T-58-11-13

MOTOROLA

LM140,A Series
LM340,A Series

Specifications and Applications Information

THREE-TERMINAL POSITIVE VOLTAGE REGULATORS

This family of fixed voltage regulators are monolithic integrated circuits capable of driving loads in excess of 1.0 ampere. These three-terminal regulators employ internal current limiting, thermal shutdown, and safe-area compensation. Devices are available with improved specifications, including a 2% output voltage tolerance, on A-suffix 5.0, 12 and 15 volt device types.

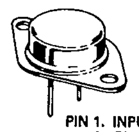
Although designed primarily as a fixed voltage regulator, these devices can be used with external components to obtain adjustable voltages and currents. This series of devices can be used with a series-pass transistor to boost output current capability at the nominal output voltage.

- Output Current in Excess of 1.0 Ampere
- No External Components Required
- Output Voltage Offered in 2% and 4% Tolerance*
- Internal Thermal Overload Protection
- Internal Short-Circuit Current Limiting
- Output Transistor Safe-Area Compensation

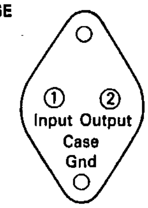
THREE-TERMINAL POSITIVE FIXED VOLTAGE REGULATORS

SILICON MONOLITHIC INTEGRATED CIRCUIT

K SUFFIX
METAL PACKAGE
CASE 1-03

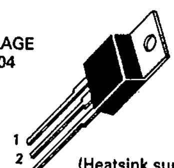


PIN 1. INPUT
2. OUTPUT
CASE GROUND



(Bottom View)

T SUFFIX
PLASTIC PACKAGE
CASE 221A-04



PIN 1. INPUT
2. GROUND
3. OUTPUT

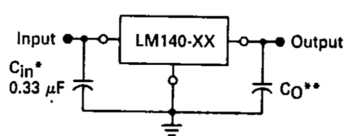
(Heatsink surface connected to Pin 2)

ORDERING INFORMATION

Device	Output Voltage and Tolerance	Tested Operating Junction Temp. Range	Package
LM140K-5.0	5.0 V ± 4%	−55°C to +150°C	Metal Power
LM140AK-5.0	5.0 V ± 2%	−55°C to +150°C	Metal Power
LM140K-8.0	8.0 V ± 4%	−55°C to +150°C	Metal Power
LM140K-12	12 V ± 4%	−55°C to +150°C	Metal Power
LM140AK-12	12 V ± 2%	−55°C to +150°C	Metal Power
LM140K-15	15 V ± 4%	−55°C to +150°C	Metal Power
LM140AK-15	15 V ± 2%	−55°C to +150°C	Metal Power
LM340K-5.0	5.0 V ± 4%	0°C to +125°C	Metal Power
LM340AK-5.0	5.0 V ± 2%	0°C to +125°C	
LM340T-5.0	5.0 V ± 4%	0°C to +125°C	Plastic Power
LM340AT-5.0	5.0 V ± 2%	0°C to +125°C	
LM340T-6.0	6.0 V ± 4%	0°C to +125°C	Plastic Power
LM340K-8.0	8.0 V ± 4%	0°C to +125°C	Metal Power
LM340T-8.0	8.0 V ± 4%	0°C to +125°C	Plastic Power
LM340K-12	12 V ± 4%	0°C to +125°C	Metal Power
LM340AK-12	12 V ± 2%	0°C to +125°C	
LM340T-12	12 V ± 4%	0°C to +125°C	Plastic Power
LM340AT-12	12 V ± 2%	0°C to +125°C	
LM340K-15	15 V ± 4%	0°C to +125°C	Metal Power
LM340AK-15	15 V ± 2%	0°C to +125°C	
LM340T-15	15 V ± 4%	0°C to +125°C	Plastic Power
LM340AT-15	15 V ± 2%	0°C to +125°C	
LM340T-18	18 V ± 4%	0°C to +125°C	Plastic Power
LM340T-24	24 V ± 4%	0°C to +125°C	Plastic Power

*2% regulators are available in 5, 12 and 15 volt devices

STANDARD APPLICATION



A common ground is required between the input and the output voltages. The input voltage must remain typically 1.7 V above the output voltage even during the low point on the input ripple voltage.

XX = these two digits of the type number indicate voltage.

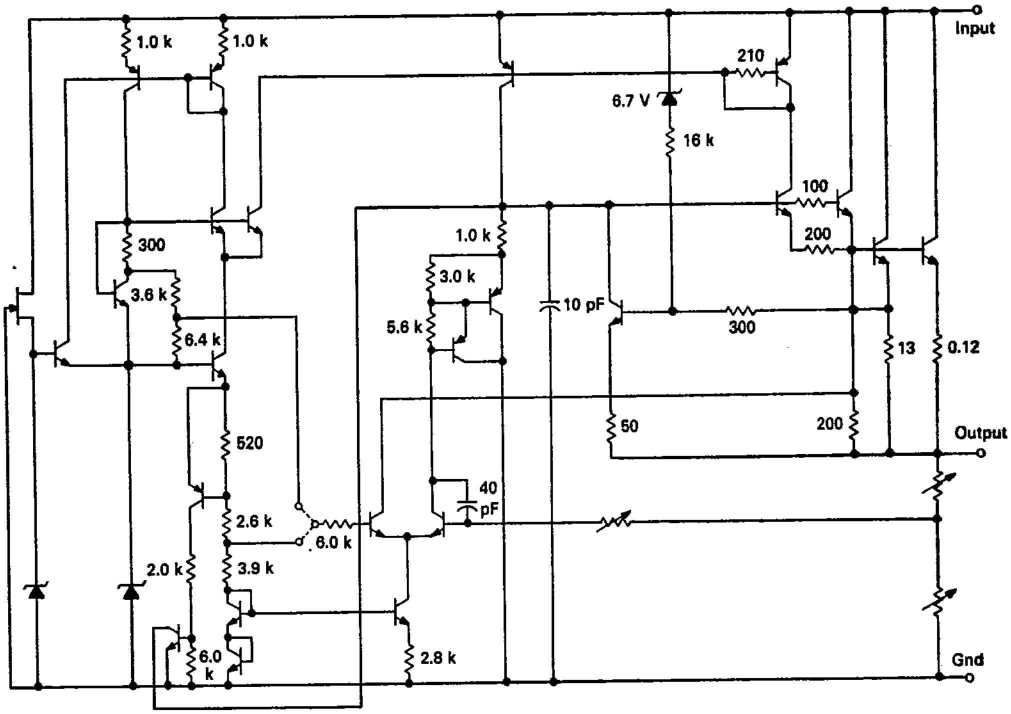
* = C_{in} is required if regulator is located an appreciable distance from power supply filter.

** = C_O is not needed for stability; however, it does improve transient response. If needed, use a 0.1 μF ceramic disc.

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

Rating	Symbol	Value	Unit
Input Voltage (5.0 V – 18 V) (24 V)	V_{in}	35 40	Vdc
Power Dissipation and Thermal Characteristics Plastic Package T_A = +25°C Derate above T_A = +25°C Thermal Resistance, Junction to Air	 P_D $1/\theta_{JA}$ θ_{JA}	 Internally Limited 15.4 65	 Watts mW/°C °C/W
T_C = +25°C Derate above T_C = +75°C (See Figure 1) Thermal Resistance, Junction to Case	P_D $1/\theta_{JC}$ θ_{JC}	Internally Limited 200 5.0	Watts mW/°C °C/W
Metal Package T_C = +25°C Derate above T_A = +25°C Thermal Resistance, Junction to Air	 P_D $1/\theta_{JA}$ θ_{JA}	 Internally Limited 22.5 45	 Watts mW/°C °C/W
T_C = +25°C Derate above T_C = +65°C (See Figure 2) Thermal Resistance, Junction to Case	P_D $1/\theta_{JC}$ θ_{JC}	Internally Limited 182 5.5	Watts mW/°C °C/W
Storage Junction Temperature Range	T_{stg}	–65 to +150	°C
Operating Junction Temperature Range LM140,A LM340,A	T_J	 –55 to +150 0 to +150	°C

EQUIVALENT SCHEMATIC DIAGRAM



DEFINITIONS

Line Regulation — The change in output voltage for a change in the input voltage. The measurement is made under conditions of low dissipation or by using pulse techniques such that the average chip temperature is not significantly affected.

Load Regulation — The change in output voltage for a change in load current at constant chip temperature.

Maximum Power Dissipation — The maximum total device dissipation for which the regulator will operate within specifications.

Quiescent Current — That part of the input current that is not delivered to the load.

Output Noise Voltage — The rms ac voltage at the output, with constant load and no input ripple, measured over a specified frequency range.

LM140/340 — 5.0

ELECTRICAL CHARACTERISTICS (V_{in} = 10 V, I_O = 500 mA, T_J = T_{low} to T_{high} (Note 1), unless otherwise noted).

Characteristic	Symbol	Min	Typ	Max	Unit
Output Voltage (T_J = +25°C) I_O = 5.0 mA to 1.0 A	V_O	4.8	5.0	5.2	Vdc
Line Regulation (Note 2) 8.0 to 20 Vdc 7.0 to 25 Vdc (T_J = +25°C) 8.0 to 12 Vdc, I_O = 1.0 A 7.3 to 20 Vdc, I_O = 1.0 A (T_J = +25°C)	Reg_{line}	— — — —	— — — —	50 50 25 50	mV
Load Regulation (Note 2) 5.0 mA ≤ I_O ≤ 1.0 A 5.0 mA ≤ I_O ≤ 1.5 A (T_J = +25°C) 250 mA ≤ I_O ≤ 750 mA (T_J = +25°C)	Reg_{load}	— — —	— — —	50 50 25	mV
Output Voltage LM140 8.0 ≤ V_{in} ≤ 20 Vdc, 5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W LM340 7.0 ≤ V_{in} ≤ 20 Vdc, 5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W	V_O	4.75 4.75	— —	5.25 5.25	Vdc
Quiescent Current I_O = 1.0 A LM140 LM340 LM140 (T_J = +25°C) LM340 (T_J = +25°C)	I_B	— — — —	— — 4.0 4.0	7.0 8.5 6.0 8.0	mA
Quiescent Current Change 8.0 ≤ V_{in} ≤ 25 Vdc, I_O = 500 mA LM140 7.0 ≤ V_{in} ≤ 25 Vdc, I_O = 500 mA LM340 5.0 mA ≤ I_O ≤ 1.0 A, V_{in} = 10 V LM140, LM340 8.0 ≤ V_{in} ≤ 20 Vdc, I_O = 1.0 A LM140 7.5 ≤ V_{in} ≤ 20 Vdc, I_O = 1.0 A LM340	ΔI_B	— — — — —	— — — — —	0.8 1.0 0.5 0.8 1.0	mA
Ripple Rejection LM140 LM340 I_O = 1.0 A (T_J = +25°C) LM140 LM340	RR	68 62 68 62	— — 80 80	— — — —	dB
Dropout Voltage	V_{in} - V_O	—	1.7	—	Vdc
Output Resistance (f = 1.0 kHz)	r_O	—	2.0	—	mΩ
Short-Circuit Current Limit (T_J = +25°C)	I_{sc}	—	2.0	—	mA
Output Noise Voltage (T_A = +25°C) 10 Hz ≤ f ≤ 100 kHz	V_n	—	40	—	μV
Average Temperature Coefficient of Output Voltage I_O = 5.0 mA	TCV_O	—	±0.6	—	mV/°C
Peak Output Current (T_J = +25°C)	I_O	—	2.4	—	A
Input Voltage to Maintain Line Regulation (T_J = +25°C) I_O = 1.0 A		7.3	—	—	Vdc

NOTES: 1. T_{low} = −55°C for LM140 T_{high} = +150°C for LM140
= 0°C for LM340 = +125°C for LM340

2. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

LM140,A, LM340,A

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LM140A/340A — 5.0

ELECTRICAL CHARACTERISTICS (V_{in} = 10 V, I_O = 1.0 A, T_J = T_{low} to T_{high} (Note 1), unless otherwise noted).

Characteristic	Symbol	Min	Typ	Max	Unit
Output Voltage (T_J = +25°C) I_O = 5.0 mA to 1.0 A	V_O	4.9	5.0	5.1	Vdc
Line Regulation (Note 2) 7.5 to 20 Vdc, I_O = 500 mA 7.3 to 20 Vdc (T_J = +25°C) 8.0 to 12 Vdc 8.0 to 12 Vdc (T_J = +25°C)	Reg_{line}	 — — — —	 — 3.0 — —	 10 10 12 4.0	mV
Load Regulation (Note 2) 5.0 mA ≤ I_O ≤ 1.0 A 5.0 mA ≤ I_O ≤ 1.5 A (T_J = +25°C) 250 mA ≤ I_O ≤ 750 mA (T_J = +25°C)	Reg_{load}	 — — —	 — — —	 25 25 15	mV
Output Voltage 7.5 ≤ V_{in} ≤ 20 Vdc, 5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W	V_O	4.8	—	5.2	Vdc
Quiescent Current (T_J = +25°C)	I_B	— —	— 3.5	6.5 6.0	mA
Quiescent Current Change 5.0 mA ≤ I_O ≤ 1.0 A, V_{in} = 10 V 8.0 ≤ V_{in} ≤ 25 Vdc, I_O = 500 mA 7.5 ≤ V_{in} ≤ 20 Vdc, I_O = 1.0 A (T_J = +25°C)	ΔI_B	 — — —	 — — —	 0.5 0.8 0.8	mA
Ripple Rejection 8.0 ≤ V_{in} ≤ 18 Vdc, f = 120 Hz I_O = 500 mA I_O = 1.0 A (T_J = +25°C)	RR	 68 68	 — 80	 — —	dB
Dropout Voltage	$V_{in} - V_O$	—	1.7	—	Vdc
Output Resistance (f = 1.0 kHz)	r_O	—	2.0	—	mΩ
Short-Circuit Current Limit (T_J = +25°C)	I_{sc}	—	2.0	—	mA
Output Noise Voltage (T_A = +25°C) 10 Hz ≤ f ≤ 100 kHz	V_n	—	40	—	μV
Average Temperature Coefficient of Output Voltage I_O = 5.0 mA	TCV_O	—	±0.6	—	mV/°C
Peak Output Current (T_J = +25°C)	I_O	—	2.4	—	A
Input Voltage to Maintain Line Regulation (T_J = +25°C)		7.3	—	—	Vdc

NOTES:

1. T_{low} = −55°C for LM140A T_{high} = +150°C for LM140A
   = 0°C for LM340A   = +125°C for LM340A
2. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

LM140/340 — 6.0

ELECTRICAL CHARACTERISTICS (V_{in} = 11 V, I_O = 500 mA, T_J = T_{low} to T_{high} (Note 1), unless otherwise noted).

Characteristic	Symbol	Min	Typ	Max	Unit
Output Voltage (T_J = +25°C) I_O = 5.0 mA to 1.0 A	V_O	5.75	6.0	6.25	Vdc
Line Regulation (Note 2) 9.0 to 21 Vdc 8.0 to 25 Vdc (T_J = +25°C) 9.0 to 13 Vdc, I_O = 1.0 A 8.3 to 21 Vdc, I_O = 1.0 A (T_J = +25°C)	Reg_{line}	— — — —	— — — —	60 60 30 60	mV
Load Regulation (Note 2) 5.0 mA ≤ I_O ≤ 1.0 A 5.0 mA ≤ I_O ≤ 1.5 A (T_J = +25°C) 250 mA ≤ I_O ≤ 750 mA (T_J = +25°C)	Reg_{load}	— — —	— — —	60 60 30	mV
Output Voltage LM140 9.0 ≤ V_{in} ≤ 21 Vdc, 5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W LM340 8.0 ≤ V_{in} ≤ 21 Vdc, 6.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W	V_O	5.7 5.7	— —	6.3 6.3	Vdc
Quiescent Current I_O = 1.0 A LM140 LM340 LM140 (T_J = +25°C) LM340 (T_J = +25°C)	I_B	— — — —	— — 4.0 4.0	7.0 8.5 6.0 8.0	mA
Quiescent Current Change 9.0 ≤ V_{in} ≤ 25 Vdc, I_O = 500 mA LM140 8.0 ≤ V_{in} ≤ 25 Vdc, I_O = 500 mA LM340 5.0 mA ≤ I_O ≤ 1.0 A, V_{in} = 11 V LM140, LM340 9.0 ≤ V_{in} ≤ 21 Vdc, I_O = 1.0 A LM140 8.6 ≤ V_{in} ≤ 21 Vdc, I_O = 1.0 A LM340	ΔI_B	— — — — —	— — — — —	0.8 1.0 0.5 0.8 1.0	mA
Ripple Rejection LM140 LM340 I_O = 1.0 A (T_J = +25°C) LM140 LM340	RR	65 59 65 59	— — 78 78	— — — —	dB
Dropout Voltage	$V_{in} - V_O$	—	1.7	—	Vdc
Output Resistance (f = 1.0 kHz)	r_O	—	2.0	—	mΩ
Short-Circuit Current Limit (T_J = +25°C)	I_{sc}	—	1.9	—	mA
Output Noise Voltage (T_A = +25°C) 10 Hz ≤ f ≤ 100 kHz	V_n	—	45	—	μV
Average Temperature Coefficient of Output Voltage I_O = 5.0 mA	TCV_O	—	±0.7	—	mV/°C
Peak Output Current (T_J = +25°C)	I_O	—	2.4	—	A
Input Voltage to Maintain Line Regulation (T_J = +25°C) I_O = 1.0 A		8.3	—	—	Vdc

NOTES:

1. T_{low} = −55°C for LM140 T_{high} = +150°C for LM140
   = 0°C for LM340 = +125°C for LM340
2. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

LM140/340 — 8.0

ELECTRICAL CHARACTERISTICS (V_{in} = 14 V, I_O = 500 mA, T_J = T_{low} to T_{high} (Note 1), unless otherwise noted).

Characteristic	Symbol	Min	Typ	Max	Unit
Output Voltage (T_J = +25°C) I_O = 5.0 mA to 1.0 A	V_O	7.7	8.0	8.3	Vdc
Line Regulation (Note 2)	Regline				mV
11 to 23 Vdc		—	—	80	
10.5 to 25 Vdc (T_J = +25°C)		—	—	80	
11 to 17 Vdc, I_O = 1.0 A		—	—	40	
10.5 to 23 Vdc, I_O = 1.0 A (T_J = +25°C)		—	—	80	
Load Regulation (Note 2)	Regload				mV
5.0 mA ≤ I_O ≤ 1.0 A		—	—	80	
5.0 mA ≤ I_O ≤ 1.5 A (T_J = +25°C)		—	—	80	
250 mA ≤ I_O ≤ 750 mA (T_J = +25°C)		—	—	40	
Output Voltage	V_O				Vdc
LM140 11.5 ≤ V_{in} ≤ 23 Vdc, 5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W		7.6	—	8.4	
LM340 10.5 ≤ V_{in} ≤ 23 Vdc, 5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W		7.6	—	8.4	
Quiescent Current	I_B				mA
I_O = 1.0 A LM140		—	—	7.0	
LM340		—	—	8.5	
LM140 (T_J = +25°C)		—	4.0	6.0	
LM340 (T_J = +25°C)		—	4.0	8.0	
Quiescent Current Change	ΔI_B				mA
11.5 ≤ V_{in} ≤ 25 Vdc, I_O = 500 mA — LM140		—	—	0.8	
10.5 ≤ V_{in} ≤ 25 Vdc, I_O = 500 mA — LM340		—	—	1.0	
5.0 mA ≤ I_O ≤ 1.0 A, V_{in} = 14 V — LM140, LM340		—	—	0.5	
11.5 ≤ V_{in} ≤ 23 Vdc, I_O = 1.0 A — LM140		—	—	0.8	
10.6 ≤ V_{in} ≤ 23 Vdc, I_O = 1.0 A — LM340		—	—	1.0	
Ripple Rejection	RR				dB
LM140		62	—	—	
LM340		56	—	—	
I_O = 1.0 A (T_J = +25°C) LM140		62	76	—	
LM340		56	76	—	
Dropout Voltage	$V_{in}-V_O$	—	1.7	—	Vdc
Output Resistance (f = 1.0 kHz)	r_O	—	2.0	—	mΩ
Short-Circuit Current Limit (T_J = +25°C)	I_{sc}	—	1.5	—	mA
Output Noise Voltage (T_A = +25°C) 10 Hz ≤ f ≤ 100 kHz	V_n	—	52	—	µV
Average Temperature Coefficient of Output Voltage I_O = 5.0 mA	TCV_O	—	±1.0	—	mV/°C
Peak Output Current (T_J = +25°C)	I_O	—	2.4	—	A
Input Voltage to Maintain Line Regulation (T_J = +25°C) I_O = 1.0 A		10.5	—	—	Vdc

NOTES:
1. T_{low} = −55°C for LM140 = 0°C for LM340; T_{high} = +150°C for LM140 = +125°C for LM340
2. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

LM140/340 — 12

ELECTRICAL CHARACTERISTICS (V_{in} = 19 V, I_O = 500 mA, T_J = T_{low} to T_{high} (Note 1), unless otherwise noted).

Characteristic	Symbol	Min	Typ	Max	Unit
Output Voltage (T_J = +25°C) I_O = 5.0 mA to 1.0 A	V_O	11.5	12	12.5	Vdc
Line Regulation (Note 2) 15 to 27 Vdc 14.6 to 30 Vdc (T_J = +25°C) 16 to 22 Vdc, I_O = 1.0 A 14.6 to 27 Vdc, I_O = 1.0 A (T_J = +25°C)	Reg_{line}	 — — — —	 — — — —	 120 120 60 120	mV
Load Regulation (Note 2) 5.0 mA ≤ I_O ≤ 1.0 A 5.0 mA ≤ I_O ≤ 1.5 A (T_J = +25°C) 250 mA ≤ I_O ≤ 750 mA (T_J = +25°C)	Reg_{load}	 — — —	 — — —	 120 120 60	mV
Output Voltage LM140 15.5 ≤ V_{in} ≤ 27 Vdc, 5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W LM340 14.5 ≤ V_{in} ≤ 27 Vdc, 5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W	V_O	 11.4 11.4	 — —	 12.6 12.6	Vdc
Quiescent Current I_O = 1.0 A LM140 LM340 LM140 (T_J = +25°C) LM340 (T_J = +25°C)	I_B	 — — — —	 — — 4.0 4.0	 7.0 8.5 6.0 8.0	mA
Quiescent Current Change 15 ≤ V_{in} ≤ 30 Vdc, I_O = 500 mA — LM140 14.5 ≤ V_{in} ≤ 30 Vdc, I_O = 500 mA — LM340 5.0 mA ≤ I_O ≤ 1.0 A, V_{in} = 19 V — LM140, LM340 15 ≤ V_{in} ≤ 27 Vdc, I_O = 1.0 A — LM140 14.8 ≤ V_{in} ≤ 27 Vdc, I_O = 1.0 A — LM340	ΔI_B	 — — — — —	 — — — — —	 0.8 1.0 0.5 0.8 1.0	mA
Ripple Rejection LM140 LM340 I_O = 1.0 A (T_J = +25°C) LM140 LM340	RR	 61 55 61 55	 — — 72 72	 — — — —	dB
Dropout Voltage	$V_{in}-V_O$	—	1.7	—	Vdc
Output Resistance (f = 1.0 kHz)	r_O	—	2.0	—	mΩ
Short-Circuit Current Limit (T_J = +25°C)	I_{sc}	—	1.1	—	mA
Output Noise Voltage (T_A = +25°C) 10 Hz ≤ f ≤ 100 kHz	V_n	—	75	—	μV
Average Temperature Coefficient of Output Voltage I_O = 5.0 mA	TCV_O	—	±1.5	—	mV/°C
Peak Output Current (T_J = +25°C)	I_O	—	2.4	—	A
Input Voltage to Maintain Line Regulation (T_J = +25°C) I_O = 1.0 A		14.6	—	—	Vdc

NOTES:
1. T_{low} = −55°C for LM140 = 0°C for LM340; T_{high} = +150°C for LM140 = +125°C for LM340
2. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

LM140A/340A — 12

ELECTRICAL CHARACTERISTICS (V_{in} = 19 V, I_O = 1.0 A, T_J = T_{low} to T_{high} (Note 1), unless otherwise noted).

Characteristic	Symbol	Min	Typ	Max	Unit
Output Voltage (T_J = +25°C) I_O = 5.0 mA to 1.0 A	V_O	11.75	12	12.25	Vdc
Line Regulation (Note 2) 14.8 to 27 Vdc, I_O = 500 mA 14.5 to 27 Vdc (T_J = +25°C) 16 to 22 Vdc 16 to 22 Vdc (T_J = +25°C)	Reg_{line}	 — — — —	 — 4.0 — —	 18 18 30 9.0	mV
Load Regulation (Note 2) 5.0 mA ≤ I_O ≤ 1.0 A 5.0 mA ≤ I_O ≤ 1.5 A (T_J = +25°C) 250 mA ≤ I_O ≤ 750 mA (T_J = +25°C)	Reg_{load}	 — — —	 — — —	 60 32 19	mV
Output Voltage 14.8 ≤ V_{in} ≤ 27 Vdc, 5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W	V_O	11.5	—	12.5	Vdc
Quiescent Current (T_J = +25°C)	I_B	— —	— 3.5	6.5 6.0	mA
Quiescent Current Change 5.0 mA ≤ I_O ≤ 1.0 A, V_{in} = 19 V 15 ≤ V_{in} ≤ 30 Vdc, I_O = 500 mA 14.8 ≤ V_{in} ≤ 27 Vdc, I_O = 1.0 A (T_J = +25°C)	ΔI_B	 — — —	 — — —	 0.5 0.8 0.8	mA
Ripple Rejection 15 ≤ V_{in} ≤ 25 Vdc, f = 120 Hz I_O = 500 mA I_O = 1.0 A, (T_J = +25°C)	RR	 61 61	 — 72	 — —	dB
Dropout Voltage	$V_{in} - V_O$	—	1.7	—	Vdc
Output Resistance (f = 1.0 kHz)	r_O	—	2.0	—	mΩ
Short-Circuit Current Limit (T_J = +25°C)	I_{sc}	—	1.1	—	mA
Output Noise Voltage (T_A = +25°C) 10 Hz ≤ f ≤ 100 kHz	V_n	—	75	—	µV
Average Temperature Coefficient of Output Voltage I_O = 5.0 mA	TCV_O	—	±1.5	—	mV/°C
Peak Output Current (T_J = +25°C)	I_O	—	2.4	—	A
Input Voltage to Maintain Line Regulation (T_J = +25°C)		14.5	—	—	Vdc

NOTES:
1. T_{low} = −55°C for LM140A T_{high} = +150°C for LM140A
   = 0°C for LM340A = +125°C for LM340A
2. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

LM140A/340 — 15

ELECTRICAL CHARACTERISTICS (V_{in} = 23 V, I_O = 500 mA, T_J = T_{low} to T_{high} (Note 1), unless otherwise noted).

Characteristic	Symbol	Min	Typ	Max	Unit
Output Voltage (T_J = +25°C) I_O = 5.0 mA to 1.0 A	V_O	14.4	15	15.6	Vdc
Line Regulation (Note 2) 18.5 to 30 Vdc 17.5 to 30 Vdc (T_J = +25°C) 20 to 26 Vdc, I_O = 1.0 A 17.7 to 30 Vdc, I_O = 1.0 A (T_J = +25°C)	Reg_{line}	— — — —	— — — —	150 150 75 150	mV
Load Regulation (Note 2) 5.0 mA ≤ I_O ≤ 1.0 A 5.0 mA ≤ I_O ≤ 1.5 A (T_J = +25°C) 250 mA ≤ I_O ≤ 750 mA (T_J = +25°C)	Reg_{load}	— — —	— — —	150 150 75	mV
Output Voltage LM140 18.5 ≤ V_{in} ≤ 30 Vdc, 5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W LM340 17.5 ≤ V_{in} ≤ 30 Vdc, 5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W	V_O	14.25 14.25	— —	15.75 15.75	Vdc
Quiescent Current I_O = 1.0 A LM140 LM340 LM140 (T_J = +25°C) LM340 (T_J = +25°C)	I_B	— — — —	— — 4.0 4.0	7.0 8.5 6.0 8.0	mA
Quiescent Current Change 18.5 ≤ V_{in} ≤ 30 Vdc, I_O = 500 mA LM140 17.5 ≤ V_{in} ≤ 30 Vdc, I_O = 500 mA LM340 5.0 mA ≤ I_O ≤ 1.0 A, V_{in} = 23 V LM140, LM340 18.5 ≤ V_{in} ≤ 30 Vdc, I_O = 1.0 A LM140 17.9 ≤ V_{in} ≤ 30 Vdc, I_O = 1.0 A LM340	ΔI_B	— — — — —	— — — — —	0.8 1.0 0.5 0.8 1.0	mA
Ripple Rejection LM140 LM340 I_O = 1.0 A (T_J = +25°C) LM140 LM340	RR	60 54 60 54	— — 70 70	— — — —	dB
Dropout Voltage	$V_{in} - V_O$	—	1.7	—	Vdc
Output Resistance (f = 1.0 kHz)	r_O	—	2.0	—	mΩ
Short-Circuit Current Limit (T_J = +25°C)	I_{sc}	—	800	—	mA
Output Noise Voltage (T_A = +25°C) 10 Hz ≤ f ≤ 100 kHz	V_n	—	90	—	µV
Average Temperature Coefficient of Output Voltage I_O = 5.0 mA	TCV_O	—	±1.8	—	mV/°C
Peak Output Current (T_J = +25°C)	I_O	—	2.4	—	A
Input Voltage to Maintain Line Regulation (T_J = +25°C) I_O = 1.0 A		17.7	—	—	Vdc

NOTES:

1. T_{low} = −55°C for LM140 T_{high} = +150°C for LM140
   = = +125°C for LM340
2. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

LM140A/340A — 15

ELECTRICAL CHARACTERISTICS (V_{in} = 23 V, I_O = 1.0 A, T_J = T_{low} to T_{high} (Note 1), unless otherwise noted).

Characteristic	Symbol	Min	Typ	Max	Unit
Output Voltage (T_J = +25°C) I_O = 5.0 mA to 1.0 A	V_O	14.7	15	15.3	Vdc
Line Regulation (Note 2) 17.9 to 30 Vdc, I_O = 500 mA 17.5 to 30 Vdc (T_J = +25°C) 20 to 26 Vdc, I_O = 1.0 A 20 to 26 Vdc, I_O = 1.0 A (T_J = +25°C)	Reg_{line}	 — — — —	 — 4.0 — —	 22 22 30 10	mV
Load Regulation (Note 2) 5.0 mA ≤ I_O ≤ 1.0 A 5.0 mA ≤ I_O ≤ 1.5 A (T_J = +25°C) 250 mA ≤ I_O ≤ 750 mA (T_J = +25°C)	Reg_{load}	 — — —	 — 12 —	 75 35 21	mV
Output Voltage 17.9 ≤ V_{in} ≤ 30 Vdc, 5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W	V_O	14.4	—	15.6	Vdc
Quiescent Current (T_J = +25°C)	I_B	— —	— 3.5	6.5 6.0	mA
Quiescent Current Change 5.0 mA ≤ I_O ≤ 1.0 A, V_{in} = 23 V 17.9 ≤ V_{in} ≤ 30 Vdc, I_O = 500 mA 17.9 ≤ V_{in} ≤ 30 Vdc, I_O = 1.0 A (T_J = +25°C)	ΔI_B	 — — —	 — — —	 0.5 0.8 0.8	mA
Ripple Rejection 18.5 ≤ V_{in} ≤ 28.5 Vdc, f = 120 Hz I_O = 500 mA I_O = 1.0 A, (T_J = +25°C)	RR	 60 60	 — 70	 — —	dB
Dropout Voltage	$V_{in} - V_O$	—	1.7	—	Vdc
Output Resistance (f = 1.0 kHz)	r_O	—	2.0	—	mΩ
Short-Circuit Current Limit (T_J = +25°C)	I_{sc}	—	800	—	mA
Output Noise Voltage (T_A = +25°C) 10 Hz ≤ f ≤ 100 kHz	V_n	—	90	—	µV
Average Temperature Coefficient of Output Voltage I_O = 5.0 mA	TCV_O	—	±1.8	—	mV/°C
Peak Output Current (T_J = +25°C)	I_O	—	2.4	—	A
Input Voltage to Maintain Line Regulation (T_J = +25°C)		17.5	—	—	Vdc

NOTES:

1. T_{low} = −55°C for LM140A T_{high} = +150°C for LM140A
   = 0°C for LM340A   = +125°C for LM340A
2. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

LM140/340 — 18

ELECTRICAL CHARACTERISTICS (V_{in} = 27 V, I_O = 500 mA, T_J = T_{low} to T_{high} (Note 1), unless otherwise noted).

Characteristic	Symbol	Min	Typ	Max	Unit
Output Voltage (T_J = +25°C) I_O = 5.0 mA to 1.0 A	V_O	17.3	18	18.7	Vdc
Line Regulation (Note 2) 21.5 to 33 Vdc 21 to 33 Vdc (T_J = +25°C) 24 to 30 Vdc, I_O = 1.0 A 21 to 33 Vdc, I_O = 1.0 A (T_J = +25°C)	Reg_{line}	 — — — —	 — — — —	 180 180 90 180	mV
Load Regulation (Note 2) 5.0 mA ≤ I_O ≤ 1.0 A 5.0 mA ≤ I_O ≤ 1.5 A (T_J = +25°C) 250 mA ≤ I_O ≤ 750 mA (T_J = +25°C)	Reg_{load}	 — — —	 — — —	 180 180 90	mV
Output Voltage LM140 22 ≤ V_{in} ≤ 33 Vdc, 5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W LM340 21 ≤ V_{in} ≤ 33 Vdc, 5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W	V_O	 17.1 17.1	 — —	 18.9 18.9	Vdc
Quiescent Current I_O = 1.0 A LM140 LM340 LM140 (T_J = +25°C) LM340 (T_J = +25°C)	I_B	 — — — —	 — — 4.0 4.0	 7.0 8.5 6.0 8.0	mA
Quiescent Current Change 22 ≤ V_{in} ≤ 33 Vdc, I_O = 500 mA LM140 21 ≤ V_{in} ≤ 33 Vdc, I_O = 500 mA LM340 5.0 mA ≤ I_O ≤ 1.0 A, V_{in} = 27 V LM140, LM340 22 ≤ V_{in} ≤ 33 Vdc, I_O = 1.0 A LM140 21 ≤ V_{in} ≤ 33 Vdc, I_O = 1.0 A LM340	ΔI_B	 — — — — —	 — — — — —	 0.8 1.0 0.5 0.8 1.0	mA
Ripple Rejection LM140 LM340 I_O = 1.0 A (T_J = +25°C) LM140 LM340	RR	 59 53 59 53	 — — 69 69	 — — — —	dB
Dropout Voltage	$V_{in} - V_O$	—	1.7	—	Vdc
Output Resistance (f = 1.0 kHz)	r_O	—	2.0	—	mΩ
Short-Circuit Current Limit (T_J = +25°C)	I_{sc}	—	500	—	mA
Output Noise Voltage (T_A = +25°C) 10 Hz ≤ f ≤ 100 kHz	V_n	—	110	—	µV
Average Temperature Coefficient of Output Voltage I_O = 5.0 mA	TCV_O	—	±2.3	—	mV/°C
Peak Output Current (T_J = +25°C)	I_O	—	2.4	—	A
Input Voltage to Maintain Line Regulation (T_J = +25°C) I_O = 1.0 A		21	—	—	Vdc

NOTES:

1. T_{low} = −55°C for LM140 T_{high} = +150°C for LM140
   = 0°C for LM340 = +125°C for LM340
2. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

LM140/340 — 24

ELECTRICAL CHARACTERISTICS (V_{in} = 33 V, I_O = 500 mA, T_J = T_{low} to T_{high} (Note 1), unless otherwise noted).

Characteristic	Symbol	Min	Typ	Max	Unit
Output Voltage (T_J = +25°C) I_O = 5.0 mA to 1.0 A	V_O	23	24	25	Vdc
Line Regulation (Note 2) 28 to 38 Vdc 27 to 38 Vdc (T_J = +25°C) 30 to 36 Vdc, I_O = 1.0 A 27.1 to 38 Vdc, I_O = 1.0 A (T_J = +25°C)	Reg_{line}	— — — —	— — — —	240 240 120 240	mV
Load Regulation (Note 2) 5.0 mA ≤ I_O ≤ 1.0 A 5.0 mA ≤ I_O ≤ 1.5 A (T_J = +25°C) 250 mA ≤ I_O ≤ 750 mA (T_J = +25°C)	Reg_{load}	— — —	— — —	240 240 120	mV
Output Voltage LM140 28 ≤ V_{in} ≤ 38 Vdc, 5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W LM340 27 ≤ V_{in} ≤ 38 Vdc, 5.0 mA ≤ I_O ≤ 1.0 A, P_D ≤ 15 W	V_O	22.8 22.8	— —	25.2 25.2	Vdc
Quiescent Current I_O = 1.0 A LM140 LM340 LM140 (T_J = +25°C) LM340 (T_J = +25°C)	I_B	— — — —	— — 4.0 4.0	7.0 8.5 6.0 8.0	mA
Quiescent Current Change 28 ≤ V_{in} ≤ 38 Vdc, I_O = 500 mA LM140 27 ≤ V_{in} ≤ 38 Vdc, I_O = 500 mA LM340 5.0 mA ≤ I_O ≤ 1.0 A, V_{in} = 33 V LM140, LM340 28 ≤ V_{in} ≤ 38 Vdc, I_O = 1.0 A LM140 27.3 ≤ V_{in} ≤ 38 Vdc, I_O = 1.0 A LM340	ΔI_B	— — — — —	— — — — —	0.8 1.0 0.5 0.8 1.0	mA
Ripple Rejection LM140 LM340 I_O = 1.0 A (T_J = +25°C) LM140 LM340	RR	56 50 56 50	— — 66 66	— — — —	dB
Dropout Voltage	$V_{in}-V_O$	—	1.7	—	Vdc
Output Resistance (f = 1.0 kHz)	r_O	—	2.0	—	mΩ
Short-Circuit Current Limit (T_J = +25°C)	I_{sc}	—	200	—	mA
Output Noise Voltage (T_A = +25°C) 10 Hz ≤ f ≤ 100 kHz	V_n	—	170	—	μV
Average Temperature Coefficient of Output Voltage I_O = 5.0 mA	TCV_O	—	±3.0	—	mV/°C
Peak Output Current (T_J = +25°C)	I_O	—	2.4	—	A
Input Voltage to Maintain Line Regulation (T_J = +25°C) I_O = 1.0 A		27.1	—	—	Vdc

NOTES:
1. T_{low} = −55°C for LM140 T_{high} = +150°C for LM140
   = 0°C for LM340 = +125°C for LM340
2. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

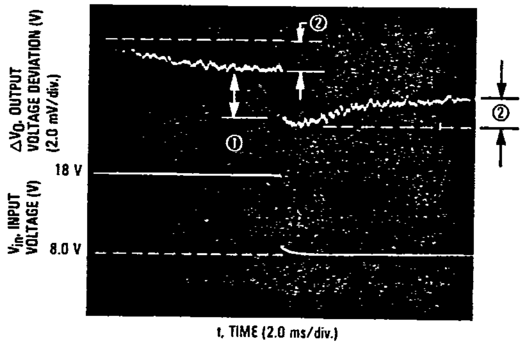
VOLTAGE REGULATOR PERFORMANCE

The performance of a voltage regulator is specified by its immunity to changes in load, input voltage, power dissipation, and temperature. Line and load regulation are tested with a pulse of short duration (< 100 μs) and are strictly a function of electrical gain. However, pulse widths of longer duration (> 1.0 ms) are sufficient to affect temperature gradients across the die. These temperature gradients can cause a change in the output voltage, in addition to changes caused by line and load regulation. Longer pulse widths and thermal gradients make it desirable to specify thermal regulation.

Thermal regulation is defined as the change in output voltage caused by a change in dissipated power for a specified time, and is expressed as a percentage output voltage change per watt. The change in dissipated power can be caused by a change in either the input voltage or the load current. Thermal regulation is a function of IC layout and die attach techniques, and usually occurs within 10 ms of a change in power dissipation. After 10 ms, additional changes in the output voltage are due to the temperature coefficient of the device.

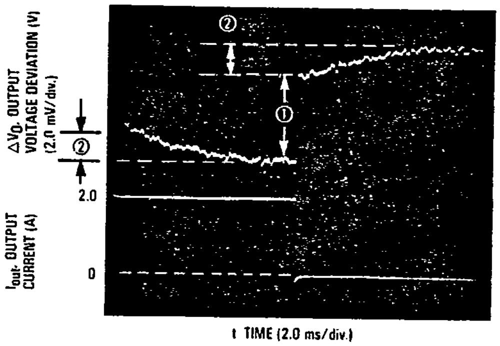
Figure 1 shows the line and thermal regulation response of a typical LM140AK-5.0 to a 10 watt input pulse. The variation of the output voltage due to line regulation is labeled ① and the thermal regulation component is labeled ②. Figure 2 shows the load and thermal regulation response of a typical LM140AK-5.0 to a 15 watt load pulse. The output voltage variation due to load regulation is labeled ① and the thermal regulation component is labeled ②.

FIGURE 1 — LINE AND THERMAL REGULATION



LM140AK-5.0
V_O = 5.0 V
V_{in} = 8.0 V → 18 V → 8.0 V ① = Reg_{line} = 2.4 mV
I_{out} = 1.0 A ② = Reg_{therm} = 0.0030%V_O/W

FIGURE 2 — LOAD AND THERMAL REGULATION



LM140AK-5.0
V_O = 5.0 V
V_{in} = 15 ① = Reg_{load} = 4.4 mV
I_{out} = 0 A → 1.5 A → 0 A ② = Reg_{therm} = 0.0020%V_O/W

FIGURE 3 — TEMPERATURE STABILITY

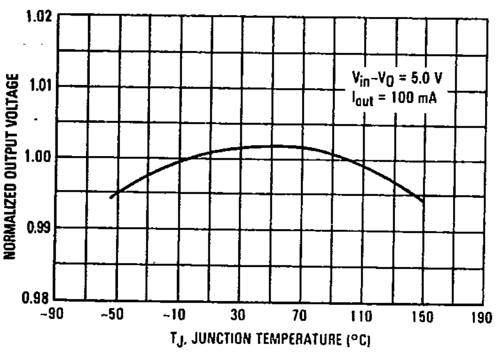


FIGURE 4 — OUTPUT IMPEDANCE

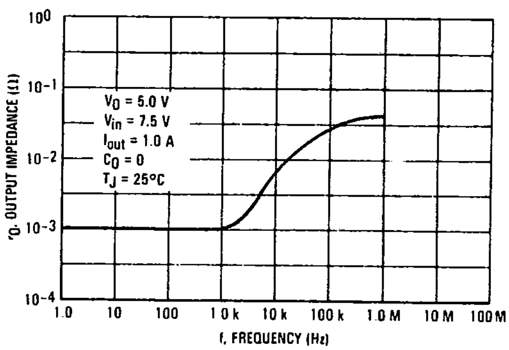


FIGURE 5 — RIPPLE REJECTION versus FREQUENCY

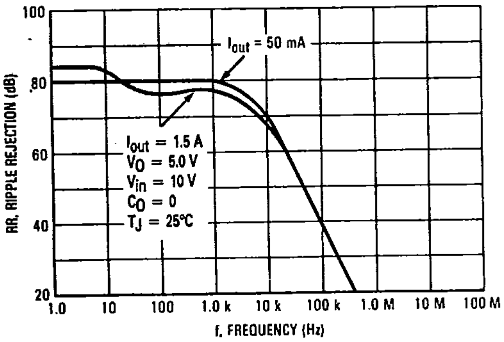


FIGURE 6 — RIPPLE REJECTION versus OUTPUT CURRENT

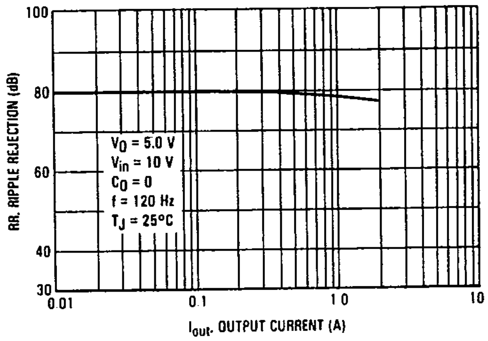


FIGURE 7 — QUIESCENT CURRENT versus INPUT VOLTAGE

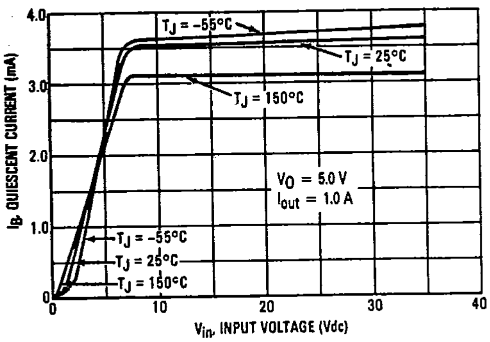


FIGURE 8 — QUIESCENT CURRENT versus OUTPUT CURRENT

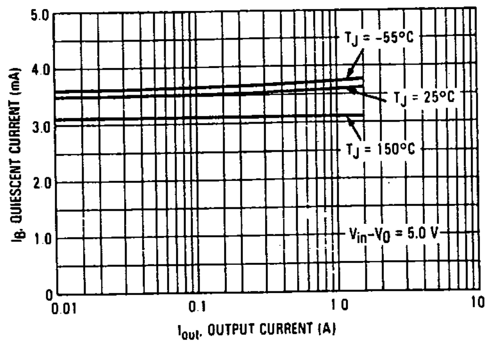


FIGURE 9 — DROPOUT VOLTAGE

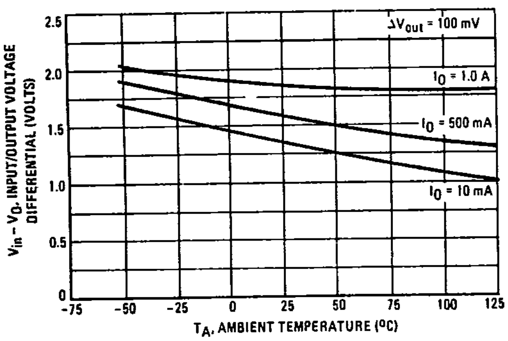


FIGURE 10 — PEAK OUTPUT CURRENT

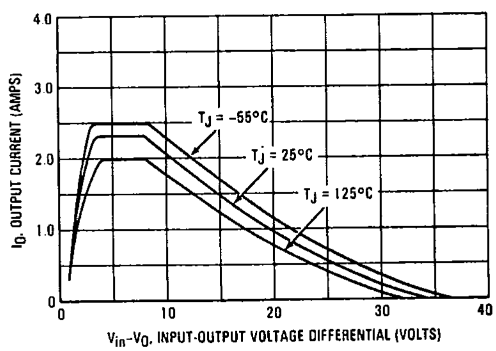


FIGURE 11 — LINE TRANSIENT RESPONSE

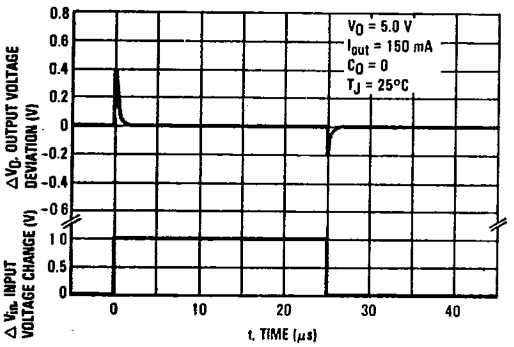


FIGURE 12 — LOAD TRANSIENT RESPONSE

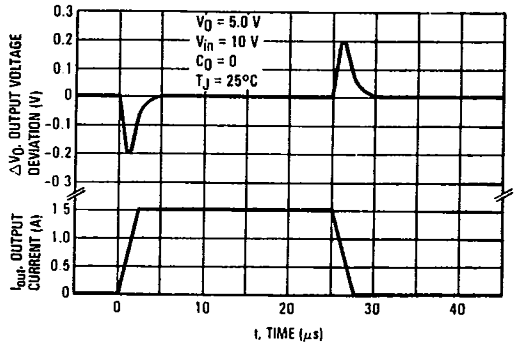


FIGURE 13 — WORST CASE POWER DISSIPATION versus AMBIENT TEMPERATURE (Case 221A)

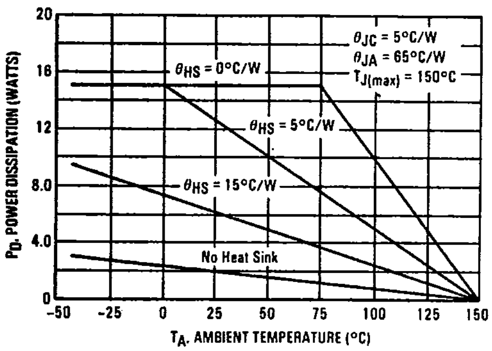
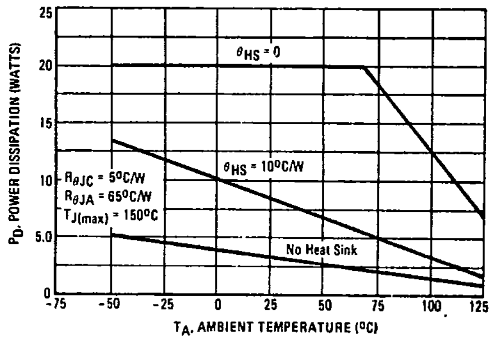


FIGURE 14 — WORST CASE POWER DISSIPATION versus AMBIENT TEMPERATURE (Case 1)



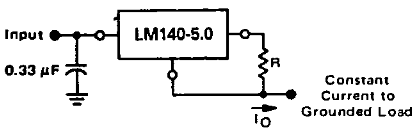
APPLICATIONS INFORMATION

Design Considerations

The LM140 Series of fixed voltage regulators are 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 capacitor should be selected to provide good high-frequency characteristics to insure stable operation under all load conditions. A 0.33 μF 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 input terminals. Normally good construction techniques should be used to minimize ground loops and lead resistance drops since the regulator has no external sense lead.

FIGURE 15 — CURRENT REGULATOR



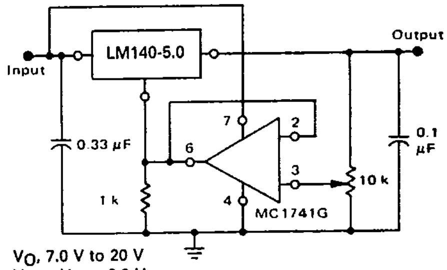
These regulators can also be used as a current source when connected as above. In order to minimize dissipation the LM140-5.0 is chosen in this application. Resistor R determines the current as follows:

$$I_O = \frac{5.0\ V}{R} + I_Q$$

$I_Q \cong 1.5$ mA over line and load changes

For example, a 1-ampere current source would require R to be a 5-ohm, 10-W resistor and the output voltage compliance would be the input voltage less 7.0 volts.

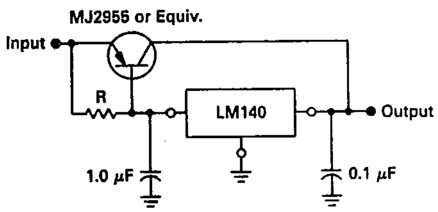
FIGURE 16 — ADJUSTABLE OUTPUT REGULATOR



V_O, 7.0 V to 20 V
$V_{IN} - V_O \geq 2.0$ V

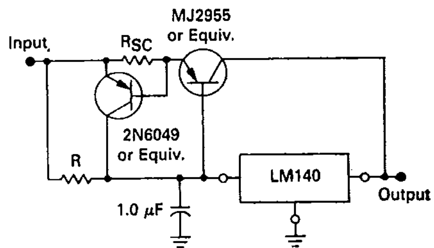
The addition of an operational amplifier allows adjustment to higher or intermediate values while retaining regulation characteristics. The minimum voltage obtainable with thi arrangement is 2.0 volts greater than the regulator voltage.

FIGURE 17 — CURRENT BOOST REGULATOR



The LM140 series can be current boosted with a PNP transistor. The MJ2955 provides current to 5.0 amperes. Resistor R in conjunction with the V_{BE} of the PNP determines when the pass transistor begins conducting; this circuit is not short-circuit proof. Input-output differential voltage minimum is increased by V_{BE} of the pass transistor.

FIGURE 18 — SHORT-CIRCUIT PROTECTION



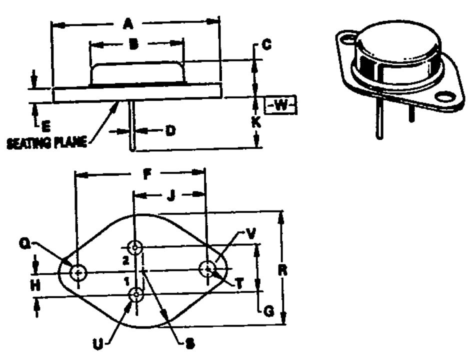
The circuit of Figure 17 can be modified to provide supply protection against short circuits by adding a short-circuit sense resistor, P_{SC}, and an additional PNP transistor. The current sensing PNP must be able to handle the short-circuit current of the three-terminal regulator. Therefore, a four-ampere plastic power transistor is specified.

SECTION 19
PACKAGE OUTLINE DIMENSIONS

K SUFFIX
METAL PACKAGE
CASE 1-03
$R_{\theta JA}$ = 45°C/W (TYP)
(TO-3)

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
B	—	22.23	—	0.875
C	6.35	11.43	0.250	0.450
D	0.97	1.09	0.038	0.043
E	—	3.43	—	0.135
F	30.15 BSC		1.187 BSC	
G	10.92 BSC		0.430 BSC	
H	5.46 BSC		0.215 BSC	
J	16.89 BSC		0.665 BSC	
K	7.92	—	0.312	—
Q	3.84	4.09	0.151	0.161
S	—	13.34	—	0.525
T	—	4.78	—	0.188
V	3.84	4.09	0.151	0.161

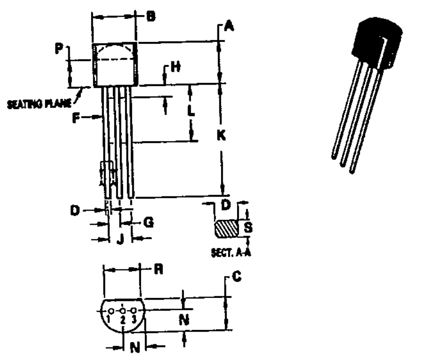
NOTES:
1. DIAMETER V AND SURFACE W ARE DATUMS.
2. POSITIONAL TOLERANCE FOR HOLE Q:
   ⌖ | φ 0.25 (0.010) Ⓜ | W | V Ⓜ
3. POSITIONAL TOLERANCE FOR LEADS:
   ⌖ | φ 0.30 (0.012) Ⓜ | W | V Ⓜ | Q Ⓜ



LP, P, Z SUFFIX
PLASTIC PACKAGE
CASE 29-04
$R_{\theta JA}$ = 200°C/W (TYP)
(TO-226AA/TO-92)

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.32	5.33	0.170	0.210
B	4.45	5.20	0.175	0.205
C	3.18	4.19	0.125	0.165
D	0.41	0.55	0.016	0.022
F	0.41	0.48	0.016	0.019
G	1.15	1.39	0.045	0.055
H	—	2.54	—	0.100
J	2.42	2.66	0.095	0.105
K	12.70	—	0.500	—
L	6.35	—	0.250	—
N	2.04	2.66	0.080	0.105
P	2.93	—	0.115	—
R	3.43	—	0.135	—
S	0.39	0.50	0.015	0.020

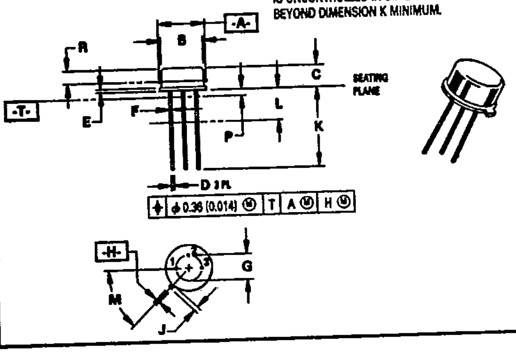
NOTES:
1. CONTOUR OF PACKAGE BEYOND ZONE "P" IS UNCONTROLLED.
2. DIM "F" APPLIES BETWEEN "H" AND "L". DIM "D" & "S" APPLIES BETWEEN "L" & 12.70mm (0.5") FROM SEATING PLANE. LEAD DIM IS UNCONTROLLED IN "H" & BEYOND 12.70mm (0.5") FROM SEATING PLANE.
3. CONTROLLING DIM: INCH.



G, H SUFFIX
METAL PACKAGE
CASE 79-05
$R_{\theta JA}$ = 185°C/W (TYP)
(TO-39)

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	9.02	9.29	0.355	0.366
B	8.01	8.50	0.315	0.335
C	4.20	4.57	0.165	0.180
D	0.44	0.53	0.017	0.021
E	0.44	0.88	0.017	0.035
F	0.41	0.48	0.016	0.019
G	5.08 BSC		0.200 BSC	
H	0.72	0.86	0.028	0.034
J	0.74	1.01	0.029	0.040
K	12.70	19.05	0.500	0.750
L	6.35	—	0.250	—
M	45° BSC		45° BSC	
P	—	1.27	—	0.050
R	2.54	—	0.100	—

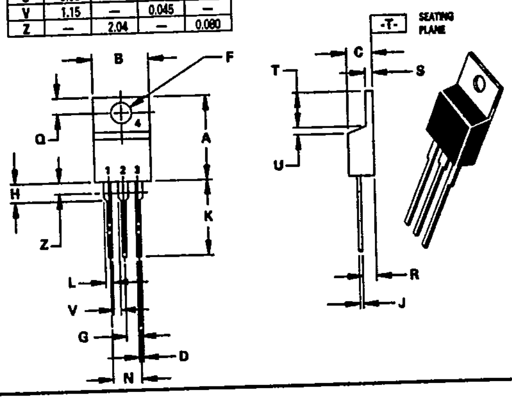
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION J MEASURED FROM DIMENSION A MAXIMUM.
4. DIMENSION B SHALL NOT VARY MORE THAN 0.25 (0.010) IN ZONE R. THIS ZONE CONTROLLED FOR AUTOMATIC HANDLING.
5. DIMENSION F APPLIES BETWEEN DIMENSION P AND L. DIMENSION D APPLIES BETWEEN DIMENSION L AND K MINIMUM. LEAD DIAMETER IS UNCONTROLLED IN DIMENSION P AND BEYOND DIMENSION K MINIMUM.



KC, T SUFFIX
PLASTIC PACKAGE
CASE 221A-04
$R_{\theta JA}$ = 65°C/W (TYP)
(TO-220AB)

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	14.48	15.75	0.570	0.620
B	9.66	10.28	0.380	0.405
C	4.07	4.82	0.160	0.190
D	0.64	0.88	0.025	0.035
F	3.61	3.73	0.142	0.147
G	2.42	2.66	0.095	0.105
H	2.80	3.93	0.110	0.155
J	0.36	0.55	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.15	1.39	0.045	0.055
N	4.83	5.33	0.190	0.210
Q	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.15	1.39	0.045	0.055
T	5.97	6.47	0.235	0.255
U	0.00	1.27	0.000	0.050
V	1.15	—	0.045	—
Z	—	2.04	—	0.080

NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIM Z DEFINES A ZONE WHERE ALL BODY AND LEAD IRREGULARITIES ARE ALLOWED.

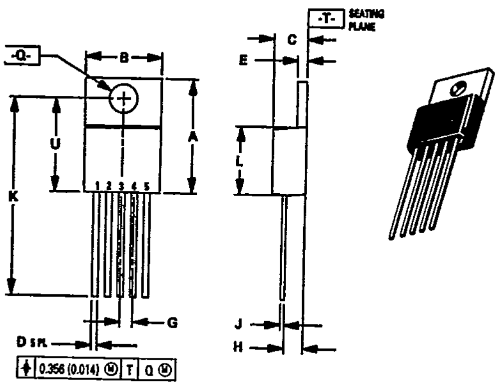


PACKAGE OUTLINE DIMENSIONS (continued)

T SUFFIX
PLASTIC PACKAGE
CASE 314D-02

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	14.529	15.570	0.572	0.613
B	9.908	10.541	0.390	0.415
C	4.318	4.572	0.170	0.180
D	0.635	0.965	0.025	0.038
E	1.169	1.397	0.046	0.055
G	1.702 BSC		0.067 BSC	
H	2.109	2.717	0.083	0.107
J	0.381	0.635	0.015	0.025
K	25.807	26.670	1.016	1.050
L	8.052	9.398	0.317	0.370
Q	3.556	3.937	0.140	0.155
U	11.889	12.827	0.468	0.505

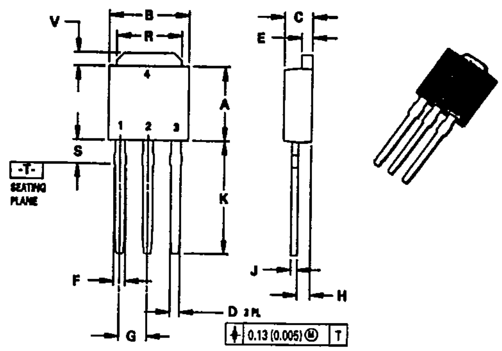
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.



DT-1 SUFFIX
PLASTIC PACKAGE
CASE 369-03

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.97	6.22	0.235	0.245
B	6.35	6.73	0.250	0.265
C	2.19	2.38	0.086	0.094
D	0.69	0.88	0.027	0.035
E	0.84	0.94	0.033	0.037
F	0.77	1.14	0.030	0.045
G	2.29 BSC		0.090 BSC	
H	0.97	1.06	0.038	0.042
J	0.46	0.58	0.018	0.023
K	8.89	9.65	0.350	0.380
R	5.21	5.46	0.205	0.215
S	1.91	2.28	0.075	0.090
V	0.89	1.27	0.035	0.050

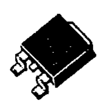
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

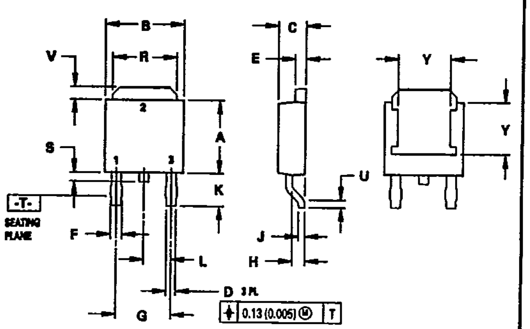


DT SUFFIX
PLASTIC PACKAGE
CASE 369A-03
DPAK

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.97	6.22	0.235	0.245
B	6.35	6.73	0.250	0.265
C	2.19	2.38	0.086	0.094
D	0.69	0.88	0.027	0.035
E	0.84	0.94	0.033	0.037
F	0.77	1.14	0.030	0.045
G	4.58 BSC		0.180 BSC	
H	0.97	1.06	0.038	0.042
J	0.46	0.58	0.018	0.023
K	2.60	2.89	0.102	0.114
L	2.29 BSC		0.090 BSC	
R	5.21	5.46	0.205	0.215
S	0.64	0.88	0.025	0.035
U	0.51	—	0.020	—
V	0.89	1.27	0.035	0.050
Y	4.32	—	0.170	—

NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.



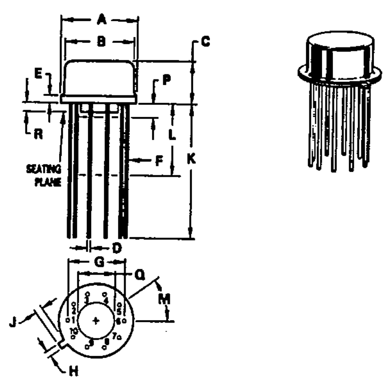


H, G SUFFIX
METAL PACKAGE
CASE 603-04
$R_{\theta JA}$ = 160°C/W
(TO-100)

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.39	0.335	0.370
B	7.75	8.51	0.305	0.335
C	4.19	4.70	0.165	0.185
D	0.407	0.533	0.016	0.021
E	—	1.02	—	0.040
F	0.406	0.483	0.016	0.019
G	5.84 BSC		0.230 BSC	
H	0.712	0.864	0.028	0.034
J	0.737	1.14	0.029	0.045
K	12.70	—	0.500	—
L	6.35	12.70	0.250	0.500
M	36° BSC		36° BSC	
P	—	1.27	—	0.050
Q	3.56	4.06	0.140	0.160
R	0.254	1.02	0.010	0.040

NOTE:
LEADS WITHIN 0.18 mm (0.007) RADIUS OF TRUE POSITION AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION.

All JEDEC Dimensions and Notes Apply.

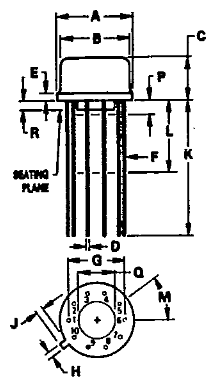


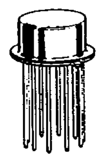
PACKAGE OUTLINE DIMENSIONS (continued)

G SUFFIX
METAL PACKAGE
CASE 603C-01
$R_{\theta JA}$ = 150°C/W (TYP)
(TO-100)

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.39	0.335	0.370
B	7.75	8.51	0.305	0.335
C	4.19	6.73	0.165	0.265
D	0.407	0.533	0.016	0.021
E	—	1.02	—	0.040
F	0.406	0.483	0.016	0.019
G	5.84 BSC		0.230 BSC	
H	0.712	0.864	0.028	0.034
J	0.737	1.14	0.029	0.045
K	12.70	—	0.500	—
L	6.35	12.70	0.250	0.500
M	36° BSC		36° BSC	
P	—	1.27	—	0.050
Q	3.56	4.06	0.140	0.160
R	0.254	1.02	0.010	0.040

NOTES:
1. LEADS WITHIN 0.18 mm (0.007) RADIUS OF TRUE POSITION TO DIM. "A" & "H" AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION.
2. LEAD DIA UNCONTROLLED BEYOND DIM "K" MIN.

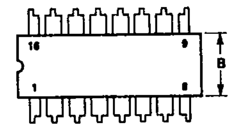


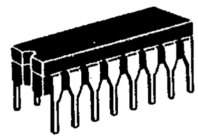


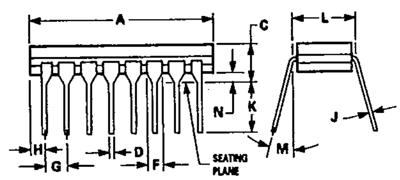
DP2, D, J, L, N SUFFIX
CERAMIC PACKAGE
CASE 620-10
$R_{\theta JA}$ = 100°C/W (TYP)

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	19.05	19.94	0.750	0.785
B	6.10	7.49	0.240	0.295
C	—	5.08	—	0.200
D	0.38	0.53	0.015	0.021
F	1.40	1.78	0.055	0.070
G	2.54 BSC		0.100 BSC	
H	0.51	1.14	0.020	0.045
J	0.20	0.30	0.008	0.012
K	3.18	4.32	0.125	0.170
L	7.62 BSC		0.300 BSC	
M	—	15°	—	15°
N	0.51	1.02	0.020	0.040

NOTES:
1. LEADS WITHIN 0.13 mm (0.005) RADIUS OF TRUE POSITION AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION.
2. PACKAGE INDEX: NOTCH IN LEAD NOTCH IN CERAMIC OR INK DOT.
3. DIM "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.
4. DIM "A" AND "B" DO NOT INCLUDE GLASS RUN-OUT.
5. DIM "F" MAY NARROW TO 0.76 mm (0.030) WHERE THE LEAD ENTERS THE CERAMIC BODY.



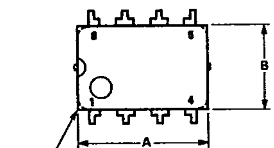


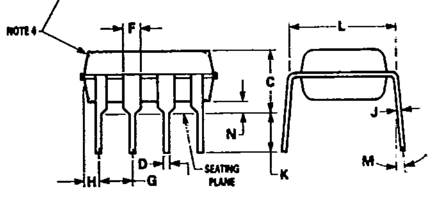


N, P1 SUFFIX
PLASTIC PACKAGE
CASE 626-05
$R_{\theta JA}$ = 100°C/W (TYP)

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	9.40	10.16	0.370	0.400
B	6.10	6.60	0.240	0.260
C	3.94	4.45	0.155	0.175
D	0.38	0.51	0.015	0.020
F	1.02	1.52	0.040	0.060
G	2.54 BSC		0.100 BSC	
H	0.76	1.27	0.030	0.050
J	0.20	0.30	0.008	0.012
K	2.92	3.43	0.115	0.135
L	7.62 BSC		0.300 BSC	
M	—	10°	—	10°
N	0.76	1.01	0.030	0.040

NOTES:
1. LEAD POSITIONAL TOLERANCE:
   ⌖ ⌀ 0.13 (0.005) Ⓜ | T | A Ⓜ | B Ⓜ
2. DIMENSION L TO CENTER OF LEADS WHEN FORMED PARALLEL.
3. PACKAGE CONTOUR OPTIONAL (ROUND OR SQUARE CORNERS).
4. DIMENSIONS A AND B ARE DATUMS.
5. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.

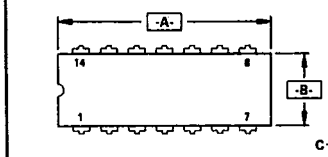


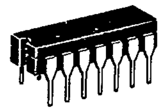


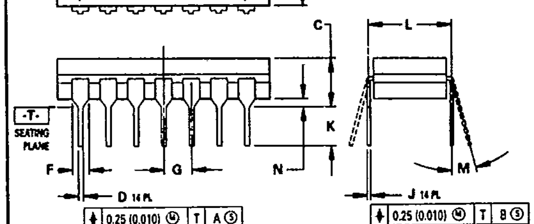
L SUFFIX
CERAMIC PACKAGE
CASE 632-08
$R_{\theta JA}$ = 100°C/W (TYP)
(TO-116)

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	19.05	19.94	0.750	0.785
B	6.23	7.11	0.245	0.280
C	3.94	5.08	0.155	0.200
D	0.39	0.50	0.015	0.020
F	1.40	1.65	0.055	0.065
G	2.54 BSC		0.100 BSC	
J	0.21	0.38	0.008	0.015
K	3.18	4.31	0.125	0.170
L	7.62 BSC		0.300 BSC	
M	0°	15°	0°	15°
N	0.51	1.01	0.020	0.040

NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION L TO CENTER OF LEAD WHEN FORMED PARALLEL.
4. DIM F MAY NARROW TO 0.76 (0.030) WHERE THE LEAD ENTERS THE CERAMIC BODY.





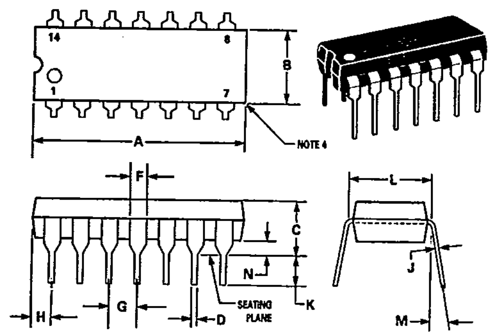


PACKAGE OUTLINE DIMENSIONS (continued)

N, P, N-14, P2 SUFFIX
PLASTIC PACKAGE
CASE 646-06
$R_{\theta JA}$ = 100°C/W (TYP)

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	18.16	19.56	0.715	0.770
B	6.10	6.60	0.240	0.260
C	3.69	4.69	0.145	0.185
D	0.38	0.53	0.015	0.021
F	1.02	1.78	0.040	0.070
G	2.54 BSC		0.100 BSC	
H	1.32	2.41	0.052	0.095
J	0.20	0.38	0.008	0.015
K	2.92	3.43	0.115	0.135
L	7.62 BSC		0.300 BSC	
M	0°	10°	0°	10°
N	0.39	1.01	0.015	0.039

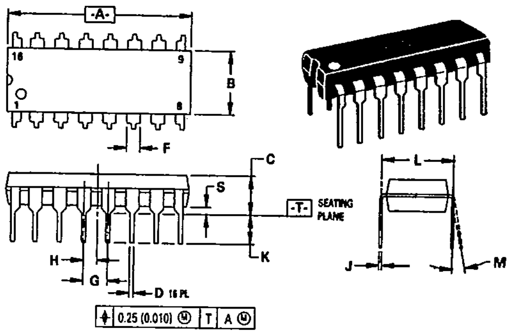
NOTES:
1. LEADS WITHIN 0.13 mm (0.005) RADIUS OF TRUE POSITION AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION.
2. DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.
3. DIMENSION "B" DOES NOT INCLUDE MOLD FLASH.
4. ROUNDED CORNERS OPTIONAL.



N, P SUFFIX
PLASTIC PACKAGE
CASE 648-08
$R_{\theta JA}$ = 100°C/W (TYP)

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	18.80	19.55	0.740	0.770
B	6.35	6.85	0.250	0.270
C	3.69	4.44	0.145	0.175
D	0.39	0.53	0.015	0.021
F	1.02	1.77	0.040	0.070
G	2.54 BSC		0.100 BSC	
H	1.27 BSC		0.050 BSC	
J	0.21	0.38	0.008	0.015
K	2.80	3.30	0.110	0.130
L	7.50	7.74	0.295	0.305
M	0°	10°	0°	10°
S	0.51	1.01	0.020	0.040

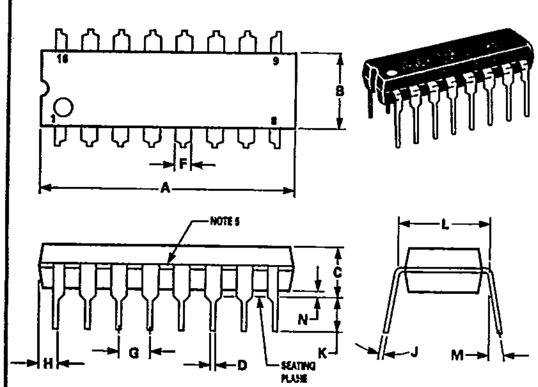
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.
4. DIMENSION "B" DOES NOT INCLUDE MOLD FLASH.
5. ROUNDED CORNERS OPTIONAL.



P SUFFIX
PLASTIC PACKAGE
CASE 648C-02

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	18.80	21.34	0.740	0.840
B	6.10	6.60	0.240	0.260
C	3.69	4.69	0.145	0.185
D	0.38	0.53	0.015	0.021
F	1.02	1.78	0.040	0.070
G	2.54 BSC		0.100 BSC	
H	0.38	2.41	0.015	0.095
J	0.20	0.38	0.008	0.015
K	2.92	3.43	0.115	0.135
L	7.62 BSC		0.300 BSC	
M	0°	10°	0°	10°
N	0.39	1.01	0.015	0.040

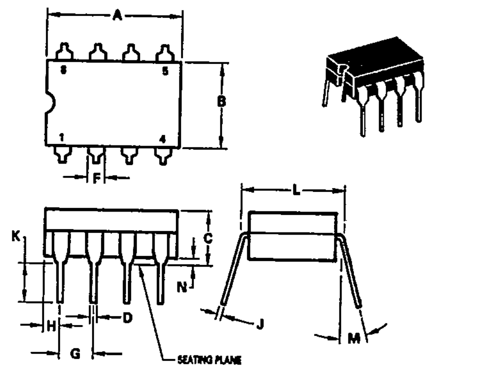
NOTES:
1. LEADS WITHIN 0.13 mm (0.005) RADIUS OF TRUE POSITON AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION.
2. DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.
3. DIMENSION "B" DOES NOT INCLUDE MOLD FLASH.
4. ROUNDED CORNERS OPTIONAL.
5. EXTERNAL LEAD CONNECTION, BETWEEN 4 AND 5, 12 AND 13 AS SHOWN.



J-8, J, JG, U, Z SUFFIX
CERAMIC PACKAGE
CASE 693-02
$R_{\theta JA}$ = 100°C/W (TYP)

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	9.91	10.92	0.390	0.430
B	6.22	6.99	0.245	0.275
C	4.32	5.08	0.170	0.200
D	0.41	0.51	0.016	0.020
F	1.40	1.65	0.055	0.065
G	2.54 BSC		0.100 BSC	
H	1.14	1.65	0.045	0.065
J	0.20	0.30	0.008	0.012
K	3.18	4.06	0.125	0.160
L	7.37	7.87	0.290	0.310
M	—	15°	—	15°
N	0.51	1.02	0.020	0.040

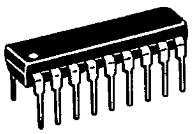
NOTES:
1. LEADS WITHIN 0.13 mm (0.005) RAD OF TRUE POSITION AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION.
2. DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.



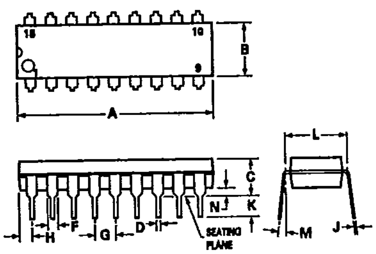
PACKAGE OUTLINE DIMENSIONS (continued)

A, B, N, P SUFFIX
PLASTIC PACKAGE
CASE 707-02
$R_{\theta JA}$ = 100°C/W (TYP)

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	22.22	23.24	0.875	0.915
B	6.10	6.60	0.240	0.260
C	3.56	4.57	0.140	0.180
D	0.36	0.56	0.014	0.022
F	1.27	1.78	0.050	0.070
G	2.54 BSC		0.100 BSC	
H	1.02	1.52	0.040	0.060
J	0.20	0.30	0.008	0.012
K	2.92	3.43	0.115	0.135
L	7.62 BSC		0.300 BSC	
M	0°	15°	0°	15°
N	0.51	1.02	0.020	0.040



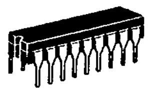
NOTES:
1. POSITIONAL TOLERANCE OF LEADS (D), SHALL BE WITHIN 0.25mm(0.010) AT MAXIMUM MATERIAL CONDITION, IN RELATION TO SEATING PLANE AND EACH OTHER.
2. DIMENSION L TO CENTER OF LEADS WHEN FORMED PARALLEL.
3. DIMENSION B DOES NOT INCLUDE MOLD FLASH.

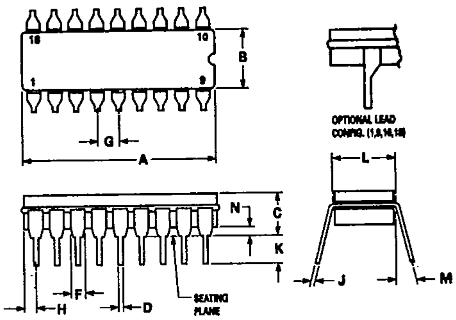


J, L SUFFIX
CERAMIC PACKAGE
CASE 726-04
$R_{\theta JA}$ = 100°C/W (TYP)

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	22.35	23.11	0.880	0.910
B	6.10	7.49	0.240	0.295
C	—	5.08	—	0.200
D	0.38	0.53	0.015	0.021
F	1.40	1.78	0.055	0.070
G	2.54 BSC		0.100 BSC	
H	0.51	1.14	0.020	0.045
J	0.20	0.30	0.008	0.012
K	3.18	4.32	0.125	0.170
L	7.62 BSC		0.300 BSC	
M	0°	15°	0°	15°
N	0.51	1.02	0.020	0.040

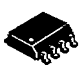
NOTES:
1. LEADS, TRUE POSITIONED WITHIN 0.25 mm (0.010) DIA. AT SEATING PLANE, AT MAXIMUM MATERIAL CONDITION.
2. DIM "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.
3. DIM "A" & "B" INCLUDES MENISCUS.
4. "F" DIMENSION IS FOR FULL LEADS. "HALF" LEADS ARE OPTIONAL AT LEAD POSITIONS 1, 9, 10, AND 18.



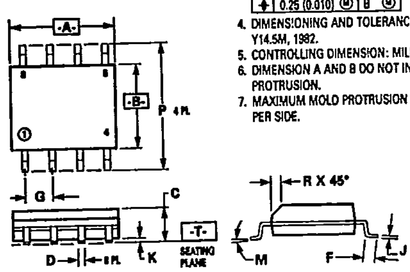


D SUFFIX
CASE 751-03
PLASTIC PACKAGE
SO-8, SOP-8
$R_{\theta JA}$ = 190°C/W (SO-8)
$R_{\theta JA}$ = 160°C/W (SOP-8)

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.80	5.00	0.189	0.196
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.054	0.068
D	0.35	0.49	0.014	0.019
F	0.40	1.25	0.016	0.049
G	1.27 BSC		0.050 BSC	
J	0.19	0.25	0.008	0.009
K	0.10	0.25	0.004	0.009
M	0°	7°	0°	7°
P	5.80	6.20	0.229	0.244
R	0.25	0.50	0.010	0.019



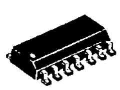
NOTES:
1. DIMENSIONS A AND B ARE DATUMS AND T IS A DATUM SURFACE.
2. POSITIONAL TOLERANCE FOR D DIMENSION (8 PLACES):
   ⌖ 0.25 (0.010) Ⓜ T B Ⓢ A Ⓢ
3. POSITIONAL TOLERANCE FOR P DIMENSION (4 PLACES):
   ⌖ 0.25 (0.010) Ⓜ B Ⓜ
4. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
5. CONTROLLING DIMENSION: MILLIMETER.
6. DIMENSION A AND B DO NOT INCLUDE MOLD PROTRUSION.
7. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.

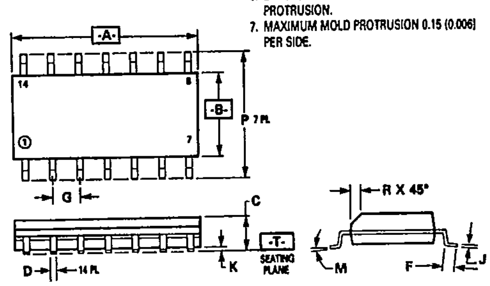


D SUFFIX
PLASTIC PACKAGE
CASE 751A-02
SO-14
$R_{\theta JA}$ = 145°C/W (TYP)

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.55	8.75	0.337	0.344
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.054	0.068
D	0.35	0.49	0.014	0.019
F	0.40	1.25	0.016	0.049
G	1.27 BSC		0.050 BSC	
J	0.19	0.25	0.008	0.009
K	0.10	0.25	0.004	0.009
M	0°	7°	0°	7°
P	5.80	6.20	0.229	0.244
R	0.25	0.50	0.010	0.019

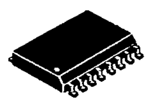
NOTES:
1. DIMENSIONS A AND B ARE DATUMS AND T IS A DATUM SURFACE.
2. POSITIONAL TOLERANCE FOR D DIMENSION (14 PLACES):
   ⌖ 0.25 (0.010) Ⓜ T B Ⓢ A Ⓢ
3. POSITIONAL TOLERANCE FOR P DIMENSION (7 PLACES):
   ⌖ 0.25 (0.010) Ⓜ B Ⓜ
4. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
5. CONTROLLING DIMENSION: MILLIMETER.
6. DIMENSION A AND B DO NOT INCLUDE MOLD PROTRUSION.
7. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.



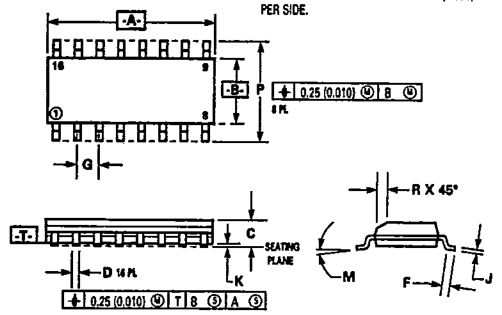


DW SUFFIX
PLASTIC PACKAGE
CASE 751G-01
SO-16L

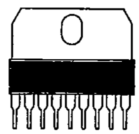
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.15	10.45	0.400	0.411
B	7.40	7.60	0.292	0.299
C	2.35	2.65	0.093	0.104
D	0.35	0.49	0.014	0.019
F	0.50	0.90	0.020	0.035
G	1.27 BSC		0.050 BSC	
J	0.25	0.32	0.010	0.012
K	0.10	0.25	0.004	0.009
M	0°	7°	0°	7°
P	10.05	10.55	0.395	0.415
	0.25	0.75	0.010	0.029



NOTES:
1. DIMENSIONS A AND B ARE DATUMS AND T IS A DATUM SURFACE.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
3. CONTROLLING DIMENSION: MILLIMETER.
4. DIMENSION A AND B DO NOT INCLUDE MOLD PROTRUSION.
5. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.



CASE 762-01
PLASTIC MEDIUM
POWER PACKAGE
SIP-9



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	22.40	23.00	0.873	0.897
B	6.40	6.60	0.252	0.260
C	3.45	3.65	0.136	1.143
D	0.40	0.56	0.015	0.021
E	9.35	9.60	0.368	0.377
F	1.40	1.60	0.055	0.062
G	2.54 BSC		0.100BSC	
H	1.51	1.71	0.059	0.067
J	0.380	0.400	0.014	0.015
K	3.95	4.20	0.155	0.165
M	30° BSC		30° BSC	
N	2.50	2.70	0.099	0.106
Q	3.15	3.45	0.124	0.136
R	13.60	13.90	0.536	0.547
S	1.65	1.95	0.064	0.076
U	22.00	22.20	0.866	0.874
V	0.55	0.75	0.021	0.029
W	2.89 BSC		0.113 BSC	
X	0.65	0.75	0.025	0.029
Y	2.70	2.80	0.106	0.110

NOTES:
1. DIMENSIONS A, AND C ARE DATUMS. AND -T- IS A DATUM PLANE.
2. POSITIONAL TOLERANCE FOR LEAD DIMENSION D:
   ⌖ | ϕ 0.25 (0.010) Ⓜ | -T- | A Ⓜ
3. POSITIONAL TOLERANCE FOR LEAD DIMENSION J:
   ⌖ | ϕ 0.25 (0.010) Ⓜ | -T- | C Ⓜ
4. POSITIONAL TOLERANCE FOR LEAD DIMENSION Q:
   ⌖ | ϕ 0.25 (0.010) Ⓜ | -T- | A Ⓜ
5. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1982.
6. CONTROLLING DIMENSION: MILLIMETER.