MIC5247

150 mA Low Voltage µCap Linear Regulator

Features

- Ultra-Low Noise
- Low Voltage Outputs
- Load Independent, Ultra-Low Ground Current: 85 µA
- 150 mA Output Current
- Current Limiting
- Thermal Shutdown
- Tight Load and Line Regulation
- "Zero" Off-Mode Current
- Stability with Low-ESR Capacitors
- Fast Transient Response
- Logic-Controlled Enable Input

Applications

- Cellular Phones and Pagers
- Cellular Accessories
- Battery-Powered Equipment
- Laptop, Notebook, and Palmtop Computers
- PCMCIA VCC and VPP Regulation/Switching
- Consumer/Personal Electronics
- SMPS Post-Regulator/DC-to-DC Modules
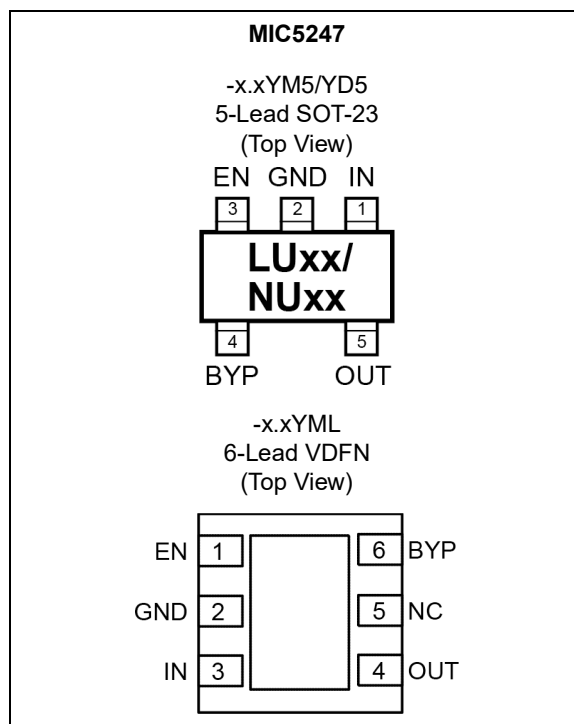- High-Efficiency Linear Power Supplies

General Description

The MIC5247 is an efficient and precise, low-voltage CMOS linear regulator optimized for ultra-low noise applications. The MIC5247 offers better than 1% initial accuracy and 85 µA constant ground current over load (typically 85 µA). The MIC5247 provides a very low-noise output, ideal for RF applications where quiet voltage sources are required. A noise bypass pin is also available for further reduction of output noise.

Designed specifically for handheld and battery-powered devices, the MIC5247 provides a logic compatible enable pin. When disabled, power consumption drops nearly to zero. The MIC5247 also works with low-ESR ceramic capacitors, reducing the amount of board space necessary for power applications, critical in handheld wireless devices.
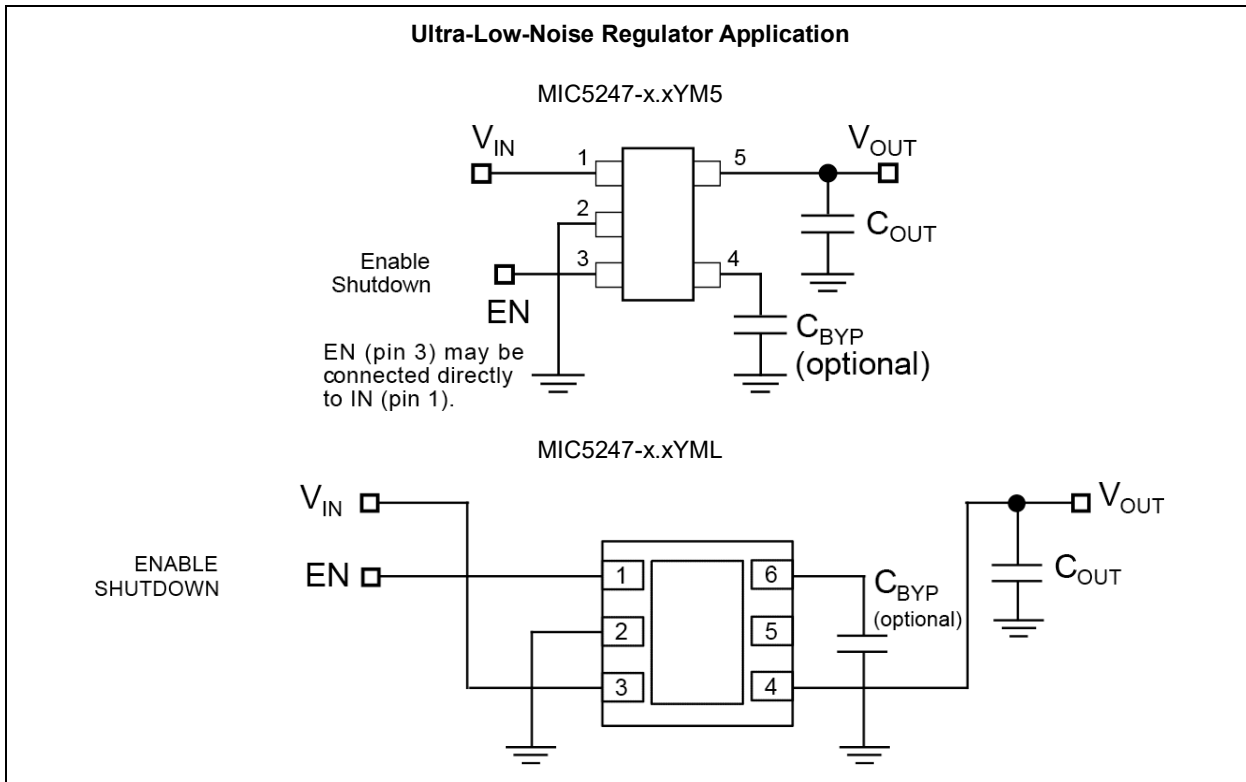
Key features include current limit, thermal shutdown, a push-pull output for faster transient response, and an active clamp to speed up device turnoff. Available in the 6-lead 2 mm × 2 mm VDFN package and the 5-lead SOT-23 package, the MIC5247 also offers a range of fixed output voltages.

Package Types

MIC5247
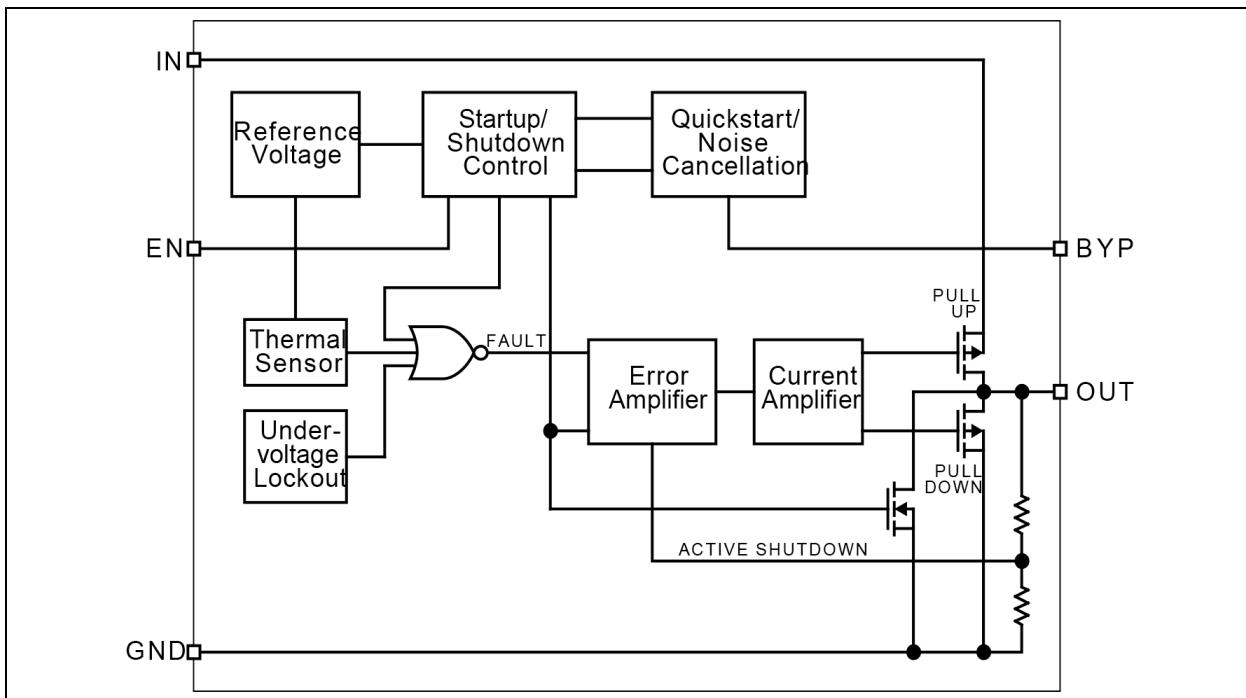
-x.xYM5/YD5
5-Lead SOT-23
(Top View)

LUxx/NUxx

-x.xYML
6-Lead VDFN
(Top View)

MIC5247

Typical Application Circuits

Ultra-Low-Noise Regulator Application

MIC5247-x.xYM5

EN (pin 3) may be connected directly to IN (pin 1).

MIC5247-x.xYML

Functional Block Diagram

1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Input Voltage (V_{IN}) .... 0V to +7V
Enable Input Voltage (V_{EN}) .... 0V to V_{IN}
ESD Rating .... Note 1

Operating Ratings ‡

Input Voltage (V_{IN}) .... +2.7V to +6V
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: Devices are ESD sensitive. Handling precautions recommended.

ELECTRICAL CHARACTERISTICS

$V_{IN} = V_{OUT} + 1.0V$; $V_{IN} = V_{EN}$; $I_{OUT} = 100$ μA; $T_J = 25°C$, **bold** values valid for $-40°C ≤ T_J ≤ +125°C$; unless noted. (See Note 1)

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Output Voltage Accuracy	V_O	−1	—	+1	%	$I_{OUT} = 0$ mA
		−2	—	**+2**		
Line Regulation	ΔV_{LNR}	−0.3	—	+0.3	%/V	$V_{IN} = 2.7V$ to 6V
Load Regulation	ΔV_{LDR}	—	2	3	%	$I_{OUT} = 0.1$ mA to 150 mA (Note 2)
		—	3	4	%	$I_{OUT} = 0.1$ mA to 150 mA, $V_{OUT} = 1.5V$ or 1.6V
Dropout Voltage	$V_{IN} - V_{OUT}$	—	150	—	mV	$I_{OUT} = 150$ mA (Note 3)
Quiescent Current	I_Q	—	0.2	1	μA	$V_{EN} ≤ 0.4V$ (shutdown)
Ground Pin Current (Note 4)	I_{GND}	—	85	150	μA	$I_{OUT} = 0$ mA
		—	85	150	μA	$I_{OUT} = 150$ mA
Power Supply Rejection	PSRR	—	50	—	dB	$f ≤ 1$ kHz
Current Limit	I_{LIM}	160	300	—	mA	$V_{OUT} = 0V$
Output Voltage Noise	e_n	—	30	—	μVrms	COUT = 10 μF, CBYP = 0.01 μF, f = 10 Hz to 100 kHz
Enable Input						
Enable Input Logic-Low Voltage	V_{IL}	—	0.8	**0.4**	V	$V_{IN} = 2.7V$ to 5.5V, regulator shutdown
Enable Input Logic-High Voltage	V_{IH}	**1.6**	1	—	V	$V_{IN} = 2.7V$ to 5.5V, regulator enabled
Enable Input Current	I_{EN}	—	0.01	—	μA	$V_{IL} ≤ 0.4V$
		—	0.01	—	μA	$V_{IH} ≥ 1.6V$
Shutdown Resistance Discharge	—	—	500	—	Ω	—

MIC5247

ELECTRICAL CHARACTERISTICS

$V_{IN} = V_{OUT} + 1.0V$; $V_{IN} = V_{EN}$; $I_{OUT} = 100 \ \mu A$; $T_J = 25°C$, **bold** values valid for $-40°C \leq T_J \leq +125°C$; unless noted. (See Note 1)

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Thermal Protection						
Thermal Shutdown Temperature	—	—	+150	—	°C	—
Thermal Shutdown Hysteresis	—	—	+10	—	°C	—

Note 1: Specification for packaged product only.

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 a 1V differential. For outputs below 2.7V, dropout voltage is the input-to-output voltage differential with the minimum input voltage 2.7V. Minimum input operating voltage is 2.7V.

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.

TEMPERATURE SPECIFICATIONS (Note 1)

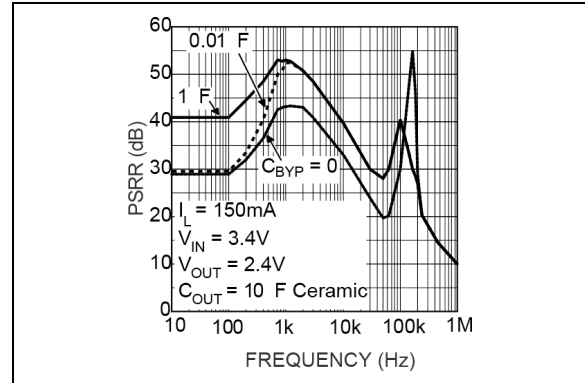| Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Operating Junction Temperature Range	T_J	–40	—	+125	°C	—
Maximum Junction Temperature	$T_{J(MAX)}$	—	—	+150	°C	—
Lead Temperature	—	—	—	+260	°C	Soldering, 5 seconds
Storage Temperature	T_S	–65	—	+150	°C	—
Package Thermal Resistance						
Thermal Resistance, 5-Lead SOT-23	θ_{JA}	—	+235	—	°C/W	—
Thermal Resistance, 6-Lead VDFN	θ_{JA}	—	+90	—	°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 rating. Sustained junction temperatures above that maximum can impact device reliability.
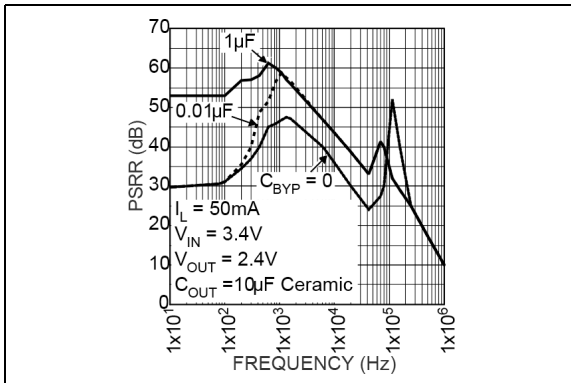
2.0 TYPICAL PERFORMANCE CURVES

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.
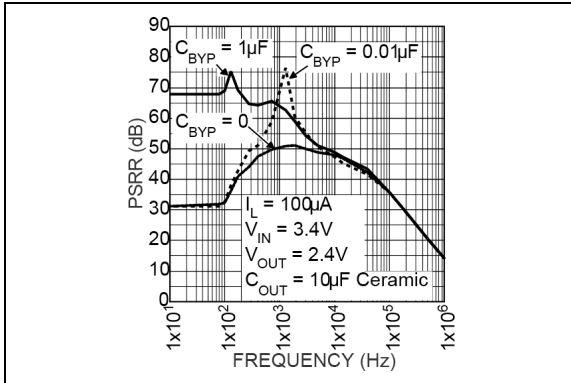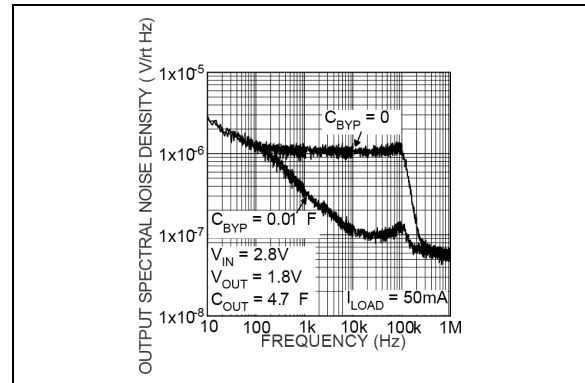

FIGURE 2-1: Power Supply Rejection Ratio.

FIGURE 2-2: Power Supply Rejection Ratio.

FIGURE 2-3: Power Supply Rejection Ratio.

FIGURE 2-4: Power Supply Rejection Ratio.

FIGURE 2-5: Noise Performance.
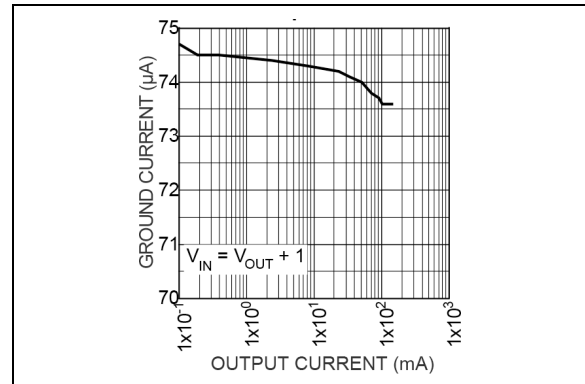
FIGURE 2-6: Ground Current vs. Output Current.

MIC5247
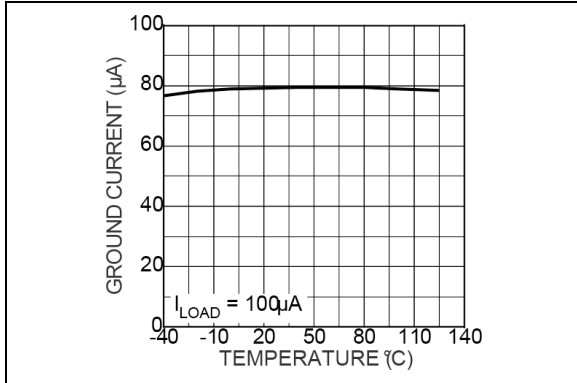
FIGURE 2-7: *Ground Pin Current.*
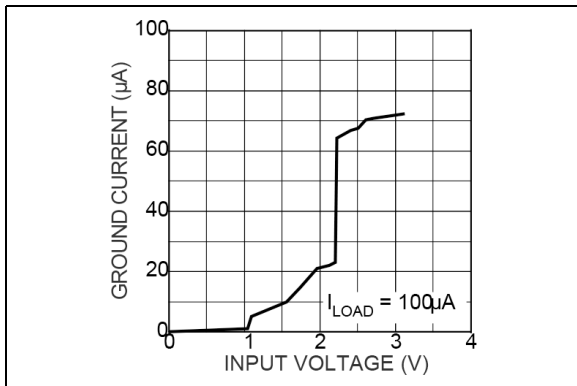

FIGURE 2-8: *Ground Pin Current.*

FIGURE 2-9: *Ground Pin Current.*
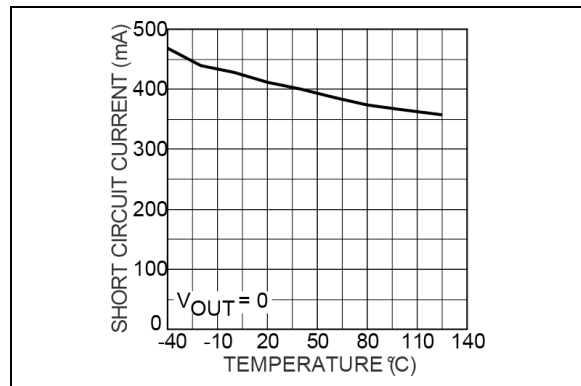

FIGURE 2-10: *Ground Pin Current.*
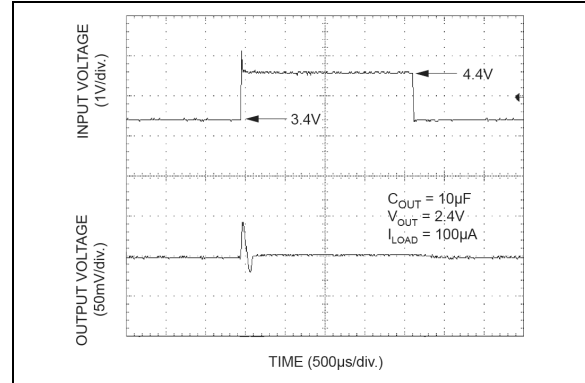

FIGURE 2-11: *Dropout Characteristics.*
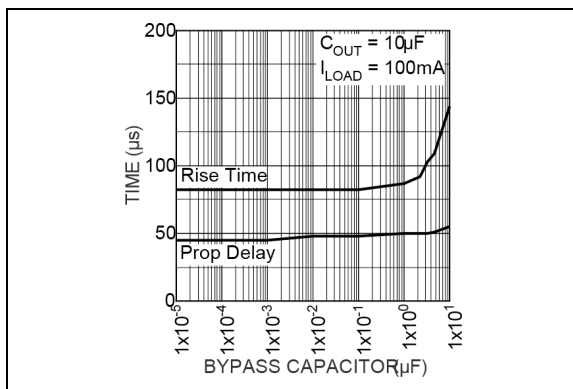

FIGURE 2-12: *Short Circuit Current vs. Temperature.*
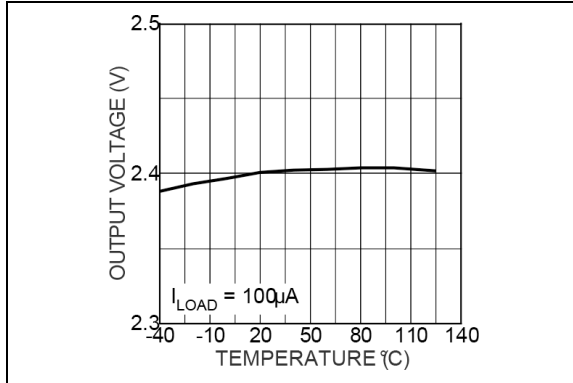
FIGURE 2-13: *Output Voltage vs. Temperature.*

FIGURE 2-14: *Turn-On Time vs. Bypass Capacitor.*
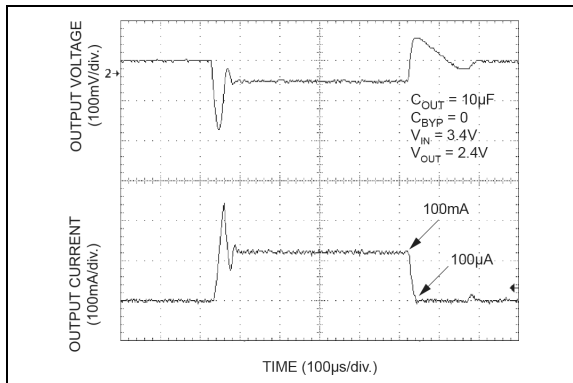
FIGURE 2-15: *Load Transient Response.*

FIGURE 2-16: *Line Transient Response.*

MIC5247

3.0 PIN DESCRIPTIONS

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

TABLE 3-1: PIN FUNCTION TABLE

Pin Number 5-Lead SOT-23	Pin Number 6-Lead VDFN	Pin Name	Description
1	3	IN	Supply Input.
2	2	GND	Ground.
3	1	EN	Enable/Shutdown (Input): CMOS-compatible input. Logic high = enable; logic low = shutdown. Do not leave open.
4	6	BYP	Reference Bypass: Connect external 0.01 µF capacitor to GND to reduce output noise. May be left open.
5	4	OUT	Regulator Output.
—	5	NC	No Internal Connection.
—	EP	GND	Ground. Internally connected to the exposed pad. Connect to ground pin.

4.0 APPLICATION INFORMATION

4.1 Enable/Shutdown

The MIC5247 comes with an active-high enable pin that can disable the regulator. Forcing the enable pin low disables the regulator and sends it into a "zero" off-mode-current state. In this state, current consumed by the regulator goes nearly to zero. Forcing the enable pin high enables the output voltage.

This part is CMOS and the enable pin cannot be left floating, because a floating enable pin may cause an indeterminate state on the output.

4.2 Input Capacitor

An input capacitor is not required for stability. A 1 µF input capacitor is recommended when the bulk AC supply capacitance is more than 10 inches away from the device or when the supply is a battery.

4.3 Output Capacitor

The MIC5247 requires an output capacitor for stability. The design requires 1 µF or greater on the output to maintain stability. The capacitor can be a low-ESR ceramic chip capacitor.

The MIC5247 has been designed to work specifically with low-cost, small chip capacitors. Tantalum capacitors can also be used for improved capacitance over temperature. The value of the capacitor can be increased without bound.

4.4 Bypass Capacitor

A capacitor can be placed from the noise bypass pin to ground to reduce output voltage noise. The capacitor bypasses the internal reference. A 0.01 µF capacitor is recommended for applications that require low-noise outputs.

The bypass capacitor can be increased without bound, further reducing noise and improving PSRR. Turn-on time remains constant with respect to bypass capacitance. Refer to Figure 2-14.

4.5 Transient Response

The MIC5247 implements a unique output stage to dramatically improve transient response recovery time. The output is a push-pull configuration with a P-Channel MOSFET pass device and an N-Channel MOSFET clamp. The N-Channel clamp is a significantly smaller device that prevents the output voltage from overshooting when a heavy load is removed.

This feature helps to speed up the transient response by significantly decreasing transient response recovery time during the transition from heavy load (100 mA) to light load (85 µA).

4.6 Active Shutdown

The MIC5247 also features an active shutdown clamp, which is an N-Channel MOSFET that turns on when the device is disabled. This allows the output capacitor and load to discharge, de-energizing the load.

4.7 Thermal Considerations

The MIC5247 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:

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

$T_{J(MAX)}$ 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 MIC5247.

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

Package	θ_{JA} Recommended Minimum Footprint	θ_{JA} 1" Square Copper Clad	θ_{JC}
5-Lead SOT-23	235°C/W	185°C/W	145°C/W

The actual power dissipation of the regulator circuit can be determined using Figure 4-2:

EQUATION 4-2:

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

MIC5247

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 MIC5247-2.4YM5 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:

$$P_{D(MAX)} = \left(\frac{125°C - 25°C}{235°C/W} \right)$$

Where:

$P_{D(MAX)} = 425 \text{ mW}$

The junction-to-ambient thermal resistance for the minimum footprint is 235°C/W, from Table 4-1. The maximum power dissipation must not be exceeded for proper operation. Using the output voltage of 2.4V and an output current of 150 mA, the maximum input voltage can be determined. Because this device is CMOS and the ground current is typically 100 µA over the load range, the power dissipation contributed by the ground current is < 1% and can be ignored for this calculation.

EQUATION 4-4:

$$425\,mW = (V_{IN} - 2.4V) \times 150\,mA$$
$$425\,mW = V_{IN} \times 150\,mA - 360\,mW$$
$$785\,mW = V_{IN} \times 150\,mA$$
$$V_{IN(MAX)} = 5.2\,V$$

Therefore, a 2.4V application at 150mA of output current can accept a maximum input voltage of 5.2V in a 5-Lead SOT-23 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.

4.8   Fixed Regulator Applications
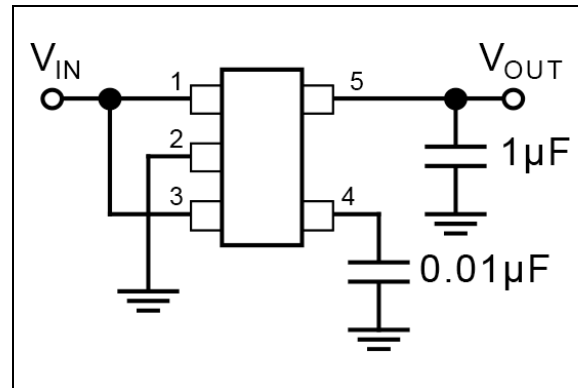
FIGURE 4-1:   MIC5247-x.xYM5, *Ultra-Low-Noise Fixed Voltage Application.*

Figure 4-1 includes a 0.01 µF 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} = 1 µF minimum.
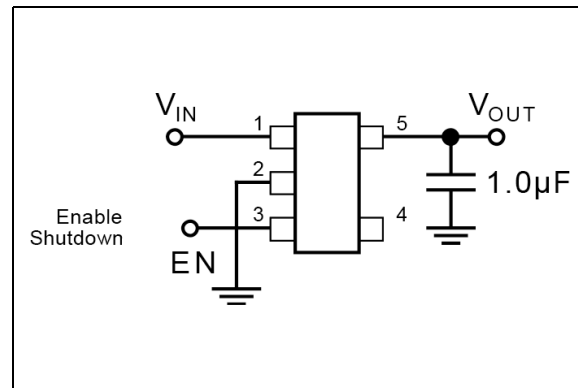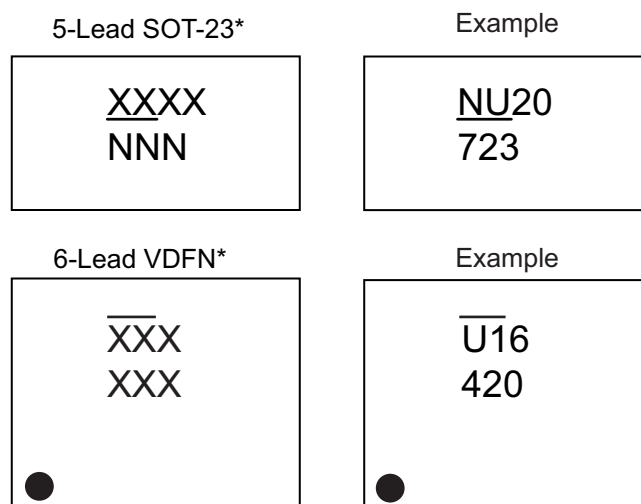

FIGURE 4-2:   MIC5247-x.xYM5, *Low-Noise Fixed Voltage Application.*

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

5.0   PACKAGING INFORMATION

5.1   Package Marking Information

5-Lead SOT-23*

XXXX
NNN

Example

NU20
723

6-Lead VDFN*

X̄X̄X̄
XXX
●

Example

Ū16
420
●

TABLE 5-1:   ORDERING INFORMATION

Pb Free	Marking	Voltage	Pb Free	Marking	Voltage
MIC5247-1.5YM5	LU15	1.5V	MIC5247-1.8YD5	NU18	1.8V
MIC5247-1.6YM5	LU16	1.6V	MIC5247-2.0YD5	NU20	2.0V
MIC5247-1.8YM5	LU18	1.8V	MIC5247-1.5YML	Ū15	1.5V
MIC5247-1.85YM5	LU1J	1.85V	MIC5247-1.6YML	Ū16	1.6V
MIC5247-2.0YM5	LU20	2.0V	MIC5247-1.8YML	Ū18	1.8V
MIC5247-2.4YM5	LU24	2.4V	MIC5247-1.85YML	Ū1J	1.85V

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.

MIC5247

6-Lead VDFN Package Outline and Recommended Land Pattern

MICROCHIP

6-Lead Very Thin Plastic Dual Flat, No Lead Package (JDA) - 2x2 mm Body [VDFN]
Micrel Legacy Package

**Note:** For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging

TOP VIEW

SIDE VIEW

BOTTOM VIEW
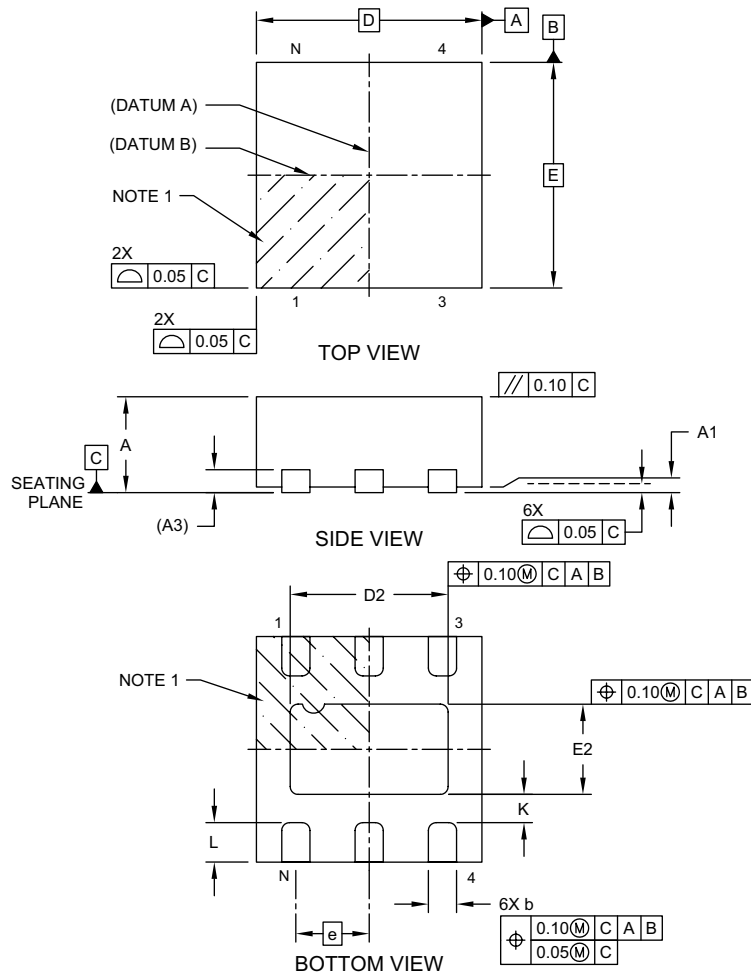
Microchip Technology Drawing C04-1016A Sheet 1 of 2

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6-Lead Very Thin Plastic Dual Flat, No Lead Package (JDA) - 2x2 mm Body [VDFN]
Micrel Legacy Package

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging
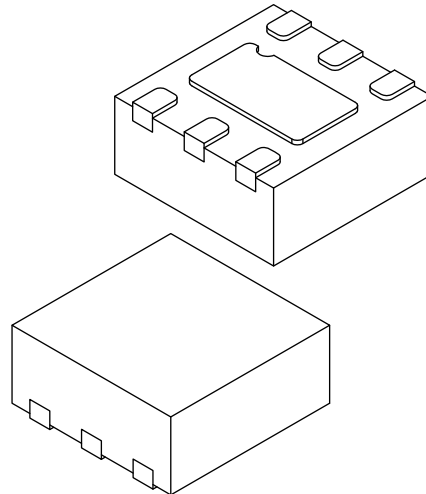
Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Terminals	N		6	
Pitch	e		0.65 BSC	
Overall Height	A	0.80	0.85	0.90
Standoff	A1	0.00	0.02	0.05
Terminal Thickness	A3		0.203 REF	
Overall Length	D		2.00 BSC	
Exposed Pad Length	D2	1.35	1.40	1.45
Overall Width	E		2.00 BSC	
Exposed Pad Width	E2	0.75	0.80	0.85
Terminal Width	b	0.20	0.25	0.30
Terminal Length	L	0.30	0.35	0.40
Terminal-to-Exposed-Pad	K	0.20	-	-

Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Package is saw singulated
3. Dimensioning and tolerancing per ASME Y14.5M

    BSC: Basic Dimension. Theoretically exact value shown without tolerances.
    REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-1016A Sheet 2 of 2

MIC5247

6-Lead Very Thin Plastic Dual Flat, No Lead Package (JDA) - 2x2 mm Body [VDFN]
Micrel Legacy Package

Note: For the most current package drawings, please see the Microchip Packaging Specification located at
http://www.microchip.com/packaging
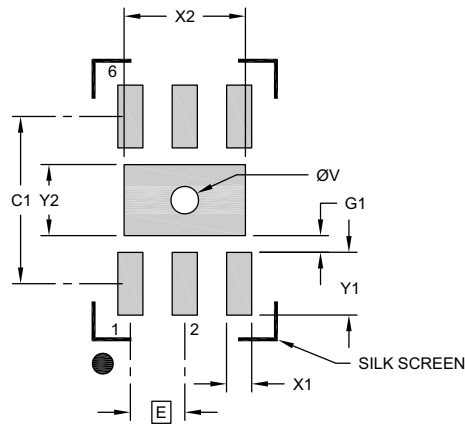
RECOMMENDED LAND PATTERN

	Units	MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Contact Pitch	E		0.65 BSC	
Optional Center Pad Width	X2			0.85
Optional Center Pad Length	Y2			1.45
Contact Pad Spacing	C1		2.00	
Contact Pad Width (X6)	X1			0.30
Contact Pad Length (X6)	Y1			0.75
Contact Pad to Center Pad (X6)	G1	0.20		
Thermal Via Diameter	V	0.27	0.30	0.33

Notes:
1. Dimensioning and tolerancing per ASME Y14.5M
    BSC: Basic Dimension. Theoretically exact value shown without tolerances.
2. For best soldering results, thermal vias, if used, should be filled or tented to avoid solder loss during
   reflow process

Microchip Technology Drawing C04-21016A

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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

TOP VIEW

2.90±0.10
0.95 TYP
3 2 1
1.60±0.10
2.80±0.20
0.250 (MIN)
0.500 (MAX)

SIDE VIEW

10° TYP
(2 PLCS)
10° TYP
(2 PLCS)
1.10±0.20
0.90 (MIN)
1.45 (MAX)
SEATING PLANE
0.00 (MIN)
0.15 (MAX)

DETAIL

10° TYP
(2 PLCS)
0.20 bsc
Gauge Plane
0°~ 3°
0.45±0.1

END VIEW

10° TYP
(2 PLCS)
0.60 (MIN)
0.20 (MAX)

RECOMMENDED LAND PATTERN

1.90 BSC
0.95 BSC
2.60±0.05
3.63±0.05
1.00±0.02
0.66±0.02
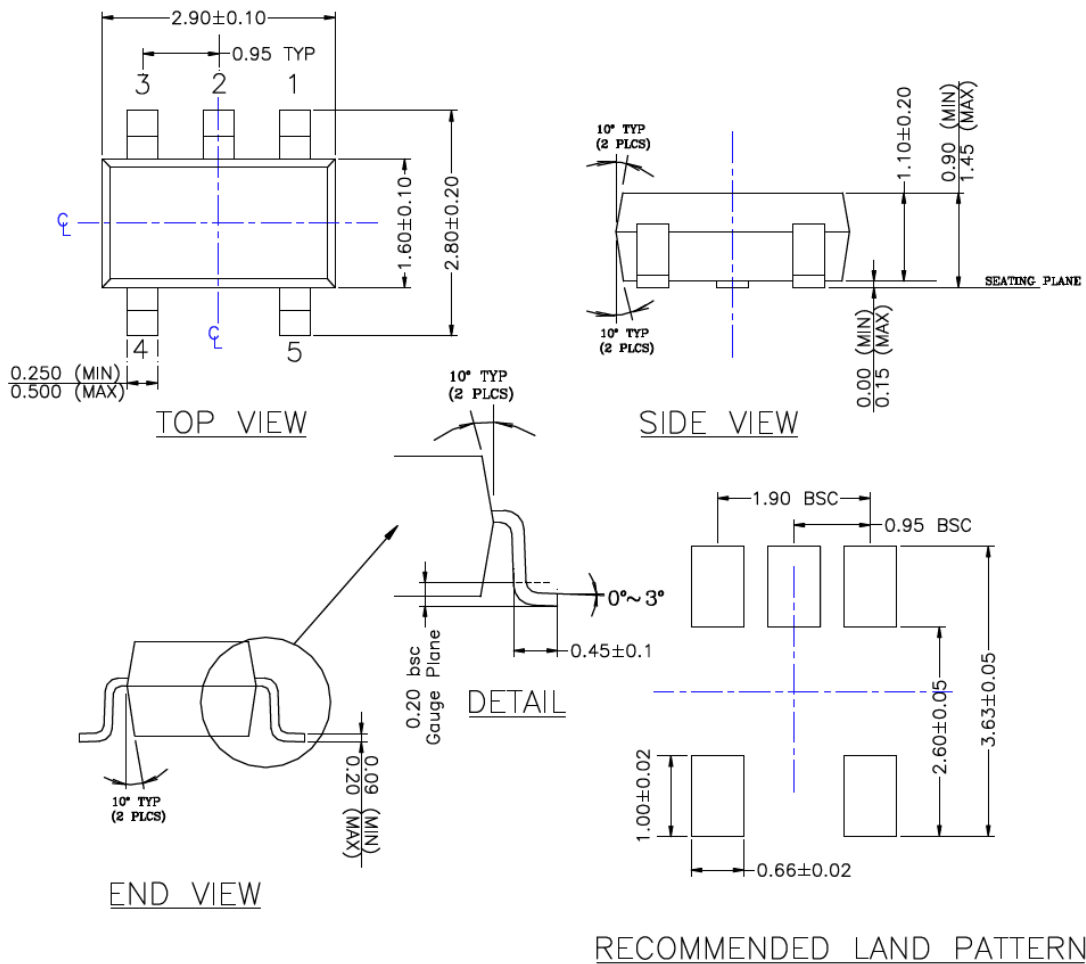
NOTE:
1. PACKAGE OUTLINE EXCLUSIVE OF MOLD FLASH & BURR.
2. PACKAGE OUTLINE INCLUSIVE OF SOLER PLATING.
3. DIMENSION AND TOLERANCE PER ANSI Y14.5M, 1982.
4. FOOT LENGTH MEASUREMENT BASED ON GAUGE PLANE METHOD.
5. DIE FACES UP FOR MOLD, AND FACES DOWN FOR TRIM/FORM.
6. ALL DIMENSIONS ARE IN MILLIMETERS.

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging.

NOTES:

APPENDIX A: REVISION HISTORY

Revision A (October 2021)

- Converted Micrel document MIC5247 to Microchip data sheet DS20006596A.
- Minor text changes throughout.

MIC5247

NOTES:

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, contact your local Microchip representative or sales office.

PART No.	-X.X	X	XX	-XX
Device	Output Voltage	Junction Temp. Range	Package	Media Type

Device:	MIC5247: 150mA Low Voltage µCap Linear Regulator
Output Voltage:	-1.5 = 1.5V (M5 and ML option only) -1.6 = 1.6V (M5 and ML option only) -1.8 = 1.8V -1.85 = 1.85V (M5 and ML option only) -2.0 = 2.0V (M5 and D5 option only) -2.4 = 2.4V (M5 option only)
Junction Temperature Range:	Y = –40°C to +125°C
Package:	M5 = 5-Lead SOT-23 D5 = 5-Lead SOT-23 ML = 6-Lead VDFN
Media Type:	-TX = 3000/Reverse Reel (M5 option only) -TX = 3000/Reel (D5 option only) -TR = 3000/Reverse Reel (M5 option only) -TR = 3000/Reel (D5 option only) -TR = 5000/Reel (ML option only)

Examples:

a) MIC5247-1.6YM5-TX: MIC5247, 1.6V Output Voltage, –40°C to +125°C Temp. Range, 5-Lead SOT-23, 3000/Reverse Reel

b) MIC5247-1.5YM5-TR: MIC5247, 1.5V Output Voltage, –40°C to +125°C Temp. Range, 5-Lead SOT-23, 3000/Reverse Reel

c) MIC5247-2.0YD5-TX: MIC5247, 2.0V Output Voltage, –40°C to +125°C Temp. Range, 5-Lead SOT-23, 3000/Reel

d) MIC5247-1.8YD5-TR: MIC5247, 1.8V Output Voltage, –40°C to +125°C Temp. Range, 5-Lead SOT-23, 3000/Reel

e) MIC5247-1.85YML-TR: MIC5247, 1.85V Output Voltage, –40°C to +125°C Temp. Range, 6-Lead VDFN, 5000/Reel

Note 1: Tape and Reel identifier only appears in the catalog part number description. This identifier is used for ordering purposes and is not printed on the device package. Check with your Microchip Sales Office for package availability with the Tape and Reel option.

NOTES:

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specifications contained in their particular Microchip Data Sheet.

- Microchip believes that its family of products is secure when used in the intended manner and under normal conditions.

- There are dishonest and possibly illegal methods being used in attempts to breach the code protection features of the Microchip devices. We believe that these methods require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Attempts to breach these code protection features, most likely, cannot be accomplished without violating Microchip's intellectual property rights.

- Microchip is willing to work with any customer who is concerned about the integrity of its code.

- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of its code. Code protection does not mean that we are guaranteeing the product is "unbreakable." Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

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