



## SY88353BL

### 3.3V, 3.2 Gbps Limiting Post Amplifier with Programmable Decision Threshold

#### General Description

The SY88353BL limiting post amplifier is designed for use in fiber-optic receivers, and is specially optimized for WDM applications where optical amplifiers such as EDFAs and Raman amplifier are used. The device connects to typical transimpedance amplifiers (TIAs). The linear signal from TIAs can contain significant amounts of noise that is unevenly distributed between top and bottom rails due to the ASE noise generated by the optical amplifiers, crosstalk, or non-linear effect in the fiber. In order to optimize the BER in such noisy conditions, the decision threshold between bit 1 and bit 0, needs to be moved to the rail that contains less noise. The SY88353BL features a pin at which an external voltage can be applied to move the crossing point up and down, from 20% to 80%, for BER optimization purposes.

The SY88353BL operates from a single +3.3V power supply, over temperatures ranging from  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ . Signals with data rates from 155Mbps up to 3.2Gbps, and as small as  $10\text{mV}_{\text{pp}}$ , can be amplified to drive devices with CML or PECL inputs.

The SY88353L features a Loss-of-Signal (LOS) open-collector TTL output. A programmable Loss-of-Signal level set pin ( $\text{LOS}_{\text{LVL}}$ ) sets the sensitivity of the input amplitude detection. LOS asserts high if the input amplitude falls below the threshold sets by  $\text{LOS}_{\text{LVL}}$  and de-asserts low otherwise. The enable bar input ( $\text{/EN}$ ) de-asserts the true output signal without removing the input signal. The LOS output can be fed back to the  $\text{/EN}$  input to maintain output stability under a loss-of-signal condition. Typically, 3.3dB LOS hysteresis is provided to prevent chattering.

All support documentation can be found on Micrel's web site at: [www.micrel.com](http://www.micrel.com).

#### Features

- Single 3.3V power supply
- Fast LOS release/assert
- 155Mbps to 3.2Gbps operation
- Low-noise CML data outputs
- Chatter-free Open-Collector TTL loss-of-signal (LOS) output
- TTL  $\text{/EN}$  input
- Programmable LOS level set ( $\text{LOS}_{\text{LVL}}$ )
- Programmable Decision Threshold
- Available in a tiny 3mm x 3mm MLF<sup>®</sup> package

#### Applications

- WDM Systems
- Gigabit Ethernet, 1X and 2X Fibre Channel
- SONET/SDH: OC-3/12/24/48 – STM1/4/8/16
- Low-gain TIA interface

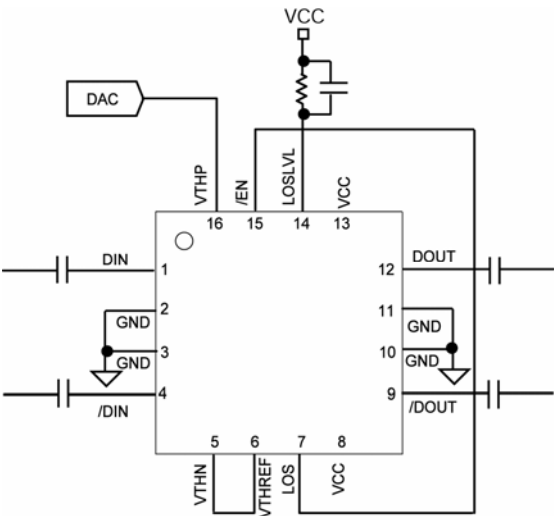
#### Markets

- Datacom/telecom
- Optical transceiver

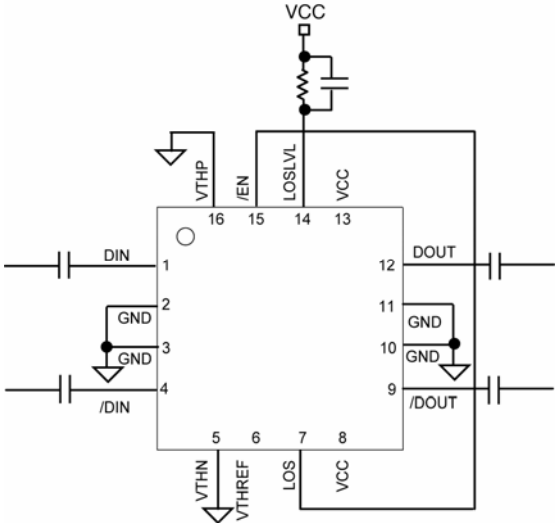
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Typical Application Circuit



Programmable Decision Threshold



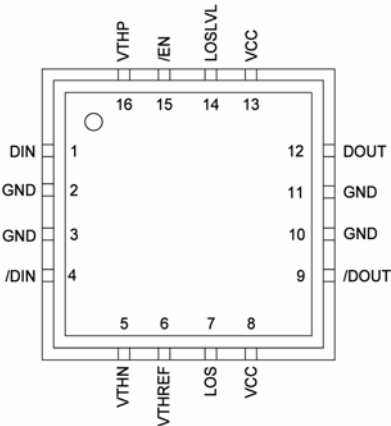
Fixed Decision Threshold

Ordering Information

| Part Number                  | Package Type | Operating Range | Package Marking                      | Lead Finish       |
|------------------------------|--------------|-----------------|--------------------------------------|-------------------|
| SY88353BLMG                  | MLF-16       | Industrial      | 353B with Pb-Free bar line indicator | NiPdAu<br>Pb-Free |
| SY88353BLMGTR <sup>(1)</sup> | MLF16        | Industrial      | 353B with Pb-Free bar line indicator | NiPdAu<br>Pb-Free |

Note:  
1. Tape and Reel.

Pin Configuration



16-Pin MLF® (MLF-16)

## Pin Description

| Pin Number   | Pin Name | Type                        | Pin Function                                                                                                                                                                                                    |
|--------------|----------|-----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1            | DIN      | Data Input                  | True data input.                                                                                                                                                                                                |
| 4            | /DIN     | Data Input                  | Complementary data input.                                                                                                                                                                                       |
| 5            | VTHN     | DC Input                    | Tie this pin to pin 6 (VTHREF) and apply a DC voltage on pin 16 (VTHP) for signal crossing adjustment. Connect to ground if no crossing adjustment is needed.                                                   |
| 6            | VTHREF   |                             | 1.25V Reference voltage (referenced to ground) for decision threshold adjustment.                                                                                                                               |
| 7            | LOS      | Open-collector TTL output   | Loss-of-Signal: asserts high when the data input amplitude falls below the threshold set by $LOS_{LVL}$ .                                                                                                       |
| 9            | /DOUT    | CML Output                  | Complementary data output.                                                                                                                                                                                      |
| 12           | DOUT     | CML Output                  | True data output.                                                                                                                                                                                               |
| 14           | LOSLVL   | Input                       | Loss-of-Signal Level Set. A resistor from this pin to $V_{CC}$ sets the threshold for the data input amplitude at which LOS will be asserted.                                                                   |
| 15           | /EN      | TTL Input: Default is HIGH. | /Enable: This input enables the outputs when it is LOW. Note that this input is internally connected to a 25k $\Omega$ pull-up resistor and will default to a logic HIGH state if left open.                    |
| 16           | VTHP     | DC Input                    | Apply a DC voltage from 0 to 2.4V to adjust the signal crossing level when pin 5 (VTHN) is tied to pin 6 (VTHREF). 1.25V sets the crossing close to 50%. Connect to ground if no crossing adjustment is needed. |
| 2, 3, 10, 11 | GND      | Ground                      | Device ground.                                                                                                                                                                                                  |
| 8, 13        | VCC      | Power Supply                | Positive power supply.                                                                                                                                                                                          |

**Absolute Maximum Ratings<sup>(1)</sup>**

|                                      |                                          |
|--------------------------------------|------------------------------------------|
| Supply Voltage ( $V_{CC}$ )          | 0V to +4.0V                              |
| Input Voltage (DIN, /DIN)            | 0 to $V_{CC}$                            |
| Output Current ( $I_{OUT}$ )         |                                          |
| Continuous                           | $\pm 25\text{mA}$                        |
| /EN Voltage                          | 0 to $V_{CC}$                            |
| $V_{REF}$ Current                    | -800 $\mu\text{A}$ to +500 $\mu\text{A}$ |
| $LOS_{LVL}$ Voltage                  | $V_{REF}$ to $V_{CC}$                    |
| Lead Temperature (soldering, 20sec.) | +260°C                                   |
| Storage Temperature ( $T_s$ )        | -65°C to +150°C                          |

**Operating Ratings<sup>(2)</sup>**

|                                           |                 |
|-------------------------------------------|-----------------|
| 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 |
| Supply Voltage ( $V_{CC}$ )               | +3.0V to +3.6V  |
| Ambient Temperature ( $T_A$ )             | -40°C to +85°C  |
| Package Thermal Resistance <sup>(3)</sup> |                 |
| MLF <sup>®</sup>                          |                 |
| ( $\theta_{JA}$ ) Still-air               | 60°C/W          |
| ( $\psi_{JB}$ )                           | 33°C/W          |

**DC Electrical Characteristics**

$V_{CC} = 3.0$  to  $3.6\text{V}$ ;  $T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ , typical values at  $V_{CC} = 3.3\text{V}$ ,  $T_A = 25^\circ\text{C}$ .

| Symbol       | Parameter                            | Condition      | Min              | Typ              | Max              | Units    |
|--------------|--------------------------------------|----------------|------------------|------------------|------------------|----------|
| $I_{CC}$     | Power Supply Current                 | No output load |                  | 45               | 62               | mA       |
| $LOS_{LVL}$  | $LOS_{LVL}$ Voltage                  |                | $V_{CC} - 1.3$   |                  | $V_{CC}$         | V        |
| $V_{OH}$     | DOOUT, /DOOUT HIGH Voltage           |                | $V_{CC} - 0.020$ | $V_{CC} - 0.005$ | $V_{CC}$         | V        |
| $V_{OL}$     | DOOUT, /DOOUT LOW Voltage            |                | $V_{CC} - 0.475$ | $V_{CC} - 0.400$ | $V_{CC} - 0.350$ | V        |
| $V_{OFFSET}$ | Differential Output Offset           |                |                  |                  | $\pm 80$         | mV       |
| $V_{THREF}$  | Decision Threshold Reference Voltage |                |                  | 1.25             |                  | V        |
| $Z_0$        | Single-Ended Output Impedance        |                | 40               | 50               | 60               | $\Omega$ |
| $Z_I$        | Single-Ended Input Impedance         |                | 40               | 50               | 60               | $\Omega$ |

**TTL DC Electrical Characteristics**

$V_{CC} = 3.0$  to  $3.6\text{V}$ ;  $T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ , typical values at  $V_{CC} = 3.3\text{V}$ ,  $T_A = 25^\circ\text{C}$ .

| Symbol    | Parameter                                | Condition                                            | Min  | Typ | Max       | Units                          |
|-----------|------------------------------------------|------------------------------------------------------|------|-----|-----------|--------------------------------|
|           | Output signal Crossing Range Lower Limit | VTHN connected to VTHREF and 0-2.4V applied to VTHP. |      |     | 20        | %                              |
|           | Output signal Crossing Range Upper Limit |                                                      | 80   |     |           | %                              |
| $V_{IH}$  | /EN Input HIGH Voltage                   |                                                      | 2.0  |     |           | V                              |
| $V_{IL}$  | /EN Input LOW Voltage                    |                                                      |      |     | 0.8       | V                              |
| $I_{IH}$  | /EN Input HIGH Current                   | $V_{IN} = 2.7\text{V}$<br>$V_{IN} = V_{CC}$          |      |     | 20<br>100 | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{IL}$  | /EN Input LOW Current                    | $V_{IN} = 0.5\text{V}$                               | -0.3 |     |           | mA                             |
| $I_{CEX}$ | LOS Output Leakage Current               | $V_{OUT} = V_{CC}$                                   |      |     | 100       | $\mu\text{A}$                  |
| $V_{OL}$  | LOS Output LOW Level                     | Sinking 2mA                                          |      |     | 0.5       | V                              |

## AC Electrical Characteristics

$V_{CC} = 3.0$  to  $3.6V$ ;  $R_{Load} = 50\Omega$  to  $V_{CC}$ ;  $T_A = -40^{\circ}C$  to  $+85^{\circ}C$ , typical values at  $V_{CC} = 3.3V$ ,  $T_A = 25^{\circ}C$ .

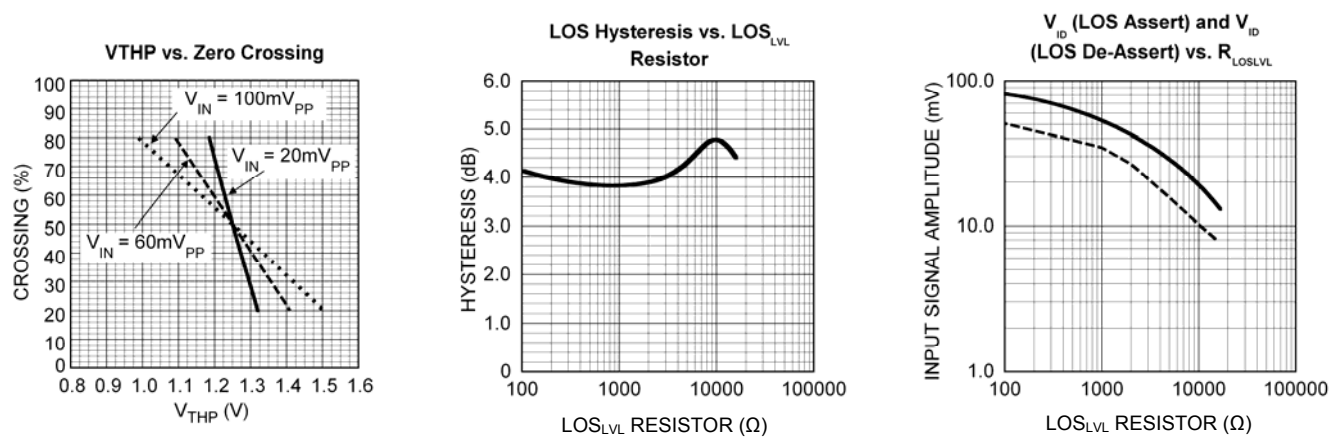
| Symbol        | Parameter                             | Condition                         | Min | Typ     | Max  | Units                                |
|---------------|---------------------------------------|-----------------------------------|-----|---------|------|--------------------------------------|
| $t_r, t_f$    | Output Rise/Fall Time<br>(20% to 80%) | Note 4                            |     | 60      | 100  | ps                                   |
| $t_{JITTER}$  | Deterministic<br>Random               | Note 5<br>Note 6                  |     | 15<br>5 |      | ps <sub>P</sub><br>ps <sub>RMS</sub> |
| $V_{ID}$      | Differential Input Voltage Swing      |                                   | 20  |         | 1800 | mV <sub>PP</sub>                     |
| $V_{OD}$      | Differential Output Voltage Swing     | Note 4                            | 700 | 800     | 950  | mV <sub>PP</sub>                     |
| $T_{OFF}$     | LOS Release Time                      | Note 9                            |     | 2       | 10   | μs                                   |
| $T_{ON}$      | LOS Assert Time                       | Note 9                            |     | 2       | 10   | μs                                   |
| $LOS_{AL}$    | Low LOS Assert Level                  | $R_{LOSLVL} = 15k\Omega$ , Note 7 |     | 9       |      | mV <sub>PP</sub>                     |
| $LOS_{DL}$    | Low LOS De-assert Level               | $R_{LOSLVL} = 15k\Omega$ , Note 7 |     | 13      |      | mV <sub>PP</sub>                     |
| $HYS_L$       | Low LOS Hysteresis                    | $R_{LOSLVL} = 15k\Omega$ , Note 8 |     | 3.2     |      | dB                                   |
| $LOS_{AM}$    | Medium LOS Assert Level               | $R_{LOSLVL} = 5k\Omega$ , Note 7  |     | 17      |      | mV <sub>PP</sub>                     |
| $LOS_{DM}$    | Medium LOS De-assert Level            | $R_{LOSLVL} = 5k\Omega$ , Note 7  |     | 25      |      | mV <sub>PP</sub>                     |
| $HYS_M$       | Medium LOS Hysteresis                 | $R_{LOSLVL} = 5k\Omega$ , Note 8  |     | 3.3     |      | dB                                   |
| $LOS_{AH}$    | High LOS Assert Level                 | $R_{LOSLVL} = 100\Omega$ , Note 7 |     | 47      |      | mV <sub>PP</sub>                     |
| $LOS_{DH}$    | High LOS De-assert Level              | $R_{LOSLVL} = 100\Omega$ , Note 7 |     | 70      |      | mV <sub>PP</sub>                     |
| $HSY_H$       | High LOS Hysteresis                   | $R_{LOSLVL} = 100\Omega$ , Note 8 |     | 3.4     |      | dB                                   |
| $B_{3dB}$     | 3dB Bandwidth                         |                                   |     | 2.0     |      | GHz                                  |
| $A_{V(Diff)}$ | Differential Voltage Gain             |                                   |     | 38      |      | dB                                   |
| $S_{21}$      | Single-Ended Small-Signal Gain        |                                   | 26  | 32      |      | dB                                   |

### Notes:

- 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 ratings conditions for extended periods may affect device reliability.
- The data sheet limits are not guaranteed if the device is operated beyond the operating ratings.
- Package Thermal Resistance assumes exposed pad is soldered (or equivalent) to the devices most negative potential on the PCB.  $\psi_{JB}$  uses a 4-layer and  $\theta_{JA}$  in still-air number, unless otherwise stated.
- Amplifier in limiting mode. Input is a 200MHz square wave.
- Deterministic jitter measured using 2.5Gbps K28.5 pattern,  $V_{ID} = 10mV_{PP}$ .
- Random jitter measured using 2.5Gbps K28.7 pattern,  $V_{ID} = 10mV_{PP}$ .
- 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.
- This specification defines electrical hysteresis as  $20\log$  (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 upon that ratio, the optical hysteresis corresponding to the electrical hysteresis range 1dB-4.5 dB, shown in the AC characteristics table, will be 0.5dB-3dB Optical Hysteresis.
- In real world applications, the LOS Release/Assert time can be strongly influenced by the RC time constant of the AC-coupling cap and the 50Ω input termination. To keep this time low, use a decoupling cap with the lowest value that is allowed by the data rate and the number of consecutive identical bits in the application. Typical values are in the range of 0.001μF to 1.0μF.

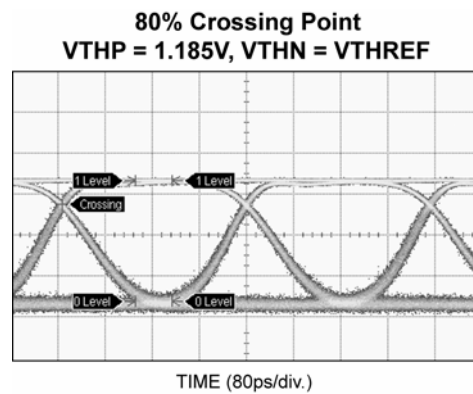
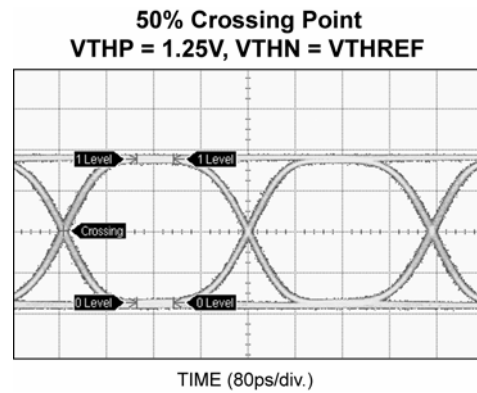
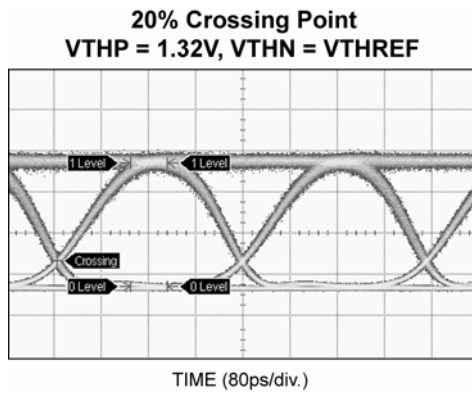
## Typical Operating Characteristics

$V_{CC} = 3.3V$ ,  $T_A = 25^\circ C$ ,  $R_L = 50\Omega$  to  $V_{CC}-2V$ , unless otherwise stated.

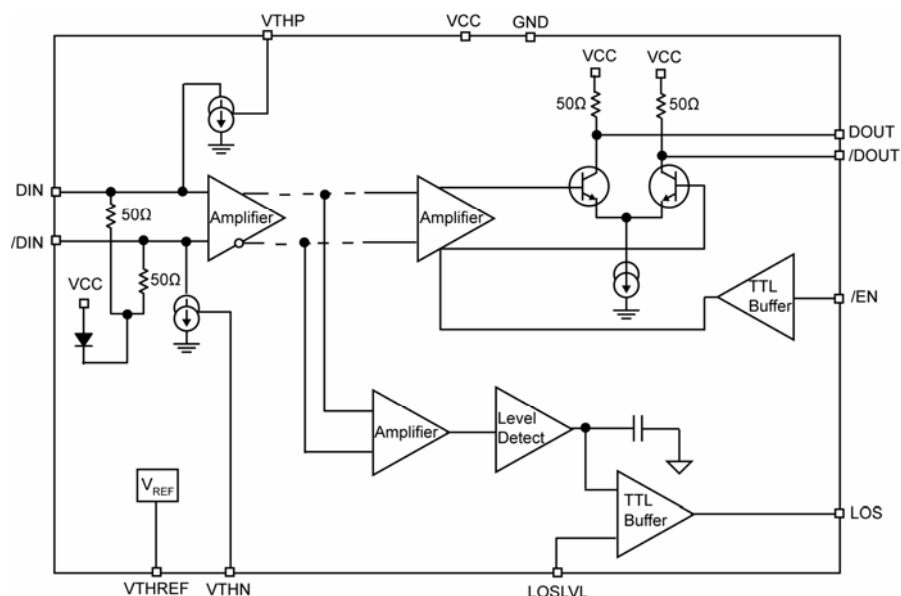


## Functional Characteristics

$V_{CC} = 3.3V$ ,  $T_A = 25^\circ C$ ,  $R_L = 50\Omega$  to  $V_{CC}-2V$ , unless otherwise stated.



## Functional Block Diagram



## Detailed Description

The SY88353L limiting post amplifier operates from a single +3.3V power supply, over temperatures from  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ . Signals with data rates from 155Mbps up to 3.2Gbps, and as small as  $10\text{mV}_{\text{pp}}$ , can be amplified. Figure 1 shows the allowed input voltage swing. The SY88353L generates a LOS output that can be feedback to /EN for output stability in the absence of a signal at the input.  $\text{LOSL}_{\text{LVL}}$  sets the sensitivity of the input amplitude detection. The amplifier features a signal crossing adjustment for BER optimization in optical links using optical amplifiers such in WDM applications.

### Input Amplifier/Buffer

Figure 2 shows a simplified schematic of the input stage. The input amplifier allows signals as small as  $10\text{mV}_{\text{pp}}$  to be detected and amplified. The input amplifier allows input signals as large as  $1800\text{mV}_{\text{pp}}$ . Input signals are linearly amplified with a typical 38dB differential voltage gain. Since it is a limiting amplifier, the SY88353BL outputs typically  $800\text{mV}_{\text{pp}}$  voltage-limited waveforms for input signals that are greater than  $12\text{mV}_{\text{pp}}$ . Applications requiring the SY88353L to operate with high gain should have the upstream TIA placed as close as possible to the SY88353BL's input pins to ensure the best performance of the device.

### Output Buffer

The SY88353BL's CML output buffer is designed to drive  $50\Omega$  lines and is internally terminated with  $50\Omega$  to  $V_{\text{CC}}$ . Figure 3 shows a simplified schematic of the output stage.

### Loss-of-Signal

The SY88353L generates a chatter-free loss-of-signal (LOS) open-collector, TTL output, as shown in Figure 4. LOS is used to determine if 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  $\text{LOSL}_{\text{LVL}}$  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, 3.3dB LOS hysteresis is provided to prevent chattering.

### Loss-of-Signal-Level Set

A programmable LOS level set pin ( $\text{LOSL}_{\text{LVL}}$ ) sets the threshold of the input amplitude detection. Connecting an external resistor between  $V_{\text{CC}}$  and  $\text{LOSL}_{\text{LVL}}$  sets the voltage at  $\text{LOSL}_{\text{LVL}}$ . This voltage ranges from  $V_{\text{CC}}$  to  $V_{\text{CC}} - 1.3\text{V}$ . The external resistor creates a voltage divider between  $V_{\text{CC}}$  and  $V_{\text{CC}} - 1.3\text{V}$ , as shown in Figure 5.

### Hysteresis

The SY88353L typically provides 3.3dB LOS electrical hysteresis, which is defined as  $20\log(V_{\text{IN}_{\text{LOS-De-assert}}}/V_{\text{IN}_{\text{LOS-Assert}}})$ . Since the relationship between the voltage out of the ROSA and optical power at its input is linear, the optical hysteresis will be typically half of the electrical hysteresis reported in the datasheet. In practice, the ratio between electrical and optical hysteresis is found to be within the range 1.5 to 1.8dB. Thus, 3.3dB electrical hysteresis will correspond to an optical hysteresis within the range 1.8 to 2.2dB.

## Signal Crossing Adjustment

In order to optimize the decision threshold level and hence, the BER of the optical link, the SY88353L provides two pins for output signal crossing control. The signal crossing can be adjusted by connecting VTHN (pin 5) to VTHREF (pin 6), and applying a DC signal at VTHP (pin 16). By varying the DC signal at VTHP from – 0V to 2.5V – while the input signal to the post amplifier is less than 100mV<sub>pp</sub>, the crossing of the output signal will change from 20% to 80% reaching 50% when VTHP

= VTHREF = 1.25V. If the crossing control function is not needed, VTHN and VTHP must be connected to ground.

The zero crossing vs. VTHP plot, shown on page 6, shows how the crossing of the output signal changes with the voltage applied at VTHP (pin 16) while VTHN (pin 5) is tied to VTHREF (pin 6) for different input signal levels.

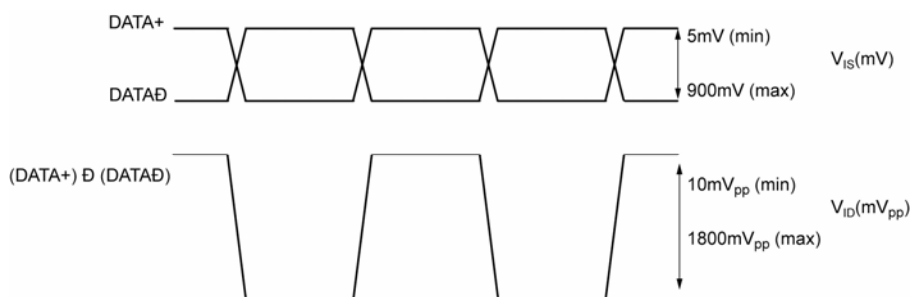


Figure 1.  $V_{IS}$  and  $V_{ID}$  Definition

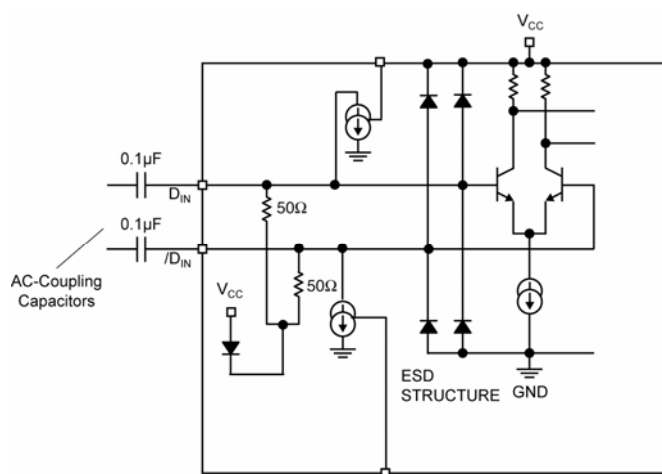


Figure 2. Input Structure

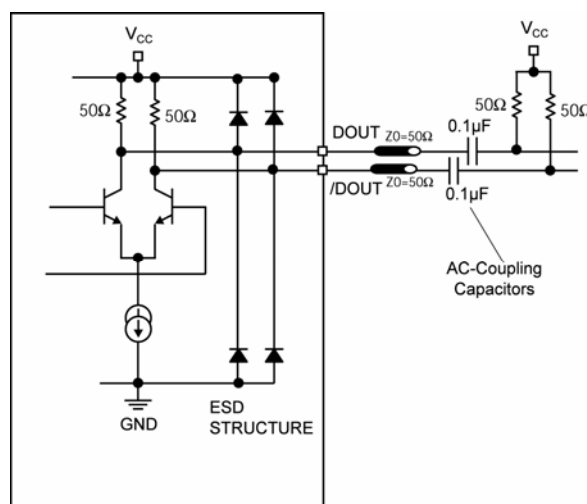


Figure 3. Output Structure

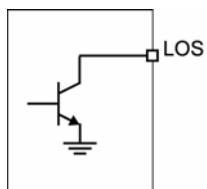
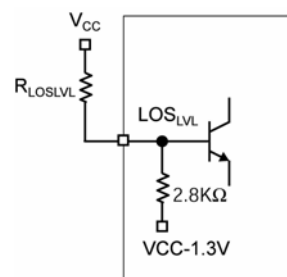


Figure 4. LOS Output Structure

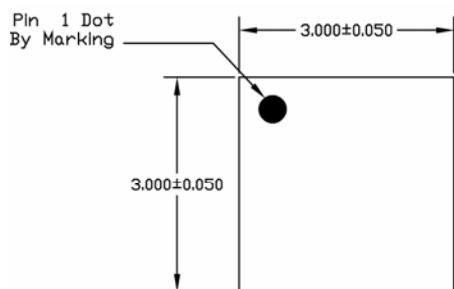
Figure 5.  $LOS_{LVL}$  Setting Circuit

*Note: Recommended value for  $R_{LOSLVL}$  is  $15k\Omega$  or less.*

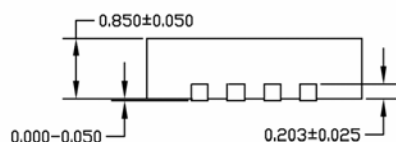
## Related Product and Support Documentation

| Part Number | Function                                                      | Data Sheet Link                                                                                                                 |
|-------------|---------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|
| AN-45       | Notes on Sensitivity and Hysteresis in Micrel Post Amplifiers | <a href="http://www.micrel.com/product-info/app_hints+notes.shtml">http://www.micrel.com/product-info/app_hints+notes.shtml</a> |

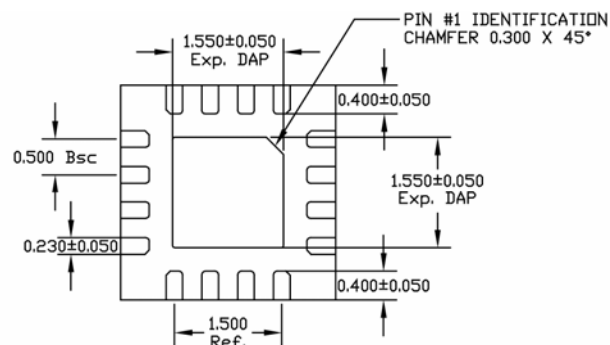
## Package Information



TOP VIEW



SIDE VIEW



BOTTOM VIEW

NOTE:

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

### 16-Pin (3mm x 3mm) MLF<sup>®</sup> (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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