APPENDIX-B

Appendix -B

General Description

The LM101A series are general purpose operational amplifiers which feature improved performance over industry standards like the LM709. Advanced processing techniques make possible an order of magnitude reduction in input currents, and a redesign of the biasing circuitry reduces the temperature drift of input current. Improved specifications include:

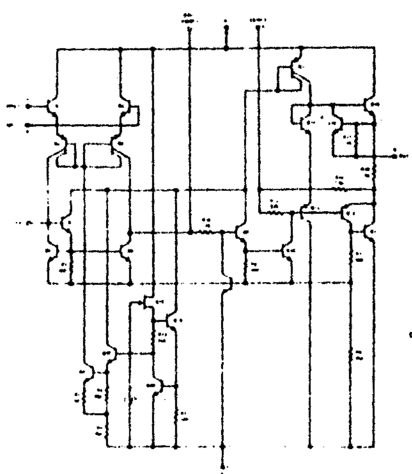
- Offset voltage 3 mV maximum over temperature (LM101A/LM201A)
- Input current 100 nA maximum over temperature (LM101A/LM201A)
- Offset current 20 nA maximum over temperature (LM101A/LM201A)
- Guaranteed drift characteristics
- Offsets guaranteed over entire common mode and supply voltage ranges
- Slew rate of 10V/μs as a summing amplifier

This amplifier offers many features which make its application nearly foolproof: overload protection on the input and output, no latch-up when the common mode range is exceeded, freedom from oscillations and compensation with a single 30 pF capacitor. It has advantages over internally compensated amplifiers in that the frequency compensation can be tailored to the particular application. For example, in low frequency circuits it can be overcompensated for increased stability margin. Or the compensation can be optimized to give more than a factor of ten improvement in high frequency performance for most applications.

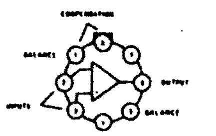
In addition, the device provides better accuracy and lower noise in high impedance circuitry. The low input currents also make it particularly well suited for long interval integrators or timers, sample and hold circuits and low frequency waveform generators. Further, replacing circuits where matched transistor pairs buffer the inputs of conventional IC op amps, it can give lower offset voltage and drift at a lower cost.

The LM101A is guaranteed over a temperature range of −55°C to +125°C, the LM201A from −25°C to +85°C, and the LM301A from 0°C to 70°C.

Schematic ** and Connection Diagrams (Top Views)

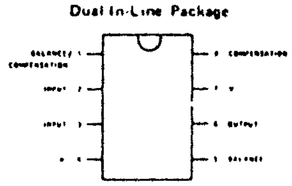


Metal Can Package



Order Number LM101AH, LM201AH or LM301AH
See NS Package H08C

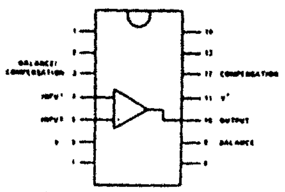
Dual-In-Line Package



Order Number
LM101AJ, LM201AJ, LM301AJ
See NS Package J08A

Order Number LM301AN
See NS Package N08A

Dual-In-Line Package



Note: Pin 6 connected to bottom of package.

Order Number LM101AJ-14
LM201AJ-14 or LM301AJ-14
See NS Package J14A

**Pin connections shown are for metal can

Absolute Maximum Ratings

	LM101A/LM201A	LM301A
Supply Voltage	±22V	±18V
Power Dissipation (Note 1)	500 mW	500 mW
Differential Input Voltage	±30V	±30V
Input Voltage (Note 2)	±15V	±15V
Output Short Circuit Duration (Note 3)	Indefinite	Indefinite
Operating Temperature Range	−55°C to +125°C (LM101A) −25°C to +85°C (LM201A)	0°C to +70°C
Storage Temperature Range	−65°C to +150°C	−65°C to +150°C
Lead Temperature (Soldering, 10 seconds)	300°C	300°C

Electrical Characteristics (Note 4)

PARAMETER	CONDITIONS	LM101A/LM201A			LM301A			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$T_A = 25°C$							
LM101A, LM201A, LM301A	$R_S \leq 50\ k\Omega$		0.7	2.0		2.0	7.5	mV
Input Offset Current	$T_A = 25°C$		1.5	10		3.0	50	nA
Input Bias Current	$T_A = 25°C$		30	75		70	250	nA
Input Resistance	$T_A = 25°C$	1.5	4.0		0.5	2.0		MΩ
Supply Current	$T_A = 25°C$							
	$V_S = \pm 20V$		1.8	3.0				mA
	$V_S = \pm 15V$					1.8	3.0	mA
Large Signal Voltage Gain	$T_A = 25°C$, $V_S = \pm 15V$	50	160		25	160		V/mV
	$V_{OUT} = \pm 10V$ $R_L \geq 2\ k\Omega$							
Input Offset Voltage	$R_S \leq 50\ k\Omega$			3.0			10	mV
	$R_S \leq 10\ k\Omega$							mV
Average Temperature Coefficient of Input Offset Voltage	$R_S \leq 50\ k\Omega$		3.0	15		6.0	30	μV/°C
	$R_S \leq 10\ k\Omega$							μV/°C
Input Offset Current				20			70	nA
	$T_A = T_{MAX}$							nA
	$T_A = T_{MIN}$							nA
Average Temperature Coefficient of Input Offset Current	$25°C \leq T_A \leq T_{MAX}$		0.01	0.1		0.01	0.3	nA/°C
	$T_{MIN} \leq T_A \leq 25°C$		0.02	0.2		0.02	0.6	nA/°C
Input Bias Current				0.1			0.3	μA
Supply Current	$T_A = T_{MAX}$ $V_S = \pm 20V$		1.2	2.5				mA
Large Signal Voltage Gain	$V_S = \pm 15V$ $V_{OUT} = \pm 10V$	25			15			V/mV
	$R_L \geq 2k$							
Output Voltage Swing	$V_S = \pm 15V$							
	$R_L = 10\ k\Omega$	±12	±14		±12	±14		V
	$R_L = 2\ k\Omega$	±10	±13		±10	±13		V
Input Voltage Range	$V_S = \pm 20V$	±15						V
	$V_S = \pm 15V$		+15 13		±12	+15, 13		V
Common Mode Rejection Ratio	$R_S \leq 50\ k\Omega$	80	96		70	90		dB
	$R_S \leq 10\ k\Omega$							dB
Supply Voltage [illegible] Ratio	$R_S \leq 50\ k\Omega$	80	96		70	96		dB
	$R_S \leq 10\ k\Omega$							dB

Note 1: The maximum junction temperature of the LM101A is 150°C, and that of the LM201A/LM301A is 100°C. For operating at elevated temperatures, devices in the TO 5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case. The thermal resistance of the dual-in-line package is 187°C/W, junction to ambient.

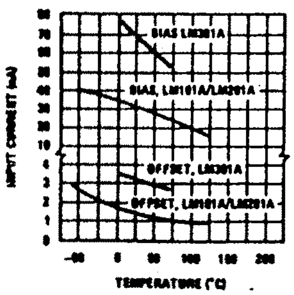
Note 2: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage

Note 3: Continuous short circuit is allowed for case temperatures to 125°C and ambient temperatures to 75°C for LM101A/LM201A, and 70°C and 55°C respectively for LM301A.

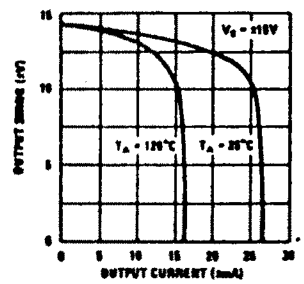
Note 4: Unless otherwise specified, these specifications apply for C1 = 30 pF, ±5V ≤ V_S ≤ ±20V and −55°C ≤ T_A ≤ +125°C (LM101A), ±5V ≤ V_S ≤ ±20V and −25°C ≤ T_A ≤ +85°C (LM201A), ±5V ≤ V_S ≤ ±15V and 0°C ≤ T_A ≤ +70°C (LM301A).

Typical Performance Characteristics (Continued)

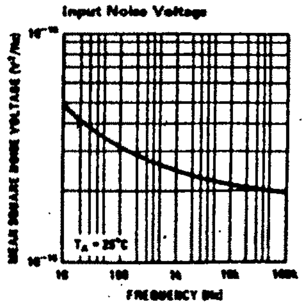
Input Current, LM101A/LM201A/LM301A



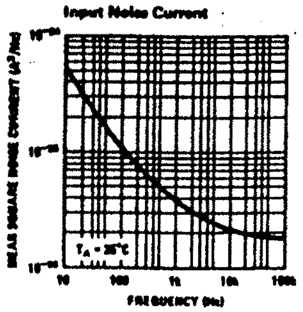
Current Limiting



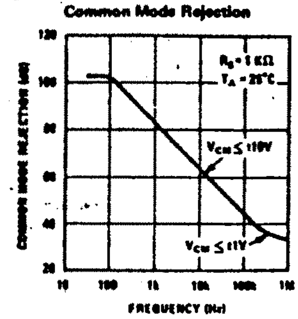
Input Noise Voltage



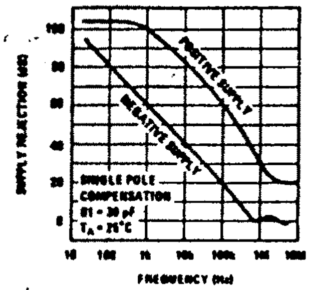
Input Noise Current



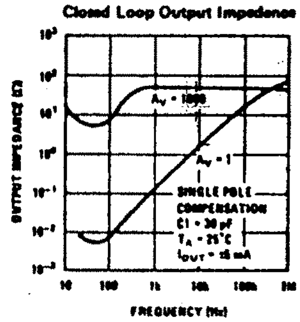
Common Mode Rejection



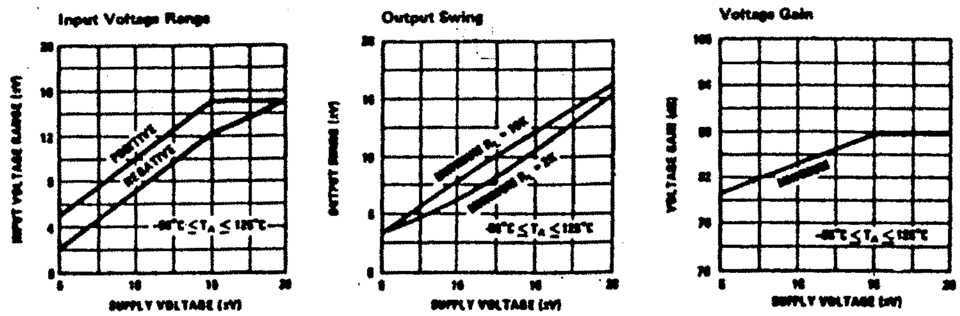
Power Supply Rejection



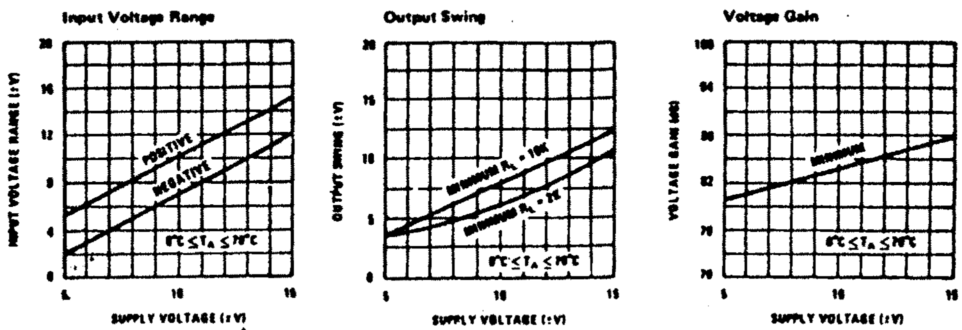
Closed Loop Output Impedance



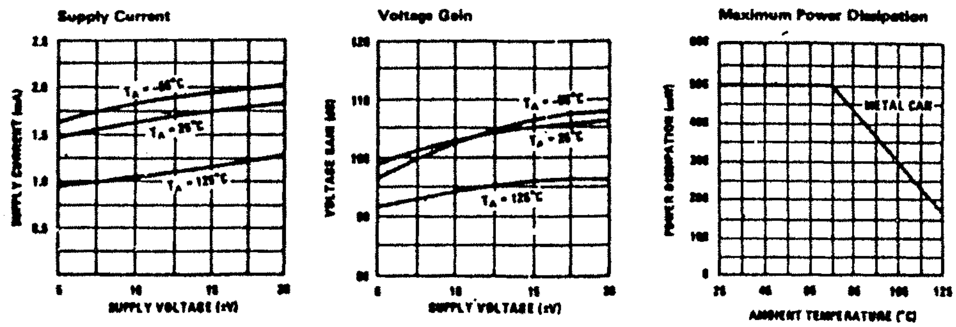
Guaranteed Performance Characteristics LM101A/LM201A



Guaranteed Performance Characteristics LM301A

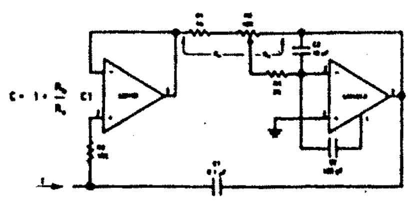


Typical Performance Characteristics



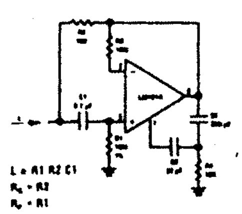
Typical Applications **

Variable Capacitance Multiplier



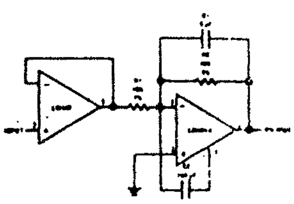
$C = 1 + \frac{R_b}{R_a} C1$

Simulated Inductor

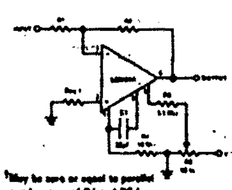


$L \approx R1\,R2\,C1$
$R_S = R2$
$R_P = R1$

Fast Inverting Amplifier With High Input Impedance

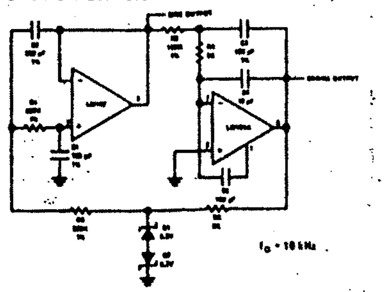


Inverting Amplifier with Balancing Circuit



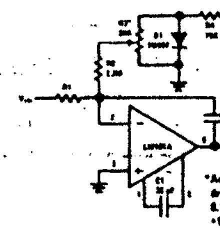
†May be zero or equal to parallel combination of R1 and R2 for minimum offset.

Sine Wave Oscillator



$f_o = 10\ kHz$

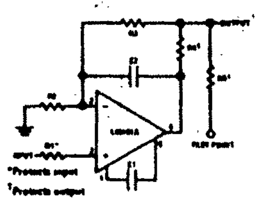
Integrator with Bias Current Compensation



*Adjust for zero integrator drift. Current drift typically 0.1 nA/°C over −55°C to +125°C temperature range.

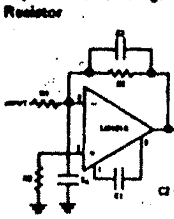
Application Hints **

Protecting Against Gross Fault Conditions



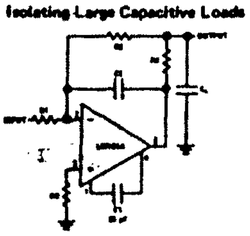
*Protects input
†Protects output
‡Protects output—not needed when R4 is used.

Compensating For Stray Input Capacitances Or Large Feedback Resistor



$C2 = \frac{R1\,C_S}{R2}$

Isolating Large Capacitive Loads



Although the LM101A is designed for trouble free operation, experience has indicated that it is wise to observe certain precautions given below to protect the devices from abnormal operating conditions. It might be pointed out that the advice given here is applicable to practically any IC op amp, although the exact reason why may differ with different devices.

When driving either input from a low-impedance source, a limiting resistor should be placed in series with the input lead to limit the peak instantaneous output current of the source to something less than 100 mA. This is especially important when the inputs go outside a piece of equipment where they could accidentally be connected to high voltage sources. Large capacitors on the input (greater than 0.1 μF) should be treated as a low source impedance and isolated with a resistor. Low impedance sources do not cause a problem unless their output voltage exceeds the supply voltage. However, the supplies go to zero when they are turned off, so the isolation is usually needed.

The output circuitry is protected against damage from shorts to ground. However, when the amplifier output is connected to a test point, it should be isolated by a limiting resistor, as test points frequently get shorted to bad places. Further, when the amplifier drives a load external to the equipment, it is also advisable to use some sort of limiting resistance to preclude mishaps.

Precautions should be taken to insure that the power supplies for the integrated circuit never become reversed—even under transient conditions. With reverse voltages greater than 1V, the IC will conduct excessive current, fuzing internal aluminum interconnects. If there is a possibility of this happening, clamp diodes with a high peak current rating should be installed on the supply lines. Reversal of the voltage between V^+ and V^- will always cause a problem, although reversals with respect to ground may also give difficulties in many circuits.

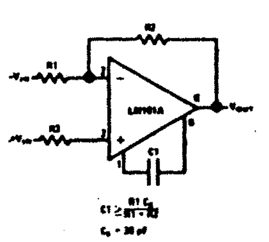
The minimum values given for the frequency compensation capacitor are stable only for source resistances less than 10 kΩ, stray capacitances on the summing junction less than 5 pF and capacitive loads smaller than 100 pF. If any of these conditions are not met, it becomes necessary to overcompensate the amplifier with a larger compensation capacitor. Alternately, lead capacitors can be used in the feedback network to negate the effect of stray capacitance and large feedback resistors or an RC network can be added to isolate capacitive loads.

Although the LM101A is relatively unaffected by supply bypassing, this cannot be ignored altogether. Generally it is necessary to bypass the supplies to ground at least once on every circuit card, and more bypass points may be required if more than five amplifiers are used. When feed-forward compensation is employed, however, it is advisable to bypass the supply leads of each amplifier with low inductance capacitors because of the higher frequencies involved.

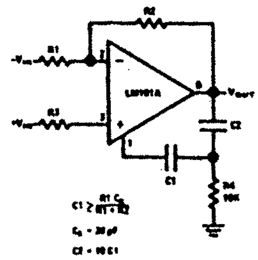
**Pin connections shown are for metal can.

Typical Performance Characteristics for Various Compensation Circuits**

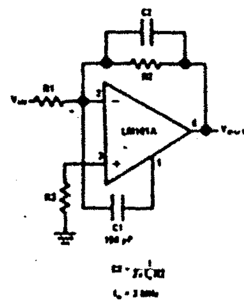
Single Pole Compensation



Two Pole Compensation

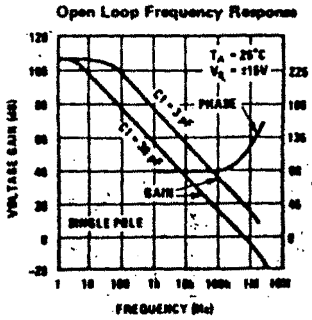


Feedforward Compensation

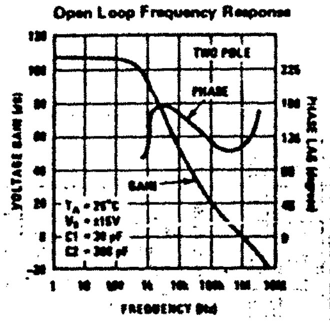


**Pin connections shown are for metal can.

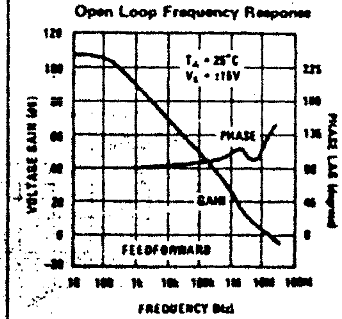
Open Loop Frequency Response



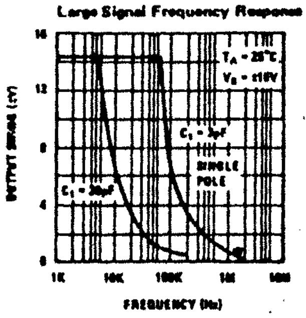
Open Loop Frequency Response



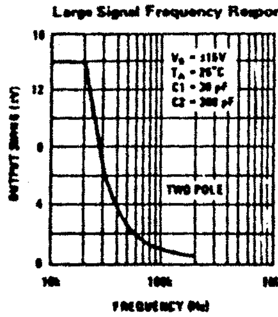
Open Loop Frequency Response



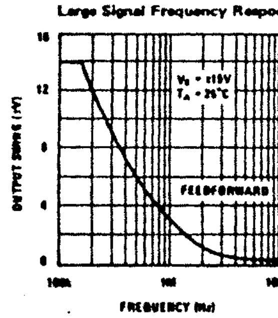
Large Signal Frequency Response



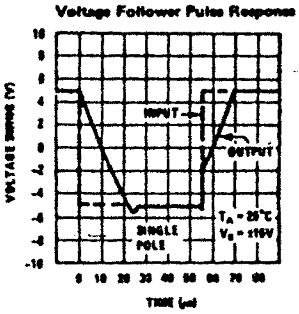
Large Signal Frequency Response



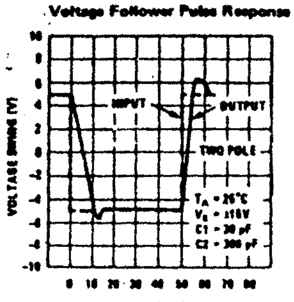
Large Signal Frequency Response



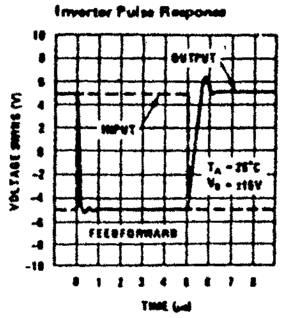
Voltage Follower Pulse Response



Voltage Follower Pulse Response

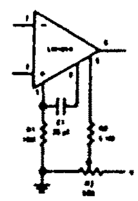


Inverter Pulse Response

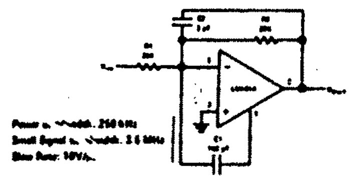


Typical Applications** (Continued)

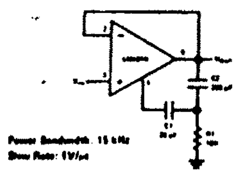
Standard Compensation and Offset Balancing Circuit



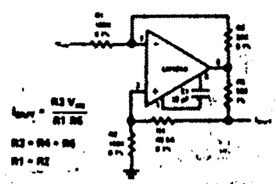
Fast Summing Amplifier



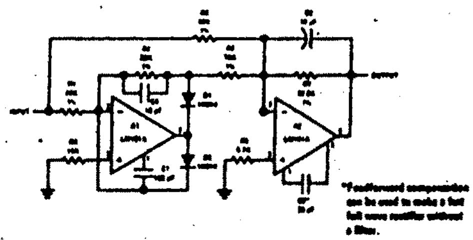
Fast Voltage Follower



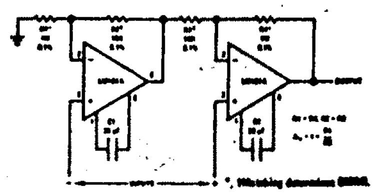
Bilateral Current Source



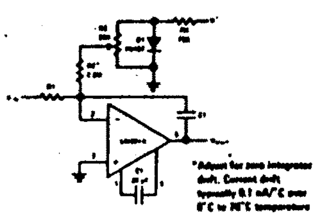
Fast AC/DC Converter*



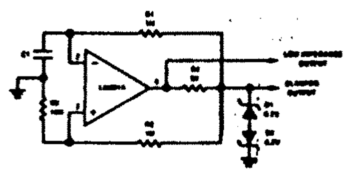
Instrumentation Amplifier



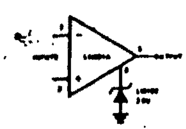
Integrator with Bias Current Compensation



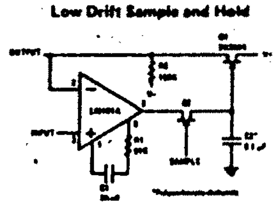
Low Frequency Square Wave Generator



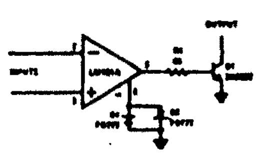
Voltage Comparator for Driving RTL Logic or High Current Driver



Low Drift Sample and Hold



Voltage Comparator for Driving DTL or TTL Integrated Circuits



Appendix B

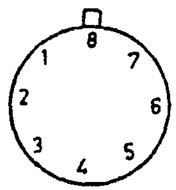
~~APPENDIX C~~

IMPORTANT DATA AND PIN CONNECTION DIAGRAMS FOR SOME LINEAR ICs

General Purpose Op-Amps

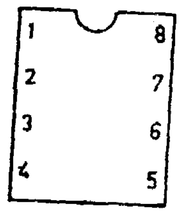
(μA 101 A, μA 202 A, μA 301 A)

(TOP VIEW)



8-lead metal package

(TOP VIEW)



8-lead DIP package

1. —offset null/frequ. compen.
2. —In
3. +In
4. V⁻
5. +offset null
6. out
7. V+
8. Freq. compen.

Absolute maximum ratings :

Supply voltage :	
μA 101 A, μA 201 A	±22 V
μA 301 A	±18 V
Differential input voltage	±30 V
Input voltage for $V_{CC} < \pm 15$ V	±15 V

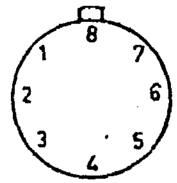
Super Beta Op-Amps

(μA 108 A, μA 208 A, μA 308 A)

These Op-Amps have low input offset-voltage, high input impedance (typ. 70 MΩ for 108 A and 208 A and 40 MΩ for 308 A), low offset and bias currents. They are used in high speed sample and hold circuits and precision high speed summing

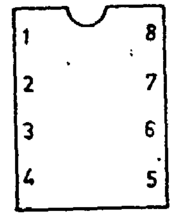
amplifier where high accuracy and low drift performance is required.

TOP VIEW



8-lead metal package

TOP VIEW



8-lead DIP package

1. Frequ. compen. 1
2. —In
3. +In
4. V⁻
5. NC
6. out
7. V+
8. Frequ. compen. 2.

Absolute maximum ratings :

Internal power dissipation	
8 L—metal can	1 W
8 L—molded DIP	0·93 W
SO—8	0·81 W
Supply voltage	
μA 108 A, μA 208 A	±20 V
μA 308 A	±18 V
Differential Input current	±10 mA
Input voltage	±15 V.

Quad Op-Amps

(μA 124, μA 224. μA 324, μA 2902)

These are four independent high gain frequency compensated Op-Amps designed to operate from single or dual power supply some typical features are as below.

—Input common mode voltage range includes ground or negative supply

—Output voltage can swing to ground or negative

—Wide supply range,

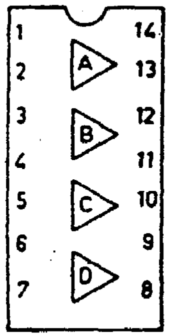
single supply	3 V to 30 V
dual supply	+1·5 V to ±16 V

—Power drain suitable for battery operation.

—Internal power dissipation :

14 L—ceramic DIP	1·36 W,
14 L—molded DIP	1·04 W, and
SO—14	0·93 W.

(TOP VIEW)



14-lead DIP and SO-14 package

1. A out	2. $-A$
3. $+A$	4. V^+
5. $+B$	6. $-B$
7. out B	8. out C
9. $-C$	10. $+C$
11. V^- or gnd.	12. $+D$
13. $-D$	14. out D.

Note. Four amplifiers are designated as A, B, C, and D.

Quad Op-Amps

(μA 148, μA 248, μA 348)

These are four independent high gain internally frequency compensated low power Op-Amps whose characteristics are identical to μA 741. Total supply current for all four amplifiers is comparable to the supply current of single μA 741 type Op-Amp. They have following features :

—μA 741 Op-Amp operating characteristics

—Low supply current drain

—Class AB output ; no crossover distortion

—Lead compatible with μA 324

—Gain×BW for μA 148 is 1 mHz (typ.)

—Overload protection.

Pin configuration of 14-lead DIP is identical to μA 124 quad

Absolute maximum ratings :

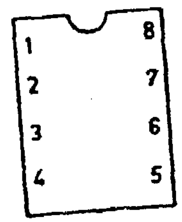
Internal power dissipation	
14—L molded DIP	1·04 W
14—L ceramic DIP	1·36 W
Supply voltage	
μA 148	±22 V
μA 248, 348	±18 V

High Performance Op-Amp

(μA 709)

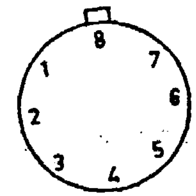
This is a high gain amplifier and is used in following applications : dc servos, high impedance analogue computers, low level instrumentation, generation of linear and non-linear transfer function.

(TOP VIEW)



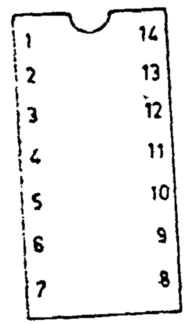
8-lead DIP and SO-8 pack

(TOP VIEW)



8-lead metal pack lead-4 connected to case.

(TOP VIEW)



14-lead DIP

1. NC	2. NC
3. In freq. compen.	4. $-$In
5. +In	6. V^-
7. NC	8. NC
9. out freq. compen.	10. out
11. V+	12. In freq. compen. 2
13. NC	14. NC

Absolute Maximum Ratings :

Input power dissipation	
8L metal can	1 W
8L molded DIP	0·93 W
14L molded DIP	1·04 W

Table D-3. General-Purpose Quad. Op-Amps

V_{io} : Input offset voltage
I_{io} : Input offset current
I_B : Input bias current
SR = Slew Rate.

CMR : Common mode range
DIR : Differential input range
Icc : Supply current

Device	*V_{io} max (mV)*	*I_{io} max (nA)*	*I_B max (nA)*	*Volt. gain min (V/V)*	*Unity gain BW typ. (MHz)*	*SR typ. (V/μS)*	*Supply volt. range (V)*	*CMR (V)*	*DIR (V)*	*Icc max (mA)*	*Features**
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*
LM 124	7	100	150	25 K	1	...	±1·5 to ±15	V⁺−2	±32	2·0	Q, R, T
LM 124 A	2	10	50	50 K	1	...	±1·5 to ±15	V⁺−2	±32	2·0	Q, R T
LM 148	6	75	325	25 K	1	0·6	±3 to ±22	±12	±30	3·6	Q, R
LM 3503	5	50	500	50 K	1	0·6	+3 to +36	±18	±36	4	Q, R, T
Industrial −25°C to +85°C											
LM 224	9	150	500	15 K	1	...	±1·5 to ±15	V⁺−1·5	±32	2·0	Q, R, T
LM 248	7·5	125	500	15 K	1	0·5	±5 to ±18	±18	±36	4·5	Q, R
Commercial 0°C to +70°C											
LM 324	9	150	500	15 K	1	...	±1·5 to ±15	V⁺−1·5	±32	2	Q, R, T
LM 348	7·5	100	400	15 K	1	...	±5 to ±18	±18	±36	4·5	Q, R
MC 3403	10	50	500	20 K	1	0·6	+3 to +36	±18	±36	7	Q, R, T

***Note.** **P.** Offset adj. capability; **Q.** Output short circuit protection; **R.** Internal compensation; **S.** External compensation; **T.** Single supply operation.

Appendix B

13·4·2. Adjustable type 723 Regulator

The type μA 723 voltage regulator consists of a temperature compensated 6·2 V Zener biased with a constant current source. A buffer amplifier provides the zener voltage as a reference voltage output that provides upto 15 mA. An error amplifier is provided to compare the reference voltage and a sample of the regulator output voltage. The error amplifier drives a series pass Darlington output pair. A current limiting transistor is also provided. Fig. 13·22 shows the circuit diagram of the device type 723.

The Zener (D_3), V_{out}, is used when the device 723 regulator required to be connected as negative regulator in such case, D_3 serves to keep the error amplifier transistor Q_{13} in the active region. In such application, anode of D_3 is connected to $-V$. The Zener diode D_3 (6·2 V), reduces the power dissipation of the series pass tansistors. The Zener diode can provide upto 25 mA.

The series pass element is realized by Q_{14} and Q_{15} which are Darlington output transistors. They boost up the output current to a value of 150 mA. The terminals V^+ and V_c are connected for normal voltage regulator use or when the regulator drives an external *npn* series pass transistor.

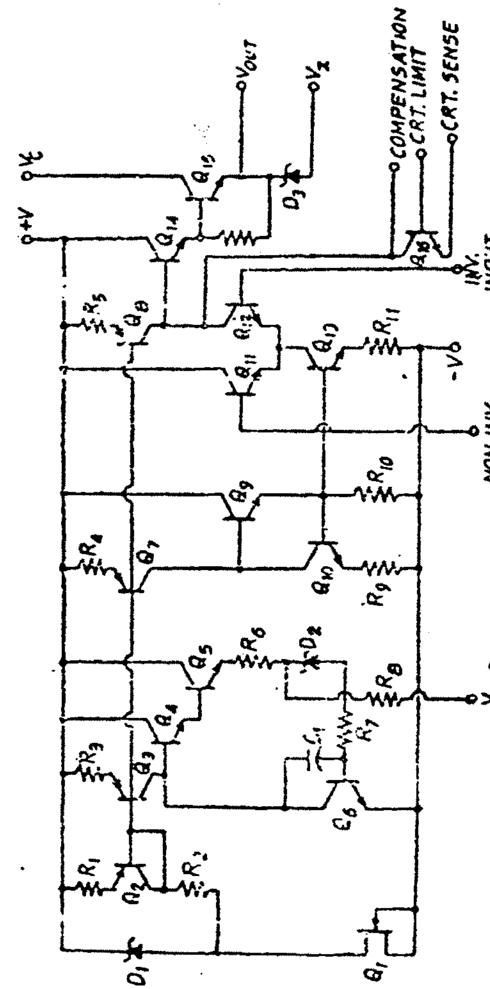


Fig. 13·22. Type 723 regulator circuit.

When type 723 device is used to drive a *pnp* or a complementary *pnp-npn* output, V_c goes to the base of *pnp* and a device resistor is used between V_c and V^+.

The transistor Q_{16} is the current limiting transistor for constant or foldback current limiting. The current limiting sense voltage varies with temperature from 0·45 at −50°C to 0·8 V at 150°C but is 0·65 V at room temperature. The sense voltage is obtained as the drop across a suitable resistor in the load current path. Depending on the nature of the current limiting desired, either the full sense voltage or portion of it is applied between the base and emitter of Q_{16}.

The error amplifier comprises of transistors Q_7 through Q_{13} and resistors R_{10} and R_{11}. The transistor pair $Q_{11}-Q_{12}$ alongwith the current source Q_{13} constitutes the conventional differential amplifier circuit. The device Q_8 provides a larger collector load impedance, thus a high gain for Q_{12}. The transistor Q_{18} provides base drive for Q_{14}. The transistor Q_{13} is temperature compensated constant current source for the emitter current of Q_{11} and Q_{12}. Q_7 provides constant current to transistors Q_9 and Q_{10} which provide temperature compensation to Q_{13}. As the base-emitter voltage of Q_{13} decreases with increase in temperature, so does the base-emitter voltage of Q_{10}, so that voltage drop across R_{11}, thus collector current of Q_{13} stays constant. Q_9 holds the base current of Q_{10} constant as the base-emitter voltage of Q_{10} changes with temperature.

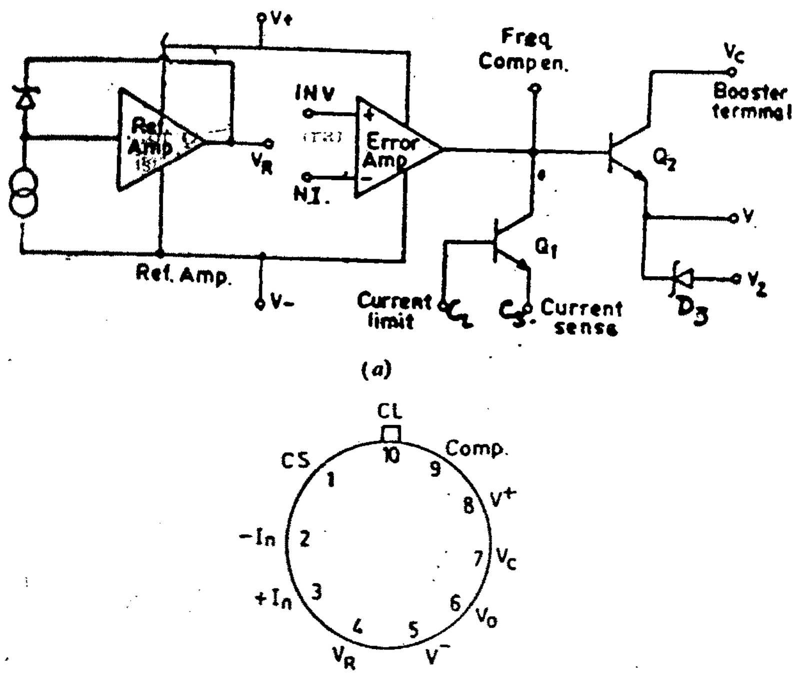
The voltage reference amplifier is realized by transistors Q_1 through Q_6 and diodes D_1 and D_2. Q_1 is FET device which provides constant current to Zener D_1 (6·2 V), so that, D_1 provides a constant voltage to R_1, R_2 and diode connected transistor Q_2. The device Q_2 provides a constant base voltage to constant current source transistors Q_3, Q_7 and Q_8. Q_2 compensates for the V_{BE} variations with temperature of Q_3, Q_7 and Q_8.

Transistor Q_3 provides a constant current to D_2 (reference zener, 6·2 V), and the reference amplifier Q_4, Q_5 and Q_6. Most of the current from Q_3 flows through Q_6. Q_4 and Q_5 provide a low impedance at the reference voltage output. The reference voltage $V_R = V_{R_8} + V_{D_2}$. Any change in voltage drop across R_8 either from temperature drift of the V_{BE} of Q_6 or D_2 or reference voltage loading, is sensed by Q_6, which provides a correcting voltage of opposite polarity at the base of Q_4.

The reference voltage is specified to be between 6·8 and 7·5 V with 7·15 V as the typical value. Thus the regulator output voltage sample divider is required to have potentiometer to sense V_{out} precisely. Frequency compensation terminal is taken from the collector of Q_{12} of error amplifier. This is required for external frequency compensation.

Fig. 13·23 *(a)* shows the functional block diagram of device 723 alongwith its pin configuration. The output stage must be compensated with a capacitor from the compensating pin to either ground or the inverting input. Recommended unity gain compensation is about 0·005 μF. If $V_o > V_R$, the closed loop gain must increase. The compensating capacitor must be reduced proportionally to the increase in gain.

If the overcurrent sense function is not going to be used, a Zener (in addition to D_3) is available using the emitter-base function between the C_S and C_L pins. The anode of this zener is C_L and may be connected directly to the output. This provides both positive and negative 6·2 V zener reference with respect to output voltage V_o.



(a)

(b)

Fig. 13·23. *(a)* Functional block diagram of type 723 regulator and *(b)* its pin configuration.

Minimum V_{in} is 9·5 to ensure proper operation of the internal reference and zener supplies. To reduce power consumption V_c need only be 3 V greater than the regulated output voltage (Providing V_{in}=9·5 V)

13·4·3. Typical Regulator Circuits using Type 723 IC

The type 723 device is the most versatile of monolithic regulators. It can be used to provide high and low positive regulated voltages, negative regulated voltages, and can be used as a positive and negative switching regulator.

The μA 723 is supplied in two packages a metal can that can dissipate 800 mW and a plastic 14 pin DIP that can dissipate 1W.

The μA 723 C can operate with an input voltage fr m 9·5 V to 40 V and provide an output voltage from 2 to 37 V. This device can provide an output current of 150 mA for $V_{in}-V_0=3V$, but I_0 drops to 10 mA for $V_{in}-V_0=38$ V. The device features worst-case load regulation of 0·6% V_0 and worst-case line regulation of 0·5% V_0. The quiescent current drain of the device is 3·5 mA maximum typically about 2·3 mA, and relatively constant with applied voltage changes. The μA 723, if powered by an ungrounded Zener diode regulator, can control an external pass transistor to regulate voltage upto 250 V.

Design of Low Voltage Regulator Using Type 723

The reference voltage V_R must be reduced for the non-inverting input of the error amplifier by means of a voltage divider as shown in Fig. 13·24. Here the circuit connections are for low output voltage range : 2 to 7 V.

For maximum temperature stability

$$R_3=\frac{R_1R_2}{R_1+R_2} \quad \text{...(13·42)}$$

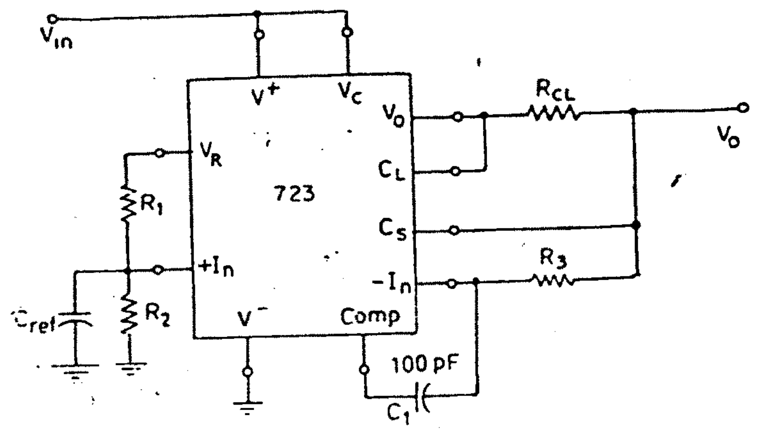


Fig. 13·24. Circuit connections for type 723 used as a low voltage regulator.

which is provided for the inverting input of the error amplifier. R_3 can be eliminated to reduce component count by using a direct connection between C_s and $-In$. The value of R_2 must be less than 10 kΩ for stability, but greater than 499 Ω to avoid loading the reference voltage. The values in the data sheet resistor chart, show

$$966\Omega < R_2 < 3{\cdot}52 \text{ K}\Omega$$

with the divider current, I_D, at about 1mA. Hence we shall assume $I_D=1$ mA through resistor divider.

Since the error amplifier draws very little current, we will neglect its input bias current. Hence

$$R_1=\frac{V_R-V_0}{I_D} \quad \text{...(13·43)}$$

$$R_2=\frac{V_0}{I_D} \quad \text{...(13·44)}$$

Alternatively, we assume value of R_2 and find out R_1 using the following equation,

$$V_0=\frac{R_2}{R_1+R_2}V_R \quad \text{...(13·45)}$$

From specifications $C_{ref}=5\ \mu$F to reduce reference noise voltage and $C_1=100$ pF for frequency stability.

The value of R_{CL} is given by

$$R_{CL}=\frac{V_{sense}}{I_m} \quad \text{...(13·46)}$$

where $V_{sense}=0{\cdot}65$ V at 25°C.

For ambient temperature other than 25°C, the value of sense ... is obtained using graph.

Voltage Regulator

(μA 723)

—Output voltage 2 to 37 V

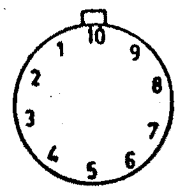
—Output current 150 mA without external pass transistor

—wine regulation, 0·01 %

—Load regulation 0·03%

—Adjustable short circuit protection.

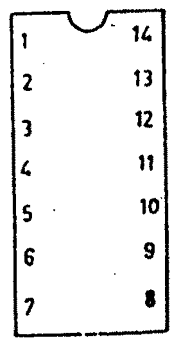
TOP VIEW



10-Lead metal can
Lead 5 connected to case

1. CS
2. −In
3. +In
4. V_R
5. V^-
6. V_0
7. V_C
8. V^+
9. Freq. compen.
10. CL

TOP VIEW



1. NC
2. CL
3. CS
4. −In
5. +In
6. V_R
7. V^-
8. NC
9. V_Z
10. V_0
11. V_C
12. V^+
13. Freq. compen,
14. NC.