MIC5387

Ultra-Small Triple 150mA Output LDO

General Description

The MIC5387 is an advanced, general-purpose, triple linear regulator offering high power supply rejection (PSRR) in an ultra-small, 6-pin, 1.6mm x 1.6mm Thin MLF® package. The MIC5387 is capable of 150mA from each output and offers high PSRR, making it an ideal solution for any portable electronic application.

Ideal for battery powered applications, the MIC5387 offers 2% initial accuracy, low dropout voltage (180mV @ 150mA), and low ground current (typically 32µA per output).

The MIC5387 is available in a lead-free (RoHS compliant) 1.6mm x 1.6mm 6-pin Thin MLF® occupying only 2.56mm^2 of PCB area, a 36% reduction in board area compared to a 2mm x 2mm Thin MLF® package.

The MIC5387 has an operating junction temperature range of –40°C to +125°C.

Datasheets and support documentation can be found on Micrel's web site at: www.micrel.com.

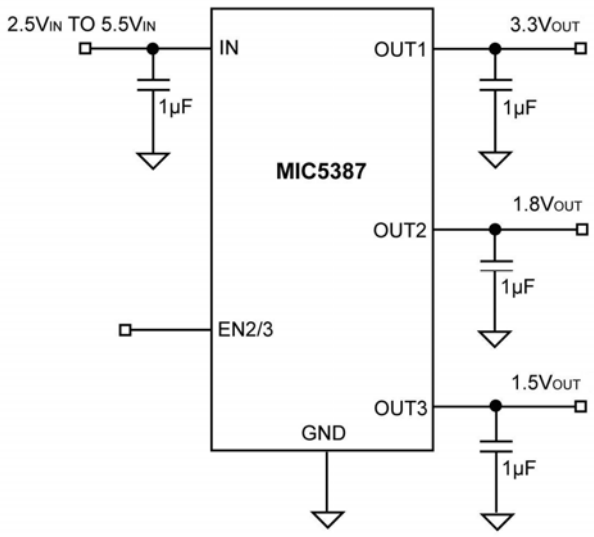
Features

- Input voltage range: 2.5V to 5.5V
- 150mA guaranteed output current for each output
- Stable with ceramic output capacitors
- Low dropout voltage: 180mV @ 150mA
- Excellent Load/Line Transient Response
- Low quiescent current: 32µA per LDO
- High PSRR: 70dB
- High output accuracy
  – ±2% initial accuracy
- Thermal-shutdown and current-limit protection
- Available in a tiny 6-pin 1.6mm x 1.6mm Thin MLF®

Applications

- Mobile phones
- Digital cameras
- GPS, PDAs, PMP
- Portable electronics

Typical Application



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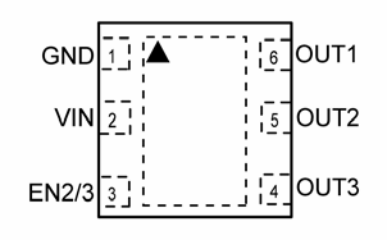
Ordering Information

Part Number	Marking Code	V_{OUT1}	V_{OUT2}	V_{OUT3}	Temperature Range	Package
MIC5387-SGFYMT	8A7	3.3V	1.8V	1.5V	–40°C to +125°C	6-Pin 1.6mm x 1.6mm Thin MLF®
MIC5387-SG4YMT	8B7	3.3V	1.8V	1.2V	–40°C to +125°C	6-Pin 1.6mm x 1.6mm Thin MLF®
MIC5387-GMGYMT	8C7	1.8V	2.8V	1.8V	–40°C to +125°C	6-Pin 1.6mm x 1.6mm Thin MLF®
MIC5387-GMMYMT	8D7	1.8V	2.8V	2.8V	–40°C to +125°C	6-Pin 1.6mm x 1.6mm Thin MLF®

Notes:

1. Other voltages available. Contact Micrel for details.
2. MLF® ▲ = Pin 1 identifier.
3. MLF® is a GREEN RoHS-compliant package. Lead finish is NiPdAu. Mold compound is Halogen Free.

Pin Configuration



6-Pin 1.6mm x 1.6mm Thin MLF® (MT)

Pin Description

Pin Number	Pin Names	Pin Function
1	GND	Ground for LDO1, 2 and 3.
2	VIN	Input supply for LDO1, 2 and 3.
3	EN2/3	Enable Input 2/3: Enables LDO2 AND LDO3, Active High. High = ON; Low = OFF. Do not leave floating.
4	OUT3	Output Voltage for LDO3.
5	OUT2	Output Voltage for LDO2.
6	OUT1	Output Voltage for LDO1.
EP	HS Pad	Exposed Heastsink Pad (connect to Ground plane for best thermal).

Absolute Maximum Ratings[1]

Supply Voltage (V_{IN}) ..... –0.3V to +6V
Enable Voltage ($V_{EN2/3}$) ..... –0.3V to V_{IN}
Power Dissipation (P_D) ..... Internally Limited[3]
Lead Temperature (soldering, 10sec) ..... 260°C
Junction Temperature (T_J) ..... –40°C to +150°C
Storage Temperature (T_s) ..... –65°C to +150°C
ESD Rating[4] 2kV

Operating Ratings[2]

Supply Voltage (V_{IN}) ..... 2.5V to 5.5V
Enable Voltage ($V_{EN2/3}$) ..... 0V to V_{IN}
Junction Temperature (T_J) ..... –40°C to +125°C
Junction Thermal Resistance
6-Pin 1.6mm x 1.6mm Thin MLF® (θ_{JA}) ..... 92.4°C/W

Electrical Characteristics[5]

$V_{IN} = V_{EN2/3} = V_{OUT} + 1V$; highest of the three outputs; $C_{IN} = C_{OUT1} = C_{OUT2} = C_{OUT3} = 1\mu F$; $I_{OUT1} = I_{OUT2} = I_{OUT3} = 100\mu A$; T_J = 25°C, **bold** values indicate –40°C to +125°C, unless noted.

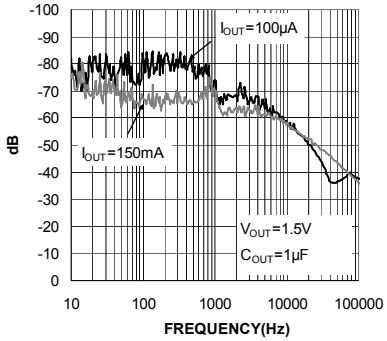
Parameter	Condition	Min.	Typ.	Max.	Units
Output Voltage Accuracy	Variation from nominal V_{OUT}	–2.0		+2.0	%
	Variation from nominal V_{OUT}; –40°C to +125°C	**–3.0**		**+3.0**	%
Line Regulation	$V_{IN} = V_{OUT}$ +1V to 5.5V; I_{OUT} = 100µA		0.02	**0.3**	%
Load Regulation[6]	I_{OUT} = 100µA to 150mA		0.65		%
Dropout Voltage[7]	I_{OUT} = 50mA; $V_{OUT} \geq$ 2.8V		55	**110**	mV
	I_{OUT} = 150mA; $V_{OUT} \geq$ 2.8V		155	**310**	mV
	I_{OUT} = 50mA; $V_{OUT} <$ 2.8V		60	**135**	mV
	I_{OUT} = 150mA; $V_{OUT} <$ 2.8V		180	**380**	mV
Ground Pin Current [8]	I_{OUT} = 0mA; $V_{EN2/3}$ = 0V , V_{OUT1} = On		32	**40**	µA
	I_{OUT} = 0mA; V_{OUT} > 1.3V $V_{EN2/3} = V_{IN}$		96	**120**	µA
Ripple Rejection	f = up to 1kHz; C_{OUT} = 1µF; $V_{OUT} <$ 2.5V		70		dB
	f = 1kHz – 10kHz; C_{OUT} = 1µF; $V_{OUT} <$ 2.5V		60		dB
Current Limit	V_{OUT} = 0V	200	325	550	mA
Output Voltage Noise	C_{OUT} = 1µF, 10Hz to 100kHz		200		μV_{RMS}
Enable Input					
Enable Input Voltage ($V_{EN2/3}$)	Logic Low			**0.2**	V
	Logic High	**1.2**			V
Enable Input Current ($V_{EN2/3}$)	$V_{IL} \leq$ 0.2V		0.01	**1**	µA
	$V_{IH} \geq$ 1.2V		0.01	**1**	µA
Turn-on Time (V_{OUT2}, V_{OUT3})	C_{OUT} = 1µF; I_{OUT} = 150mA		50	**125**	µs

Notes:

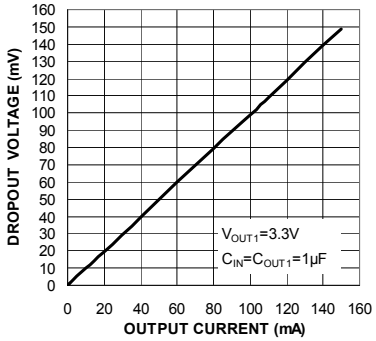
1. Exceeding the absolute maximum rating may damage the device.
2. The device is not guaranteed to function outside its operating rating.
3. The maximum allowable power dissipation of any T_A (ambient temperature) is $P_{D(max)} = (T_{J(max)} - T_A) / \theta_{JA}$. Exceeding the maximum allowable power dissipation will result in excessive die temperature, and the regulator will go into thermal shutdown.
4. Devices are ESD sensitive. Handling precautions recommended. Human body model, 1.5kΩ in series with 100pF.
5. Specification for packaged product only.
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.
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 outputs below 2.5V, dropout voltage is the input-to-output differential with the minimum input voltage 2.5V.
8. Ground-pin current is the regulator quiescent current. The total current drawn from the supply is the sum of the load current plus the ground-pin current.

Typical Characteristics

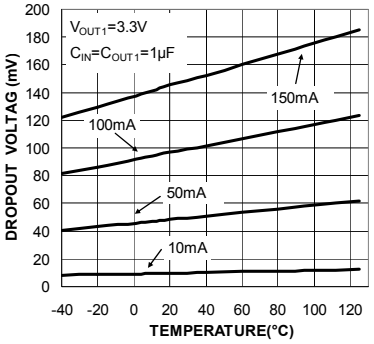
Power Supply Rejection Ratio (PSRR)



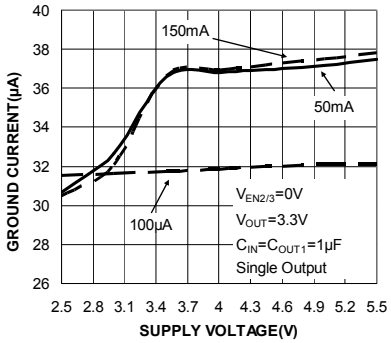
Dropout Voltage vs. Output Current



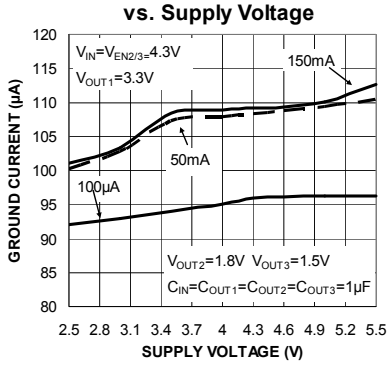
Dropout Voltage vs. Temperature



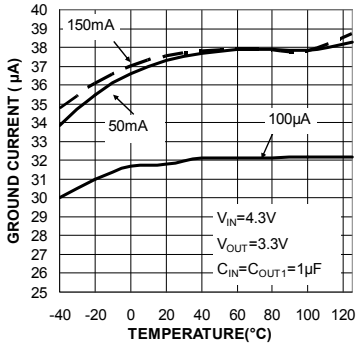
Ground Current (V_{OUT1}=3.3V) vs. Supply Voltage



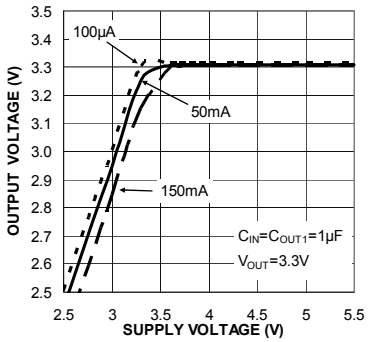
Ground Current (All V_{OUT}s) vs. Supply Voltage



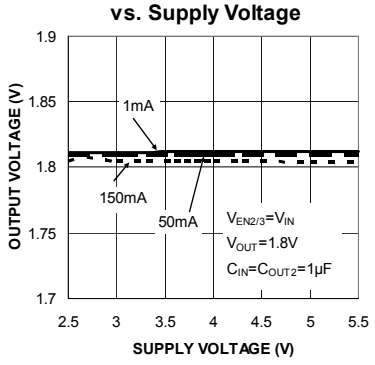
Ground Current (V_{OUT1}=3.3V) vs. Temperature



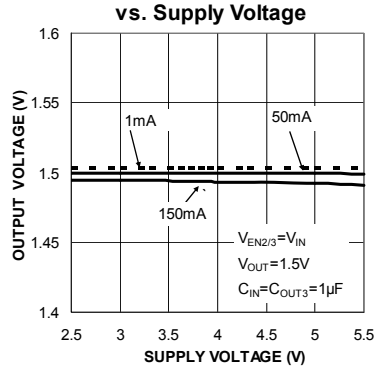
Output Voltage (V_{OUT1}=3.3V) vs. Supply Voltage



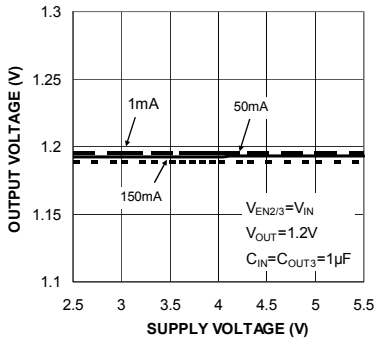
Output Voltage (V_{OUT2}=1.8V) vs. Supply Voltage



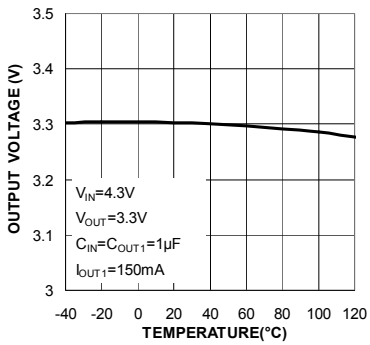
Output Voltage (V_{OUT3}=1.5V) vs. Supply Voltage



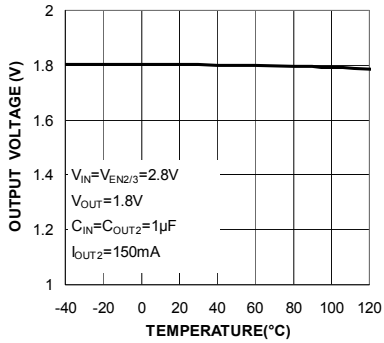
Output voltage (V_{OUT3}=1.2V) vs. Supply Voltage



Output Voltage (V_{OUT1}=3.3V) vs. Temperature

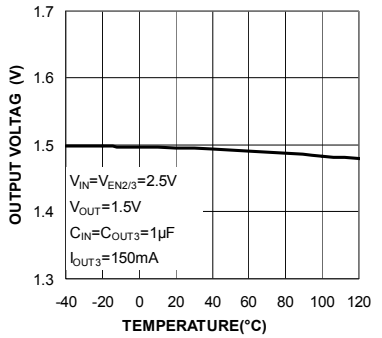


Output Voltage (V_{OUT2}=1.8V) vs. Temperature

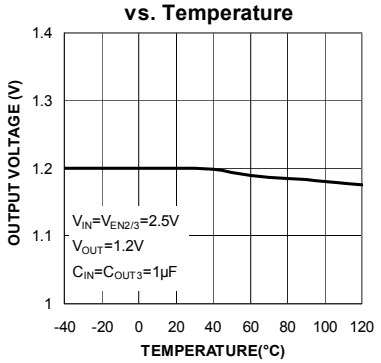


Typical Characteristics (Continued)

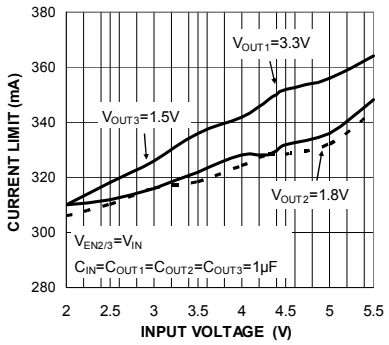
Output Voltage (V_{OUT3}=1.5V) vs. Temperature



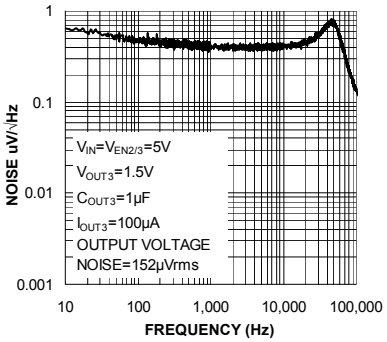
Output Voltage (V_{OUT}=1.2V) vs. Temperature



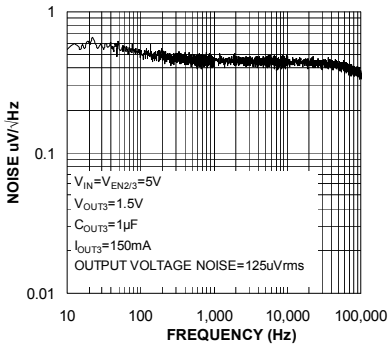
Current Limit vs. InputVoltage



Output Noise Spectral Density

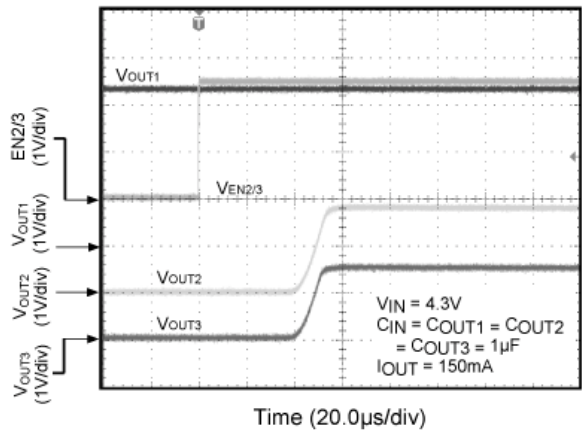


Output Noise SpectralDensity

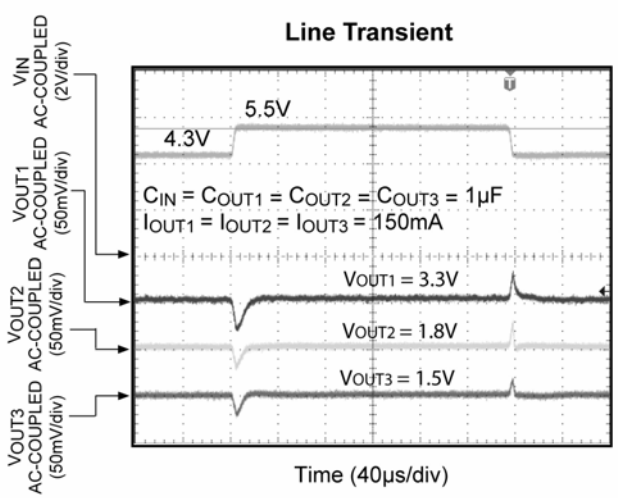


Functional Characteristics

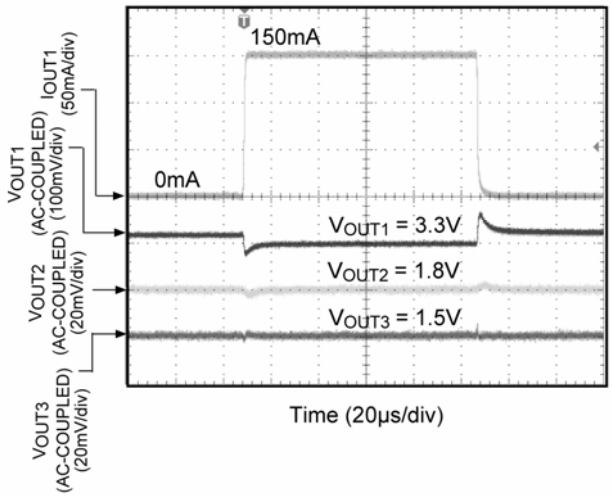
Start Up



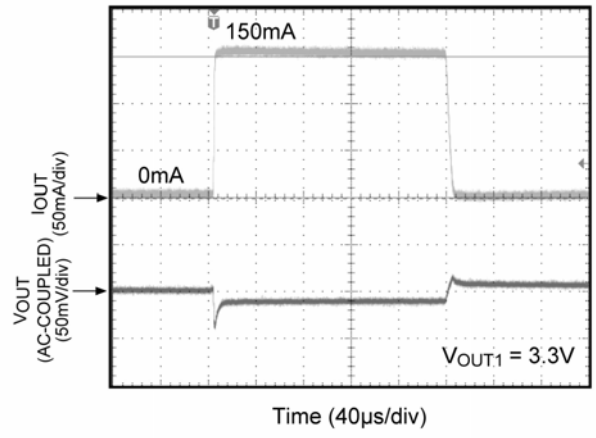
Line Transient



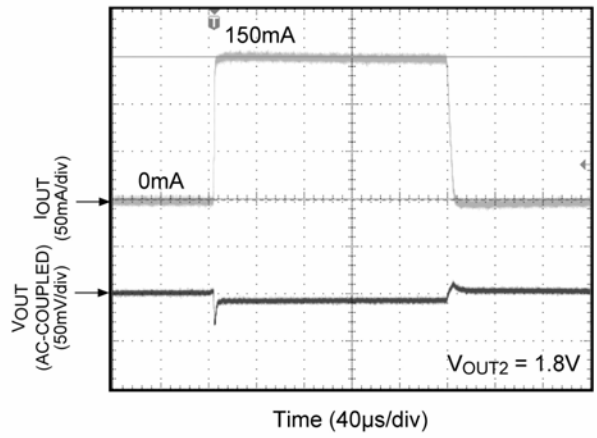
Load Transient (VOUT1)



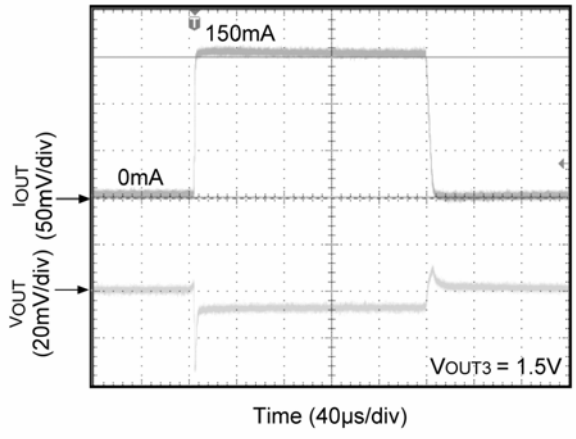
Load Transient (VOUT1)



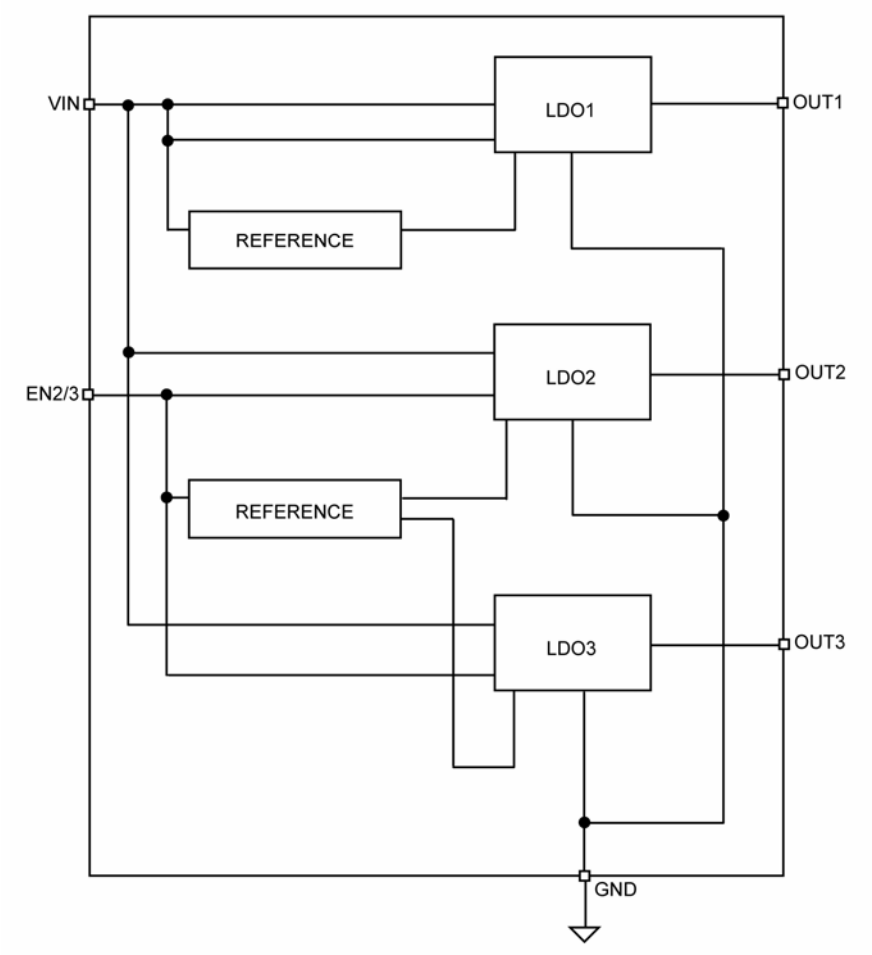
Load Transient (VOUT2)



Load Transient (VOUT3)



Block Diagram



Application Information

MIC5387 is a triple-output, low-noise 150mA LDO. The MIC5387 regulator is fully protected from damage due to fault conditions, offering linear current limiting and thermal shutdown.

Input Capacitor

The MIC5387 is a high-performance, high-bandwidth device. An input capacitor of 1µF is required from the input-to-ground to provide stability. Low-ESR ceramic capacitors provide optimal performance at a minimum of space. Additional high-frequency capacitors – such as small-valued NPO dielectric-type capacitors – help filter out high-frequency noise and are good practice in any RF-based circuit. X5R or X7R dielectrics are recommended for the input capacitor. Y5V dielectrics lose most of their capacitance over temperature and are, therefore, not recommended.

Output Capacitor

The MIC5387 requires an output capacitor of 1µF or greater for each output to maintain stability. The design is optimized for use with low-ESR ceramic chip capacitors. High-ESR capacitors are not recommended because they may cause high-frequency oscillation. The output capacitor can be increased, but performance has been optimized for a 1µF ceramic output capacitor and does not improve significantly with larger capacitance.

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 with Y5V dielectric, the value must be much higher than an X7R ceramic capacitor to ensure the same minimum capacitance over the equivalent operating temperature range.

No-Load Stability

Unlike many other voltage regulators, the MIC5387 will remain stable and in regulation with no load. This is especially important in CMOS RAM keep-alive applications.

Enable/Shutdown

The MIC5387 comes with an active-high enable (EN2/3) pin that allows the regulator to be disabled for outputs 2 and 3. Forcing the enable pin high enables the output voltage. The active-high enable pin uses CMOS technology and the enable pin cannot be left floating; a floating enable pin may cause an indeterminate state on the output. The output OUT1 does not have an enable pin and is always enabled when V_{IN} is above the minimum supply voltage of 2.5V.

Thermal Considerations

The MIC5387 is designed to provide three outputs up to 150mA each of continuous current in a very small package. Maximum ambient operating temperature can be calculated based on the output current and the voltage drop across the part. For example, if the input voltage is 3.3V and the output voltages are 1.8V, 2.8V and 2.8V each with an output current = 150mA. The actual power dissipation of the regulator circuit can be determined using the equation:

$$P_D = (V_{IN} - V_{OUT1})\, I_{OUT1} + (V_{IN} - V_{OUT2})\, I_{OUT2} + (V_{IN} - V_{OUT3})\, I_{OUT3} + V_{IN}\, I_{GND}$$

As the MIC5387 is a CMOS device, the ground current is typically <100µA over the load range, the power dissipation contributed by the ground current is <1% and may be ignored for this calculation:

$$P_D = (3.3V - 1.8V)150mA + (3.3V\text{-}2.8V)150mA + (3.3V - 2.8V)150mA$$

$$P_D = 0.375W$$

To determine the maximum ambient operating temperature of the package, use the junction-to-ambient thermal resistance of the device and the following basic equation:

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

$T_{J(MAX)}$ = 125°C, the maximum junction temperature of the die, and θ_{JA} thermal resistance = 92.4°C/W for the Thin MLF® package.

Substituting P_D for $P_{D(max)}$ and solving for the ambient operating temperature will give the maximum operating conditions for the regulator circuit.

The maximum power dissipation must not be exceeded for proper operation.

For example, when operating the MIC5387-SGFYMT at an input voltage of 3.3V and 450mA load with a minimum footprint layout, the maximum ambient operating temperature T_A can be determined as follows:

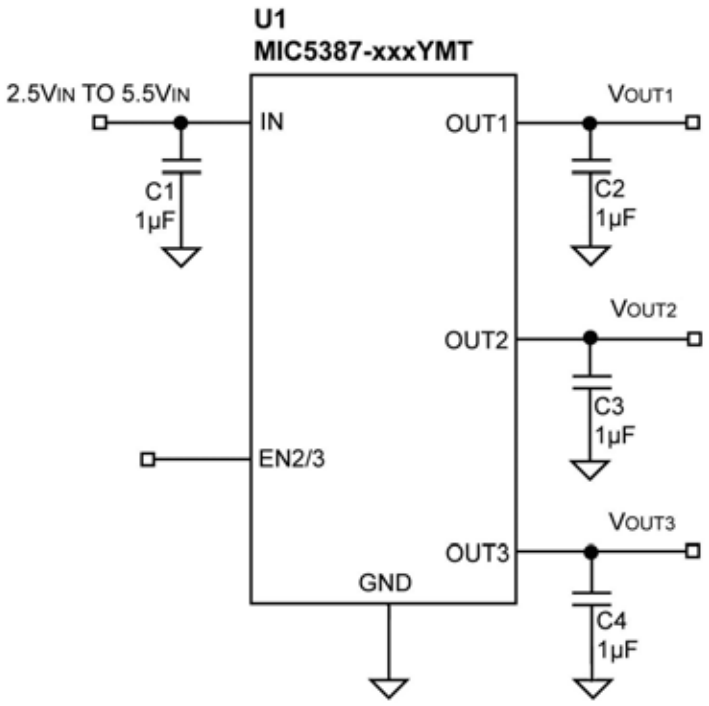
$$0.375W = (125°C - T_A) / (92.4°C/W)$$

$$T_A = 90.35°C$$

Therefore, the maximum ambient operating temperature of 90.35°C is allowed in a 1.6mm x 1.6mm thin MLF® package. For a full discussion of heat sinking and thermal effects on voltage regulators, refer to the "Regulator Thermals" section of *Micrel's Designing with Low-Dropout Voltage Regulators* handbook. This information can be found on Micrel's website at:

http://www.micrel.com/_PDF/other/LDOBk_ds.pdf

Typical Application



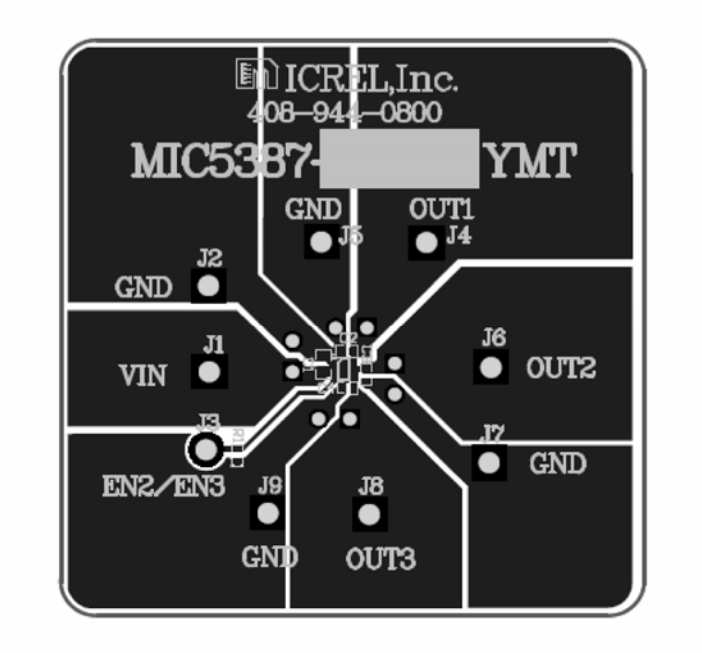
Bill of Materials

Item	Part Number	Manufacturer	Description	Qty.
C1,C2,C3,C4	C1005X5R1A105K	TDK(1)	Capacitor, 1µF Ceramic, 10V, X5R, Size 0402	4
U1	**MIC5387-xxxYMT**	**Micrel, Inc.(2)**	**Ultra-Small Triple 150mA Output LDO**	**1**

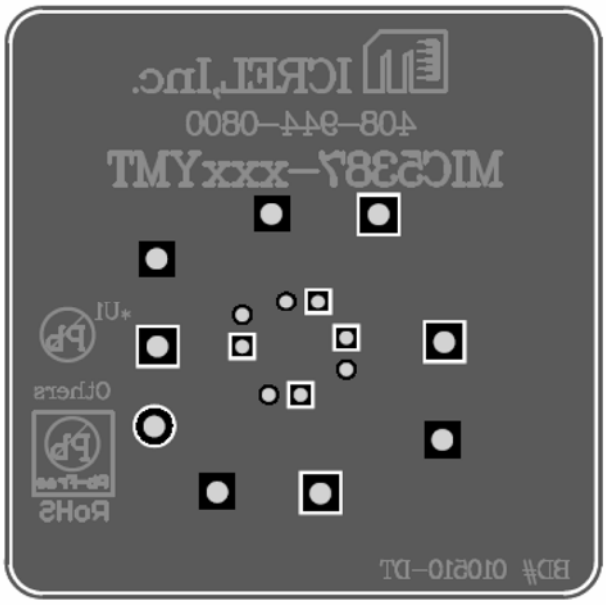
Notes:

1. TDK: www.tdk.com
2. **Micrel, Inc.: www.micrel.com**

PCB Layout Recommendations (1.6mm x 1.6mm Thin MLF®)

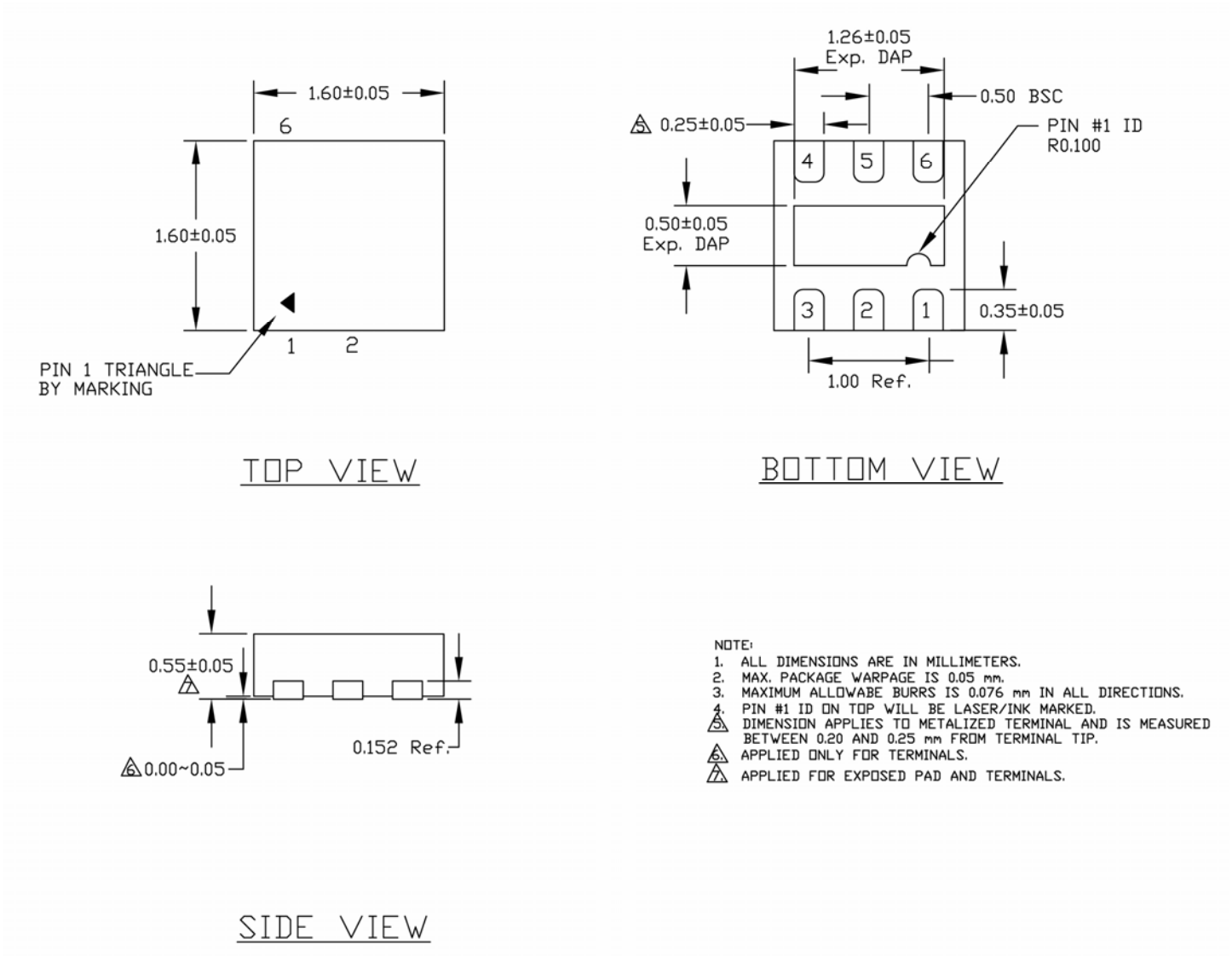


Top Layer



Bottom Layer

Package Information



6-Pin 1.6mm x 1.6mm Thin MLF® (MT)

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