NATIONAL

LH0033/LH0033C, LH0063/LH0063C fast and damn fast buffer amplifiers

general description

The LH0033/LH0033C and LH0063/LH0063C are high speed, FET input, voltage follower/buffers designed to provide high current drive at frequencies from DC to over 100 MHz. The LH0033/LH0033C will provide ±10 mA into 1 kΩ loads (±100 mA peak) at slew rates of 1500V/μs. The LH0063/LH0063C will provide ±250 mA into 50Ω loads (±500 mA peak) at slew rates of up to 6000V/μs. In addition, both exhibit excellent phase linearity up to 20 MHz.

Both are intended to fulfill a wide range of buffer applications such as high speed line drivers, video impedance transformation, nuclear instrumentation amplifiers, op amp isolation buffer for driving reactive loads and high impedance input buffers for high speed A to D's and comparators. In addition, the LH0063/LH0063C can continuously drive 50Ω coaxial cables or be used as a diddle yoke driver for high resolution CRT displays. For additional applications information, see AN-48.

advantages

- Only +10V supply needed for 5 V_{P-P} video out
- Speed does not degrade system performance
- Wide data rate range for phase encoded systems
- Output drive adequate for most loads
- Single pre-calibrated package

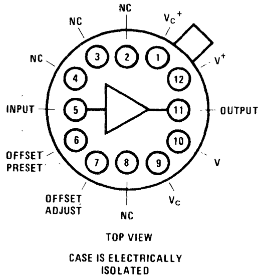
features

■ Damn fast (LH0063)	6000V/μs
■ Wide range single or dual supply operation	
■ Wide power bandwidth	DC to 100 MHz
■ High output drive	±10V with 50Ω load
■ Low phase non-linearity	2 degrees
■ Fast rise times	2 ns
■ High current gain	120 dB
■ High input resistance	10^{10} Ω

These devices are constructed using specially selected junction FET's and active laser trimming to achieve guaranteed performance specifications. The LH0033 and LH0063 are specified for operation from −55°C to +125°C; whereas, the LH0033C and LH0063C are specified from −25°C to +85°C. The LH0033/LH0033C is available in a 1.5W metal TO-8 package and a special 1/2 x 1 inch 8 pin ceramic dual-in-line package while the LH0063/LH0063C is available in a 5W 8-pin TO-3 package.

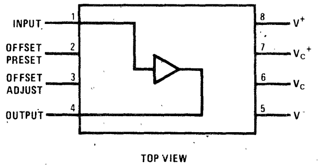
connection diagrams

LH0033/LH0033C
Metal Can Package



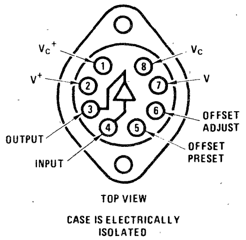
Order Number LH0033G or LH0033CG
See Package 6

LH0033/LH0033C
Dual-In-Line Package



Order Number LH0033J or LH0033CJ
See Package 12

LH0063/LH0063C
Metal Can Package



Order Number LH0063K or LH0063CK
See Package 14

absolute maximum ratings

Supply Voltage ($V^+ - V^-$)	40V
Maximum Power Dissipation (See Curves)	
LH0063/LH0063C	5W
LH0033/LH0033C	1.5W
Maximum Junction Temperature	175°C
Input Voltage	Equal to Supplies
Continuous Output Current	
LH0063/LH0063C	±250 mA
LH0033/LH0033C	±100 mA
Peak Output Current	
LH0063/LH0063C	±500 mA
LH0033/LH0033C	±250 mA
Operating Temperature Range	
LH0033 and LH0063	−55°C to +125°C
LH0033C and LH0063C	−25°C to +85°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec)	300°C

dc electrical characteristics LH0033/LH0033C: (Note 1)

PARAMETER	CONDITIONS	LIMITS						UNITS
		LH0033			LH0033C			
		MIN	TYP	MAX	MIN	TYP	MAX	
Output Offset Voltage	R_S = 100 kΩ, T_C = 25°C		5	10		12	20	mV
	R_S = 100 kΩ			15			25	mV
Average Temperature Coefficient of Offset Voltage	R_S = 100 kΩ, $-55°C \leq T_C \leq 125°C$		50			50		μV/°C
Input Bias Current	T_C = 25°C		.05	.1		.05	.15	nA
				10			5	nA
Voltage Gain	V_{IN} = 1Vrms, f = 1 kHz, R_L = 1 kΩ, R_S = 100 kΩ	.97	.98	1	.96	.98	1	V/V
Input Impedance	R_L = 1 kΩ	10^{10}	10^{11}		10^{10}	10^{11}		Ω
Output Impedance	V_{IN} = 1Vrms, f = 1 kHz, R_S = 100 kΩ, R_L = 1 kΩ		6	10		6	10	Ω
Output Voltage Swing	R_L = 1 kΩ,	±12	±13		±12	±13		V
	R_L = 100Ω, T_C = 25°C	±9			±9			V
	V_S = ±5V, R_L = 1 kΩ		6			6		V_{P-P}
Supply Current	V_{IN} = 0V, V_S = ±15V		20	22		21	24	mA
	V_S = ±5V		18			18		mA
Power Consumption	V_{IN} = 0V, V_S = ±15V		600	660		630	720	mW
	V_S = ±5V		180			180		mW

ac electrical characteristics

LH0033/LH0033C (T_C = 25°C, V_S = ±15V, R_S = 50Ω, R_L = 1 kΩ)

PARAMETER	CONDITIONS	LIMITS						UNITS
		LH0033			LH0033C			
		MIN	TYP	MAX	MIN	TYP	MAX	
Slew Rate	V_{IN} = ±10V	1000	1500		1000	1400		V/μs
Bandwidth	V_{IN} = 1Vrms		100			100		MHz
Phase Non-Linearity	BW = 1 to 20 MHz		2			2		degrees
Rise Time	ΔV_{IN} = 0.5V		2.9			3.2		ns
Propagation Delay	ΔV_{IN} = 0.5V		1.2			1.5		ns
Harmonic Distortion			<0.1			<0.1		%

Note 1: Unless otherwise specified, these specifications apply for +15V applied to pins 1 and 12, −15V applied to pins 9 and 10, and pin 6 shorted to pin 7 for the LH0033/LH0033C. For the LH0063/LH0063C, specifications apply for +15V applied to pins 1 and 2, −15V applied to pins 7 and 8, and pin 5 shorted to pin 6. Unless otherwise noted, specifications apply over a temperature range of $-55°C \leq T_C \leq +125°C$ for the LH0033 and LH0063; and $-25°C \leq T_C \leq +85°C$ for the LH0033C and LH0063C. Typical values shown are for T_C = 25°C.

dc electrical characteristics LH0063/LH0063C (Note 1)

PARAMETER	CONDITIONS	LIMITS						UNITS
		LH0063			LH0063C			
		MIN	TYP	MAX	MIN	TYP	MAX	
Output Offset Voltage	$R_S \le 100\ k\Omega$, $T_C = 25°C$		10	25		10	50	mV
	$R_S \le 100\ k\Omega$			100			100	mV
Average Temperature Coefficient of Output Offset Voltage	$R_S \le 100\ k\Omega$		300			300		$\mu V/°C$
Input Bias Current	$T_C = 25°C$		.1	.2		.1	.2	nA
				10			5	nA
Voltage Gain	$V_{IN} = \pm 10V$, $R_S \le 100\ k\Omega$, $R_L = 1\ k\Omega$	.96	.98	1	.96	.98	1	V/V
Voltage Gain	$V_{IN} = \pm 10V$, $R_S \le 100\ k\Omega$, $R_L = 50\Omega$, $T_C = 25°C$	.94	.96	.98	.92	.96	.98	V/V
Input Resistance		10^{10}	10^{11}		10^{10}	10^{11}		Ω
Input Capacitance	Case Shorted to Output		8			8		pF
Output Impedance	$V_{OUT} = \pm 10V$, $R_S = 100\ k\Omega$		1	4		1	4	Ω
Output Current Swing	$V_{IN} = \pm 10V$, $R_S \le 100\ k\Omega$	.2	.25		.2	.25		Amps
Output Voltage Swing	$R_L = 50\Omega$	±10	±13		±10	±13		V
Output Voltage Swing	$V_S = \pm 5V$, $R_L = 50\Omega$, $T_C = 25°C$	5	7		5	7		V_{P-P}
Supply Current	$T_C = 25°C$, $R_L = \infty$, $V_S = \pm 15V$		60	75		60	80	mA
Supply Current	$V_S = \pm 5V$		50			50		mA
Power Consumption	$T_C = 25°C$, $R_L = \infty$, $V_S = \pm 15V$		1.80	2.25		1.80	2.40	W
Power Consumption	$V_S = \pm 5V$		500			500		mW

ac electrical characteristics

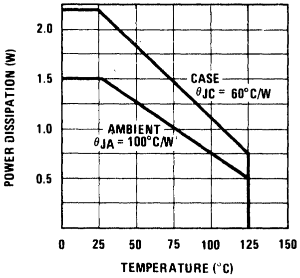
LH0063/LH0063C: ($T_C = 25°C$, $V_S = \pm 15V$, $R_S = 50\Omega$, $R_L = 50\Omega$)

PARAMETER	CONDITIONS	LIMITS						UNITS
		LH0063			LH0063C			
		MIN	TYP	MAX	MIN	TYP	MAX	
Slew Rate	$R_L = 1\ k\Omega$, $V_{IN} = \pm 10V$		6000			6000		$V/\mu s$
Slew Rate	$R_L = 50\Omega$, $V_{IN} = \pm 10V$, $T_C = 25°C$	2000	4000		2000	4000		$V/\mu s$
Bandwidth	$V_{IN} = 1$ Vrms		200			200		MHz
Phase Non-Linearity	BW = 1 to 20 MHz		2			2		degrees
Rise Time	$\Delta V_{IN} = .5V$		1.6			1.9		ns
Propagation Delay	$\Delta V_{IN} = .5V$		1.9			2.1		ns
Harmonic Distortion			<0.1			<0.1		%

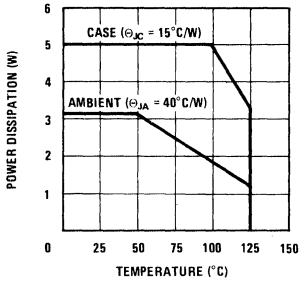
Note 1: Unless otherwise specified, these specifications apply for +15V applied to pins 1 and 12, −15V applied to pins 9 and 10, and pin 6 shorted to pin 7 for the LH0033/LH0033C. For the LH0063/LH0063C, specifications apply for +15V applied to pins 1 and 2, −15V applied to pins 7 and 8, and pin 5 shorted to pin 6. Unless otherwise noted, specifications apply over a temperature range of $-55°C \le T_C \le +125°C$ for the LH0033 and LH0063; and $-25°C \le T_C \le +85°C$ for the LH0033C and LH0063C. Typical values shown are for $T_C = 25°C$.

typical performance characteristics

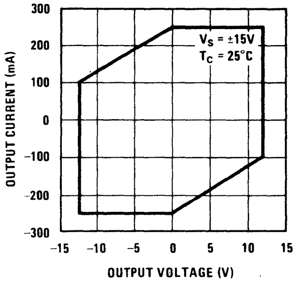
LH0033 Power Dissipation



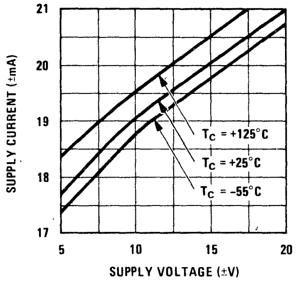
LH0063 Power Dissipation



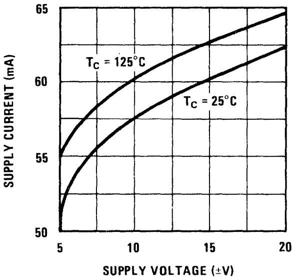
LH0063 DC Safe Operating Area



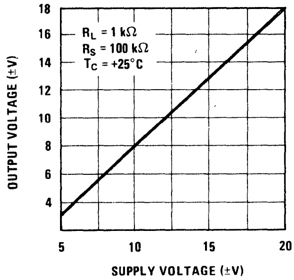
LH0033 Supply Current vs Supply Voltage



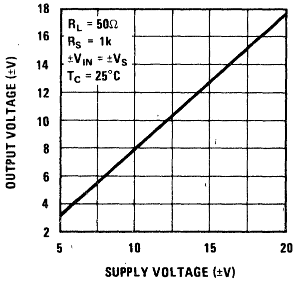
LH0063 Supply Current vs Supply Voltage



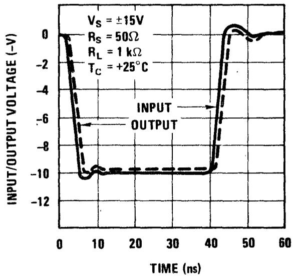
LH0033 Output Voltage vs Supply Voltage



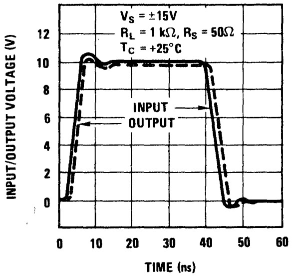
LH0063 Output Voltage vs Supply Voltage



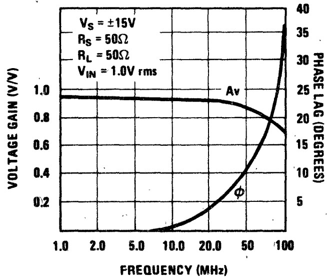
LH0033 Negative Pulse Response



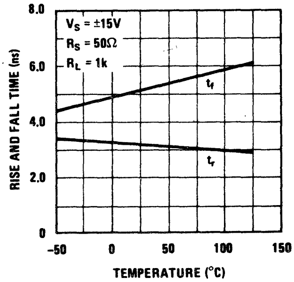
LH0033 Positive Pulse Response



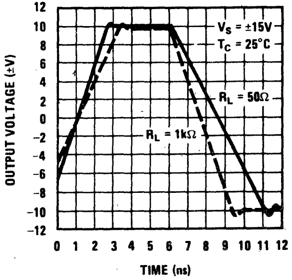
LH0033 Frequency Response



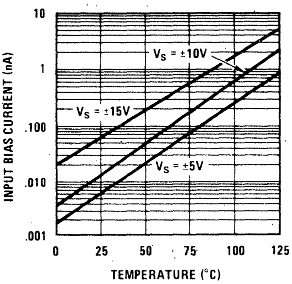
LH0033 Rise and Fall Time vs Temperature

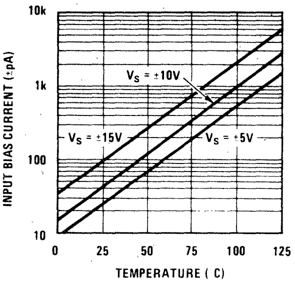


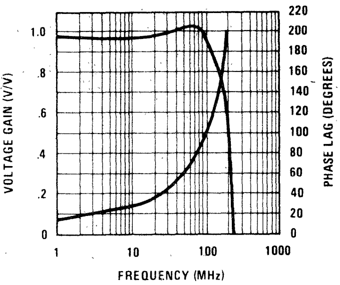
LH0063 Large Signal Pulse Response

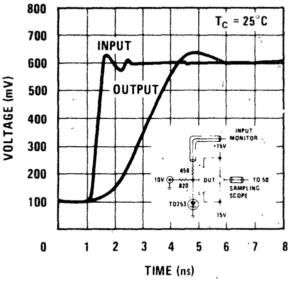


typical performance characteristics (con't)


LH0033 Input Bias Current vs Temperature


LH0063 Input Current


LH0063 Frequency Response


LH0063 Small Signal Rise Time

application hints

Recommended Layout Precautions: RF/video printed circuit board layout rules should be followed when using the LH0033 and LH0063 since they will provide power gain to frequencies over 100 MHz. Ground planes are recommended and power supplies should be decoupled at each device with low inductance capacitors. In addition, ground plane shielding may be extended to the metal case of the device since it is electrically isolated from internal circuitry. Alternatively the case should be connected to the output to minimize input capacitance.

Offset Voltage Adjustment: Both the LH0033's and LH0063's offset voltages have been actively trimmed by laser to meet guaranteed specifications when the offset preset pin is shorted to the offset adjust pin. This pre-calibration allows the devices to be used in most DC or AC applications without individually offset nulling each device. If offset null is desirable, it is simply obtained by leaving the offset preset pin open and connecting a trim pot of 100Ω for the LH0033 or 1 kΩ for the LH0063 between the offset adjust pin and V^- as illustrated in Figures 1 and 2.

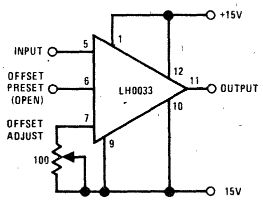


FIGURE 1. Offset Zero Adjust for LH0033 (Pin nos. shown for TO-8)

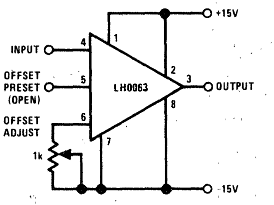


FIGURE 2. Offset Zero Adjust for LH0063

application hints (con't)

Operation from Single or Asymmetrical Power Supplies: Both device types may be readily used in applications where symmetrical supplies are unavailable or not desirable. A typical application might be an interface to a MOS shift register where $V^+ = +5V$ and $V^- = -12V$. In this case, an apparent output offset occurs due to the device's voltage gain of less than unity. This additional output offset error may be predicted by:

$$\Delta V_O \cong (1 - A_V)\frac{(V^+ - V^-)}{2} = .005\,(V^+ - V^-)$$

where:

A_V = No load voltage gain, typically .99

V^+ = Positive supply voltage

V^- = Negative supply voltage

For the above example, ΔV_O would be −35 mV. This may be adjusted to zero as described in Section 2. For AC coupled applications, no additional offset occurs if the DC input is properly biased as illustrated in the "typical applications" section.

Short Circuit Protection: In order to optimize transient response and output swing, output current limit has been omitted from the LH0033 and LH0063. Short circuit protection may be added by inserting appropriate value resistors between V^+ and $V_C{}^+$ pins and V^- and $V_C{}^-$ pins as illustrated in Figures 3 and 4. Resistor values may be predicted by:

$$R_{LIM} \cong \frac{V^+}{I_{SC}} = \frac{V^-}{I_{SC}}$$

where: $I_{SC} \leq 100$ mA for LH0033

$I_{SC} \leq 250$ mA for LH0063

The inclusion of limiting resistors in the collectors of the output transistors reduces output voltage swing. Decoupling $V_C{}^+$ and $V_C{}^-$ pins with capacitors to ground will retain full output swing for transient pulses. Alternate active current limit techniques that retain full DC output swing are shown in Figures 5, 6 and 7. In Figures 5 and 6, the current sources are saturated during normal operation thus apply full supply voltage to the V_C pins. Under fault conditions, the voltage decreases as required by the overload. For Figure 5:

$$R_{LIM} = \frac{V_{BE}}{I_{SC}} = \frac{.6V}{60\text{ mA}} = 10\Omega$$

In Figure 6, quad transistor arrays are used to minimize can count and:

$$R_{LIM} = \frac{V_{BE}}{1/3\,(I_{SC})} = \frac{.6V}{1/3\,(200\text{ mA})} = 8.2\Omega$$

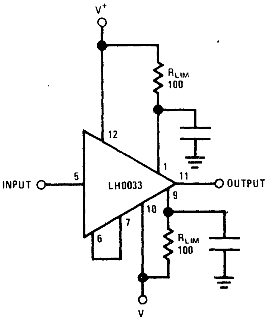


FIGURE 3. LH0033 Using Resistor Current Limiting

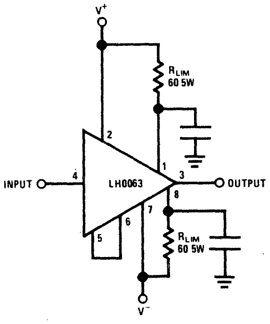


FIGURE 4. LH0063 Using Resistor Current Limiting

application hints (con't)

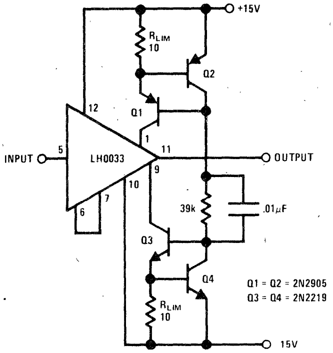


FIGURE 5. LH0033 Current Limiting Using Current Sources

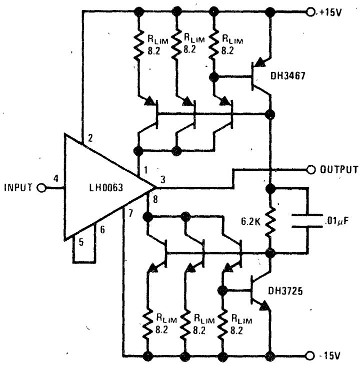


FIGURE 6. LH0063 Current Limiting Using Current Sources

Capacitive Loading: Both the LH0033 and LH0063 are designed to drive capacitive loads such as coaxial cables in excess of several thousand picofarads without susceptibility to oscillation. However, peak current resulting from $(C \times d_V/d_t)$ should be limited below absolute maximum peak current ratings for the devices.

Thus for the LH0033:

$$\left(\frac{\Delta V_{IN}}{\Delta t}\right) \times C_L \leq I_{OUT} \leq \pm 250 \text{ mA}$$

and for the LH0063:

$$\left(\frac{\Delta V_{IN}}{\Delta t}\right) \times C_L \leq I_{OUT} \leq \pm 500 \text{ mA}$$

application hints (con't)

In addition, power dissipation resulting from driving capacitative loads plus standby power should be kept below total package power rating:

$$\underset{pkg}{P_{diss}} \geq P_{DC} + P_{AC}$$

$$\underset{pkg}{P_{diss}} \geq (V^{+} - V^{-}) \times I_S + P_{AC}$$

$$P_{AC} \cong (V_{P\text{-}P})^2 \times f \times C_L$$

where $V_{P\text{-}P}$ = Peak-to-peak output voltage swing

f = frequency

C_L = Load Capacitance

Operation Within an Op Amp Loop: Both devices may be used as a current booster or isolation buffer within a closed loop with op amps such as LH0032, LH0062, or LM118. An isolation resistor of 47Ω should be used between the op amp output and the input of LH0033. The wide bandwidths and high slew rates of the LH0033 and LH0063 assure that the loop has the characteristics of the op amp and that additional rolloff is not required.

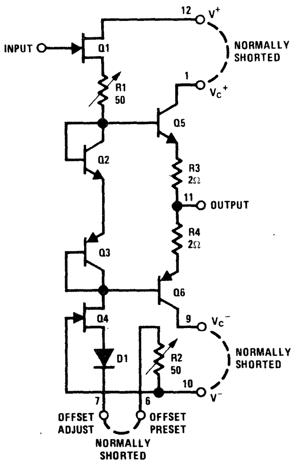
Hardware: In order to utilize the full drive capabilities of both devices, each should be mounted with a heat sink particularly for extended temperature operation. The cases of both are isolated from the circuit and may be connected to system chassis.

ACHTUNG!

Power supply bypassing is necessary to prevent oscillation with both the LH0033 and LH0063 in all circuits. Low inductance ceramic disc capacitors with the shortest practical lead lengths must be connected from each supply lead (within < ¼ to ½" of the device package) to a ground plane. Capacitors should be one or two 0.1μF in parallel for the LH0033; adding a 4.7μF solid tantalum capacitor will help in troublesome instances. For the LH0063, two 0.1μF ceramic and one 4.7μF solid tantalum capacitors in parallel will be necessary on each supply lead.

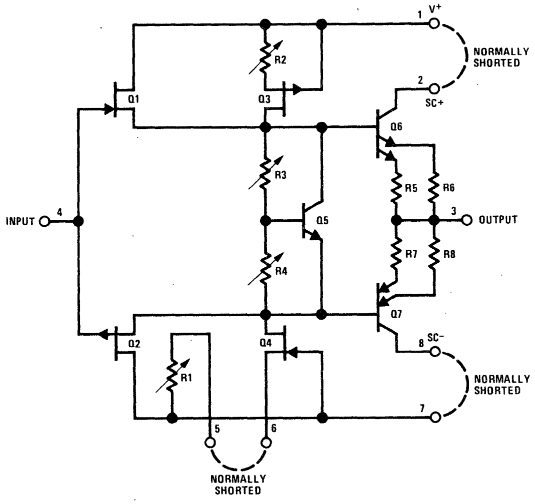
schematic diagrams

LH0033/LH0033C



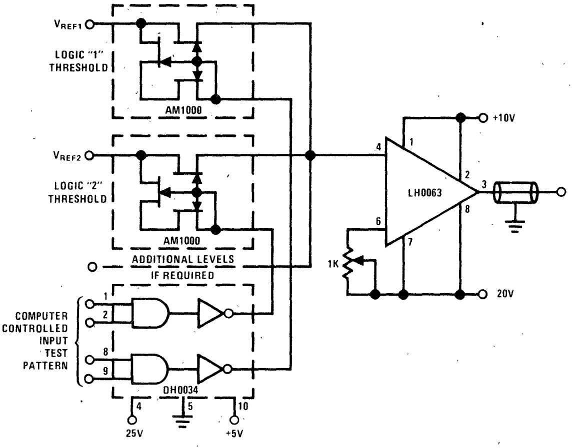
PIN NUMBERS SHOWN FOR TO-8 ("G") PACKAGE.

LH0063/LH0063C

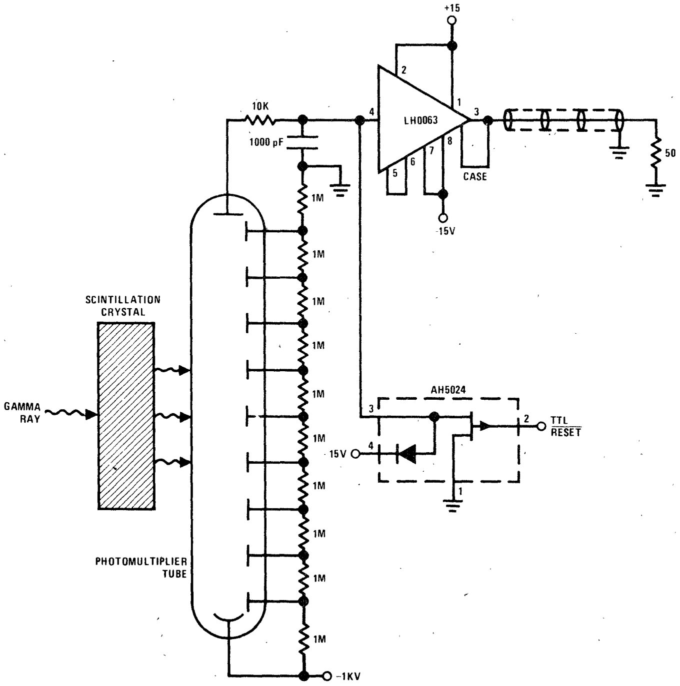


typical applications

High Speed Automatic Test Equipment Forcing Function Generator

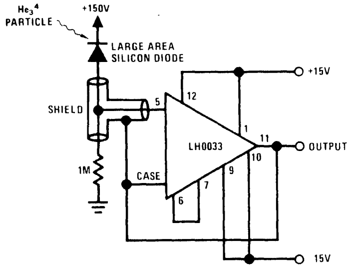


Gamma Ray Pulse Integrator

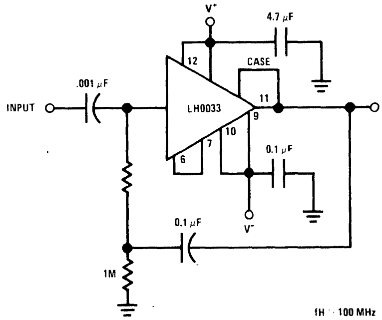


typical applications (con't)

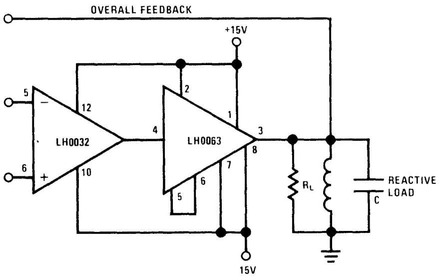
Nuclear Particle Detector



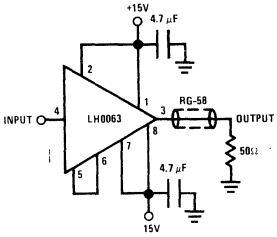
High Input Impedance AC Coupled Amplifier



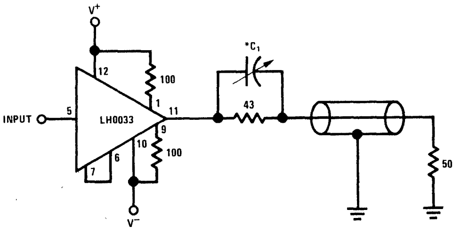
Isolation Buffer



Coaxial Cable Driver

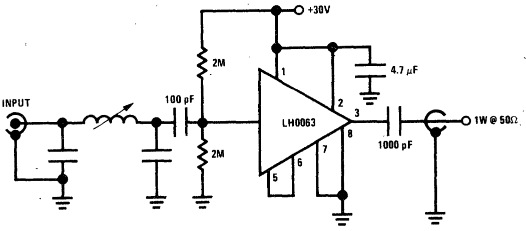


Coaxial Cable Driver



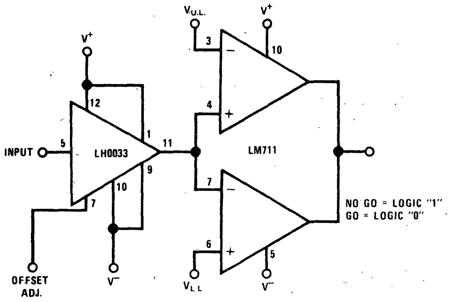
*Select C$_1$ For Optimum Pulse Response

1W CW Final Amplifier

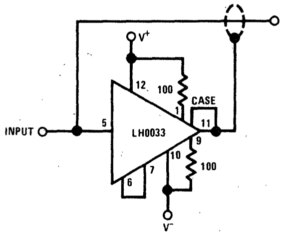


typical applications (con't)

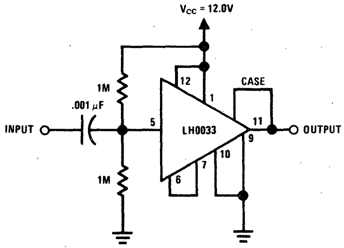
High Input Impedance Comparator With Offset Adjust



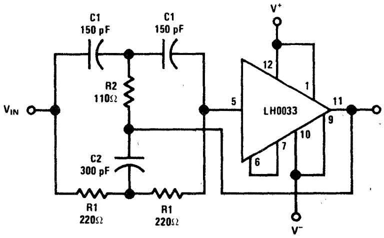
Instrumentation Shield/Line Driver



Single Supply AC Amplifier



4.5 MHz Notch Filter

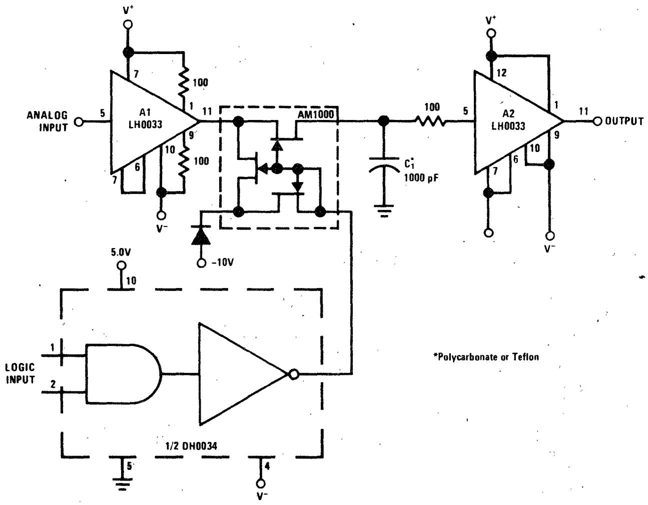


$$f_o = \frac{1}{2\pi R1C1}$$

$$R1 = 2\,R2$$

$$C1 = \frac{C2}{2}$$

High Speed Sample & Hold



*Polycarbonate or Teflon