MOTOROLA
■ SEMICONDUCTOR
TECHNICAL DATA

MC1439
MC1539

2

UNCOMPENSATED OPERATIONAL AMPLIFIER

. . . designed for use as a summing amplifier, integrator, or amplifier with operating characteristics as a function of the external feedback components.

- Low Input Offset Voltage — 3.0 mV max
- Low Input Offset Current — 60 nA max
- Large Power-Bandwidth — 20 Vp-p Output Swing at 20 kHz min
- Output Short-Circuit Protection
- Input Over-Voltage Protection
- Class AB Output for Excellent Linearity
- High Slew Rate — 34 V/µs typ

FIGURE 1 – HIGH SLEW-RATE INVERTER

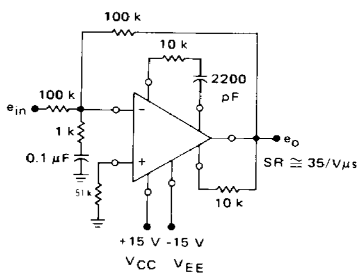


FIGURE 2 – OUTPUT NULLING CIRCUIT

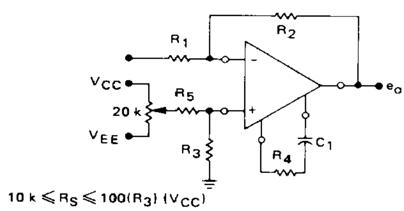
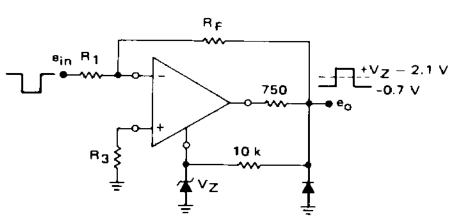


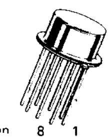
FIGURE 3 – OUTPUT LIMITING CIRCUIT

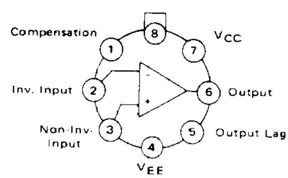


OPERATIONAL AMPLIFIER

SILICON MONOLITHIC
INTEGRATED CIRCUIT

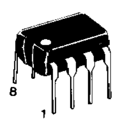
G SUFFIX
METAL PACKAGE
CASE 601

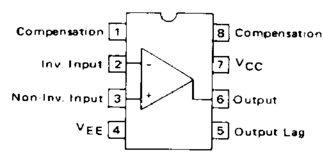




(Top View)

P1 SUFFIX
PLASTIC PACKAGE
CASE 626
(MC1439 Only)





(Top View)

ORDERING INFORMATION

Device	Temperature Range	Package
MC1439G MC1439P1	0°C to +70°C	Metal Can Plastic DIP
MC1539G	–55°C to +125°C	Metal Can

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

Characteristic	Symbol	MC1539			MC1439			Unit
		Min	Typ	Max	Min	Typ	Max	
Input Bias Current	I_{IB}							μA
(T_A = +25°C)		–	0.20	0.50	–	0.20	1.0	
(T_A = T_{low} ①)		–	0.23	0.70	–	0.23	1.5	
Input Offset Current	$\|I_{IO}\|$							nA
(T_A = T_{low})		–	–	75		–	150	
(T_A = +25°C)		–	20	60	–	20	100	
(T_A = T_{high} ①)		–	–	75	–		150	
Input Offset Voltage	$\|V_{IO}\|$							mV
(T_A = +25°C)		–	1.0	3.0	–	2.0	7.5	
(T_A = T_{low}, T_{high})		–	–	4.0	–	–		
Average Temperature Coefficient of Input Offset Voltage (T_A = T_{low} to T_{high})	$\|TCV_{IO}\|$							μV/°C
(R_S = 50 Ω)		–	3.0		–	3.0	–	
(R_S ≤ 10 kΩ)		–	5.0	–	–	5.0	–	
Input Impedance (f = 20 Hz)	z_{in}	150	300	–	100	300	–	kΩ
Input Common-Mode Voltage Range	V_{ICR}	±11	±12		±11	±12	–	V_{pk}
Equivalent Input Noise Voltage (R_S = 10 kΩ, Noise Bandwidth = 1.0 Hz, f = 1.0 kHz)	e_n	–	30		–	30		nV/(Hz)$^{1/2}$
Common-Mode Rejection Ratio (f = 1.0 kHz)	CMRR	80	110		80	110		dB
Open-Loop Voltage Gain (V_O = ±10 V, R_L = 10 kΩ, R_5 = ∞) (T_A = +25°C to T_{high})	A_{VOL}	50,000	120,000		15,000	100,000	–	–
(T_A = T_{low})		25,000	100,000	–	15,000	100,000	–	
Power Bandwidth (A_v = 1, THD ≤ 5%, V_O = 20 Vp-p)	PBW							kHz
(R_L = 2.0 kΩ)					10	50		
(R_L = 1.0 kΩ, R_5 = 10 k)		20	50					
Step Response								
Gain = 1000, no overshoot,	t_{THL}		130		–	130		ns
R1 = 1.0 kΩ, R2 = 1.0 MΩ, R3 = 1.0 kΩ,	t_{pd}		190	–		190		ns
R4 = 30 kΩ, R5 = 10 kΩ, C1 = 1000 pF	SR		6.0			6.0		V/μs
Gain = 1000, 15% overshoot,	t_{THL}		80			80		ns
R1 = 1.0 kΩ, R2 = 1.0 MΩ, R3 = 1.0 kΩ,	t_{pd}		100	–		100		ns
R4 = 0, R5 = 10 kΩ, C1 = 10 pF	SR		14		–	14		V/μs
Gain = 100, no overshoot,	t_{THL}		60			60		ns
R1 = 1.0 kΩ, R2 = 100 kΩ, R3 = 1.0 kΩ,	t_{pd}	–	100		–	100		ns
R4 = 10 kΩ, R5 = 10 kΩ, C1 = 2200 pF	SR		34			34		V/μs
Gain = 10, 15% overshoot,	t_{THL}	–	120			120		ns
R1 = 1.0 kΩ, R2 = 10 kΩ, R3 = 1.0 kΩ,	t_{pd}		80	–		80	–	ns
R4 = 1.0 kΩ, R5 = 10 kΩ, C1 = 2200 pF	SR	–	6.25	–	–	6.25		V/μs
Gain = 1, 15% overshoot,	t_{THL}	–	160		–	160		ns
R1 = 10 kΩ, R2 = 10 kΩ, R3 = 5.0 kΩ,	t_{pd}		80	–	–	80	–	ns
R4 = 390 Ω, R5 = 10 kΩ, C1 = 2200 pF	SR	–	4.2	–		4.2	–	V/μs
Output Impedance (f = 20 Hz)	z_o		4.0	–	–	4.0		kΩ
Output Voltage Swing	V_O							V_{pk}
(R_L = 2.0 kΩ, f = 1.0 kHz)		–		–	±10	±13		
(R_L = 1.0 kΩ, f = 1.0 kHz)		±10	±13	–	–	–	–	
Positive Supply Rejection Ratio (V_{EE} constant, R_5 = ∞)	PSRR+	–	50	150	–	50	200	μV/V
Negative Supply Rejection Ratio (V_{CC} constant, R_5 = ∞)	PSRR−	–	50	150		50	200	μV/V
Power Supply Current (V_O = 0)	I_{CC}	–	3.0	5.0		3.0	6.7	mAdc
	I_{EE}	–	3.0	5.0	–	3.0	6.7	

① T_{low} = 0°C for MC1439, −55°C for MC1539; T_{high} = +70°C for MC1439, +125°C for MC1539

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

Rating	Symbol	Value	Unit
Power Supply Voltage	V_{CC} V_{EE}	+18 +18	Vdc
Differential Input Voltage Range	V_{IDR}	$\pm(V_{CC} + \lvert V_{EE}\rvert)$	Vdc
Common-Mode Input Voltage Range	V_{ICR}	$+V_{CC}, -\lvert V_{EE}\rvert$	Vdc
Load Current	I_L	15	mA
Output Short-Circuit Duration	t_S	Continuous	
Power Dissipation (Package Limitation) Metal Package Derate above T_A = +25°C Plastic Dual In-Line Packages MC1439 Derate above T_A = +25°C	P_D	 680 4.6 625 5.0	 mW mW/°C mW mW/°C
Operating Temperature Range MC1539 MC1439	T_A	-55 to +125 0 to +70	°C
Storage Temperature Range Metal Packages Plastic Packages	T_{stg}	 -65 to +150 -55 to +125	°C

FIGURE 4 – EQUIVALENT CIRCUIT SCHEMATIC

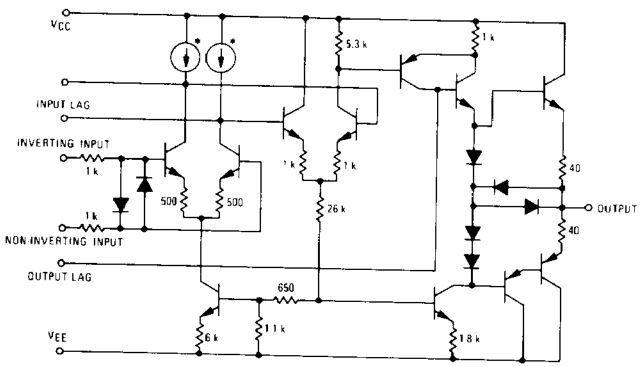


FIGURE 5 – EQUIVALENT CIRCUIT

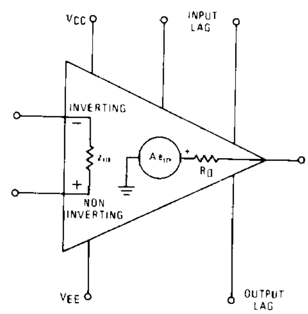
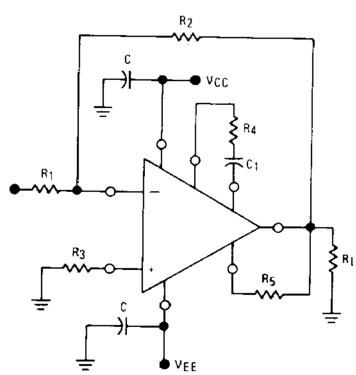


FIGURE 6 – TEST CIRCUIT



TYPICAL OUTPUT CHARACTERISTICS

(V_{CC} = +15 Vdc, V_{EE} = -15 Vdc, T_A = +25°C)

FIGURE NO.	CURVE NO.	VOLTAGE GAIN	TEST CONDITIONS (FIGURE 6)					
			R_1 (Ω)	R_2 (Ω)	R_3 (Ω)	R_4 (Ω)	R_5 (Ω)	C_1 (pF)
7,10,12	1	A_{vol}	0	∞	0	∞	∞	0
	2	1	10 k	10 k	5.0 k	390	10 k	2200
	3	10	1.0 k	10 k	1.0 k	1.0 k	10 k	2200
	4	100	1.0 k	100 k	1.0 k	10 k	10 k	2200
	5	1000	1.0 k	1.0 M	1.0 k	30 k	10 k	1000
	6	1000	1.0 k	1.0 M	1.0 k	0	10 k	10
8	1	A_{vol}	0	∞	0	∞	∞	0
	2	↓	↓	↓	↓	390	↓	2200
	3	↓	↓	↓	↓	1.0 k	↓	2200
	4	↓	↓	↓	↓	10 k	↓	2200
	5	↓	↓	↓	↓	30 k	↓	1000
	6	↓	↓	↓	↓	0	↓	10
13	ALL	1	10 k	10 k	5.0 k	390	10 k	2200
14	ALL	10	1.0 k	10 k	1.0 k	1.0 k	10 k	2200
15	ALL	100	1.0 k	100 k	1.0 k	10 k	10 k	2200
16	ALL	1000	1.0 k	1.0 M	1.0 k	30 k	10 k	2200

TYPICAL CHARACTERISTICS (continued)

(V_{CC} = +15 Vdc, V_{EE} = −15 Vdc, T_A = +25°C, unless otherwise noted.)

FIGURE 7 — LARGE-SIGNAL SWING versus FREQUENCY

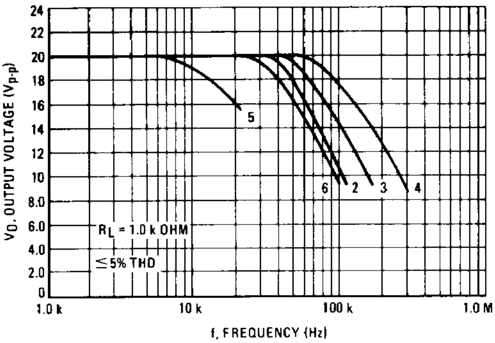


FIGURE 8 — OPEN-LOOP VOLTAGE GAIN versus FREQUENCY

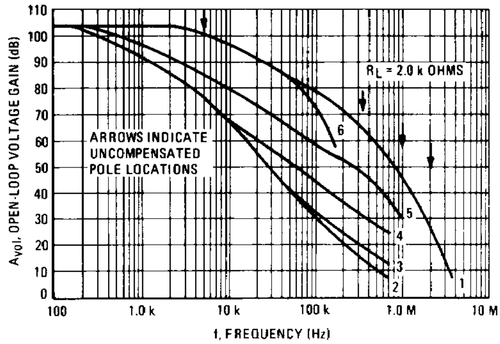


FIGURE 9 — OUTPUT VOLTAGE SWING versus LOAD RESISTANCE

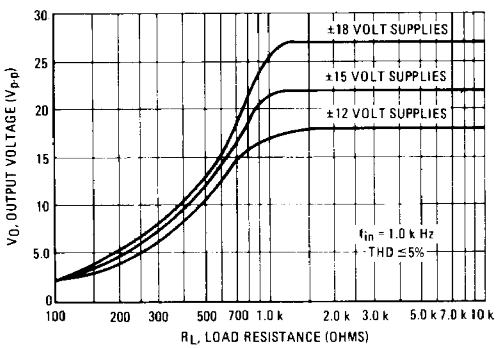


FIGURE 10 — OPEN-LOOP PHASE-SHIFT versus FREQUENCY

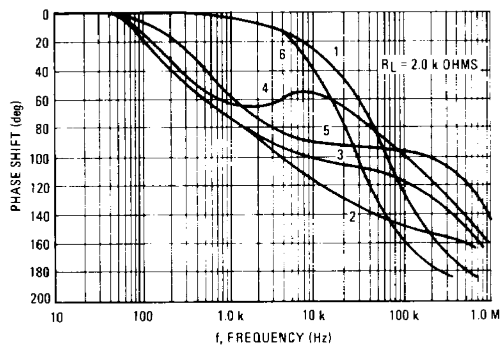


FIGURE 11 — OUTPUT VOLTAGE SWING (to clipping) versus SUPPLY

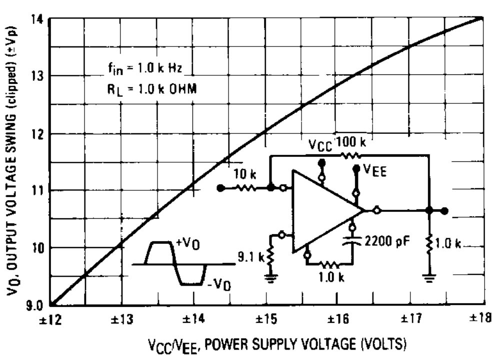
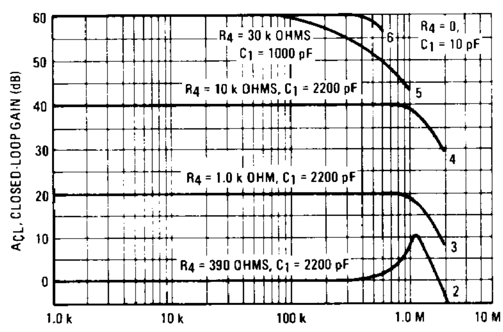


FIGURE 12 — CLOSED-LOOP GAIN versus FREQUENCY



*A_{CL} = Closed-Loop Gain

TYPICAL CHARACTERISTICS (continued)

(V_{CC} = +15 Vdc, V_{EE} = −15 Vdc, T_A = +25°C, unless otherwise noted.)

FIGURE 13 – A_{CL}* = 1 RESPONSE versus TEMPERATURE

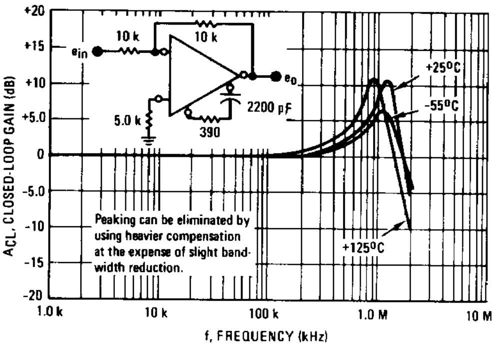


FIGURE 14 – A_{CL} = 10 RESPONSE versus TEMPERATURE

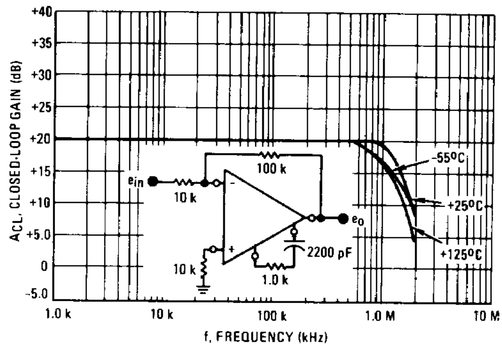


FIGURE 15 – A_{CL} = 100 RESPONSE versus TEMPERATURE

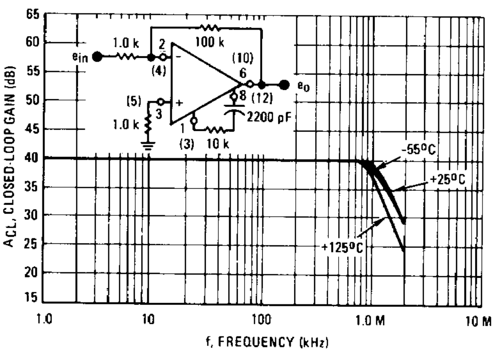


FIGURE 16 – A_{CL} = 1000 RESPONSE versus TEMPERATURE

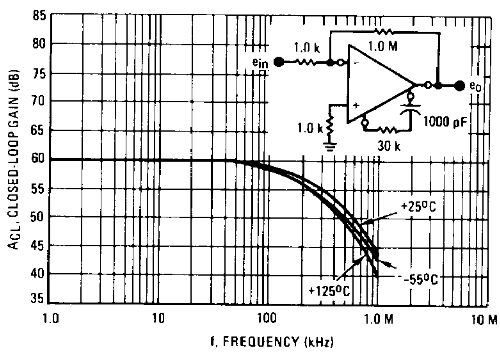


FIGURE 17 – SPECTRAL NOISE DENSITY

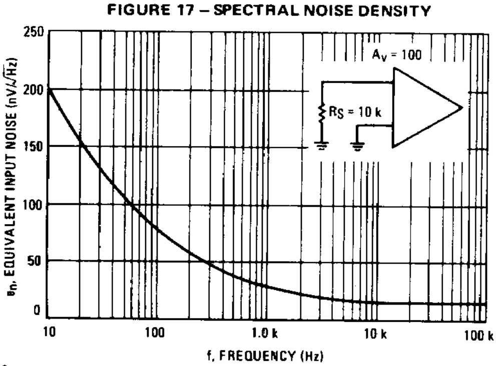
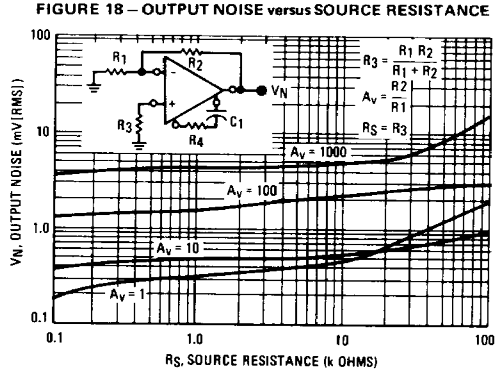


FIGURE 18 – OUTPUT NOISE versus SOURCE RESISTANCE



*A_{CL} = Closed-Loop Gain

TYPICAL CHARACTERISTICS (continued)

(V_{CC} = +15 Vdc, V_{EE} = -15 Vdc, T_A = +25°C, unless otherwise noted.)

FIGURE 19 – POWER DISSIPATION versus TEMPERATURE

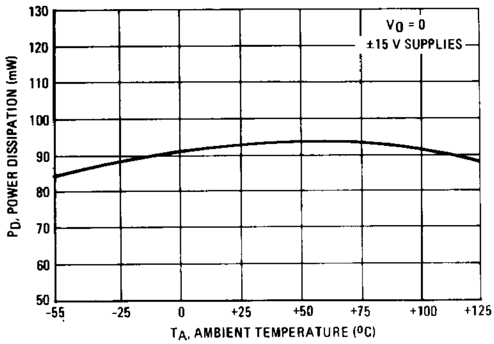


FIGURE 20 – POWER DISSIPATION versus POWER SUPPLY VOLTAGE

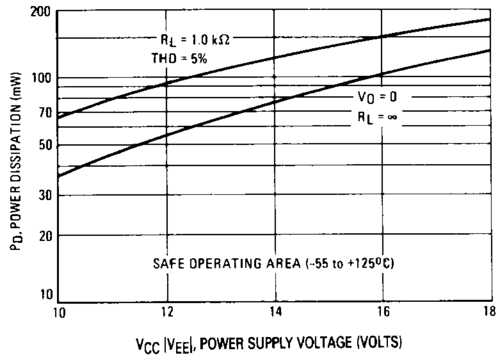


FIGURE 21 – POWER BANDWIDTH (LARGE-SIGNAL SWING versus FREQUENCY)

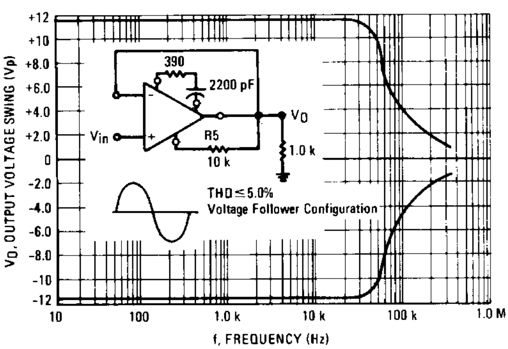


FIGURE 22 – COMMON-MODE INPUT VOLTAGE versus SUPPLY VOLTAGE

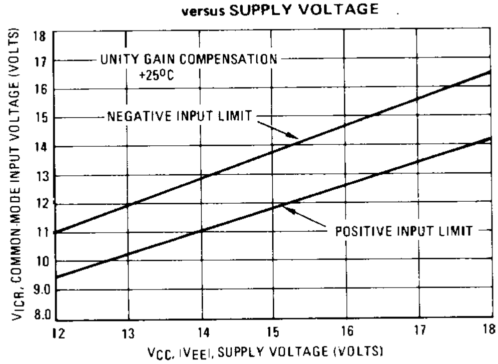


FIGURE 23 – COMMON-MODE REJECTION RATIO versus FREQUENCY

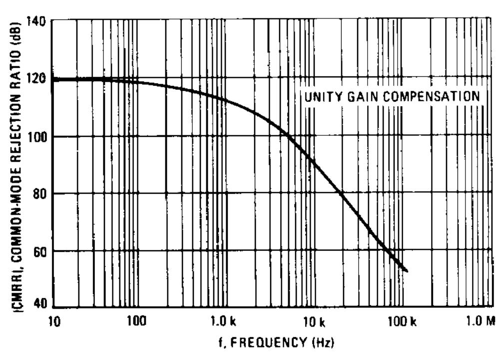


FIGURE 24 – COMMON-MODE REJECTION RATIO versus TEMPERATURE

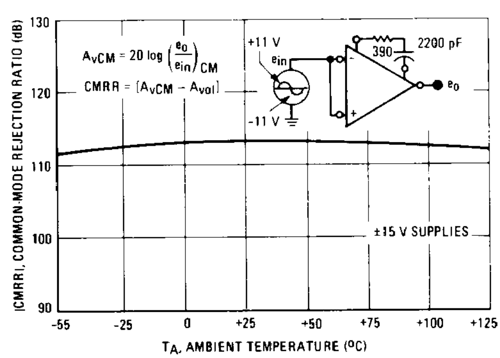
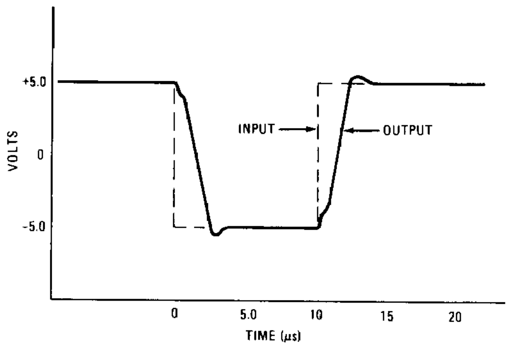
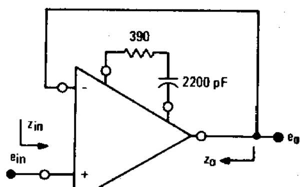


FIGURE 25 – VOLTAGE-FOLLOWER PULSE RESPONSE



TYPICAL APPLICATIONS

FIGURE 26 – VOLTAGE FOLLOWER

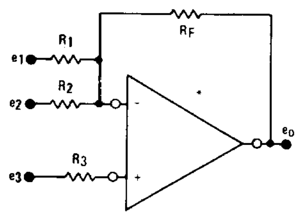


$e_{out} = e_{in} \pm V_{io}$

$z_{in} > 40$ M OHMS

$$z_{oCL} = z_{oOL}\left[\frac{1+\frac{R_F}{R_i}}{A_{ol}}\right] = 4\ k\left[\frac{1+0}{10^5}\right] \approx 0.04\ \text{OHM}$$

FIGURE 27 – DIFFERENTIAL AMPLIFIER

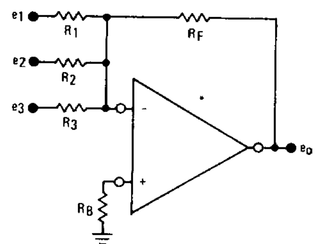


$$e_o = -\left|\frac{R_F}{R_1}e1 + \frac{R_F}{R_2}e2\right| + \left|1 + \frac{R_F}{R_3}\right| e3$$

$$\text{For } R_3 = \frac{R_1, R_2}{R_1 + R_2}$$

*Properly Compensated

FIGURE 28 – SUMMING AMPLIFIER

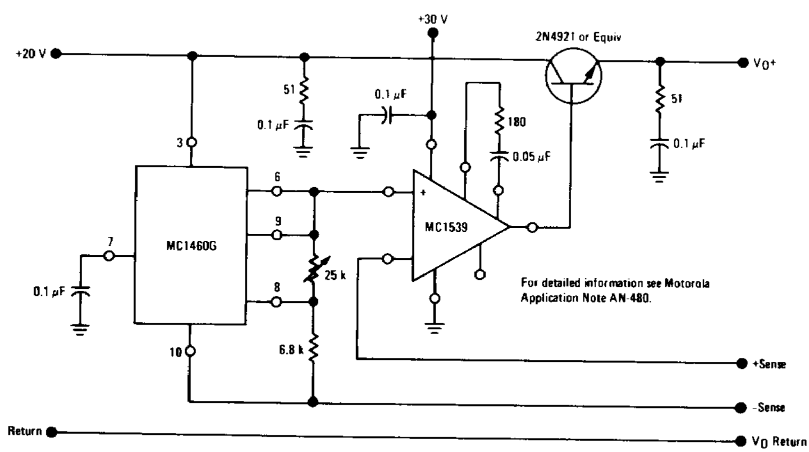


R_B = Parallel Combination of R_1, R_2, R_3, R_F.

$$e_o = -\left|\frac{R_F}{R_1}e1 + \frac{R_F}{R_2}e2 + \frac{R_F}{R_3}e3\right|$$

*Properly Compensated

FIGURE 29 – +15 VOLT REGULATOR



TYPICAL APPLICATIONS (continued)

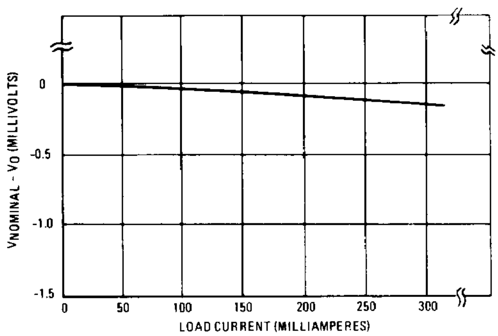


FIGURE 30 – LOAD REGULATION FOR CIRCUIT OF FIGURE 29

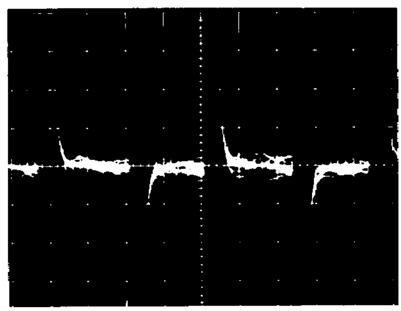


FIGURE 31 – REGULATOR OUTPUT VOLTAGE (under pulsed load condition)

Horizontal Scale: 200 μs/Div
Vertical Scale: 1 mV/Div