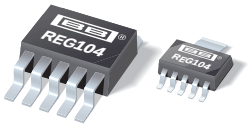


SBVS025C – SEPTEMBER 2001

DMOS
1A Low-Dropout Regulator

FEATURES

- **NEW DMOS TOPOLOGY:**
  Ultra Low Dropout Voltage:
  230mV typ at 1A and 3.3V Output
  Output Capacitor NOT Required for Stability
- **FAST TRANSIENT RESPONSE**
- **VERY LOW NOISE: 33μVrms**
- **HIGH ACCURACY: ±2% max**
- **HIGH EFFICIENCY:**
  I_{GND} = 1.7mA at I_{OUT} = 1A
  Not Enabled: I_{GND} = 0.5μA
- **2.5V, 2.7V, 3.0V, 3.3V, 5.0V AND ADJUSTABLE OUTPUT VERSIONS**
- **THERMAL PROTECTION**
- **SMALL SURFACE-MOUNT PACKAGES:**
  SOT223-5, DDPAK-5

APPLICATIONS

- **PORTABLE COMMUNICATION DEVICES**
- **BATTERY-POWERED EQUIPMENT**
- **MODEMS**
- **BAR-CODE SCANNERS**
- **BACKUP POWER SUPPLIES**

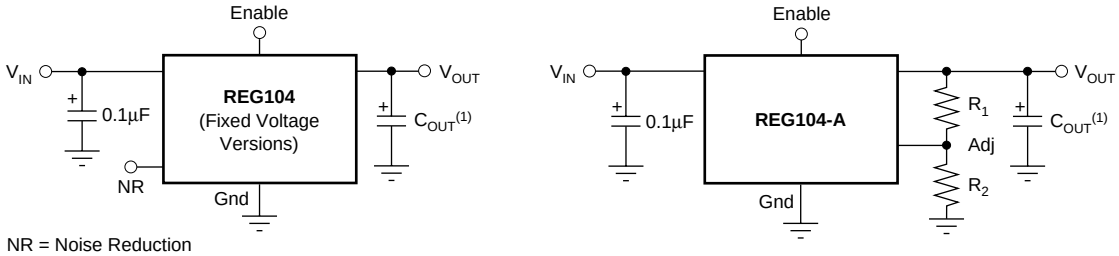
DESCRIPTION

The REG104 is a family of low-noise, low-dropout linear regulators with low ground pin current. Its new DMOS topology provides significant improvement over previous designs, including low dropout voltage (only 230mV typ at full load), and better transient performance. In addition, no output capacitor is required for stability, unlike conventional low dropout regulators that are difficult to compensate and require expensive low ESR capacitors greater than 1μF.

Typical ground pin current is only 1.7mA (at I_{OUT} = 1A) and drops to 0.5μA in "not enabled" mode. Unlike regulators with PNP pass devices, quiescent current remains relatively constant over load variations and under dropout conditions.

The REG104 has very low output noise (typically 33μVrms for V_{OUT} = 3.3V with C_{NR} = 0.01μF), making it ideal for use in portable communications equipment. On-chip trimming results in high output voltage accuracy. Accuracy is maintained over temperature, line, and load variations. Key parameters are tested over the specified temperature range (–40°C to +85°C).

The REG104 is well protected—internal circuitry provides a current limit which protects the load from damage. Thermal protection circuitry keeps the chip from being damaged by excessive temperature. The REG104 is available in the DDPAK-5 and the SOT223-5.



NOTE: (1) Optional.

Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

ABSOLUTE MAXIMUM RATINGS(1)

Supply Input Voltage, V_{IN}	–0.3V to 16V
Enable Input	–0.3V to V_{IN}
Output Short-Circuit Duration	Indefinite
Operating Temperature Range	–55°C to +125°C
Storage Temperature Range	–65°C to +150°C
Junction Temperature	–55°C to +150°C
Lead Temperature (soldering, 3s, SOT, and DDPAK)	+240°C

NOTE: (1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability.

ELECTROSTATIC DISCHARGE SENSITIVITY

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

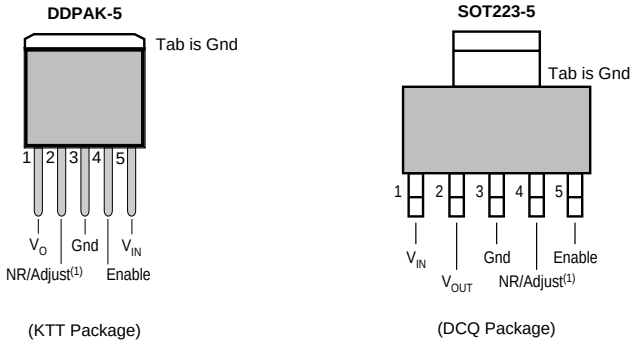
ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

PACKAGE/ORDERING INFORMATION

PRODUCT	PACKAGE-LEAD	PACKAGE DESIGNATOR	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING	ORDERING NUMBER	TRANSPORT MEDIA, QUANTITY
5V Output						
REG104FA-5	DDPAK-5	KTT	–40°C to +85°C	REG104FA-5.0	REG104FA-5	Rails, 49
"	"	"	"	"	REG104FA-5	Tape and Reel, 500
REG104GA-5	SOT223-5	DCQ	–40°C to +85°C	R104G50	REG104GA-5	Rails, 78
"	"	"	"	"	REG104GA-5	Tape and Reel, 2500
3.3V Output						
REG104FA-3.3	DDPAK-5	KTT	–40°C to +85°C	REG104FA-3.3	REG104FA-3.3	Rails, 49
"	"	"	"	"	REG104FA-3.3	Tape and Reel, 500
REG104GA-3.3	SOT223-5	DCQ	–40°C to +85°C	R104G33	REG104GA-3.3	Rails, 78
"	"	"	"	"	REG104GA-3.3	Tape and Reel, 2500
3.0V Output						
REG104FA-3	DDPAK-5	KTT	–40°C to +85°C	REG104FA-3.0	REG104FA-3	Rails, 49
"	"	"	"	"	REG104FA-3	Tape and Reel, 500
REG104GA-3	SOT223-5	DCQ	–40°C to +85°C	R104G30	REG104GA-3	Rails, 78
"	"	"	"	"	REG104GA-3	Tape and Reel, 2500
2.7V Output						
REG104FA-2.7	DDPAK-5	KTT	–40°C to +85°C	REG104FA-2.7	REG104FA-2.7	Rails, 49
"	"	"	"	"	REG104FA-2.7	Tape and Reel, 500
REG104GA-2.7	SOT223-5	DCQ	–40°C to +85°C	R104G27	REG104GA-2.7	Rails, 78
"	"	"	"	"	REG104GA-2.7	Tape and Reel, 2500
2.5V Output						
REG104FA-2.5	DDPAK-5	KTT	–40°C to +85°C	REG104FA-2.5	REG104FA-2.5	Rails, 49
"	"	"	"	"	REG104FA-2.5	Tape and Reel, 500
REG104GA-2.5	SOT223-5	DCQ	–40°C to +85°C	R104G25	REG104GA-2.5	Rails, 78
"	"	"	"	"	REG104GA-2.5	Tape and Reel, 2500
Adjustable Output						
REG104FA-A	DDPAK-5	KTT	–40°C to +85°C	REG104FA-A	REG104FA-A	Rails, 49
"	"	"	"	"	REG104FA-A	Tape and Reel, 500
REG104GA-A	SOT223-5	DCQ	–40°C to +85°C	R104GA	REG104GA-A	Rails, 78
"	"	"	"	"	REG104GA-A	Tape and Reel, 2500

PIN CONFIGURATIONS

Top View



(KTT Package) (DCQ Package)

NOTE: (1) For REG104A-A: voltage setting resistor pin.
All other models: noise reduction capacitor pin.

ELECTRICAL CHARACTERISTICS: V_S = +2.7V to +5.5V

Boldface limits apply over the specified temperature range, **T_J = –40°C to +85°C**

At T_J = +25°C, V_{IN} = V_{OUT} + 1V (V_{OUT} = 3.0V for REG104-A), V_{ENABLE} = 2V, I_{OUT} = 10mA, C_{NR} = 0.01µF, and C_{OUT} = 0.1µF[1], unless otherwise noted.

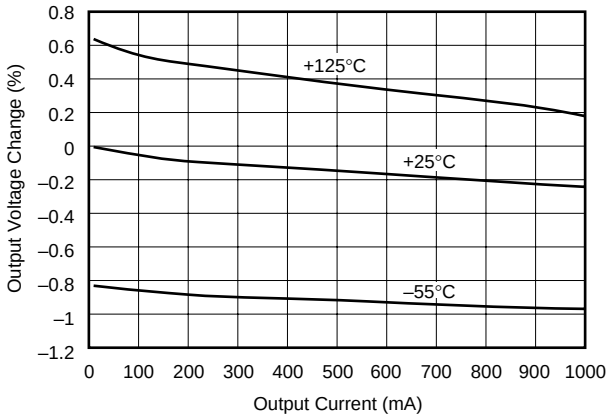
PARAMETER		CONDITION	REG104GA REG104FA MIN	TYP	MAX	UNITS
OUTPUT VOLTAGE						
Output Voltage Range	V_{OUT}					
REG104-2.5				2.5		V
REG104-2.7				2.7		V
REG104-3.0				3.0		V
REG104-3.3				3.3		V
REG104-5				5		V
REG104-A			V_{REF}		5.5	V
Reference Voltage	V_{REF}			1.295		V
Adjust Pin Current	I_{ADJ}			0.2	1	µA
Accuracy				±0.5	±2	%
T_J = –40°C to +85°C					**±3.0**	%
vs Temperature	**dV_{OUT}/dT**	**T_J = –40°C to +85°C**		**70**		ppm/°C
vs Line and Load		I_{OUT} = 10mA to 1A, V_{IN} = (V_{OUT} + 0.7V) to 15V		±0.5	±2.5	%
T_J = –40°C to +85°C		**V_{IN} = (V_{OUT} + 0.9V) to 15V**			**±3.5**	**%**
DC DROPOUT VOLTAGE[2, 3]	V_{DROP}	I_{OUT} = 10mA		3	25	mV
For all models except 5V		I_{OUT} = 1A		230	400	mV
For 5V model		I_{OUT} = 1A		320	500	mV
For all models except 5V		**I_{OUT} = 1A**			**480**	mV
T_J = –40°C to +85°C						
For 5V models		**I_{OUT} = 1A**			**580**	mV
T_J = –40°C to +85°C						
VOLTAGE NOISE						
f = 10Hz to 100kHz	V_n					
Without C_{NR} (all models)		C_{NR} = 0, C_{OUT} = 0		35µVrms/V • V_{OUT}		µVrms
With C_{NR} (all fixed voltage models)		C_{NR} = 0.01µF, C_{OUT} = 10µF		10µVrms/V • V_{OUT}		µVrms
OUTPUT CURRENT						
Current Limit[4]	I_{CL}		1.2	1.7	2.1	A
T_J = –40°C to +85°C			**1.0**		**2.2**	A
RIPPLE REJECTION						
f = 120Hz				65		dB
ENABLE CONTROL						
V_{ENABLE} High (output enabled)	V_{ENABLE}		2		V_{IN}	V
V_{ENABLE} Low (output disabled)			–0.2		0.5	V
I_{ENABLE} High (output enabled)	I_{ENABLE}	V_{ENABLE} = 2V to V_{IN}, V_{IN} = 2.1V to 6.5[5]		1	100	nA
I_{ENABLE} Low (output disabled)		V_{ENABLE} = 0V to 0.5V		2	100	nA
Output Disable Time				50		µs
Output Enable Softstart Time				1.5		ms
THERMAL SHUTDOWN						
Junction Temperature						
Shutdown				150		°C
Reset from Shutdown				130		°C
GROUND PIN CURRENT						
Ground Pin Current	I_{GND}	I_{OUT} = 10mA		0.5	0.7	mA
		I_{OUT} = 1A		1.7	1.8	mA
Enable Pin Low		V_{ENABLE} ≤ 0.5V		0.5		µA
INPUT VOLTAGE	V_{IN}					
Operating Input Voltage Range[6]			2.1		15	V
Specified Input Voltage Range		V_{IN} > 2.7V	V_{OUT} + 0.7		15	V
T_J = –40°C to +85°C		**V_{IN} > 2.9V**	**V_{OUT} + 0.9**		**15**	V
TEMPERATURE RANGE						
Specified Range	T_J		–40		+85	°C
Operating Range			–55		+125	°C
Storage Range			–65		+150	°C
Thermal Resistance						
DDPAK-5 Surface Mount	θ_{JC}	Junction-to-Case		4		°C/W
SOT223-5 Surface Mount	θ_{JC}	Junction-to-Case		15		°C/W

NOTES: (1) The REG104 does not require a minimum output capacitor for stability. However, transient response can be improved with proper capacitor selection. (2) Dropout voltage is defined as the input voltage minus the output voltage that produces a 2% change in the output voltage from the value at V_{IN} = V_{OUT} + 1V at fixed load. (3) Not applicable for V_{OUT} less than 2.7V. (4) Current limit is the output current that produces a 15% change in output voltage from V_{IN} = V_{OUT} + 1V and I_{OUT} = 10mA. (5) For V_{IN} > 6.5V, see typical characteristic "V_{ENABLE} vs I_{ENABLE}." (6) The REG104 no longer regulates when V_{IN} < V_{OUT} + $V_{DROP\ (MAX)}$. In drop-out or when the input voltage is between 2.7V and 2.1V, the impedance from V_{IN} to V_{OUT} is typically less than 1Ω at T_J = +25°C. See typical characteristic "Output Voltage Change vs V_{IN}".

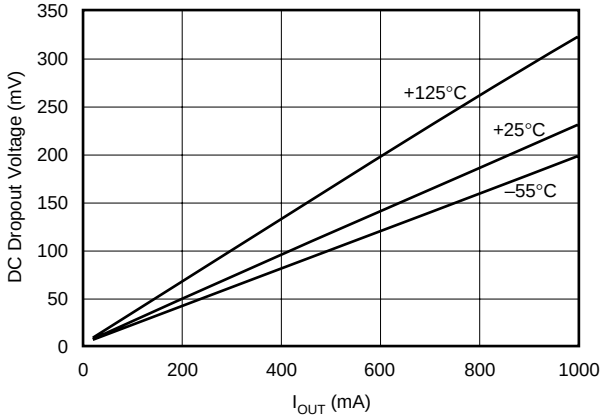
TYPICAL CHARACTERISTICS

For all models, at T_J = +25°C and V_{ENABLE} = 2V, unless otherwise noted.

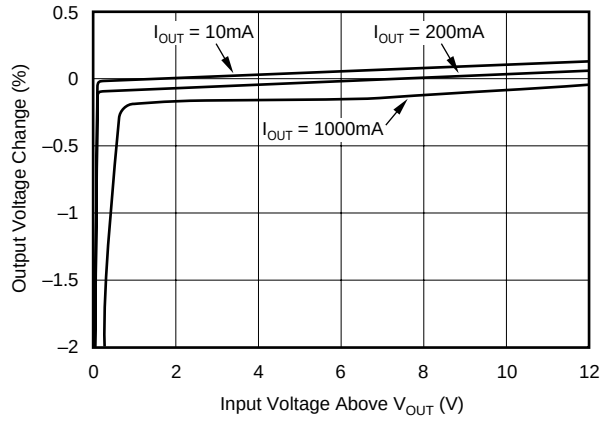
OUTPUT VOLTAGE CHANGE vs I_{OUT}
(V_{IN} = V_{OUT} + 1V, Output Voltage % Change Referred to I_{OUT} = 10mA at +25°C)



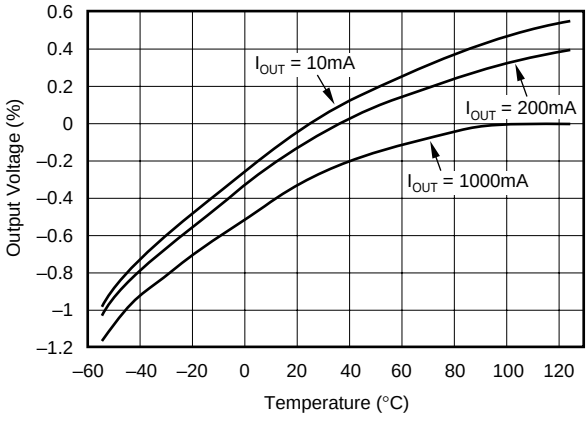
DC DROPOUT VOLTAGE vs I_{OUT}



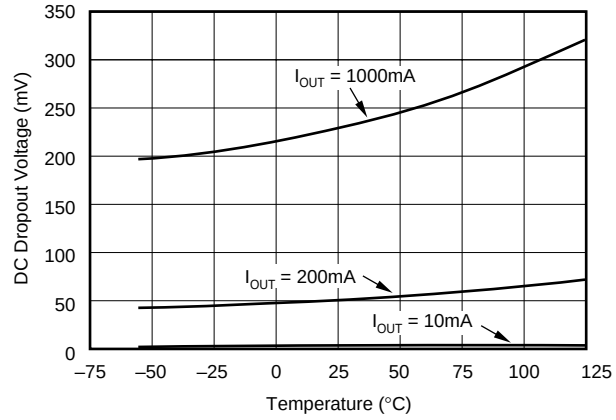
OUTPUT VOLTAGE CHANGE vs V_{IN}
(Output Voltage % Change Referred to V_{IN} = V_{OUT} + 1V at I_{OUT} = 10mA)



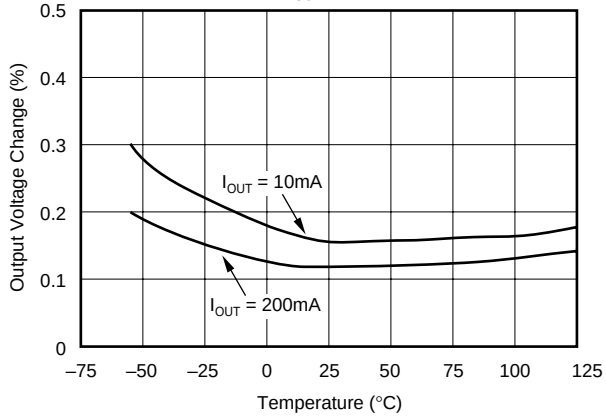
OUTPUT VOLTAGE CHANGE vs I_{OUT}
(Output Voltage % Change Referred to I_{OUT} = 10mA at +25°C)



DC DROPOUT VOLTAGE vs TEMPERATURE



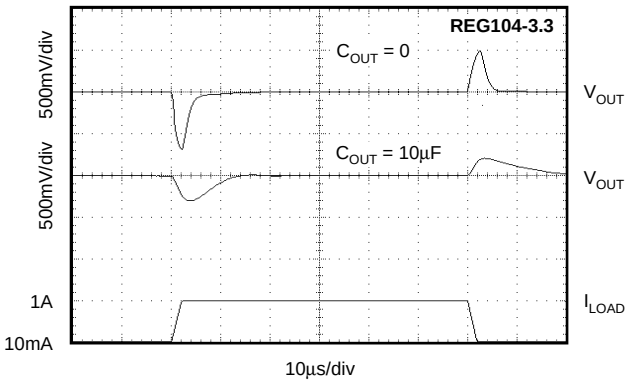
LINE REGULATION vs TEMPERATURE
(V_{IN} = V_{OUT} + 1V to 16V)



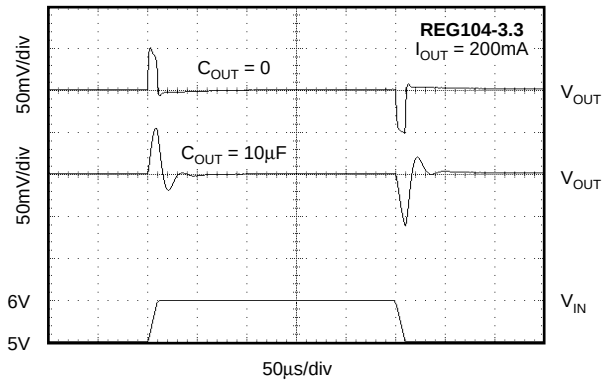
TYPICAL CHARACTERISTICS (Cont.)

For all models, at T_J = +25°C and V_{ENABLE} = 2V, unless otherwise noted.

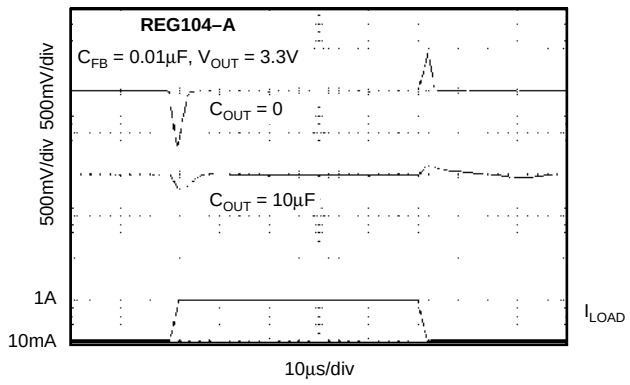
LOAD TRANSIENT RESPONSE



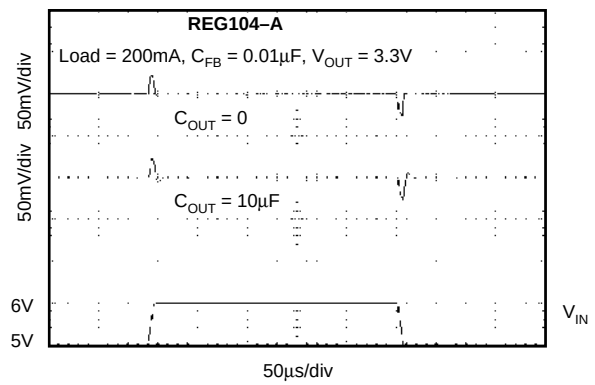
LINE TRANSIENT RESPONSE



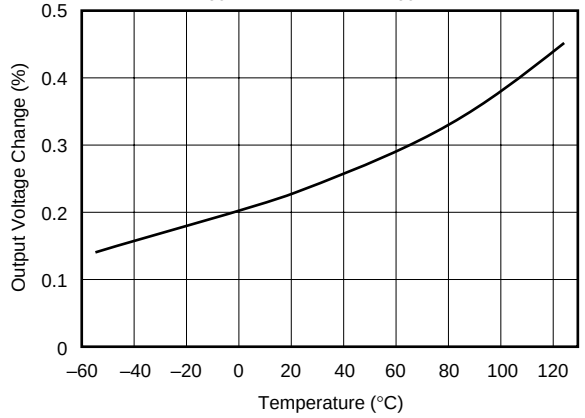
LOAD TRANSIENT RESPONSE



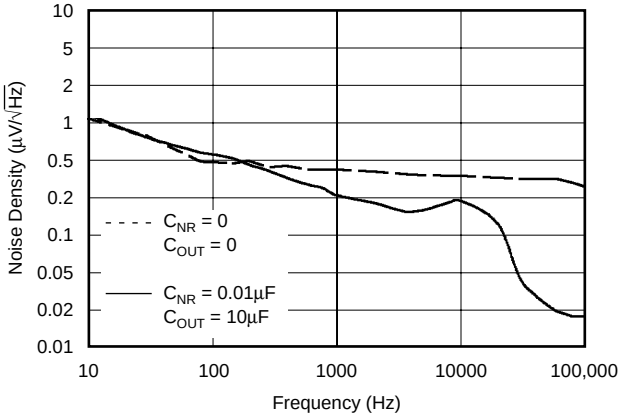
LOAD TRANSIENT RESPONSE



LOAD REGULATION vs TEMPERATURE
(V_{IN} = V_{OUT} + 1V and 10mA < I_{OUT} < 1000mA)



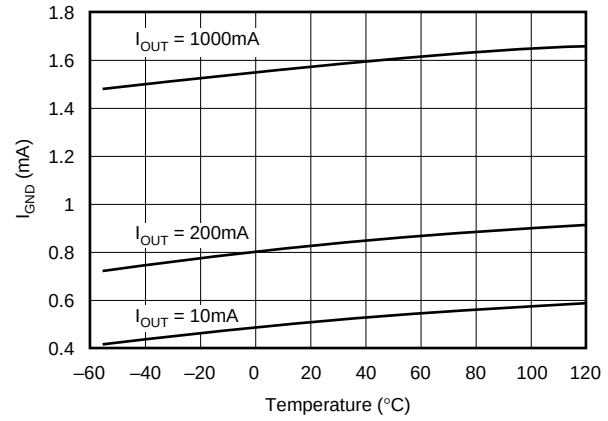
OUTPUT NOISE DENSITY



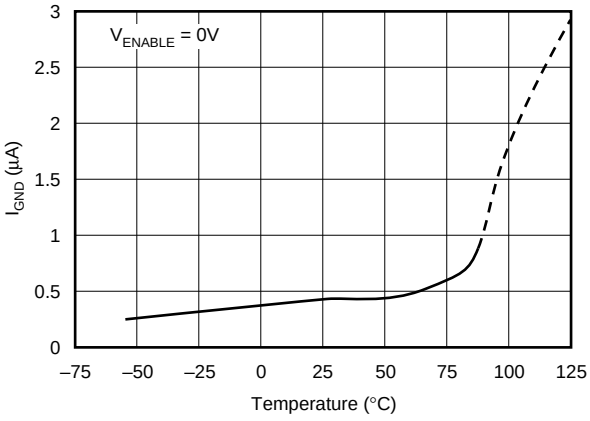
TYPICAL CHARACTERISTICS (Cont.)

For all models, at T_J = +25°C and V_{ENABLE} = 2V, unless otherwise noted.

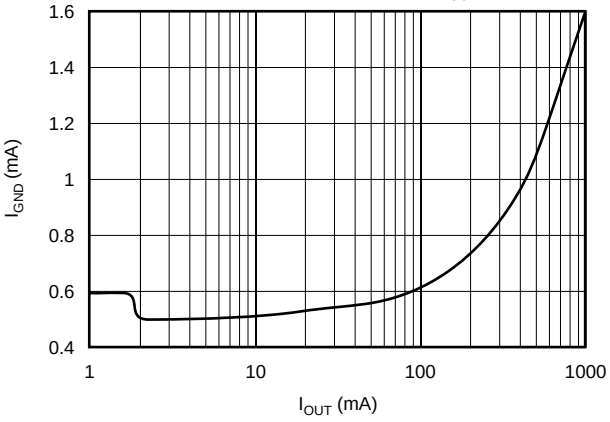
GROUND PIN CURRENT vs TEMPERATURE



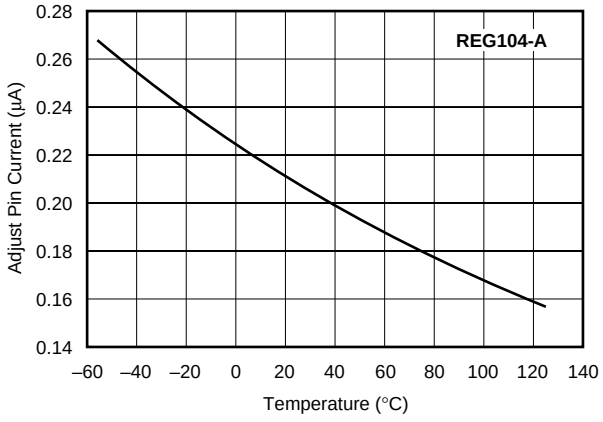
GROUND PIN CURRENT, NOT ENABLED vs TEMPERATURE



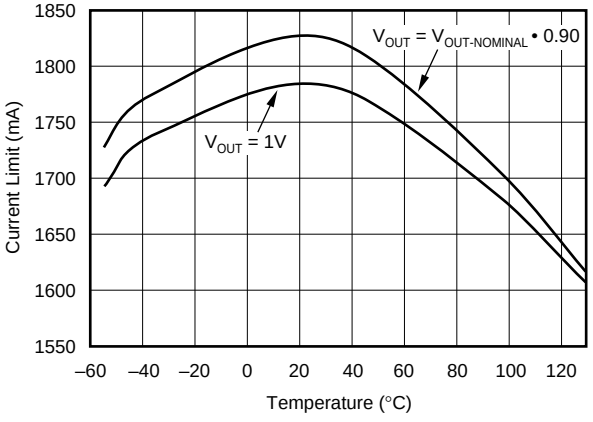
GROUND PIN CURRENT vs I_{OUT}



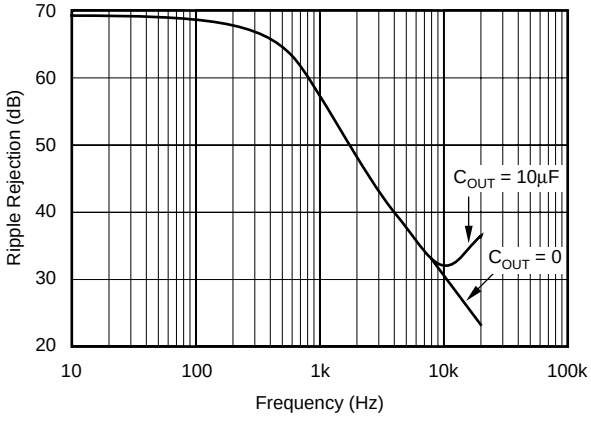
I_{ADJUST} vs TEMPERATURE



CURRENT LIMIT vs TEMPERATURE



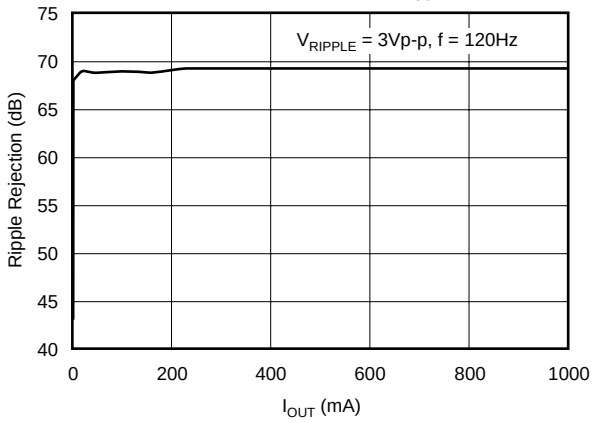
RIPPLE REJECTION vs FREQUENCY



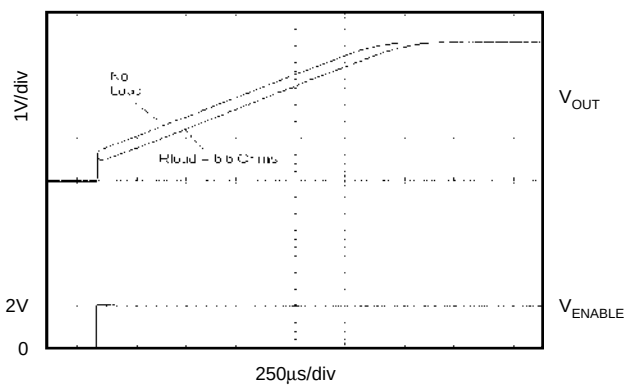
TYPICAL CHARACTERISTICS (Cont.)

For all models, at T_J = +25°C and V_{ENABLE} = 2V, unless otherwise noted.

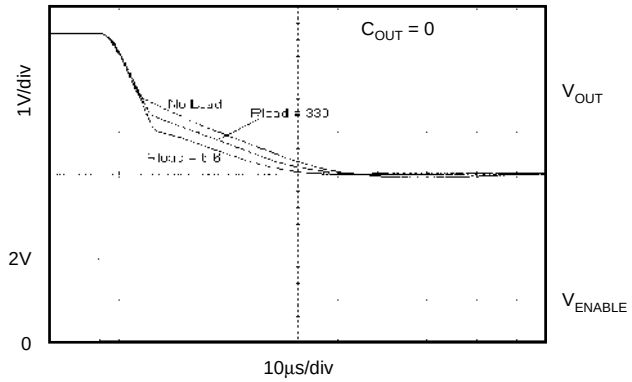
RIPPLE REJECTION vs I_{OUT}



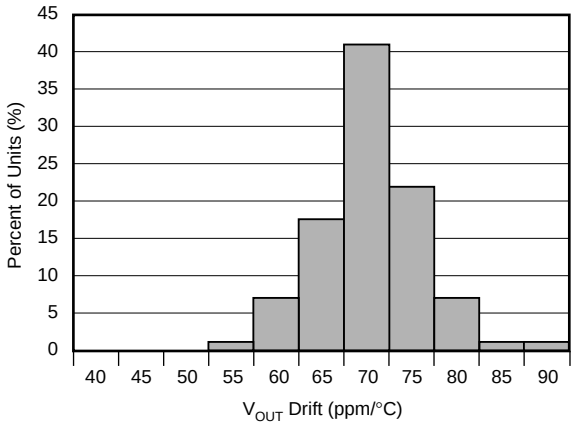
SOFT START



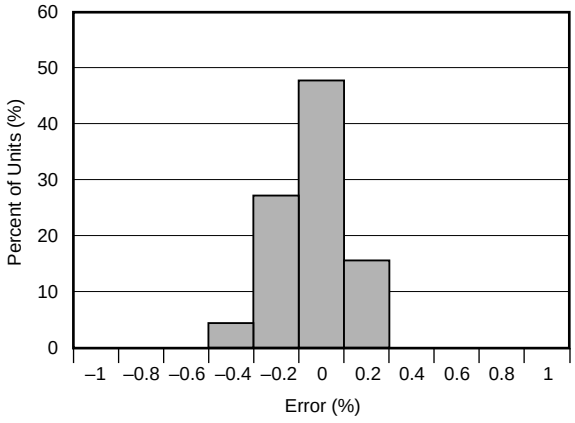
OUTPUT DISABLE TIME



OUTPUT VOLTAGE DRIFT HISTOGRAM



OUTPUT VOLTAGE ACCURACY HISTOGRAM



BASIC OPERATION

The REG104 series is a family of LDO (Low DropOut) linear regulators. The family includes five fixed output versions (2.5V to 5.0V) and an adjustable output version. An internal DMOS power device provides low dropout regulation with near constant ground pin current (largely independent of load and dropout conditions) and very fast line and load transient response. All versions include internal current limit and thermal shutdown circuitry.

Figure 1 shows the basic circuit connections for the fixed voltage models. Figure 2 gives the connections for the adjustable output version (REG104A) and example resistor values for some commonly used output voltages. Values for other voltages can be calculated from the equation shown in Figure 2.

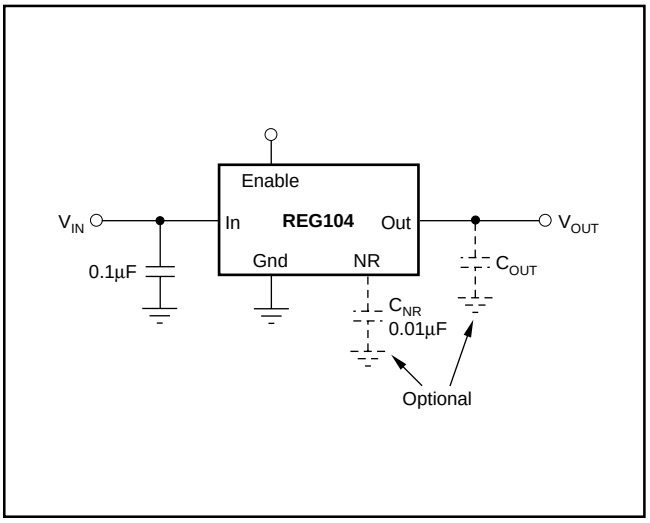


FIGURE 1. Fixed Voltage Nominal Circuit for REG104.

None of the versions require an output capacitor for regulator stability. The REG104 will accept any output capacitor type less than 1µF. For capacitance values larger than 1µF the effective ESR should be greater than 0.1Ω. This minimum ESR value includes parasitics such as printed circuit board traces, solder joints, and sockets. A minimum 0.1µF low ESR capacitor connected to the input supply voltage is recommended.

ENABLE

The Enable pin allows the regulator to be turned on and off. This pin is active HIGH and compatible with standard TTL-CMOS levels. Inputs below 0.5V (max) turn the regulator off and all circuitry is disabled. Under this condition ground-pin current drops to approximately 0.5µA.

When not used, the Enable pin may be connected to V_{IN}. Internal to the part, the Enable pin is connected to an input resistor-zener diode circuit, as shown in Figure 3, creating a nonlinear input impedance.

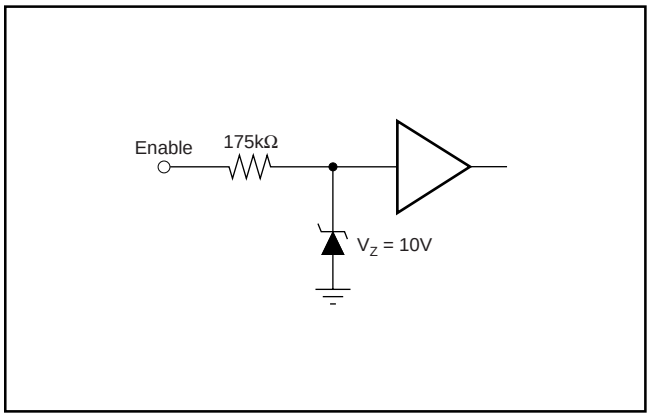
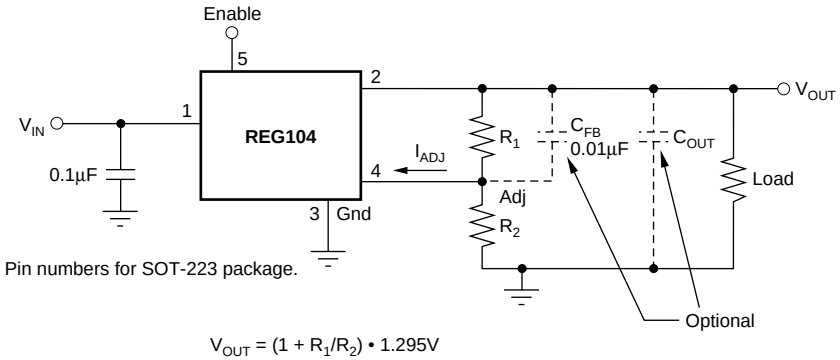


FIGURE 3. Enable Pin Equivalent Input Circuit.



EXAMPLE RESISTOR VALUES

V_{OUT} (V)	R_1 (Ω)(1)	R_2 (Ω)(1)
1.295	Short	Open
2.5	12.1k 1.21k	13k 1.3k
3	16.9k 1.69k	13k 1.3k
3.3	20k 2.0k	13k 1.3k
5	37.4k 3.74k	13k 1.3k

NOTE: (1) Resistors are standard 1% values.

To reduce current through divider, increase resistor values (see table at right).

As the impedance of the resistor divider increases, I_{ADJ} (~200nA) may introduce an error.

C_{FB} improves noise and transient response.

FIGURE 2. Adjustable Voltage Circuit for REG104A.

The Enable Pin Current versus Applied Voltage relationship is shown in Figure 4. When the Enable pin is connected to V_{IN} greater than 10V, a series resistor may be used to limit the current.

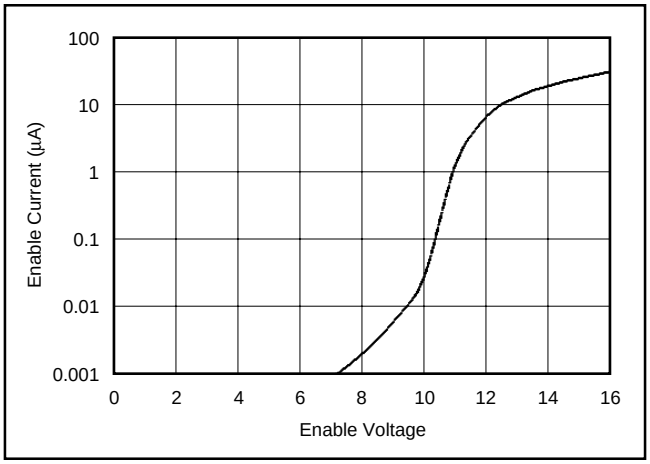


FIGURE 4. Enable Pin Current versus Applied Voltage.

OUTPUT NOISE

A precision band-gap reference is used for the internal reference voltage, V_{REF}, for the REG104. This reference is the dominant noise source within the REG104. It generates approximately 45µVrms in the 10Hz to 100kHz bandwidth at the reference output. The regulator control loop gains up the reference noise, so that the noise voltage of the regulator is approximately given by:

$$V_N = 45\mu Vrms \frac{R_1 + R_2}{R2} = 45\mu Vrms \bullet \frac{V_{OUT}}{V_{REF}}$$

Since the value of V_{REF} is 1.295V, this relationship reduces to:

$$V_N = 35 \frac{\mu Vrms}{V} \bullet V_{OUT}$$

Connecting a capacitor, C_{NR}, from the Noise-Reduction (NR) pin to ground can reduce the output noise voltage. Adding C_{NR}, as shown in Figure 5, forms a low-pass filter for the voltage reference. For C_{NR} = 10nF, the total noise in the 10Hz to 100kHz bandwidth is reduced by approximately a factor of 3.5. This noise reduction effect is shown in Figure 6.

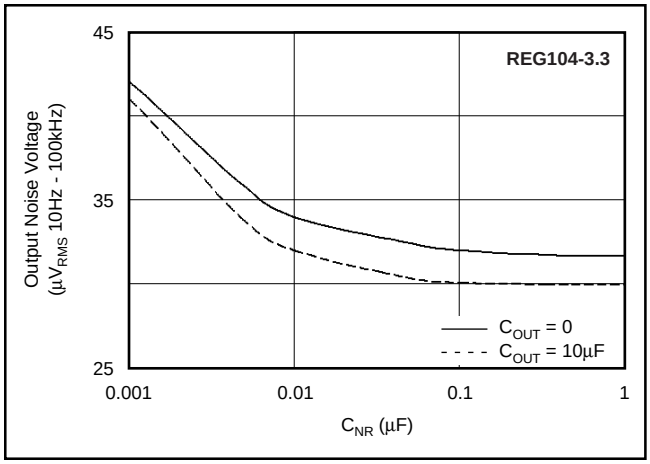


FIGURE 6. Output Noise versus Noise Reduction Capacitor.

The REG104 adjustable version does not have the noise-reduction pin available, however, the adjust pin is the summing junction of the error amplifier. A capacitor, C_{FB},

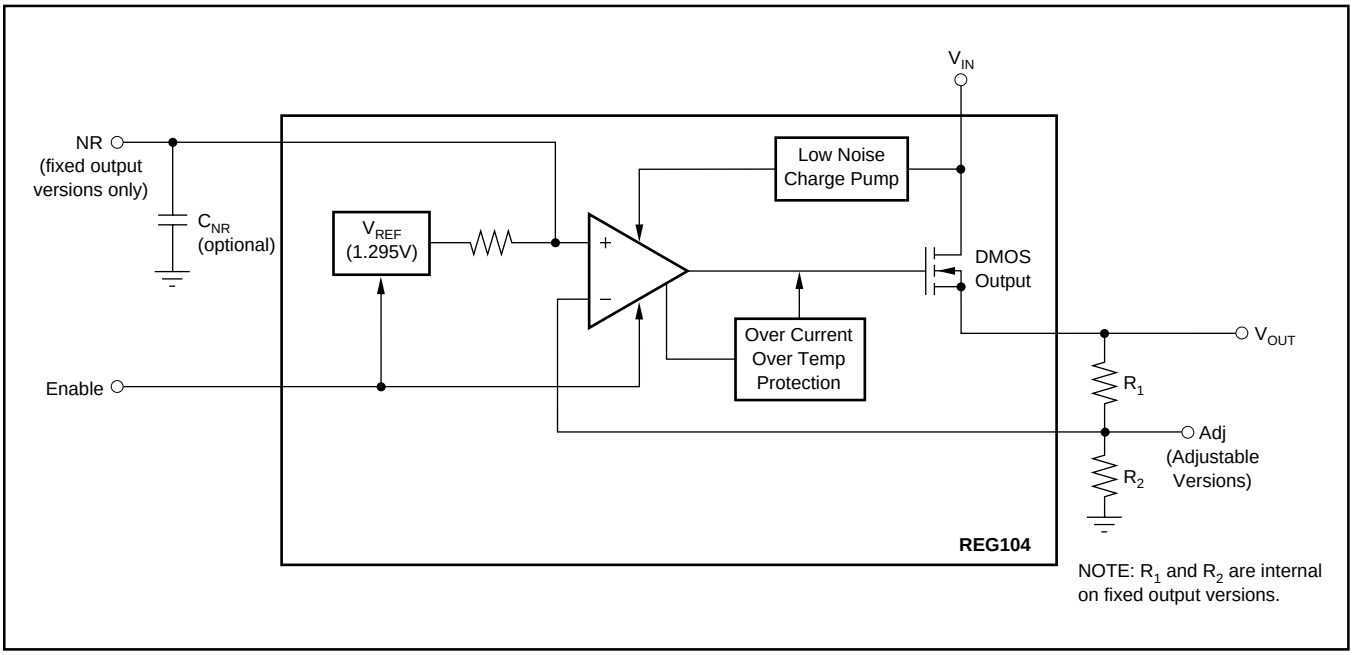


FIGURE 5. Block Diagram.

connected from the output to the adjust pin will reduce both the output noise and the peak error from a load transient. Figure 7 shows improved output noise performance for two capacitor combinations.

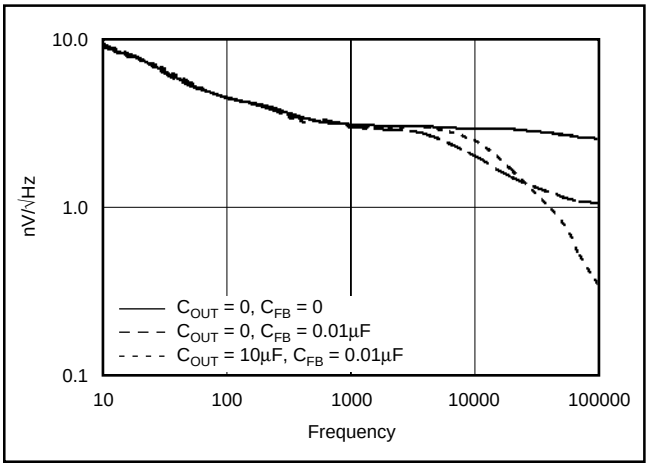


FIGURE 7. Output Noise Density on Adjustable Versions.

The REG104 utilizes an internal charge pump to develop an internal supply voltage sufficient to drive the gate of the DMOS pass element above V_{IN}. The charge-pump switching noise (nominal switching frequency = 2MHz) is not measurable at the output of the regulator.

DROP-OUT VOLTAGE

The REG104 uses an N-channel DMOS as the "pass" element. When the input voltage is within a few hundred millivolts of the output voltage, the DMOS device behaves like a resistor. Therefore, for low values of V_{IN} to V_{OUT}, the regulator's input-to-output resistance is the Rds_{ON} of the DMOS pass element (typically 230mΩ). For static (DC) loads, the REG104 will typically maintain regulation down to V_{IN} to V_{OUT} voltage drop of 230mV at full rated output current. In Figure 8, the bottom line (DC dropout) shows the minimum V_{IN} to V_{OUT} voltage drop required to prevent dropout under DC load conditions.

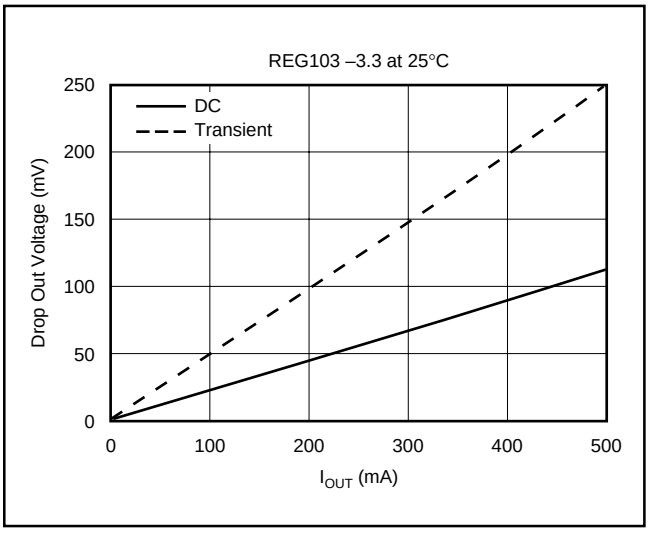


FIGURE 8. Transient and DC Dropout.

For large step changes in load current, the REG104 requires a larger voltage drop across it to avoid degraded transient response. The boundary of this "transient dropout" region is shown as the top line in Figure 8. Values of V_{IN} to V_{OUT} voltage drop above this line insure normal transient response.

In the transient dropout region between "DC" and "Transient", transient response recovery time increases. The time required to recover from a load transient is a function of both the magnitude and rate of the step change in load current and the available "headroom" V_{IN} to V_{OUT} voltage drop. Under worst-case conditions (full-scale load change with V_{IN} to V_{OUT} voltage drop close to DC dropout levels), the REG104 can take several hundred microseconds to re-enter the specified window of regulation.

TRANSIENT RESPONSE

The REG104 response to transient line and load conditions improves at lower output voltages. The addition of a capacitor (nominal value 10nF) from the output pin to ground may improve the transient response. In the adjustable version, the addition of a capacitor, C_{FB} (nominal value 10nF), from the output to the adjust pin will also improve the transient response.

THERMAL PROTECTION

Power dissipated within the REG104 will cause the junction temperature to rise. The REG104 has thermal shutdown circuitry that protects the regulator from damage. The thermal protection circuitry disables the output when the junction temperature reaches approximately 150°C, allowing the device to cool. When the junction temperature cools to approximately 130°C, the output circuitry is again enabled. Depending on various conditions, the thermal protection circuit may cycle on and off. This limits the dissipation of the regulator, but may have an undesirable effect on the load.

Any tendency to activate the thermal protection circuit indicates excessive power dissipation or an inadequate heat sink. For reliable operation, junction temperature should be limited to 125°C, maximum. To estimate the margin of safety in a complete design (including heat sink), increase the ambient temperature until the thermal protection is triggered. Use worst-case loads and signal conditions. For good reliability, thermal protection should trigger more than 35°C above the maximum expected ambient condition of your application. This produces a worst-case junction temperature of 125°C at the highest expected ambient temperature and worst-case load.

The internal protection circuitry of the REG104 has been designed to protect against overload conditions. It was not intended to replace proper heat sinking. Continuously running the REG104 into thermal shutdown will degrade reliability.

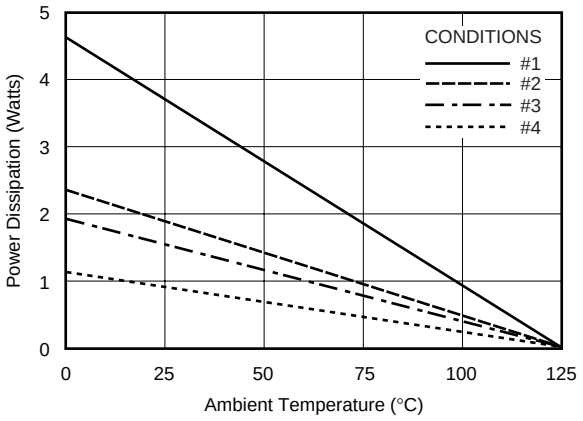
POWER DISSIPATION

The REG104 is available in two different package configurations. The ability to remove heat from the die is different for each package type and, therefore, presents different considerations in the Printed Circuit-Board (PCB) layout. The PCB area around the device that is free of other components moves the heat from the device to the ambient air. While it is difficult-to-impossible to quantify all of the variables in a thermal design of this type, performance data for several configurations are shown in Figure 9. In all cases the PCB copper area is bare copper, free of solder resist mask, and not solder plated. All examples are for 1-ounce copper. Using heavier copper will increase the effectiveness in moving the heat from the device. In those examples where there is copper on both sides of the PCB, no connection has been provided between the two sides. The addition of plated through holes will improve the heat sink effectiveness.

Power dissipation depends on input voltage and load conditions. Power dissipation is equal to the product of the average output current times the voltage across the output element, V_{IN} to V_{OUT} voltage drop.

$$P_D = (V_{IN} - V_{OUT}) \bullet I_{OUT(AVG)}$$

Power dissipation can be minimized by using the lowest possible input voltage necessary to assure the required output voltage.



CONDITION	PACKAGE	PCB AREA	THETA J-A
1	DDPAK	4in² Top Side Only	27°C/W
2	SOT-223	4in² Top Side Only	53°C/W
3	DDPAK	None	65°C/W
4	SOT-223	0.5in² Top Side Only	110°C/W

FIGURE 9. Maximum Power Dissipation versus Ambient Temperature for the Various Packages and PCB Heat Sink Configurations.

REGULATOR MOUNTING

The tab of both packages is electrically connected to ground. For best thermal performance, the tab of the DDPAK surface-mount version should be soldered directly to a circuit-board copper area. Increasing the copper area improves heat dissipation. Figure 10 shows typical thermal resistance from junction to ambient as a function of the copper area for the DDPAK, Figure 11 shows the same relationship for the SOT-223.

Although the tabs of the DDPAK and the SOT-223 are electrically grounded, they are not intended to carry any current. The copper pad that acts as a heat sink should be isolated from the rest of the circuit to prevent current flow through the device from the tab to the ground pin. Solder pad footprint recommendations for the various REG104 devices are presented in the Application Bulletin "Solder Pad Recommendations for Surface-Mount Devices" (SBFA015), available from the Texas Instruments web site (www.ti.com).

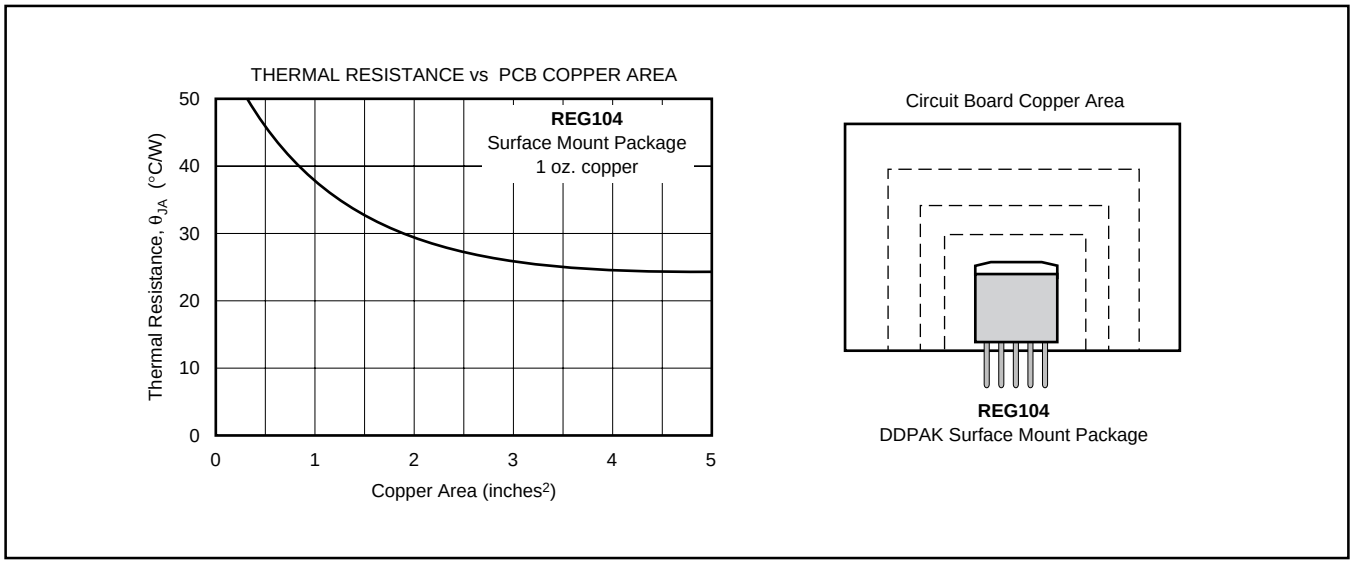


FIGURE 10. Thermal Resistance versus PCB Area for the Five Lead DDPAK.

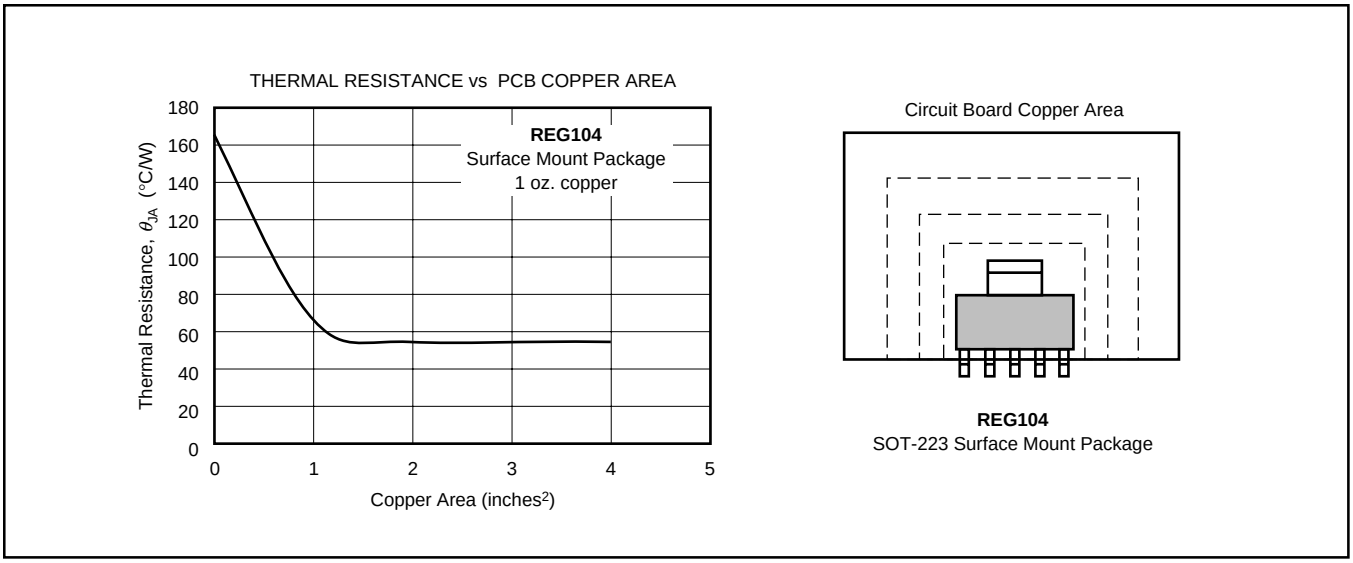
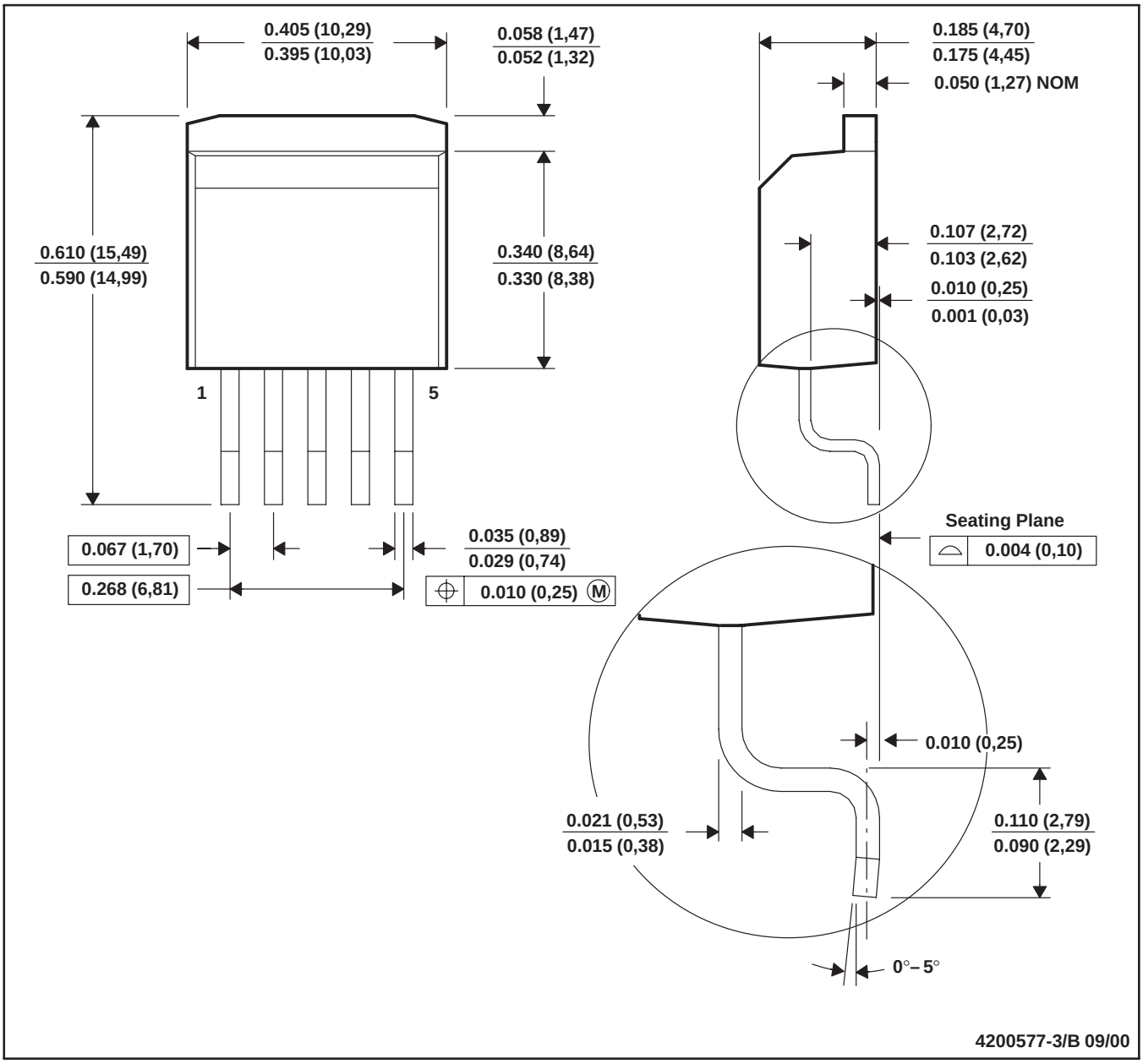


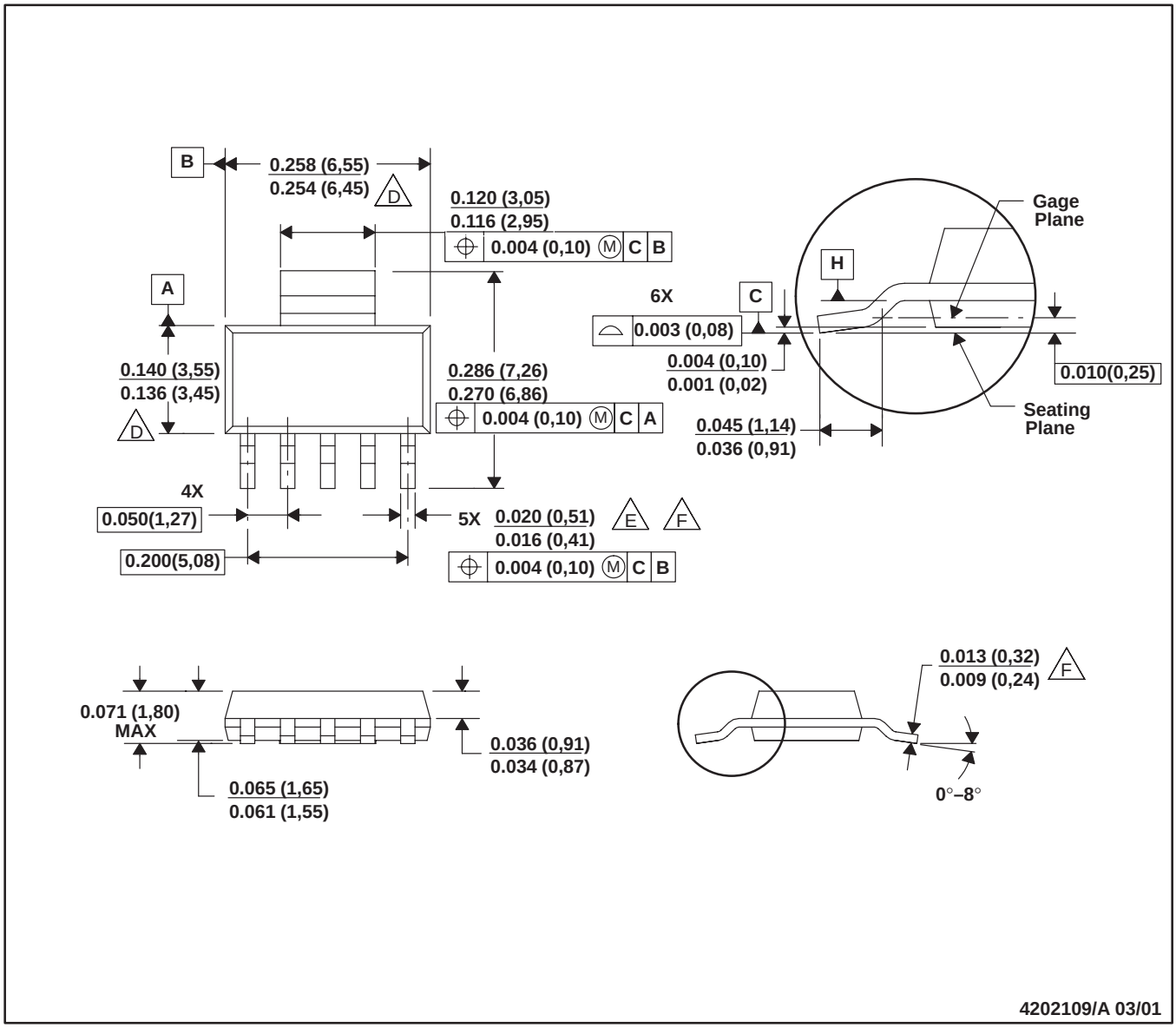
FIGURE 11. Thermal Resistance versus PCB Area for the Five Lead SOT-223.

KTT (R-PSFM-G5) **PLASTIC FLANGE-MOUNT**



NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Dimensions do not include mold protrusions, not to exceed 0.006 (0,15).

DCQ (R-PDSO-G6) **PLASTIC SMALL-OUTLINE**



NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Controlling dimension in inches
D. Body length and width dimensions are determined at the outermost extremes of the plastic body exclusive of mold flash, tie bar burrs, gate burrs, and interlead flash, but including any mismatch between the top and the bottom of the plastic body.
E. Lead width dimension does not include dambar protrusion.
F. Lead width and thickness dimensions apply to solder plated leads.
G. Interlead flash allow 0.008 inch max.
H. Gate burr/protrusion max. 0.006 inch.
I. Datums A and B are to be determined at Datum H.
J. Package dimensions per JEDEC outline drawing TO–261, issue B, dated Feb. 1999.
This variation is not yet included.

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