MIC5213

Teeny™ SC-70 µCap Low-Dropout Regulator

Final Information

General Description

The MIC5213 is a µCap 80mA linear voltage regulator in the Teeny™ SC-70 package. Featuring half the footprint of the standard SOT-23 package, this Teeny™ SC-70 regulator has very low dropout voltage (typically 20mV at light loads and 300mV at 80mA) and very low ground current (225µA at 20mA output). It also offers better than 3% initial accuracy and includes a logic-compatible enable input.

The µCap regulator design is optimized to work with low-value, low-cost ceramic capacitors. The outputs typically require only 0.47µF of output capacitance for stability.

Designed especially for hand-held, battery-powered devices, the MIC5213 can be controlled by a CMOS or TTL compatible logic signal. When disabled, power consumption drops nearly to zero. If on-off control is not required, the enable pin may be tied to the input for 3-terminal operation. The ground current of the MIC5213 increases only slightly in dropout, further prolonging battery life. Key MIC5213 features include current limiting, overtemperature shutdown, and protection against reversed battery.

The MIC5213 is available in 2.5V, 2.6V, 2.7V, 2.8V, 3.0V, 3.3V, 3.6V, and 5.0V fixed voltages. Other voltages are available; contact Micrel for details.

Features

- Teeny™ SC-70 package
- Wide selection of output voltages
- Guaranteed 80mA output
- Low quiescent current
- Low dropout voltage
- Tight load and line regulation
- Low temperature coefficient
- Current and thermal limiting
- Reversed input polarity protection
- Zero off-mode current
- Logic-controlled shutdown
- Stability with low ESR ceramic capacitors

Applications

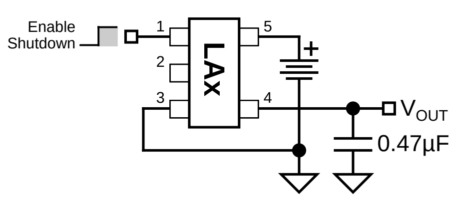
- Cellular telephones
- Laptop, notebook, and palmtop computers
- Battery-powered equipment
- Bar code scanners
- SMPS post-regulator/dc-to-dc modules
- High-efficiency linear power supplies

Ordering Information

Part Number		Marking		Voltage	Junction Temp. Range	Package
Standard	Pb-Free	Standard	Pb-Free			
MIC5213-2.5BC5	MIC5213-2.5YC5	LAM	LAM	2.5V	–40°C to +125°C	SC-70-5
MIC5213-2.6BC5	MIC5213-2.6YC5	LAQ	LAQ	2.6V	–40°C to +125°C	SC-70-5
MIC5213-2.7BC5	MIC5213-2.7YC5	LAL	LAL	2.7V	–40°C to +125°C	SC-70-5
MIC5213-2.8BC5	MIC5213-2.8YC5	LAJ	LAJ	2.8V	–40°C to +125°C	SC-70-5
MIC5213-3.0BC5	MIC5213-3.0YC5	LAG	LAG	3.0V	–40°C to +125°C	SC-70-5
MIC5213-3.3BC5	MIC5213-3.3YC5	LAE	LAE	3.3V	–40°C to +125°C	SC-70-5
MIC5213-3.6BC5	MIC5213-3.6YC5	LAD	LAD	3.6V	–40°C to +125°C	SC-70-5
MIC5213-5.0BC5	MIC5213-5.0YC5	LAB	LAB	5.0V	–40°C to +125°C	SC-70-5

Other voltages available. Contact Micrel for details.

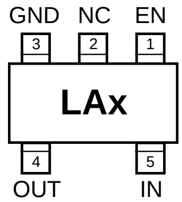
Typical Applications



Regulator Circuit

Teeny is a trademark of Micrel, Inc.

Pin Configuration



SC-70-5 (C5)

Pin Description

Pin Number	Pin Name	Pin Function
1	EN	Enable (Input): TTL/CMOS compatible control input. Logic high = enabled; logic low or open = shutdown.
2	NC	Not internally connected.
3	GND	Ground
4	OUT	Regulator Output
5	IN	Supply Input

Absolute Maximum Ratings (Note 1)

Input Supply Voltage (V_{IN}) .... –20V to +20V
Enable Input Voltage (V_{EN}) .... –20V to +20V
Power Dissipation (P_D) .... Internally Limited
Storage Temperature Range (T_S) .... –60°C to +150°C
Lead Temperature (Soldering, 5 sec.) .... 260°C
ESD, **Note 3**

Operating Ratings (Note 2)

Input Voltage (V_{IN}) .... 2.5V to 16V
Enable Input Voltage (V_{EN}) .... 0V to V_{IN}
Junction Temperature Range .... –40°C to +125°C
Thermal Resistance (θ_{JA}) .... **Note 4**

Electrical Characteristics

$V_{IN} = V_{OUT} + 1V$; $I_L = 1mA$; $C_L = 0.47\mu F$; $V_{EN} \geq 2.0V$; $T_J = 25°C$, **bold** values indicate $-40°C \leq T_J \leq +125°C$; unless noted.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_O	Output Voltage Accuracy		–3 **–4**		3 **4**	% %
$\Delta V_O/\Delta T$	Output Voltage Temp. Coefficient	**Note 5**		**50**	**200**	ppm/°C
$\Delta V_O/V_O$	Line Regulation	$V_{IN} = V_{OUT} + 1V$ to 16V		0.008	0.3 **0.5**	% %
$\Delta V_O/V_O$	Load Regulation	$I_L = 0.1mA$ to 80mA, **Note 6**		0.08	0.3 **0.5**	% %
$V_{IN}–V_O$	Dropout Voltage, **Note 7**	$I_L = 100\mu A$		20		mV
		$I_L = 20mA$		200	**350**	mV
		$I_L = 50mA$		250		mV
		$I_L = 80mA$		280	**600**	mV
I_Q	Quiescent Current	$V_{EN} \leq 0.4V$ (shutdown)		0.01	10	µA
I_{GND}	Ground Pin Current, **Note 8**	$I_L = 100\mu A$, $V_{EN} \geq 2.0V$ (active)		180		µA
		$I_L = 20mA$, $V_{EN} \geq 2.0V$ (active)		225	**750**	µA
		$I_L = 50mA$, $V_{EN} \geq 2.0V$ (active)		850		µA
		$I_L = 80mA$, $V_{EN} \geq 2.0V$ (active)		1800	**3000**	µA
I_{GNDDO}	Ground Pin Current in Dropout	$V_{IN} = V_{OUT(nominal)} - 0.5V$, **Note 8**		200	**300**	µA
I_{LIMIT}	Current Limit	$V_{OUT} = 0V$		180	**250**	mA
$\Delta V_O/\Delta P_D$	Thermal Regulation	**Note 9**		0.05		%/W
Enable Input						
V_{IL}	Enable Input Voltage Level	Logic Low (off)			**0.6**	V
V_{IH}		Logic High (on)	**2.0**			V
I_{IL}	Enable Input Current	$V_{IL} \leq 0.6V$		0.01	1	µA
I_{IH}		$V_{IH} \geq 2.0V$		8	**50**	µA

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

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

Note 3. Devices are ESD sensitive. Handling precautions recommended.

Note 4. The maximum allowable power dissipation is a function of the maximum junction temperature, $T_{J(max)}$, the junction-to-ambient thermal resistance, θ_{JA}, and the ambient temperature, T_A. The maximum allowable power dissipation at any ambient temperature is calculated using: $P_{D(max)} = (T_{J(max)} - T_A) \div \theta_{JA}$. Exceeding the maximum allowable power dissipation will result in excessive die temperature, and the regulator will go into thermal shutdown. θ_{JA} of the SC-70-5 is 450°C/W, mounted on a PC board.

Note 5. Output voltage temperature coefficient is defined as the worst case voltage change divided by the total temperature range.

Note 6. Regulation is measured at constant junction temperature using low duty cycle pulse testing. Changes in output voltage due to heating effects are covered by the thermal regulation specification.

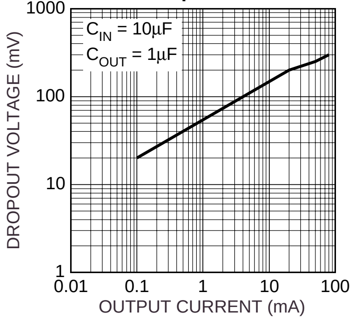
Note 7. Dropout voltage is defined as the input to output differential at which the output voltage drops 2% below its nominal value measured at 1V differential.

Note 8. Ground pin current is the regulator quiescent current plus pass transistor base current. The total current drawn from the supply is the sum of the load current plus the ground pin current.

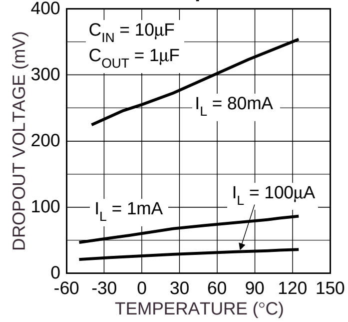
Note 9. Thermal regulation is defined as the change in output voltage at a time “t” after a change in power dissipation is applied, excluding load or line regulation effects. Specifications are for an 80mA load pulse at $V_{IN} = 16V$ for t = 10ms.

Typical Characteristics

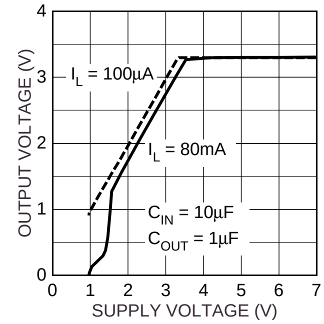
Dropout Voltage vs. Output Current



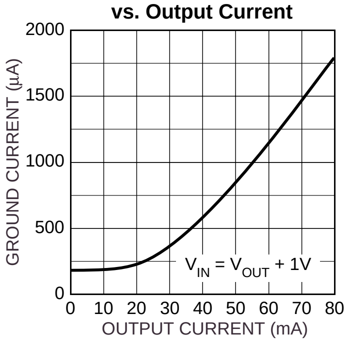
Dropout Voltage vs. Temperature



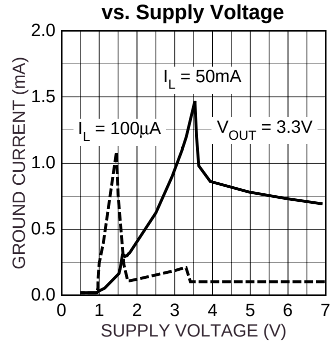
Dropout Characteristics



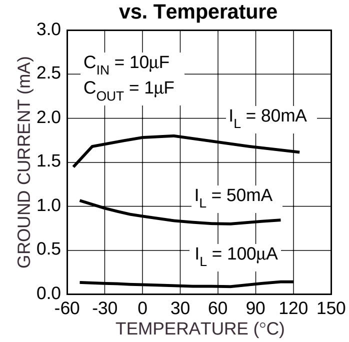
Ground Current vs. Output Current



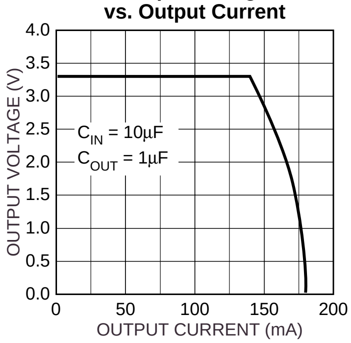
Ground Current vs. Supply Voltage



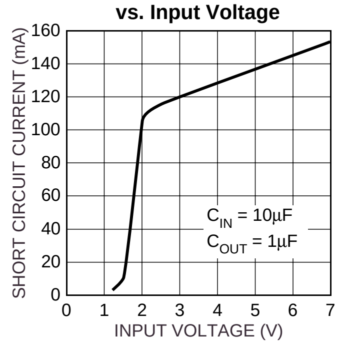
Ground Current vs. Temperature



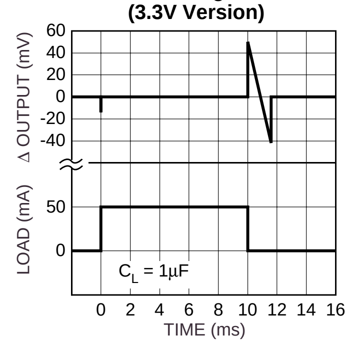
Output Voltage vs. Output Current



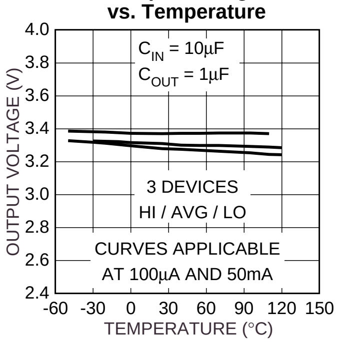
Short Circuit Current vs. Input Voltage



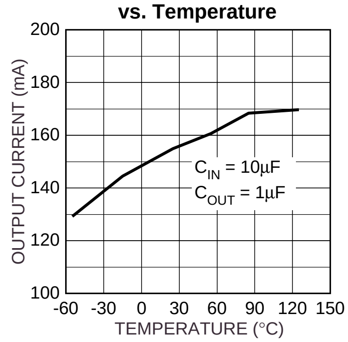
Thermal Regulation (3.3V Version)



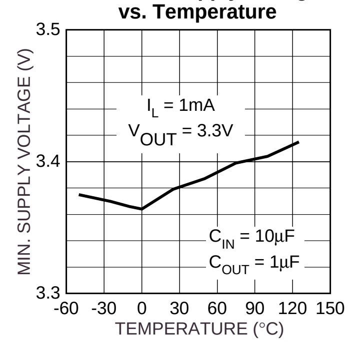
Output Voltage vs. Temperature

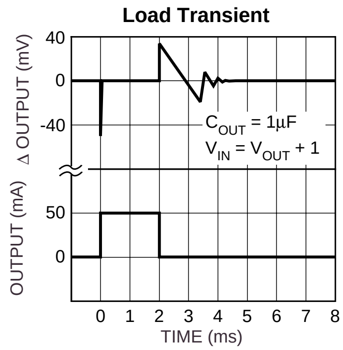


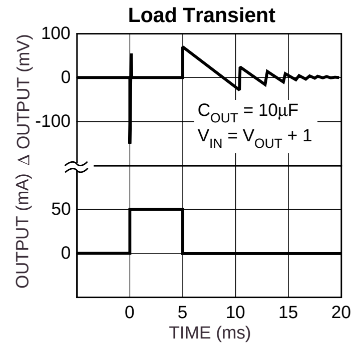
Short Circuit Current vs. Temperature

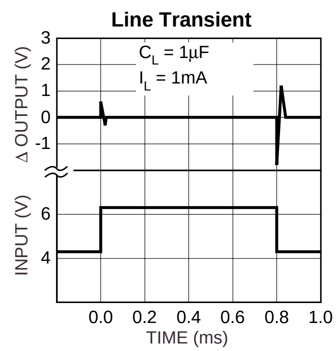


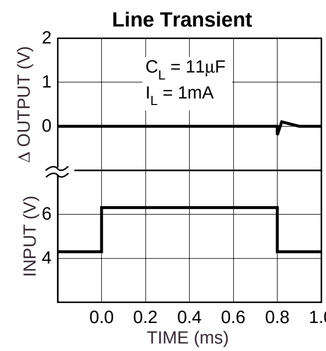
Minimum Supply Voltage vs. Temperature

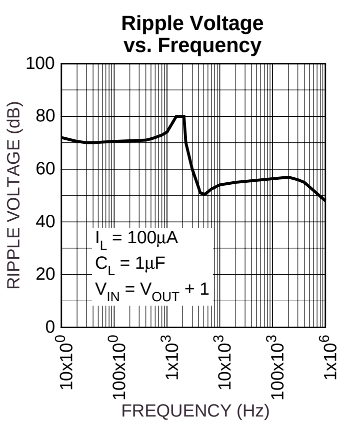


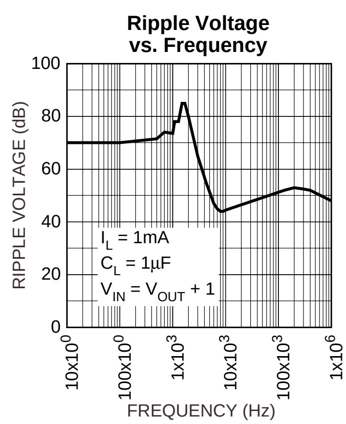

Load Transient
Δ OUTPUT (mV)
OUTPUT (mA)
40
0
-40
50
0
COUT = 1µF
VIN = VOUT + 1
0 1 2 3 4 5 6 7 8
TIME (ms)

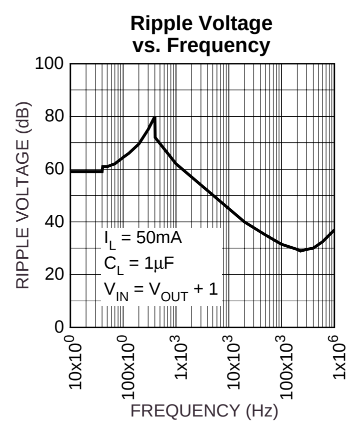

Load Transient
Δ OUTPUT (mV)
OUTPUT (mA)
100
0
-100
50
0
COUT = 10µF
VIN = VOUT + 1
0 5 10 15 20
TIME (ms)

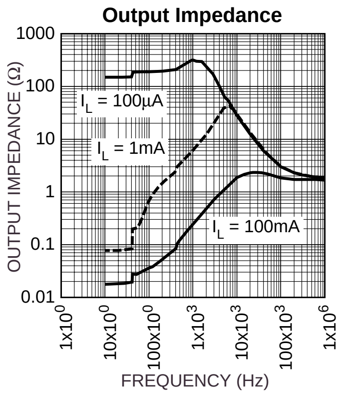

Line Transient
Δ OUTPUT (V)
INPUT (V)
3
2
1
0
-1
6
4
CL = 1µF
IL = 1mA
0.0 0.2 0.4 0.6 0.8 1.0
TIME (ms)

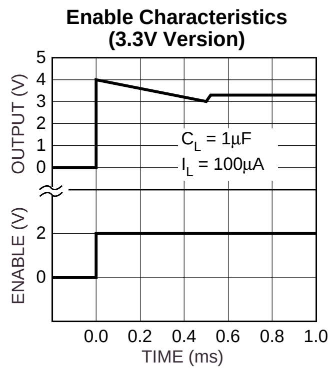

Line Transient
Δ OUTPUT (V)
INPUT (V)
2
1
0
6
4
CL = 11µF
IL = 1mA
0.0 0.2 0.4 0.6 0.8 1.0
TIME (ms)

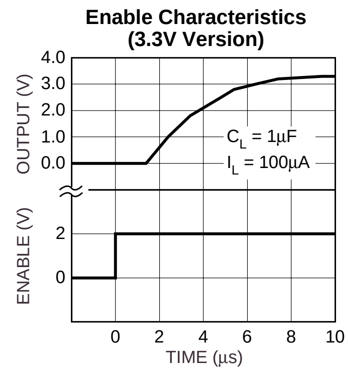

Ripple Voltage
vs. Frequency
RIPPLE VOLTAGE (dB)
100
80
60
40
20
0
IL = 100µA
CL = 1µF
VIN = VOUT + 1
10x10^0
100x10^0
1x10^3
10x10^3
100x10^3
1x10^6
FREQUENCY (Hz)

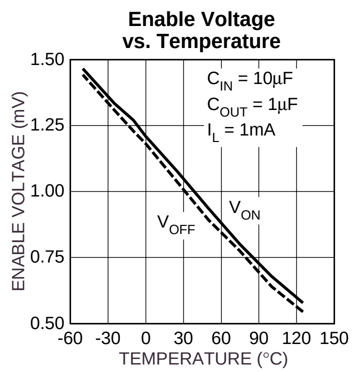

Ripple Voltage
vs. Frequency
RIPPLE VOLTAGE (dB)
100
80
60
40
20
0
IL = 1mA
CL = 1µF
VIN = VOUT + 1
10x10^0
100x10^0
1x10^3
10x10^3
100x10^3
1x10^6
FREQUENCY (Hz)

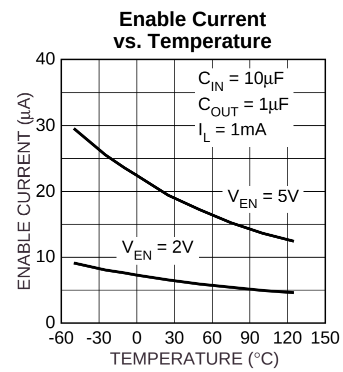

Ripple Voltage
vs. Frequency
RIPPLE VOLTAGE (dB)
100
80
60
40
20
0
IL = 50mA
CL = 1µF
VIN = VOUT + 1
10x10^0
100x10^0
1x10^3
10x10^3
100x10^3
1x10^6
FREQUENCY (Hz)


Output Impedance
OUTPUT IMPEDANCE (Ω)
FREQUENCY (Hz)
I L = 100µA
I L = 1mA
I L = 100mA


Enable Characteristics
(3.3V Version)
OUTPUT (V)
ENABLE (V)
TIME (ms)
C L = 1µF
I L = 100µA


Enable Characteristics
(3.3V Version)
OUTPUT (V)
ENABLE (V)
TIME (µs)
C L = 1µF
I L = 100µA


Enable Voltage
vs. Temperature
ENABLE VOLTAGE (mV)
TEMPERATURE (°C)
C IN = 10µF
C OUT = 1µF
I L = 1mA
V ON
V OFF


Enable Current
vs. Temperature
ENABLE CURRENT (µA)
TEMPERATURE (°C)
C IN = 10µF
C OUT = 1µF
I L = 1mA
V EN = 5V
V EN = 2V

Applications Information

Input Capacitor

A 0.1µF capacitor should be placed from IN to GND if there is more than 10 inches of wire between the input and the ac filter capacitor or when a battery is used as the input.

Output Capacitor

Typical PNP-based regulators require an output capacitor to prevent oscillation. The MIC5213 is ultrastable, requiring only 0.47µF of output capacitance for stability. The regulator is stable with all types of capacitors, including the tiny, low-ESR ceramic chip capacitors. The output capacitor value can be increased without limit to improve transient response.

No-Load Stability

The MIC5213 will remain stable and in regulation with no load (other than the internal voltage divider) unlike many other voltage regulators. This is especially important in CMOS RAM keep-alive applications.

Enable Input

The MIC5213 features nearly zero off-mode current. When EN (enable input) is held below 0.6V, all internal circuitry is powered off. Pulling EN high (over 2.0V) re-enables the device and allows operation. When EN is held low, the regulator typically draws only 10nA of current. While the logic threshold is TTL/CMOS compatible, EN may be pulled as high as 20V, independent of V_{IN}.

Thermal Behavior

The MIC5213 is designed to provide 80mA of continuous current in a very small profile package. Maximum power dissipation can be calculated based on the output current and the voltage drop across the part. To determine the maximum power dissipation of the package, use the junction-to-ambient thermal resistance of the device and the following basic equation:

$$P_{D(max)} = \frac{T_{J(max)} - T_A}{\theta_{JA}}$$

$T_{J(max)}$ is the maximum junction temperature of the die, 125°C, and T_A is the maximum ambient temperature. θ_{JA} is the junction-to-ambient thermal resistance ambient of the regulator. The θ_{JA} of the MIC5213 is 450°C/W.

The actual power dissipation of the regulator circuit can be determined using one simple equation.

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

Substituting $P_{D(max)}$, determined above, for P_D and solving for the operating conditions that are critical to the application will give the maximum operating conditions for the regulator circuit. For example, if we are operating the MIC5213-3.0BC5 at room temperature, with a minimum footprint layout, we can determine the maximum input voltage for a set output current.

$$P_{D(max)} = \frac{125 - 25}{450°C/W}$$

$$P_{D(max)} = 222mW$$

To prevent the device from entering thermal shutdown, maximum power dissipation cannot be exceeded. Using the output voltage of 3.0V, and an output current of 80mA, we can determine the maximum input voltage. Ground current, maximum of 3mA for 80mA of output current, can be taken from the "Electrical Characteristics" section of the data sheet.

$$222mW = (V_{IN} - 3.0V)\ 80mA + V_{IN} \times 3mA$$

$$222mW = (80mA \times V_{IN} + 3mA \times V_{IN}) - 240mW$$

$$462mW = 83mA \times V_{IN}$$

$$V_{IN} = 5.57V \text{ max.}$$

Therefore, a 3.0V application at 80mA of output current can accept a maximum input voltage of 5.6V in an SC-70-5 package. For a full discussion of heat sinking and thermal effects on voltage regulators, refer to Regulator Thermals section of Micrel's *Designing with Low-Dropout Voltage Regulators* handbook.

Fixed Voltage Regulator

The MIC5213 is ideal for general-purpose voltage regulation in any handheld device. Applications that are tight for space can easily use the Teeny™ SC-70 regulator which occupies half the space of a SOT-23-5 regulator. The MIC5203 offers a smaller system solution, only requiring a small multilayer ceramic capacitor for stability.

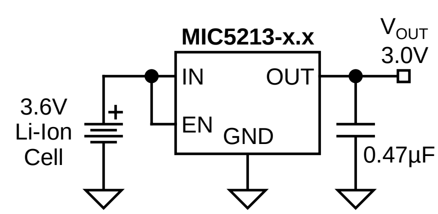
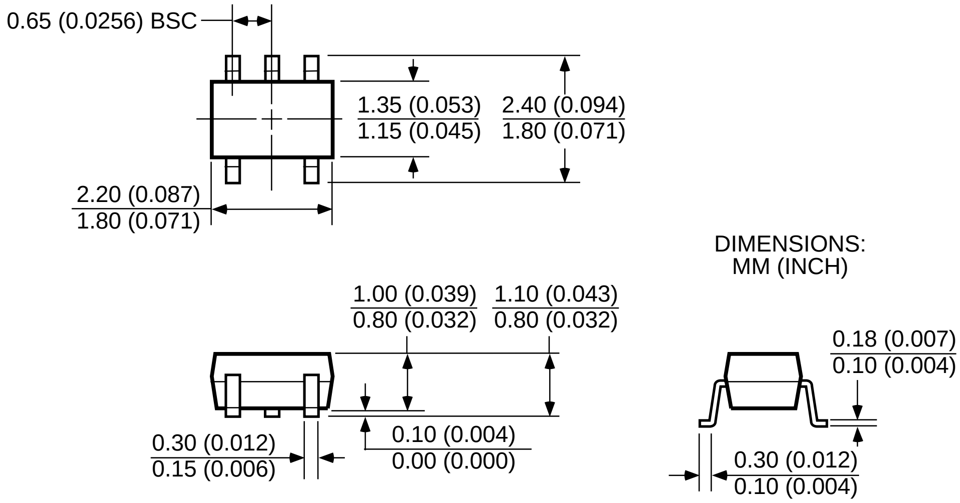


Figure 1. Single-Cell Regulator

Package Information



SC-70-5 (C5)

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