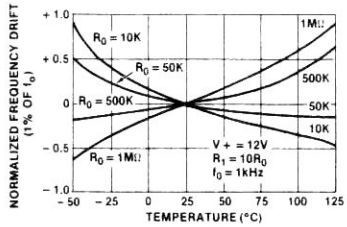

Figure 8—Typical Center Frequency Drift vs Temperature

DESCRIPTION OF CIRCUIT CONTROLS

Signal Input (Pin 2)

Signal is ac coupled to this terminal. The internal impedance at Pin 2 is 20 kΩ. Recommended input signal level is in the range of 10 mVrms to 3 Vrms.

Quadrature Phase Detector Output (Pin 3)

This is the high-impedance output of quadrature phase detector, and is internally connected to the input of lock-detect voltage-comparator. In tone detection applications, Pin 3 is connected to ground through a parallel combination of R_D and C_D (See Fig. 2) to eliminate the chatter at lock-detect outputs. If the tone-detect section is not used, Pin 3 can be left open circuited.

Lock-Detect Output, Q (Pin 5)

The output at Pin 5 is at "high" state when the PLL is out of lock and goes to "low" or conducting state when the PLL is locked. It is an open-collector type output and requires a pull-up resistor, R_L, to V+ for proper operation. At "low" state, it can sink up to 5 mA of load current.

Lock-Detect Complement, $\overline{Q}$ (Pin 6)

The output at Pin 6 is the logic complement of the lock-detect output at Pin 5. This output is also an open-collector type stage which can sink 5 mA of load current at low or "on" state.

FSK Data Output (Pin 7)

This output is an open-collector logic stage which requires a pull-up resistor, R_L, to V+ for proper operation. It can sink 5 mA of load current. When decoding FSK signals, FSK data output is at "high" or off state for low input frequency; and at "low" or on state for high input frequency. If no input signal is present, the logic state at Pin 7 is indeterminate.

FSK Comparator Input (Pin 8)

This is the high-impedance input to the FSK voltage comparator. Normally, and FSK post-detection or data filter is connected between this terminal and the PLL phase-detector output (Pin 11). This data filter is formed by R_F and C_F of Figure 2. The threshold voltage of the comparator is set by the internal reference voltage, V_R, available at Pin 10.

Reference Voltage, V_R (Pin 10)

This pin is internally biased at the reference voltage level, V_R: $V_R = V+/2 - 650$ mV. The dc voltage level at this pin forms an internal reference for the voltage levels at pins 5, 8, 11 and 12. Pin 10 must be bypassed to ground with a 0.1 μF capacitor, for proper operation of the circuit.

Loop Phase Detector Output (Pin 11)

This terminal provides a high-impedance output for the loop phase-detector. The PLL loop filter is formed by R_1 and C_1 connected to Pin 11 (See Fig. 2). With no input signal, or with no phase-error within the PLL, the dc level at Pin 11 is very nearly equal to V_R.The peak voltage swing available at the phase detector output is equal to $\pm V_R$.

VCO Control Input (Pin 12)

VCO free-running frequency is determined by external timing resistor, R_O, connected from this terminal to ground. The VCO free-running frequency, f_O, is:

$$f_O = \frac{1}{R_O C_O} \text{ Hz}$$

where C_O is the timing capacitor across Pins 13 and 14. For optimum temperature stability, R_O must be in the range of 10 KΩ to 100 KΩ (See Fig. 8).

This terminal is a low-impedance point, and is internally biased at a dc level equal to V_R. The maximum timing current drawn from Pin 12 must be limited to ≤ 3 mA for proper operating of the circuit.

VCO Timing Capacitor (Pins 13 and 14)

VCO frequency is inversely proportional to the external timing capacitor, C_O, connected across these terminals (See Fig. 5). C_O must be non-polar, and in the range of 200 pF to 10 μF.

VCO Frequency Adjustment

VCO can be fine-tuned by connecting a potentiometer, R_X, in series with R_O at Pin 12 (See Fig. 9).

VCO Free-Running Frequency, f_O

XR-2211 does not have a separate VCO output terminal. Instead, the VCO outputs are internally connected to the phase-detector sections of the circuit. However, for set-up or adjustment purposes, VCO free-running frequency can be measured at Pin 3 (with C_D disconnected), with no input and with Pin 2 shorted to Pin 10.

APPLICATIONS INFORMATION

FSK DECODING

Figure 9 shows the basic circuit connection for FSK decoding. With reference to Figures 2 and 9, the functions of external components are defined as follows: R_O and C_O set the PLL center frequency, R_1 sets the system bandwidth, and C_1 sets the loop filter time constant and the loop damping factor. C_F and R_F form a one-pole post-detection filter for the FSK data output. The resistor R_B (= 510 KΩ) from pin 7 to pin 8 introduces positive feedback across FSK comparator to facilitate rapid transition between output logic states.

Recommended component values for some of the most commonly used FSK bands are given in Table I.

ADJUSTMENT PROCEDURE

With the input open-circuited, the loop phase detector output voltage is essentially undefined and VCO frequency may be anywhere within the lock range. There are several ways that f_O can be monitored:

1. Short pin 2 to pin 10 and measure f_O at pin 3 with C_D disconnected;
2. Open R_1 and monitor pin 13 or 14 with a high-impedance probe; or
3. Remove the resistor between pins 7 and 8 and find the input frequency at which the FSK output changes state.

NOTE: Do NOT adjust the center frequency of the XR-2211 by monitoring the timing capacitor frequency with everything connected and no input signal applied.

TYPICAL APPLICATIONS

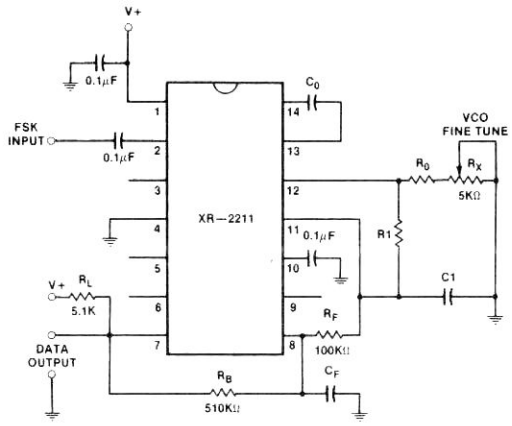

Figure 9—Circuit Connection for FSK Decoding

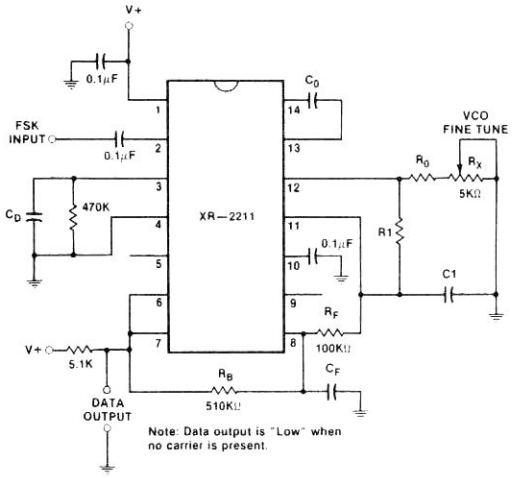

Figure 10—External Connectors for ESK Demodulation with Carrier-Detect Capability

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TABLE I

FSK BAND	COMPONENT VALUES	
300 Baud f_1 = 1070 Hz f_2 = 1270 Hz	C_O = 0.039 μF C_1 = 0.01 μF R_1 = 100 KΩ	C_F = 0.005 μF R_O = 18 KΩ
300 Baud f_1 = 2025 Hz f_1 = 2225 Hz	C_O = 0.022 μF C_1 = 0.0047 μF R_1 = 200 KΩ	C_F = 0.005 μF R_O = 18 KΩ
1200 Baud f_1 = 1200 Hz f_2 = 2200 Hz	C_O = 0.027 μF C_1 = 0.01 μF R_1 = 30 KΩ	C_F = 0.0022 μF R_O = 18 KΩ

Recommended Component Values for Commonly Used FSK Bands (See Circuit of Fig. 9).

FSK DECODING WITH CARRIER-DETECT

The lock-detect section of XR-2211 can be used as a carrier-detect option, for FSK decoding. The recommended circuit connection for this application is shown in Fig. 10. The open-collector lock-detect output, pin 6, is shorted to data output (pin 7). Thus, data output will be disabled at "low" state, until there is a carrier within the detection band of the PPL, and the pin 6 output goes "high", to enable the data output.

The minimum value of the lock-detect filter capacitance C_D is inversely proportional to the capture range, $+\Delta f_c$. This is the range of incoming frequencies over which the loop can acquire lock and is always less than the tracking range. It is further limited by C_1.For most applications, $\Delta f_c > \Delta f/2$. For R_D = 470 KΩ, the approximate minimum value of C_D can be determined by:

$$C_D\,(\mu F) \geq 16/\text{capture range in Hz.}$$

With values of C_D that are too small, chatter can be observed on the lock-detect output as an incoming signal frequency approaches the capture bandwidth. Excessively-large values of C_D will slow the response time of the lock-detect output.

TONE DETECTION

Figure 11 shows the generalized circuit connection for tone detection. The logic outputs, Q and $\overline{Q}$ at pins 5 and 6 are normally at "high" and "low" logic states, respectively. When a tone is present within the detection band of the PLL, the logic state at these outputs become reversed for the duration of the input tone. Each logic output can sink 5 mA of load current.

Both logic outputs at pins 5 and 6 are open-collector type stages, and require external pull-up resistors R_{L1} and R_{L2}, as shown in Fig. 11.

With reference to Figs. 2 and 11, the functions of the external circuit components can be explained as follows: R_O and C_O set VCO center frequency; R_1 sets the detection bandwidth; C_1 sets the low pass-loop filter time constant and the loop damping factor. R_{L1} and R_{L2} are the respective pull-up resistors for the Q and $\overline{Q}$ logic outputs.

LINEAR FM DETECTION

XR-2211 can be used as a linear FM detector for a wide range of analog communications and telemetry applications. The recommended circuit connection for this application is shown in Fig. 12. The demodulated output is taken from the loop phase detector output (Pin 11), through a post detection filter made up of R_F and C_F, and an external buffer amplifier. This buffer amplifier is necessary because of the high impedance output at pin 11. Normally, a non-inverting unity gain op amp can be used as a buffer amplifier, as shown in Fig. 12.

TYPICAL APPLICATION (Cont'd)

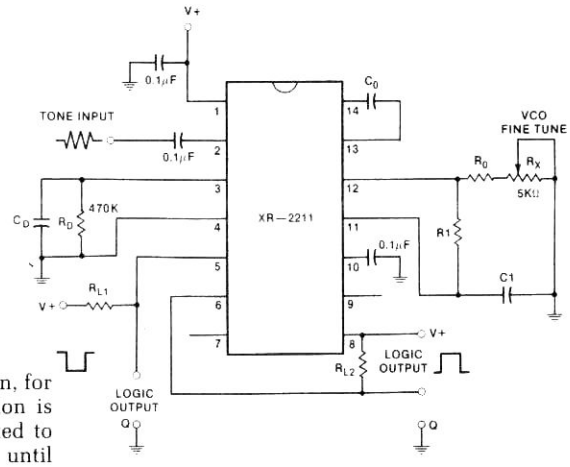


Figure 11—Circuit Connection for Tone Detection

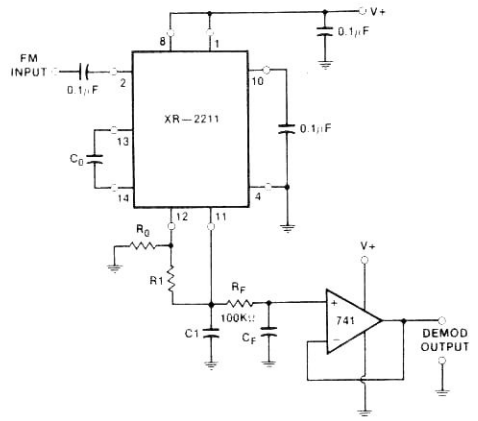


Figure 12—Linear FM Detector Using XR—2211 and an External Op. Amp.

QUAD COMPARATOR

339
276-1712

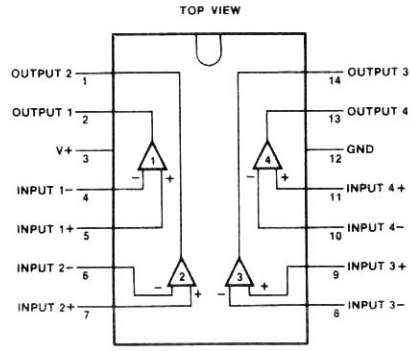
GENERAL DESCRIPTION

The 339 series consists of four independent voltage comparators which were designed specifically to operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage. These comparators also have a unique characteristic in that the input common-mode voltage range includes ground, even though operated from a single power supply voltage.

FEATURES

- Wide single supply:
  Voltage range 2 V_{DC} to 32 V_{DC} or dual supplies ± 1 V_{DC} to ± 16 V_{DC}
- Very low supply current drain (0.8 mA)—independent of supply voltage (1 mW/comparator at +5 V_{DC})
- Input common-mode voltage range includes ground
- Differential input voltage range equal to the power supply voltage
- Low output 1 mV at 5 μA: saturation voltage 70 mV at 1 mA
- Output voltage compatible with TTL (fanout of 2), DTL, ECL, MOS and CMOS logic systems

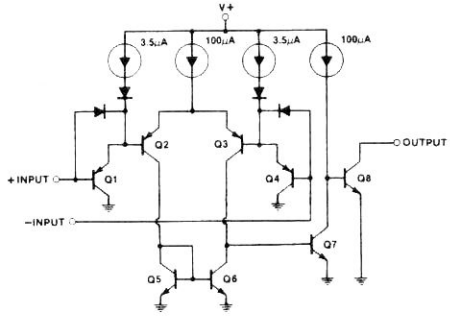
PIN CONNECTION



ABSOLUTE MAXIMUM RATINGS

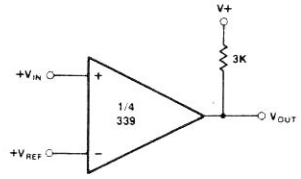
Supply Voltage, V^+	32 V_{DC} or ± 16 V_{DC}
Differential Input Voltage	36 V_{DC}
Input Voltage	−0.3 V_{DC} to +36 V_{DC}
Power Dissipation	
Molded DIP	570 mW
Cavity DIP	900 mW
Output Short-Circuit to GND	Continuous
Input Current ($V_{IN} < -0.3$ V_{DC})	50 mA
Operating Temperature Range	0 to +70°C
Storage Temperature Range	−65 to +150°C
Lead Temperature (Soldering, 10 seconds)	300°C

INTERNAL CIRCUIT

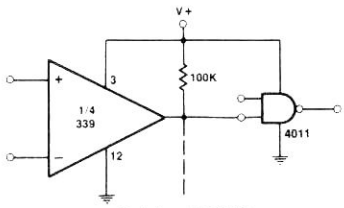


TYPICAL APPLICATIONS

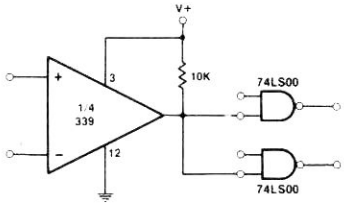
5 VOLT GROUP



Basic Comparator

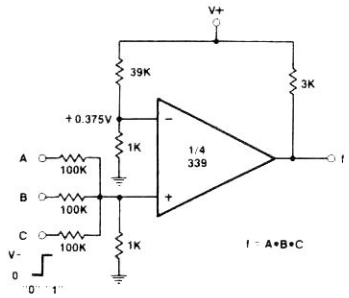


Driving CMOS

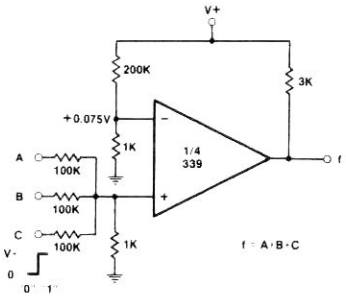


Driving TTL

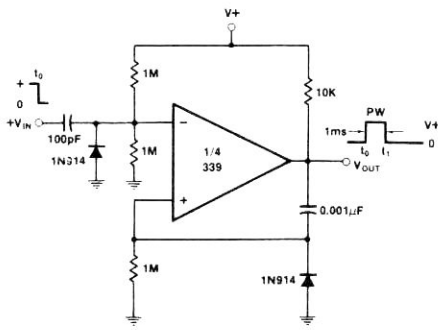
15V GROUP



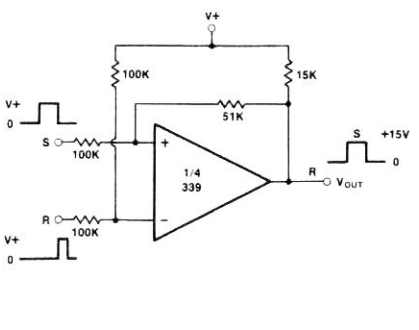
AND Gate



OR Gate



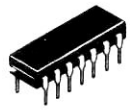
One-Shot Multivibrator



Bi-Stable Multivibrator

565
276-1720

PHASE LOCKED LOOP



GENERAL DESCRIPTION

The 565 phase-locked loop (PLL) is a self-contained, adaptable filter and demodulator for the frequency range from 0.001 Hz to 500kHz. The circuit comprises a voltage-controlled oscillator of exceptional stability and linearity, a phase comparator, an amplifier and a low-pass filter as shown in the block diagram. The center frequency of the PLL is determined by the free-running frequency of the VCO; this frequency can be adjusted externally with a resistor or a capacitor. The low-pass filter, which determines the capture characteristics of the loop, is formed by an internal resistor and an external capacitor.

FEATURES

- Highly stable center frequency (200ppm/°C typ.)
- Wide operating voltage range (±6 to ±12 volts)
- Highly linear demodulated output (0.2% typ.)
- Center frequency programming by means of a resistor or capacitor, voltage or current
- TTL and LS compatible square-wave output; loop can be opened to insert digital frequency divider.
- Highly linear triangle wave output
- Reference output for connection of comparator in frequency discriminator
- Bandwidth adjustable from < ±1% to > ±60%
- Frequency adjustable over 10 to 1 range with same capacitor

APPLICATIONS

- Frequency shift keying
- Modems
- Telemetry receivers
- Tone decoders
- SCA receivers
- Wideband FM discriminators
- Data synchronizers
- Tracking filters
- Signal restoration
- Frequency multiplication & division

ABSOLUTE MAXIMUM RATINGS

Maximum operating voltage	±12V
Input voltage	3Vp-p
Power dissipation	300mW
Operating temperature range	0 to +70°C
Storage temperature	−65 to +150°C

DESIGN FORMULAS (See Figure 1, Page 100)

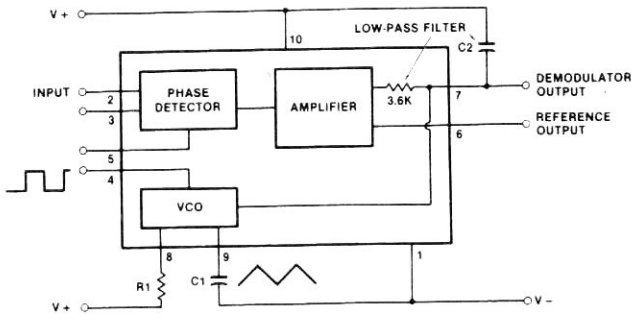
Free-running frequency of VCO: $f_o \cong \frac{1.2}{4R1C1}$ in Hz

Lock-range $f_L = \pm \frac{8f_o}{V_{CC}}$ in Hz

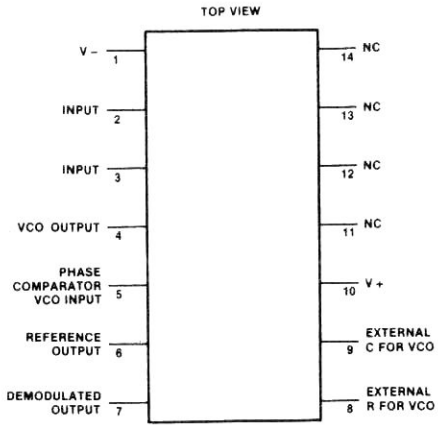
Capture-range: $f_C \cong \pm \frac{1}{2\pi}\sqrt{\frac{2\pi f_L}{\tau}}$

where $\tau = (3.6 \times 10^3) \times C2$

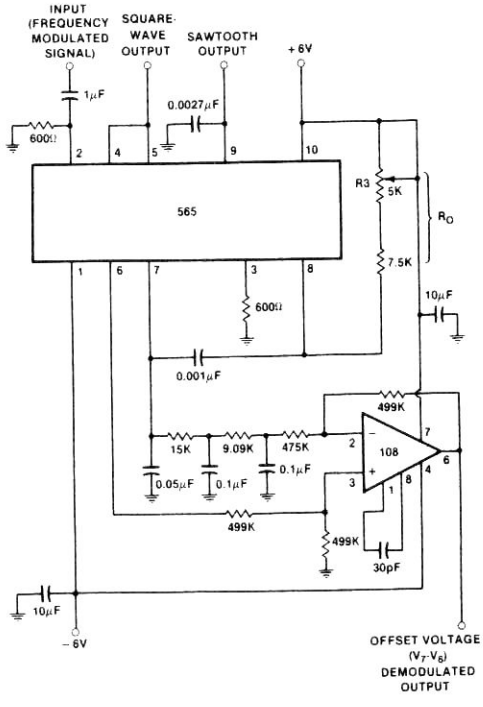
BLOCK DIAGRAM



PIN CONNECTION



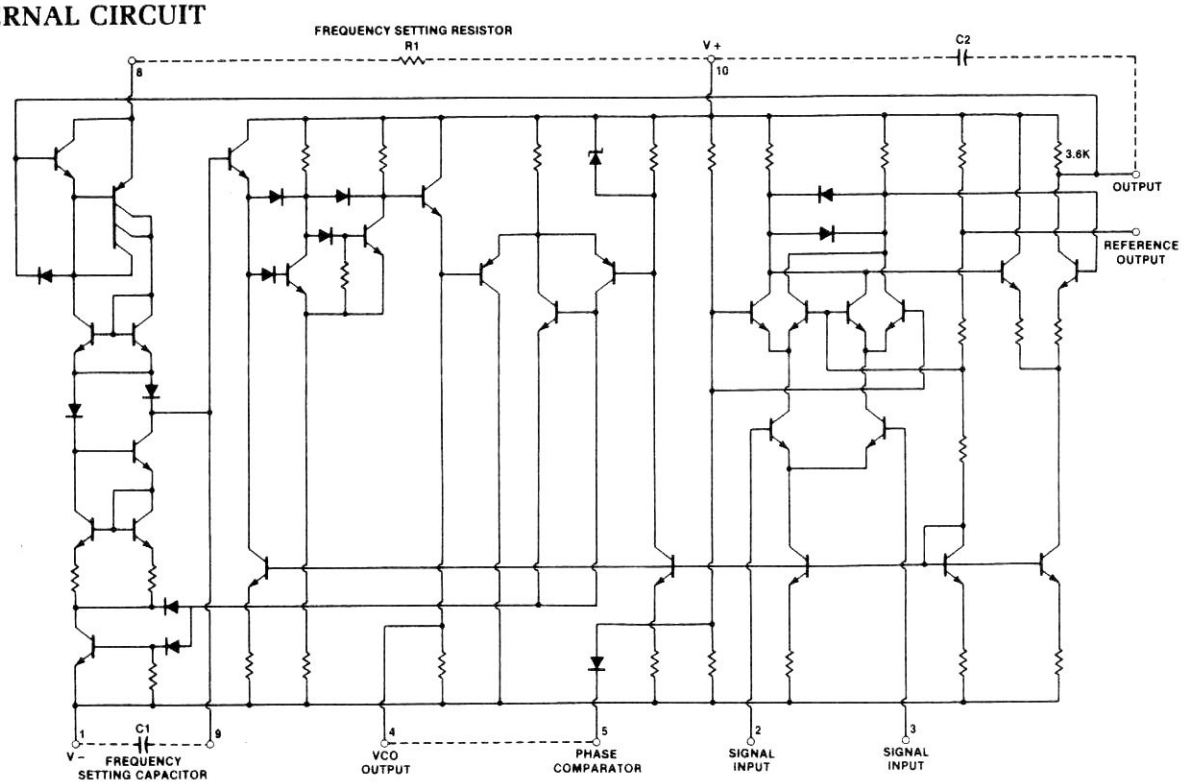
TEST CIRCUIT



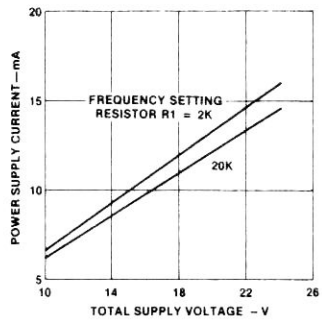
Test Circuit

565 276-1720

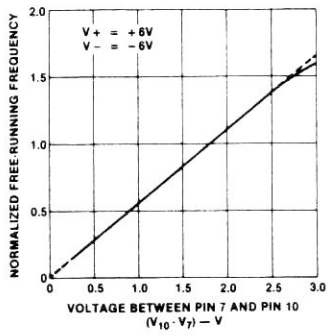
INTERNAL CIRCUIT



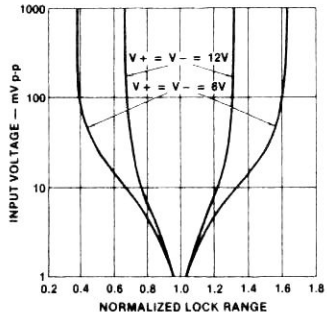
TYPICAL CHARACTERISTICS



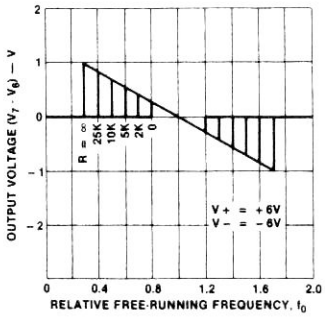
Power Supply Current vs Total Supply Voltage



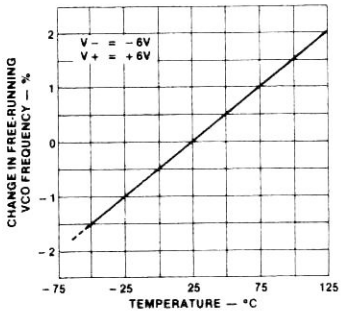
Normalized Free Running Frequency vs Voltage Between Pin 7 and Pin 10



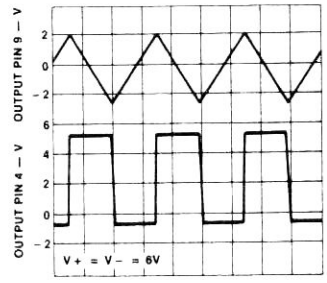
Input Voltage vs Normalized Lock Range



Output Voltage vs Relative Free Running Frequency



Change in Free-Running VCO Frequency vs Temperature



VCO Output Waveform

565 276-1720

TYPICAL APPLICATIONS

FM Demodulation

The 565 Phase Locked Loop is a general purpose circuit designed for highly linear FM demodulation. During lock, the average dc level of the phase comparator output signal is directly proportional to the frequency of the input signal. As the input frequency shifts, it is this output signal which causes the VCO to shift its frequency to match that of the input. Consequently, the linearity of the phase comparator output with frequency is determined by the voltage-to-frequency transfer function of the VCO.

Because of its unique and highly linear VCO, the 565 PLL can lock to and track an input signal over a very wide brandwidth (typically ±60%) with very high linearity (typically, within 0.5%).

A typical connection diagram is shown in Figure 1. The VCO free-running frequency is given approximately by

$$f_o = \frac{1.2}{4R1C1}$$

and should be adjusted to be at the center of the input signal frequency range. C1 can be any value, but R1 should be within the range of 2000 to 20.000 ohms with an optimum value on the order of 4000 ohms. The source can be direct coupled if the dc resistances seen from pins 2 and 3 are equal and there is no dc voltage difference between the pins. A short between pins 4 and 5 connects the VCO to the phase comparator. Pin 6 provides a dc reference voltage that is close to the dc potential of the demodulated output (pin 7). Thus, if a resistance is connected between pins 6 and 7, the gain of the output stage can be reduced with little change in the dc voltage level at the output. This allows the lock range to be decreased with little change in the free-running frequency. In this manner the lock range can be decreased from ±60% of f_o to approximately ±20% of f_o (at ±6V).

A small capacitor (typically 0.001 μF) should be connected between pins 7 and 8 to eliminate possible oscillation in the control current source.

A single-pole loop filter is formed by the capacitor C2, connected between pin 7 and the positive supply, and an internal resistance of approximately 3600 ohms.

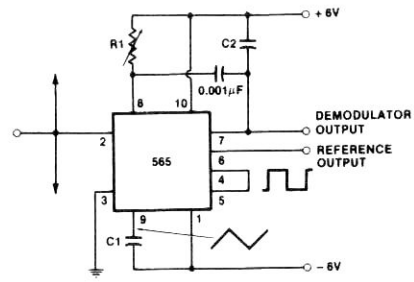


Figure 1 — FM Demodulation

Frequency Shift Keying (FSK)

FSK refers to data transmission by means of a carrier which is shifted between two preset frequencies. This frequency shift is usually accomplished by driving a VCO with the binary data signal so that the two resulting frequencies correspond to the "0" and "1" states (commonly called space and mark) of the binary data signal.

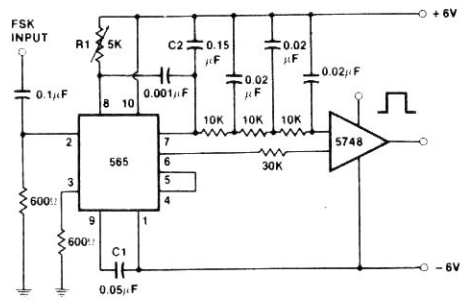


Figure 2 — Frequency Shift Keying (FSK)

SCA (Background Music) Decoder

Some FM stations are authorized by the FCC to broadcast uninterrupted background music for commercial use. To do this a frequency modulated subcarrier of 67kHz is used. The frequency is chosen so as not to interfere with the normal stereo or monaural program; in addition, the level of the subcarrier is only 10% of the amplitude of the combined signal.

The SCA signal can be filtered out and demodulated with the 565 Phase Locked Loop without the use of any resonant circuits.

A resistive voltage divider is used to establish a bias voltage for the input (pins 2 and 3). The demodulated (multiplex) FM signal is fed to the input through a two-stage high-pass filter, both to effect capacitive coupling and to attenuate the strong signal of the regular channel. A total signal amplitude, between 80mV and 300mV, is required at the input. Its source should have an impedance of less than 10,000 ohms.

The Phase Locked Loop is tuned to 67kHz with a 5000 ohm potentiometer, only approximate tuning is required, since the loop will seek the signal.

The demodulated output (pin 7) passes through a three-stage low-pass filter to provide de-emphasis and attenuate the high-frequency noise which often accompanies SCA transmission. Note that no capacitor is provided directly at pin 7; thus, the circuit is operating as a first-order loop. The demodulated output signal is in the order of 50mV and the frequency response extends to 7kHz.

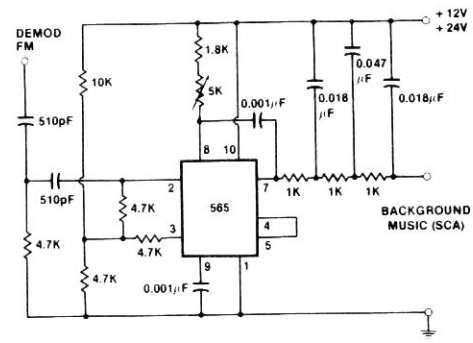


Figure 3 — SCA Decoder

TONE DECODER

567
276-1721

GENERAL DESCRIPTION

The 567 is a general purpose tone decoder designed to provide a saturated transistor switch to ground when an input signal is present within the passband. The circuit consists of an I and Q detector driven by a voltage controlled oscillator which determines the center frequency of the decoder. External components are used to independently set center frequency, bandwidth and output delay.

FEATURES

- 20 to 1 frequency range with an external resistor
- Logic compatible output with 100 mA current sinking capability
- Bandwidth adjustable from 0 to 14%
- High rejection of out of band signals and noise
- Immunity to false signals
- Highly stable center frequency
- Center frequency adjustable from 0.01 Hz to 500 kHz

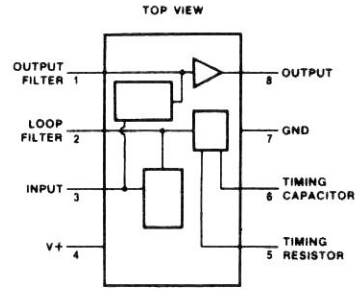
APPLICATIONS

- Touch tone decoding
- Precision oscillator
- Frequency monitoring and control
- Wide band FSK demodulation
- Ultrasonic controls
- Carrier current remote controls
- Communications paging decoders

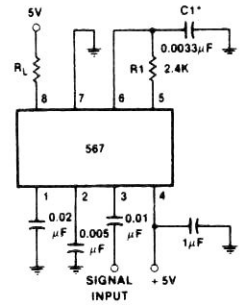
ABSOLUTE MAXIMUM RATINGS

Supply Voltage	9V
Power Dissipation	300 mW
V_8 (Output Voltage)	15V
V_3 (−Voltage at Input)	−10V
V_3 (+Voltage at Input)	V_8+0.5V
Operating Temperature	0 to +70°C
Storage Temperature Range	−65 to +150°C

PIN CONNECTION



TYPICAL APPLICATIONS



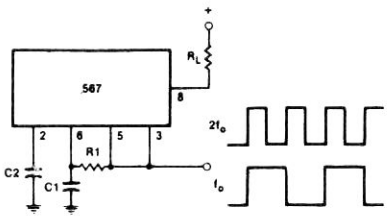
*Note: Adjust for f_o = 100kHz.
f_i = 100kHz +5V

The center frequency of the tone decoder is equal to the free-running frequency of the VCO.
This is given by $f_o \cong 1/R1C1$
The band width of the filter may be found from the approximation

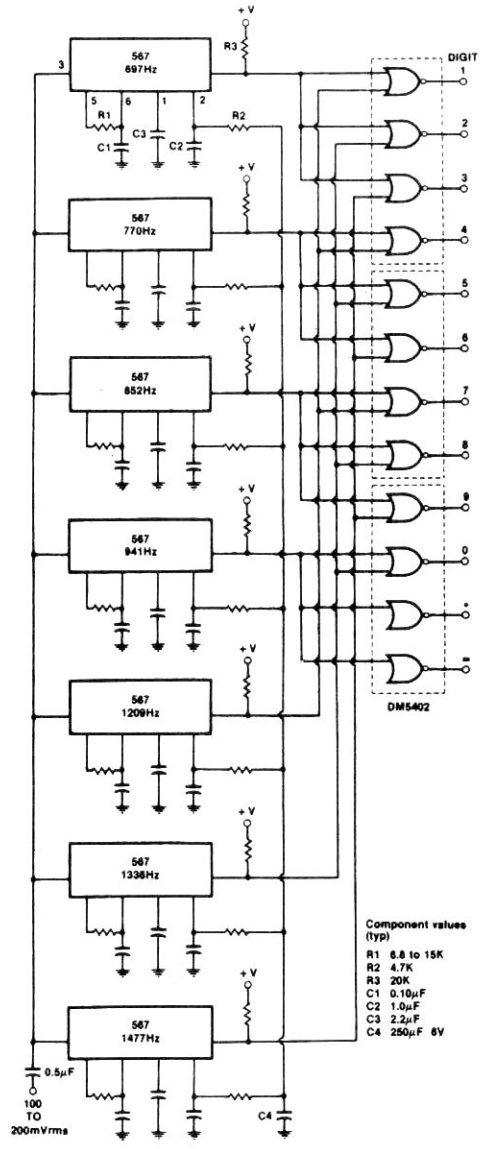
$$BW = 1070\sqrt{\frac{V_{IN}}{f_o C2}} \text{ in \% of } f_o.$$

Where: V_{IN} = input voltage (volts rms), $V_{IN} \leq 200$mV.
C2 = Capacitance at pin 2 in μF.

AC Test Circuit



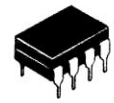
Oscillator with Double Frequency Output



Touch-Tone Decoder

3909
276-1705

LED FLASHER/OSCILLATOR



GENERAL DESCRIPTION

The 3909 is a monolithic oscillator specifically designed to flash light emitting diodes. By using the timing capacitor for voltage boost, it delivers pulses of 2 or more volts to the LED while operating on a supply of 1.5V or less. The circuit is inherently self-starting, and requires addition of only a battery and capacitor to function as a LED flasher.

It has been optimized for low power drain and operation from weak batteries so that continuous operation life exceeds that expected from battery rating.

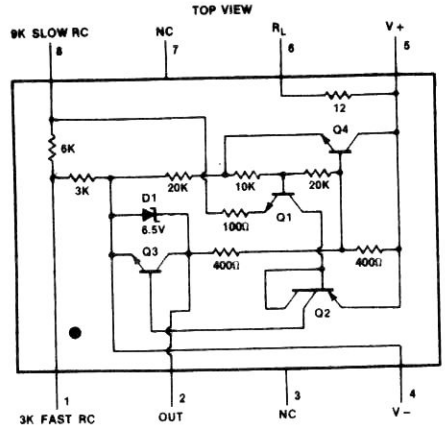
Application is made simple by inclusion of internal timing resistors and an internal LED current limit resistor.

Timing capacitors will generally be of the electrolytic type, and a small 3V rated part will be suitable for any LED flasher using a supply up to 6V. However, when picking flash rates, it should be remembered that some electrolytics have very broad capacitance tolerances, for example −20% to +100%.

FEATURES

- Operation over one year from one C size flashlight cell
- Bright, high current LED pulse
- Minimum external parts
- Low voltage operation, from just over 1V to 5V
- Low current drain, averages under 0.5 mA during battery life
- Powerful: as an oscillator directly drives an 8Ω speaker

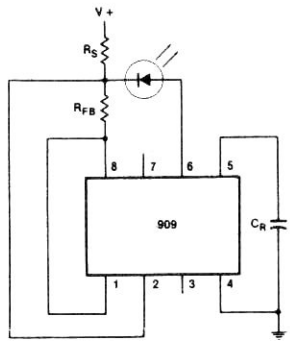
PIN CONNECTION



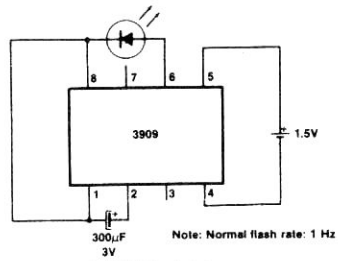
ABSOLUTE MAXIMUM RATINGS

Power Dissipation	500 mW
V+ Voltage	6.4V
Pulse Width	6 ms
Peak LED Current	45 mA
Operating Current	75 mA
Flash Frequency	1.3 Hz
High Flash Frequency	1.1 kHz
Operating Temperature Range	−25 to +70°C

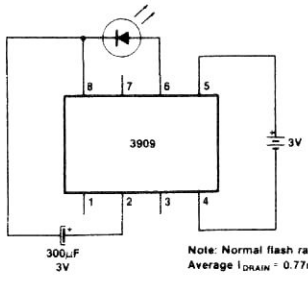
TYPICAL APPLICATIONS



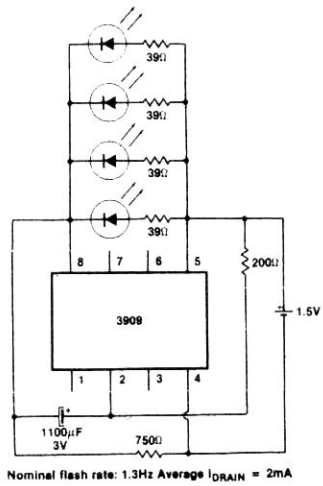
Warning Flasher High Voltage Powered



1.5V Flasher

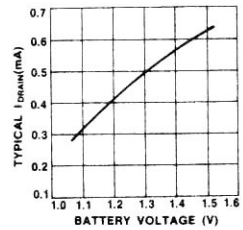


3V Flasher



Parallel LED's

TYPICAL CHARACTERISTICS



Drain Current vs Battery Voltage

ESTIMATED BATTERY LIFE
(CONTINUOUS 1.5V FLASHER OPERATION)

SIZE CELL	TYPE	
	STANDARD	ALKALINE
AA	3 MONTHS	6 MONTHS
C	7 MONTHS	15 MONTHS
D	1.3 YEARS	2.6 YEARS

Note: Estimates are made from our tests and manufacturers data. Conditions are fresh batteries and room temperature. Clad or "leak-proof" batteries are recommended for any application of five months or more. Nickel Cadmium cells are not recommended.

TYPICAL OPERATING CONDITIONS

V+	NORMAL FLASH Hz	C_T	R_S 1W	R_{FB}	$V+_{RANGE}$
6V	2	400µF	1K	1.5K	5-25V
15V	2	180µF	3.9K	1K	13-50V
100V	1.7	180µF	43K	1K	85-200V

TUNES SYNTHESIZER

AY-3-1350
276-1782

GENERAL DESCRIPTION

The AY-3-1350 is an N-channel MOS microcomputer based synthesizer of pre-programmed tunes for applications in toys, musical boxes, and doorchimes. The standard device has a set of 25 different popular and classical tunes chosen for their international acceptance. In addition there are 3 chimes making a total of 28 tunes.

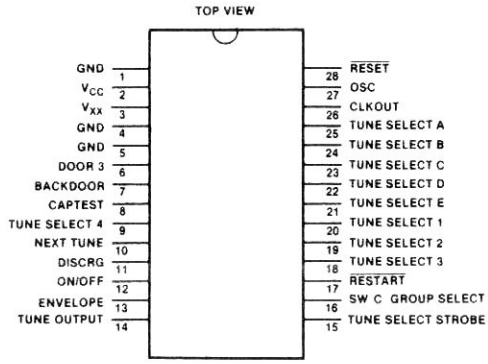
The chip is mask-programmable during manufacture enabling the quantity user to select his own music. Up to 28 tunes of varying length can be chosen.

The device has multi-mode operation making it suitable for a wide variety of applications.

FEATURES

- 25 different tunes plus 3 chimes
- Mask programmable with customer specified tunes for toys, musical boxes, etc.
- Minimal external components
- Automatic switch-off signal at end of tune for power savings
- Envelope control to give organ or piano quality
- Sequential tune mode
- 4 door capability when used as doorchime
- Operation with tunes in external PROM if required
- Single supply (+5V) operation

PIN CONNECTION



TUNES

The standard AY-3-1350 contains the following tunes:

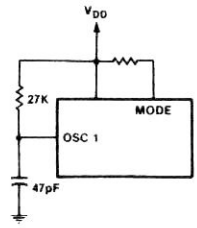
A0	Toreador	A3	O Sole Mio
B0	William Tell	B3	Santa Lucia
C0	Hallelujah Chorus	C3	The End
D0	Star Spangled Banner	D3	Blue Danube
E0	Yankee Doodle	E3	Brahms' Lullaby
A1	John Brown's Body	A4	Hell's Bells
B1	Clementine	B4	Jingle Bells
C1	God Save the Queen	C4	La Vie en Rose
D1	Colonel Bogey	D4	Star Wars
E1	Marseillaise	E4	Beethoven's 9th
A2	America, America		
B2	Deutschland Leid		
C2	Wedding March	Chime X	Westminster Chime
D2	Beethoven's 5th	Chime Y	Simple Chime
E2	Augustine	Chime Z	Descending Octave Chime

ABSOLUTE MAXIMUM RATINGS

Primary Supply Voltage, V_{DD} 7V
Output Buffer Supply Voltage, V_{XX} 9V
Primary Supply Current (No Load), I_{DO} 55mA
Output Buffer Supply Current (No Load), I_{XX} 5mA
Logic Input Low Voltage, V_{IL} 0.8V
Logic Input High Voltage (Note 2), V_{IH1} ..... V_{DD}V
(Except $\overline{\text{RESET}}$ and OSC when driven externally)
Logic Input High Voltage, V_{IH2} ..... V_{DD}V
($\overline{\text{RESET}}$ and OSC)
Logic Output High Voltage (Note 2), V_{OH}(I_{OH} = 100μA) 2.4V
Logic Output Low Voltage, V_{OL} (I_{OL} = 1.6μA, V_{XX} = 4.5V) 0.45V
(I_{OL} = 5mA, V_{XX} = 9V) 0.90V
(I_{OL} = 5mA, V_{XX} = 9V) 0.50V
(I_{OL} = 10mA, V_{XX} = 9V) (Note 1) 0.90V
Operating Temperature ..... 0 to 70°C

Notes: 1. Total I_{OL} for all registers must be less than 150mA under any conditions.
2. Except following pins which have open drain outputs/inputs: 6, 7, 8, 12 and 13.

TEST CIRCUIT



Test Circuit

AY-3-1350 276-1782

TYPICAL APPLICATIONS

Implementation

There are many ways to connect the standard device depending on the exact application. Figure 1 shows just one implementation of the device in a doorchime. This circuit gives access to all 25 tunes from switch A and one of 5 tunes from switch C as well as the descending active chime from switch B. The tune selected for switch B follows the tunes list according to the setting of the two tune select switches (A-E and 0-4). The tune selected from switch C in Figure 1 is one of the five tunes A0 through E0 depending on the setting of the letter switch. For example, with the letter switch set at E and the number switch set at 4, the tunes available will be:

Switch A: Beethoven's 9th (E4)
Switch C: Yankee Doodle (EO)
Switch B: Descending Octave Chime (Chime Z)

When the letter switch is in position F there will be chimes on all doors independent of the number switch setting as follows:

Switch A: Westminster Chime
Switch C: Simple Chime
Switch B: Descending Octave Chime

There is virtually no power consumption in the standby condition (external transistor leakages only). When any door switch is activated the circuit powers up, plays a tune, and then automatically powers down again to conserve the battery, even if the operator keeps his finger on the switch to the end of the tune. He must release it and re-press to play again with the circuit in Figure 1. Activating any of the door switches will pull point A to ground turning on the PNP transistor in the power supply line. This causes +5V to be applied to the AY-3-1350 and the first operation of the chip is to put ON/OFF (pin 12) to logic 0. This maintains the power through the PNP, even after the switch is released. The device can turn off its own power at the end of a tune by raising ON/OFF to logic 1.

Figure 1 shows only a typical one-chip implementation. Further options come from use of different switching and/or from use of the next tune facilities built into the chip. These will now be considered in turn.

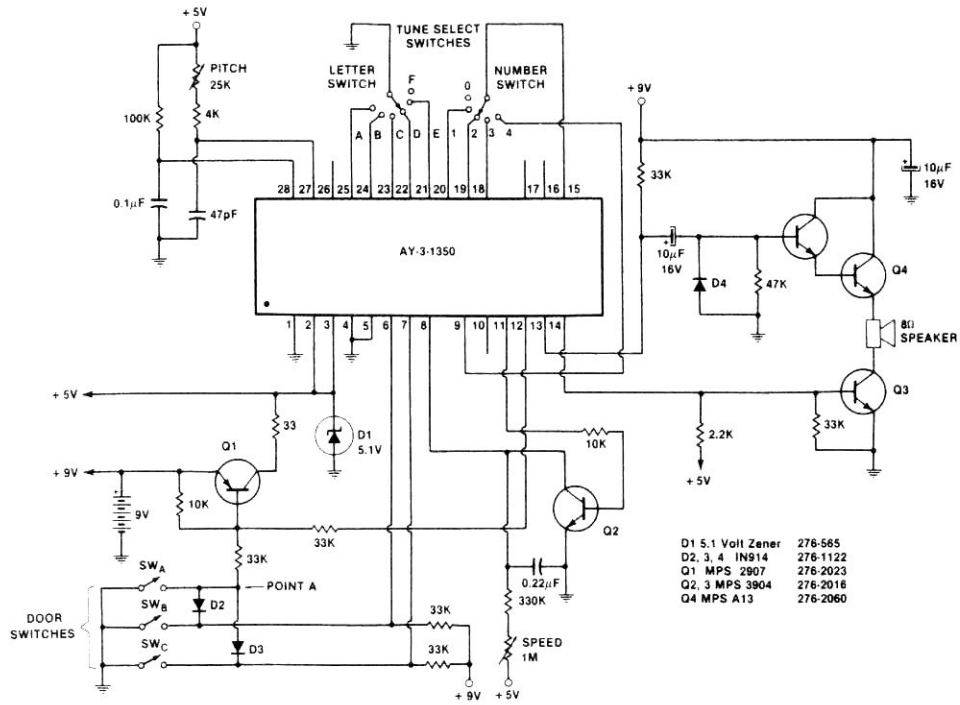


Figure 1—System Diagram

TYPICAL APPLICATIONS (Cont'd)

Switching Options

In Figure 1 the Switch C Group Select pin (16) is not connected, and one of the five tunes (A0 through E0) will play if switch C is activated. Other number groups can be chosen by connecting the Switch C Group Select pin as follows:

Switch C Group Select pin (16) is connected to:	Switch C Tunes
no other pin	A0-E0
Tune Select 1 (pin 20)	A1-E1
Tune Select 2 (pin 19)	A2-E2
Tune Select 3 (pin 18)	A3-E3
Tune Select 4 (pin 9)	A4-E4

Which of the five possible switch C tunes will be played depends on the current setting of the LETTER SWITCH A-E.

Switch C selection can be made by hard-wire connection for a permanent selection or a third switch can be added for an additional group selection feature.

LED Direct Drive

V_{XX} drives the gate of the output buffer, allowing adjustment of drive capability:

V_{XX}	V_{OUT}	I_{SINK} (typ.)
5V	0.4V	2.5mA
5V	0.7V	4.2mA
10V	0.4V	5.8mA
10V	0.7V	10.0mA
10V	1.0V	14.1mA

Using the power-up circuit of Figure 1, the AY-3-1350 will have +5V applied and be latched within a few microseconds (dependant upon external components) from any bell-push closing. The device starts to operate when the RESET pin reaches logic 1 (about 10ms with components shown) but in fact the tune select switches are not interrogated until approximately 6 ms later. The total is sufficient for most bell-pushes to complete any bounce period and for a firm selection of tunes to be made.

Next Tune Facilities

At the end of tune play the circuit of Figure 1 powers down because ON/OFF (pin 12) is raised to a logic 1. This simplified flow diagram in Figure 3 shows that before the power down there is a test for connection between NEXT TUNE (pin 10) then RESTART (pin 17) with TUNESELECT 4 (pin 9). At this time NEXT TUNE (pin 10) then RESTART (pin 17), which is normally at logic 1, output a logic 0. This is looked for at input TUNESELECT 4 (pin 9). If neither is found the power down system is reached as in Figure 1.

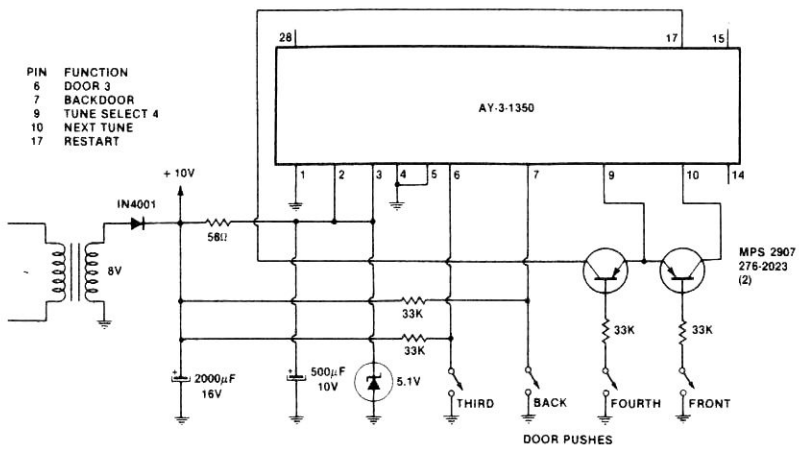


Figure 2

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TYPICAL APPLICATIONS (Cont'd)

A NEXT TUNE (pin 10)—TUNE SELECT 4 (pin 9) connection at the moment of test causes the next tune in the list to be played after a short pause (equal to a musical breve—the actual time depends on the setting of the tune speed control). The order of the tunes is A0 to E4 as given in the listing of standard AY-3-1350 tunes. If the last tune (E4) was played then the circuit will go on to play the first tune A0 (and then successive ones). The chimes are not included in the cycling sequence.

A RESTART (pin 17)—TUNESELECT 4 (pin 9) connection at the moment of test at the end of a tune causes the same selected tune to be played again. Figure 3 shows that in this case the tune sensing mechanism is passed through once more so the tune would be different the second time if the switches were altered while the first tune was playing.

The connections referred to cannot be permanent because otherwise the circuit would never stop playing tunes. Figure 2 shows how transistors are used to make the connection in a practical application.

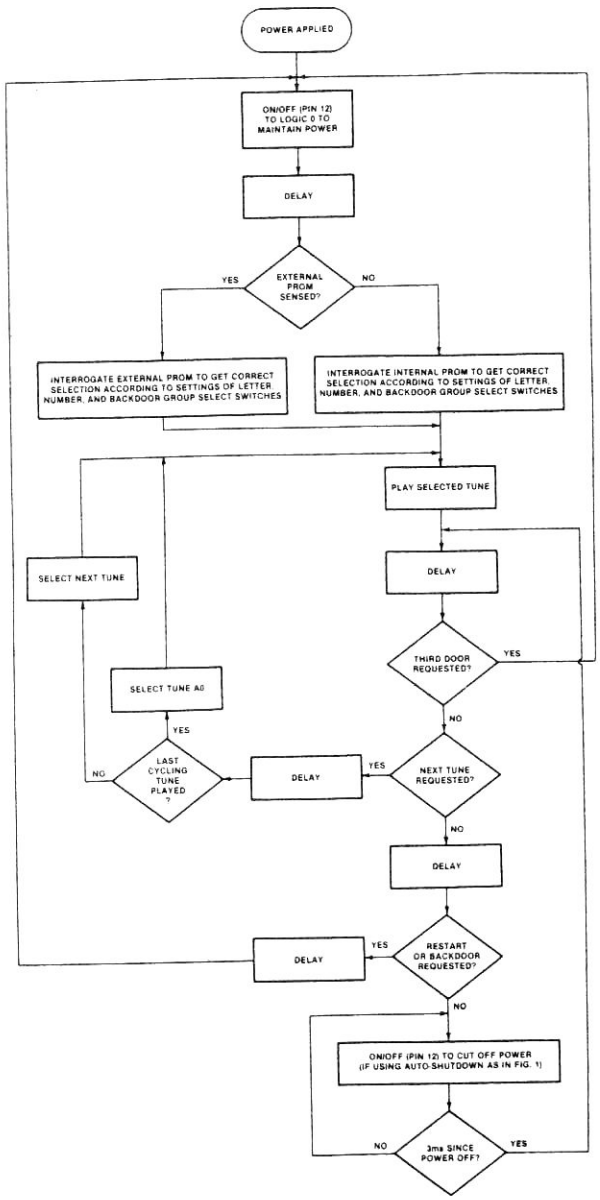


Figure 3—Flow Diagram

SPEECH PROCESSOR SP0256

276-1784

GENERAL DESCRIPTION

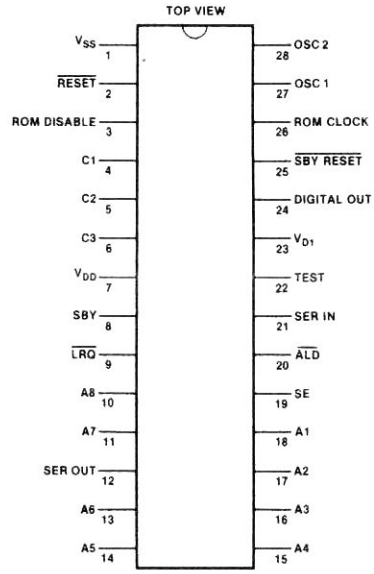
The SPO256 (Speech Processor) is a single chip N-Channel MOS LSI device that is able, using its stored program to synthesize speech or complex sounds.

The achievable output is equivalent to a flat frequency response ranging from 0 to 5KHz, a dynamic range of 42dB, and a signal to noise ratio of approximately 35 dB.

The SPO256 incorporates four basic functions:

A. A software programable digital filter that can be made to model a VOCAL TRACT.
B. A 16K ROM which stores both data and instructions (THE PROGRAM).
C. A MICROCONTROLLER which controls the data flow from the ROM to the digital filter, the assembly of the "word settings" necessary for linking speech elements together, and the amplitude and pitch information to excite the digital filter.
D. A PULSE WIDTH MODULATOR that creates a digital output which is converted to an analog signal when filtered by an external low pass filter.

PIN CONNECTION



FEATURES

- Natural Speech
- Wide Operating Voltage
- Simple Interface to Most Microcomputers or Microprocessors
- Supports L.P.C. Synthesis: Formant Synthesis: Allophone Synthesis

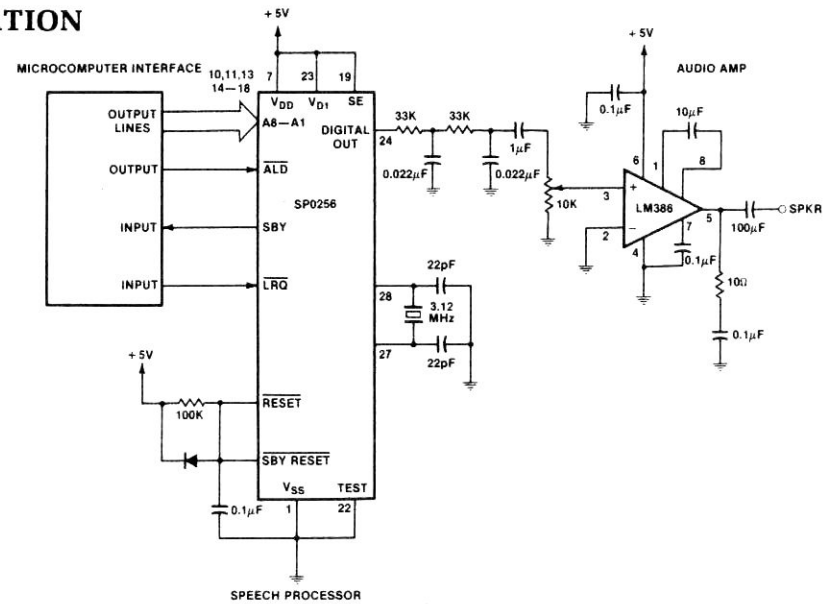
ABSOLUTE MAXIMUM RATINGS

Supply Voltage (V_{DD}) ..... 7 V
(V_{D1}) ..... 7 V
All Pins With Respect to V_{SS}) ..... −0.3 To 8 V
Supply Current (I_{DD}) (V_{D1}, V_{DD}=7V)
(Reset and SBY Reset High) ..... 90 mA
Supply Current (I_{D1} (V_{D1}, V_{DD}=7V)
(Reset and SBY Reset High) ..... 21 mA
Storage Temperature Range ..... −25°C To 125°C
Operating Temperature Range ..... 0°C To 70°C

STANDARD CONDITIONS

Clock-Crystal Frequency ..... 3.120 MHz

TYPICAL APPLICATION



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ALLOPHONE USAGE WITH A MICROPROCESSOR

The SPO256 requires the use of a processor to concatenate the speech sounds to form words.

The SPO256 is controlled using the address pins (A1-A8), ALD (Address Load), and SE (Strobe Enable). The object for controlling the chip is to load an address into it which contains the desired allophone. The speech data for the allophone set is contained within the internal 16 K ROM of the SPO256.

This particular application (Allophone Set) requires only six address pins (A1-A6) to address all the 59 allophones plus five pauses, a total of 64 locations. For simplicity, since only six address pins are needed to address the 64 locations, pins A7 and A8 can be tied low (to ground) and now any further references to the address bus will include A1-A6 and A7=A8=0.

There are two modes available for loading an address into the chip. SE (Strobe Enable) controls the mode that will be used.

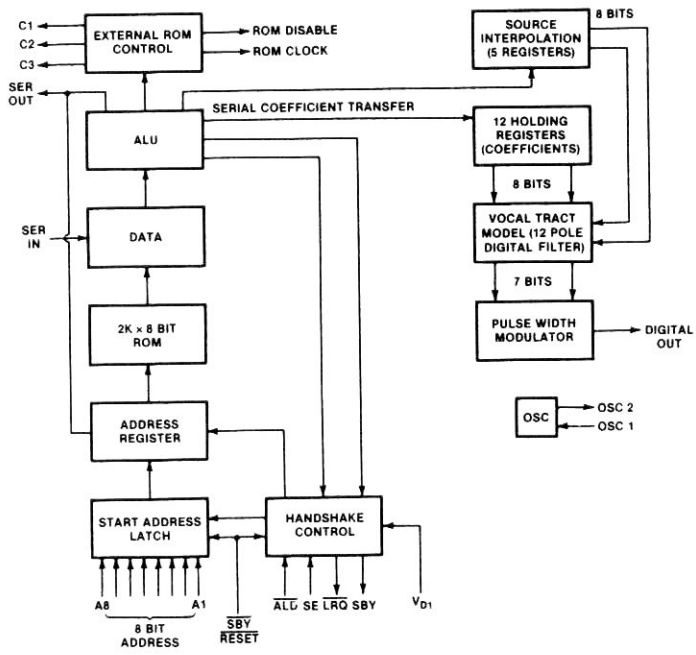
Mode 0. (SE=0) will latch in an address when any one or more of the address pins makes a low to high transition. For example, to load the address one (1), A2 to A6=0 and A1 is pulsed high. To load the address twelve (12 octal), A1=A3=A5=A6=0, A2 and A4 are pulsed high simultaneously. (Note that an address of zero cannot be loaded using this mode).

Mode 1 (SE=1) will latch in an address using the ALD pin. First, setup the desired address on the address bus (A1=A6) and then pulse ALD low. Any address can be loaded using this mode, but certain setup and hold times are required.

Two microprocessor interface pins are available for quick loading of addresses. They are LRQ and SBY. LRQ (Load Request) tells the processor when the input buffer is full. SBY (Stand By) tells the processor that the chip has stopped talking and no new address has been loaded. Either interface pin can be used when concatenating allophones. LRQ is an active low signal, when LRQ goes low it is time to load a new address to the chip. If LRQ is high, then simply wait for it to go low before loading the address. SBY will stay high until an address is loaded, then it will go low and stay low until all the internal instructions (Speech Code) from that one address are completed. Once this signal goes high, it is time to load a new address. Since speech does not require very fast address loading, it would be acceptable to use SBY to interface to the processor.

To end a word using allophones it is necessary to load a pause to complete the word. For example, the word "TWO" can be implemented using the following allophones, TT2-VW2-PA1. PA1 is actually not an allophone but a pause which is needed to end the word.

BLOCK DIAGRAM



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ALLOPHONE BASED SPEECH PROCESSOR—SP0256-AL2

PIN FUNCTIONS

PIN NUMBER	NAME	FUNCTION
1	V_{SS}	Ground
2	$\overline{\text{RESET}}$	A logic 0 resets that portion of the SP powered by V_{DD}. Must be returned to a logic 1 for normal operation.
3	ROM DISABLE	For use with an external serial speech ROM, a logic 1 disables the external ROM.
4, 5, 6	C1, C2, C3	Output control lines for use with an external serial speech ROM.
7	V_{DD}	Power supply for all portions of the SP except the microprocessor interface logic.
8	SBY	STANDBY. A logic 1 output indicates that the SP is inactive and V_{DD} can be powered down externally to conserve power. When the SP is reactivated by an address being loaded, SBY will go to a logic 0.
9	$\overline{\text{LRQ}}$	$\overline{\text{LOAD REQUEST}}$. $\overline{\text{LRQ}}$ is a logic 1 output whenever the input buffer is full. When $\overline{\text{LRQ}}$ goes to a logic 0, the input port may be loaded by placing the 8 address bits on A1-A8 and pulsing the $\overline{\text{ALD}}$ output.
10, 11, 13, 14, 15, 16, 17, 18,	A8, A7, A6, A5, A4, A3, A2, A1	8 bit address which defines any one of 256 speech entry points.
12	SER OUT	SERIAL ADDRESS OUT. This output transfers a 16-bit address serially to an external speech ROM.
19	SE	STROBE ENABLE. Normally held in a logic 1 state. When tied to ground, $\overline{\text{ALD}}$ is disabled and the SP will automatically latch in the address on the input bus approximately 1μs after detecting a logic 1 on any address line.
20	$\overline{\text{ALD}}$	$\overline{\text{ADDRESS LOAD}}$. A negative pulse on this input loads the 8 address bits into the input port. The negative edge of this pulse causes $\overline{\text{LRQ}}$ to go high.
21	SER IN	SERIAL IN. This is an 8-bit serial data input from an external speech ROM.
22	TEST	This pin should be grounded for normal operation.
23	VD1	Power supply for the microprocessor interface logic and controller.
24	DIGITAL OUT	Pulse width modulated digital speech output which, when filtered by a 5KHz low pass filter and amplified, will drive a loudspeaker.
25	$\overline{\text{SBY RESET}}$	$\overline{\text{STANDBY RESET}}$. A logic 0 resets the microprocessor interface logic and the address latches. Must be returned to a logic 1 for normal operation.
26	ROM CLOCK	This is a 1.56MHz clock output used to drive an external serial speech ROM.
27	OSC1	XTAL IN. Input connection for a 3.12MHz crystal.
28	OSC2	XTAL OUT. Output connection for a 3.12MHz crystal

ALLOPHONE SPEECH SYNTHESIS

INTRODUCTION

The allophone speech synthesis technique provides the user with the ability to synthesize an unlimited vocabulary at a very low bit rate. Fifty-nine discrete speech sounds (called allophones) and five pauses are stored at different addresses in the SPO256 internal ROM. Each speech sound was excised from a word and analyzed using linear predictive coding (LPC). Any English word or phrase can be created by addressing the appropriate combination of allophones and pauses. Since there is a total of 64 address locations each requires a 6 bit address. Assuming that speech contains 10 to 12 sounds per second, allophone synthesis requires addressing less than 100 bits per second.

LINGUISTICS

A few basic linguistic concepts will help you start your own library of "allophone words". (See Table 1 for Allophone Dictionary). First, there is no one-to-one correspondence between written letters and speech sounds; secondly, speech sounds are acoustically different depending upon their position within

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LINGUISTICS (Continued)

a word; and lastly, the human ear may perceive the same acoustic signal differently in the context of different sounds.

The first point compares to the problem that a child encounters when learning to read. Each sound in a language may be represented by more than one letter and, conversely each letter may represent more than one sound. (See the examples in Table 2.) Because of these spelling irregularities, it is necessary to think in terms of *sounds*, not letters, when using allophones.

The second, and equally important, point to understand, is that the acoustic signal of a speech sound may differ depending upon its position within a word. For example, the initial *K* sound in *coop* will be acoustically different from the *K*'s in *keep* and *speak*. The *K*'s in *coop* and *keep* differ due to the influence of the vowels which follow them, and the final *K* in speak is usually not as loud as initial *K*'s.

Finally, a listener may identify the same acoustic signal differently depending on the context in which it is perceived. Don't be surprised, therefore, if an allophone word sounds slightly different when used in various phrases.

PHONEMES OF ENGLISH

The sounds of a language are called phonemes, and each language has a set which is slightly different from that of other languages. Table 3 contains a chart of all the consonant phonemes of English, table 4 all the vowel phonemes.

Consonants are produced by creating an occlusion or constriction in the vocal tract which produces an aperiodic sound source. If the vocal cords are vibrating at the same time, as in the case of the voiced fricatives VV, DH, ZZ, and ZH, (See Table 5) there are two sound sources: one which is aperiodic and one which is periodic.

Vowels are usually produced with a relatively open vocal tract and a periodic sound source provided by the vibrating vocal cords. They are classified according to whether the front or back of the tongue is high or low (See Table 4) whether they are long or short, and whether the lips are rounded or unrounded. In English all rounded vowels are produced in or near the back of the mouth (UW, UH, OW, AO, OR, AW).

Speech sounds which have features in common behave in similar ways. For example, the voiceless stop consonants PP, TT and KK (See Table 3) should be preceded by 50-80 msec of silence, and the voiced stop consonants BB, DD, and GG by 10-30 msec of silence.

ALLOPHONES

Phoneme is the name given to a group of similar sounds in a language. Recall that a phoneme is acoustically different depending upon its position within a word. Each of these positional variants is an allophone of the same phoneme. An allophone, therefore, is the manifestation of a phoneme in the speech signal. It is for this reason that our inventory of English speech sounds is called an allophone set.

HOW TO USE THE ALLOPHONE SET

(See Table 1 for instructions on how to create all the sample words mentioned in this section.) The allophone set (Refer to Table 5) contains two or three versions of some phonemes. It may be necessary to use one allophone of a particular phoneme for word-or-syllable-final position. A detailed set of guidelines for using the allophones is given in Table 5. Note that these are suggestions, not rules.

For example, DD2 sounds good in initial position and DD1 sounds good in final position, as a "daughter" and "collide". One of the differences between the initial and final versions of a consonant is that an initial version may be longer than the final version. Therefore, to create an initial SS, you can use two SSs instead of the usual single SS at the end of a word or syllable, as in "sister". Note that this can be done with TH and FF, and the inherently short vowels (to be discussed below), but with no other consonants. You will want to experiment with some consonants such as *str, cl*) to discover which versions works best in the cluster. For example, KK1 sounds good before LL as in "clown", and KK2 sounds good before WW as in "square". One allophone of a particular phoneme may sound better before or after back vowels and another

HOW TO USE THE ALLOPHONE SET (Continued)

before or after front vowels. KK3 sounds good before UH and KK1 sounds good before IY, as in "cookie". Some sounds (PP, BB, TT, DD, KK, GG, CH, and JH) require a brief duration of silence before them. For most of these, the silence has already been added but you may decide you want to add more. Therefore, there are several pauses included in the allophone set varying from 10-200 msec. To create the final sounds in the words "letter" and "little" use the allophone ER and EL.

Remember that you must always think about how a word *sounds*, not how it is spelled. For example, the NG sound is represented by the letter N in "uncle". And remember that some sounds may not even be represented in words by any letters, as the YY in "computer".

As mentioned earlier there are some vowels which can be doubled to make longer versions for stressed syllables. These are the inherently short vowels IH, EH, EA, EX, AA, and UH. For example, in the word "extent" use one EH in the first syllable, which is unstressed and two EHs in the second syllable which is stressed. Of the inherently long vowels there is one, UW, which has a long and shot version. The short one UW1, sounds good after YY in computer. The long version, UW2, sounds good in monosyllabic worlds like "two". Included in the vowel set is a group called R-colored vowels. These are vowel + R combinations. For example, the AR in "alarm" and the OR in "score". Of the R-colored vowels there is one, ER, which has a long and short version. The short version is good for polysyllabic words with final ER sounds like "letter", and the long versions is good for monosyllablic words like "fir". One final suggestion is that you may want to add a pause of 30-50 msec between words, when creating sentences, and a pause of 100-200 msec between clauses.

Note: Every utterance must be followed by a pause in order to make the chip stop talking the last allophone.

TABLE 1: THE ALLOPHONE DICTIONARY

NUMBERS

zero	ZZ YR OW
one, won	WW SX ZX NN1
two, to, too	TT2 UW2
three	TH RR1 IY
four, for, fore	FF FF OR
five	FF FF AY VV
six	SS SS IH IH PA3 KK2 SS
seven	SS SS EH EH VV IH NN1
eight, ate	EY PA3 TT2
nine	NN1 AA AY NN1
ten	TT2 EH EH NN1
eleven	IH LL EH EH VV IH NN1
twelve	TT2 WH EH EH LL VV
thirteen	TH ER1 PA2 PA3 TT2 IY NN1
fourteen	FF OR PA2 PA3 TT2 IY NN1
fifteen	FF IH FF PA2 PA3 TT2 IY NN1
sixteen	SS SS IH PA3 KK2 SS PA2 PA3 TT2 IY NN1
seventeen	SS SS EH VV TH NN1 PA2 PA3 TT2 IY NN1
eighteen	EY PA2 PA3 TT2 IY NN1
nineteen	NN1 AY NN1 PA2 PA3 TT2 IY NN1
twenty	TT2 WH EH EH NN1 PA2 PA3 TT2 IY
thirty	TH ER2 PA2 PA3 TT2 IY
forty	FF OR PA3 TT2 IY
fifty	FF FF IH FF FF PA2 PA3 TT2 IY
sixty	SS SS IH PA3 KK2 SS PA2 PA3 TT2 IY
seventy	SS SS EH VV IH NN1 PA2 PA3 TT2 IY
eighty	EY PA3 TT2 IY
ninety	NN1 AY NN1 PA3 TT2 IY
hundred	HH2 AX AX NN1 PA2 DD2 RR2 IH IH PA1 DD1
thousand	TH AA AW ZZ TH PA1 PA1 NN1 DD1
million	MM IH IH LL YY1 AX NN1

DAY OF THE WEEK:

Sunday	SS SS AX AX NN1 PA2 DD2 EY
Monday	MM AX AX NN1 PA2 DD2 EY
Tuesday	TT2 UW2 ZZ PA2 DD2 EY
Wednesday	WW EH EH NN1 ZZ PA2 DD2 EY
Thursday	TH ER2 ZZ PA2 DD2 EY
Friday	FF RR2 AY PA2 DD2 EY
Saturday	SS SS AE PA3 TT2 PA2 DD2 EY

MONTHS:

January	JH AE AE NN1 YY2 XR IY
February	FF EH EH PA2 BR RR2 UW2 XR IY
March	MM AR PA3 CH
April	EY PA3 PP RR2 IH IH LL
May	MM EY
June	JH UW2 NN1
July	JH UW1 LL AY
August	AO AO PA2 GG2 AX SS PA3 TT1
September	SS SS EH PA3 PP PA3 TT2 EH EH PA1 BB2 ER1
October	AA PA2 KK2 PA3 TT2 OW PA1 BB2 ER1
November	NN2 OW VV EH EH MM PA1 BB2 ER1
December	DD2 IY SS SS EH EH MM PA1 BB2 ER1

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ALLOPHONE DICTIONARY (Continued)

LETTERS:

A	EY
B	BB2 IY
C	SS SS IY
D	DD2 IY
E	IY
F	EH EH FF FF
G	JH IY
H	EY PA2 PA3 CH
I	AA AY
J	JH EH EY
K	KK1 EH EY
L	EH EH EL
M	EH EH EM
N	EH EH NN1
O	OW
P	PP IY
Q	KK1 YY1 UW2
R	AR
S	EH EH SS SS
T	TT2 IY
U	YY1 UW2
V	VV IY
W	DD2 AX PA2 BB2 YY1 UW2
X	EH EH PA3 KK2 SS SS
Y	WW AY
Z	ZZ IY

DICTIONARY

alarm	AX LL AR MM
bathe	BB2 EH DH2
bather	BB2 EY DH2 ER1
bathing	BB2 EY DH2 IH NG
beer	BB2 YR
bread	BB1 RR2 EH EH PA1 DD1
by	BB2 AA AY
calendar	KK1 AE AE LL EH NN1 PA2 DD2 ER1
clock	KK1 LL AA AA PA3 KK2
clown	KK1 LL AW NN1
check	CH EH EH PA3 KK2
checked	CH EH EH PA3 KK2 PA2 TT2
checker	CH EH EH PA3 KK1 ER1
checkers	CH EH EH PA3 KK1 ER1 ZZ
checking	CH EH EH PA3 KK1 IH NG
checks	CH EH EH PA3 KK1 SS
cognitive	KK3 AA AA GG3 NN1 IH PA3 TT2 IH VV
collide	KK3 AX LL AY DD1
computer	KK1 AX MM PP1 YY1 UW1 TT2 ER
cookie	KK3 UH KK1 IY
coop	KK3 UW2 PA3 PP
correct	KK1 ER2 EH EH PA2 KK2 PA2 TT1
corrected	KK1 ER2 EH EH PA2 KK2 PA2 TT2 IH PA2 DD1
correcting	KK1 ER2 EH EH PA2 KK2 PA2 TT2 IH NG
corrects	KK1 ER2 EH EH PA2 KK2 PA2 TT1 SS
crown	KK1 RR2 AW NN1
date	DD2 EY PA3 TT2
daughter	DD2 AO TT2 ER1
day	DD2 EH EY
divided	DD2 IH VV AY PA2 DD2 IH PA2 DD1
emotional	IY MM OW SH AX NN1 AX EL
engage	EH EH PA1 NN1 GG1 EY PA2 JH
engagement	EH EH PA1 NN1 GG1 EY PA2 JH MM EH EH NN1 PA2 PA3 TT2
engages	EH EH PA1 NN1 GG1 EY PA2 JH IH ZZ
engaging	EH EH PA1 NN1 GG1 EY PA2 JH IH NG
enrage	EH NN1 RR1 EY PA2 JH
enraged	EH NN1 RR1 EY PA2 JH PA2 DD1
enrages	EH NN1 RR1 EY PA2 JH IH ZZ
enraging	EH NN1 RR1 EY PA2 JH IH NG
escape	EH SS SS PA3 KK1 PA2 PA3 PP
escaped	EH SS SS PA3 KK1 PA2 PA3 PP PA2 TT2
escapes	EH SS SS PA3 KK1 PA2 PA3 PP SS
escaping	EH SS SS PA3 KK1 PA2 PA3 PP IH NG
equal	IY PA2 PA3 KK3 WH AX EL
equals	IH PA2 PA3 KK3 WH AX EL ZZ
error	EH XR OR
extent	EH KK1 SS TT2 EH EH NN1 TT2
fir	FF ER2
freeze	FF FF RR1 IY ZZ
freezer	FF FF RR1 IY ZZ ER1
freezers	FF FF RR1 IY ZZ ER1 ZZ
freezing	FF FF RR1 IY ZZ IH NG
frozen	FF FF RR1 OW ZZ EH NN1
gauge	GG1 EY PA2 JH
gauged	GG1 EY PA2 JH PA2 DD1
gauges	GG1 EY PA2 JH IH ZZ
gauging	GG1 EY PA2 JH IH NG
hello	HH EH LL AX OW
hour	AW ER1
infinitive	IH NN1 FF FF IH IH NN1 IH PA2 PA3 TT2 IH VV
intrigue	IH NN1 PA3 TT2 RR2 IY PA1 GG3
intrigued	IH NN1 PA3 TT2 RR2 IY PA1 GG3 PA2 DD1
intrigues	IH NN1 PA3 TT2 RR2 IY PA1 GG3 ZZ
intriguing	IH NN1 PA3 TT2 RR2 IY PA1 GG3 IH NG
investigate	IH IH NN1 VV EH EH SS PA2 PA3 TT2 IH PA1 GG1 EY PA2 TT2
investigated	IH IH NN1 VV EH EH SS PA2 PA3 TT2 IH PA1 GG1 EY PA2 TT2 IH PA2 DD1
investigater	IH IH NN1 VV EH EH SS PA2 PA3 TT2 IH PA1 GG1 EY PA2 TT2 ER1
investigaters	IH IH NN1 VV EH EH SS PA2 PA3 TT2 IH PA1 GG1 EY PA2 TT2 ER1 ZZ
investigates	IH IH NN1 VV EH EH SS PA2 PA3 TT2 IH PA1 GG1 EY PA2 TT1 SS
investigating	EH EH NN1 VV EH EH SS PA2 PA3 TT2 IH PA1 GG1 EY PA2 TT2 IH NG
key	KK1 IY
legislate	LL EH EH PA2 JH JH SS SS LL EY PA2 PA3 TT2
legislated	LL EH EH PA2 JH JH SS SS LL EY PA2 PA3 TT2 IH DD1
legislates	LL EH EH PA2 JH JH SS SS LL EY PA2 PA3 TT1 SS

ALLOPHONE DICTIONARY
DICTIONARY (Continued)

legislating	LL EH EH PA2 JH JH SS SS LL EY PA2 PA3 TT 2 IH NG
legislature	LL EH EH PA2 JH JH SS SS LL EY PA2 PA3 CH ER1
letter	LL EH EH PA3 TT2 ER1
litter	LL IH IH PA3 TT2 ER1
little	LL IH IH PA3 TT2 EL
memory	MM EH EH MM ER2 IY
memories	MM EH EH MM ER2 IY ZZ
minute	MM 1H NN1 IH PA3 TT2
month	MM AX NN1 TH
nip	NN1 IH IH PA2 PA3 PP
nipped	NN2 IH IH PA2 PA3 PP PA3 TT2
nipping	NN1 IH IH PA2 PA3 PP IH NG
nips	NN1 IH IH PA2 PA3 PP SS
no	NN2 AX OW
physical	FF FF IH ZZ IH PA3 KK1 AX EL
pin	PP IH IH NN1
pinned	PP IH IH NN1 PA2 DD1
pinning	PP IH IH NN1 IH NG1
pins	PP IH IH NN1 ZZ
pledge	PP LL EH FH PA3 JH
pledged	PP LL EH EH PA3 JH PA2 DD1
pledges	PP LL EH EH PA3 JH IH ZZ
pledging	PP LL EH EH PA3 JH IH NG
plus	PP LL AX AX SS SS
ray	RR1 EH EY
rays	RR1 EH EY ZZ
ready	RR1 EH EH PA1 DD2 IY
red	RR1 EH FH PA1 DD1
robot	RR1 OW PA2 BB2 AA PA3 TT2
robots	RR1 OW PA2 BB2 AA PA3 TT1 SS
score	SS SS PA3 KK3 OR
second	SS SS EH PA3 KK1 IH NN1 PA2 DD1
sensitive	SS SS EH EH NN1 SS SS IH PA2 PA3 TT2 IH VV
sensitivity	SS SS EH EH NN1 SS SS IH PA2 PA3 TT2 IH VV IH PA2 PA3 TT2 IY
sincere	SS SS IH IH NN1 SS SS YR
sincerely	SS SS IH IH NN1 SS SS YR LL IY
sincerity	SS SS IH IH NN1 SS SS EH EH RR1 IH PA2 PA3 TT2 IY
sister	SS SS IH IH SS PA3 TT2 ER1
speak	SS SS PA3 IY PA3 KK2
spell	SS SS PA3 PP EH EH EL
spelled	SS SS PA3 PP EH EH EL PA3 DD1
speller	SS SS PA3 PP EH EH EL ER2
spellers	SS SS PA3 PP EH EH EL ER2 ZZ
spelling	SS SS PA3 PP EH EH EL IH NG
spells	SS SS PA3 PP EH EH EL ZZ
start	SS SS PA3 TT2 AR PA3 TT2
started	SS SS PA3 TT2 AR PA3 TT2 IH PA1 DD2
starter	SS SS PA3 TT2 AR PA3 TT2 ER1
starting	SS SS PP3 TT2 AR PA3 TT2 IH NG
starts	SS SS PP3 TT2 AR PA3 TT1 SS
stop	SS SS PA3 TT1 AA AA PA3 PP
stopped	SS SS PA3 TT1 AA AA PA3 PP PA3 TT2
stopper	SS SS PA3 TT1 AA AA PA3 PP ER1
stopping	SS SS PA3 TT1 AA AA PA3 PP IH NG
stops	SS SS PA3 TT1 AA AA PA3 PP SS
subject (noun)	SS SS AX AX PA2 BB1 PA2 JH EH PA3 KK2 PA3 TT2
subject (verb)	SS SS AX PA2 BB1 PA2 JH EH EH PA3 KK2 PA3 TT2
sweat	SS SS WW EH EH PA3 TT2
sweated	SS SS WW EH EH PA3 TT2 IH PA3 DD1
sweater	SS SS WW EH EH PA3 TT2 ER1
sweaters	SS SS WW EH EH PA3 TT2 ER1 ZZ
sweating	SS SS WW EH EH PA3 TT2 IH NG
sweats	SS SS WW EH EH PA3 TT2 SS
switch	SS SS WH IH IH PA3 CH
switched	SS SS WH IH IH PA3 CH PA3 TT2
switches	SS SS WH IH IH PA3 CH IH ZZ2
switching	SS SS WH IH IH PA3 CH IH NG2
system	SS SS IH IH SS SS PA3 TT2 EH MM
systems	SS SS IH IH SS SS PA3 TT2 EH MM ZZ
talk	TT2 AO AO PA2 KK2
talked	TT2 AO AO PA3 KK2 PA3 TT2
talker	TT2 AO AO PA3 KK1 ER1
talkers	TT2 AO AO PA3 KK1 ER1 ZZ
talking	TT2 AO AO PA3 KK1 IH NG
talks	TT2 AO AO PA2 KK2 SS
thread	TH RR1 EH EH PA2 DD1
threaded	TH RR1 EH EH PA2 DD2 IH PA2 DD1
threader	TH RR1 EH EH PA2 DD2 ER1
threaders	TH RR1 EH EH PA2 DD2 ER1 ZZ
threading	TH RR1 EH EH PA2 DD2 IH NG
threads	TH RR1 EH EH PA2 DD2 ZZ
then	DH1 EH EH NN1
time	TT2 AA AY MM
times	TT2 AA AY MM ZZ
uncle	AX NG PA3 KK3 EL
whale	WW EY EL
whaler	WW EY LL ER1
whalers	WW EY LL ER1 ZZ
whales	WW EY EL ZZ
whaling	WW EY LL TH NG
year	YY2 YR
yes	YYS EH EH SS SS

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TABLE 2—EXAMPLES OF SPELLING IRREGULARITIES

	Same sound represented by different letters	Different sounds represented by the same letters
Vowels	mEAt fEEt pEte pEOple pennY	vEIn forEIgn dEIsm dEIcer gEIsha
Consonants	SHip tenSIon preCIous naTIon	althouGH GHastly couGH hiccouGH

TABLE 3—CONSONANT PHONEMES OF ENGLISH

		LABIAL	LABIO-DENTAL	INTER-DENTAL	ALVEO-LAR	PALATAL	VELAR	GLOTTAL
Stops:	Voiceless Voiced	PP BB			TT DD		KK GG	
Fricatives:	Voiceless Voiced	WH	FF VV	TH DH	SS ZZ	SH ZH*		HH
Affricates:	Voiceless Voiced					CH JH		
Nasals	Voiced	MM			NN		NG*	
Resonants	Voiced	WW			RR,LL	YY		

These do not occur in word-initial position in English.

Labial: Upper and Lower Lips Touch or Approximate
Labio-Dental: Upper Teeth and Lower Lip Touch
Inter-Dental: Tongue Between Teeth
Alveolar: Tip of Tongue Touches or Approximates Alveolar Ridge (just behind upper teeth)
Palatal: Body of Tongue Approximates Palate (roof of mouth)
Velar: Body of Tongue Touches Velum (posterior portion of roof of mouth)
Glottal: Glottis (opening between vocal cords)

TABLE 4—VOWEL PHONEMES OF ENGLISH

	FRONT	CENTRAL	BACK
High	YR IY IH*		UW# UH*#
Mid	EY EH* XR	ER AX*	OW# OY#
Low	AE*	AW# AY AR AA*	AO*# OR#

*SHORT VOWELS
#ROUNDED VOWELS

TABLE 5—GUIDELINES FOR USING THE ALLOPHONES

Silence

PA1	(10 ms)	—before BB, DD, GG and JH
PA2	(30 ms)	—before BB, DD, GG, and JH
PA3	(50 ms)	—before PP, TT, KK, and CH, and between words
PA4	(100 ms)	—between clauses and sentences
PA5	(200 ms)	—between clauses and sentences

Short Vowels

*/IH/	—sitting, stranded
*/EH/	—extent, gentlemen
*/AE/	—extract, acting
*/UH/	—cookie, full
*/AO/	—talking, song
*/AX/	—lapel, instruct
*/AA/	—pottery, cotton

Long Vowels

/IY/	—treat, people, penny
/EY/	—great, statment, tray
/AY/	—Kite, sky, mighty
/OY/	—noise, toy, voice
/UW1/	—after clusters with YY; computer
/UW2/	—in monosyllabic words: two, food
/OW/	—zone, close, snow
/AW/	—sound, mouse, down
/EL/	—little, angle, gentlemen

R-Colored Vowels

/ER1/	—letter, furniture, interrupt
/ER2/	—monosyllables: bird, fern, burn
/OR/	—fortune, adorn, store
/AR/	—farm, alarm, garment
/YR/	—hear, earring, irresponsible
/XR/	—hair, declare, stare

Resonants

/WW/	—we, warrant, linguist
/RR1/	—initial position: read, write, x-ray
/RR2/	—initial clusters: brown, crane, grease
/LL/	—like, hello, steel
/YY1/	—clusters: cute, beauty, yarn, yo-yo
/YY2/	—initial position: yes, yarn, yo-yo

Voiced Fricatives

/VV/	—vest, prove, even
/DH1/	—word-initial position: this, then, they
/DH2/	—word-final and between vowels: bathe, bathing
/ZZ/	—zoo, phase
/ZH/	—beige, pleasure

Voiceless Fricatives

*/FF/	—) These may be doubled for initial position and used singly in final position
*/TH/	—)
*/SS/	—)
/SH/	—shirt, leash, nation
/HH1/	—before front vowels, RY, IY, IH EY, EH, XR, AE
/HH2/	—before back vowels: UW, UH, OW, OY, AO, OR, AR
/WH/	—white, whim, twenty

Voiced Stops

/BB1/	—final position: rib; between vowels: fibber; —in clusters: bleed, brown
/BB2/	—initial position before a vowel: beast
/DD1/	—final position: played, end
/DD2/	—initial position: down; clusters: drain
/GG1/	—before high front vowels: YR, IY, IH, EY, EH, XR
/GG2/	—before high back vowels: UW, UH, OW, OY, AX; and —clusters; green, glue
/GG3/	—before low vowels: AE, AW, AY, AR, AA, AO, OR, ER; and —medial clusters: anger; and final position: peg

Voiceless Stops

/PP/	—pleasure, ample, trip
/TT1/	—final clusters before SS: tests, its
/TT2/	—all other positions: test, street
/KK1/	—before front vowels: YR, IY, IH, EY, EH, XR, AY, AE, ER, AX; —initial clusters: cute, clown, scream
/KK2/	—final position: speak; final clusters: task
/KK3/	—before back vowels: UW, UH, OW, OY, OR, AR, AQ; —initial clusters: crane, quick, clown, scream

Affricates

/CH/	—church, feature
/JH/	—judge, injure

Nasal

/MM/	—milk, alarm, ample
/NN/	—before front and central vowels: YR, IY, IH, EY, EH, XR, AE, ER, AX, AW, AY, UW; final clusters: earn
/NN2/	—before back vowels: UH, OW, OY, CR, AR, AA
/NG/	—string, anger

*These allophones can be doubled.

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TABLE 6—ALLOPHONE ADDRESS TABLE

OCTAL ADDRESS	ALLOPHONE	SAMPLE WORD	DURATION
000	PA1	PAUSE	10MS
001	PA2	PAUSE	30MS
002	PA3	PAUSE	50MS
003	PA4	PAUSE	100MS
004	PA5	PAUSE	200MS
005	/OY/	Boy	420MS
006	/AY/	Sky	260MS
007	/EH/	End	70Ms
010	/KK3/	Comb	120MS
011	/PP/	Pow	210MS
012	/JH/	Dodge	140MS
013	/NN1/	Thin	140MS
014	/IH/	Sit	70MS
015	/TT2/	to	140MS
016	/RR1/	Rural	170MS
017	/AX/	Succeed	70MS
020	/MM/	Milk	180MS
021	/TT1/	Part	100MS
022	/DH1/	They	290MS
023	/IY/	See	250MS
024	/EY/	Beige	280MS
025	/DD1/	Could	70MS
026	/UW1/	To	100MS
027	/AO/	Aught	100MS
030	/AA/	Hot	100MS
031	/YY2/	Yes	180MS
032	/AE/	Hat	120MS
033	/HH1/	He	130MS
034	/BB1	Business	80MS
035	/TH/	Thin	180MS
036	/UH/	Book	100MS
037	/UW2/	Food	260MS
040	/AW/	Out	370MS
041	/DD2/	Do	160MS
042	/GG3/	Wig	140MS
043	/VV/	Vest	190MS
044	/GG1/	Got	80MS
045	/SH/	Ship	160MS
046	/ZH/	Azure	190MS
047	/RR2/	Brain	120MS
050	/FF/	Food	150MS
051	/KK2/	Sky	190MS
052	/KK1/	Can't	160MS
053	/ZZ/	Zoo	210MS
054	/NG/	Anchor	220MS
055	/LL/	Lake	110MS
056	/WW/	Wool	180MS
057	/XR/	Repair	360MS
060	/WH/	Whig	200MS
061	/YY1/	yes	130MS
062	/CH/	Church	190MS
063	/ER1/	Fir	160MS
064	/ER2/	Fir	300MS
065	/OW/	Beau	240MS
066	/DH2/	They	240MS
067	/SS/	Vest	90MS
070	/NN2/	No	190MS
071	/HH2/	Hoe	180MS
072	/OR/	Store	330MS
073	/AR/	Alarm	290MS
074	/YR/	Clear	350MS
075	/GG2/	Guest	40MS
076	/EL/	Saddle	190MS
077	/BB2/	Business	50MS

RADIO CONTROL ELECTRONIC KIT 277-1012

GENERAL DESCRIPTION

This module was designed for radio control of cars, racers and boats. It can be operated in forward, forward with right turn, forward with left turn and backward. The carrier frequency is 27 MHz. The control commands are transmitted by tone pulse.

Forward—without carrier.
Forward W/right turn—carrier with 3000 Hz pulse modulation.
Forward W/left turn—carrier with 500 Hz pulse modulation.
Backward—carrier only.

There are some wires & external components that you need.
Please see External Component Requirements.

EXTERNAL COMPONENT REQUIREMENTS

Transmitter	Recommendations
Ant Transmitting antenna	0.5 meter (20 inch) length telescope antenna or steel wire.
S1 Functional switch for driving	Two poles, two throw switch (DPDT) (275-663)
S2 Functional switch for steering	Two poles, two throw switch with center off. (DPDT) (275-664)
Battery snap	For 006P 9V battery (270-325)
Receiver	**Recommendations**
Ant. Receiving antenna	0.3 meter (12 inch) length steel wire
M1 Steering motor	3V motor (Mabuchi motor RN-140-14180)
M2 Driving motor	3V motor (Mabuchi motor RE-280-2865)
S1 ON/OFF switch	2 poles, 2 throw slide switch (DPDT) (275-607)
Battery snap	For 006P 9V battery (270-325)
Battery holder	For two D cells 1.5V (270-386)

CONTROL INSTRUCTIONS

The receiver will respond to commands as follows:

Action	Command
Forward	ON/OFF switch of receiver is switched ON.
Forward and Right	Poles of functional switch S2 are at the "R" position
Forward and Left	Poles of functional switch S2 are at the "L" position
Backward	Poles of functional switch S1 are at the "B" position

Note: There are no steering functions while the car is being driven backward. If the system is out of command, please read the trouble shooting.

SIMPLE ADJUSTMENTS

1. Adjust L1 for best response to 27.145 MHz signal from a standard signal generator. Insert a 5 pF capacitor in series between the signal generator and receiver's antenna input.
2. Adjust L3 for maximum transmitter output power as indicated on a field strength meter.
3. Adjust L4 for proper transmitter oscillation as indicated by maximum reading on a field strength meter.

TROUBLESHOOTING

Trouble	Possible Cause	Solution
No function	Low battery voltage	Replace batteries
	Poor soldering	Checked soldering
	Wrong connection	Checked connection
	Corroded functional switch and ON/OFF switch.	Replace functional switch and ON/OFF switch
Insufficient control distance	Low battery voltage	Replace batteries
	Poor soldering for antenna	Checked soldering for antenna
	Length of antennas are not suitable	Replace with suitable antenna.

277-1012

ABSOLUTE MAXIMUM RATINGS

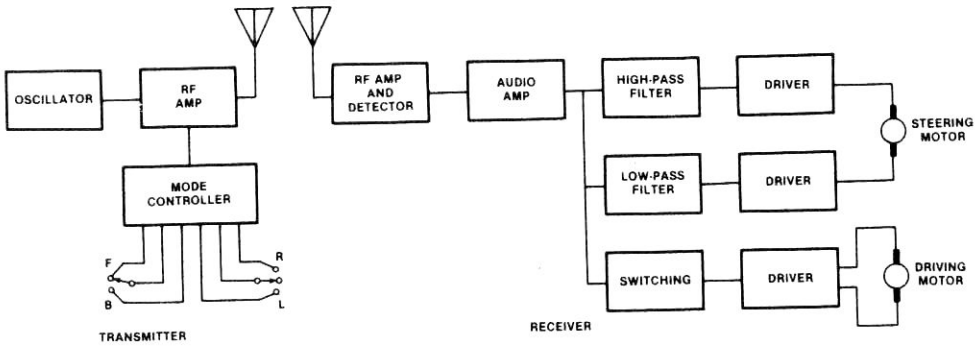
Transmitter

Frequency	27.145 MHz
Current	17mA
Operating Voltage	9V
Battery Life	10 Hours

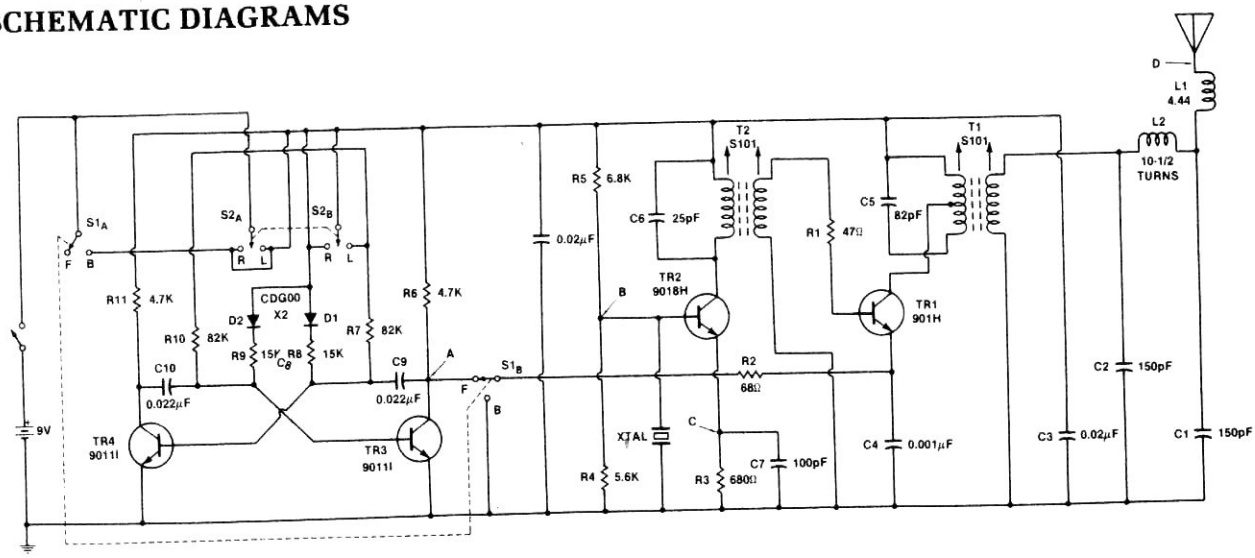
Receiver

Frequency	27.145 MHz
Current	12mA
Operating Voltage	9V

BLOCK DIAGRAM



SCHEMATIC DIAGRAMS



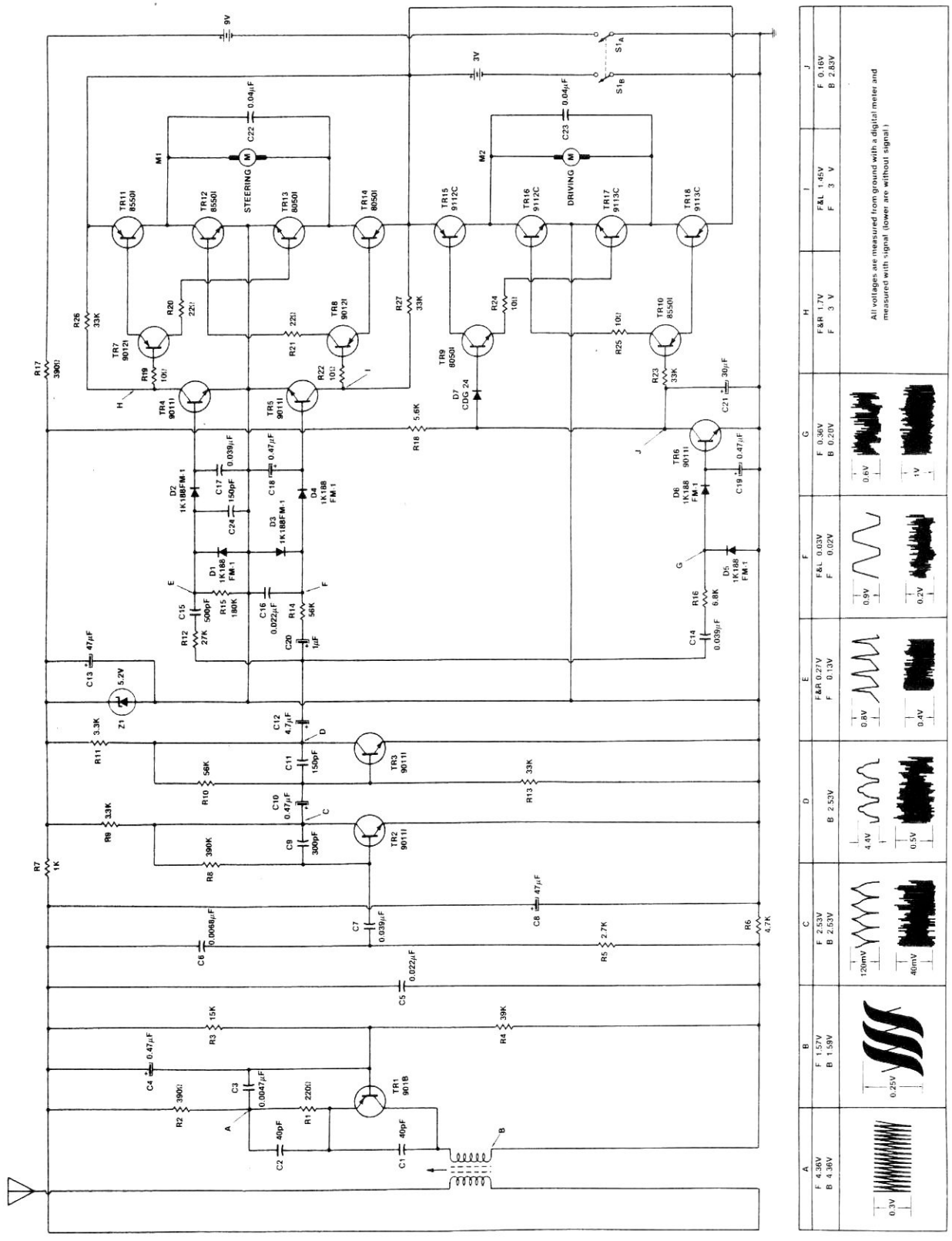
	A		B	C	D		
VOLTAGE	2.9V	2.3V	2.2V	4.0V	B = CARRIER	F&L = 500Hz	F&R = 3000Hz
WAVEFORM	5V	5V					

Note:All voltages are measured from ground with digital meter.

Transmitter

277-1012

SCHEMATIC DIAGRAMS (Cont'd)



UM1285-8 277-221 VHF MODULATOR

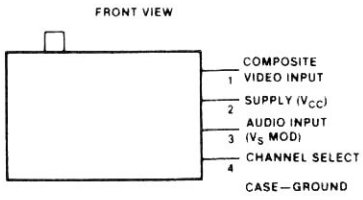
GENERAL DESCRIPTION

The UM1285-8 is a high performance intercarrier vestigial sideband modulator which is primarily intended for use in color TV games, home computer, graphics, teletext and view data adapters. The modulator has a very linear transfer characteristic which ensures good chroma levels and freedom from sync compression and associated frame and line jitter problems, good subcarrier inter modulation performance minimizes the on screen bar pattern due to chroma and sound subcarrier beats.

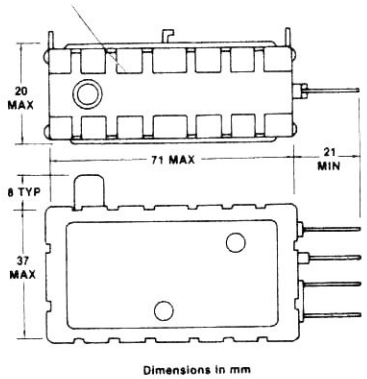
FEATURES

- Compact & low profile
- Rugged & stable
- Good modulation linearity
- Low chroma/sound beat product (55 dB typ)
- Pretuned vision carriers Ch 3, Ch 4
- Pretuned sound subcarrier 4.5 MHz
- Pretuned vestigial sideband filter
- Built-in voltage regulator
- Negative transfer characteristic
- For color application
- 75 ohm output from a standard phono socket

PIN CONNECTION



DIMENSIONAL DIAGRAM



Dimensions in mm

ABSOLUTE MAXIMUM RATINGS

Voltage between Pin 1, 3, 4, and Case Ground ..... – 3.0 to + 15 V
Voltage between Pin 3 and V_{CC} ..... – 3.0 to + 8.0 V
(Refer to table for high voltage application.)
Operating Temperature Range ..... 0 to + 45°C
Storage Temperature Range ..... – 20 to + 70°C

ELECTRICAL CHARACTERISTICS

V_{CC} ..... + 5.8 to 6.2 V
(Refer to table for higher supply voltage application.)
RF Output Load 75Ω
Channel 3 Video Carrier ..... 61.25 MHz
Channel 4 Video Carrier ..... 67.65 MHz
Sound Carrier ..... 4.500 MHz
Video Carrier output (Vmod = 2.2 V) ..... 1.5 mVrms
Video Carrier output (Vmod = 2.8 V) ..... 18 dB WRT V_O(HI)
Sound Carrier output ..... 22 dB WRT V_O(HI)
Spurious/Harmonic ..... 30 dB WRT V_O(HI)
Voltage Standing Wave Ratio (CH 3 and CH 4) 1.7
ΔF for Change in Temperature ..... ±10 kHz/°C
ΔF for Change in Temperature ..... ±750 Hz/°C
ΔF for 1 Volt Change in V_{CC} ..... ±30 kHz/V
ΔF for 1 Volt Change in V_{CC} ..... ±5 kHz/V
RF Output Impedance 75Ω
– 3DB Bandwidth (RF)
CH 3 ..... 14 MHz
CH 4 ..... 5.0 MHz
Supply Current ..... 30 mA
Frequency modulating ..... 8 kHz/Volt
Sensitivity Chroma/Sound Beat Level ..... 55 dB WRT V_O(HI)

TABLE

Supply Voltage V_{CC}	Volt	6.0	7.5	9.0	12.0	15.0
Series Resistor R_S	Ohm	0	47	100	180	270

Series resistor with respect to supply voltage

RF OUTPUT SOCKET

Phono Socket Typical Phono Plug

UM1285-5 277-221

TYPICAL CHARACTERISTICS

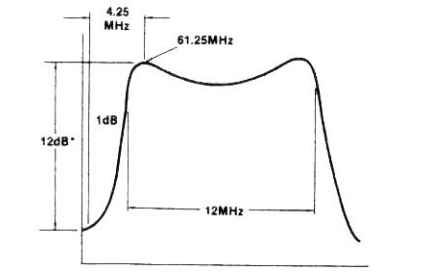
The UM1285-8 is designed to work over a wide range of supply voltage from 6 to 15 V (V_{CC}). A built-in 5.0 V (V_{DD}) voltage regulator is provided to achieve excellent stability against voltage change. A series resistor is recommended in putting between power source and modulator supply input for purpose of current limiting.

Modulation occurs when a positive going voltage is applied to the modulation input (video) pin. The transfer characteristic is negative, that means a positive input causes the RF output to decrease. Peak RF output is specified when the video input is at 2.2 V.

RF channel frequency of Ch 3 or Ch 4 can be selected by connecting channel select pin to ground level (0V) to have Ch 3, or open connection to have Ch 4.

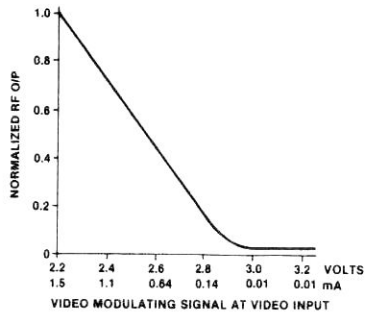
FCC APPROVABLE

The UM1285-8 is FCC approvable due to its very low radiation, stabilized carrier oscillators and vestigial side bank filter which ensures all side band components outside FCC limits are greater than 30 dB down.



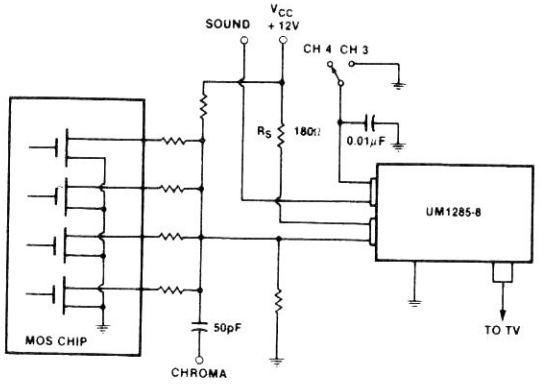
*Note: Subcarriers are > 18dB down wrt carrier at input to bandpass filter giving maximum out of band level of < – 30dB wrt carrier.

Typical Bandpass Filter Response

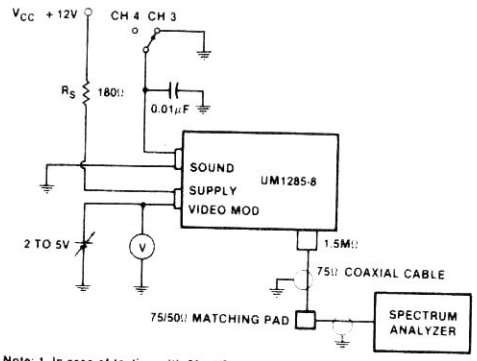


Typical Transfer Characteristic

TYPICAL APPLICATIONS



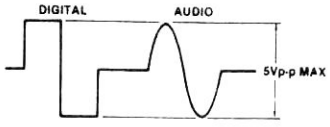
Typical Application



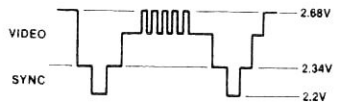
Note: 1. In case of testing with 50Ω I/P spectrum analyzer, matching pad 75/50Ω (attenuation 10dB) shound be employed.
2. Standard RF coaxial cable should be 1.5 meters long and 75Ω characteristic impedance.

Test Circuit

TYPICAL INPUT WAVEFORMS



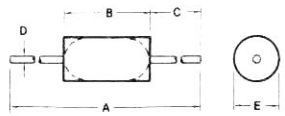
Sound I/P Setup



Modulated Input Voltage Setup

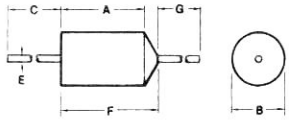
QUICK CASE REFERENCE

A1

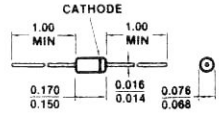


May show color bands to denote polarity.

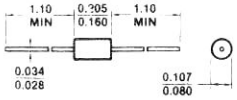
A3



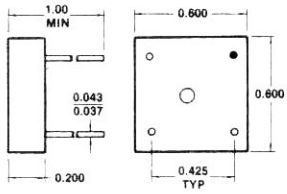
A4



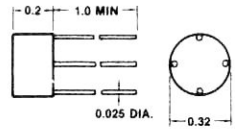
DO41



M532A

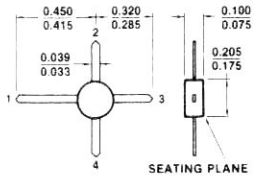


M548



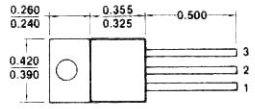
Positive: Red or Square Lead

MACRO-X



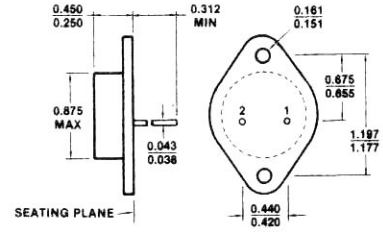
1-COLLECTOR
2-EMITTER
3-BASE
4-EMITTER

MU27



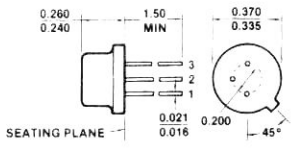
SCR	TRIAC
1-CATHODE	1-ANODE 1
2-ANODE	2-ANODE 2
3-GATE	3-GATE

TO3



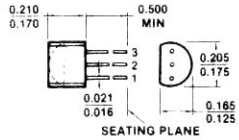
1-BASE
2-EMITTER
CASE-COLLECTOR

TO5



1-EMITTER
2-BASE
3-COLLECTOR

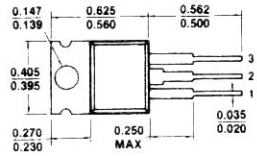
TO92



N-CHANNEL FET	UNIJUNCTION	BIPOLAR	BIPOLAR J★
1-SOURCE	1-BASE 1	1-EMITTER	1-EMITTER
2-GATE	2-EMITTER	2-BASE	2-COLLECTOR
3-DRAIN	3-BASE 2	3-COLLECTOR	3-BASE

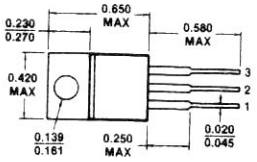
★Japanese device types

TO220



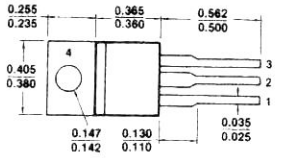
BIPOLAR	TRIAC
1-BASE	1-ANODE 1
2-COLLECTOR	2-ANODE 2
3-EMITTER	3-GATE

TO220AB



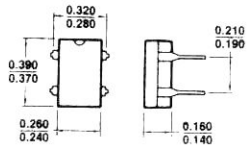
1-GATE
2-DRAIN
3-SOURCE

TO220AB-2

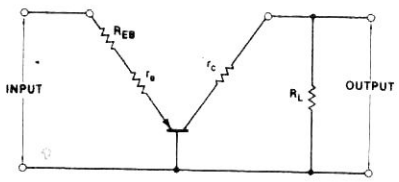


1-BASE
2-COLLECTOR
3-EMITTER
4-COLLECTOR

Y1



USEFUL INFORMATION



Parameters of Common-Base Circuit

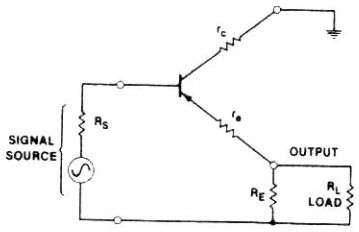
Input Impedance $Z_{in} = r_{tr}$

Load Impedance $Z_L = R_L$ in parallel with input impedance of following stage.

Current Gain $A_i = \alpha = \frac{\beta}{1 + \beta}$

(In practice, α is 0.95 to 0.995, or approximately 1.)

Voltage Gain $A_v \approx \frac{Z_L}{r_{tr}} = g_m Z_L$



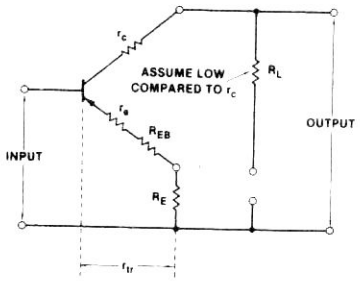
Parameters of Common-Collector Circuit

Input Impedance $Z_{in} = (\beta + 1)Z_L$
where,
Z_L is R_L in parallel with R_E.

Output Impedance $Z_{out} = \frac{R_s}{\beta + 1}$
where,
R_s is the output impedance of the signal source.

Current Amplification $A_i \approx \beta$

Voltage Amplification A_v = Less than unity



Parameters of Common-Emitter Circuit

Input Impedance $Z_{in} = h_{fe} r_{tr}$

Load Impedance $Z_L = R_L$ in parallel with input impedance of next stage.

Current Gain $A_i = \frac{\Delta I_C}{\Delta I_B} = h_{fe}$
where,

$$h_{fe} = \beta = \frac{I_c}{I_b} = \frac{\alpha}{1 - \alpha}$$

Voltage Gain $A_v = \frac{\Delta V_C}{\Delta V_B} = \frac{Z_L}{r_{tr}} = g_m Z_L$

Power Gain $A_p = \frac{V_{out} I_{out}}{V_{in} I_{in}} = \beta \frac{Z_L}{r_{tr}}$

IMPORTANT SUGGESTIONS ON THE USE AND REPLACEMENT OF TRANSISTORS

You can use various styles and sizes of transistors in any given circuit application, as long as the electrical characteristics of the device are within the required range of operation. Thus, a tab-type device can be used to replace a TO-3 or TO-66 case device; or a small epoxy-type device can be used in place of TO-5 or other size transistor.

Generally speaking, you must observe the following maximum characteristics of a transistor when contemplating substitution or selection:

Power dissipation
Maximum collector current
Maximum collector-to-emitter voltage
Maximum collector-to-base voltage
Maximum emitter-to-base voltage

Also, it is useful to consider the following characteristics for actual circuit operation:

Gain
Frequency limitations

Caution: It may be necessary in some cases to adjust bias values to achieve required operation. With tuned circuits, it is a good practice to check alignment after replacing any transistor.

When replacing power transistors, always check driver devices to be sure they are OK. Also, check other circuit components to be sure they were not shorted (or otherwise defective) when the original device failed. If you fail to correct such problems before applying power to the circuit once again, the replacement transistor could easily be permanently damaged. Be sure to use proper heat-sink precautions and use silicon grease to reduce the thermal resistance between the case of the transistor and the heat-sink.

Always observe temperature limitations as specified with transistor ratings.

It almost goes without saying, but let us remind you anyway—

Always observe voltage polarity with all semiconductor devices.

CROSS-REFERENCE/SUBSTITUTION LISTING

Most users of semiconductors realize that it is almost impossible to guarantee absolute equivalents (as in the case of tubes). Thus, the only way to create replacement or cross-reference listings is by carefully evaluating each characteristic of both devices (original transistor and the possible alternate). This is how the Technical Staff of Radio Shack went about preparing the following cross-reference/replacement lists.

IMPORTANT NOTE

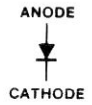
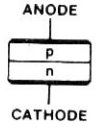
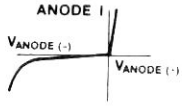
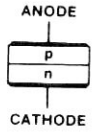
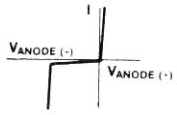
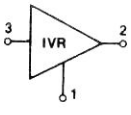
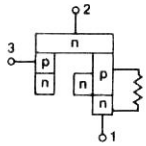
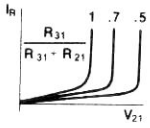
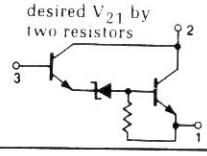
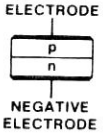
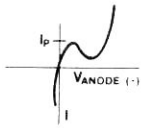
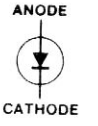
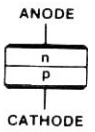
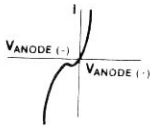
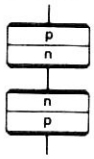
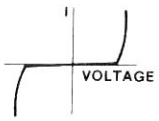
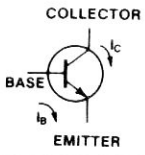
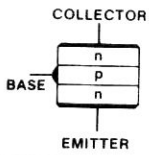
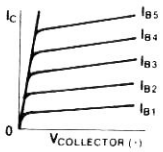
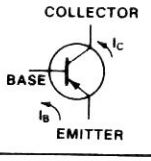
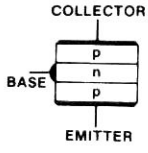
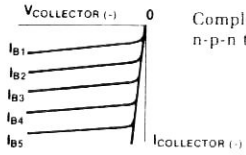
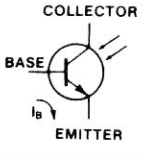
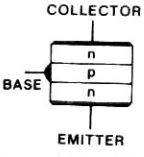
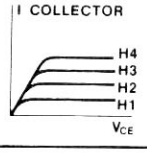
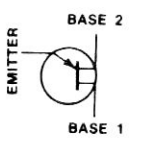
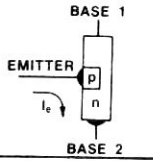
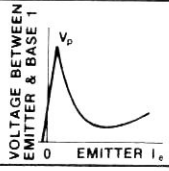
We caution you that in many cases the listed cross reference ARCHER device may be different in appearance, size or mounting style. Thus, before beginning replacement or installation procedures, check to be sure you have enough room for proper mounting.

Also, when making substitutions or replacements in radio or high frequency circuitry, it may be necessary to realign tunable circuit elements. This is true even when making **exact** replacements (junction capacitances normally vary between devices even from the same production run).

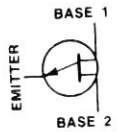
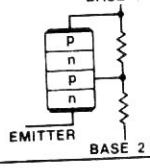
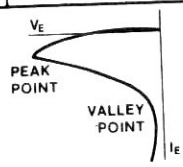
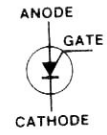
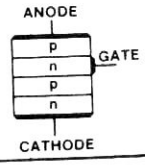
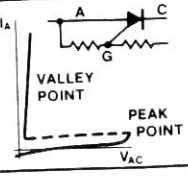
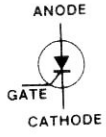
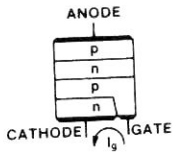
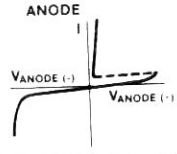
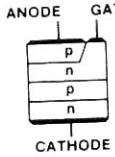
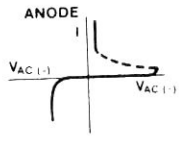
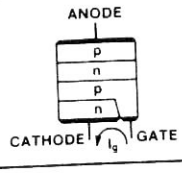
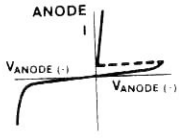
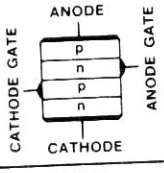
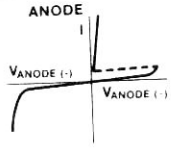
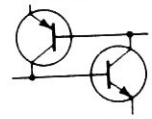
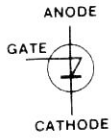
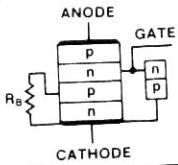
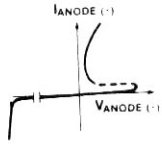
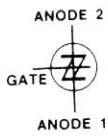
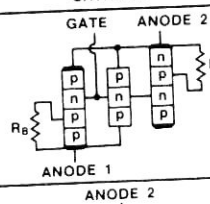
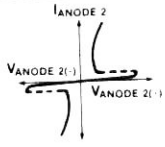
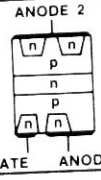
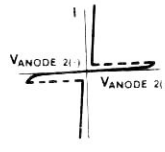
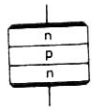
Information contained in this guide is based on the latest available data and is believed to be accurate. Every care has been taken to assure technical accuracy. However, Radio Shack does not assume responsibility for any contingencies of the use of this information. Nor does Radio Shack assume any responsibility for any infringements of patents or other rights of third parties which may result from its use.

When you are looking for a specific number and it does not show up in the following listing—refer to the technical data provided for our line of ARCHER devices. With this information you probably will be able to make a suitable substitution.

MAJOR SEMICONDUCTOR COMPONENTS

NAME OF DEVICE	CIRCUIT SYMBOL	COMMONLY USED JUNCTION SCHEMATIC	ELECTRICAL CHARACTERISTICS		MAX RATINGS AVAILABLE	MAJOR APPLICATIONS	ROUGHLY ANALOGOUS TO:
Diode or Rectifier				Conducts easily in one direction, blocks in the other	1500 Amps 3000 Volts	Rectification Blocking Detecting Steering	Check valve Diode tube Gas diode
Avalanche (Zener) Diode				Constant voltage characteristic in negative quadrant	22 Volts 1 Watt	Regulation Reference Clipping	V-R tube
Integrated Voltage Regulator (IVR)				Programmed to desired V_{21} by two resistors 	40 Volts 100 mA 0.4 Watts	Shunt voltage regulator Reference element Error modifier Level sensing Level shifting	Avalanche Diode
Tunnel Diode				Displays negative resistance when current exceeds peak point current I_p	Peak point current = 100 mA Resistive cutoff freq. = 40 Gc	UHF converter Logic circuits Microwave circuits Level sensing	None
Back Diode				Similar characteristics to conventional diode except very low forward voltage drop	5 mA 400 mV	Microwave mixers and low power oscillators	None
Thyrector				Rapidly increasing current above rated voltage in either direction	70 A peak pulse (2" Sq. cell)	Transient voltage suppression and arc suppression	Thyrite Two avalanche diodes in inverse-series connection
n-p-n Transistor				Constant collector current for given base drive	300 Volts 25 Watts	Amplification Switching Oscillation	Pentode Tube
p-n-p Transistor				Complement to n-p-n transistor	75 Volts 25 Watts	Amplification Switching Oscillation	None
Photo Transistor				Incident light acts as base current of the photo transistor	45 Volts 0.25 Amps 0.6 Watts	Tape readers Card readers Position sensor Tachometers	None
Unijunction Transistor (UJT)				Unijunction emitter blocks until its voltage reaches V_p; then conducts	35 Volts 0.450 Watts	Interval timing Oscillation Level Detector SCR Trigger	None

MAJOR SEMICONDUCTOR COMPONENTS

NAME OF DEVICE	CIRCUIT SYMBOL	COMMONLY USED JUNCTION SCHEMATIC	ELECTRICAL CHARACTERISTICS	MAX RATINGS AVAILABLE	MAJOR APPLICATIONS	ROUGHLY ANALOGOUS TO:
Complementary Unijunction Transistor (CUJT)			 Functional complement to UJT	30 Volts 0.30 Watts 0.15 Amps	High stability timers Oscillators and level detectors	None
Programmable Unijunction Transistor (PUT)			 Programmed by two resistors for V_p, I_p, I_v. Function equivalent to normal UJT.	40 Volts 0.30 Watts 0.15 Amps	Low cost timers and oscillators Long period timers SCR trigger Level detector	UJT
Silicon Controlled Rectifier (SCR)			 With anode voltage (+), SCR can be triggered by I_g, remaining in conduction until anode I is reduced to zero	1000 Amps 1800 Volts	Power switching Phase control Inverters Choppers	Gas thyratron or ignitron
Complementary Silicon Controlled Rectifier (CSCR)			 Polarity complement to SCR	50 Volts 0.25 Amps 0.45 Watts	Ring counters Low speed logic Lamp driver	None
Light Activated SCR* (LASCR)			 Operates similar to SCR, except can also be triggered into conduction by light falling on junctions	1.6 Amps 200 Volts	Relay Replacement Position controls Photoelectric applications Slave flashes	None
Silicon Controlled Switch* (SCS)			 Operates similar to SCR except can also be triggered on by a negative signal on anode-gate. Also several other specialized modes of operation	100 Volts 200 mA	Logic applications Counters Nixie drivers Lamp drivers	Complementary transistor pair 
Silicon Unilateral Switch (SUS)			 Similar to SCS but zener added to anode gate to trigger device into conduction at ~ 8 volts. Can also be triggered by negative pulse at gate lead.	0.350 Watts 0.200 Amps 10 Volts	Switching Circuits Counters SCR Trigger Oscillator	Shockley or 4-layer diode
Silicon Bilateral Switch (SBS)			 Symmetrical bilateral version of the SUS. Breaks down in both directions as SUS does in forward.	0.350 Watts 0.200 Amps 10 Volts	Switching Circuits Counters TRIAC Phase Control	Two inverse Schockley diodes
Triac			 Operates similar to SCR except can be triggered into conduction in either direction by (+) or (-) gate signal	25 Amps 500 Volts	AC switching Phase control Relay replacement	Two SCR's in inverse parallel
Diac Trigger			 When voltage reaches trigger level (about 35 volts), abruptly switches down about 10 volts.	40 Volts 2 Amps peak	Triac and SCR trigger Oscillator	Neon lamp

*Light Activated SCS also available.

GLOSSARY OF WORDS, SYMBOLS AND ABBREVIATIONS

The following letter symbols and abbreviations are recommended by the Joint Electron Device Engineering Council (JEDEC) of the Electronic Industries Association (EIA) and the National Electrical Manufacturers Association (NEMA) for use in semiconductor device data sheets and specifications.

A, a —Anode
B, b —Base
$\mathbf{b}_{fs}$ —Common-source small-signal forward transfer susceptance
$\mathbf{b}_{is}$ —Common-source small-signal input susceptance
$\mathbf{b}_{os}$ —Common-source small-signal output susceptance
$\mathbf{b}_{rs}$ —Common-source small-signal reverse transfer susceptance
C, c —Collector
$\mathbf{C}_{cb}$ —Collector-base interterminal capacitance
$\mathbf{C}_{ce}$ —Collector-emitter interterminal capacitance
$\mathbf{C}_{ds}$ —Drain-source capacitance
$\mathbf{C}_{du}$ —Drain-substrate capacitance
$\mathbf{C}_{eb}$ —Emitter-base interterminal capacitance
$\mathbf{C}_{ibo}$ —Common-base open-circuit input capacitance
$\mathbf{C}_{ibs}$ —Common-base short-circuit input capacitance
$\mathbf{C}_{ieo}$ —Common-emitter open-circuit input capacitance
$\mathbf{C}_{ies}$ —Common-emitter short-circuit input capacitance
$\mathbf{C}_{iss}$ —Common-source short-circuit input capacitance
$\mathbf{C}_{obo}$ —Common-base open-circuit output capacitance
$\mathbf{C}_{obs}$ —Common-base short-circuit output capacitance
$\mathbf{C}_{oeo}$ —Common-emitter open-circuit output capacitance
$\mathbf{C}_{oes}$ —Common-emitter short-circuit output capacitance
$\mathbf{C}_{oss}$ —Common-source short-circuit output capacitance
$\mathbf{C}_{rbs}$ —Common-base short-circuit reverse transfer capacitance
$\mathbf{C}_{rcs}$ —Common-collector short-circuit reverse transfer capacitance
$\mathbf{C}_{res}$ —Common-emitter short-circuit reverse transfer capacitance
$\mathbf{C}_{rss}$ —Common-source short-circuit reverse transfer capacitance
$\mathbf{C}_{tc}$ —Collector depletion-layer capacitance
$\mathbf{C}_{te}$ —Emitter depletion-layer capacitance
D, d —Drain
E, e —Emitter
η —Intrinsic standoff ratio
$\mathbf{f}_{hfb}$ —Common-base small-signal short-circuit forward current transfer ratio cutoff frequency
$\mathbf{f}_{hfc}$ —Common-collector small-signal short-circuit forward current transfer ratio cutoff frequency
$\mathbf{f}_{hfe}$ —Common-emitter small-signal short-circuit forward current transfer ratio cutoff frequency
$\mathbf{f}_{max}$ —Maximum frequency of oscillation
$\mathbf{F}_T$ —Transition frequency (frequency at which common-emitter small-signal forward current transfer ratio extrapolates to unity)
G, g —Gate
$\mathbf{g}_{fs}$ —Common-source small-signal forward transfer conductance
$\mathbf{g}_{is}$ —Common-source small-signal input conductance
$\mathbf{g}_{MB}$ —Common-base static transconductance
$\mathbf{g}_{MC}$ —Common-collector static transconductance
$\mathbf{g}_{ME}$ —Common-emitter static transconductance
$\mathbf{g}_{os}$ —Common-source small-signal output conductance
$\mathbf{G}_{PB}$ —Common-base large-signal insertion power gain
$\mathbf{G}_{pb}$ —Common-base small-signal insertion power gain
$\mathbf{G}_{PC}$ —Common-collector large-signal insertion power gain
$\mathbf{G}_{pc}$ —Common-collector small-signal insertion power gain
$\mathbf{G}_{PE}$ —Common-emitter large-signal insertion power gain
$\mathbf{G}_{pe}$ —Common-emitter small-signal insertion power gain
$\mathbf{G}_{pg}$ —Common-gate small-signal insertion power gain
$\mathbf{G}_{ps}$ —Common-source small-signal insertion power gain
$\mathbf{g}_{rs}$ —Common-source small-signal reverse transfer conductance
$\mathbf{G}_{TB}$ —Common-base large-signal transducer power gain
$\mathbf{G}_{tb}$ —Common-base small-signal transducer power gain
$\mathbf{G}_{TC}$ —Common-collector large-signal transducer power gain
$\mathbf{G}_{tc}$ —Common-collector small-signal transducer power gain
$\mathbf{G}_{TE}$ —Common-emitter large-signal transducer power gain
$\mathbf{G}_{te}$ —Common-emitter small-signal transducer power gain
$\mathbf{G}_{tg}$ —Common-gate small-signal transducer power gain
$\mathbf{G}_{ts}$ —Common-source small-signal transducer power gain
$\mathbf{h}_{FB}$ —Common-base static forward current transfer ratio
$\mathbf{h}_{fb}$ —Common-base small-signal short-circuit forward current transfer ratio
$\mathbf{h}_{FC}$ —Common-collector static forward current transfer ratio
$\mathbf{h}_{fc}$ —Common-collector small-signal short-circuit forward current transfer ratio
$\mathbf{h}_{FE}$ —Common-emitter static forward current transfer ratio
$\mathbf{h}_{fe}$ —Common-emitter small-signal short-circuit forward current transfer ratio
$\mathbf{h}_{FEL}$ —Inherent large-signal forward current transfer ratio
$\mathbf{h}_{IB}$ —Common-base static input resistance
$\mathbf{h}_{ib}$ —Common-base small-signal short-circuit input impedance
$\mathbf{h}_{IC}$ —Common-collector static input resistance
$\mathbf{h}_{ic}$ —Common-collector small-signal short-circuit input impedance
$\mathbf{h}_{IE}$ —Common-emitter static input resistance
$\mathbf{h}_{ie}$ —Common-emitter small-signal short-circuit input impedance
$\mathbf{h}_{ie(imag)}$—Imaginary part of common-emitter small-signal short-circuit input impedance
$\mathbf{h}_{ie(real)}$ —Real part of common-emitter small-signal short-circuit input impedance
$\mathbf{h}_{ob}$ —Common-base small-signal open-circuit output admittance
$\mathbf{h}_{oc}$ —Common-collector small-signal open-circuit output admittance
$\mathbf{h}_{oe}$ —Common-emitter small-signal open-circuit output admittance
$\mathbf{h}_{oe(imag)}$—Imaginary part of common-emitter small-signal open-circuit output admittance

$\mathbf{h_{oe(real)}}$ —Real part of common-emitter small-signal open-circuit output admittance

$\mathbf{h_{rb}}$ —Common-base small-signal open-circuit reverse voltage transfer ratio

$\mathbf{h_{rc}}$ —Common-collector small-signal open-circuit reverse voltage transfer ratio

$\mathbf{h_{re}}$ —Common-emitter small-signal open-circuit reverse voltage transfer ratio

$\mathbf{I_B}$ —Base-terminal dc current

$\mathbf{I_b}$ —Alternating component (rms value) of base-terminal current

$\mathbf{i_B}$ —Instantaneous total value of base-terminal current

$\mathbf{I_{BEV}}$ —Base cutoff current, dc

$\mathbf{I_{B2(mod)}}$ —Interbase modulated current

$\mathbf{I_C}$ —Collector-terminal dc current

$\mathbf{I_c}$ —Alternating component (rms value) of collector-terminal current

$\mathbf{i_C}$ —Instantaneous total value of collector-terminal current

$\mathbf{I_{CBO}}$ —Collector cutoff current (dc), emitter open

$\mathbf{I_{CEO}}$ —Collector cutoff current (dc), base open

$\mathbf{I_{CER}}$ —Collector cutoff current (dc), specified resistance between base and emitter

$\mathbf{I_{CES}}$ —Collector cutoff current (dc), base shorted to emitter

$\mathbf{I_{CEV}}$ —Collector cutoff current (dc), specified voltage between base and emitter

$\mathbf{I_{CEX}}$ —Collector cutoff current (dc), specified circuit between base and emitter

$\mathbf{I_D}$ —Drain current, dc

$\mathbf{I_{D(off)}}$ —Drain cutoff current

$\mathbf{I_{D(on)}}$ —On-state drain current

$\mathbf{I_{DSS}}$ —Zero-gate-voltage drain current

$\mathbf{I_E}$ —Emitter-terminal dc current

$\mathbf{I_e}$ —Alternating component (rms value) of emitter-terminal current

$\mathbf{i_E}$ —Instantaneous total value of emitter-terminal current

$\mathbf{I_{EBO}}$ —Emitter cutoff current (dc), collector open

$\mathbf{I_{EB20}}$ —Emitter reverse current

$\mathbf{I_{EC(ofs)}}$ —Emitter-collector offset current

$\mathbf{I_{ECS}}$ —Emitter cutoff current (dc), base short-circuited to collector

$\mathbf{I_{E1E2(off)}}$ —Emitter cutoff current

$\mathbf{I_F}$ —For voltage-regulator and voltage-reference diodes: dc forward current. For signal diodes and rectifier diodes: dc forward current (no alternating component)

$\mathbf{I_f}$ —Alternating component of forward current (rms value)

$\mathbf{i_F}$ —Instantaneous total forward current

$\mathbf{I_{F(AV)}}$ —Forward current, dc (with alternating component)

$\mathbf{I_{FM}}$ —Maximum (peak) total forward current

$\mathbf{I_{F(OV)}}$ —Forward current, overload

$\mathbf{I_{FRM}}$ —Maximum (peak) forward current, repetitive

$\mathbf{I_{F(RMS)}}$ —Total rms forward current

$\mathbf{I_{FSM}}$ —Maximum (peak) forward current, surge

$\mathbf{I_G}$ —Gate current, dc

$\mathbf{I_{GF}}$ —Forward gate current

$\mathbf{I_{GR}}$ —Reverse gate current

$\mathbf{I_{GSS}}$ —Reverse gate current, drain short-circuited to source

$\mathbf{I_{GSSF}}$ —Forward gate current, drain short-circuited to source

$\mathbf{I_{GSSR}}$ —Reverse gate current, drain short-circuited to source

$\mathbf{I_I}$ —Inflection-point current

$\mathbf{Im(h_{ie})}$—Imaginary part of common-emitter small-signal short-circuit input impedance

$\mathbf{Im(h_{oe})}$—Imaginary part of common-emitter small-signal open-circuit output admittance

$\mathbf{I_O}$ —Average forward current, 180° conduction angle, 60-Hz half sine wave

$\mathbf{I_P}$ —Peak-point current

$\mathbf{I_R}$ —For voltage-regulator and voltage-reference diodes: dc reverse current. For signal diodes and rectifier diodes: dc reverse current (no alternating component)

$\mathbf{I_r}$ —Alternating component of reverse current (rms value)

$\mathbf{i_R}$ —Instantaneous total reverse current

$\mathbf{I_{R(AV)}}$—Reverse current, dc (with alternating component)

$\mathbf{I_{RM}}$ —Maximum (peak) total reverse current

$\mathbf{I_{RRM}}$ —Maximum (peak) reverse current, repetitive

$\mathbf{I_{R(RMS)}}$ —Total rms reverse current

$\mathbf{I_{RSM}}$ —Maximum (peak) surge reverse current

$\mathbf{I_S}$ —Source current, dc

$\mathbf{I_{SDS}}$ —Zero-gate-voltage source current

$\mathbf{I_{S(off)}}$ —Source cutoff current

$\mathbf{I_V}$ —Valley-point current

$\mathbf{I_Z}$ —Regulator current, reference current (dc)

$\mathbf{I_{ZK}}$ —Regulator current, reference current (dc near breakdown knee)

$\mathbf{I_{ZM}}$ —Regulator current, reference current (dc maximum rated current)

K, k —Cathode

$\mathbf{L_c}$ —Conversion loss

M —Figure of merit

$\mathbf{NF_o}$ —Overall noise figure

$\mathbf{NR_o}$ —Output noise ratio

$\mathbf{P_{BE}}$ —Power input (dc) to base, common emitter

$\mathbf{p_{BE}}$ —Instantaneous total power input to base, common emitter

$\mathbf{P_{CB}}$ —Power input (dc) to collector, common base

$\mathbf{p_{CB}}$ —Instantaneous total power input to collector, common base

$\mathbf{P_{CE}}$ —Power input (dc) to collector, common emitter

$\mathbf{p_{CE}}$ —Instantaneous total power input to collector, common emitter

$\mathbf{P_{EB}}$ —Power input (dc) to emitter, common base

$\mathbf{p_{EB}}$ —Instantaneous total power input to emitter, common base

$\mathbf{P_F}$ —Forward power dissipation, dc (no alternating component)

$\mathbf{p_F}$ —Instantaneous total forward power dissipation

$\mathbf{P_{F(AV)}}$—Forward power dissipation, dc (with alternating component)

$\mathbf{P_{FM}}$ —Maximum (peak) total forward power dissipation

$\mathbf{P_{IB}}$ —Common-base large-signal input power

$\mathbf{p_{ib}}$ —Common-base small-signal input power

$\mathbf{P_{IC}}$ —Common-collector large-signal input power

$\mathbf{p_{ic}}$ —Common-collector small-signal input power

$\mathbf{P_{IE}}$ —Common-emitter large-signal input power

$\mathbf{p_{ie}}$ —Common-emitter small-signal input power

$\mathbf{P_{OB}}$ —Common-base large-signal output power

$\mathbf{p_{ob}}$ —Common-base small-signal output power

$\mathbf{P_{OC}}$ —Common-collector large-signal output power

$\mathbf{p_{oc}}$ —Common-collector small-signal output power

$\mathbf{P_{OE}}$ —Common-emitter large-signal output power

$\mathbf{p_{oe}}$ —Common-emitter small-signal output power

$\mathbf{P_R}$ —Reverse power dissipation, dc (no alternating component)

$\mathbf{p_R}$ —Instantaneous total reverse power dissipation

$\mathbf{P_{R(AV)}}$—Reverse power dissipation, dc (with alternating component)

P_{RM} —Maximum (peak) total reverse power dissipation
P_T —Total nonreactive power input to all terminals
p_T —Nonreactive power input, instantaneous total, to all terminals
Q_S —Stored charge
r_{BB} —Interbase resistance
$r_b'C_c$ —Collector-base time constant
$r_{CE(sat)}$ —Saturation resistance, collector-to-emitter
$r_{DS(on)}$ —Static drain-source on-state resistance
$r_{ds(on)}$ —Small-signal drain-source on-state resistance
$\mathbf{Re(h_{ie})}$—Real part of common-emitter small-signal short-circuit input impedance
$\mathbf{Re(h_{oe})}$—Real part of common-emitter small-signal open-circuit output admittance
$r_{e1e2(on)}$—Small-signal emitter-emitter on-state resistance
r_j —Dynamic resistance at inflection point
R_θ —Thermal resistance
$R_{\theta CA}$ —Thermal resistance, case to ambient
$R_{\theta JA}$ —Thermal resistance, junction to ambient
$R_{\theta JC}$ —Thermal resistance, junction to case
S, s —Source
T_A —Ambient temperature or free-air temperature
T_C —Case temperature
t_d —Delay time
$t_{d(off)}$ —Turn-off delay time
$t_{d(on)}$ —Turn-on delay time
t_f —Fall time
t_{fr} —Forward recovery time
T_j —Junction temperature
t_{off} —Turn-off time
t_{on} —Turn-on time
t_p —Pulse time
t_r —Rise time
t_{rr} —Reverse recovery time
t_s —Storage time
TSS —Tangential signal sensitivity
T_{stg} —Storage temperature
t_w —Pulse average time
U, u —Bulk (substrate)
V_{BB} —Base supply voltage (dc)
V_{BC} —Average or dc voltage, base to collector
V_{bc} —Instantaneous value of alternating component of base-collector voltage
V_{BE} —Average or dc voltage, base to emitter
v_{be} —Instantaneous value of alternating component of base-emitter voltage
$V_{(BR)}$ —Breakdown voltage (dc)
$v_{(BR)}$ —Breakdown voltage (instantaneous total)
$V_{(BR)CBO}$ —Collector-base breakdown voltage, emitter open
$V_{(BR)CEO}$ —Collector-emitter breakdown voltage, base open
$V_{(BR)CER}$ —Collector-emitter breakown voltage, resistance between base and emitter
$V_{(BR)CES}$ —Collector-emitter breakdown voltage, base shorted to emitter
$V_{(BR)CEV}$ —Collector-emitter breakdown voltage, specified voltage between base and emitter
$V_{(BR)CEX}$ —Collector-emitter breakdown voltage, specified circuit between base and emitter
$V_{(BR)EBO}$ —Emitter-base breakdown voltage, collector open
$V_{(BR)ECO}$ —Emitter-collector breakdown voltage, base
$V_{(BR)E1E2}$ —Emitter-emitter breakdown voltage
$V_{(BR)GSS}$ —Gate-source breakdown voltage
$V_{(BR)GSSF}$—Forward gate-source breakdown voltage
$V_{(BR)GSSR}$—Reverse gate-source breakdown voltage
V_{B2B1} —Interbase voltage
V_{CB} —Average or dc voltage, collector to base
v_{cb} —Instantaneous value of alternating component of collector-base voltage
$V_{CB(fl)}$ —Collector-base dc open-circuit voltage (floating potential)
V_{CBO} —Collector-base voltage, dc, emitter open
V_{CC} —Collector supply voltage (dc)
V_{CE} —Average or dc voltage, collector to emitter
v_{ce} —Instantaneous value of alternating component of collector-emitter voltage
$V_{CE(fl)}$—Collector-emitter dc open-circuit voltage (floating potential)
V_{CEO} —Collector-emitter voltage (dc), base open
$V_{CE(ofs)}$ —Collector-emitter offset voltage
V_{CER} —Collector-emitter voltage (dc), resistance between base and emitter
V_{CES} —Collector-emitter voltage (dc), base shorted to emitter
$V_{CE(sat)}$ —Collector-emitter dc saturation voltage
V_{CEV} —Collector-emitter voltage (dc), specified voltage between base and emitter
V_{CEX} —Collector-emitter voltage (dc), specified circuit between base and emitter
V_{DD} —Drain supply voltage (dc)
V_{DG} —Drain-gate voltage
V_{DS} —Drain-source voltage
$V_{DS(on)}$ —Drain-source on-state voltage
V_{DU} —Drain-substrate voltage
V_{EB} —Average or dc voltage, emitter to base
v_{eb} —Instantaneous value of alternating component of emitter-base voltage
$V_{EB(fl)}$—Emitter-base dc open-circuit voltage (floating potential)
V_{EBO} —Emitter-base voltage (dc), collector open
$V_{EB1(sat)}$—Emitter saturation voltage
V_{EC} —Average or dc voltage, emitter to collector
v_{ec} —Instantaneous value of alternating component of emitter-collector voltage
$V_{EC(fl)}$—Emitter-collector dc open-circuit voltage (floating potential)
$V_{EC(ofs)}$—Emitter-collector offset voltage
V_{EE} —Emitter supply voltage (dc)
V_F —For voltage-regulator and voltage-reference diodes: dc forward voltage. For signal diodes and rectifier diodes: dc forward voltage (no alternating component)
V_f —Alternating component of forward voltage (rms value)
V_F —Instantaneous total forward voltage
$V_{F(AV)}$—Forward voltage, dc (with alternating component)
V_{FM} —Maximum (peak) total forward voltage
$V_{F(RMS)}$—Total rms forward voltage
V_{GG} —Gate supply voltage (dc)
V_{GS} —Gate-source voltage
V_{GSF} —Forward gate-source voltage
$V_{GS(off)}$ —Gate-source cutoff voltage
V_{GSR} —Reverse gate-source voltage
$V_{GS(th)}$ —Gate-source threshold voltage
V_{GU} —Gate-substrate voltage
V_I —Inflection-point voltage
V_{OB1} —Base-1 peak voltage
V_P —Peak-point voltage
V_{PP} —Projected peak-point voltage
V_R —For voltage-regulator and voltage-reference diodes: dc reverse voltage. For signal diodes and rectifier diodes: dc reverse voltage (no alternating component)
V_r —Alternating component of reverse voltage (rms value)

v_R —Instantaneous total reverse voltage
$V_{R(AV)}$ —Reverse voltage, dc (with alternating component)
V_{RM} —Maximum (peak) total reverse voltage
V_{RRM} —Repetitive peak reverse voltage
$V_{R(RMS)}$—Total rms reverse voltage
V_{RSM} —Nonrepetitive peak reverse voltage
V_{RT} —Reach-through voltage
V_{RWM}—Working peak reverse voltage
V_{SS} —Source supply voltage (dc)
V_{SU} —Source-substrate voltage
$V_{(TO)}$ —Threshold voltage
V_V —Valley-point voltage
V_Z —Regulator voltage, reference voltage (dc)
V_{ZM} —Regulator voltage, reference voltage (dc at maximum rated current)
y_{fb} —Common-base small-signal short-circuit forward transfer admittance
y_{fc} —Common-collector small-signal short-circuit forward transfer admittance
y_{fe} —Common-emitter small-signal short-circuit forward transfer admittance
y_{fs} —Common-source small-signal short-circuit forward transfer admittance
$y_{fs(imag)}$—Common-source small-signal forward transfer susceptance
$y_{fs(real)}$ —Common-source small-signal forward transfer conductance
y_{ib} —Common-base small-signal short-circuit input admittance
y_{ic} —Common-collector small-signal short-circuit input admittance
y_{ie} —Common-emitter small-signal short-circuit input admittance
$y_{ie(imag)}$—Imaginary part of small-signal short-circuit input admittance (common-emitter)
$y_{ie(real)}$ —Real part of small-signal short-circuit input admittance (common-emitter)
y_{is} —Common-source small-signal short-circuit input admittance
$y_{is(imag)}$—Common-source small-signal input susceptance
$y_{is(real)}$—Common-source small-signal input conductance
y_{ob} —Common-base small-signal short-circuit output admittance
y_{oc} —Common-collector small-signal short-circuit output admittance
y_{oe} —Common-emitter small-signal short-circuit output admittance
$y_{oe(imag)}$—Imaginary part of small-signal short-circuit output admittance (common-emitter)
$y_{oe(real)}$ —Real part of small-signal short-circuit output admittance (common-emitter)
y_{os} —Common-source small-signal short-circuit output admittance
$y_{os(imag)}$—Common-source small-signal output susceptance
$y_{os(real)}$ —Common-source small-signal output conductance
y_{rb} —Common-base small-signal short-circuit reverse transfer admittance
y_{rc} —Common-collector small-signal short-circuit reverse transfer admittance
y_{re} —Common-emitter small-signal short-circuit reverse transfer admittance
y_{rs} —Common-source small-signal short-circuit reverse transfer admittance
$y_{rs(imag)}$—Common-source small-signal reverse transfer susceptance
$y_{rs(real)}$ —Common-source small-signal reverse transfer conductance
z_{if} —Intermediate-frequency impedance
z_m —Modulator-frequency load impedance
z_{rf} —Radio-frequency impedance
$Z_{\theta JA(t)}$—Junction-to-ambient transient thermal impedance
$Z_{\theta JC(t)}$—Junction-to-case transient thermal impedance
$Z_{\theta(t)}$ —Transient thermal impedance
z_v —Video impedance
z_z —Regulator impedance, reference impedance (small-signal at I_z)
z_{zk} —Regulator impedance, reference impedance (small-signal at I_{ZK})
z_{zm} —Regulator impedance, reference impedance (small-signal at I_{ZM})

PREFIX AND MANUFACTURER IDENTIFICATION

PREFIX	MANUFACTURER
BA	Rohm
CEX	Control Electronics
DAC	National Semiconductor
FND	Fairchild
FRL	Litronix
ICM	Intersil
LF	National Semiconductor
LM	National Semiconductor
MA	National Semiconductor
MC	Motorola
MJ	Motorola
MM	National Semiconductor. Motorola or Teledyne
MOC	Motorola
MPS	Motorola
MRF	Motorola
MU	Motorola
MV	General Instrument
NE	Signetics
NSM	National Semiconductor
PCIM	PC International
S	American Micro Systems
SAD	Reticon
SE	Signetics
SEL	Sanken
SCS	Spectronics
SLP	Sanyo
SN	Texas Instrument
TA	Toshiba
TIL	Texas Instrument
TIP	Motorola
TLO	Texas Instrument
TL	Texas Instrument
TLG	Toshiba
TLR	Toshiba
VN	Siliconix
XC	Xciton

GENERIC PART NUMBER PREFIX CODE

AD	Analog To Digital	DA	Digital To Analog	LM	Linear Monolithic
AH	Analog Hybrid	DM	Digital Monolithic	MM	MOS Monolithic
AM	Analog Monolithic	LF	Linear FET	TBA	Linear Monolithic
CD	CMOS Digital	LH	Linear Hybrid		

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