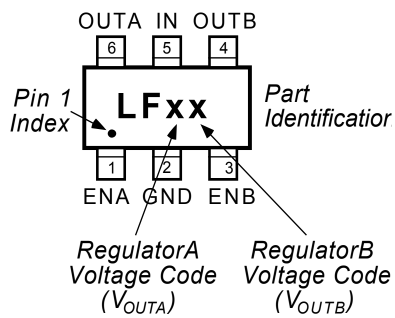
Ordering Information

Part Number		Pb-Free Part Number			Voltage Side A / Side B	Temperature Range	Package
Standard	**Mark Code**	**Full**	**Manufacturing**	**Mark Code**			
MIC5211-1.8BM6	LFBB	MIC5211-1.8YM6		LFBB	1.8V	0ºC to +125ºC	SOT-23-6
MIC5211-2.5BM6	LFCC	Contact Factory		LFCC	2.5V	–40ºC to +125ºC	SOT-23-6
MIC5211-2.7BM6	LFDD	MIC5211-2.7YM6		LFDD	2.7V	–40ºC to +125ºC	SOT-23-6
MIC5211-2.8BM6	LFEE	MIC5211-2.8YM6		LFEE	2.8V	–40ºC to +125ºC	SOT-23-6
MIC5211-3.0BM6	LFGG	MIC5211-3.0YM6		LFGG	3.0V	–40ºC to +125ºC	SOT-23-6
MIC5211-3.3BM6	LFLL	MIC5211-3.3YM6		LFLL	3.3V	–40ºC to +125ºC	SOT-23-6
MIC5211-3.6BM6	LFQQ	MIC5211-3.6YM6		LFQQ	3.6V	–40ºC to +125ºC	SOT-23-6
MIC5211-5.0BM6	LFXX	MIC5211-5.0YM6		LFXX	5.0V	–40ºC to +125ºC	SOT-23-6
Dual-Voltage Regulators							
MIC5211-1.8/2.5BM6	LFBC	MIC5211-1.8/2.5YM6	MIC5211-BCYM6	LFBC	1.8V / 2.5V	0ºC to +125ºC	SOT-23-6
MIC5211-1.8/3.3BM6	LFBL	MIC5211-1.8/3.3YM6	MIC5211-BLYM6	LFBL	1.8V / 3.3V	0ºC to +125ºC	SOT-23-6
MIC5211-2.5/3.3BM6	LFCL	MIC5211-2.5/3.3YM6	MIC5211-CLYM6	LFCL	2.5V / 3.3V	–40ºC to +125ºC	SOT-23-6
MIC5211-3.3/5.0BM6	LFLX	MIC5211-3.3/5.0YM6	MIC5211-LXYM6	LFLX	3.3V / 5.0V	–40ºC to +125ºC	SOT-23-6

Other voltages available. Contact Micrel for details.

Pin Configuration



Voltage	Code
1.8V	B
2.5V	C
2.7V	D
2.8V	E
3V	G
3.15V	H
3.3V	L
3.6V	Q
5V	X

Pin Description

Pin Number	Pin Name	Pin Function
1	ENA	Enable/Shutdown A (Input): CMOS compatible input. Logic high = enable, logic low or open = shutdown.
2	GND	Ground
3	ENB	Enable/Shutdown B (Input): CMOS compatible input. Logic high = enable, logic low or open = shutdown.
4	OUTB	Regulator Output B
5	IN	Supply Input
6	OUTA	Regulator Output A

Absolute Maximum Ratings (Note 1)

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

Operating Ratings (Note 2)

Supply Input Voltage (V_{IN})................................2.5V to 16V
Enable Input Voltage (V_{EN}) ....0V to 16V
Junction Temperature (T_J) (except 1.8V).. –40°C to +125°C
1.8V only.. 0°C to +125°C
6-lead SOT-23-6 (θ_{JA}) .... **Note 4**

Electrical Characteristics

$V_{IN} = V_{OUT} + 1V$; $I_L = 1mA$; $C_L = 0.1\mu F$, and $V_{EN} \geq 2.0V$; $T_J = 25°C$, **bold** values indicate –40°C to +125°C; for one-half of dual MIC5211; unless noted.

Symbol	Parameter	Conditions	Min	Typical	Max	Units
V_O	Output Voltage Accuracy	variation from nominal V_{OUT}	–3 **–4**		3 **4**	% %
$\Delta V_O/\Delta T$ ppm/°C	Output Voltage Temperature Coeffcient	**Note 5**		**50**	**200**	
$\Delta V_O/V_O$	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 50mA, **Note 6**		0.08	0.3 **0.5**	% %
$V_{IN} – V_O$	Dropout Voltage, **Note 7**	I_L = 100µA		20		mV
		I_L = 20mA		200	**450**	mV
		I_L = 50mA		250	**500**	mV
I_Q	Quiescent Current	$V_{EN} \leq 0.4V$ (shutdown)		0.01	**10**	µA
I_{GND}	Ground Pin Current	$V_{EN} \geq 2.0V$, I_L = 100µA (active)		90		µA
	Note 8	I_L = 20mA (active)		225	**450**	µA
		I_L = 50mA (active)		750	**1200**	µA
I_{LIMIT}	Current Limit	V_{OUT} = 0V		140	**250**	mA
$\Delta V_O/\Delta P_D$	Thermal Regulation	**Note 9**		0.05		%/W
Enable Input						
V_{IL} V_{IH}	Enable Input Voltage Level	logic low (off) logic high (on)	 **2.0**		**0.6**	V V
I_{IL}	Enable Input Current	$V_{IL} \leq 0.6V$		0.01	**1**	µA
I_{IH}		$V_{IH} \geq 2.0V$		3	**50**	µA

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

Note 2: The device is not guareented to function outside itsperating rating.

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

Note 4: The maximum allowable power dissipation at any T_A (ambient temperature) is $P_{D(max)} = (T_{J(max)} – T_A) / \theta_{JA}$. Exceeding the maximum allowable power dissipation will result in excessive die temperature, and the regulator will go into thermal shutdown. The θ_{JA} is 220°C/W for the SOT-23-6 mounted on a printed circuit board.

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

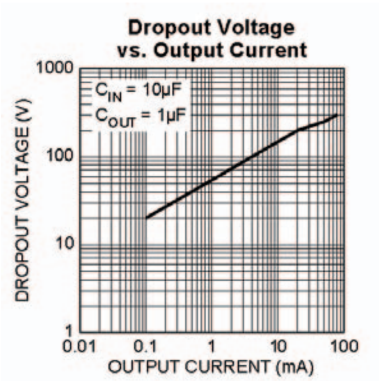
Note 6: Regulation is measured at constant junction temperature using low duty cycle pulse testing. Parts are tested for load regulation in the load range from 0.1mA to 50mA. Change in output voltage due to heating effects are covered by thermal regulation specification.

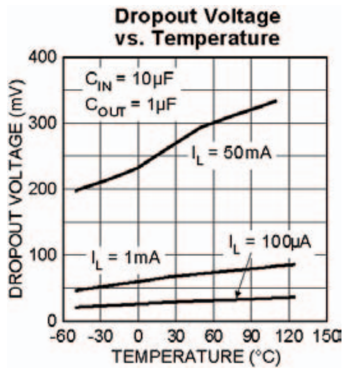
Note 7: Dropout voltage is defined as the input to output differential at which the output voltage drops 2% below its nominal value measured at 1V differential. For output voltages below 2.5V, dropout voltage is the input-to-output voltage differential with the minimum voltage being 2.5V. Minimum input opertating voltage is 2.5V.

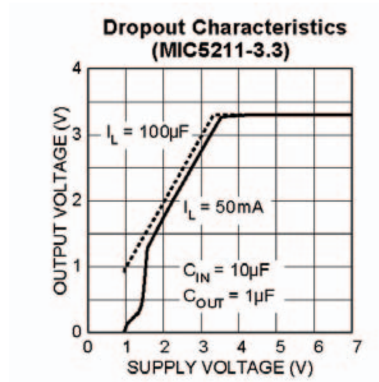
Note 8: Ground pin current is the quiescent current per regulator plus pass transistor base current. The total current drawn from the supply is the sum of the load current plus the ground pin current.

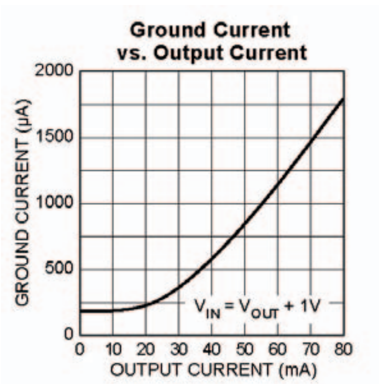
Note 9: Thermal regulation is defined as the change in output voltage at a time "t" after a change in power dissipation is applied, excluding load or line regulation effects. Specifications are for a 50mA load pulse at V_{IN} = 16V for t = 10ms.

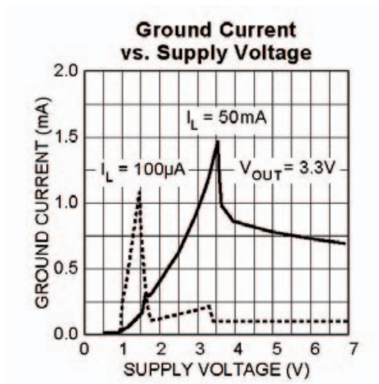
Typical Characteristics

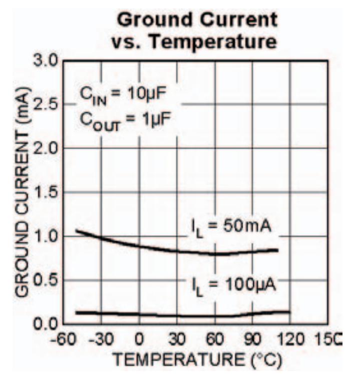


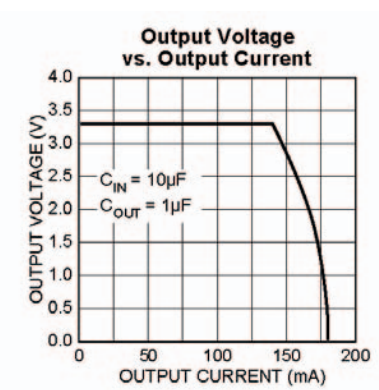


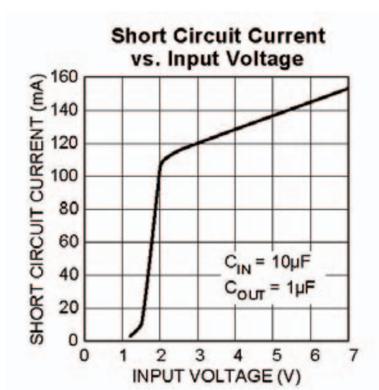


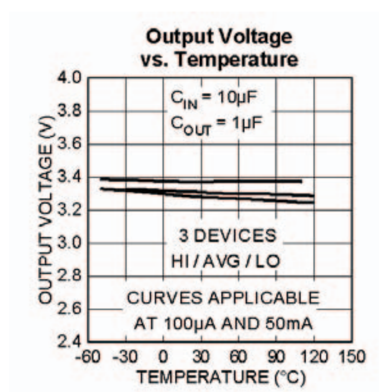


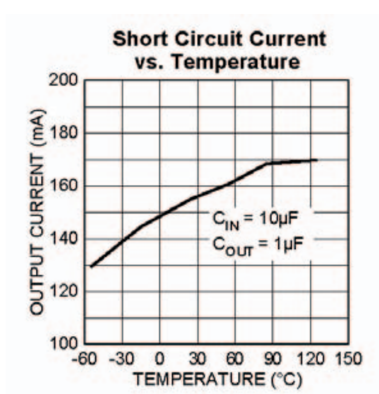


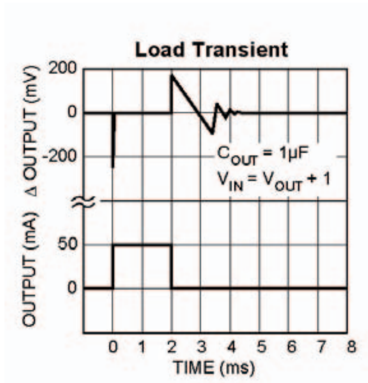


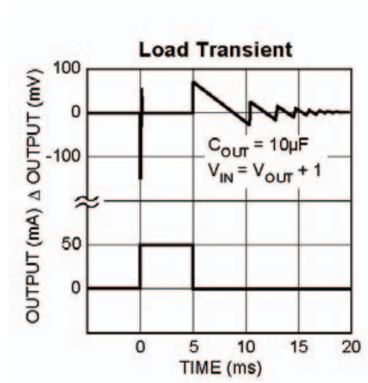


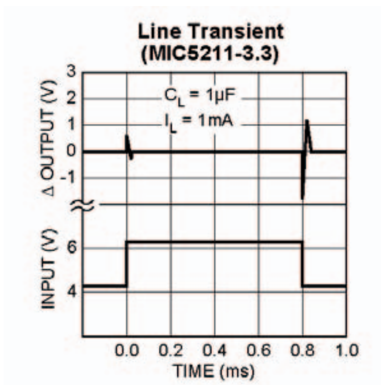


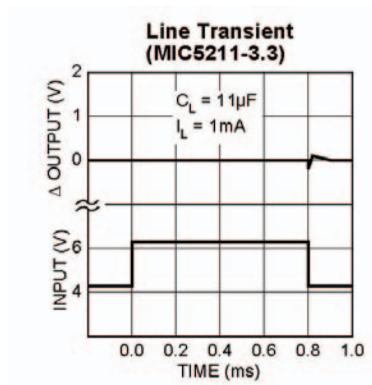


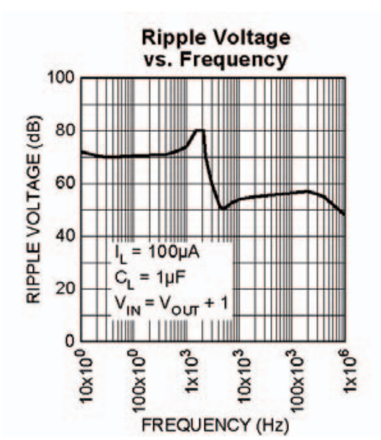


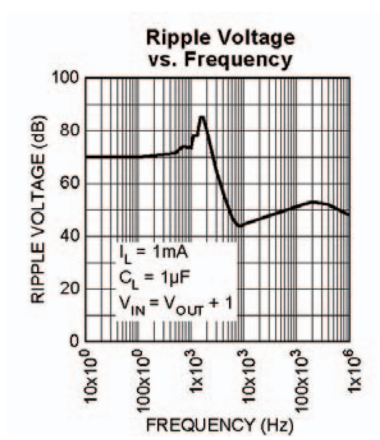

Load Transient
Δ OUTPUT (mV)
OUTPUT (mA)
200
0
-200
50
0
C_OUT = 1μF
V_IN = V_OUT + 1
0 1 2 3 4 5 6 7 8
TIME (ms)

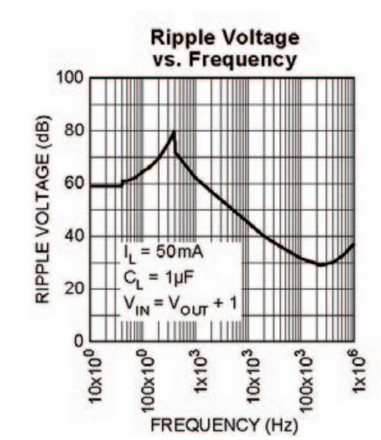

Load Transient
Δ OUTPUT (mV)
OUTPUT (mA)
100
0
-100
50
0
C_OUT = 10μF
V_IN = V_OUT + 1
0 5 10 15 20
TIME (ms)

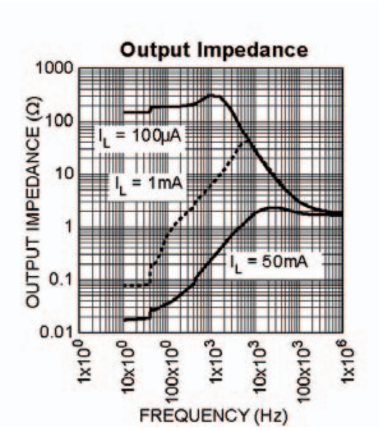

Line Transient
(MIC5211-3.3)
Δ OUTPUT (V)
INPUT (V)
3
2
1
0
-1
6
4
C_L = 1μF
I_L = 1mA
0.0 0.2 0.4 0.6 0.8 1.0
TIME (ms)

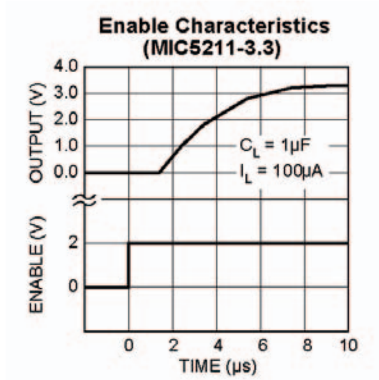

Line Transient
(MIC5211-3.3)
Δ OUTPUT (V)
INPUT (V)
2
1
0
6
4
C_L = 11μF
I_L = 1mA
0.0 0.2 0.4 0.6 0.8 1.0
TIME (ms)

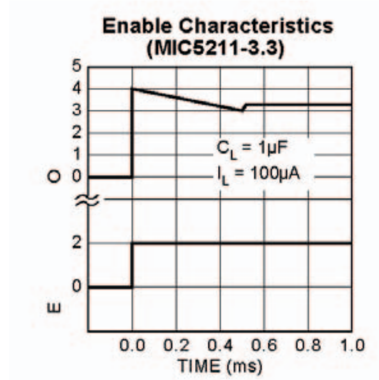

Ripple Voltage
vs. Frequency
RIPPLE VOLTAGE (dB)
100
80
60
40
20
0
I_L = 100μA
C_L = 1μF
V_IN = V_OUT + 1
10x10^0
100x10^0
1x10^3
10x10^3
100x10^3
1x10^6
FREQUENCY (Hz)

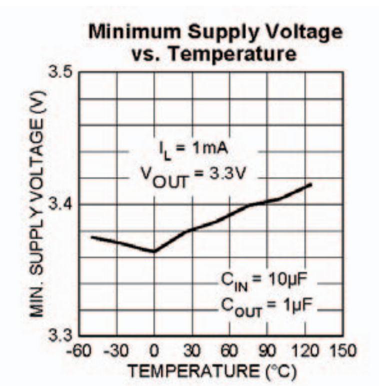

Ripple Voltage
vs. Frequency
RIPPLE VOLTAGE (dB)
100
80
60
40
20
0
I_L = 1mA
C_L = 1μF
V_IN = V_OUT + 1
10x10^0
100x10^0
1x10^3
10x10^3
100x10^3
1x10^6
FREQUENCY (Hz)

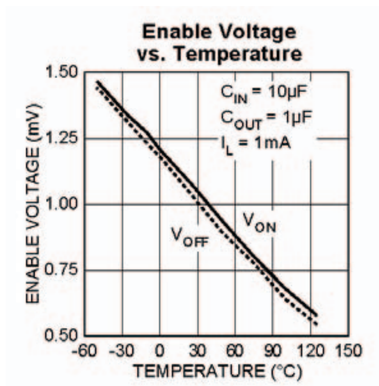

Ripple Voltage
vs. Frequency
RIPPLE VOLTAGE (dB)
100
80
60
40
20
0
I_L = 50mA
C_L = 1μF
V_IN = V_OUT + 1
10x10^0
100x10^0
1x10^3
10x10^3
100x10^3
1x10^6
FREQUENCY (Hz)

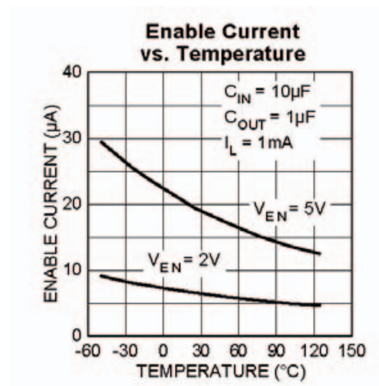

Output Impedance
1000
100
10
1
0.1
0.01
OUTPUT IMPEDANCE (Ω)
I_L = 100µA
I_L = 1mA
I_L = 50mA
1x10⁰
10x10⁰
100x10⁰
1x10³
10x10³
100x10³
1x10⁶
FREQUENCY (Hz)

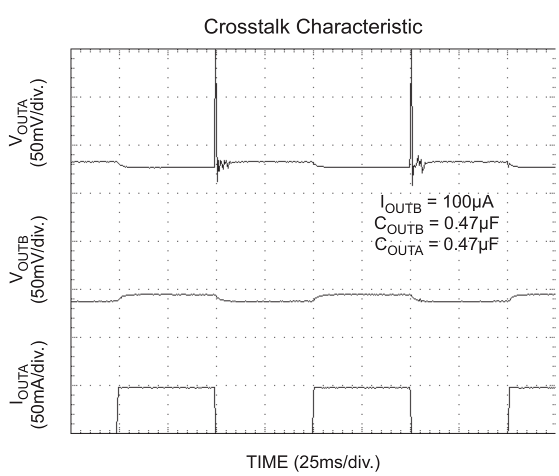

Enable Characteristics
(MIC5211-3.3)
4.0
3.0
2.0
1.0
0.0
OUTPUT (V)
ENABLE (V)
2
0
C_L = 1µF
I_L = 100µA
0
2
4
6
8
10
TIME (µs)


Enable Characteristics
(MIC5211-3.3)
5
4
3
2
1
0
O
E
2
0
C_L = 1µF
I_L = 100µA
0.0
0.2
0.4
0.6
0.8
1.0
TIME (ms)


Minimum Supply Voltage
vs. Temperature
3.5
3.4
3.3
MIN. SUPPLY VOLTAGE (V)
I_L = 1mA
V_{OUT} = 3.3V
C_{IN} = 10µF
C_{OUT} = 1µF
-60
-30
0
30
60
90
120
150
TEMPERATURE (°C)


Enable Voltage
vs. Temperature
1.50
1.25
1.00
0.75
0.50
ENABLE VOLTAGE (mV)
C_{IN} = 10µF
C_{OUT} = 1µF
I_L = 1mA
V_{ON}
V_{OFF}
-60
-30
0
30
60
90
120
150
TEMPERATURE (°C)


Enable Current
vs. Temperature
40
30
20
10
0
ENABLE CURRENT (µA)
C_{IN} = 10µF
C_{OUT} = 1µF
I_L = 1mA
V_{EN} = 5V
V_{EN} = 2V
-60
-30
0
30
60
90
120
150
TEMPERATURE (°C)


Crosstalk Characteristic
V_{OUTA} (50mV/div.)
V_{OUTB} (50mV/div.)
I_{OUTA} (50mA/div.)
I_{OUTB} = 100µA
C_{OUTB} = 0.47µF
C_{OUTA} = 0.47µF
TIME (25ms/div.)

Applications Information

Enable/Shutdown

ENA and ENB (enable/shutdown) may be controlled separately. Forcing ENA/B high (>2V) enables the regulator. The enable inputs typically draw only 15μA.

While the logic threshold is TTL/CMOS compatible, ENA/B may be forced as high as 20V, independent of V_{IN}. ENA/B may be connected to the supply if the function is not required.

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 MIC5211 is ultrastable, requiring only 0.1μF of output capacitance per regulator 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.

The capacitor should have a resonant frequency above 500kHz. Ceramic capacitors work, but some dielectrics have poor temperature coefficients, which will affect the value of the output capacitor over temperature. Tantalum capacitors are much more stable over temperature, but typically are larger and more expensive. Aluminum electrolytic capacitors will also work, but they have electrolytes that freeze at about –30°C. Tantalum or ceramic capacitors are recommended for operation below –25°C.

No-Load Stability

The MIC5211 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.

Thermal Shutdown

Thermal shutdown is independent on both halves of the dual MIC5211, however, an overtemperature condition in one half may affect the other half because of proximity.

Thermal Considerations

When designing with a dual low-dropout regulator, both sections must be considered for proper operation. The part is designed with thermal shutdown, therefore, the maximum junction temperature must not be exceeded. Since the dual regulators share the same substrate, the total power dissipation must be considered to avoid thermal shutdown. Simple thermal calculations based on the power dissipation of both regulators will allow the user to determine the conditions for proper operation.

The maximum power dissipation for the total regulator system can be determined using the operating temperatures and the thermal resistance of the package. In a minimum footprint configuration, the SOT-23-6 junction-to-ambient thermal resistance (θ_{JA}) is 220°C/W. Since the maximum junction temperature for this device is 125°C, at an operating temperature of 25°C the maximum power dissipation is:

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

$$P_{D(max)} = \frac{125°C - 25°C}{220°C/W}$$

$$P_{D(max)} = 455mW$$

The MIC5211-3.0 can supply 3V to two different loads independently from the same supply voltage. If one of the regulators is supplying 50mA at 3V from an input voltage of 4V, the total power dissipation in this portion of the regulator is:

$$P_{D1} = (V_{IN} - V_{OUT})\ I_{OUT} + V_{IN} \bullet I_{GND}$$

$$P_{D1} = (4V - 3V)\ 50mA + 4V \bullet 0.85mA$$

$$P_{D1} = 53.4mW$$

Up to approximately 400mW can be dissipated by the remaining regulator (455mW – 53.4mW) before reaching the thermal shutdown temperature, allowing up to 50mA of current.

$$P_{D2} = (V_{IN} - V_{OUT})\ I_{OUT} + V_{IN} \bullet I_{GND}$$

$$P_{D2} = (4V - 3V)\ 50mA + 4V \bullet 0.85mA$$

$$P_{D2} = 53.4mW$$

The total power dissipation is:

$$P_{D1} + P_{D2} = 53.4mW + 53.4mW$$

$$P_{D1} + P_{D2} = 106.8mW$$

Therefore, with a supply voltage of 4V, both outputs can operate safely at room temperature and full load (50mA).

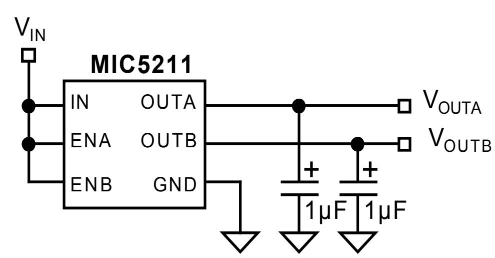


Figure 1. Thermal Conditions Circuit

In many applications, the ambient temperature is much higher. By recalculating the maximum power dissipation at 70°C ambient, it can be determined if both outputs can supply full load when powered by a 4V supply.

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

$$P_{D(max)} = \frac{125°C - 70°C}{220°C/W}$$

$$P_{D(max)} = 250mW$$

At 70°C, the device can provide 250mW of power dissipation, suitable for the above application.

When using supply voltages higher than 4V, do not exceed the maximum power dissipation for the device. If the device is operating from a 7.2V-nominal two-cell lithium-ion battery and both regulators are dropping the voltage to 3.0V, then output current will be limited at higher ambient temperatures.

For example, at 70°C ambient the first regulator can supply 3.0V at 50mA output from a 7.2V supply; however, the second regulator will have limitations on output current to avoid thermal shutdown. The dissipation of the first regulator is:

$$P_{D1} = (7.2V - 3V)\ 50mA + 7.2V \cdot 0.85mA$$

$$P_{D1} = 216mW$$

Since maximum power dissipation for the dual regulator is 250mW at 70°C, the second regulator can only dissipate up to 34mW without going into thermal shutdown. The amount of current the second regulator can supply is:

$$P_{D2(max)} = 34mW$$

$$(7.2V - 3V)\ I_{OUT2(max)} = 34mW$$

$$4.2V \bullet I_{OUT2(max)} = 34mW$$

$$I_{OUT2(max)} = 8mA$$

The second regulator can provide up to 8mA output current, suitable for the keep-alive circuitry often required in handheld applications.

Refer to Application Hint 17 for heat sink requirements when higher power dissipation capability is needed. Refer to Designing with Low Dropout Voltage Regulators for a more thorough discussion of regulator thermal characteristics.

Dual-Voltage Considerations

For configurations where two different voltages are needed in the system, the MIC5211 has the option of having two independent output voltages from the same input. For example, a 3.3V rail and a 5.0V rail can be supplied from the MIC5211 for systems that require both voltages. Important considerations must be taken to ensure proper functionality of the part. The input voltage must be high enough for the 5V section to operate correctly, this will ensure the 3.3V section proper operation as well.

Both regulators live off of the same input voltage, therefore the amount of output current each regulator supplies may be limited thermally. The maximum power the MIC5211 can dissipate at room temperature is 455mW, as shown in the "Thermal Considerations" section. If we assume 6V input voltage and 50mA of output current for the 3.3V section of the regulator, then the amount of output current the 5V section can provide can be calculated based on the power dissipation.

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

$$P_{D(3.3V)} = (6V - 3.3V)\ 50mA + 6V \cdot 0.85mA$$

$$P_{D(3.3V)} = 140.1mW$$

$$P_{D(max)} = 455mW$$

$$P_{D(max)} - P_{D(3.3V)} = P_{D(5V)}$$

$$P_{D(5V)} = 455mW - 140.1mW$$

$$P_{D(5V)} = 314.9mW$$

Based on the power dissipation allowed for the 5V section, the amount of output current it can source is easily calculated.

$$P_{D(5V)} = 314.9mW$$

$$314.9mW = (6V - 5V)\ I_{MAX} - 6V \cdot I_{GND}$$

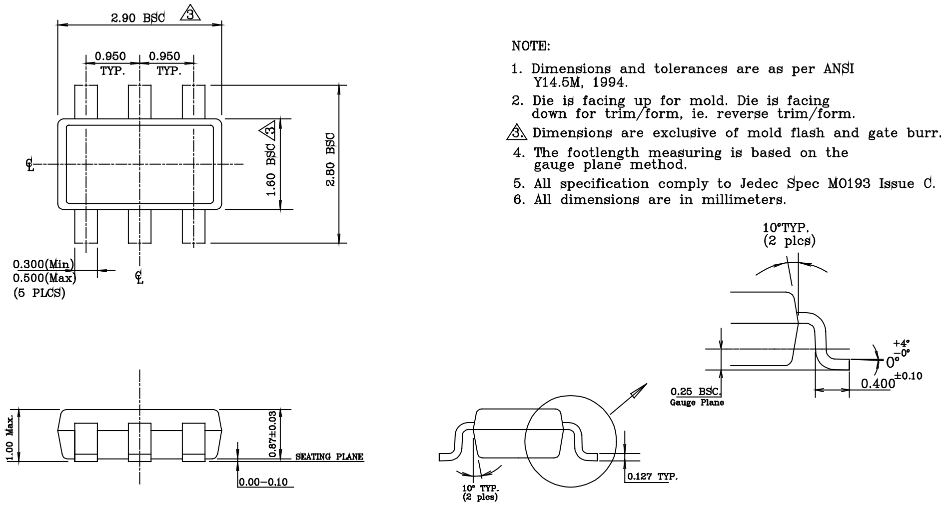
(I_{GND} typically adds less than 5% to the total power dissipation and in this case can be ignored)

$$314.9mW = (6V - 5V)\ I_{MAX}$$

$$I_{MAX} = 314.9mA$$

I_{MAX} exceeds the maximum current rating of the device. Therefore, for this condition, the MIC5211 can supply 50mA of output current from each section of the regulator.

Package Information



SOT-23-6 (M6)

MICREL INC. 2180 FORTUNE DRIVE SAN JOSE, CA 95131 USA
TEL + 1 (408) 944-0800 FAX + 1 (408) 474-1000 WEB http://www.micrel.com