# 3.3V/5V 3.2Gbps CML LOW-POWER LIMITING POST AMPLIFIER WITH TTL LOS

**SY88773V**

## FEATURES

- **Multi-rate up to 3.2Gbps operation**
- **Wide gain-bandwidth product**
  - **38dB differential gain**
  - **2GHz 3dB bandwidth**
- **Low noise 50Ω CML data outputs**
  - **800mV$_{PP}$ output swing**
  - **60ps edge rates**
  - **5ps$_{(RMS)}$ typ. random jitter**
  - **15ps$_{(PP)}$ typ. deterministic jitter**
- **Chatter-free, Loss-of-Signal (LOS) output**
  - **4.6dB electrical hysteresis**
  - **OC-TTL output with internal 4.75kΩ pull-up resistor**
- **Programmable LOS sensitivity using single external resistor**
- **Integrated input bias reference**
- **TTL /EN input allows feedback from LOS**
- **Wide operating range**
  - **Single 3.3V ±10% or 5V ±10% power supply**
  - **–40°C to +85°C industrial temperature range**
- **Available in tiny 10-pin EPAD-MSOP and 16-pin MLF™ packages**

## APPLICATIONS

- **1.25Gbps and 2.5Gbps Gigabit Ethernet**
- **1.062Gbps and 2.125Gbps Fibre Channel**
- **155Mbps, 622Gbps, 1.25Gbps, and 2.5Gbps SONET/SDH**
- **Gigabit interface converter (GBIC)**
- **Small form factor (SFF) and small form factor pluggable (SFP) transceivers**
- **Parallel 10G Ethernet**
- **High-gain line driver and line receiver**

## DESCRIPTION

The SY88773V 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 SY88773V quantizes these signals and outputs typically 800mV$_{PP}$ voltage-limited waveforms.

The SY88773V operates from a single +3.3V ±10% or +5V ±10% power supply, over an industrial temperature range of –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 PECL inputs.

The SY88773V incorporates a loss-of-signal (LOS), open-collector TTL output with internal 4.75kΩ pull-up resistor. 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. LOS can be fed back to the enable (/EN) input to maintain output stability under a loss-of-signal condition. /EN de-asserts the true output signal without removing the input signal. Typically 4.6dB LOS hysteresis is provided to prevent chattering.

Please see Micrel's website at www.micrel.com for a complete selection of optical module ICs. The following table summarizes the differences between devices in Micrel's latest family of Limiting Amplifiers.

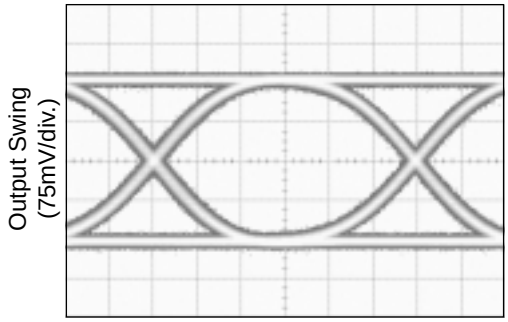
All support documentation can be found on Micrel's web site at www.micrel.com.

| Part Number | Integrated 50Ω Input Termination | LOS or SD | Active LOW or HIGH Enable |
|---|---|---|---|
| SY88773V | No | LOS | LOW |
| SY88823V | No | SD | HIGH |
| SY88843V | Yes | SD | HIGH |
| SY88973V | Yes | LOS | LOW |

**Table 1. Limiting Amplifiers Selection Guide**

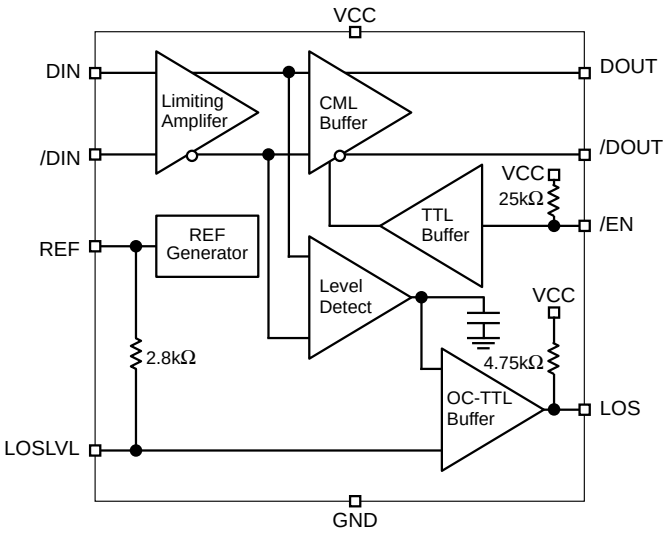
## TYPICAL PERFORMANCE

**3.3V, 25°C, 10mV$_{pp}$ Input**
**@3.2Gbps $2^{31}$–1 PRBS, $R_{LOAD}$ = 50Ω to $V_{CC}$**

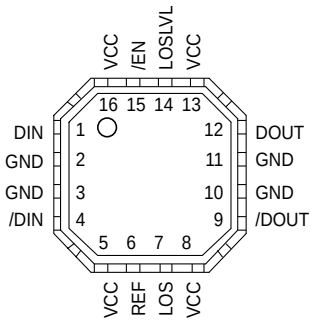



*Micro* LeadFrame and MLF are trademarks of Amkor Technology

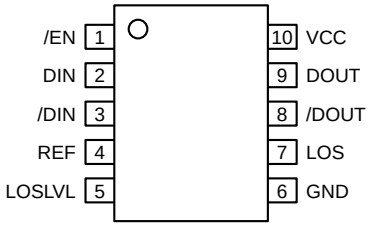
## FUNCTIONAL BLOCK DIAGRAM



## PACKAGE/ORDERING INFORMATION




**16-Pin MLF (MLF-16)**




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

### Ordering Information[1]

| Part Number | Package Type | Operating Range | Package Marking | Lead Finish |
|---|---|---|---|---|
| SY88773VKI | K10-2 | Industrial | 773V | Sn-Pb |
| SY88773VKITR[2] | K10-2 | Industrial | 773V | Sn-Pb |
| SY88773VMI | MLF-16 | Industrial | 773V | Sn-Pb |
| SY88773VMITR[2] | MLF-16 | Industrial | 773V | Sn-Pb |
| SY88773VEY[3] | K10-2 | Industrial | 773V with Pb-Free bar-line indicator | Pb-Free Matte-Sn |
| SY88773VEYTR[2, 3] | K10-2 | Industrial | 773V with Pb-Free bar-line indicator | Pb-Free Matte-Sn |
| SY88773VMG[3] | MLF-16 | Industrial | 773V with Pb-Free bar-line indicator | Pb-Free NiPdAu |
| SY88773VMGTR[2, 3] | MLF-16 | Industrial | 773V with Pb-Free bar-line indicator | Pb-Free NiPdAu |

**Notes:**

1. Contact factory for die availability. Dice are guaranteed at $T_A$ = 25°C, DC Electricals only.
2. Tape and Reel.
3. Pb-Free package is recommended for new designs.

## PIN DESCRIPTION

| Pin Number (MSOP) | Pin Number (MLF™) | Pin Name | Type | Pin Function |
|---|---|---|---|---|
| 1 | 15 | /EN | TTL Input: Default is high. | Enable: De-asserts true data output when high. Incorporates 25kΩ pull-up to VCC. |
| 2, 3 | 1, 4 | DIN, /DIN | Differential Data Input | Differential Data Input. Inputs must be biased to meet common-mode range. |
| 4 | 6 | REF | | Reference Voltage: Bypass with 0.01µF low ESR capacitor from REF to VCC to stabilize LOSLVL and REF. |
| 5 | 14 | LOSLVL | Input: Default is maximum sensitivity. | Loss-of-Signal Level Set: A resistor from this pin to VCC 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 soldered (or equivalent) to the same potential as the ground pins. |
| 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 LOSLVL. |
| 8, 9 | 9, 12 | DOUT, /DOUT | Differential CML Output | Differential Data Output. |
| 10 | 5, 8, 13, 16 | VCC | Power Supply | Positive Power Supply. Bypass with 0.1µF\|\|0.01µF low ESR capacitors. 0.01µF capacitors should be as close as possible to VCC pins. |

## Absolute Maximum Ratings[1]

Supply Voltage ($V_{CC}$) ..... 0V to +7.0V
/EN, LOSLVL Voltage ..... 0 to $V_{CC}$
REF Current ..... ±1mA
LOS Current ..... ±5mA
DOUT, /DOUT Current ..... ±25mA
DIN, /DIN Current ..... ±10mA
Storage Temperature ($T_S$) ..... –65°C to +150°C
Lead Temperature (soldering, 20 sec.) ..... +260°C

## Operating Ratings[2]

Supply Voltage ($V_{CC}$) ..... +3.0V to +3.6V or
..... +4.5V to +5.5V
Ambient Temperature ($T_A$) ..... –40°C to +85°C
Junction Temperature ($T_J$) ..... –40°C to +120°C
Package 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 or 4.5V to 5.5V, $T_A$ = –40°C to +85°C; typical values at $V_{CC}$ = 3.3V, $T_A$ = 25°C.

| Symbol | Parameter | Condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $I_{CC}$ | Power Supply Current | 3.3V, **Note 4**<br>5V, **Note 4** | | 28<br>30 | 42<br>45 | mA<br>mA |
| | Power Supply Current | 3.3V, **Note 5**<br>5V, **Note 5** | | 45<br>47 | 62<br>65 | mA<br>mA |
| $V_{REF}$ | REF Voltage | | | $V_{CC}$–1.3 | | V |
| $V_{LOSLVL}$ | LOSLVL Voltage Range | | $V_{REF}$ | | $V_{CC}$ | V |
| $V_{OH}$ | DOUT, /DOUT HIGH Voltage | **Note 6** | $V_{CC}$–0.020 | $V_{CC}$–0.005 | $V_{CC}$ | V |
| $V_{OL}$ | DOUT, /DOUT LOW Voltage | 3.3V, **Note 6**<br>5V, **Note 6** | $V_{CC}$–0.475<br>$V_{CC}$–0.510 | $V_{CC}$–0.400<br>$V_{CC}$–0.400 | $V_{CC}$–0.350<br>$V_{CC}$–0.350 | V<br>V |
| $V_{OFFSET}$ | Differential Output Offset | **Note 6** | | | ±80 | mV |
| $Z_O$ | Single-Ended Output Impedance | | 40 | 50 | 60 | Ω |
| $V_{IHCMR}$ | Input Common Mode Range | **Note 7** | GND+2.15 | | $V_{CC}$ | V |

## TTL DC ELECTRICAL CHARACTERISTICS

$V_{CC}$ = 3.0V to 3.6V or 4.5V to 5.5V, $T_A$ = –40°C to +85°C.

| Symbol | Parameter | Condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $V_{OH}$ | LOS Output HIGH Level | Sourcing 100µA | 2.4 | | $V_{CC}$ | V |
| $V_{OL}$ | LOS Output LOW Level | Sinking 2mA | | | 0.5 | V |
| $V_{IH}$ | /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 |

**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 Ratlng 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. Thermal performance assumes the use of 4-layer PCB. Exposed pad must be soldered (or equivalent) to the device's most negative potential on the PCB.
4. Excludes current of CML output stage. See “Detailed Description.”
5. Total device current with no output load.
6. Output levels are based on a 50Ω to $V_{CC}$ load impedance. If the load impedance is different, the output level will be changed. Amplifier is in limiting mode.
7. The $V_{IHCMR}$ range is referenced to the most positive side of the differential input signal.

## AC ELECTRICAL CHARACTERISTICS

$V_{CC}$ = 3.0V to 3.6V or 4.5V to 5.5V, $T_A$ = –40°C to +85°C, $R_{LOAD}$ = 50Ω to $V_{CC}$; typical values at $V_{CC}$ = 3.3V, $T_A$ = 25°C.

| Symbol | Parameter | Condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| PSRR | Power Supply Rejection Ratio | | | 35 | | dB |
| $t_r$,$t_f$ | Output Rise/Fall Time (20% to 80%) | **Note 8** | | 60 | 120 | ps |
| $t_{JITTER}$ | Deterministic<br>Random | **Note 9** | | 15<br>5 | | $ps_{PP}$<br>$ps_{RMS}$ |
| $V_{ID}$ | Differential Input Voltage Swing | | 10 | | 1800 | $mV_{PP}$ |
| $V_{OD}$ | Differential Output Voltage Swing | 3.3V, **Note 8**<br>5V, **Note 8** | 700<br>700 | 800<br>800 | 950<br>1020 | $mV_{PP}$<br>$mV_{PP}$ |
| HYS | LOS Hysteresis | **Note 10** | 2 | 4.6 | 8 | dB |
| $t_{OFF}$ | LOS Release Time | | | 0.1 | 0.5 | µs |
| $t_{ON}$ | LOS Assert Time | | | 0.2 | 0.5 | µs |
| $V_{SR}$ | LOS Sensitivity Range | **Note 11** | 10 | | 35 | $mV_{PP}$ |
| $B_{–3dB}$ | –3dB Bandwidth | | | 2.0 | | GHz |
| $A_{V(Diff)}$ | Differential Voltage Gain | | 32 | 38 | | dB |
| $S_{21}$ | Single-Ended Small-Signal Gain | | 26 | 32 | | dB |

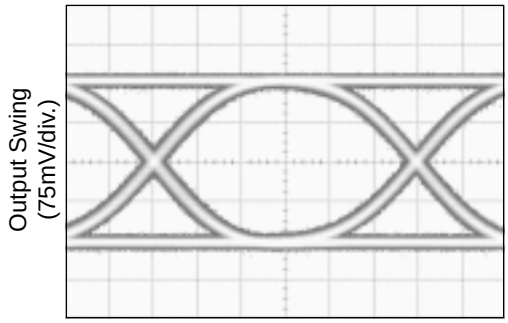
**Notes:**

8. Amplifier in limiting mode. Input is a 200MHz square wave, $t_r$ < 300ps.
9. Deterministic jitter measured using 2.488Gbps K28.5 pattern, $V_{ID}$ = 10$mV_{PP}$. Random jitter measured using 2.488Gbps K28.7 pattern, $V_{ID}$ = 10$mV_{PP}$.
10. Electrical signal.
11. This is the detectable range of input amplitudes that can assert LOS. The input amplitude to de-assert LOS is 2–8dB higher than the assert amplitude. See “Typical Operating Characteristics” for graphs showing how to choose a particular $V_{LOSLVL}$ or $R_{LOSLVL}$ for a particular LOS assert, and its associated de-assert, amplitude. If increased LOS sensitivity and hysteresis are required, an application note entitled “Notes on Sensitivity and Hysteresis in Micrel Post Amplifiers” is available at http://www.micrel.com/product-info/app_hints+notes.shtml.

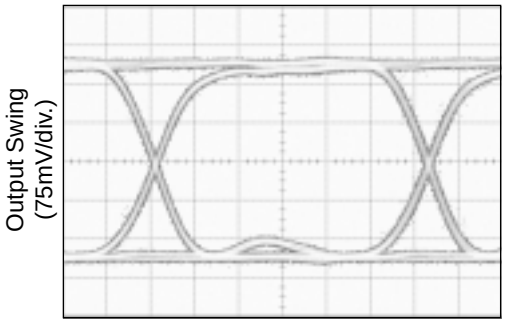
## TYPICAL OPERATING CHARACTERISTICS

$V_{CC}$ = 3.3V, $T_A$ = 25°C, $R_{LOAD}$ = 50Ω to $V_{CC}$, unless otherwise stated.

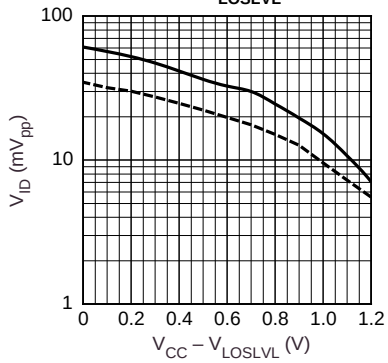
**10mV$_{pp}$ Input @3.2Gbps $2^{31}$–1 PRBS**



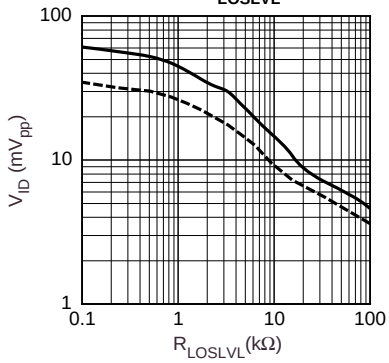

**1.8V$_{pp}$ Input @3.2Gbps $2^{31}$–1 PRBS**



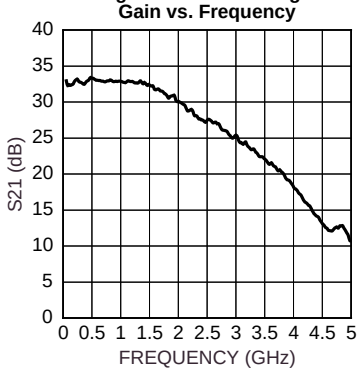

**$V_{ID}$ to Assert/De-assert LOS vs. $V_{LOSLVL}$**



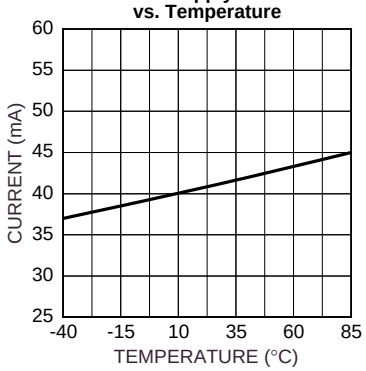

**$V_{ID}$ to Assert/De-assert LOS vs. $R_{LOSLVL}$**



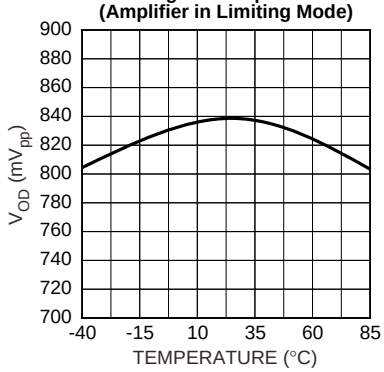

**Single-Ended Small-Signal Gain vs. Frequency**



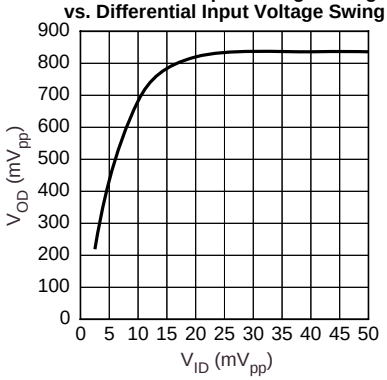

**Power Supply Current vs. Temperature**




**Differential Output Voltage Swing vs. Temperature (Amplifier in Limiting Mode)**




**Differential Output Voltage Swing vs. Differential Input Voltage Swing**



## DETAILED DESCRIPTION

The SY88773V low-power, limiting post amplifier operates from a single +3.3V or +5V 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 SY88773V generates an LOS output, providing feedback to /EN for output stability. LOSLVL sets the sensitivity of the input amplitude detection.

### Input Amplifier/Buffer

The SY88773V input is designed for $V_{REF}$ as its nominal DC bias point. If AC-coupling to the SY88773V, REF can be used as the DC bias point by externally connecting the inputs through appropriate termination resistors to REF. If DC-coupling to the SY88773V, ensure the upstream device's output swing meets the SY88773V's common mode range. Figure 2 shows a simplified schematic of the input structure.

The high-sensitivity of the input amplifier detects and amplifies signals as small as 10mV$_{pp}$. The input amplifier allows input signals as large as 1800mV$_{pp}$. Input signals are linearly amplified with a typically 38dB differential voltage gain. Since it is a limiting amplifier, the SY88773V outputs typically 800mV$_{pp}$ voltage-limited waveforms for input signals that are greater than 10mV$_{pp}$. Applications requiring the SY88773V to operate with high-gain should have the upstream TIA placed as close as possible to the SY88773V's input pins to ensure the device's best performance.

### Output Buffer

The SY88773V's CML output buffer is designed to drive 50Ω lines. The output buffer requires appropriate termination for proper operation. An external 50Ω resistor to VCC or equivalent for each output pin provides appropriate output buffer termination. Figure 3 shows a simplified schematic of the output structure and includes an appropriate termination method. Of course, driving a downstream device with a CML input that is internally terminated with 50Ω to VCC eliminates the need for external termination. As noted in the previous section, the amplifier outputs, typically 800mV$_{pp}$, waveforms across 25Ω total loads. The output buffer, thus, switches typically 16mA tail-current. Figure 4 shows the power supply current measurement which excludes the 16mA tail-current.

### Loss-of-Signal

The SY88773V incorporates a chatter-free, LOS open-collector TTL output with internal 4.75kΩ pull-up resistor as shown in Figure 5. LOS is used to determine that the input amplitude is too small to be considered a valid input. LOS asserts high if the input amplitude falls below the threshold set by LOSLVL and de-asserts low otherwise. LOS can be fed back to the enable (/EN) input to maintain output stability under a loss-of-signal condition. /EN de-asserts low the true output signal without removing the input signals. Typically, 4.6dB LOS hysteresis is provided to prevent chattering.

### Loss-of-Signal Level Set

A programmable, loss-of-signal level set pin sets the threshold of the input amplitude detection. Connecting an external resistor between VCC and LOSLVL sets the voltage at LOSLVL. This voltage ranges from $V_{CC}$ to $V_{REF}$. The external resistor creates a voltage divider between VCC and REF as shown in Figure 6. If desired, an appropriate external voltage may be applied rather than using a resistor. The relationship between $V_{LOSLVL}$ and $R_{LOSLVL}$ is given by:

$$V_{LOSLVL} = V_{CC} - 1.3\frac{R_{LOSLVL}}{R_{LOSLVL} + 2.8}$$

where voltages are in volts and resistances are in kΩ.

The smaller the external resistor, which implies a smaller voltage difference from LOSLVL to VCC, the lower the LOS sensitivity. Hence, larger input amplitude is required to de-assert LOS. The "Typical Operating Characteristics" section contains graphs showing the relationship between the input amplitude detection sensitivity and $V_{LOSLVL}$ or $R_{LOSLVL}$.

### Hysteresis

The SY88773V provides typically 4.6dB 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, hence, the ratios change linearly. Therefore, the optical hysteresis in dB is half the electrical hysteresis in dB given in the datasheet. The SY88773V provides typically 2.3dB LOS optical hysteresis. As the SY88773V is an electrical device, this datasheet refers to hysteresis in electrical terms. With 4.6dB LOS hysteresis, a voltage factor of 1.7 is required to de-assert LOS.

### Hysteresis and Sensitivity Improvement

If increased LOS sensitivity and hysteresis are required, an application note entitled "Notes on Sensitivity and Hysteresis in Micrel Post Amplifiers" is available at http://www.micrel.com/product-info/app_hints+notes.shtml.

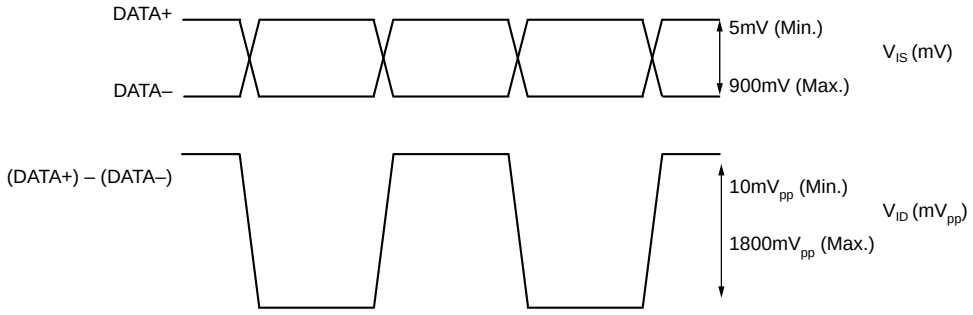



**Figure 1. $V_{IS}$ and $V_{ID}$ Definition**

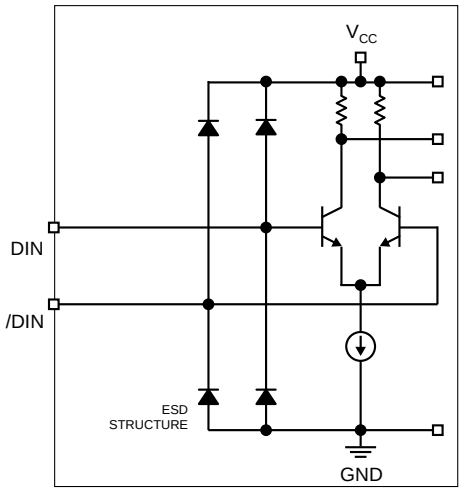



**Figure 2. Input Structure**

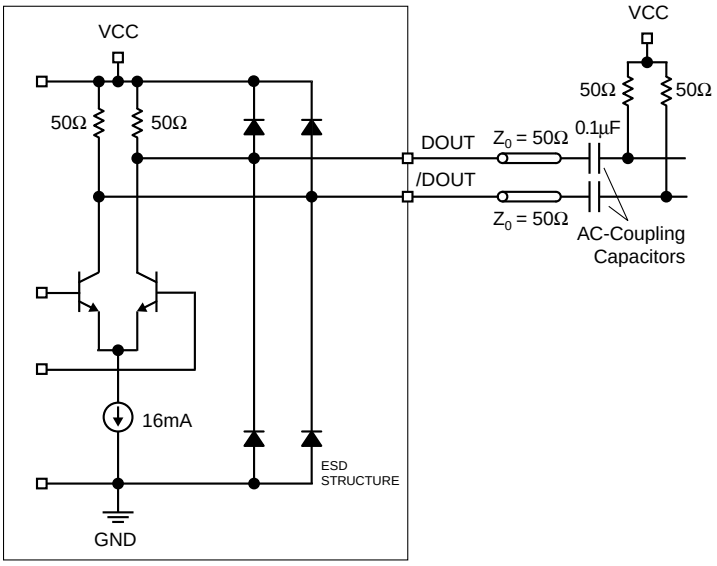



**Figure 3. Output Structure**

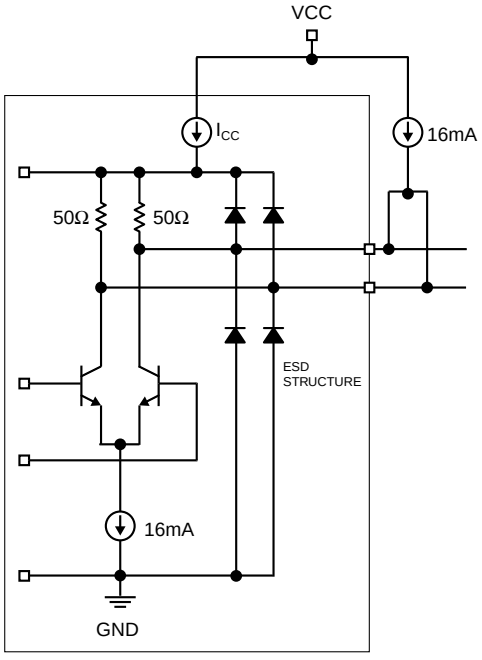



**Figure 4. Power Supply Current Measurement**

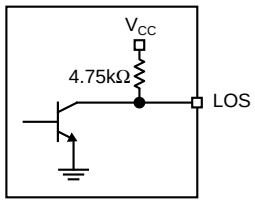



**Figure 5. LOS Output Structure**

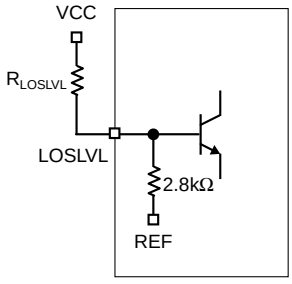
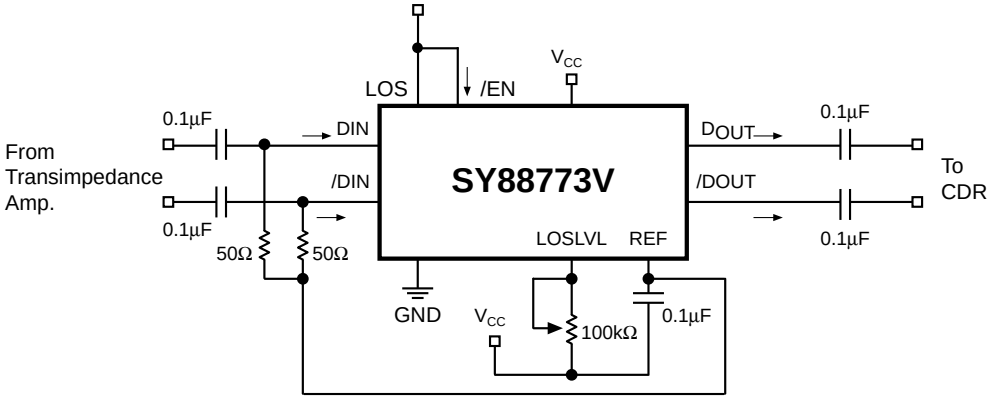



**Figure 6. LOSLVL Setting Circuit**

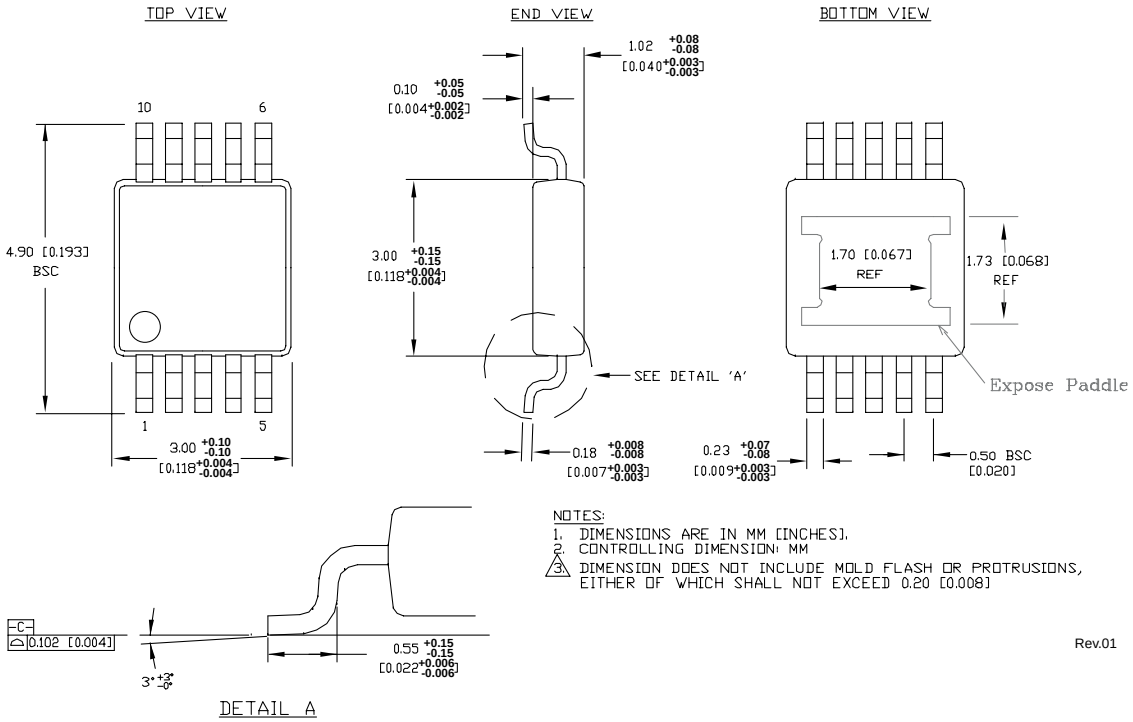
## TYPICAL APPLICATIONS CIRCUIT



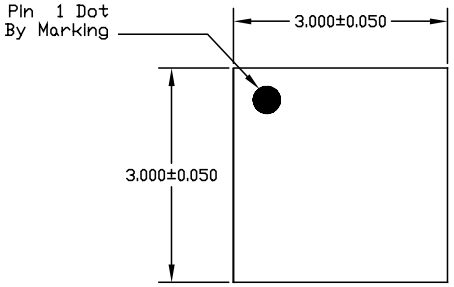

## RELATED PRODUCT AND SUPPORT DOCUMENTATION

| Part Number | Function | Data Sheet Link |
|---|---|---|
| SY88773V | 3.3V/5V 3.2Gbps CML Low-Power, Limiting Post Amplifier w/ TTL LOS | http://www.micrel.com/_PDF/HBW/sy88773v.pdf |
| SY88823V | 3.3V/5V 3.2Gbps CML Low-Power, Limiting Post Amplifier w/ TTL SD | http://www.micrel.com/_PDF/HBW/sy88823v.pdf |
| SY88843V | 3.3V/5V 3.2Gbps CML Low-Power, Limiting Post Amplifier w/ TTL SD | http://www.micrel.com/_PDF/HBW/sy88843v.pdf |
| SY88973V | 3.3V/5V 3.2Gbps CML Low-Power, Limiting Post Amplifier w/ TTL LOS | http://www.micrel.com/_PDF/HBW/sy88973v.pdf |
| Application Notes | Notes on Sensitivity and Hysteresis in Micrel Post Amplifiers | http://www.micrel.com/product-info/app_hints+notes.shtml |

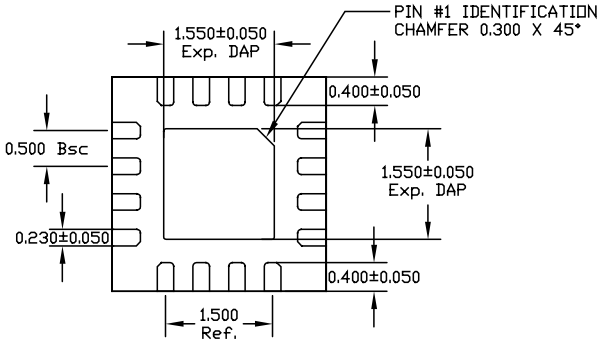
## 10 LEAD EPAD-MSOP (K10-2)



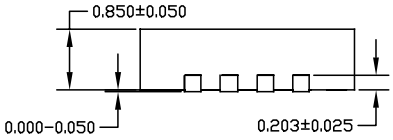
## 16-PIN *Micro*LEADFRAME™ (MLF-16)




TOP VIEW

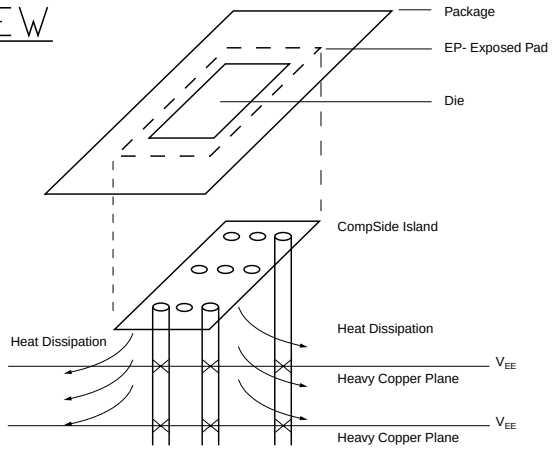



BOTTOM VIEW




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.




**PCB Thermal Consideration for 16-Pin MLF™ Package**
**(Always solder, or equivalent, the exposed pad to the PCB)**

**Package Notes:**

1. Package meets Level 2 qualification.
2. All parts are dry-packaged before shipment.
3. Exposed pads must be soldered to a ground for proper thermal management.

**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

The information furnished by Micrel in this data sheet is believed to be accurate and reliable. However, no responsibility is assumed by Micrel for its use. Micrel reserves the right to change circuitry and specifications at any time without notification to the customer.

Micrel Products are not designed or authorized for use as components in life support appliances, devices or systems where malfunction of a product can reasonably be expected to result in personal injury. Life support devices or systems are devices or systems that (a) are intended for surgical implant into the body or (b) support or sustain life, and whose failure to perform can be reasonably expected to result in a significant injury to the user. A Purchaser's use or sale of Micrel Products for use in life support appliances, devices or systems is at Purchaser's own risk and Purchaser agrees to fully indemnify Micrel for any damages resulting from such use or sale.

© 2005 Micrel, Incorporated.