MIC5205

150 mA Low-Noise LDO Regulator

Features

- Ultra-Low Noise Output
- High Output Voltage Accuracy
- Guaranteed 150 mA Output
- Low Quiescent Current
- Low Dropout Voltage
- Extremely Tight Load and Line Regulation
- Very Low Temperature Coefficient
- Current and Thermal Limiting
- Reverse-Battery Protection
- Zero Off-Mode Current
- Logic-Controlled Electronic Enable

Applications

- Cellular Telephones
- Laptop, Notebook, and Palmtop Computers
- Battery-Powered Equipment
- PCMCIA V_{CC} and V_{PP} Regulation/Switching
- Consumer/Personal Electronics
- SMPS Post-Regulator and DC/DC Modules
- High-Efficiency Linear Power Supplies

General Description

The MIC5205 is an efficient linear voltage regulator with ultra low-noise output, very low dropout voltage (typically 17 mV at light loads and 165 mV at 150 mA), and very low ground current (600 µA at 100 mA output). The MIC5205 offers better than 1% initial accuracy.

Designed especially for hand-held, battery-powered devices, the MIC5205 includes a CMOS or TTL compatible enable/shutdown control input. When shut down, power consumption drops nearly to zero. Regulator ground current increases only slightly in dropout, further prolonging battery life.

Key MIC5205 features include a reference bypass pin to improve its already excellent low-noise performance, reversed-battery protection, current limiting, and overtemperature shutdown.

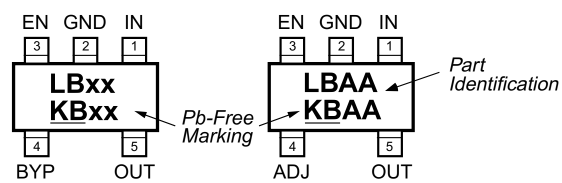
The MIC5205 is available in fixed and adjustable output voltage versions in a small SOT-23-5 package.

For low-dropout regulators that are stable with ceramic output capacitors, see the µCap MIC5245/6/7 family.

Package Type

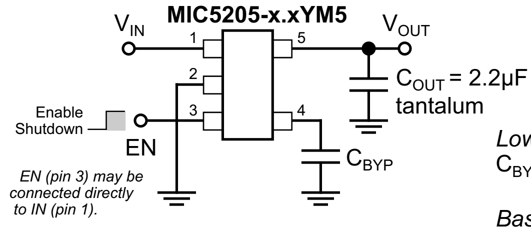
MIC5205

5-Lead SOT-23 (M5)



Typical Application Circuit

MIC5205
5-Lead SOT-23

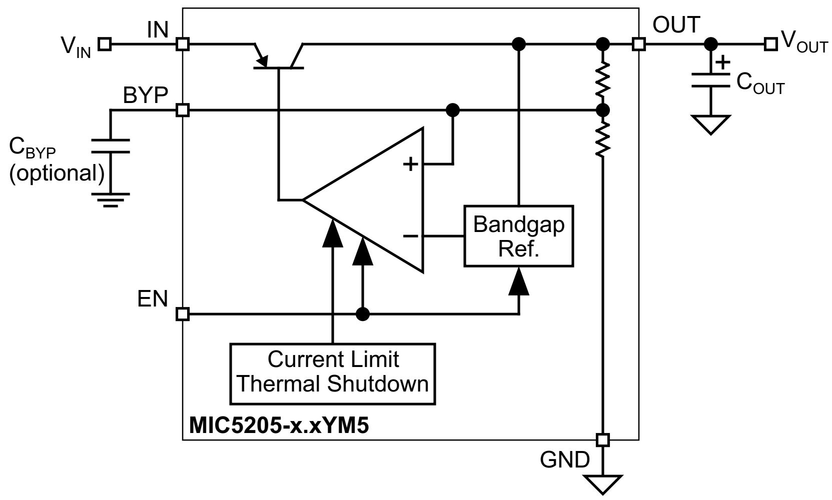


Low-Noise Operation:
C_{BYP} = 470pF, C_{OUT} ≥ 2.2µF

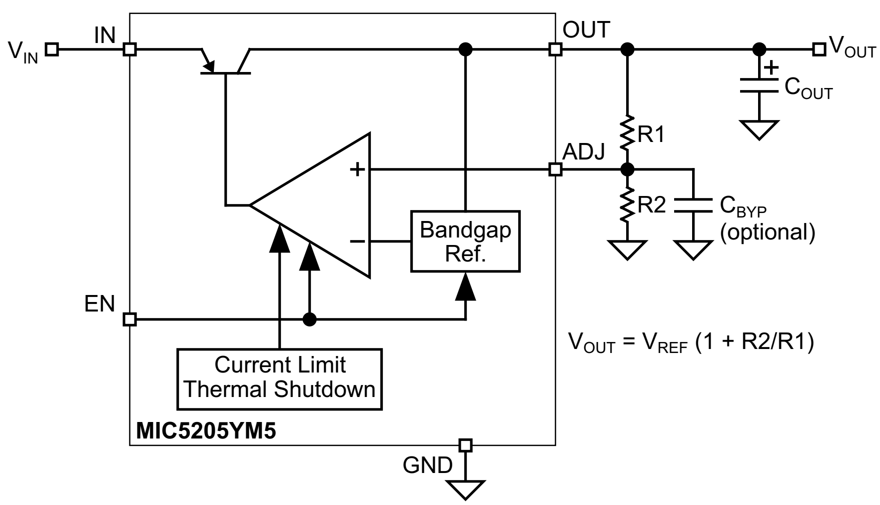
Basic Operation:
C_{BYP} = not used, C_{OUT} ≥ 1µF

Functional Block Diagrams

Ultra-Low Noise Fixed Regulator



Ultra-Low Noise Adjustable Regulator



$V_{OUT} = V_{REF}$ (1 + R2/R1)

1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Input Voltage (V_{IN}) .... –20V to +20V
Enable Input Voltage (V_{EN}) .... –20V to +20V
Power Dissipation (P_D) (Note 1) .... Internally Limited

Operating Ratings ‡

Supply Input Voltage (V_{IN}) .... +2.5V to +16V
Enable Input Voltage (V_{EN}) .... 0V to V_{IN}

† Notice: Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational sections of this specification is not intended. Exposure to maximum rating conditions for extended periods may affect device reliability.

‡ Notice: The device is not guaranteed to function outside its operating ratings.

Note 1: 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} of the MIC5205-xxYM5 (all versions) is 220°C/W mounted on a PC board.

TABLE 1-1: ELECTRICAL CHARACTERISTICS

Electrical Characteristics: $V_{IN} = V_{OUT}$ +1V; I_L = 100 µA; C_L = 1.0 µF; V_{EN} ≥ 2.0V; T_J = +25°C, **bold** values indicate –40°C < T_J < +125°C, unless noted.

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Output Voltage Accuracy	V_O	–1	—	1	%	Variation from specified V_{OUT}
		–2	—	**2**		
Output Voltage Temperature Coefficient	$\Delta V_O/\Delta T$	—	40	—	ppm/°C	Note 1
Line Regulation	$\Delta V_O/V_O$	—	0.004	0.012	%/V	$V_{IN} = V_{OUT}$ + 1V to 16V
		—	—	**0.05**		
Load Regulation	$\Delta V_O/V_O$	—	0.02	0.2	%	I_L = 0.1 mA to 150 mA, Note 2
		—	—	**0.5**		
Dropout Voltage, Note 3	$V_{IN} – V_O$	—	10	50	mV	I_L = 100 µA
		—	—	**70**	mV	
		—	110	150	mV	I_L = 50 mA
		—	—	**230**	mV	
		—	140	250	mV	I_L = 100 mA
		—	—	**300**	mV	
		—	165	275	mV	I_L = 150 mA
		—	—	**350**	mV	
Quiescent Current	I_{GND}	—	0.01	1	µA	V_{EN} ≤ 0.4V (shutdown)
		—	—	**5**	µA	V_{EN} ≤ 0.18V (shutdown)

TABLE 1-1: ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: $V_{IN} = V_{OUT}$ +1V; I_L = 100 µA; C_L = 1.0 µF; $V_{EN} \geq 2.0V$; T_J = +25°C, **bold** values indicate –40°C < T_J < +125°C, unless noted.

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Ground Pin Current, Note 4	I_{GND}	—	80	125	µA	$V_{EN} \geq 2.0V$, I_L = 100 µA
		—	—	**150**	µA	
		—	350	600	µA	I_L = 50 mA
		—	—	**800**	µA	
		—	600	1000	µA	I_L = 100 mA
		—	—	**1500**	µA	
		—	1300	1900	µA	I_L = 150 mA
		—	—	**2500**	µA	
Ripple Rejection	PSRR	—	75	—	dB	Frequency = 100 Hz, I_L = 100 µA
Current Limit	I_{LIMIT}	—	320	500	mA	V_{OUT} = 0V
Thermal Regulation	$\Delta V_O/\Delta P_D$	—	0.05	—	%/W	Note 5
Output Noise	e_{NO}	—	260	—	nV/√Hz	I_L = 50 mA, C_L = 2.2 µF, 470 pF from BYP to GND
ENABLE Input						
Enable Input Logic-Low Voltage	V_{IL}	—	—	0.4	V	Regulator shutdown
		—	—	**0.18**		
Enable Input Logic-High Voltage	V_{IH}	**2.0**	—	—	V	Regulator enabled
Enable Input Current	I_{IL}	—	0.01	–1	µA	$V_{IL} \leq 0.4V$
		—	—	**–2**		$V_{IL} \leq 0.18V$
	I_{IH}	2	5	20		V_{IL} = 2.0V
		—	—	**25**		V_{IL} = 2.0V

Note 1: Output voltage temperature coefficient is defined as the worst case voltage change divided by the total temperature range.

2: Regulation is measured at constant junction temperature using low duty cycle pulse testing. Parts are tested for load regulation in the load range from 0.1 mA to 150 mA. Changes in output voltage due to heating effects are covered by the thermal regulation specification.

3: 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.

4: 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.

5: 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 150 mA load pulse at V_{IN} = 16V for t = 10 ms.

TEMPERATURE SPECIFICATIONS (Note 1)

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Junction Operating Temperature Range	T_J	–40	—	+125	°C	—
Storage Temperature Range	T_S	–65	—	+150	°C	—
Lead Temperature	—	—	—	+260	°C	Soldering, 5s
Package Thermal Resistances						
Thermal Resistance SOT-23-5	θ_{JA}	—	220	—	°C/W	Note 2
	θ_{JC}	—	130	—	°C/W	—

Note 1: The maximum allowable power dissipation is a function of ambient temperature, the maximum allowable junction temperature and the thermal resistance from junction to air (i.e., T_A, T_J, θ_{JA}). Exceeding the maximum allowable power dissipation will cause the device operating junction temperature to exceed the maximum +125°C rating. Sustained junction temperatures above +125°C can impact the device reliability.

2: 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} of the MIC5205-xxYM5 (all versions) is 220°C/W mounted on a PC board.

2.0 TYPICAL PERFORMANCE CURVES

Note:	The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

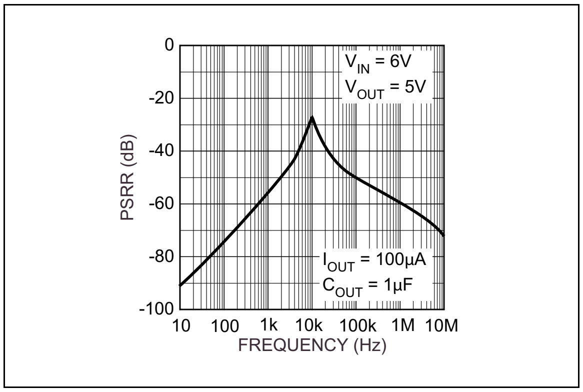


FIGURE 2-1: *Power Supply Rejection Ratio.*

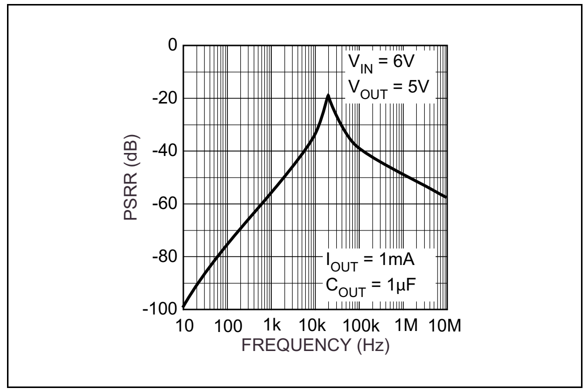


FIGURE 2-4: *Power Supply Rejection Ratio.*

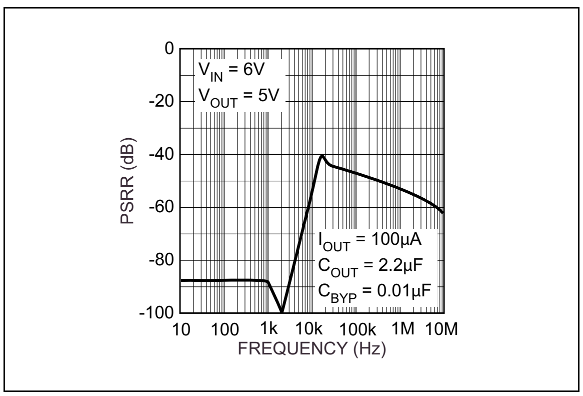


FIGURE 2-2: *Power Supply Rejection Ratio.*

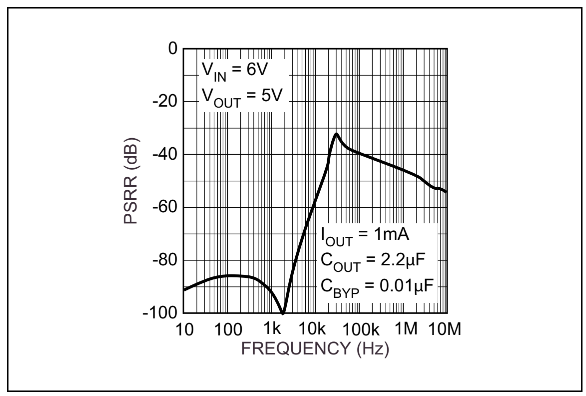


FIGURE 2-5: *Power Supply Rejection Ratio.*

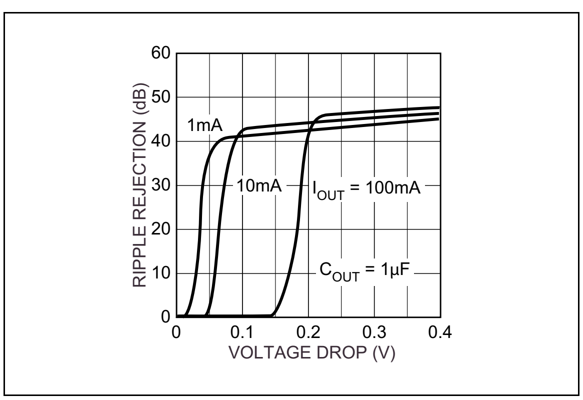


FIGURE 2-3: *Power Supply Ripple Rejection vs. Voltage Drop.*

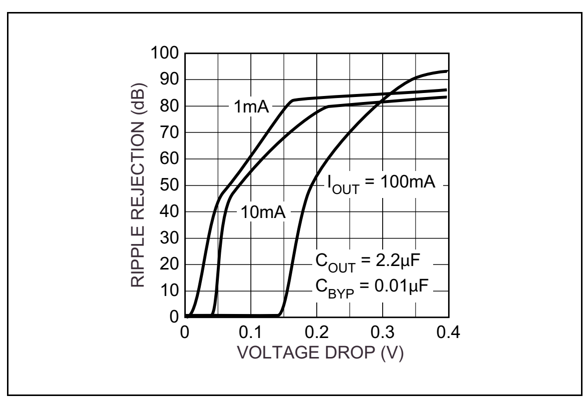


FIGURE 2-6: *Power Supply Ripple Rejection vs. Voltage Drop.*

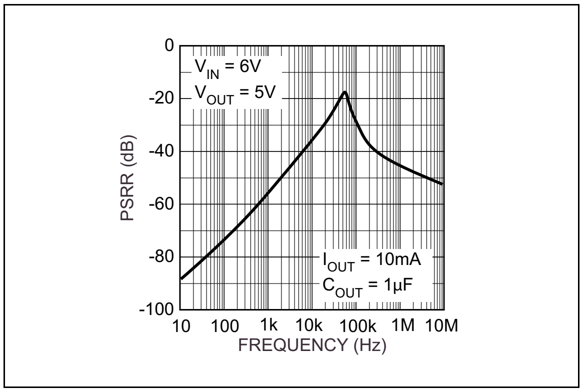


FIGURE 2-7: *Power Supply Rejection Ratio.*

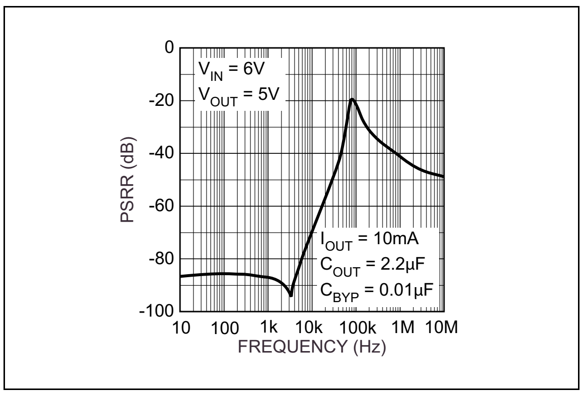


FIGURE 2-8: *Power Supply Rejection Ratio.*

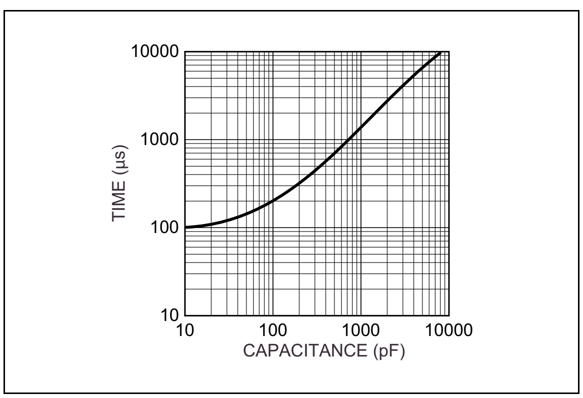


FIGURE 2-9: *Turn-On Time vs. Bypass Capacitance.*

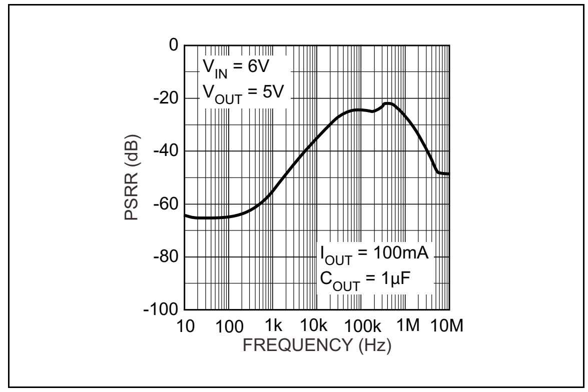


FIGURE 2-10: *Power Supply Rejection Ratio.*

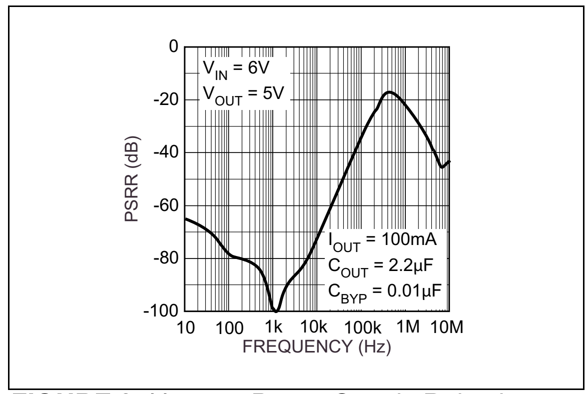


FIGURE 2-11: *Power Supply Rejection Ratio.*

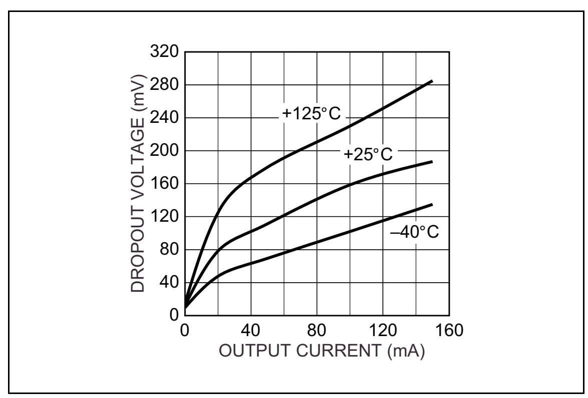


FIGURE 2-12: *Dropout Voltage vs. Output Current.*

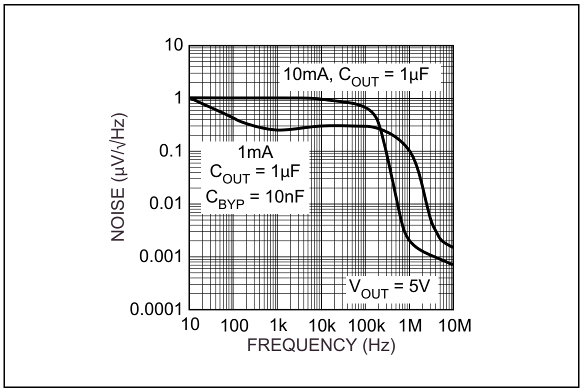


FIGURE 2-13: *Noise Performance.*

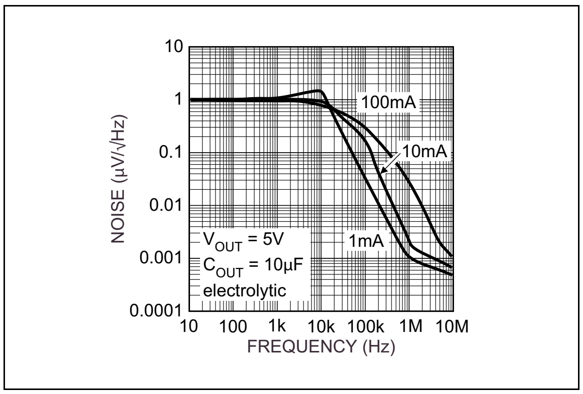


FIGURE 2-14: *Noise Performance.*

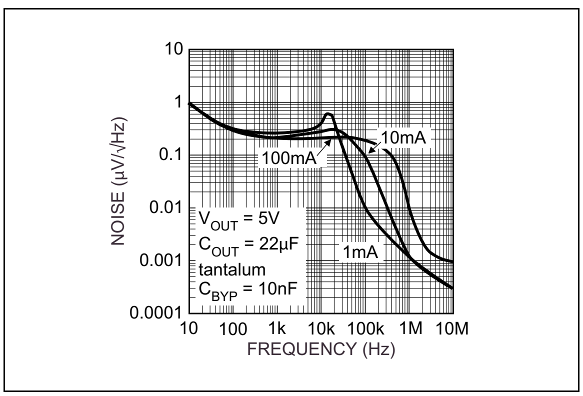


FIGURE 2-15: *Noise Performance.*

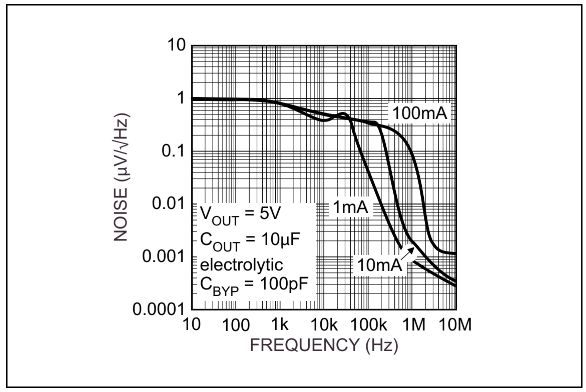


FIGURE 2-16: *Noise Performance.*

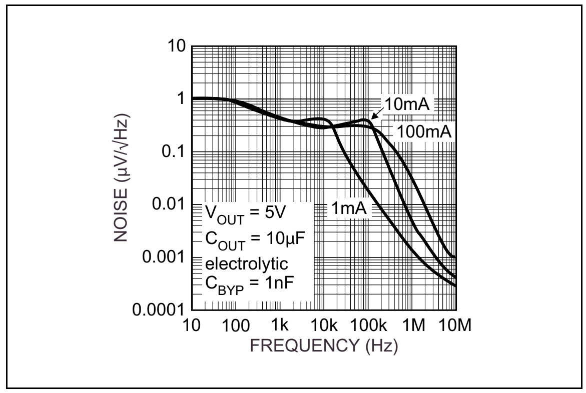


FIGURE 2-17: *Noise Performance.*

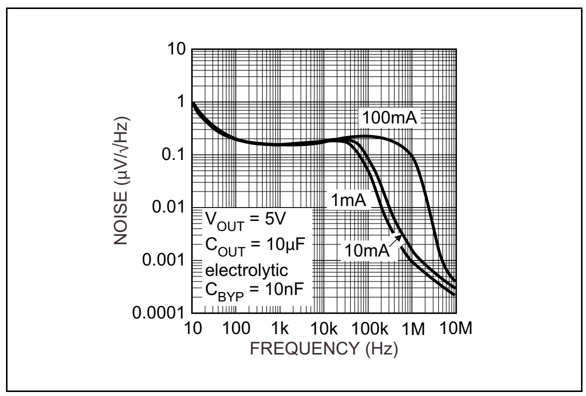


FIGURE 2-18: *Noise Performance.*

3.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in Table 3-1.

TABLE 3-1: PIN FUNCTION TABLE

Pin Number Fixed Version	Pin Number Adj. Version	Pin Name	Description
1	1	IN	Supply Input
2	2	GND	Ground
3	3	EN	Enable/Shutdown (Input): CMOS compatible input. Logic-high = enable, logic-low or open = shutdown
4	—	BYP	Reference Bypass: Connect external 470 pF capacitor to GND to reduce output noise. May be left open.
—	4	ADJ	Adjust (Input): Adjustable regulator feedback input. Connect to resistor voltage divider.
5	5	OUT	Regulator Output

4.0 APPLICATION INFORMATION

4.1 Enable/Shutdown

Forcing EN (enable/shutdown) high (greater than 2V) enables the regulator. EN is compatible with CMOS logic gates.

If the enable/shutdown feature is not required, connect EN (pin 3) to IN (supply input, pin 1). See Figure 4-1.

4.2 Input Capacitor

A 1 µF capacitor should be placed from IN to GND if there are more than 10 inches of wire between the input and the AC filter capacitor or if a battery is used as the input.

4.3 Reference Bypass Capacitor

BYP (reference bypass) is connected to the internal voltage reference. A 470 pF capacitor (C_{BYP}) connected from BYP to GND quiets this reference, providing a significant reduction in output noise. C_{BYP} reduces the regulator phase margin; when using C_{BYP}, output capacitors of 2.2 µF or greater are generally required to maintain stability.

The start-up speed of the MIC5205 is inversely proportional to the size of the reference bypass capacitor. Applications requiring a slow ramp-up of output voltage should consider larger values of C_{BYP}. Likewise, if rapid turn-on is necessary, consider omitting C_{BYP}.

If output noise is not a major concern, omit C_{BYP} and leave BYP open.

4.4 Output Capacitor

An output capacitor is required between OUT and GND to prevent oscillation. The minimum size of the output capacitor is dependent upon whether a reference bypass capacitor is used. 1.0 µF minimum is recommended when C_{BYP} is not used (see Figure 4-2). 2.2 µF minimum is recommended when C_{BYP} is 470 pF (see Figure 4-1). Larger values improve the regulator's transient response. The output capacitor value may be increased without limit.

The output capacitor should have an ESR (effective series resistance) of about 5Ω or less and a resonant frequency above 1 MHz. Ultra-low-ESR capacitors can cause a low amplitude oscillation on the output and/or underdamped transient response. Most tantalum or aluminum electrolytic capacitors are adequate; film types will work, but are more expensive. Because many aluminum electrolytics have electrolytes that freeze at about –30°C, solid tantalums are recommended for operation below –25°C.

At lower values of output current, less output capacitance is required for output stability. The capacitor can be reduced to 0.47 µF for current below 10 mA or 0.33 µF for currents below 1 mA.

4.5 No-Load Stability

The MIC5205 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.

4.6 Thermal Considerations

The MIC5205 is designed to provide 150 mA of continuous current in a very small 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:

EQUATION 4-1:

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

$T_{J(MAX)}$ is the maximum junction temperature of the die, 125°C, and T_A is the ambient operating temperature. θ_{JA} is layout dependent; Table 4-1 shows examples of junction-to-ambient thermal resistance for the MIC5205.

TABLE 4-1: SOT-23-5 THERMAL RESISTANCE

Package	θ_{JA} Rec. Min. Footprint	θ_{JA} Square Copper Clad	θ_{JC}
SOT-23-5 (M5)	220°C/W	170°C/W	130°C/W

The actual power dissipation of the regulator circuit can be determined using the equation:

EQUATION 4-2:

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

Substituting $P_{D(MAX)}$ 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, when operating the MIC5205-3.3YM5 at room temperature with a minimum footprint layout, the maximum input voltage for a set output current can be determined as follows:

EQUATION 4-3:

$$P_{D(MAX)} = \frac{(125°C - 25°C)}{220°C/W} = 455mW$$

The junction-to-ambient thermal resistance for the minimum footprint is 220°C/W, from Table 4-1. The maximum power dissipation must not be exceeded for proper operation. Using the output voltage of 3.3V and an output current of 150 mA, the maximum input voltage can be determined. From the Electrical Characteristics table, the maximum ground current for 150 mA output current is 2500 µA or 2.5 mA.

EQUATION 4-4:

$$455mW = (V_{IN} - 3.3V) \times 150mA + V_{IN} \times 2.5mA$$

EQUATION 4-5:

$$455mW = V_{IN} \times 150mA - 495mW + V_{IN} \times 2.5mA$$

EQUATION 4-6:

$$950mW = V_{IN} \times 152.5mA$$

$V_{IN(MAX)}$ then equates out to 6.23V. Therefore, a 3.3V application at 150 mA of output current can accept a maximum input voltage of 6.2V in a SOT-23-5 package. For a full discussion of heat sinking and thermal effects on voltage regulators, refer to the Regulator Thermals section of Microchip's Designing with Low-Dropout Voltage Regulators handbook.

4.7 Fixed Regulator Applications

Figure 4-1 includes a 470 pF capacitor for low-noise operation and shows EN (pin 3) connected to IN (pin 1) for an application where enable/shutdown is not required. C_{OUT} = 2.2 µF minimum.

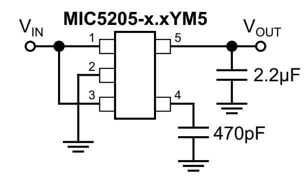


FIGURE 4-1: *Ultra-Low Noise Fixed Voltage Application.*

Figure 4-2 is an example of a low-noise configuration where C_{BYP} is not required. C_{OUT} = 1 µF minimum.

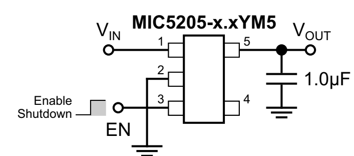


FIGURE 4-2: *Low Noise Fixed Voltage Application.*

4.8 Adjustable Regulator Applications

The MIC5205YM5 can be adjusted to a specific output voltage by using two external resistors (Figure 4-3). The resistors set the output voltage based on the following equation:

EQUATION 4-7:

$$V_{OUT} = 1.242V \times \left(\frac{R2}{R1} + 1\right)$$

This equation is correct due to the configuration of the bandgap reference. The bandgap voltage is relative to the output, as seen in the block diagram. Traditional regulators normally have the reference voltage relative to ground and have a different V_{OUT} equation.

Resistor values are not critical because ADJ (adjust) has a high input impedance, but for best results use resistors of 470 kΩ or less. A capacitor from ADJ to ground provides greatly improved noise performance.

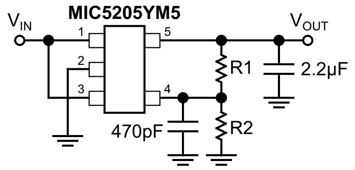


FIGURE 4-3: Ultra-Low Noise.

4.9 Adjustable Voltage Application

Figure 4-3 includes the optional 470 pF noise bypass capacitor from ADJ to GND to reduce output noise.

4.10 Dual-Supply Operation

When used in dual supply systems where the regulator load is returned to a negative supply, the output voltage must be diode clamped to ground.

5.0 PACKAGING INFORMATION

5.1 Package Marking Information

5-Lead SOT-23* (Fixed)	Example
XXXX NNN	KB33 943

5-Lead SOT-23* (Adjustable)	Example
XXXX NNN	KBAA 102

Legend:	XX...X	Product code or customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week '01')
	NNN	Alphanumeric traceability code
	e3	Pb-free JEDEC® designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator (e3) can be found on the outer packaging for this package.
	●, ▲, ▼	Pin one index is identified by a dot, delta up, or delta down (triangle mark).

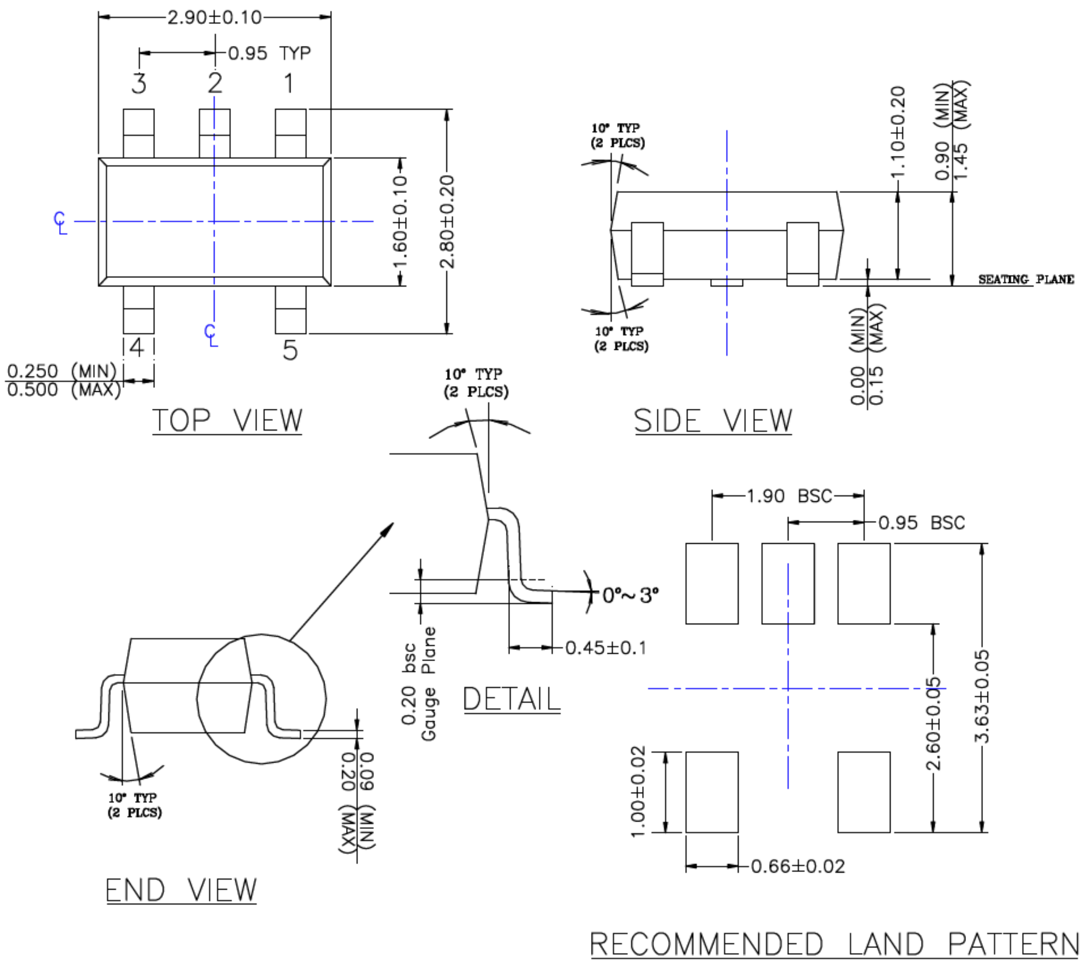
Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information. Package may or may not include the corporate logo.

Underbar (_) and/or Overbar (‾) symbol may not be to scale.

5-Lead SOT-23 Package Outline and Recommended Land Pattern

TITLE
5 LEAD SOT23 PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

DRAWING #	SOT23-5LD-PL-1	**UNIT**	MM



NOTE:
1. PACKAGE OUTLINE EXCLUSIVE OF MOLD FLASH & BURR.
2. PACKAGE OUTLINE INCLUSIVE OF SOLER PLATING.
3. DIMENSION AND TOLERANCE PER ANSI Y14.5M, 1982.
4. FOOT LENGTH MEASUREMENT BASED ON GAUGE PLANE METHOD.
5. DIE FACES UP FOR MOLD, AND FACES DOWN FOR TRIM/FORM.
6. ALL DIMENSIONS ARE IN MILLIMETERS.