MC3405
MC3505

Dual Operational Amplifier and Dual Comparator

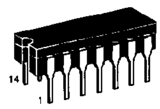
DUAL OPERATIONAL AMPLIFIER/ DUAL VOLTAGE COMPARATOR

SILICON MONOLITHIC INTEGRATED CIRCUIT

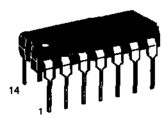
The MC3405/3505 contains two differential-input operational amplifiers and two comparators, each set capable of single supply operation. This operational amplifier-comparator circuit fulfills its applications as a general purpose product for automotive and consumer circuits as well as an industrial building block.

The MC3405 is specified over the commercial operating temperature range of 0° to +70°C, while the MC3505 is specified over the military operating range of –55° to +125°C.

- Operational Amplifiers Equivalent in Performance to MC3403/3503
- Comparators Similar in Performance to LM339/139
- Single Supply Operation: 3.0 V to 36 V
- Split Supply Operation: ±1.5 V to ±18 V
- Low Supply Current Drain
- Operational Amplifiers are Internally Frequency Compensated
- Comparators TTL and CMOS Compatible

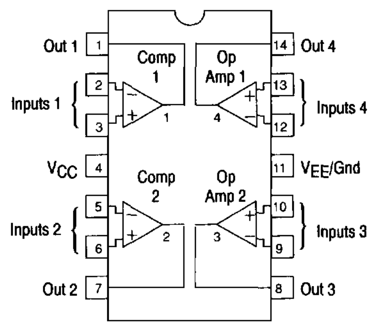


L SUFFIX
CERAMIC PACKAGE
CASE 632



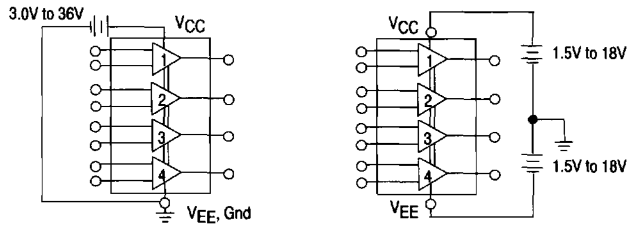
P SUFFIX
PLASTIC PACKAGE
CASE 646

PIN CONNECTIONS



(Top View)

Single Supply | **Split Supplies**



ORDERING INFORMATION

Device	Temperature Range	Package
MC3405L	0° to +70°C	Ceramic DIP
MC3405P	0° to +70°C	Plastic DIP
MC3505L	–55° to +125°C	Ceramic DIP

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OPERATIONAL AMPLIFIER SECTION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Supply Voltage — Single Supply Split Supplies	V_{CC} V_{CC}, V_{EE}	36 ±18	Vdc
Input Differential Voltage Range	V_{IDR}	±36	Vdc
Input Common Mode Voltage Range	V_{ICR}	±18	Vdc
Operating Ambient Temperature Range — MC3505 MC3405	T_A	–55 to +125 0 to +70	°C
Storage Temperature Range — Ceramic Package Plastic Package	Tstg	–65 to +150 –55 to +125	°C
Operating Junction Temperature Range — Ceramic Package Plastic Package	T_J	175 150	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 5.0 V, V_{EE} = Gnd, T_A = 25°C, unless otherwise noted.)

Characteristics	Symbol	MC3505 Min	MC3505 Typ	MC3505 Max	MC3405 Min	MC3405 Typ	MC3405 Max	Unit
Input Offset Voltage	V_{IO}	—	2.0	5.0	—	2.0	10	mV
Input Offset Current	I_{IO}	—	30	50	—	30	50	nA
Input Bias Current	I_{IB}	—	–200	–500	—	–200	–500	nA
Large-Signal, Open-Loop Voltage Gain (R_L = 2.0 kΩ)	A_{VOL}	20	200	—	20	200	—	V/mV
Power Supply Rejection	PSR	—	—	150	—	—	150	µV/V
Output Voltage Range (Note 1) (R_L = 10 kΩ, V_{CC} = 5.0 V) (R_L = 10 kΩ, 5.0 V ≤ V_{CC} ≤ 30 V)	V_{OR}	 3.3 V_{CC} –2.0	 3.5 V_{CC} –1.7	 — —	 3.3 V_{CC} –2.0	 3.5 V_{CC} –1.7	 — —	V_{p-p}
Power Supply Current (Notes 2 and 3)	I_{CC}	—	2.5	4.0	—	2.5	7.0	mA
Channel Separation f = 1.0 kHz to 20 kHz (Input Referenced)	—	—	–120	—	—	–120	—	dB

ELECTRICAL CHARACTERISTICS (V_{CC} = +15 V, V_{EE} = –15 V, T_A = 25°C, unless otherwise noted.)

Characteristics	Symbol	MC3505 Min	MC3505 Typ	MC3505 Max	MC3405 Min	MC3405 Typ	MC3405 Max	Unit
Input Offset Voltage (T_A = T_{low} + T_{high}) (Note 4)	V_{IO}	— —	2.0 —	5.0 6.0	— —	2.0 —	10 12	mV
Average Temperature Coefficient of Input Offset Voltage	$\Delta V_{IO}/\Delta T$	—	15	—	—	15	—	µV/°C
Input Offset Current (T_A = T_{low} to T_{high}) (Note 4)	I_{IO}	— —	— —	50 200	— —	— —	50 200	nA
Input Bias Current (T_A = T_{low} to T_{high}) (Note 4)	I_{IB}	— —	–200 –300	–500 –1500	— —	–200 —	–500 –800	nA
Input Common Mode Voltage Range	V_{ICR}	+13 –V_{EE}	—	—	+13 –V_{EE}	—	—	Vdc
Large Signal, Open-Loop Voltage Gain (V_O = ±10 V, R_L = 2.0 kΩ) (T_A = T_{low} to T_{high}) (Note 4)	A_{VOL}	 50 25	 200 100	 — —	 20 15	 200 100	 — —	V/mV
Common Mode Rejection	CMR	70	90	—	70	90	—	dB
Power Supply Rejection Ratio	PSRR	—	30	150	—	30	150	µV/V
Output Voltage (R_L = 10 kΩ) (R_L = 2.0 kΩ) (R_L = 2.0 kΩ, T_A = T_{low} to T_{high}) (Note 4)	V_O	 ±12 ±10 ±10	 ±13.5 ±13 —	 — — —	 ±12 ±10 ±10	 ±13.5 ±13 —	 — — —	Vdc
Output Short Circuit Current	I_{SC}	±10	±30	±45	±10	±20	±45	mA
Power Supply Current (Notes 2 and 3)	I_{CC}, I_{EE}	—	2.8	4.0	—	2.8	7.0	mA
Phase Margin	ϕm	—	60	—	—	60	—	Degrees
Small-Signal Bandwidth (A_V = 1, R_L = 10 kΩ, V_O = 50 mV)	BW	—	1.0	—	—	1.0	—	MHz
Power Bandwidth (A_V = 1, R_L = 2.0 kΩ, V_O = 20 V_{p-p}, THD = 5%)	BWp	—	9.0	—	—	9.0	—	kHz
Rise Time/Fall Time	t_{TLH}, t_{THL}	—	0.35	—	—	0.35	—	µs
Overshoot (A_V = 1, R_L = 10 kΩ, V_O = 50 mV)	OS	—	20	—	—	20	—	%
Slew Rate	SR	—	0.6	—	—	0.6	—	V/µs

NOTES:
1. Output will swing to groung.
2. Not to exceed maximum package power dissipation.
3. For Operational Amplifier and Comparator.
4. T_{low} = –55°C for MC3505 T_{high} = +125°C for MC3505
= 0°C for MC3405 = +70°C for MC3405

COMPARATOR SECTION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Supply Voltage — Single Supply Split Supplies	V_{CC} V_{CC}, V_{EE}	36 ±18	Vdc
Input Differential Voltage Range	V_{IDR}	±36	Vdc
Input Common Mode Voltage Range	V_{ICR}	–0.3 to +36	Vdc
Sink Current	I_{Sink}	20	mA
Operating Ambient Temperature Range — MC3505 MC3405	T_A	–55 to +125 0 to +70	°C
Storage Temperature Range — Ceramic Package Plastic Package	Tstg	–65 to +150 –55 to +125	°C
Operating Junction Temperature Range — Ceramic Package Plastic Package	T_J	175 150	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 5.0 V, V_{EE} = Gnd, T_A = 25°C, unless otherwise noted.)

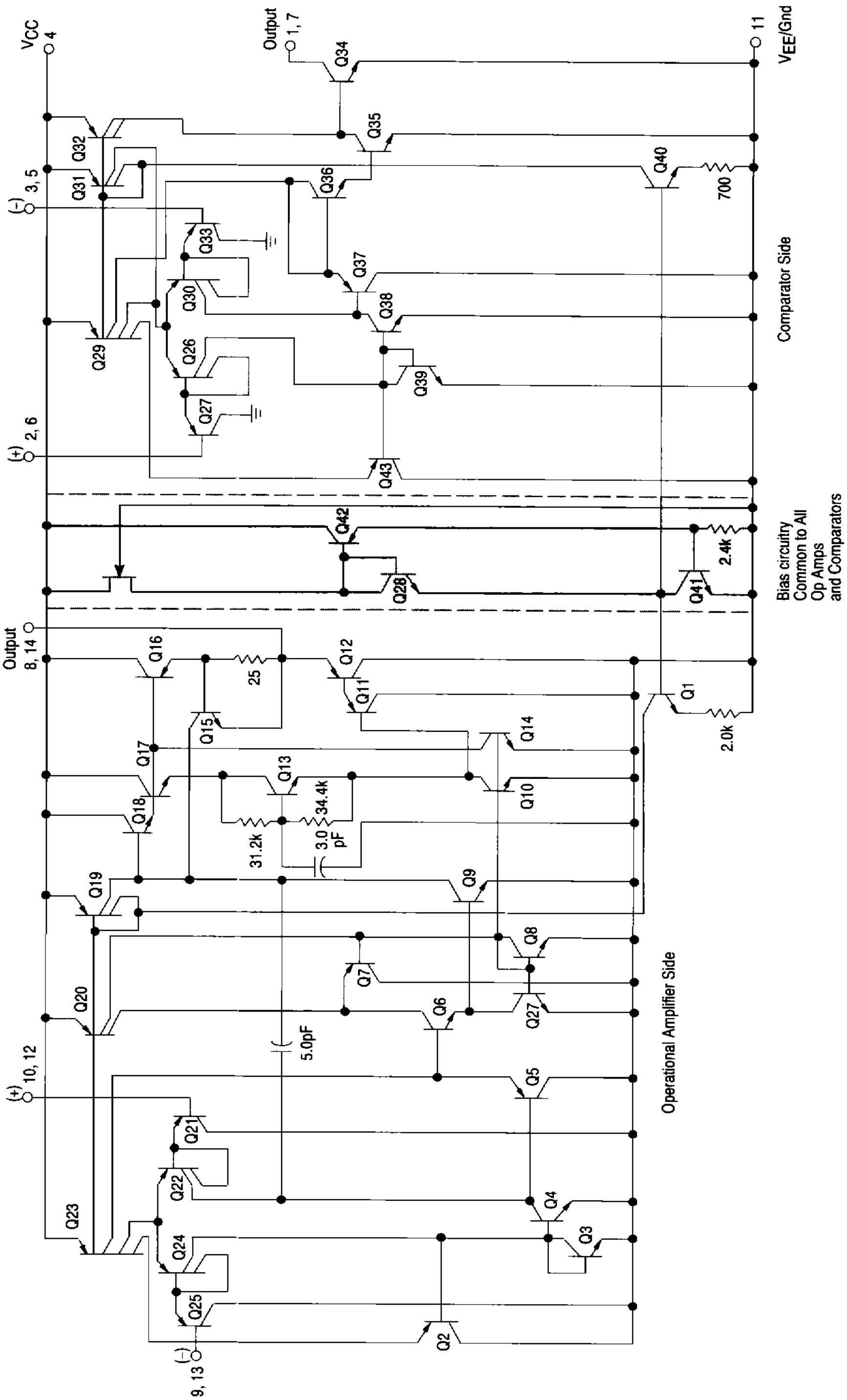
		MC3505			MC3405			
Characteristics	**Symbol**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Unit**
Input Offset Voltage (T_A = T_{low} to T_{high}) (Notes 1 and 2)	V_{IO}	— —	2.0 —	5.0 9.0	— —	2.0 —	10 12	mV
Average Temperature Coefficient of Input Offset Voltage	$\Delta V_{IO}/\Delta T$	—	15	—	—	15	—	µV/°C
Input Offset Current (T_A = T_{low} to T_{high}) (Note 1)	I_{IO}	— —	50 —	75 150	— —	50 —	100 200	nA
Input Bias Current (T_A = T_{low} to T_{high}) (Note 1)	I_{IB}	— —	–125 —	–500 –1500	— —	–125 —	–500 –800	nA
Input Common Mode Voltage Range (T_A = T_{low} to T_{high}) (Note 1)	V_{ICR}	0 0	V_{CC} –1.5 V_{CC} –1.7	V_{CC} –1.7 V_{CC} –2.0	0 0	V_{CC} –1.5 V_{CC} –1.7	V_{CC} –1.7 V_{CC} –2.0	Vp-p
Input Differential Voltage (All V_{in} ≥ 0 Vdc)	V_{ID}	—	—	36	—	—	36	V
Large-Signal, Open-Loop Voltage Gain (R_L = 15 kΩ)	A_{VOL}	—	200	—	—	200	—	V/mV
Output Sink Current (–V_{in} ≥ 1.0 Vdc, +V_{in}= 0, V_O ≤ 1.5 V)	I_{Sink}	6.0	16	—	6.0	16	—	mA
Low Level Output Voltage (+V_{in}= 0 V, –V_{in}= 1.0 V, I_{Sink} = 4.0 mA) (T_A = T_{low} to T_{high}) (Note 1)	V_{OL}	— —	350 —	500 700	— —	350 —	500 700	µA
Output Leakage Current (+V_{in} ≥ 1.0 Vdc, –V_{in}= 0, V_O = 5.0 Vdc) (T_A = T_{low} to T_{high}) (Note 1)	I_{OL}	— —	0.1 0.1	1.0 1.0	— —	0.1 0.1	1.0 1.0	µA
Large-Signal Response	—	—	300	—	—	300	—	ns
Response Time (Note 3) (V_{RL} = 5.0 Vdc, R_L = 5.1 kΩ)	—	—	1.3	—	—	1.3	—	µs

NOTES: 1. T_{low} = –55°C for MC3505 = 0°C for MC3405; T_{high} = +125°C for MC3505 = +70°C for MC3405

2. V_O ≅ 1.4 V, R_S = 0 Ω with V_{CC} from 5.0 Vdc to 30 Vdc, and over the input common mode range 0 to V_{CC} –1.7 V.

3. The response time specified is for a 100 mV input step with 5.0 mV overdrive. For larger signals 300 ns is typical.

Circuit Schematic
(1/2 of Circuit Shown)



OPERATIONAL AMPLIFIER SECTION

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Figure 1. Sine Wave Response

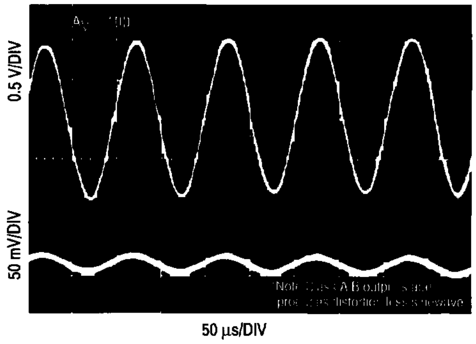


Figure 2. Open-Loop Frequency Response

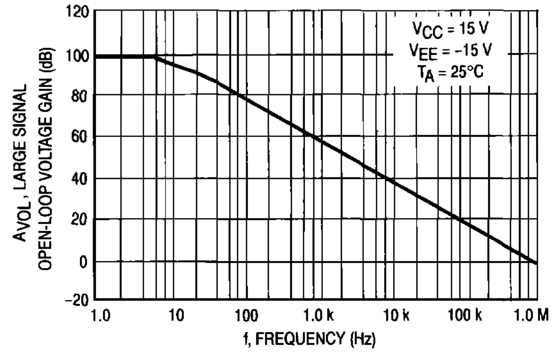


Figure 3. Power Bandwidth

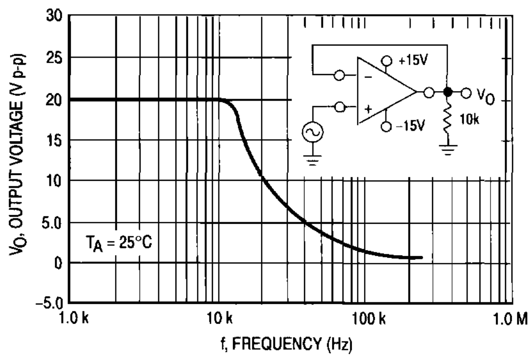


Figure 4. Output Swing versus Supply Voltage

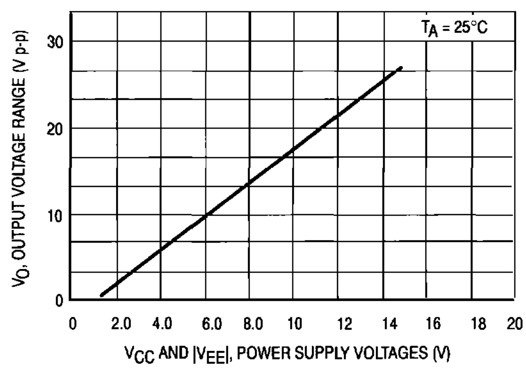


Figure 5. Input Bias Current versus Temperature

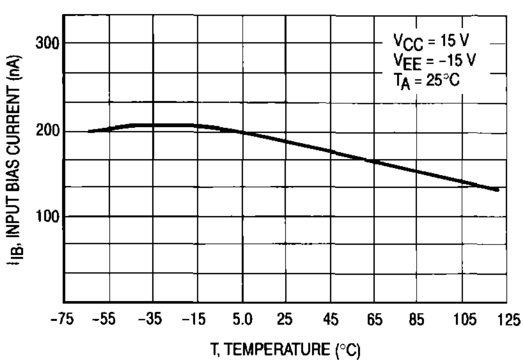
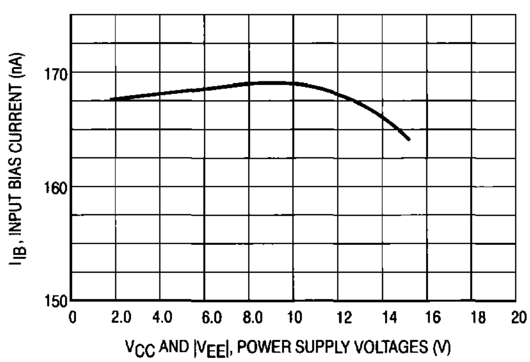


Figure 6. Input Bias Current versus Supply Voltage



COMPARATOR SECTION

Figure 7. Normalized Input Offset Voltage

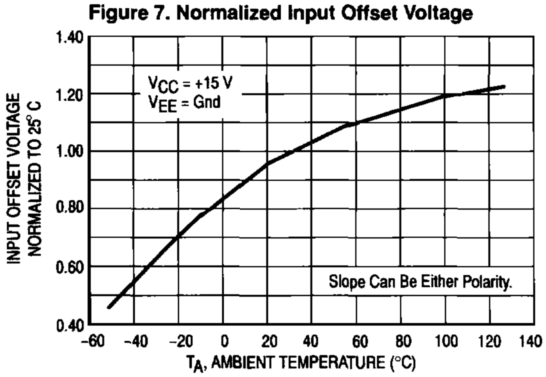


Figure 8. Input Bias Current

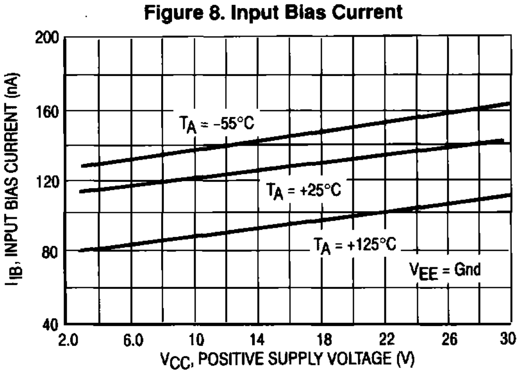


Figure 9. Normalized Input Offset Current

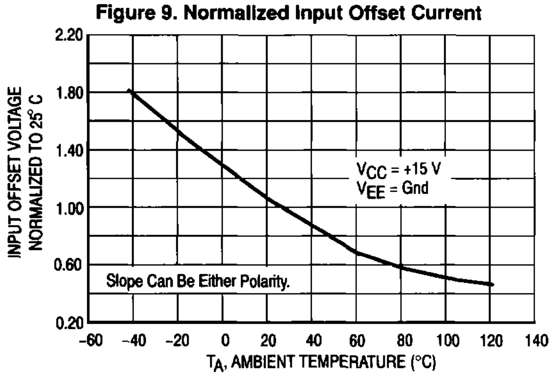


Figure 10. Output Sink Current versus Output Voltage

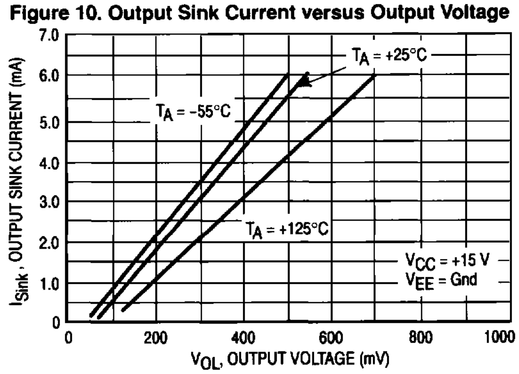
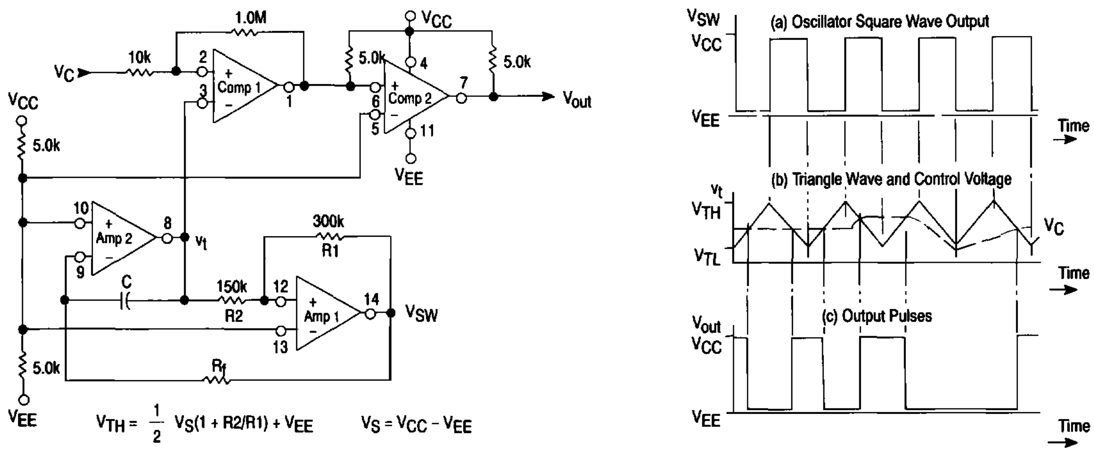


Figure 11. Pulse Width Modulator Schematic and Waveforms



$$V_{TH} = \frac{1}{2} V_S(1 + R2/R1) + V_{EE} \qquad V_S = V_{CC} - V_{EE}$$

$$V_{TL} = \frac{1}{2} V_S(1 - R2/R1) + V_{EE}$$

Oscillator Frequency $f = \frac{R1}{4R_fCR2}$

$$\text{Pulse Width} = \left(\frac{1}{f}\right)\left(\frac{V_C - V_{TL}}{V_{TH} - V_{TL}}\right) \quad \text{when: } V_{TL} < V_C < V_{TH}$$

$$\text{Duty Cycle in \%} = \left(\frac{V_C - V_{TL}}{V_{TH} - V_{TL}}\right)(100)$$

Figure 12. Window Comparator

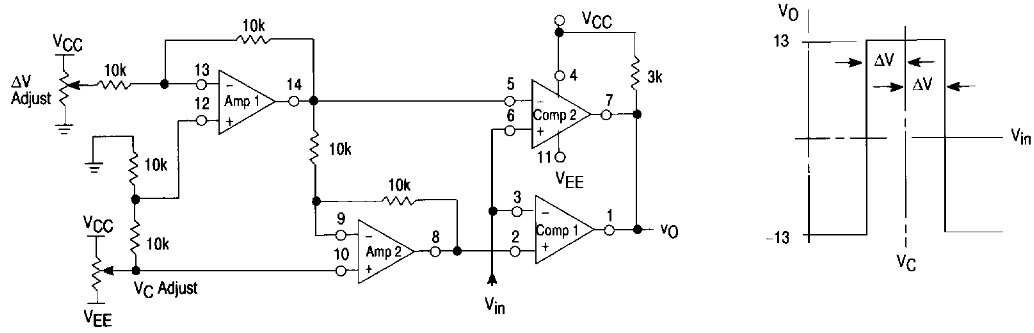
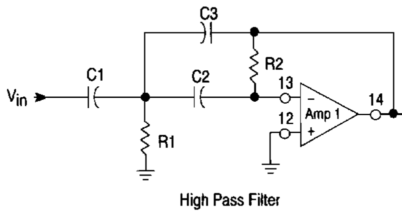
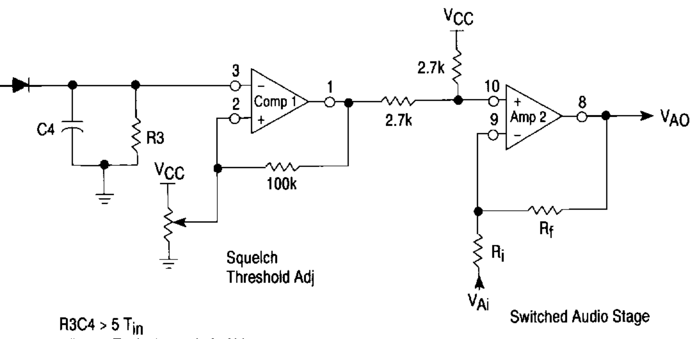


Figure 13. Squelch Circuit for AM or FM





High Pass Filter

Given: A_o, Q, $\omega_o = 2\pi f_o$

Choose: C = C1 = C2, a convenient value

Calculate: $R2 = \frac{Q}{\omega_o C}(2A_o + 1)$

$C3 = \frac{C}{A_o}$

$R1 = \frac{A_o}{Q\omega_o C(2A_o + 1)}$

$R3C4 > 5\ T_{in}$

Where : T_{in} is the period of V_{in}

Q = Quality Factor

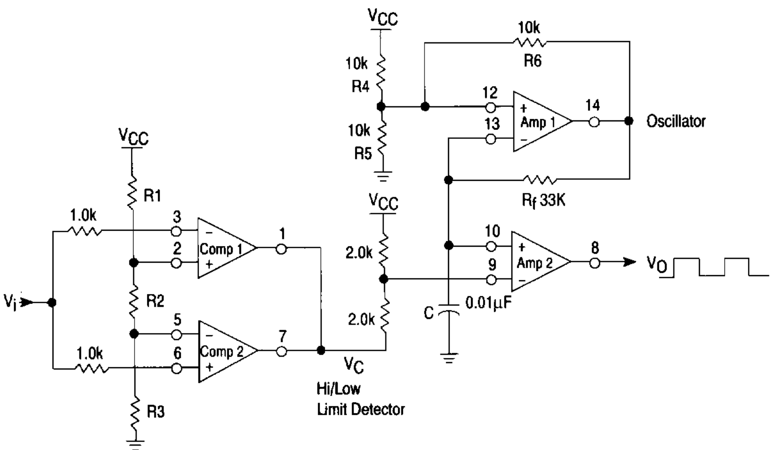
A_o = High Frequency Gain

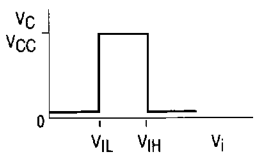
ω_o = Break Frequency

Gain of Audio Stage

$A_{CL} = \frac{R_f}{R_i}$

Figure 14. High/Low Limit Alarm





$V_{IL} = V_{CC}\ \frac{R3}{R1 + R2 + R3}$

$V_{IH} = V_{CC}\ \frac{R2 + R3}{R1 + R2 + R3}$

Oscillator

If R4 = R5 = R6

$f = 0.72/R_fC$

As shown, f = 2.2 kHz

V_O will oscillate if $V_{IH} < V_i$, or $V_{IL} > V_i$

V_O will be low if $V_{IL} < V_i < V_{IH}$

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Figure 15. Zero Crossing Detector with Temperature Sensor

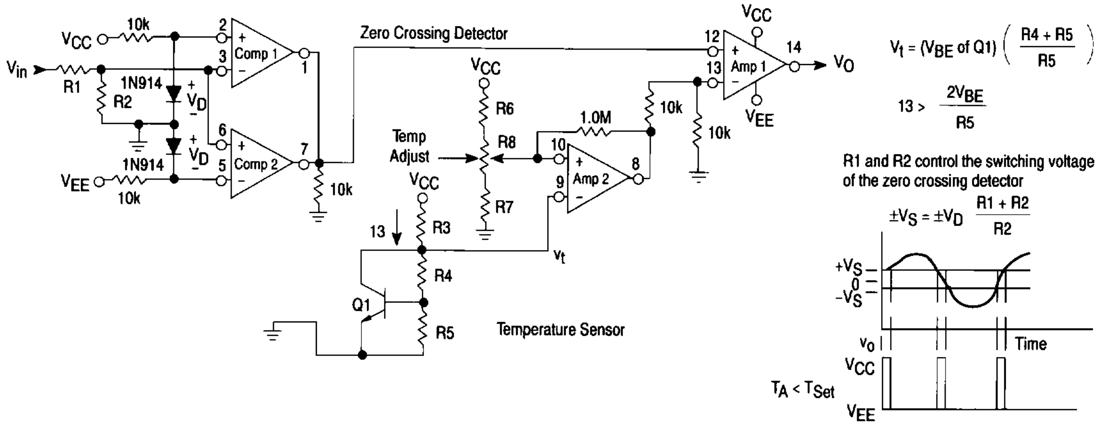
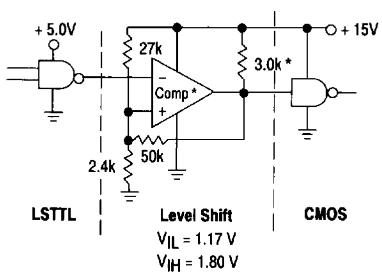
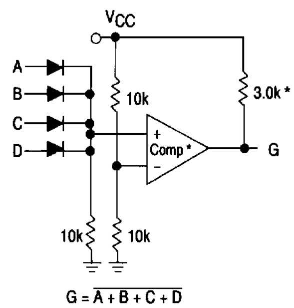


Figure 16. LSTTL to CMOS Interface with Hysteresis



*The same configuration may be used with an op amp if the 3.0 k resistor is removed.

Figure 17. NOR Gate



*The same configuration may be used with an op amp if the 3.0 k resistor is removed.