MICREL®

Innovation Through Technology™

MIC3287

1.2MHz PWM White LED Driver with OVP in Thin SOT-23 and 2mm x 2mm MFL™

General Description

The MIC3287 is a 1.2MHz pulse width modulated (PWM) step-up switching regulator that is optimized for constant current white LED driving applications. With a maximum output voltage of 24V and a switch current of over 350mA, the MIC3287 drives a string of up to 4 white LEDs in series, ensuring uniform brightness and eliminating several ballast resistors.

The MIC3287 implements a constant frequency 1.2MHz PWM current-mode control scheme. The high frequency PWM operation saves board space by reducing external component sizes. The added benefit of the constant frequency PWM control scheme as opposed to variable frequency control schemes is much lower noise and input ripple injected back to the battery source. To optimize efficiency, the feedback voltage is set to only 250mV. The MIC3287 is also available with a maximum 24V over-voltage protection.

The MIC3287 is available in low profile Thin SOT-23 5-pin and Thin SOT-23 6-pin packages. The MIC3287 has a junction temperature range of –40°C to +125°C.

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

Features

- 2.8V to 5.5V Input Voltage
- 350mA Switch Current
- 1.2 MHz PWM Operation
- 250mV Feedback Voltage
- 24V Output Over-Voltage Protection (OVP) Option
- <1% Line and Load Regulation
- <1µA Shutdown Current
- Over-Temperature Protection
- Under-Voltage Lock Out (UVLO)
- Low Profile Thin SOT-23-5 Package Option
- Low Profile Thin SOT-23-6 Package Option
- 8-pin 2mm x 2mm MLF™ Package Option
- –40°C to +125°C Junction Temperature Range
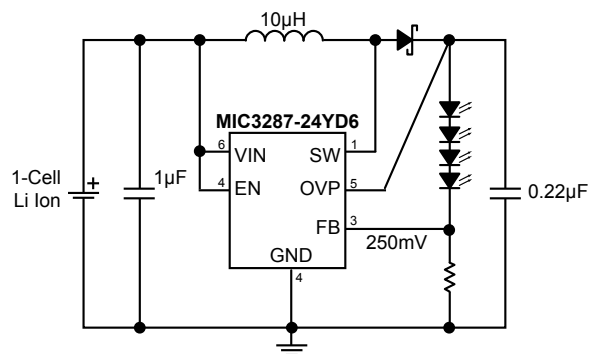
Applications

- White LED Driver for Backlighting:
  - Cell phones
  - PDAs
  - GPS systems
  - Digital cameras
  - MP3 players
  - IP phones
- LED Flashlights
- Constant Current Power Supplies

Typical Application
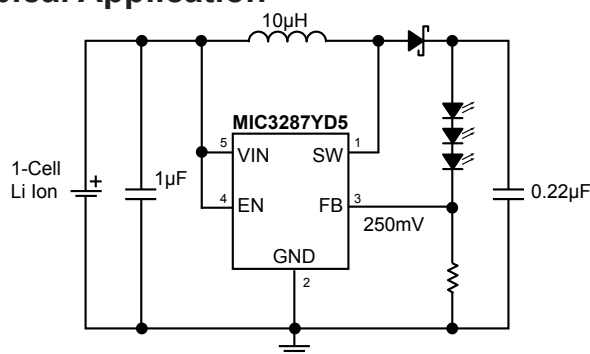

3-Series White LED Driver in Thin SOT-23-5

**4-Series White LED Driver with Output OVP in Thin SOT-23-6**

*MLF and Micro*Lead*Frame are trademarks of Amkor Technology, Inc.*

Micrel, Inc. • 2180 Fortune Drive • San Jose, CA 95131 • USA • tel + 1 (408) 944-0800 • fax + 1 (408) 474-1000 • http://www.micrel.com

Ordering Information

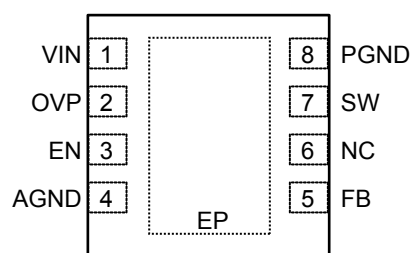| Part Number	Marking Code	Overvoltage Protection	Junction Temp. Range	Package	Lead Finish
MIC3287YD5	WGAA	N/A	-40°C to +125°C	Thin SOT-23-5	Lead Free
MIC3287-24YD6	WHAA	24V	-40°C to +125°C	Thin SOT-23-6	Lead Free
MIC3287-24YML	WLA	24V	-40°C to +125°C	8-Pin 2mm x 2mm MLF	Lead Free

Pin Configuration
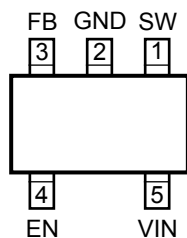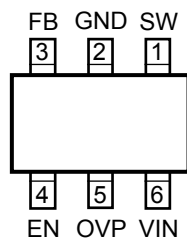
TSOT-23-5 (YD5)   **TSOT-23-6 (YD6)**   **8-Pin 2mm x 2mm MLF™ (YML)**

Ordering Information

Pin Number TSOT-23-5	Pin Number TSOT-23-6	Pin Number 8-Pin MLF	Pin Name	Pin Function
1	1	7	SW	Switch Node (Input): Internal power bipolar collector.
2	2	4	AGND	Analog Ground (Return): Ground.
2	2	8	PGND	Power Ground (Return): Ground.
3	3	5	FB	Feedback (Input): Output voltage sense node. Connect the cathode of the LED to this pin. A resistor from this pin to ground sets the LED current.
4	4	3	EN	Enable (Input): Logic high enables regulator. Logic low shuts down regulator.
5	6	1	VIN	Supply (Input): 2.8V to 5.5V for internal circuitry.
—	5	2	OVP	Overvoltage Protection (Input): Connect to the output.
—	—	6	NC	Not Connected
—	—	EP	EP	Exposed Backside Pad: Connect to ground.

Absolute Maximum Ratings[1]

Supply Voltage (V_{IN})...6V
Switch Voltage (V_{SW}) ....–0.3V to 34V
Enable Pin Voltage (V_{EN}) ....–0.3 to V_{IN}
FB Voltage (V_{FB}) 6V
Switch Current (I_{SW})..1.2A
Ambient Storage Temperature (T_S) ....–65°C to +150°C
ESD Rating[3] 2kV

Operating Ratings[2]

Supply Voltage (V_{IN})..2.8V to 5.5V
Output Voltage (V_{OUT})[4] ....V_{IN} to V_{OUT}
Junction Temperature Range (T_J) .... –40°C to +125°C
Package Thermal Impedance
Thin SOT-23-5 (θ_{JA})[5]..207°C/W
Thin SOT-23-6 (θ_{JA})[5]..134°C/W
8-Pin MLF (θ_{JA}) ....90°C/W

Electrical Characteristics[6]

T_A = 25°C, V_{IN} = V_{EN} = 3.6V, V_{OUT} = 10V, I_{OUT} = 10mA, unless otherwise noted. **Bold** values indicate –40°C ≤ T_J ≤125°C.

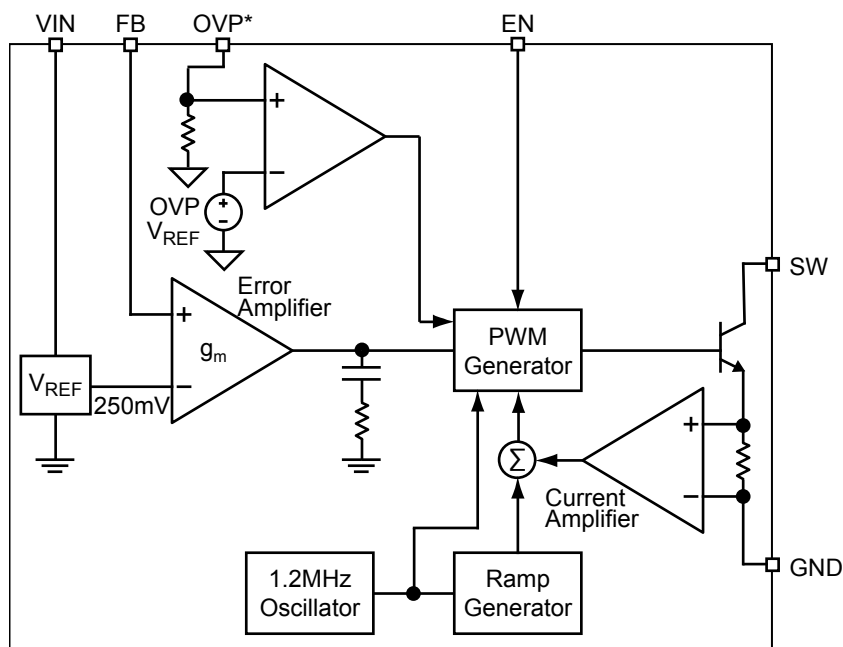| Symbol	Parameter	Condition	Min	Typ	Max	Units
V_{IN}	Supply Voltage Range		**2.8**		**5.5**	V
V_{UVLO}	Under Voltage Lockout		1.8	2.1	2.4	V
I_{VIN}	Quiescent Current	V_{FB} > 500mV, (not switching)		2.1	5	mA
I_{SD}	Shutdown Current	V_{EN} = 0V[7]		0.04	**1**	µA
V_{FB}	Feedback Voltage	(±7.5%)	231	250	269	mV
I_{FB}	Feedback Input Current	V_{FB} = 250mV		–450		nA
	Line Regulation	3V ≤ V_{IN} ≤ 5V[8]		0.4	1	%
	Load Regulation	5mA ≤ I_{OUT} ≤ 20mA[8]		0.5		%
D_{MAX}	Maximum Duty Cycle		**85**	90		%
I_{SW}	Switch Current Limit	V_{IN} = 3.6V	350			mA
V_{SW}	Switch Saturation Voltage	V_{IN} = 3.6V, I_{SW} = 300mA		250		mV
I_{SW}	Switch Leakage Current	V_{EN} = 0V, V_{SW} = 10V		0.01	**1**	µA
V_{EN}	Enable Threshold	TURN ON TURN OFF	**1.5**		**0.4**	V V
I_{EN}	Enable Pin Current	V_{EN} = 10V		21	40	µA
f_{SW}	Oscillator Frequency		1	1.2	1.4	MHz
V_{OVP}	Overvoltage Protection	MIC3287 - 24YD6 MIC3287-24YML	17	19	24	V
T_J	Overtemperature Threshold Shutdown	 Hysteresis		150 10		°C °C

Notes:

1. Absolute maximum ratings indicate limits beyond which damage to the component may occur. Electrical specifications do not apply when operating the device outside of its operating ratings. 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 will result in excessive die temperature, and the regulator will go into thermal shutdown.
2. This device is not guaranteed to operate beyond its specified operating ratings.
3. Devices are inherently ESD sensitive. Handling precautions required. Human body model.
4. For options with OVP.
5. Using 4 layer PCB.
6. Specification for packaged product only.
7. I_{SD} = I_{VIN}.
8. Guaranteed by design.

Typical Characteristics

**3 Series
White LED Efficiency**

**4 Series
White LED Efficiency**

**Enable Pin Current
vs. Temperature**

**Frequency
vs. Temperature**

**Feedback Voltage
vs. Temperature**

**Feedback Voltage
vs. Input Voltage**

**Shutdown Current
vs. Input Voltage**

**Quiescent Current
vs. Input Voltage**

**Curremt Limit
vs. Temperature**

**Current Limit
vs. Input Voltage**
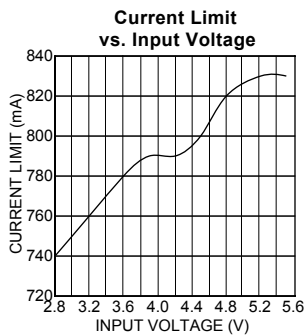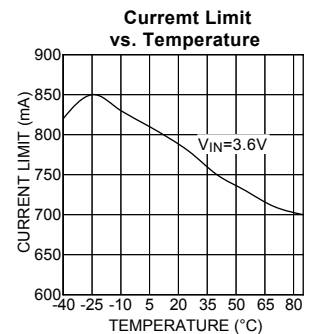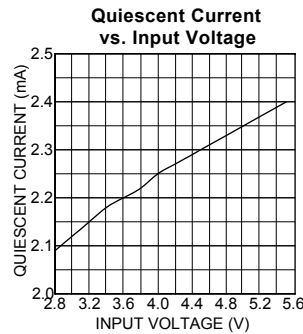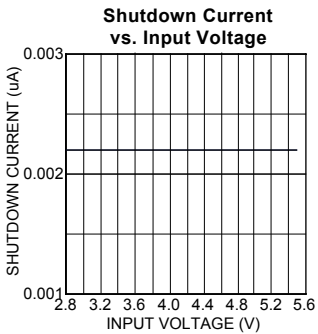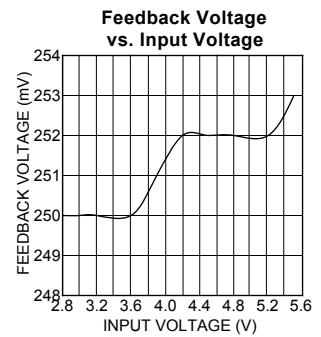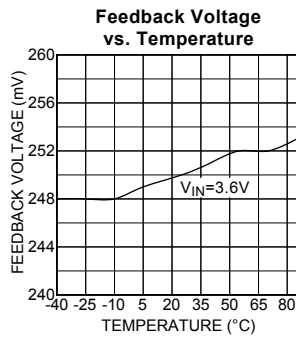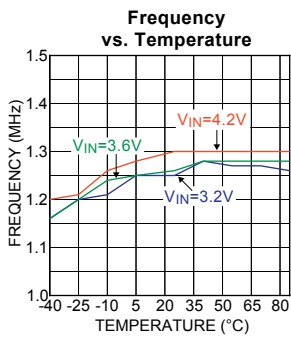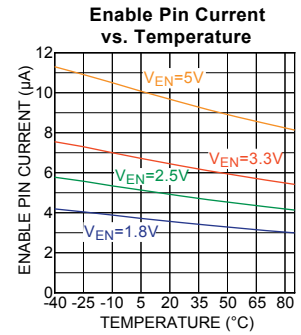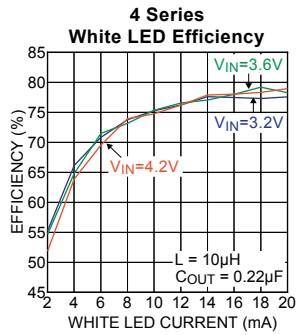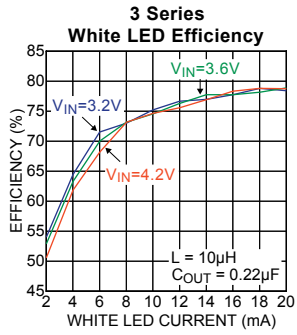
Functional Diagram

* OVP available on TSOP-23-6 and MLF™ package options only.

MIC3287 Block Diagram

Functional Description

The MIC3287 is a constant frequency pulse width modulated (PWM) current-mode step-up regulator. The block diagram is shown above. The MIC3287 is composed of an oscillator, slope compensation ramp generator, current amplifier, g_m error amplifier, PWM generator, and a 350mA minimum bipolar output transistor. The oscillator generates a 1.2MHz clock. The clock's two functions are to trigger the PWM generator that turns on the output transistor and to reset the slope compensation ramp generator. The current amplifier is used to measure the switch current by amplifying the voltage signal from the internal sense resistor. The output of the current amplifier is summed with the output of the slope compensation ramp generator. This summed current-loop signal is fed to one of the inputs of the PWM generator.

The g_m error amplifier measures the LED current through the external sense resistor and amplifies the error between the detected signal and the internal 250mV reference voltage. The output of the g_m error amplifier provides the voltage-loop signal that is fed to the other input of the PWM generator. When the current-loop signal exceeds the voltage-loop signal, the PWM generator turns off the bipolar output transistor. The next clock period initiates the next switching cycle, thus maintaining the constant frequency current-mode PWM control. The LED current is set by the feedback resistor:

$$I_{LED} = \frac{250mV}{R_{FB}}$$

The enable pin shuts down the internal power bipolar transistor and disables the control circuitry to reduce input current-to-leakage levels. Enable pin input current is zero at zero volts.

External Component Selection

The table below shows recommended inductor and output capacitor combinations for optimal performance.

Series LEDs	L	Min C_{OUT}
2	22µH	2.2µF
	15µH	1µF
	10µH	0.22µF
	6.8µH	0.22µF
	4.7µH	0.22µF
3	22µH	2.2µF
	15µH	1µF
	10µH	0.22µF
	6.8µH	0.22µF
	4.7µH	0.27µF
4	22µH	1µF
	15µH	1µF
	10µH	0.22µF
	6.8µH	0.27µF
	4.7µH	0.27µF

Dimming Control

There are two techniques for dimming control. One is PWM dimming, and the other is continuous dimming.

1. PWM dimming control is implemented by applying a PWM signal to the EN pin, as shown in Figure 1. The MIC3287 is turned on and off by the PWM signal. With this method, the LEDs operate with either zero or full current. The average LED current is increased proportionally to the duty-cycle of the PWM signal. This technique has high-efficiency because the IC and the LEDs consume no current during the off time of the PWM signal. Typical PWM frequency should be between 100Hz and 10kHz.

2. Continuous dimming control is implemented by applying a DC control voltage to the FB pin of the MIC3287 through a series resistor, as shown in Figure 2. The LED intensity (current) can be dynamically varied with the applied DC control voltage. The DC voltage can come from a DAC signal, or a filtered PWM signal. The advantage of the filtered PWM signal approach is a high frequency PWM signal (>10kHz) can be used to control LED intensity (current).
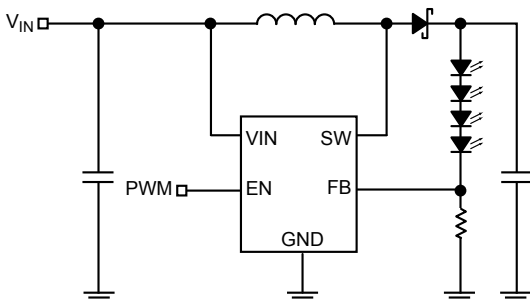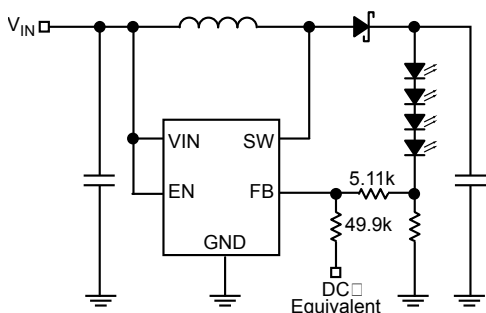

Figure 1. PWM Dimming Method

Figure 2. Continuous Dimming

Open-Circuit Protection

If the LEDs are disconnected from the circuit, or in the case that an LED fails, the sense resistor will then pull the FB pin to ground. This will cause the MIC3287 to switch with a high duty-cycle, resulting in output over-voltage. This may cause the SW pin voltage to exceed its maximum voltage rating, damaging the IC and the external components. To ensure the highest level of protection, the MIC3287 has buit-in 24V over-voltage protection functionality in the TSOT-23-6 pin and 8-pin MLF™ package options. The OVP will clamp the output voltage to within the specified limits.

Start-Up and Inrush Current

If the inrush current needs to be limited, a soft-start circuit, similar to Figure 3, could be implemented. The soft-start capacitor, C_{SS}, provides overdrive to the FB pin at start-up, resulting in gradual increase of switch duty cycle and limited inrush current.
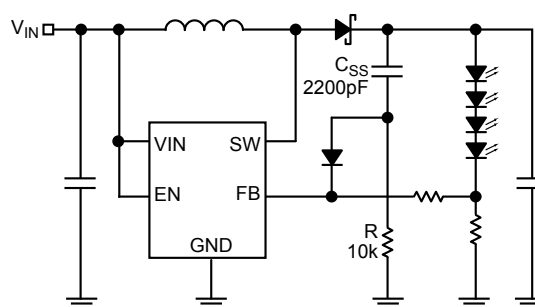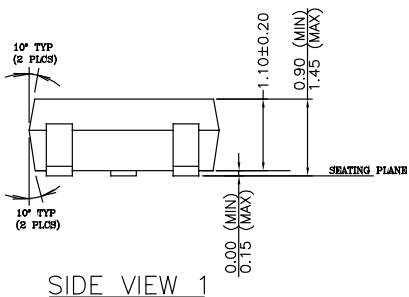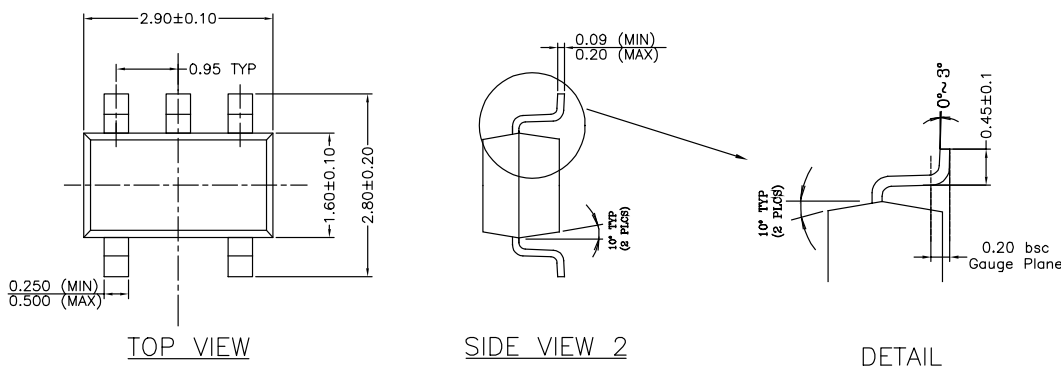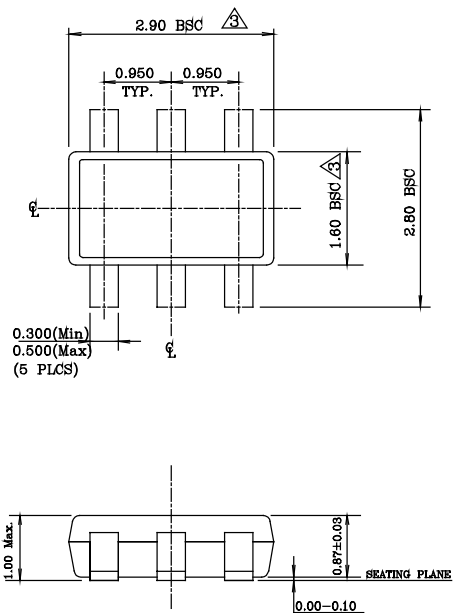

Figure 3. Soft-Start Circuit

Package Information

TOP VIEW

SIDE VIEW 2

DETAIL

2.90±0.10

0.95 TYP

1.60±0.10

2.80±0.20

0.250 (MIN)
0.500 (MAX)

0.09 (MIN)
0.20 (MAX)

10° TYP
(2 PLCS)

0°~3°

0.45±0.1

10° TYP
(2 PLCS)

0.20 bsc
Gauge Plane

SIDE VIEW 1

10° TYP
(2 PLCS)

1.10±0.20

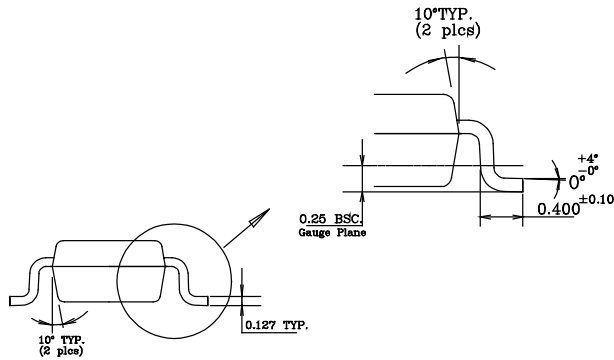0.90 (MIN)
1.45 (MAX)

SEATING PLANE

0.00 (MIN)
0.15 (MAX)

10° TYP
(2 PLCS)

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.
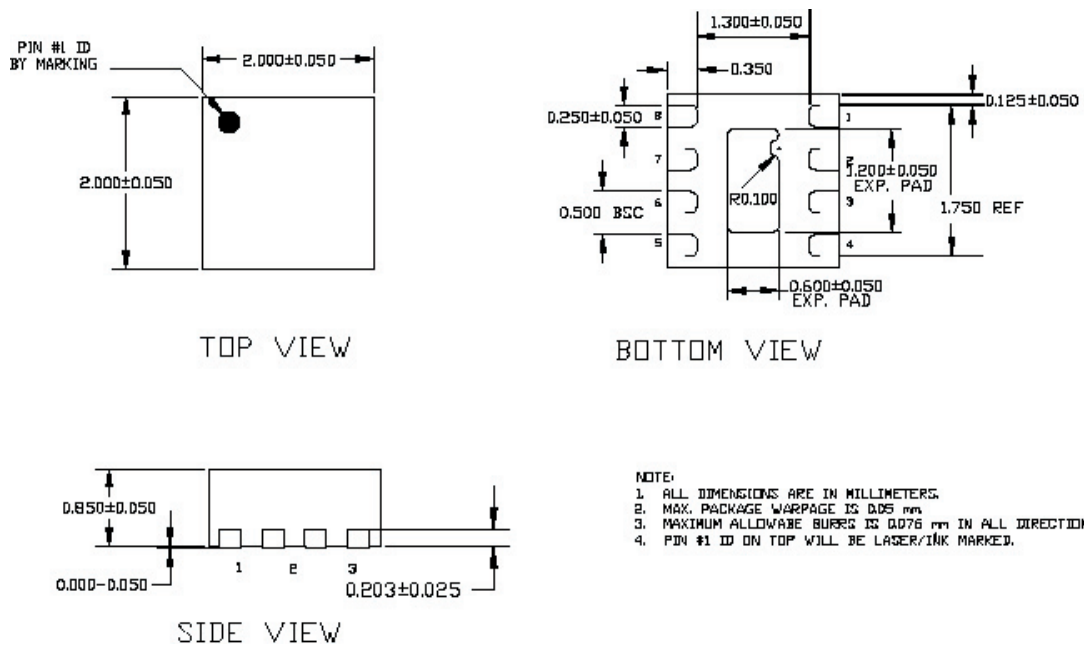5. DIE FACES UP FOR MOLD, AND FACES DOWN FOR TRIM/FORM.

5-Pin TSOT (YD5)

2.90 BSC

0.950 TYP.   0.950 TYP.

1.60 BSC

2.80 BSC

0.300(Min)
0.500(Max)
(5 PLCS)

1.00 Max.

0.87±0.03

SEATING PLANE

0.00-0.10

NOTE:
1. Dimensions and tolerances are as per ANSI Y14.5M, 1994.
2. Die is facing up for mold. Die is facing down for trim/form, ie. reverse trim/form.
3. Dimensions are exclusive of mold flash and gate burr.
4. The footlength measuring is based on the gauge plane method.
5. All specification comply to Jedec Spec MO193 Issue C.
6. All dimensions are in millimeters.

10°TYP.
(2 plcs)

10°TYP.
(2 plcs)

0.127 TYP.

0.25 BSC.
Gauge Plane

+4°
0° -0°

0.400 ±0.10

6-Pin TSOT (YD6)

PIN #1 ID
BY MARKING

2.000±0.050

2.000±0.050

TOP VIEW

1.300±0.050

0.350

0.250±0.050

0.500 BSC

R0.100

0.125±0.050

1.200±0.050
EXP. PAD

1.750 REF

0.600±0.050
EXP. PAD

BOTTOM VIEW

0.850±0.050

0.000–0.050

0.203±0.025

SIDE VIEW

NOTE:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. MAX. PACKAGE WARPAGE IS 0.05 mm.
3. MAXIMUM ALLOWABE BURRS IS 0.076 mm IN ALL DIRECTIONS.
4. PIN #1 ID ON TOP WILL BE LASER/INK MARKED.

8-Pin 2mm x 2mm MLF™ (ML)