LM2936-5.0EP Enhanced Plastic Ultra-Low Quiescent Current 5V Regulator

Check for Samples: LM2936-5.0EP

FEATURES

- **Ultra Low Quiescent Current (I_Q ≤ 15 µA for I_O = 100 µA)**
- **Fixed 5V, 50 mA Output**
- **±2% Initial Output Tolerance**
- **±3% Output Tolerance Over Line, Load, and Temperature**
- **Dropout Voltage Typically 200 mV @ I_O = 50 mA**
- **Reverse Battery Protection**
- **−50V Reverse Transient Protection**
- **Internal Short Circuit Current Limit**
- **Internal Thermal Shutdown Protection**
- **40V Operating Voltage Limit**
- **60V Operating Voltage Limit for LM2936HVEP**
- **Shutdown Pin Available with LM2936BMEP Package**

APPLICATIONS

- **Selected Military Applications**
- **Selected Avionics Applications**

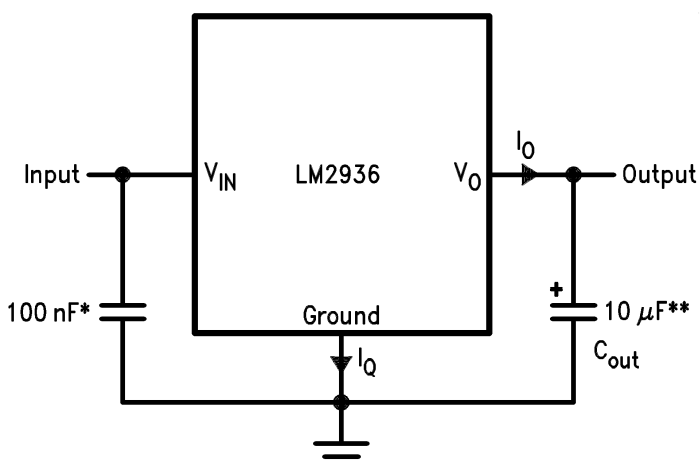
DESCRIPTION

The LM2936EP ultra-low quiescent current regulator features low dropout voltage and low current in the standby mode. With less than 15 µA quiescent current at a 100 µA load, the LM2936EP is ideally suited for automotive and other battery operated systems. The LM2936EP retains all of the features that are common to low dropout regulators including a low dropout PNP pass device, short circuit protection, reverse battery protection, and thermal shutdown. The LM2936EP has a 40V maximum operating voltage limit, a −40°C to +125°C operating temperature range, and ±3% output voltage tolerance over the entire output current, input voltage, and temperature range. The LM2936EP is available in a TO-92 package, a SOIC-8 surface mount package, and a TO-252 surface mount power package.

ENHANCED PLASTIC

- Extended Temperature Performance of −40°C to +125°C
- Baseline Control - Single Fab & Assembly Site
- Process Change Notification (PCN)
- Qualification & Reliability Data
- Solder (PbSn) Lead Finish is Standard
- Enhanced Diminishing Manufacturing Sources (DMS) Support

TYPICAL APPLICATION



* Required if regulator is located more than 2″ from power supply filter capacitor.
** Required for stability. Must be rated for 10 µF minimum over intended operating temperature range. Effective series resistance (ESR) is critical, see curve. Locate capacitor as close as possible to the regulator output and ground pins. Capacitance may be increased without bound.

CONNECTION DIAGRAMS

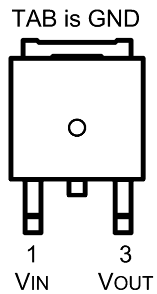


Figure 1. TO-252 (Top View)
See Package Number NDP0003B

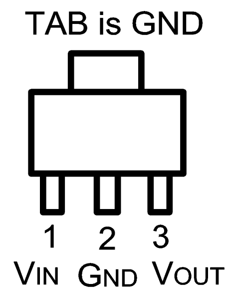


Figure 2. SOT-223 (Top View)
See Package Number MA04A

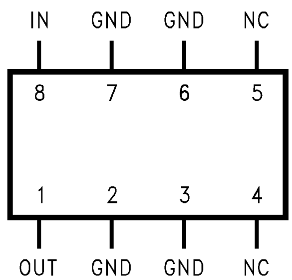


Figure 3. 8-Pin SOIC (D) (Top View)
See Package Number D0008A

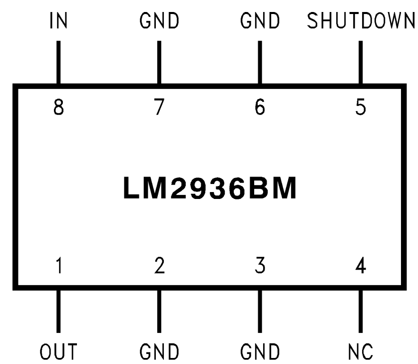


Figure 4. 8-Pin SOIC (D) (Top View)
See Package Number D0008A

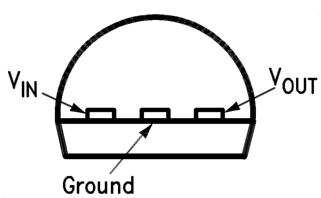


Figure 5. TO-92 (Bottom View)
See Package Number LP0003A

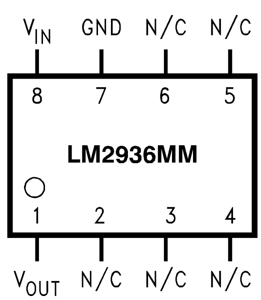


Figure 6. 8-Pin VSSOP (DGK) (Top View)
See Package Number DGK0008A

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

ABSOLUTE MAXIMUM RATINGS [1][2]

Input Voltage (Survival)	+60V, −50V
ESD Susceptibility [3]	2000V
Power Dissipation [4]	Internally limited
Junction Temperature (T_{Jmax})	150°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec.)	260°C

(1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. DC and AC electrical specifications do not apply when operating the device beyond its specified operating ratings.
(2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/ Distributors for availability and specifications.
(3) Human body model, 100 pF discharge through a 1.5 kΩ resistor.
(4) The maximum power dissipation is a function of T_{Jmax}, θ_{JA}, and T_A. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{Jmax} - T_A)/\theta_{JA}$. If this dissipation is exceeded, the die temperature will rise above 150°C and the LM2936EP will go into thermal shutdown.

OPERATING RATINGS

Operating Temperature Range	−40°C to +125°C
Maximum Operating Input Voltage - LM2936EP	+40V
Maximum Operating Input Voltage - LM2936HVEP only	+60V
Maximum Shutdown Pin Voltage - LM2936BMEP only	0V to 40V
TO-92 (LP0003A) θ_{JA}	195°C/W
VSSOP-8 (DGK0008A) θ_{JA}	200°C/W
SOIC-8 (D0008A) θ_{JA}	140°C/W
SOIC-8 (D0008A) θ_{JC}	45°C/W
TO-252 (NDP0003B) θ_{JA}	136°C/W
TO-252 (NDP0003B) θ_{JC}	6°C/W
SOT-223 (MA04A) θ_{JA}	149°C/W
SOT-223 (MA04A) θ_{JC}	36°C/W

ELECTRICAL CHARACTERISTICS

V_{IN} = 14V, I_O = 10 mA, T_J = 25°C, unless otherwise specified. **Boldface** limits apply over entire operating temperature range

Parameter	Conditions	Min (1)	Typical (2)	Max (1)	Units
LM2936HVEP Only					
Output Voltage	5.5V ≤ V_{IN} ≤ 48V, 100 µA ≤ I_O ≤ 50 mA (3)	**4.85**	**5.00**	**5.15**	V
Line Regulation	6V ≤ V_{IN} ≤ 60V, I_O = 1mA		15	35	mV
All LM2936EP					
Output Voltage		4.90	5.00	5.10	V
	5.5V ≤ V_{IN} ≤ 26V, 100 µA ≤ I_O ≤ 50 mA (3)	**4.85**	**5.00**	**5.15**	
Quiescent Current	I_O = 100 µA, 8V ≤ V_{IN} ≤ 24V		9	15	µA
	I_O = 10 mA, 8V ≤ V_{IN} ≤ 24V		0.20	0.50	mA
	I_O = 50 mA, 8V ≤ V_{IN} ≤ 24V		1.5	2.5	mA
Line Regulation	9V ≤ V_{IN} ≤ 16V		5	10	mV
	6V ≤ V_{IN} ≤ 40V, I_O = 1 mA		10	30	
Load Regulation	100 µA ≤ I_O ≤ 5 mA		10	30	mV
	5 mA ≤ I_O ≤ 50 mA		10	30	
Dropout Voltage	I_O = 100 µA		0.05	0.10	V
	I_O = 50 mA		0.20	0.40	V
Short Circuit Current	V_O = 0V	65	120	250	mA
Output Impedance	I_O = 30 mAdc and 10 mArms, $_f$ = 1000 Hz		450		mΩ
Output Noise Voltage	10 Hz–100 kHz		500		µV
Long Term Stability			20		mV/1000 Hr
Ripple Rejection	V_{ripple} = $1V_{rms}$, f_{ripple} = 120 Hz	−40	−60		dB
Reverse Polarity Transient Input Voltage	R_L = 500Ω, T = 1 ms	−50	−80		V
Output Voltage with Reverse Polarity Input	V_{IN} = −15V, R_L = 500Ω		0.00	−0.30	V
Maximum Line Transient	R_L = 500Ω, V_O ≤ 5.5V, T = 40ms	60			V
Output Bypass Capacitance (C_{OUT}) ESR	C_{OUT} = 10µF 0.1mA ≤ I_{OUT} ≤ 50mA	0.3		8	Ω
Shutdown Input − LM2936BMEP Only					
Output Voltage, V_{OUT}	Output Off, V_{SD}=2.4V, R_{LOAD} = 500Ω		0	0.010	V
Shutdown High Threshold Voltage, V_{IH}	Output Off, R_{LOAD} = 500Ω	2.00	1.1		V
Shutdown Low Threshold Voltage, V_{IL}	Output On, R_{LOAD} = 500Ω		1.1	0.60	V
Shutdown High Current, I_{IH}	Output Off, V_{SD} = 2.4V, R_{LOAD} = 500Ω		12		µA
Quiescent Current	Output Off, V_{SD} = 2.4V, R_{LOAD} = 500Ω Includes I_{IH}Current		30		µA

(1) Data sheet min/max specification limits are ensured by design, test, or statistical analysis.
(2) Typicals are at 25°C (unless otherwise specified) and represent the most likely parametric norm.
(3) To ensure constant junction temperature, pulse testing is used.

TYPICAL PERFORMANCE CHARACTERISTICS

Maximum Power Dissipation (TO-92)

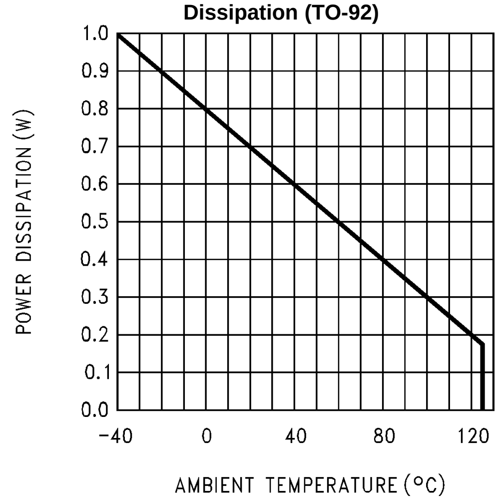


Figure 7.

Dropout Voltage

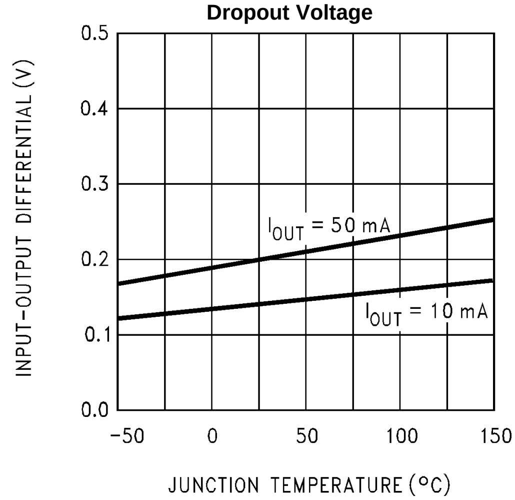


Figure 8.

Dropout Voltage

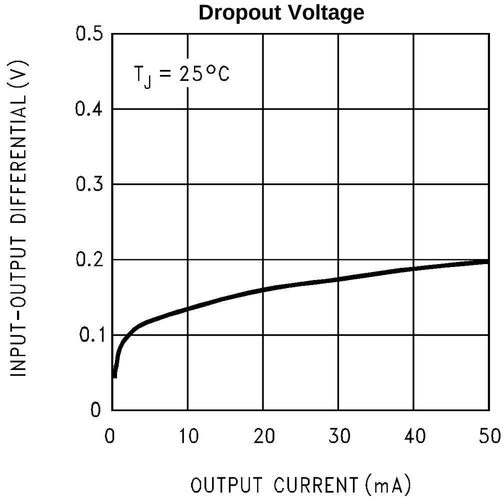


Figure 9.

Quiescent Current

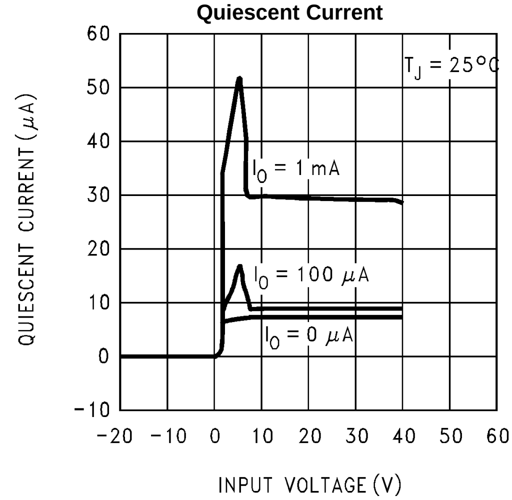


Figure 10.

Quiescent Current

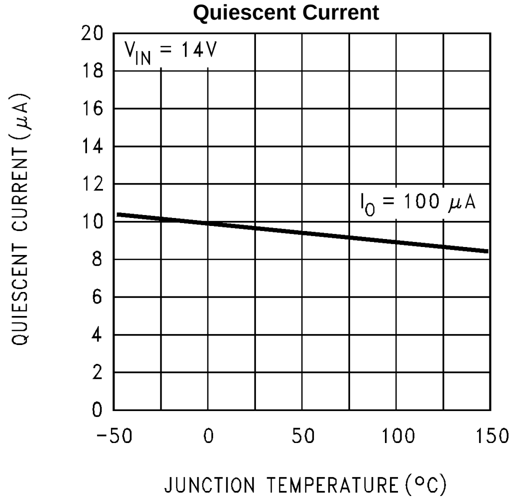


Figure 11.

Quiescent Current

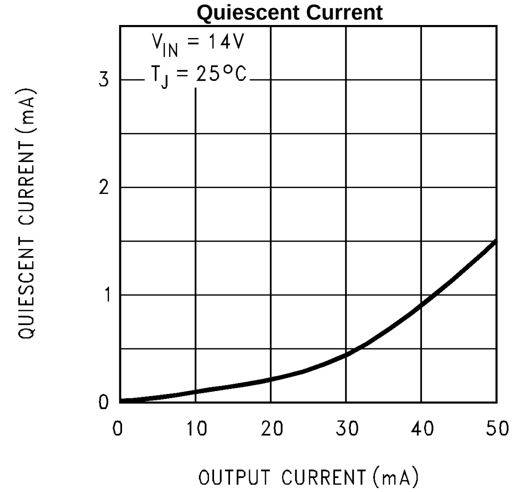


Figure 12.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Quiescent Current

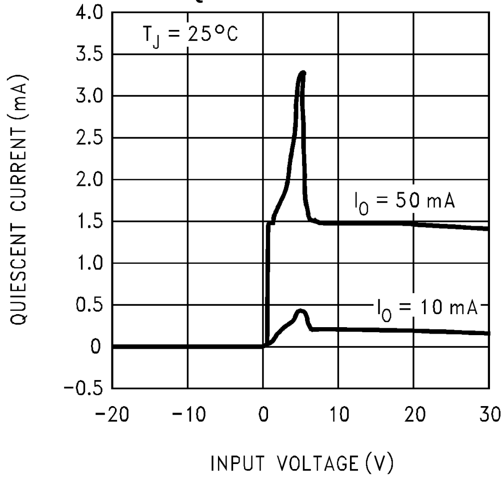


Figure 13.

Quiescent Current

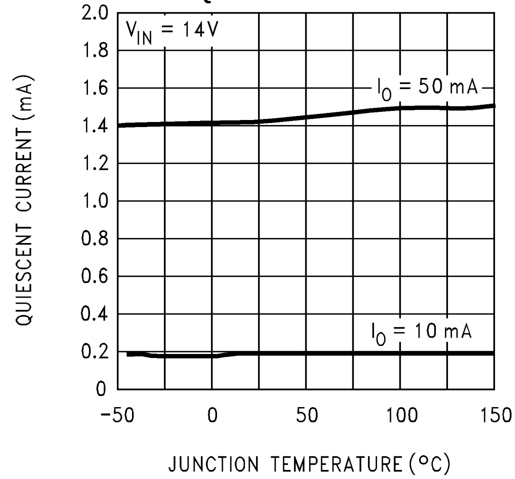


Figure 14.

Output Capacitor ESR

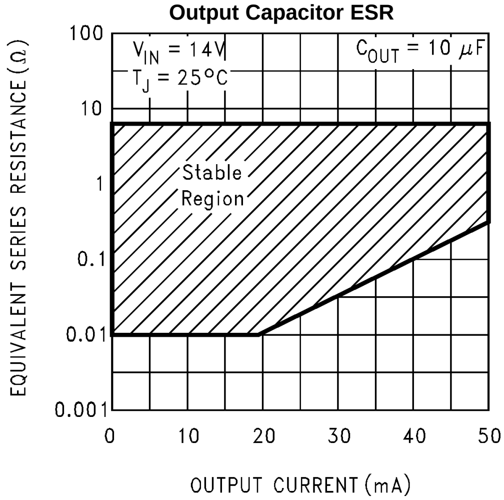


Figure 15.

Peak Output Current

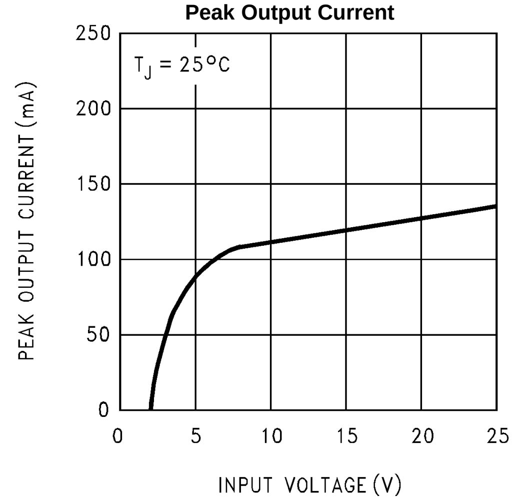


Figure 16.

Peak Output Current

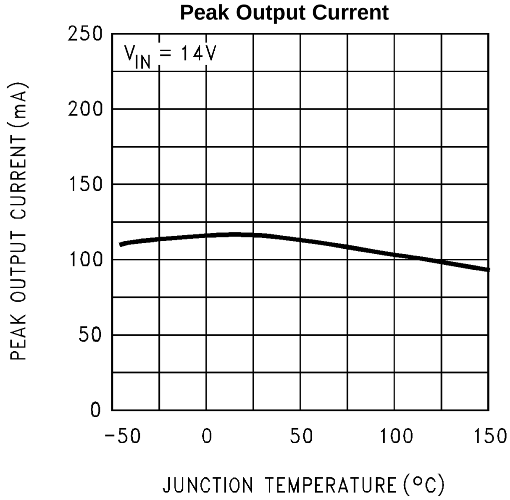


Figure 17.

Current Limit

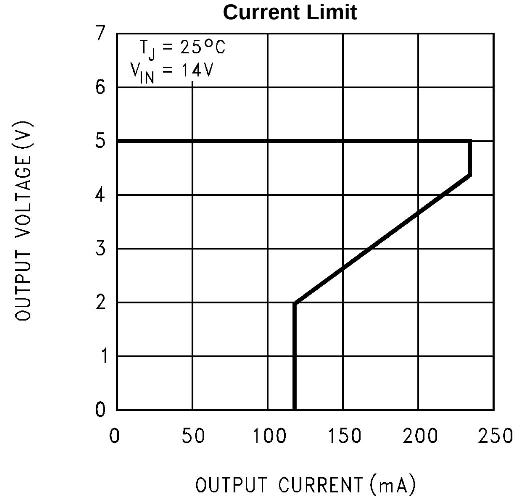


Figure 18.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Line Transient Response

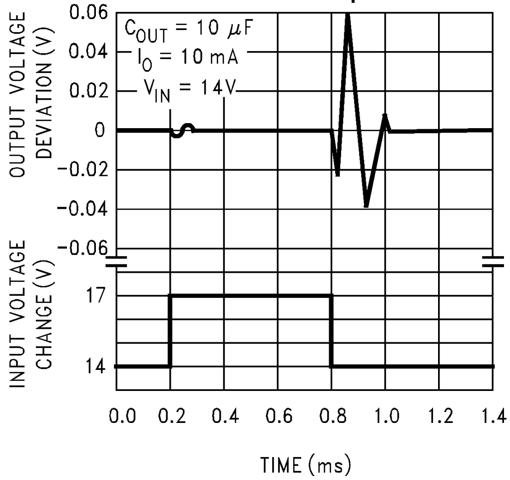


Figure 19.

Output at Voltage Extremes

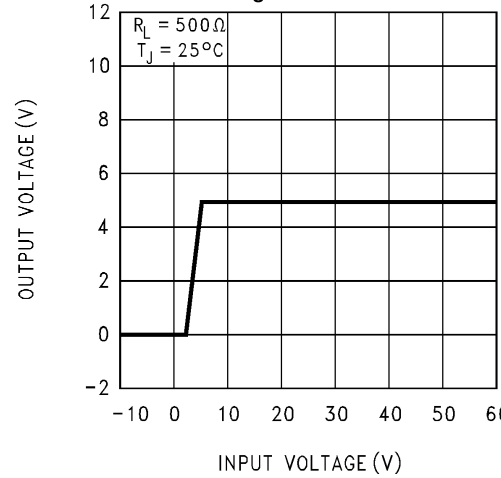


Figure 20.

Ripple Rejection

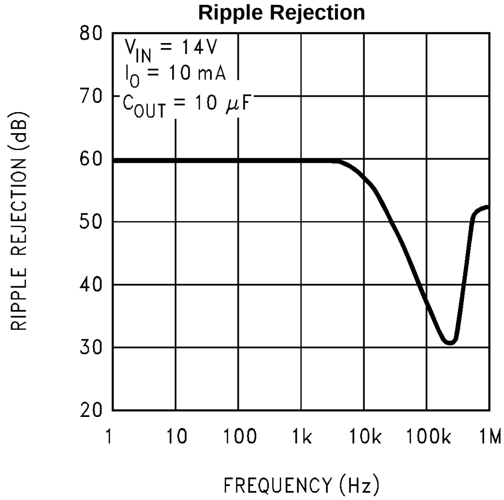


Figure 21.

Load Transient Response

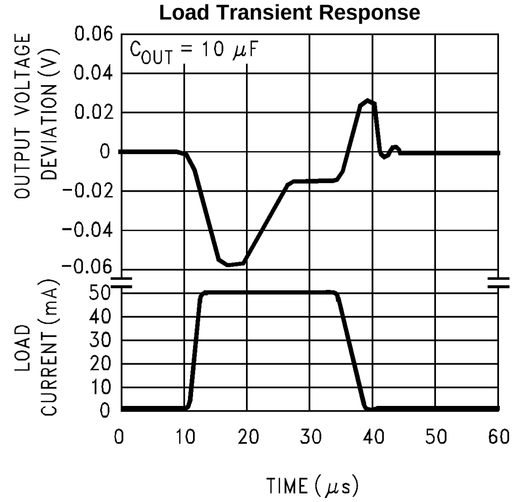


Figure 22.

Low Voltage Behavior

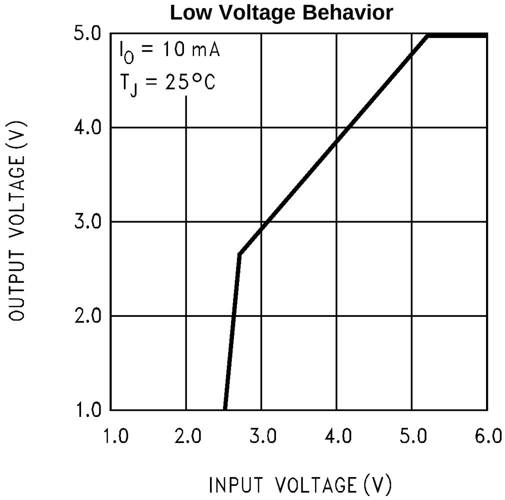


Figure 23.

Output Impedance

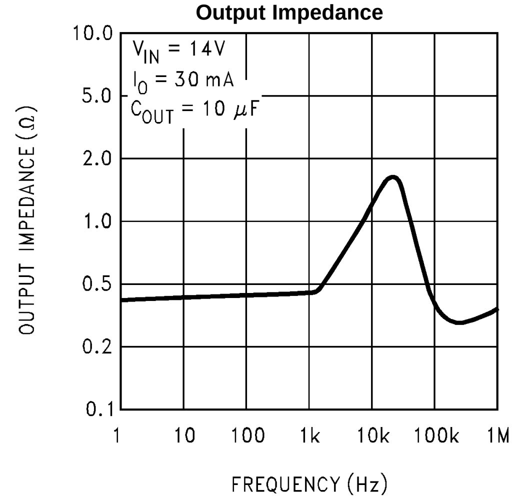


Figure 24.

APPLICATIONS INFORMATION

Unlike other PNP low dropout regulators, the LM2936EP remains fully operational to 40V. Owing to power dissipation characteristics of the available packages, full output current cannot be ensured for all combinations of ambient temperature and input voltage. As an example, consider an LM2936ZEP operating at 25°C ambient. Using the formula for maximum allowable power dissipation (see[(1)]), we find that P_{Dmax} = 641 mW at 25°C. Including the small contribution of the quiescent current to total power dissipation the maximum input voltage (while still delivering 50 mA output current) is 17.3V. The LM2936ZEP will go into thermal shutdown if it attempts to deliver full output current with an input voltage of more than 17.3V. Similarly, at 40V input and 25°C ambient the LM2936ZEP can deliver 18 mA maximum.

Under conditions of higher ambient temperatures, the voltage and current calculated in the previous examples will drop. For instance, at the maximum ambient of 125°C the LM2936ZEP can only dissipate 128 mW, limiting the input voltage to 7.34V for a 50 mA load, or 3.5 mA output current for a 40V input.

The junction to ambient thermal resistance θ_{JA} rating has two distinct components: the junction to case thermal resistance rating θ_{JC}; and the case to ambient thermal resistance rating θ_{CA}. The relationship is defined as: $\theta_{JA} = \theta_{JC} + \theta_{CA}$.

For the SOIC-8 and TO-252 surface mount packages the θ_{JA} rating can be improved by using the copper mounting pads on the printed circuit board as a thermal conductive path to extract heat from the package.

On the SOIC-8 package the four ground pins are thermally connected to the backside of the die. Adding approximately 0.04 square inches of 2 oz. copper pad area to these four pins will improve the θ_{JA} rating to approximately 110°C/W. If this extra pad are is placed directly beneath the package there should not be any impact on board density.

On the TO-252 package the ground tab is thermally connected to the backside of the die. Adding 1 square inch of 2 oz. copper pad area directly under the ground tab will improve the θ_{JA} rating to approximately 50°C/W.

While the LM2936EP has an internally set thermal shutdown point of typically 150°C, this is intended as a safety feature only. Continuous operation near the thermal shutdown temperature should be avoided as it may have a negative affect on the life of the device.

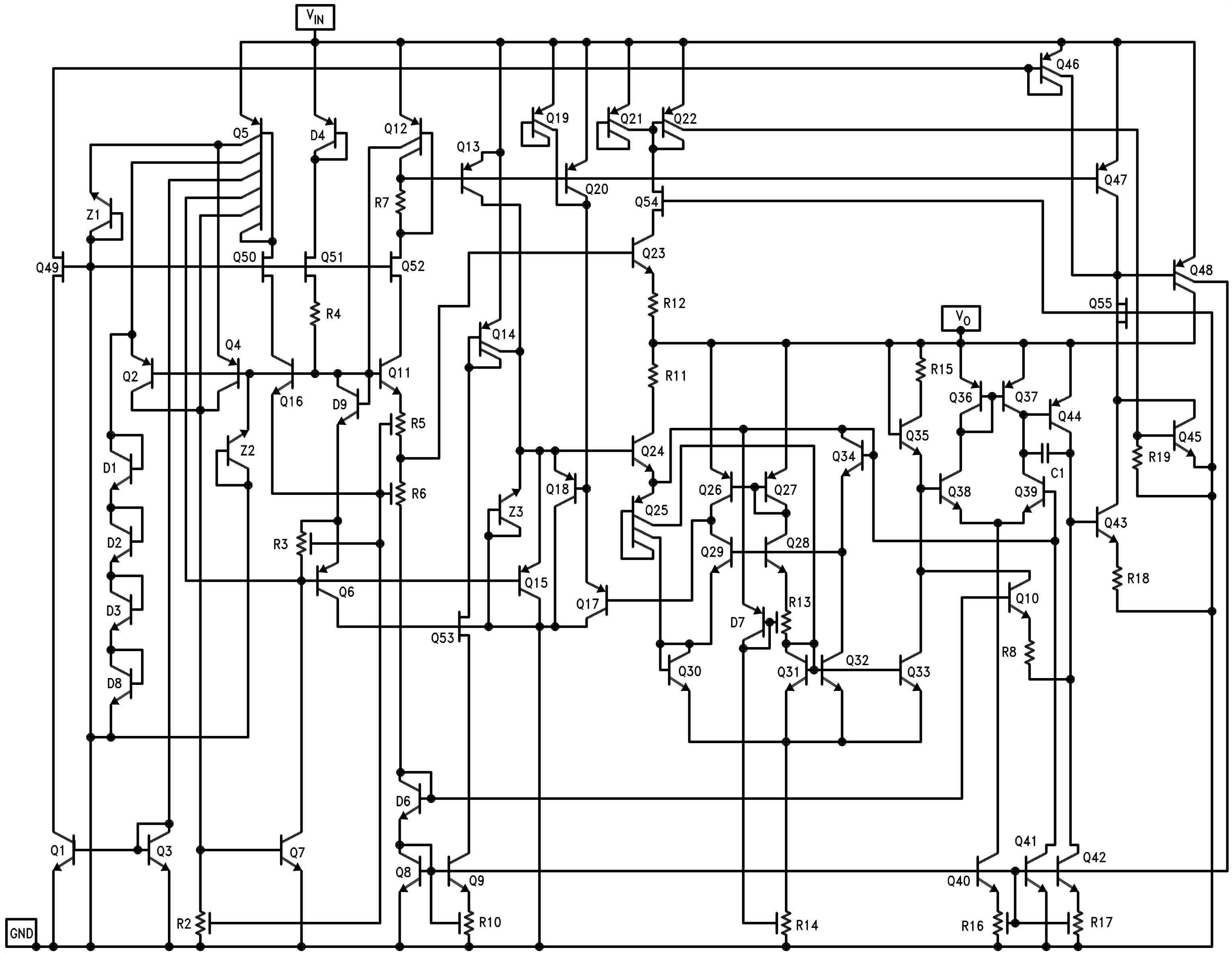
While the LM2936EP maintains regulation to 60V, it will not withstand a short circuit above 40V because of safe operating area limitations in the internal PNP pass device. Above 60V the LM2936EP will break down with catastrophic effects on the regulator and possibly the load as well. Do not use this device in a design where the input operating voltage may exceed 40V, or where transients are likely to exceed 60V.

SHUTDOWN PIN

The LM2936BMEP has a pin for shutting down the regulator output. Applying a Logic Level High (>2.0V) to the Shutdown pin will cause the output to turn off. Leaving the Shutdown pin open, connecting it to Ground, or applying a Logic Level Low (<0.6V) will allow the regulator output to turn on.

(1) The maximum power dissipation is a function of T_{Jmax}, θ_{JA}, and T_A. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{Jmax} - T_A)/\theta_{JA}$. If this dissipation is exceeded, the die temperature will rise above 150°C and the LM2936EP will go into thermal shutdown.

EQUIVALENT SCHEMATIC DIAGRAM



REVISION HISTORY

Changes from Revision A (April 2013) to Revision B	Page
• Changed layout of National Data Sheet to TI format	9