LINEAR TECHNOLOGY

5A Low Dropout Fast Response Positive Regulators Adjustable and Fixed

FEATURES

- **Fast Transient Response**
- **Guaranteed Dropout Voltage at Multiple Currents**
- Load Regulation: 0.05% Typ
- Trimmed Current Limit
- On-Chip Thermal Limiting
- Standard 3-Pin Power Package

APPLICATIONS

- Pentium® Processor Supplies
- PowerPC™ Supplies
- Other 2.5V to 3.6V Microprocessor Supplies
- Low Voltage Logic Supplies
- Battery-Powered Circuitry
- Post Regulator for Switching Supply

| LT1585ACT	Adjustable
LT1585ACT-3.3	3.3V Fixed

DESCRIPTION

The LT®1585A/LT1585A-3.3 are low dropout 3-terminal regulators with 5A output current capability. Design has been optimized for low voltage applications where transient response and minimum input voltage are critical. Similar to the LT1084 family, these regulators feature lower dropout voltage and faster transient response. These improvements make them ideal for low voltage microprocessor applications requiring a regulated 2.5V to 3.6V output with an input supply below 7V.

Current limit is trimmed to ensure specified output current and controlled short-circuit current. On-chip thermal limiting provides protection against any combination of overload that would create excessive junction temperatures.

The LT1585A/LT1585A-3.3 are available in the industry standard 3-pin TO-220 power package.

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Pentium is a registered trademark of Intel Corporation. PowerPC is a trademark of IBM Corporation.

TYPICAL APPLICATION

3.3V, 5A Regulator
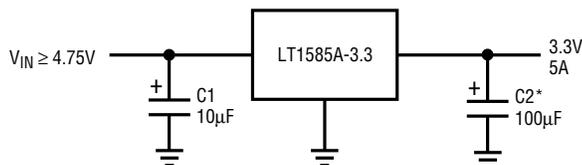
* REQUIRED FOR STABILITY

1585A TA01

NOTE: MICROPROCESSOR APPLICATIONS WITH LOAD TRANSIENTS OF 3.8A REQUIRE OUTPUT DECOUPLING CAPACITANCE >1300µF ON FIXED VOLTAGE PARTS TO ACHIEVE < 50mV OF DEVIATION FROM NOMINAL OUTPUT. CONSULT FACTORY FOR DETAILS

Dropout Voltage vs Output Current
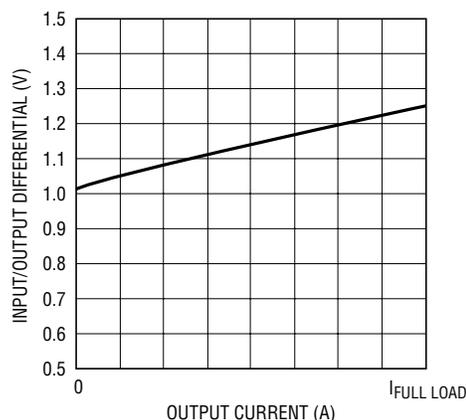
LT1585A TA02

LT1585A/LT1585A-3.3

ABSOLUTE MAXIMUM RATINGS

V_{IN} 7V
Operating Junction Temperature Range
   Control Section .... 0°C to 125°C
   Power Transistor .... 0°C to 150°C

Storage Temperature Range .... −65°C to 150°C
Lead Temperature (Soldering, 10 sec) .... 300°C

PRECONDITIONING

100% Thermal Limit Functional Test

PACKAGE/ORDER INFORMATION

FRONT VIEW	ORDER PART NUMBER
3 — V_{IN} 2 — V_{OUT} 1 — ADJ T PACKAGE 3-LEAD PLASTIC TO-220 θ_{JA} = 50°C/W	LT1585ACT

FRONT VIEW	ORDER PART NUMBER
3 — V_{IN} 2 — V_{OUT} 1 — GND T PACKAGE 3-LEAD PLASTIC TO-220 θ_{JA} = 50°C/W	LT1585ACT-3.3

Consult factory for Industrial and Military grade parts.

ELECTRICAL CHARACTERISTICS

PARAMETER		CONDITIONS		MIN	TYP	MAX	UNITS
Reference Voltage	LT1585A	$(V_{IN} - V_{OUT})$ = 3V, T_J = 25°C, I_{OUT} = 10mA 1.5V ≤ $(V_{IN} - V_{OUT})$ ≤ 5.75V, 10mA ≤ I_{OUT} ≤ 5A	●	1.238 (−1%) 1.225 (−2%)	1.250 1.250	1.262 (+1%) 1.275 (+2%)	V V
Output Voltage	LT1585A-3.3	V_{IN} = 5V, T_J = 25°C, I_{OUT} = 0mA 4.75V ≤ V_{IN} ≤ 7V, 0mA ≤ I_{OUT} ≤ 5A	●	3.267 (−1%) 3.235 (−2%)	3.300 3.300	3.333 (+1%) 3.365 (+2%)	V V
Line Regulation (Notes 1, 2)	LT1585A LT1585A-3.3	2.75V ≤ V_{IN} ≤ 7V, I_{OUT} = 10mA 4.75V ≤ V_{IN} ≤ 7V, I_{OUT} = 0mA	●		0.005	0.2	%
Load Regulation (Notes 1, 2, 3)	LT1585A LT1585A-3.3	$(V_N - V_{OUT})$ = 3V, T_J = 25°C, 10mA ≤ I_{OUT} ≤ $I_{FULL\ LOAD}$ V_{IN} = 5V, T_J = 25°C, 0mA ≤ I_{OUT} ≤ $I_{FULL\ LOAD}$	●		0.05 0.05	0.3 0.5	% %
Dropout Voltage	LT1585A LT1585A-3.3	ΔV_{REF} = 1%, I_{OUT} = 3A ΔV_{OUT} = 1%, I_{OUT} = 3A	●		1.150	1.300	V
	LT1585A LT1585A-3.3	ΔV_{REF} = 1%, I_{OUT} = 5A ΔV_{OUT} = 1%, I_{OUT} = 5A	●		1.200	1.400	V
Current Limit (Note 3)	LT1585A LT1585A-3.3	$(V_{IN} - V_{OUT})$ = 5.5V $(V_{IN} - V_{OUT})$ = 5.5V	●	5.0	6.0		A
Adjust Pin Current	LT1585A		●		55	120	μA
Adjust Pin Current Change (Note 3)	LT1585A	1.5V ≤ $(V_{IN} - V_{OUT})$ ≤ 5.75V, 10mA ≤ I_{OUT} ≤ $I_{FULL\ LOAD}$	●		0.2	5	μA
Minimum Load Current	LT1585A	1.5V ≤ $(V_{IN} - V_{OUT})$ ≤ 5.75V	●		2	10	mA
Quiescent Current	LT1585A-3.3	V_{IN} = 5V	●		8	13	mA

ELECTRICAL CHARACTERISTICS

PARAMETER		CONDITIONS		MIN	TYP	MAX	UNITS
Ripple Rejection	LT1585A	f = 120Hz, C_{OUT} = 100µF Tant., $(V_{IN} - V_{OUT})$ = 3V, I_{OUT} = 5A					
	LT1585A-3.3	f = 120Hz, C_{OUT} = 100µF Tant., V_{IN} = 6.3V, I_{OUT} = 5A	●	60	72		dB
Thermal Regulation	LT1585A LT1585A-3.3	T_A = 25°C, 30ms Pulse T_A = 25°C, 30ms Pulse			0.004	0.02	%/W
Temperature Stability			●		0.5		%
Long-Term Stability		T_A = 125°C, 1000 Hrs.			0.03	1.0	%
RMS Output Noise (% of V_{OUT})		T_A = 25°C, 10Hz ≤ f ≤ 10kHz			0.003		%
Thermal Resistance Junction to Case	LT1585A	T Package: Control Circuitry/Power Transistor				0.7/3.0	°C/W

The ● denotes specifications which apply over the specified operating temperature range.

Note 1: See thermal regulation specifications for changes in output voltage due to heating effects. Load and line regulation are measured at a constant junction temperature by low duty cycle pulse testing.

**Note 2:** Line and load regulation are guaranteed up to the maximum power dissipation 28.8W for the LT1585A in T package. Power dissipation is determined by input/output differential and the output current. Guaranteed maximum output power will not be available over the full input/output voltage range.

Note 3: $I_{FULL\ LOAD}$ is defined as the maximum value of output load current as a function of input-to-output voltage. $I_{FULL\ LOAD}$ is equal to 5A for the LT1585A/LT1585A-3.3. The LT1585A has constant current limit with changes in input-to-output voltage.

TYPICAL PERFORMANCE CHARACTERISTICS

LT1585A Dropout Voltage vs Output Current
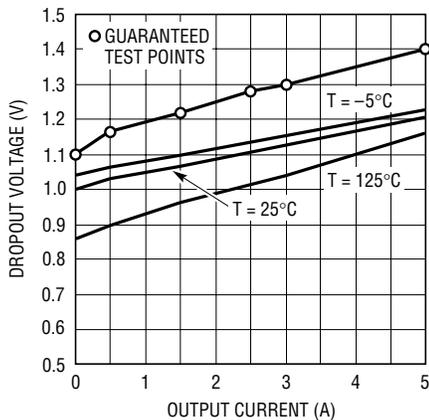
LT1585A • TPC01

LT1585A Short-Circuit Current vs Temperature
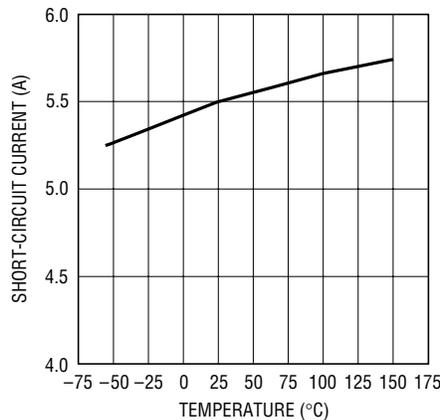
LT1585A • TPC02

LT1585A Load Regulation vs Temperature
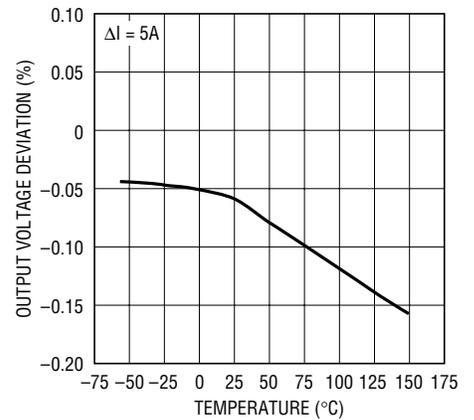
LT1585A • TPC03

TYPICAL PERFORMANCE CHARACTERISTICS

LT1585A Reference Voltage vs Temperature
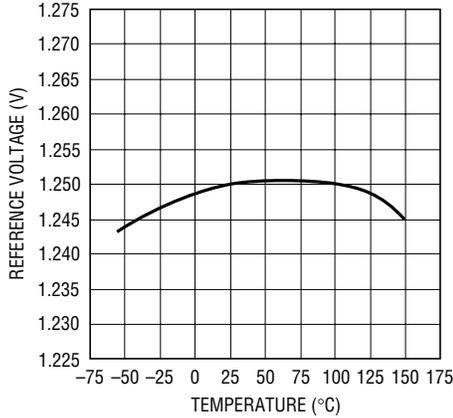
LT1585A • TPC04

Output Voltage vs Temperature Using Adjustable LT1585A

V_{OUT} SET WITH 1% RESISTORS
V_{OUT} = 3.6V
V_{OUT} = 3.45V
V_{OUT} = 3.38V
V_{OUT} = 3.3V
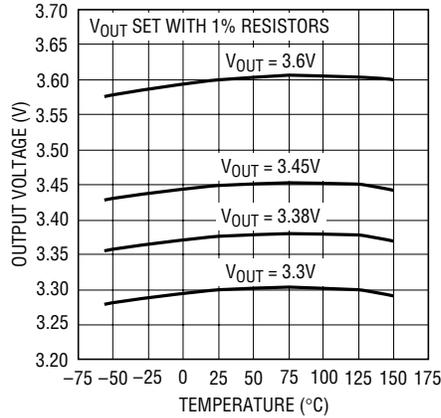
LT1585A • TPC05

LT1585A-3.3 Output Voltage vs Temperature

V_{OUT} = 3.3V
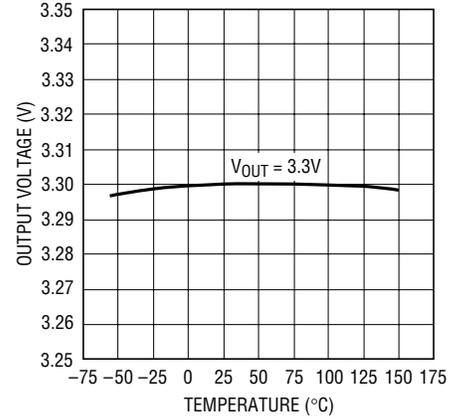
LT1585A • TPC06

LT1585A Minimum Load Current vs Temperature
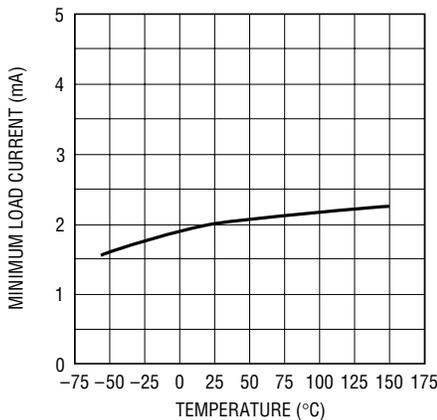
LT1585A • TPC07

LT1585A Adjust Pin Current vs Temperature
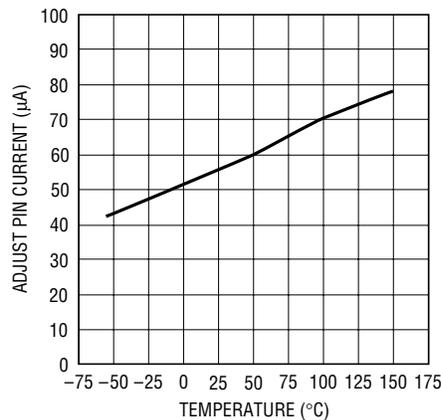
LT1585A • TPC08

LT1585A-3.3 Quiescent Current vs Temperature
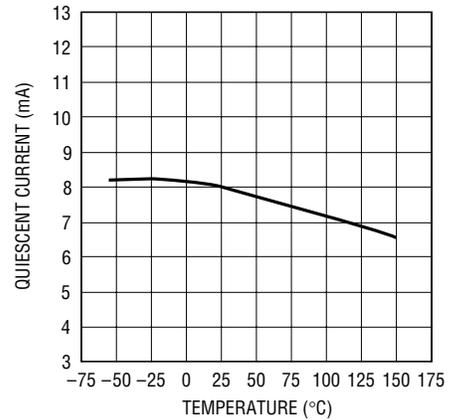
LT1585A • TPC09

LT1585A-3.3 Ripple Rejection vs Frequency

LT1585A-3.3: $(V_{IN} - V_{OUT}) \leq 3V$
$0.5V \leq V_{RIPPLE} \leq 2V$
$I_{OUT} = I_{FULL\ LOAD}$
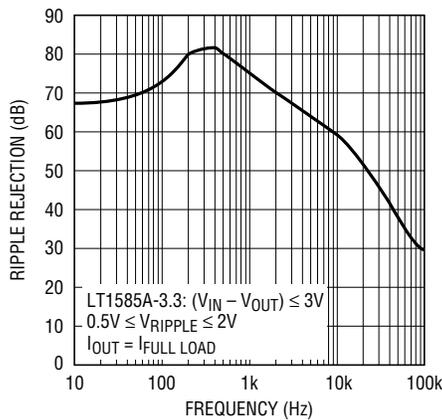
LT1585A • TPC10

LT1585A Maximum Power Dissipation*
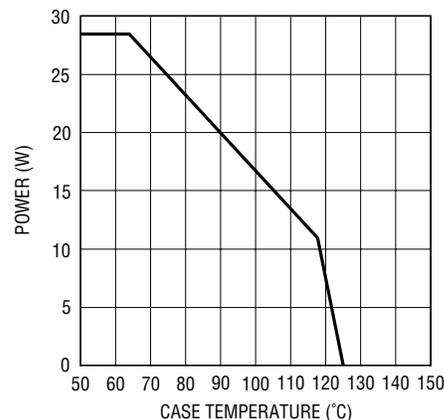
LT1585A • TPC11

*AS LIMITED BY MAXIMUM JUNCTION TEMPERATURE

SIMPLIFIED SCHEMATIC

LT1585A • BD

FOR FIXED VOLTAGE DEVICE
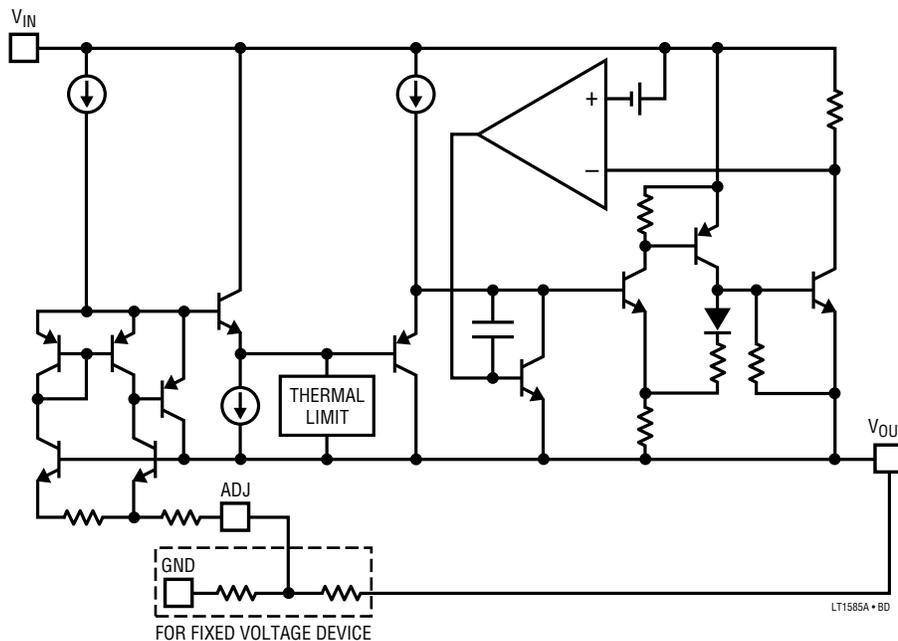
APPLICATIONS INFORMATION

General

The LT1585A/LT1585A-3.3 3-terminal regulators are easy to use and have all the protection features expected in high performance linear regulators. The devices are short-circuit protected, safe-area protected and provide thermal shutdown to turn off the regulators should the junction temperature exceed about 150°C. The regulators include an adjustable and a fixed 3.3V version.

These ICs are pin compatible with the LT1083/LT1084/ LT1085 family of linear regulators but offer lower dropout voltage and faster transient response. The trade-off for this improved performance is a 7V maximum supply voltage. Similar to the LT1083/LT1084/LT1085 family, the LT1585A/LT1585A-3.3 regulators require an output capacitor for stability. However, the improved frequency compensation permits the use of capacitors with much lower ESR while still maintaining stability. This is critical in addressing the needs of modern, low voltage, high speed microprocessors.

Current generation microprocessors cycle load current from almost zero to amps in tens of nanoseconds. Output voltage tolerances are tighter and include transient response as part of the specification. The LT1585A/ LT1585A-3.3 are specifically designed to meet the fast current load-step requirements of these microprocessors and save total cost by needing less output capacitance in order to maintain regulation.

Stability

The circuit design in the LT1585A/LT1585A-3.3 requires the use of an output capacitor as part of the frequency compensation. For all operating conditions, the addition of a 100μF solid tantalum or aluminum electrolytic on the output ensures stability. Normally, the LT1585A/ LT1585A-3.3 can use smaller value capacitors. Many different types of capacitors are available and have widely varying characteristics. These capacitors differ in capaci-

APPLICATIONS INFORMATION

tor tolerance (sometimes ranging up to ±100%), equivalent series resistance, equivalent series inductance and capacitance temperature coefficient. The LT1585A/LT1585A-3.3 frequency compensation optimizes frequency response with low ESR capacitors. In general, use capacitors with an ESR of less than 1Ω.

On the adjustable LT1585A, bypassing the adjust terminal improves ripple rejection and transient response. Bypassing the adjust pin increases the required output capacitor value. The value of 100µF tantalum or aluminum covers all cases of bypassing the adjust terminal. With no adjust pin bypassing, smaller values of capacitors provide equally good results.

Normally, capacitor values on the order of several hundred microfarads are used on the output of the regulators to ensure good transient response with heavy load current changes. Output capacitance can increase without limit and larger values of output capacitance further improve the stability and transient response of the LT1585A/LT1585A-3.3.

Large load current changes are exactly the situation presented by modern microprocessors. The load current step contains higher order frequency components that the output decoupling network must handle until the regulator throttles to the load current level. Capacitors are not ideal elements and contain parasitic resistance and inductance. These parasitic elements dominate the change in output voltage at the beginning of a transient load step change. The ESR of the output capacitors produces an instantaneous step in output voltage ($\Delta V = \Delta I \cdot ESR$). The ESL of the output capacitors produces a droop proportional to the rate of change of output current ($V = L \cdot \Delta I/\Delta t$). The output capacitance produces a change in output voltage proportional to the time until the regulator can respond ($\Delta V = \Delta t \cdot \Delta I/C$). These transient effects are illustrated in Figure 1.

The use of capacitors with low ESR, low ESL and good high frequency characteristics is critical in meeting the output voltage tolerances of these high speed micropro-
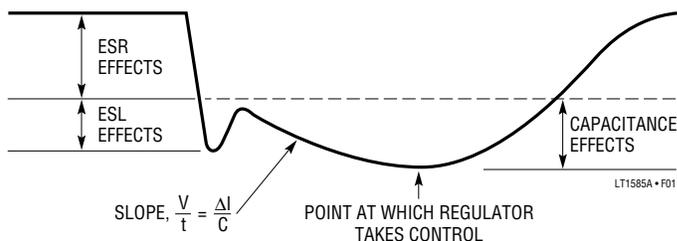
Figure 1

cessors. These requirements dictate a combination of high quality, surface mount tantalum capacitors and ceramic capacitors. The location of the decoupling network is critical to transient response performance. Place the decoupling network as close as possible to the processor pins because trace runs from the decoupling capacitors to the processor pins are inductive. The ideal location for the decoupling network is actually inside the microprocessor socket cavity. In addition, use large power and ground plane areas to minimize distribution drops.

A possible stability problem that occurs in monolithic linear regulators is current limit oscillations. The LT1585A/LT1585A-3.3 essentially have a flat current limit over the range of input supply voltage. The lower current limit rating and 7V maximum supply voltage rating for these devices permit this characteristic. Current limit oscillations are typically nonexistent, unless the input and output decoupling capacitors for the regulators are mounted several inches from the terminals.

Protection Diodes

In normal operation, the LT1585A/LT1585A-3.3 do not require any protection diodes. Older 3-terminal regulators require protection diodes between the output pin and the input pin or between the adjust pin and the output pin to prevent die overstress.

On the adjustable LT1585A, internal resistors limit internal current paths on the adjust pin. Therefore, even with bypass capacitors on the adjust pin, no protection diode is needed to ensure device safety under short-circuit conditions.

APPLICATIONS INFORMATION

A protection diode between the input and output pins is usually not needed. An internal diode between the input and output pins on the LT1585A/LT1585A-3.3 can handle microsecond surge currents of 50A to 100A. Even with large value output capacitors it is difficult to obtain those values of surge currents in normal operation. Only with large values of output capacitance, such as 1000µF to 5000µF, and with the input pin instantaneously shorted to ground can damage occur. A crowbar circuit at the input of the LT1585A/LT1585A-3.3 can generate those levels of current, and a diode from output to input is then recommended. This is shown in Figure 2. Usually, normal power supply cycling or system "hot plugging and unplugging" will not generate current large enough to do any damage.

The adjust pin can be driven on a transient basis ±7V with respect to the output, without any device degradation. As with any IC regulator, exceeding the maximum input-to-output voltage differential causes the internal transistors to break down and none of the protection circuitry is then functional.
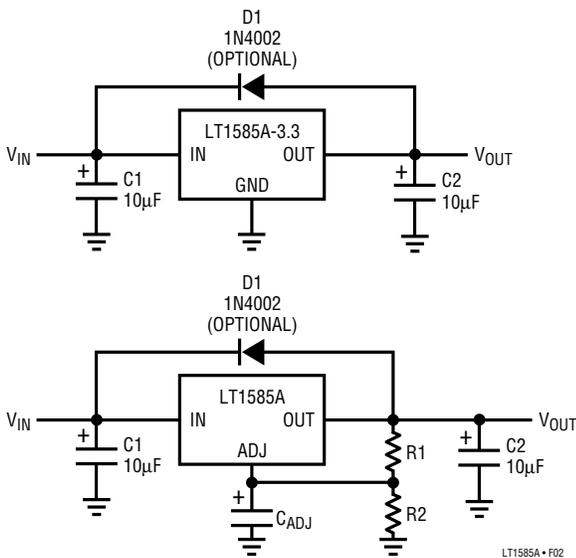

Figure 2

Ripple Rejection

The typical curve for ripple rejection reflects values for the LT1585A-3.3 fixed output voltage part. In applications that require improved ripple rejection, use the adjustable device. A bypass capacitor from the adjust pin to ground reduces the output ripple by the ratio of V_{OUT}/1.25V. The impedance of the adjust pin capacitor at the ripple frequency should be less than the value of R1 (typically in the range of 100Ω to 120Ω) in the feedback divider network in Figure 2. Therefore, the value of the required adjust pin capacitor is a function of the input ripple frequency. For example, if R1 equals 100Ω and the ripple frequency equals 120Hz, the adjust pin capacitor should be 22µF. At 10kHz, only 0.22µF is needed.

Output Voltage

The LT1585A adjustable regulator develops a 1.25V reference voltage between the output pin and the adjust pin (see Figure 3). Placing a resistor R1 between these two terminals causes a constant current to flow through R1 and down through R2 to set the overall output voltage. Normally, this current is the specified minimum load current of 10mA. The current out of the adjust pin adds to the current from R1 and is typically 55µA. Its output voltage contribution is small and only needs consideration when very precise output voltage setting is required.


$$V_{OUT} = V_{REF} (1 + R2/R1) + I_{ADJ} (R2)$$
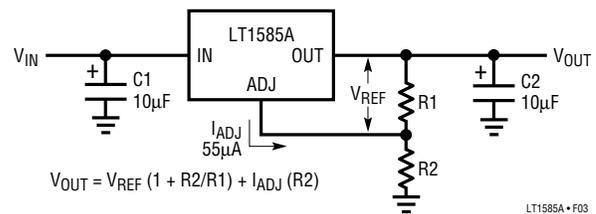
Figure 3. Basic Adjustable Regulator

APPLICATIONS INFORMATION

Load Regulation

It is not possible to provide true remote load sensing because the LT1585A/LT1585A-3.3 are 3-terminal devices. Load regulation is limited by the resistance of the wire connecting the regulators to the load. Load regulation per the data sheet specification is measured at the bottom of the package.

For fixed voltage devices, negative side sensing is a true Kelvin connection with the ground pin of the device returned to the negative side of the load. This is illustrated in Figure 4.

For adjustable voltage devices, negative side sensing is a true Kelvin connection with the bottom of the output divider returned to the negative side of the load. The best load regulation is obtained when the top of resistor divider R1 connects directly to the regulator output and not to the load. Figure 5 illustrates this point. If R1 connects to the load, the effective resistance between the regulator and the load is:

$R_P(1 + R2/R1)$, R_P = Parasitic Line Resistance

The connection shown in Figure 5 does not multiply R_P by the divider ratio. As an example, R_P is about four milliohms per foot with 16-gauge wire. This translates to 4mV per foot at 1A load current. At higher load currents, this drop represents a significant percentage of the overall regulation. It is important to keep the positive lead between the regulator and the load as short as possible and to use large wire or PC board traces.
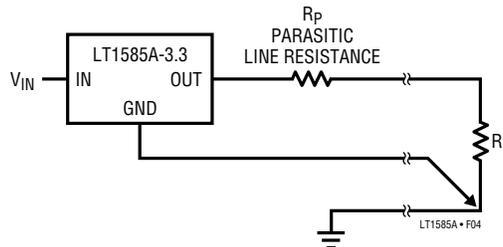

**Figure 4. Connection for Best Load Regulation**
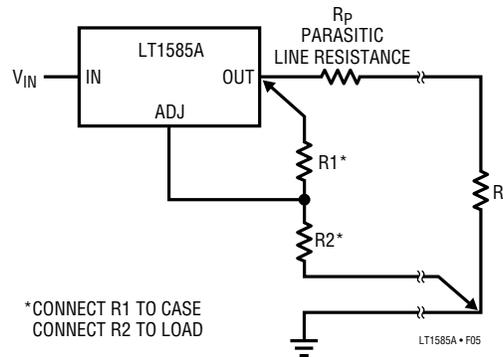
Figure 5. Connection for Best Load Regulation

APPLICATIONS INFORMATION

Thermal Considerations

The LT1585A/LT1585A-3.3 family protects the device under overload conditions with internal power and thermal limiting circuitry. However, for normal continuous load conditions, do not exceed maximum junction temperature ratings. It is important to consider all sources of thermal resistance from junction-to-ambient. These sources include the junction-to-case resistance, the case-to-heat sink interface resistance and the heat sink resistance. Thermal resistance specifications have been developed to more accurately reflect device temperature and ensure safe operating temperatures. The Electrical Characteristics section provides a separate thermal resistance and maximum junction temperature for both the control circuitry and the power transistor. Older regulators, with a single junction-to-case thermal resistance specification, use an average of the two values provided here and allow excessive junction temperatures under certain conditions of ambient temperature and heat sink resistance. Calculate the maximum junction temperature for both sections to ensure that both thermal limits are met.

Junction-to-case thermal resistance is specified from the IC junction to the bottom of the case directly below the die. This is the lowest resistance path for heat flow. Proper mounting ensures the best thermal flow from this area of the package to the heat sink. Linear Technology strongly recommends thermal compound at the case-to-heat sink interface. Use a thermally conductive spacer if the case of the device must be electrically isolated and include its contribution to the total thermal resistance. Please consult "Mounting Considerations for Power Semiconduc-

tors" *1990 Linear Applications Handbook, Volume I*, Pages RR3-1 to RR3-20. The output connects to the case of both the LT1585A and the LT1585A-3.3.

For example, using an LT1585ACT-3.3 (TO-220, commercial) and assuming:

V_{IN}(Max Continuous) = 5.25V (5V + 5%), V_{OUT} = 3.3V, I_{OUT} = 5A

T_A = 70°C, $\theta_{HEAT\ SINK}$ = 3°C/W

$\theta_{CASE-TO-HEAT\ SINK}$ = 1°C/W (with Thermal Compound)

Power dissipation under these conditions is equal to:

$P_D = (V_{IN} - V_{OUT})(I_{OUT}) = (5.25 - 3.3)(5) = 9.75W$

Junction temperature will be equal to:

$T_J = T_A + P_D(\theta_{HEAT\ SINK} + \theta_{CASE-TO-HEAT\ SINK} + \theta_{JC})$

For the Control Section:

T_J = 70°C + 9.75W (3°C/W + 1°C/W + 0.7°C/W)
    = 115.8°C
115.8°C < 125°C = T_{JMAX} (Control Section Commercial range)

For the Power Transistor:

T_J = 70°C + 9.75W (3°C/W + 1°C/W + 3°C/W)
    = 138.3°C
138.3°C < 150°C = T_{JMAX} (Power Transistor Commercial Range)

In both cases the junction temperature is below the maximum rating for the respective sections, ensuring reliable operation.

TYPICAL APPLICATIONS

**Minimum Parts Count LT1585A Adjustable Circuit
for the Intel 120MHz Pentium Processor**

THERMALLOY
7020B-MT

PLACE IN MICROPROCESSOR
SOCKET CAVITY

4.75V TO
5.25V

IN   OUT

LT1585ACT

ADJ

C1 TO C3
220µF
10V
AVX TPS
3 EACH

C4
330nF
16V
AVX X7R 0805

R1
110Ω
0.1%

R2
197Ω
0.1%

3.50V
5A

C5 TO C10
100µF
10V
AVX TPS
6 EACH

C11 TO C20
1µF
16V
AVX Y5V 0805
10 EACH

LT1585A TA04

AVX CORP. (803) 448-9411
THERMALLOY INC. (214) 243-4321
DO NOT SUBSTITUTE COMPONENTS.
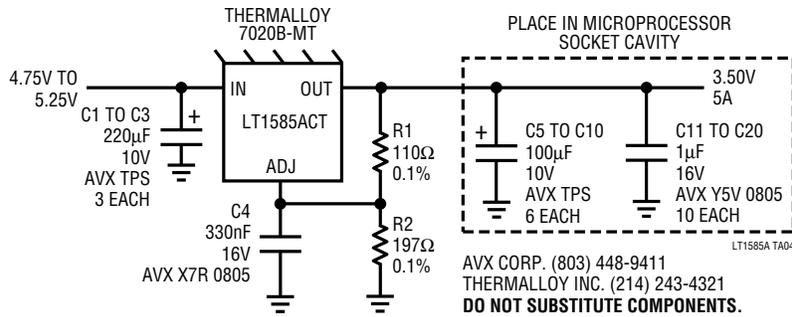
**LT1585A Transient Response
for 3.8A Load Current Step***
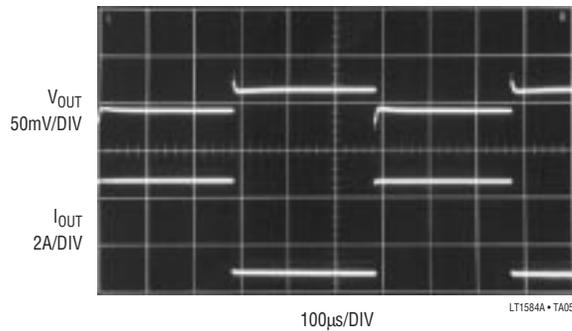
V_{OUT}
50mV/DIV

I_{OUT}
2A/DIV

100µs/DIV

LT1584A • TA05

* TRANSIENT RESPONSE MEASURED WITH AN INTEL
POWER VALIDATOR. V_{OUT} IS MEASURED AT THE
POWER VALIDATOR

TYPICAL APPLICATIONS

Guaranteed LT1585A Circuit for the Intel 100MHz and Higher Frequency Pentium Processors
(Meets Intel Specifications with Worst-Case Tolerances)
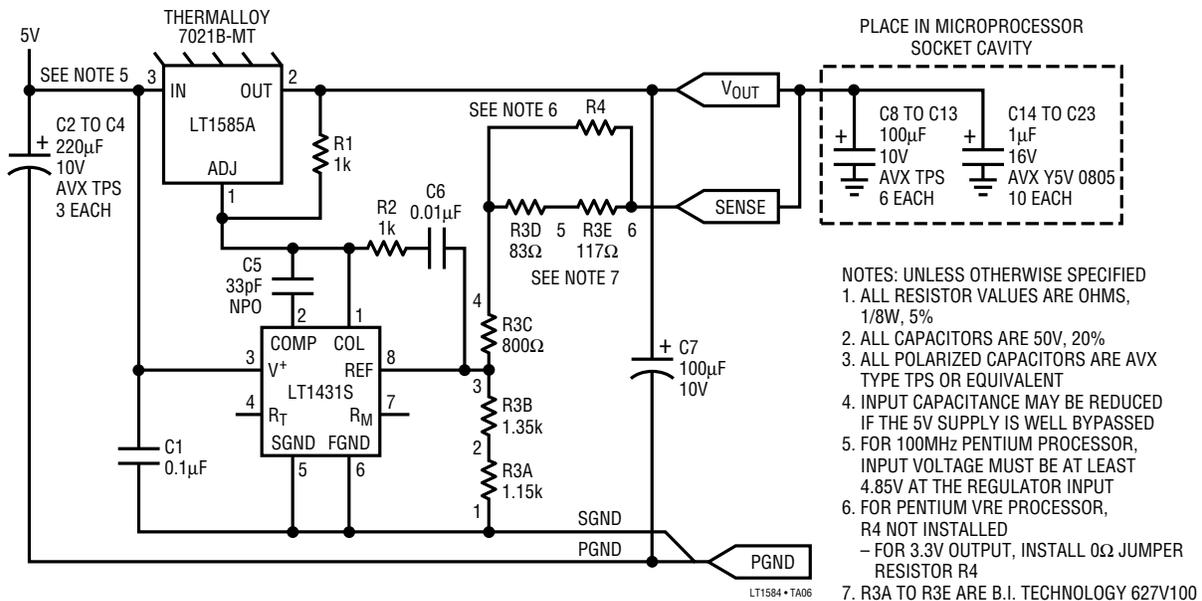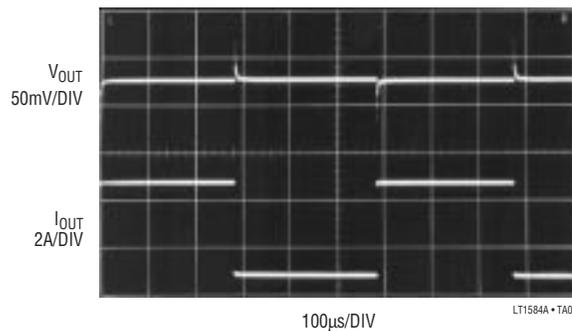
NOTES: UNLESS OTHERWISE SPECIFIED
1. ALL RESISTOR VALUES ARE OHMS, 1/8W, 5%
2. ALL CAPACITORS ARE 50V, 20%
3. ALL POLARIZED CAPACITORS ARE AVX TYPE TPS OR EQUIVALENT
4. INPUT CAPACITANCE MAY BE REDUCED IF THE 5V SUPPLY IS WELL BYPASSED
5. FOR 100MHz PENTIUM PROCESSOR, INPUT VOLTAGE MUST BE AT LEAST 4.85V AT THE REGULATOR INPUT
6. FOR PENTIUM VRE PROCESSOR, R4 NOT INSTALLED
   – FOR 3.3V OUTPUT, INSTALL 0Ω JUMPER RESISTOR R4
7. R3A TO R3E ARE B.I. TECHNOLOGY 627V100

LT1584 • TA06

LT1585A/LT1431 Transient Response
for 3.8A Load Current Step*

100µs/DIV

LT1584A • TA06

* TRANSIENT RESPONSE MEASURED WITH AN INTEL POWER VALIDATOR. V_OUT IS MEASURED AT THE POWER VALIDATOR

PACKAGE DESCRIPTION Dimensions in inches (millimeters) unless otherwise noted.

**T Package
3-Lead Plastic TO-220**

0.390 – 0.415
(9.906 – 10.541)

0.147 – 0.155
(3.734 – 3.937)
DIA

0.165 – 0.180
(4.293 – 4.699)

0.045 – 0.055
(1.143 – 1.397)

0.230 – 0.270
(5.842 – 6.858)

0.570 – 0.620
(14.478 – 15.748)

0.460 – 0.500
(11.684 – 12.700)

0.330 – 0.370
(8.382 – 9.398)

0.980 – 1.070
(24.892 – 27.178)

0.520 – 0.570
(13.208 – 14.478)

0.218 – 0.252
(5.537 – 6.401)

0.013 – 0.023
(0.330 – 0.584)

0.095 – 0.115
(2.413 – 2.921)

0.090 – 0.110
(2.286 – 2.794)

0.028 – 0.038
(0.711 – 0.965)

0.050
(1.270)
TYP

T3 (TO-220) 0595
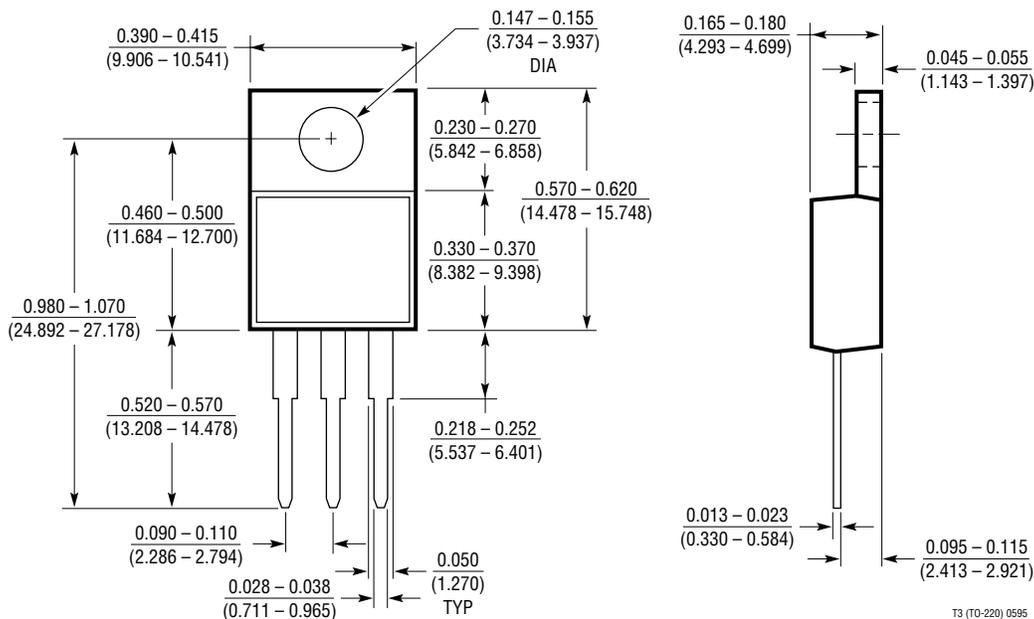
RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LTC1430	High Power Step-Down Switching Regulator	5V to 3.3V at 10A
LT1580	7A Very Low Dropout Linear Regulator	0.54V Dropout at 7A, Fixed 2.5V$_{OUT}$ and Adjustable
LT1584	7A Low Dropout Fixed and Adjustable Linear Regulators	Fast Transient Response for Microprocessor Applications
LT1587	3A Low Dropout Fixed and Adjustable Linear Regulators	Fast Transient Response for Microprocessor Applications

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