# SY88313BL

## 3.3V, 3.2Gbps CML Low-Power Limiting Post Amplifier with TTL Loss-of-Signal

## General Description

The SY88313BL low-power limiting post amplifier is designed for use in fiber-optic receivers. The device connects to typical transimpedance amplifiers (TIAs). The linear signal output from TIAs can contain significant amounts of noise and may vary in amplitude over time. The SY88313BL quantizes these signals and outputs CML-level waveforms.

The SY88313BL operates from a single +3.3V ±10% supply, over temperatures ranging from –40°C to +85°C. With its wide bandwidth and high gain, signals with data rates up to 3.2Gbps, and as small as $10mV_{PP}$, can be amplified to drive devices with CML inputs or AC-coupled CML/PECL inputs.

The SY88313BL generates a loss-of-signal (LOS) open-collector TTL output. A programmable loss-of-signal level set pin (LOSLVL) sets the sensitivity of the input amplitude detection. LOS asserts high if the input amplitude falls below the threshold set by LOSLVL and de-asserts low otherwise. The enable bar input (/EN) de-asserts the true output signal without removing the input signal. The LOS output can be fed back to the /EN input to maintain output stability under a loss-of-signal condition. Typically, 3.4dB LOS hysteresis is provided to prevent chattering.

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

## Features

- Single 3.3V power supply
- DC to 3.2Gbps operation
- Low-noise CML data outputs
- Chatter-free Open-Collector TTL loss-of-signal (LOS) output with internal 4.75kΩ pull-up resistor
- TTL /EN input
- Internal 50Ω input termination
- Programmable LOS level set (LOSLVL)
- Ideal for multi-rate applications
- Available in a tiny 10-pin EPAD MSOP and 16-pin MLF® package

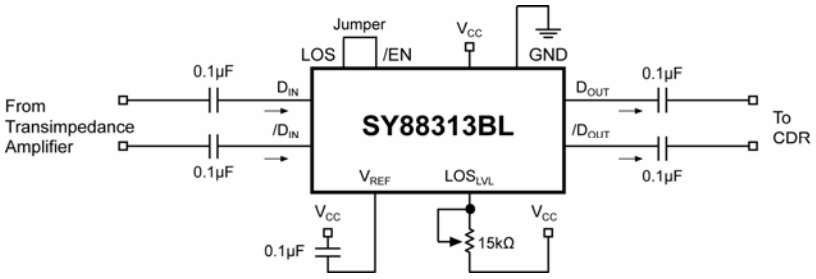
## Applications

- APON/BPON, GEPON, EPON, and GPON
- Gigabit Ethernet
- Fibre Channel
- OC-3/12/24/48 SONET/SDH
- High-gain line driver and line receiver
- Low-gain TIA interface

## Markets

- FTTP/FTTH
- Datacom/Telecom
- Optical Transceivers

## Typical Application




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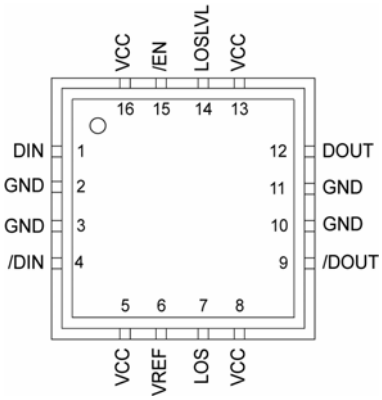
## Ordering Information[1]

| Part Number | Package Type | Operating Range | Package Marking | Lead Finish |
|---|---|---|---|---|
| SY88313BLMG | MLF-16 | Industrial | 313B with Pb-Free bar-line indicator | NiPdAu Pb-Free |
| SY88313BLMGTR[2] | MLF-16 | Industrial | 313B with Pb-Free bar-line indicator | NiPdAu Pb-Free |
| SY88313BLEY | K10-2 | Industrial | 313B with Pb-Free bar-line indicator | Matte-Sn Pb-Free |
| SY88313BLEYTR[2] | K10-2 | Industrial | 313B with Pb-Free bar-line indicator | Matte-Sn Pb-Free |

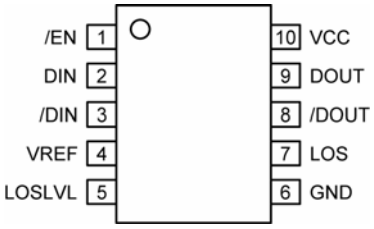
**Notes:**

1. Contact factory for die availability. Dice are guaranteed at $T_A$ = 25C, DC Electricals only.
2. Tape and Reel.

## Pin Configuration




**16-Pin MLF® (MLF-16)**




**10-Pin EPAD-MSOP (K10-2)**

## Pin Description

| Pin Number (MSOP) | Pin Number (MLF®) | Pin Name | Type | Pin Function |
|---|---|---|---|---|
| 1 | 15 | /EN | TTL Input: Default is high. | Enable Bar: De-assert true data output when high. |
| 2 | 1 | DIN | Data Input | True data input with 50Ω termination to $V_{REF}$. |
| 3 | 4 | /DIN | Data Input | Complementary data input with 50Ω termination to $V_{REF}$. |
| 4 | 6 | VREF | | Reference Voltage: Placing a capacitor here to $V_{CC}$ helps stabilize $LOS_{LVL}$. |
| 5 | 14 | LOSLVL | Input: Default is maximum sensitivity | Loss-of-Signal Level Set: A resistor from this pin to $V_{CC}$ sets the threshold for the data input amplitude at which the LOS output will be asserted. |
| 6 Exposed Pad | 2, 3, 10, 11 Exposed Pad | GND | Ground | Device ground. Exposed pad must be connected to PCB ground plane. |
| 7 | 7 | LOS | Open Collector TTL Output with Internal 4.75kΩ pull-up resistor | Loss-of-Signal: Asserts high when the data input amplitude falls below the threshold set by $LOS_{LVL}$. |
| 8 | 9 | /DOUT | CML Output | Complementary data output. |
| 9 | 12 | DOUT | CML Output | True data output. |
| 10 | 5, 8, 13, 16 | VCC | Power Supply | Positive power supply. |

## Absolute Maximum Ratings[1]

Supply Voltage ($V_{CC}$) ..... +0V to +4.0V
Input Voltage (DIN, /DIN) ..... 0 to $V_{CC}$
Output Current ($I_{OUT}$) ..... ± 25mA
/EN Voltage ..... 0 to $V_{CC}$
VREF Current ..... ±1mA
LOSLVL Voltage ..... $V_{REF}$ to $V_{CC}$
Lead Temperature (soldering, 20sec.) ..... +260°C
Storage Temperature ($T_s$) ..... -65°C to +150°C

## Operating Ratings[2]

Supply Voltage ($V_{CC}$) ..... +3.0V to +3.6V
Ambient Temperature ($T_A$) ..... –40°C to +85°C
Junction Temperature ($T_J$) ..... –40°C to +120°C
Junction Thermal Resistance[3]
MLF®
($\theta_{JA}$) Still-air ..... 61°C/W
($\psi_{JB}$) ..... 38°C/W

EPAD-MSOP
($\theta_{JA}$) Still-air ..... 38°C/W
($\psi_{JB}$) ..... 22°C/W

## DC Electrical Characteristics

$V_{CC}$ = 3.0V to 3.6V; $R_L$ = 50Ω to $V_{CC}$; $T_A$ = –40°C to +85°C, unless otherwise stated.

| Symbol | Parameter | Condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $I_{CC}$ | Power Supply Current | No output load. | | 47 | 65 | mA |
| $LOS_{LVL}$ | LOSLVL Voltage | | $V_{REF}$ | | $V_{CC}$ | V |
| $V_{OH}$ | CML Output HIGH Voltage | | $V_{CC}$-0.020 | $V_{CC}$-0.005 | $V_{CC}$ | V |
| $V_{OL}$ | CML Output LOW Voltage | $V_{CC}$ = 3.3V | $V_{CC}$-0.475 | $V_{CC}$-0.400 | $V_{CC}$-0.350 | V |
| $V_{OFFSET}$ | Differential Output Offset | | | | ±80 | mV |
| $Z_O$ | Single-Ended Output Impedance | | 40 | 50 | 60 | Ω |
| $Z_I$ | Single-Ended Input Impedance | | 40 | 50 | 60 | Ω |
| $V_{REF}$ | Reference Voltage | | | $V_{CC}$-1.28 | | V |

## TTL DC Electrical Characteristics

$V_{CC}$ = 3.0V to 3.6V; $R_L$ = 50Ω to $V_{CC}$; $T_A$ = –40°C to +85°C, unless otherwise stated.

| Symbol | Parameter | Condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $V_{IH}$ | /EN Input HIGH Voltage | | 2.0 | | | V |
| $V_{IL}$ | /EN Input LOW Voltage | | | | 0.8 | V |
| $I_{IH}$ | /EN Input HIGH Current | $V_{IN}$ = 2.7V<br>$V_{IN}$ = $V_{CC}$ | | | 20<br>100 | µA<br>µA |
| $I_{IL}$ | /EN Input LOW Current | $V_{IN}$ = 0.5V | -0.3 | | | mA |
| $V_{OH}$ | LOS Output HIGH Level | $V_{CC}$ ≥ 3.3V, $I_{OH}$ (max) <160µA<br>$V_{CC}$ < 3.3V, $I_{OH}$ (max) <160µA | 2.4<br>2.0 | | | V<br>V |
| $V_{OL}$ | LOS Output LOW Level | $I_{OL}$ = +2mA | | | 0.5 | V |

**Notes:**

1. Permanent device damage may occur if absolute maximum ratings are exceeded. This is a stress rating only and functional operation is not implied at conditions other than those detailed in the operational sections of this data sheet. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.
2. The data sheet limits are not guaranteed if the device is operated beyond the operating ratings.
3. Package thermal resistance assumes exposed pad is soldered (or equivalent) to the device's most negative potential (GND) on the PCB. $\psi_{JB}$ uses 4-layer ($\theta_{JA}$) in still-air number, unless otherwise stated.

## AC Electrical Characteristics

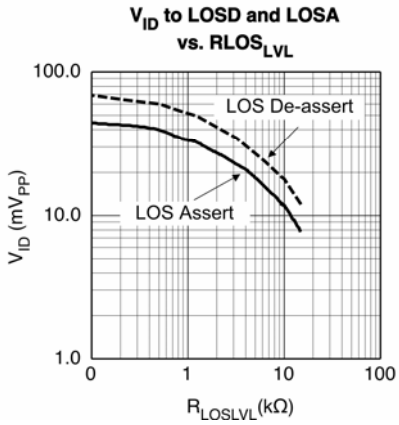
$V_{CC}$ = 3.0V to 3.6V; $R_{LOAD}$ = 50Ω to $V_{CC}$; $T_A$ = –40°C to +85°C.

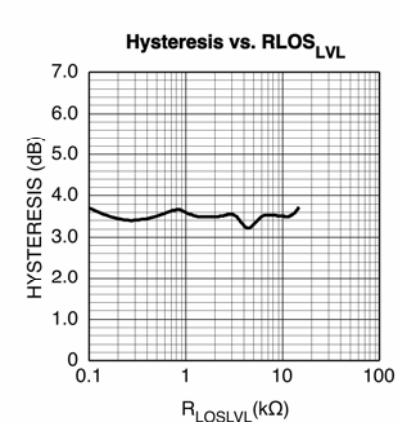
| Symbol | Parameter | Condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $t_r$, $t_f$ | Output Rise/Fall Time (20% to 80%) | Note 4 | | 60 | 120 | ps |
| $t_{JITTER}$ | Deterministic<br>Random | Note 5<br>Note 6 | | 15<br>5 | | $ps_{PP}$<br>$ps_{RMS}$ |
| $V_{ID}$ | Differential Input Voltage Swing | Figure 1 | 10 | | 1800 | $mV_{PP}$ |
| $V_{OD}$ | Differential Output Voltage Swing | $V_{ID} \geq 18mV_{PP}$ Figure 1 | 700 | 800 | 950 | $mV_{PP}$ |
| $T_{OFF}$ | LOS Release Time | | | 2 | 10 | µs |
| $T_{ON}$ | LOS Assert Time | | | 2 | 10 | µs |
| $LOS_{AL}$ | Low LOS Assert Level | $R_{LOSLVL}$ = 15kΩ, Note 8 | | 7.8 | | $mV_{PP}$ |
| $LOS_{DL}$ | Low LOS De-assert Level | $R_{LOSLVL}$ = 15kΩ, Note 8 | | 12 | | $mV_{PP}$ |
| $HYS_L$ | Low LOS Hysteresis | $R_{LOSLVL}$ = 15kΩ, Note 7 | | 3.7 | | dB |
| $LOS_{AM}$ | Medium LOS Assert Level | $R_{LOSLVL}$ = 5kΩ, Note 8 | 10 | 17 | | $mV_{PP}$ |
| $LOS_{DM}$ | Medium LOS De-assert Level | $R_{LOSLVL}$ = 5kΩ, Note 8 | | 25 | 40 | $mV_{PP}$ |
| $HYS_M$ | Medium LOS Hysteresis | $R_{LOSLVL}$ = 5kΩ, Note 7 | 2 | 3.3 | 4.5 | dB |
| $LOS_{AH}$ | High LOS Assert Level | $R_{LOSLVL}$ = 100Ω, Note 8 | 30 | 45 | | $mV_{PP}$ |
| $LOS_{DH}$ | High LOS De-assert Level | $R_{LOSLVL}$ = 100Ω, Note 8 | | 69 | 95 | $mV_{PP}$ |
| $HYS_H$ | High LOS Hysteresis | $R_{LOSLVL}$ = 100Ω, Note 7 | 2 | 3.7 | 4.5 | dB |
| $B_{-3dB}$ | 3dB Bandwidth | | | 2 | | GHz |
| $A_{V(Diff)}$ | Differential Voltage Gain | | 32 | 38 | | dB |
| $S_{21}$ | Single-ended Small-Signal Gain | | 26 | 32 | | dB |

**Notes:**

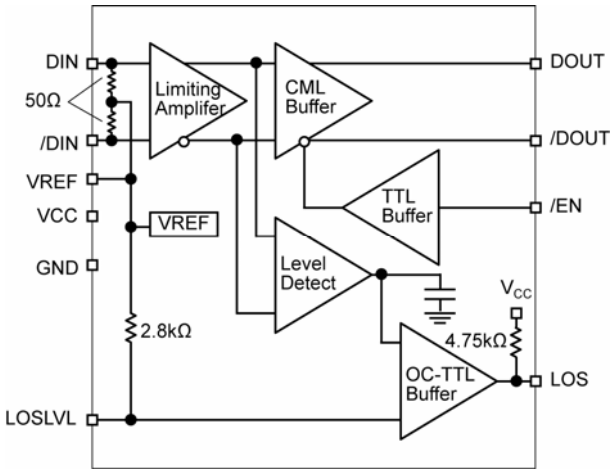
4. Amplifier in limiting mode. Input is a 200MHz square wave.
5. Deterministic jitter measured using 3.2Gbps K28.5 pattern, $V_{ID}$ = $10mV_{PP}$.
6. Random jitter measured using 3.2Gbps K28.7 pattern, $V_{ID}$ = $10mV_{PP}$.
7. This specification defines electrical hysteresis as 20log (LOS De-assert/LOS Assert). The ratio between optical hysteresis and electrical hysteresis is found to vary between 1.5 and 2 depending upon the level of received optical power and ROSA characteristics. Based on that ratio, the optical hysteresis corresponding to the electrical hysteresis range 2dB-4.5dB, shown in the AC characteristics table, will be 1dB-3dB Optical Hysteresis.
8. See “Typical Operating Characteristics” for a graph showing how to choose a particular $R_{LOSLVL}$ for a particular LOS assert and its associated de-assert amplitude.

## Typical Characteristics



## Functional Diagram




## Detailed Description

The SY88313BL low-power limiting post amplifier operates from a single +3.3V power supply, over temperatures from –40°C to +85°C. Signals with data rates up to 3.2Gbps and as small as $10mV_{PP}$ can be amplified. Figure 1 shows the allowed input voltage swing. The SY88313BL generates a LOS output. $LOS_{LVL}$ sets the sensitivity of the input amplitude detection.

### Input Amplifier/Buffer

Figure 2 shows a simplified schematic of the SY88313BL's input stage. The high-sensitivity of the input amplifier allows signals as small as $10mV_{PP}$ to be detected and amplified. The input amplifier also allows input signals as large as $1800mV_{PP}$. Input signals are linearly amplified with a typical 38dB differential voltage gain. Since it is a limiting amplifier, the SY88313BL outputs typically $800mV_{PP}$ voltage-limited waveforms for input signals that are greater than $12mV_{PP}$. Applications requiring the SY88313BL to operate with high-gain should have the upstream TIA placed as close as possible to the SY88313BL's input pins to ensure the best performance of the device.

### Output Buffer

The SY88313BL's CML output buffer is designed to drive 50Ω lines. The output buffer requires appropriate termination for proper operation. An external 50Ω resistor to $V_{CC}$ for each output pin provides this. Figure 3 shows a simplified schematic of the output stage.

### Loss-of-Signal

The SY88313BL generates a chatter-free LOS open-collector TTL output with an internal 4.75kΩ pull-up resistor as shown in Figure 5. LOS is used to determine that the input amplitude is large enough to be considered a valid input. LOS asserts high if the input amplitude falls below the threshold set by $LOS_{LVL}$ and de-asserts low otherwise. LOS can be fed back to the enable bar (EN) input to maintain output stability under a loss of signal condition. /EN de-asserts the true output signal without removing the input signals. Typical 3.4dB LOS hysteresis is provided to prevent chattering.

### Loss-of-Signal Level Set

A programmable LOS level set pin ($LOS_{LVL}$) sets the threshold of the input amplitude detection. Connecting an external resistor between $V_{CC}$ and $LOS_{LVL}$ sets the voltage at $LOS_{LVL}$. This voltage ranges from $V_{CC}$ to $V_{REF}$. The external resistor creates a voltage divider between $V_{CC}$ and $V_{REF}$ as shown in Figure 6.

### Hysteresis

The SY88313BL provides typically 3.4dB LOS electrical hysteresis. By definition, a power ratio measured in dB is 10log (power ratio). Power is calculated as $V^2_{IN}/R$ for an electrical signal. Hence, the same ratio can be stated as 20log (voltage ratio). While in linear mode, the electrical voltage input changes linearly with the optical power and therefore, the ratios change linearly. Thus, the optical hysteresis in dB is half the electrical hysteresis in dB given in the data sheet. Since the SY88313BL is an electrical device, this data sheet refers to hysteresis in electrical terms. With 3.4dB LOS hysteresis, a voltage factor of 1.5 is required to assert or de-assert LOS.

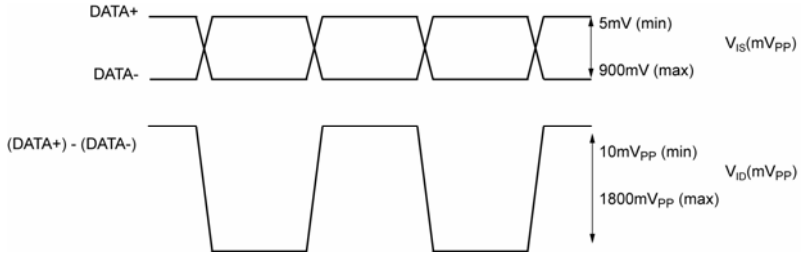



**Figure 1. $V_{IS}$ and $V_{ID}$ Definition**

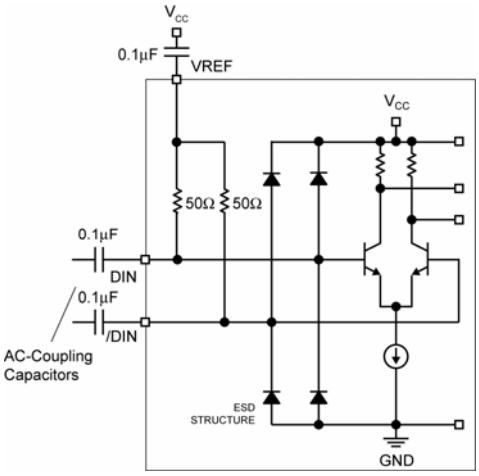



**Figure 2. Input Structure**

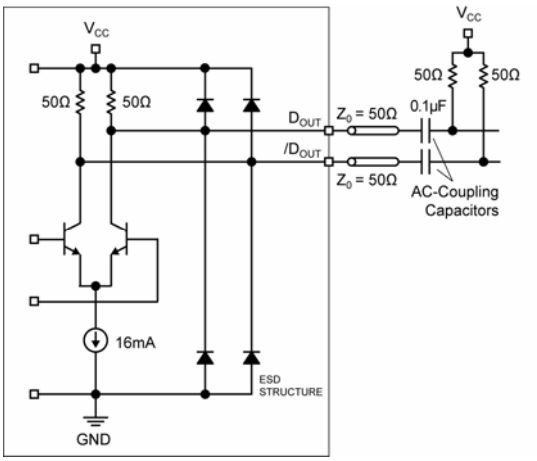



**Figure 3. Output Structure**

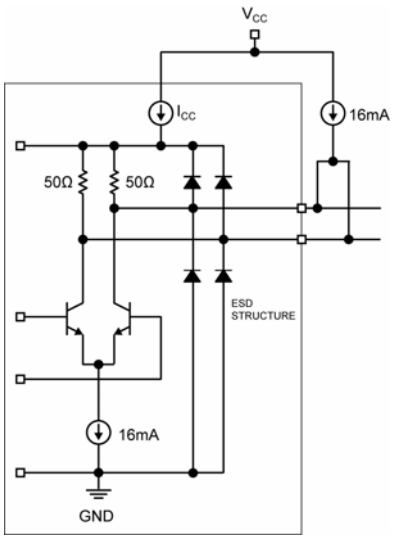



**Figure 4. Power Supply Current Measurement**

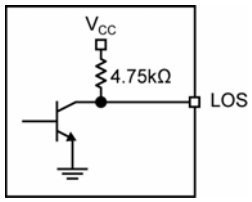



**Figure 5. LOS Output Structure**

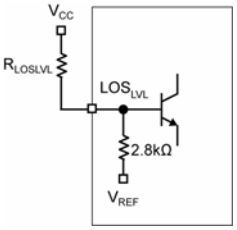
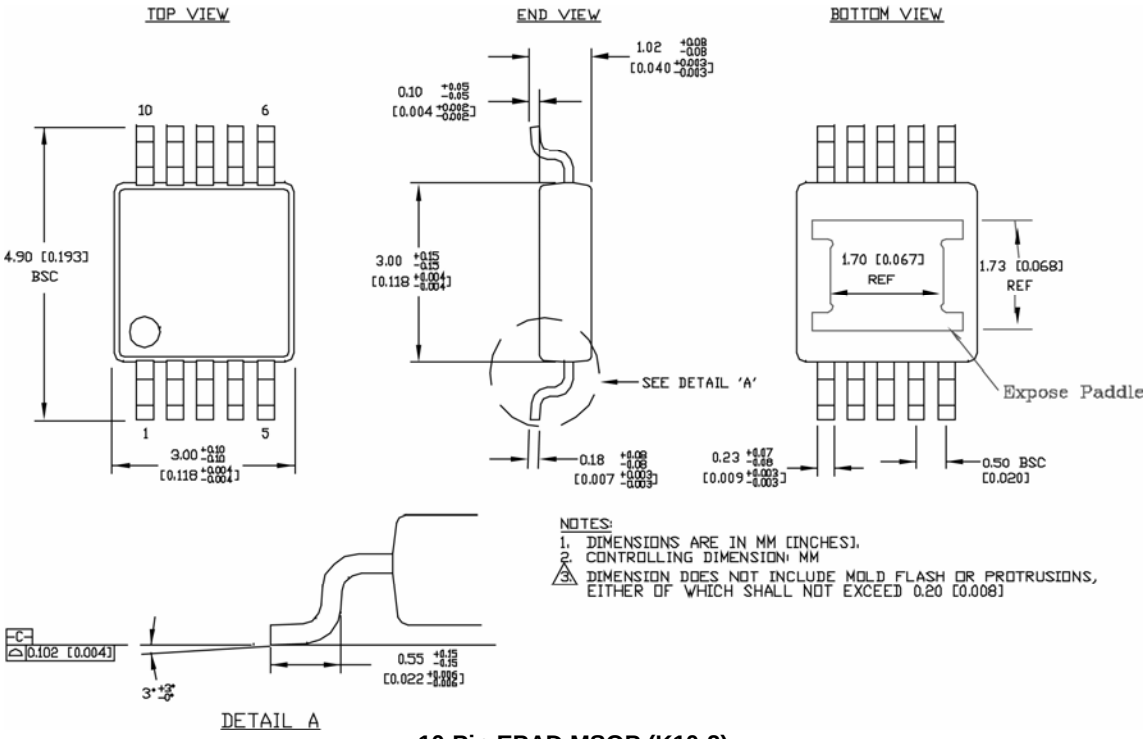
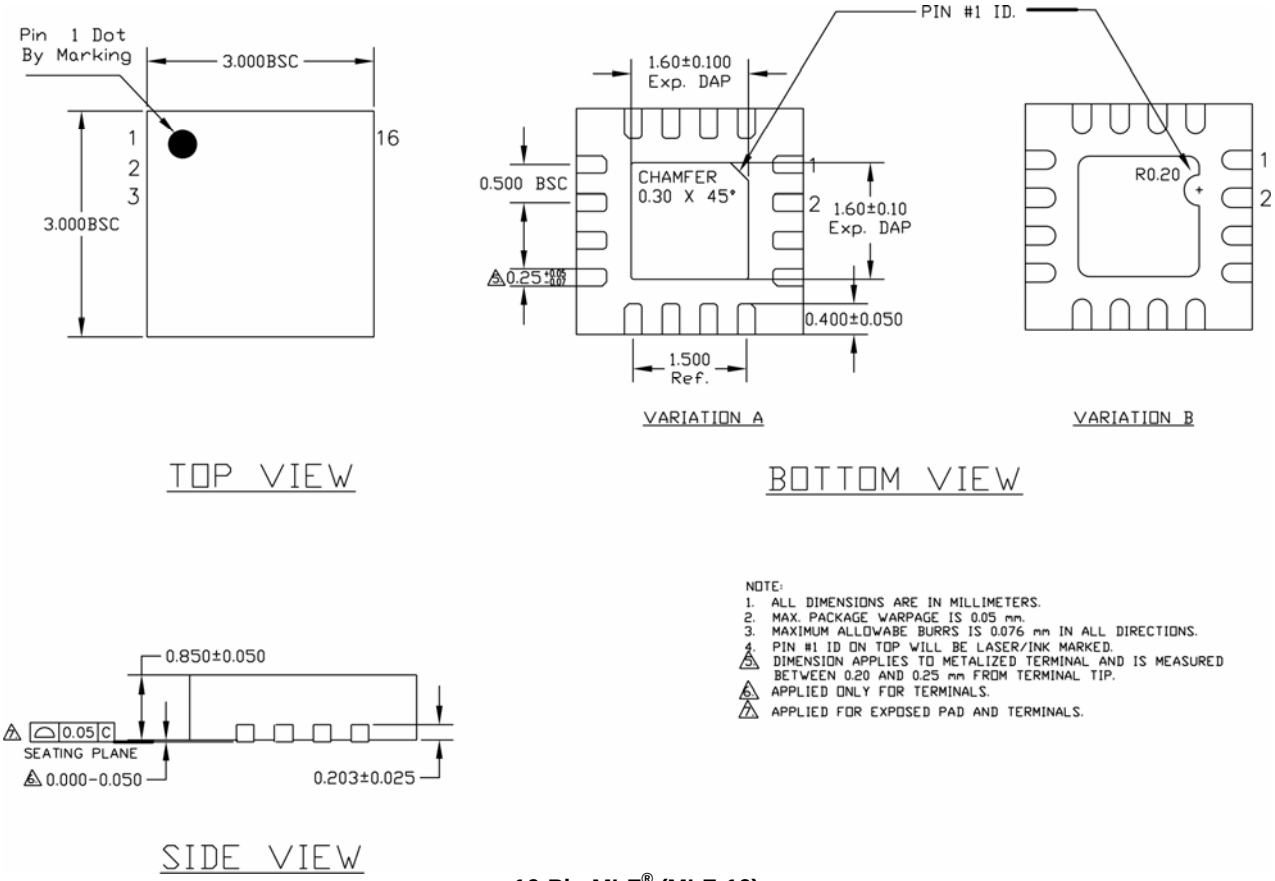



**Figure 6. $LOS_{LVL}$ Setting Circuit**

## Package Information




**10-Pin EPAD MSOP (K10-2)**




**16-Pin MLF® (MLF-16)**

**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

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