MIC37252

2.5A, Low Voltage µCap LDO Regulator

General Description

The Micrel MIC37252 is a 2.5A low-dropout linear voltage regulator that provides a low voltage, high current output with a minimum of external components. It offers high precision, low dropout and low ground current.

The MIC37252 operates from an input voltage of 3.0V to 6.0V. It is designed to drive digital circuits requiring low voltage at high currents (i.e., PLDs, DSP, microcontroller, etc.). It is available in an adjustable output voltage capable of 1.24V to 5.5V.

Features of the MIC37252 LDO include thermal and current limit protection, and reverse current and reverse battery protection.

Junction temperature range of the MIC37252 is from –40°C to +125°C.

For higher currents see the MIC3730x family of LDOs.

## Features

- 2.5A minimum guaranteed output current
- **Ideal for 3.3V to 1.8V conversion**
- Stable with ceramic or tantalum capacitor
- ±2.0% initial output tolerance
- Dropout voltage = 550mV @ 2.5A
- Excellent line and load regulation specifications
- Logic controlled shutdown
- Thermal shutdown and current limit protection
- Reverse-leakage protection
- S-Pak and TO-263 packages

Applications

- LDO linear regulator for low-voltage digital IC
- PC add-in cards
- High efficiency linear power supplies
- SMPS post regulator
- Battery charger

Typical Application

Adjustable Regulator
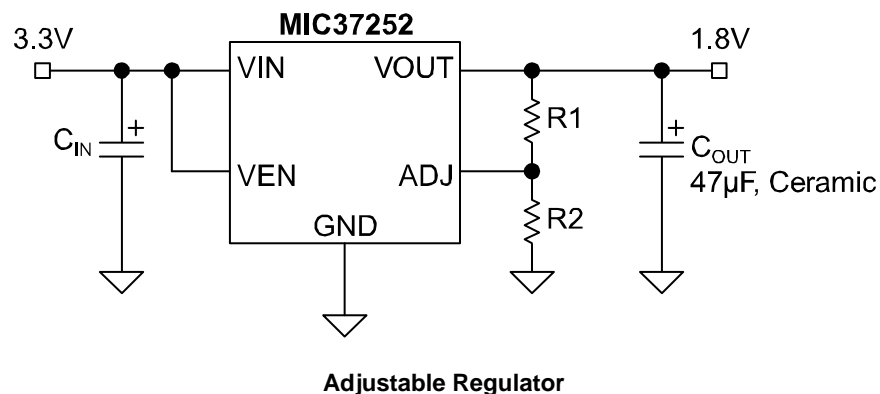
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Ordering Information

Part Number		Output Current	Voltage*	Junction Temperature Range	Package
Standard	RoHS Compliant**				
MIC37252BR	MIC37252WR	2.5A	Adj.	–40° to +125°C	S-Pak-5
MIC37252BU	MIC37252WU	2.5A	Adj.	–40° to +125°C	TO-263-5

*For other voltages, please contact Micrel Marketing.

**RoHS compliant with "high melting solder" exemption.

Pin Configuration

TAB

5 ADJ
4 VOUT
3 GND
2 VIN
1 EN
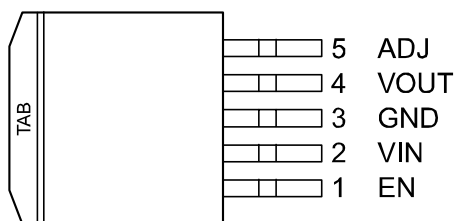
S-PAK5 (R)
TO-263 (U)

Pin Description

Pin Number	Pin Name	Pin Function
1	EN	Enable (Input): CMOS compatible input. Logic high = enable, logic low = shutdown.
2	VIN	Input voltage which supplies current to the output power device.
3	GND	Ground (TAB is connected to ground on S-Pak).
4	VOUT	Regulator Output.
5	ADJ	Adjustable regulator feedback input. Connect to resistor voltage divider.

Absolute Maximum Ratings[1]

Supply Voltage (V_{IN})..6.5V
Enable Input Voltage (V_{EN})...6.5V
Power Dissipation ....Internally Limited
Junction Temperature ....–40°C ≤ T_J ≤ +125°C
Storage Temperature ....–65°C ≤ T_J ≤ +150°C
Lead Temperature (soldering, 5sec.)..........................260°C
EDS[3]

Operating Ratings[2]

Supply voltage (V_{IN}) .... 3.0V to 6.0V
Enable Input Voltage (V_{EN})................................. 0V to 6.0V
Junction Temperature Range ....–40°C ≤ T_J ≤ +125°C
Maximum Power Dissipation[4]
Package Thermal Resistance
    S-Pak (θ_{JC}) ....2°C/W
    TO-263-5 (θ_{JC})..2°C/W

Electrical Characteristics[5]

T_A = 25°C with V_{IN} = V_{OUT} + 1V; V_{EN} = V_{IN}; I_L = 10mA, **bold** values indicate –40°C< T_J < +125°C, unless otherwise noted.

Parameter	Condition	Min	Typ	Max	Units
Output Voltage Accuracy	I_L = 10mA	-2		+2	%
	10mA < I_{OUT} < $I_{L(max)}$, V_{OUT} + 1 ≤ V_{IN} ≤ 6V	**-3**		**+3**	%
Output Voltage Line Regulation	V_{IN} = V_{OUT} + 1.0V to 6.0V, I_L = 10mA		0.02	**0.5**	%
Output Voltage Load Regulation	I_L = 10mA to 2.5A		0.2	**1**	%
V_{IN} – V_{OUT}; Dropout Voltage, **Note 6**	I_L = 1.5A		400	**500**	mV
	I_L = 2.5A		550	**1000**	mV
Ground Pin Current, **Note 7**	I_L = 2.5A		40	**60**	mA
Ground Pin Current in Shutdown	V_{IL} ≤ 0.5V, V_{IN} = V_{OUT} + 1V		1.0		µA
Current Limit	V_{OUT} = 0; V_{IN} = 3.3V		3		A
Start-up Time	V_{EN} = V_{IN}, I_{OUT} = 10mA, C_{OUT} = 47µF		150	**250**	µs
Enable Input					
Enable Input Threshold	Regulator enable	**2.25**			V
	Regulator shutdown			**0.8**	V
Enable Pin Input Current	V_{IL} ≤ 0.8V (Regulator shutdown)			2 **4**	µA µA
	V_{IH} ≥ 2.25V (Regulator enable)	1	10	**30**	µA
Reference Voltage		1.215 **1.202**	1.240	1.265 **1.277**	V V
Adjust Pin Bias Current			40	80 **120**	nA nA

Notes:

1. Exceeding the absolute maximum rating may damage the device.

2. The device is not guaranteed to function outside its operating rating.

3. Device is ESD sensitive. Handling precautions recommended.

4. $P_{D(max)}$ = $T_{J(max)}$ – T_A) / θ_{JA}, where θ_{JA}, depends upon the printed circuit layout. See "Applications Information."

5. Specification for packaged product only

6. V_{DO} = V_{IN} – V_{OUT} when V_{OUT} decreased to 98% of its nominal output voltage with V_{IN} = V_{OUT} + 1V. For output voltages below 2V, dropout voltage specification does not apply due to a minimum input operating voltage of 3V

7. I_{GND} is the quiescent current. I_{IN} = I_{GND} + I_{OUT}.

Typical Characteristics

PSRR

PSRR

Dropout Voltage

Dropout vs. Temperature

Output Voltage vs. Temperature

Enable Pin Current vs. Temperature

Short Circuit Current vs. Temperature

Ground Current vs. Supply Voltage

Ground Current vs. Temperature

Ground Current vs. Output Current

Output Voltage vs. Load Current

Dropout Characteristics
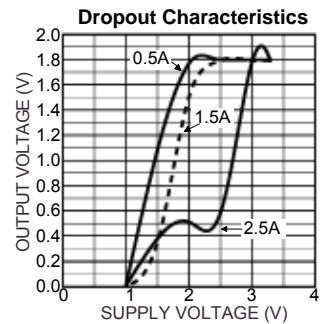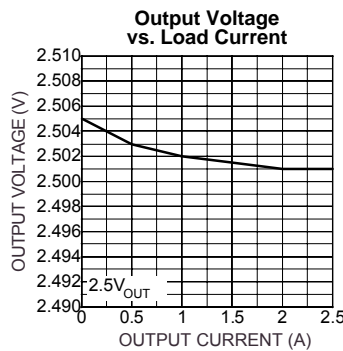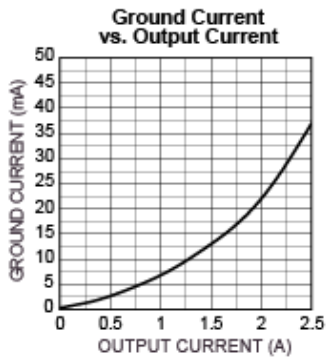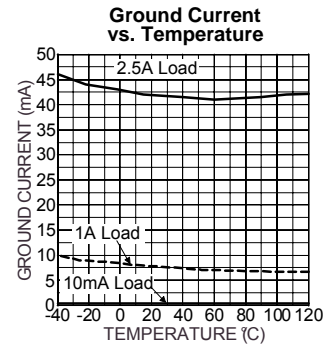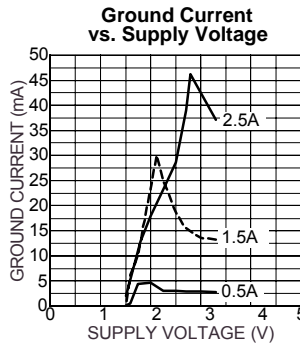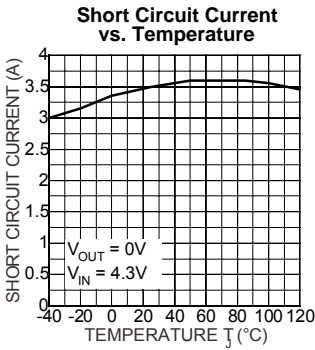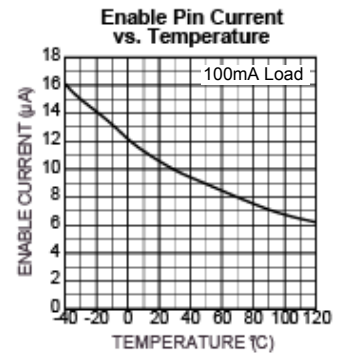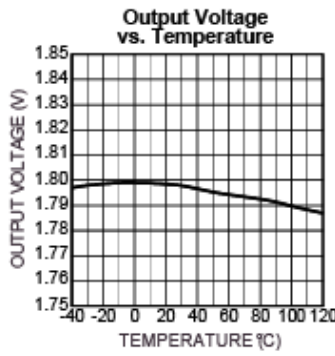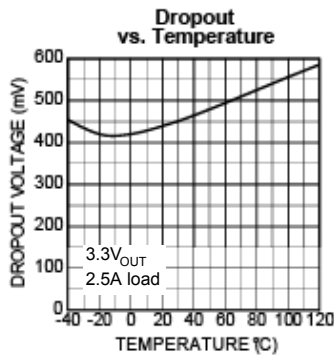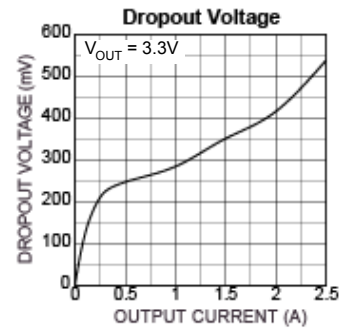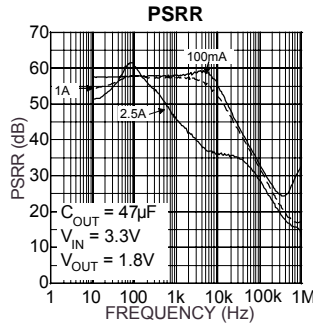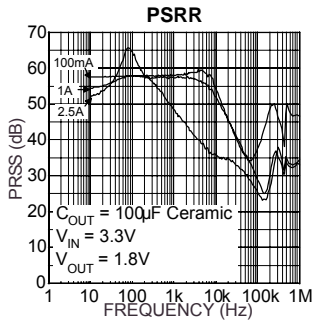
Functional Characteristics

LoadTransient Response

V_{IN} = 3.3V
V_{OUT} = 1.8V
C_{OUT} = 47µF

OUTPUT VOLTAGE (100mV/div.)

OUTPUT CURRENT (1A/div.)

2A

10mA

TIME (400µs/div.)

LoadTransient Response

V_{IN} = 3.3V
V_{OUT} = 1.8V
C_{OUT} = 47µF

OUTPUT VOLTAGE (200mV/div.)

OUTPUT CURRENT (1A/div.)

2.5A

10mA

TIME (400µs/div.)

MIC37252 Start Up

Load = 2A

INPUT VOLTAGE (1V/div.)

OUTPUT VOLTAGE (1V/div.)

TIME (100µs/div.)

Line Transient Response

OUTPUT VOLTAGE (20mV/div.)

INPUT VOLTAGE (2V/div.)

5V

3.3V

TIME (100µs/div.)

Application Information

The MIC37252 is a high-performance low-dropout voltage regulator suitable for moderate to high-current regulator applications. Its 550mV dropout voltage at full load makes it especially valuable in battery-powered systems and as high-efficiency noise filters in post-regulator applications. Unlike older NPN-pass transistor designs, where the minimum dropout voltage is limited by the base-to-emitter voltage drop and collector-to-emitter saturation voltage, dropout performance of the PNP output of these devices is limited only by the low V_{CE} saturation voltage.

A trade off for the low dropout voltage is a varying base drive requirement. Micrel's Super βeta PNP® process reduces this drive requirement to only 2% to 5% of the load current.

The MIC37252 regulator is fully protected from damage due to fault conditions. Current limiting is provided. This limiting is linear; output current during overload conditions is constant. Thermal shutdown disables the device when the die temperature exceeds the maximum safe operating temperature. Transient protection allows device (and load) survival even when the input voltage spikes above and below nominal. The output structure of these regulators allows voltages in excess of the desired output voltage to be applied without reverse current flow.

Thermal Design

Linear regulators are simple to use. The most complicated design parameters to consider are thermal characteristics. Thermal design requires the following application-specific parameters:

- Maximum ambient temperature (T_A)
- Output current (I_{OUT})
- Output voltage (V_{OUT})
- Input voltage (V_{IN})
- Ground current (I_{GND})

First, calculate the power dissipation of the regulator from these numbers and the device parameters from this datasheet.

$$P_D = (V_{IN} - V_{OUT}) I_{OUT} + V_{IN} I_{GND}$$

Where the ground current is approximated by using numbers from the "Electrical Characteristics" or "Typical Characteristics." Then the heat sink thermal resistance is determined with this formula:

$$\theta_{SA} = ((T_{J(MAX)} - T_A)/ P_D) - (\theta_{JC} + \theta_{CS})$$

Where $T_{J(MAX)} \leq 125°C$ and θ_{CS} is between 0°C and 2°C/W. The heat sink may be significantly reduced in applications where the minimum input voltage is known and is large compared with the dropout voltage. Use a series input resistor to drop excessive voltage and distribute the heat between this resistor and the regulator. The low dropout properties of Micrel Super βeta PNP® regulators allow significant reductions in regulator power dissipation and the associated heat sink without compromising performance. When this technique is employed, a capacitor of at least 1.0μF is needed directly between the input and regulator ground. Refer to *Application Note 9* for further details and examples on thermal design and heat sink applications.

Output Capacitor

The MIC37252 requires an output capacitor for stable operation. As a μCap LDO, the MIC37252 can operate with ceramic output capacitors as long as the amount of capacitance is 47μF or greater. For values of output capacitance lower than 47μF, the recommended ESR range is 200mΩ to 2Ω. The minimum value of output capacitance recommended for theMIC37252 is 10μF.

For 47μF or greater the ESR range recommended is less than1Ω. Ultra-low ESR, ceramic capacitors are recommended for output capacitance of 47μF or greater to help improve transient response and noise reduction at high frequency. X7R/X5R dielectric-type ceramic capacitors are recommended because of their temperature performance. X7R-type capacitors change capacitance by 15% over their operating temperature range and are the most stable type of ceramic capacitors. Z5U and Y5V dielectric capacitors change value by as much as 50% and 60% respectively over their operating temperature ranges. To use a ceramic chip capacitor withY5V dielectric, the value must be much higher than an X7Rceramic capacitor to ensure the same minimum capacitance over the equivalent operating temperature range. The MIC37252 has excellent transient response to variations in input voltage and load current. The device has been designed to respond quickly to load current variations and input voltage variations. Large output capacitors are not required to obtain this performance. A standard 47μF output capacitor is all that is required. Larger values help to improve performance even further.

Input Capacitor

An input capacitor of 1.0μF or greater is recommended when the device is more than 4 inches away from the bulk supply capacitance, or when the supply is a battery. Small, surface-mount chip capacitors can be used for the bypassing. The capacitor should be place within 1" of the device for optimal performance. Larger values will help to improve ripple rejection by bypassing the input to the regulator, further improving the integrity of the output voltage.

Transient Response and 5V to 3.3V or 3.3V to 1.8VConversions

The MIC37252 has excellent transient response to variations in input voltage and load current. The device has been designed to respond quickly to load current variations and input voltage variations. Large output capacitors are not required to obtain this performance. A standard 10μF output capacitor, preferably tantalum, is all that is required. Larger values help to improve performance even further.

By virtue of its low dropout voltage, this device does not saturate into dropout as readily as similar NPN-based designs. When converting from 3.3V to 1.8V, the NPN-based regulators are already operating in dropout, with typical dropout requirements of 2V or greater. To convert down to1.8V without operating in dropout, NPN-based regulators require an input voltage of 3.8V at the very least. The MIC37252 regulator will provide excellent performance with an input as low as 3.0V. This gives the PNP-based regulators a distinct advantage over older NPN-based linear regulators.

Minimum Load Current

The MIC37252 regulator is specified between finite loads. If the output current is too small, leakage currents dominate and the output voltage rises. A 10mA minimum load current is necessary for proper operation.

Enable Input

The MIC37252 also features an enable input for on/off control of the device. Its shutdown state draws "zero" current (only microamperes of leakage). The enable input is TTL/CMOS compatible for simple logic interface, but can be connected to up to VIN. When enabled, it draws approximately 15μA.

Adjustable Regulator Design

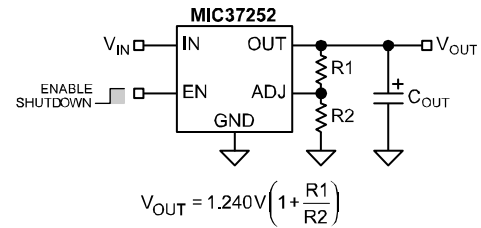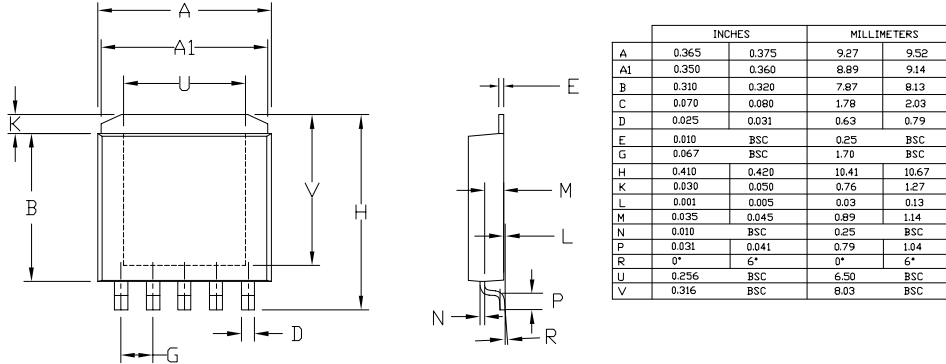$$V_{OUT} = 1.240V\left(1 + \frac{R1}{R2}\right)$$

Figure 2. Adjustable Regulator with Resistors

The MIC37252 allows programming of the output voltage anywhere between 1.24V and the 5.5V maximum operating rating of the family. Two resistors are used. Resistors values are recommended to be less than 10kΩ in value to improve stability. The resistor values can be sized to draw the mini-mum load current for this device. The resistor values are calculated by:

$$R1 = R2\left(\frac{V_{OUT}}{1.240} - 1\right)$$
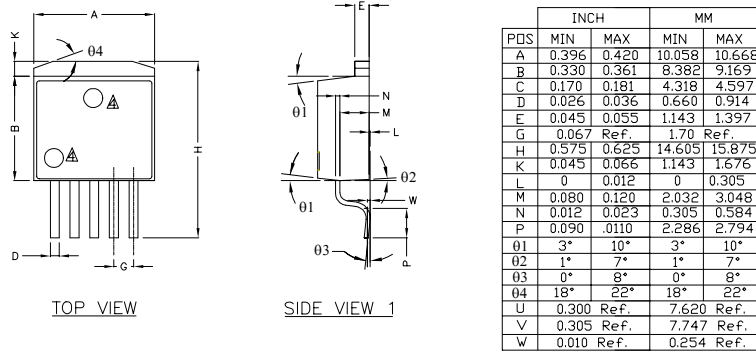
Where V_{OUT} is the desired output voltage. Figure 2 shows component definition. Applications with widely varying load currents may scale the resistors to draw the minimum load current required for proper operation (see above).

Package Information

	INCHES		MILLIMETERS	
A	0.365	0.375	9.27	9.52
A1	0.350	0.360	8.89	9.14
B	0.310	0.320	7.87	8.13
C	0.070	0.080	1.78	2.03
D	0.025	0.031	0.63	0.79
E	0.010	BSC	0.25	BSC
G	0.067	BSC	1.70	BSC
H	0.410	0.420	10.41	10.67
K	0.030	0.050	0.76	1.27
L	0.001	0.005	0.03	0.13
M	0.035	0.045	0.89	1.14
N	0.010	BSC	0.25	BSC
P	0.031	0.041	0.79	1.04
R	0°	6°	0°	6°
U	0.256	BSC	6.50	BSC
V	0.316	BSC	8.03	BSC

1. DIMENSION DOES NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
2. DIMENSION INCLUDES PLATING THICKNESS.

5-Pin S-PAK (R)

POS	INCH		MM	
	MIN	MAX	MIN	MAX
A	0.396	0.420	10.058	10.668
B	0.330	0.361	8.382	9.169
C	0.170	0.181	4.318	4.597
D	0.026	0.036	0.660	0.914
E	0.045	0.055	1.143	1.397
G	0.067	Ref.	1.70	Ref.
H	0.575	0.625	14.605	15.875
K	0.045	0.066	1.143	1.676
L	0	0.012	0	0.305
M	0.080	0.120	2.032	3.048
N	0.012	0.023	0.305	0.584
P	0.090	.0110	2.286	2.794
θ1	3°	10°	3°	10°
θ2	1°	7°	1°	7°
θ3	0°	8°	0°	8°
θ4	18°	22°	18°	22°
U	0.300	Ref.	7.620	Ref.
V	0.305	Ref.	7.747	Ref.
W	0.010	Ref.	0.254	Ref.

TOP VIEW

SIDE VIEW 1

BOTTOM VIEW

SIDE VIEW 2

NOTE:
1. PACKAGE OUTLINE EXCLUSIVE OF MOLD FLASH & METAL BURR.
2. PACKAGE OUTLINE INCLUSIVE OF PLATING THICKNESS.
3. FOOT LENGTH MEASURED AT INTERCEPT POINT BETWEEN DATUM A & LEAD SURFACE
⚠ PACKAGE TOP MARK MAY BE IN TOP CENTER OR LOWER LEFT CORNER

5-Pin TO-263 (U)

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