



## SY88053AL

### 3.3V, 12.5Gbps Limiting Post Amplifier with Programmable Decision Threshold

#### General Description

The SY88053AL, limiting post amplifier is designed for use in fiber-optic receivers for applications up to 12.5Gbps. It features a decision threshold control that can be used for offset compensation or to optimize the Bit Error Rate (BER) in noisy applications as WDM where optical amplifiers such as EDFAs and Raman amplifier are used. This device connects to typical transimpedance amplifiers (TIAs). The signal from TIAs can contain significant amounts of noise unevenly distributed between its top and bottom rails due to the Amplified Spontaneous Emission (ASE) noise generated by the optical amplifiers. 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. An external voltage applied at the VTHP pin on the SY88053AL will move the crossing point up and down, from 20% to 80%, to achieve the best BER.

The SY88053AL operates from a single +3.3V power supply, over temperatures ranging from  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ , and can detect and amplify signals up to 12.5Gbps and amplitude as low as  $15\text{mV}_{\text{PP}}$ .

The SY88053AL generates 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 set by  $\text{LOS}_{\text{LVL}}$  and de-asserts low otherwise. The enable 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 implement the squelch function that maintains output stability under a loss-of-signal condition.

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
- Up to 12.5Gbps operation
- Programmable Decision Threshold
- Low-noise CML data outputs
- TTL  $/\text{EN}$  input
- Programmable LOS level ( $\text{LOS}_{\text{LVL}}$ )
- Available in a tiny 3mm x 3mm MLF<sup>®</sup> package

#### Applications

- WDM Systems
- 10xGigabit Ethernet, 8xFibre Channel
- SONET/SDH:OC192 – STM64
- Low-gain TIA interface

#### Markets

- Datacom/telecom
- Optical transceiver

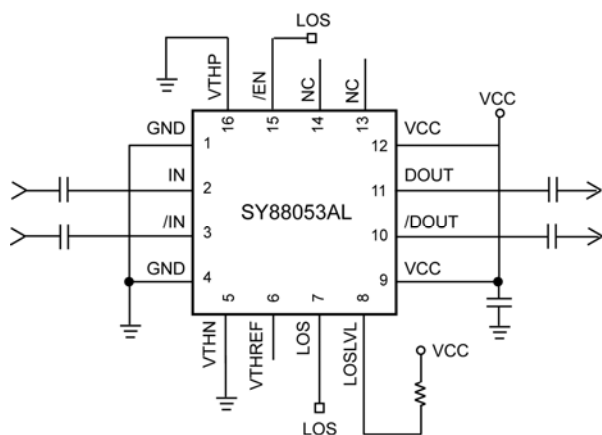
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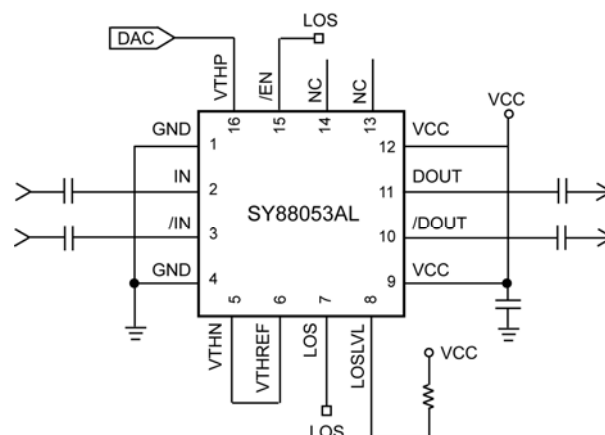
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M9999-052610-A  
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## Typical Application Circuit



Fixed Decision Threshold



Programmable Decision Threshold

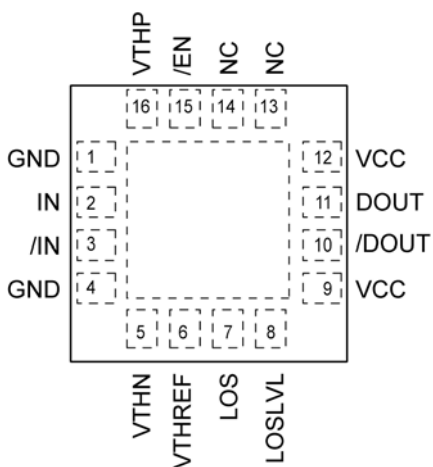
## Ordering Information

| Part Number                  | Package Type | Operating Range | Package Marking                      | Lead Finish    |
|------------------------------|--------------|-----------------|--------------------------------------|----------------|
| SY88053ALMG                  | MLF-16       | Industrial      | 053A with Pb-Free bar line indicator | NiPdAu Pb-Free |
| SY88053ALMGTR <sup>(1)</sup> | MLF16        | Industrial      | 053A with Pb-Free bar line indicator | NiPdAu Pb-Free |

**Note:**

1. Tape and Reel.

## Pin Configuration



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

## Pin Description

| Pin Number | Pin Name    | Type                      | Pin Function                                                                                                                                                                                                    |
|------------|-------------|---------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2, 3       | DIN, /DIN   | Data Input                | Differential data inputs. Each input is internally terminated to approximately $V_{CC} - 1.3V$ by a $50\Omega$ resistor. AC-Couple input signals.                                                               |
| 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      | DC Output                 | 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 $LOS_{LVL}$ .                                                                                                       |
| 8          | LOSLVL      | DC 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.                                                                   |
| 10, 11     | /DOUT, DOUT | CML Output                | Differential data outputs. Unused output should be terminated $50\Omega$ -to- $V_{CC}$ .                                                                                                                        |
| 13, 14     | NC, NC      | No Connection             | Unused pins.                                                                                                                                                                                                    |
| 15         | /EN         | TTL Input                 | /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. |
| 1,4        | GND         | Ground                    | Device ground. Exposed pad must be soldered (or equivalent) to the same potential as the ground pins.                                                                                                           |
| 9, 12      | VCC         | Power Supply              | Positive power supply. Bypass with $0.1\mu F    0.01\mu F$ low ESR capacitors. $0.01\mu F$ capacitors should be as close as possible to VCC pins.                                                               |

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

Supply Voltage ( $V_{CC}$ ) ..... 0V to +4.0V  
 Input Voltage (DIN, /DIN) ..... ( $V_{CC}-1.0V$ ) to ( $V_{CC}+0.5V$ )  
 Output Current ( $I_{OUT}$ ) .....  $\pm 25mA$   
 EN Voltage ..... 0 to  $V_{CC}$   
 LOS<sub>LVL</sub> Voltage .....  $V_{CC}-1.3V$  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  
 Package Thermal Resistance<sup>(3)</sup>  
 MLF®  
 ( $\theta_{JA}$ ) Still-air ..... 60°C/W  
 ( $\psi_{JB}$ ) ..... 33°C/W

**DC Electrical Characteristics**

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

| Symbol             | Parameter                            | Condition                 | Min            | Typ            | Max            | Units    |
|--------------------|--------------------------------------|---------------------------|----------------|----------------|----------------|----------|
| $I_{CC}$           | Power Supply Current                 | Note 4                    |                | 50             | 70             | mA       |
| LOS <sub>LVL</sub> | LOS <sub>LVL</sub> Voltage           |                           | $V_{CC}-1.3$   |                | $V_{CC}$       | V        |
| $V_{OH}$           | DOUT, /DOUT HIGH Voltage             |                           | $V_{CC}-0.020$ | $V_{CC}-0.005$ | $V_{CC}$       | V        |
| $V_{OL}$           | DOUT, /DOUT LOW Voltage              |                           | $V_{CC}-0.400$ | $V_{CC}-0.350$ | $V_{CC}-0.300$ | V        |
| $V_{OFFSET}$       | Differential Output Offset           | VTHP and VTHN tied to GND |                |                | $\pm 80$       | mV       |
| $V_{THREF}$        | Decision Threshold Reference Voltage |                           |                | 1.25           |                | V        |
| $Z_0$              | Single-Ended Output Impedance        |                           | 45             | 50             | 55             | $\Omega$ |
| $Z_I$              | Single-Ended Input Impedance         |                           | 45             | 50             | 55             | $\Omega$ |

**TTL DC Electrical Characteristics**

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

| Symbol   | Parameter                                | Condition                            | Min  | Typ | Max       | Units              |
|----------|------------------------------------------|--------------------------------------|------|-----|-----------|--------------------|
|          | Output Signal Crossing Range Lower Limit | Note 5                               |      |     | 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                   | $V_{IN} = 2.7V$<br>$V_{IN} = V_{CC}$ |      |     | 20<br>100 | $\mu A$<br>$\mu A$ |
| $I_{IL}$ | /EN Input LOW Current                    | $V_{IN} = 0.5V$                      | -0.3 |     |           | mA                 |
| $V_{OH}$ | LOS Output HIGH Level                    | Sourcing 100 $\mu A$                 | 2.4  |     |           | V                  |
| $V_{OL}$ | LOS Output LOW Level                     | Sinking 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 ratings 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 devices most negative potential on the PCB.  $\psi_{JB}$  uses a 4-layer and  $\theta_{JA}$  in still air unless otherwise stated.
4. VTHN and VTHP are both at GND potential and with outputs Q and /Q loaded and with the device enabled.
5. VTHN connected to VTHREF and DC voltage between 0V and 2.4V applied to VTHP. Input at DIN is between 15mVpp to 60mVpp. See Figure on page 7

## 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  $V_{CC} = 3.3V$ ,  $T_A = 25^\circ C$ .

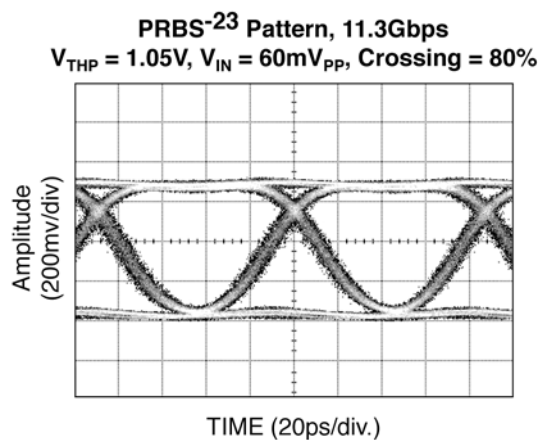
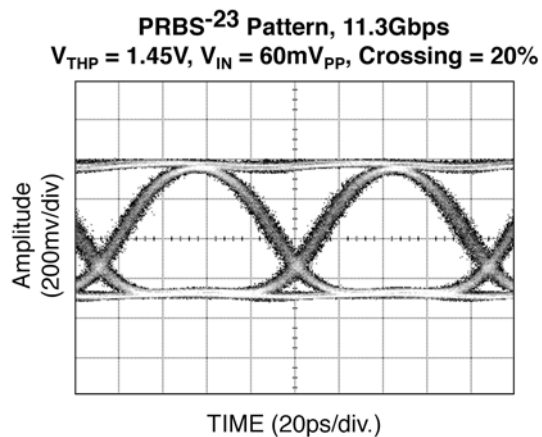
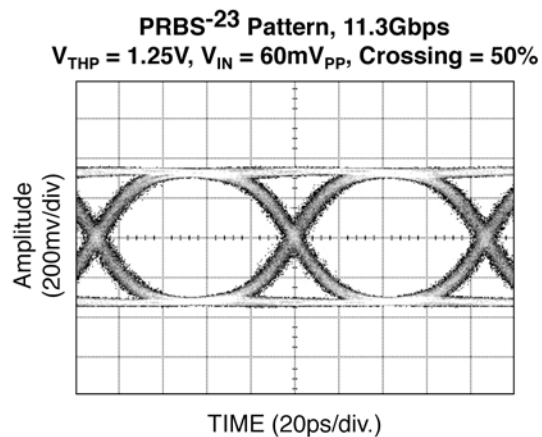
| Symbol        | Parameter                             | Condition                          | Min | Typ     | Max  | Units                                 |
|---------------|---------------------------------------|------------------------------------|-----|---------|------|---------------------------------------|
| $t_r, t_f$    | Output Rise/Fall Time<br>(20% to 80%) | Note 6                             |     | 25      | 35   | ps                                    |
| $t_{JITTER}$  | Deterministic<br>Random               | Note 7<br>Note 8                   |     | 10<br>1 |      | ps <sub>PP</sub><br>ps <sub>RMS</sub> |
| $V_{ID}$      | Differential Input Voltage Swing      |                                    | 15  |         | 1800 | mV <sub>PP</sub>                      |
| $V_{OD}$      | Differential Output Voltage Swing     | Note 6                             | 600 | 700     | 800  | mV <sub>PP</sub>                      |
| $T_{OFF}$     | LOS Release Time                      | Note 11                            |     | 100     | 500  | ns                                    |
| $T_{ON}$      | LOS Assert Time                       | Note 11                            |     | 100     | 500  | ns                                    |
| $LOS_{AL}$    | Low LOS Assert Level                  | $R_{LOSLVL} = 10k\Omega$ , Note 9  | 5   | 14      |      | mV <sub>PP</sub>                      |
| $LOS_{DL}$    | Low LOS De-assert Level               | $R_{LOSLVL} = 10k\Omega$ , Note 9  |     | 20      | 25   | mV <sub>PP</sub>                      |
| $HSY_L$       | Low LOS Hysteresis                    | $R_{LOSLVL} = 10k\Omega$ , Note 10 | 2   | 3.0     | 6    | dB                                    |
| $LOS_{AM}$    | Medium LOS Assert Level               | $R_{LOSLVL} = 5k\Omega$ , Note 9   | 10  | 21      |      | mV <sub>PP</sub>                      |
| $LOS_{DM}$    | Medium LOS De-assert Level            | $R_{LOSLVL} = 5k\Omega$ , Note 9   |     | 30      | 40   | mV <sub>PP</sub>                      |
| $HSY_M$       | Medium LOS Hysteresis                 | $R_{LOSLVL} = 5k\Omega$ , Note 10  | 2   | 3.0     | 6    | dB                                    |
| $LOS_{AH}$    | High LOS Assert Level                 | $R_{LOSLVL} = 100\Omega$ , Note 9  | 35  | 55      |      | mV <sub>PP</sub>                      |
| $LOS_{DH}$    | High LOS De-assert Level              | $R_{LOSLVL} = 100\Omega$ , Note 9  |     | 76      | 85   | mV <sub>PP</sub>                      |
| $HSY_H$       | High LOS Hysteresis                   | $R_{LOSLVL} = 100\Omega$ , Note 10 | 2   | 3.0     | 6    | dB                                    |
| $B_{3dB}$     | 3dB Bandwidth                         |                                    |     | 10      |      | GHz                                   |
| $A_{V(Diff)}$ | Differential Voltage Gain             |                                    |     | 38      |      | dB                                    |
| $S_{21}$      | Single-Ended Small-Signal Gain        |                                    | 26  | 32      |      | dB                                    |

### Notes:

6. Amplifier in limiting mode. Input is a 200MHz square wave.
7. Deterministic jitter measured using 10 Gbps K28.5 pattern,  $V_{ID} = 60mV_{PP}$ .
8. Random jitter measured using 10Gbps K28.7 pattern,  $V_{ID} = 60mV_{PP}$ .
9. 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.
10. This specification defines electrical hysteresis as  $20\log (LOS\ De\text{-}Assert/LOS\ Assert)$ . 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 1dB-4.5 dB, shown in the AC characteristics table, will be 0.5dB-3dB Optical Hysteresis.
11. 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 50 $\Omega$  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 0.001 $\mu F$  to 1.0 $\mu F$ ).

## Typical Functional Characteristics

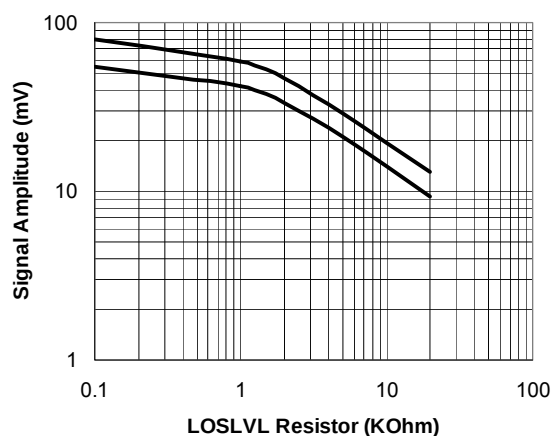
$V_{CC} = 3.3V$ ,  $T_A = 25^\circ C$ ,  $V_{THN}$  tied to  $V_{THREF}$ ,  $R_L = 50\Omega$  to  $V_{CC}-2V$ , unless otherwise stated.



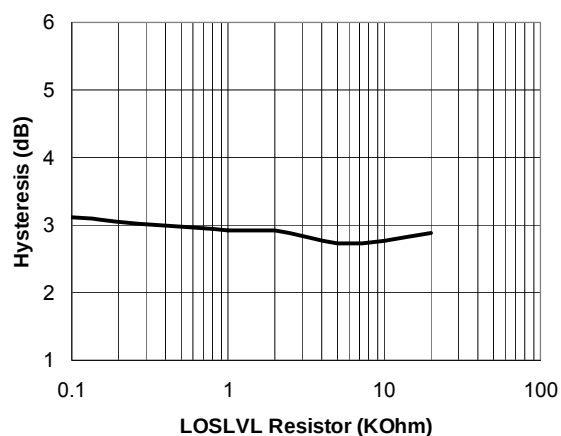
## Typical Operating Characteristics

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

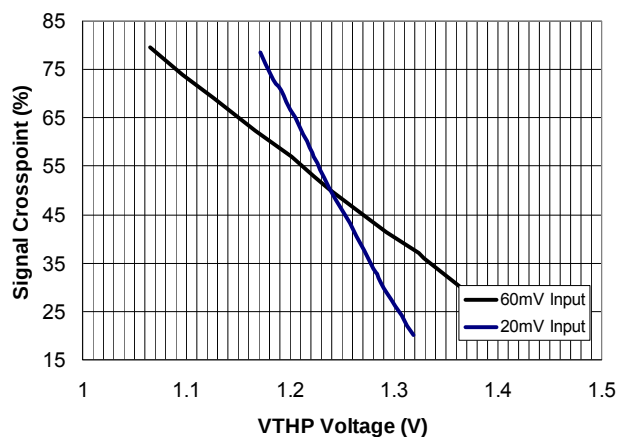
### LOS Assert/De-Assert Levels



### LOS Hysteresis



### Crosspoint Adjustment



## Detailed Description

The SY88053AL is a high-sensitivity limiting post amplifier that operates from a single +3.3V power supply over temperatures from  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ . Signals with data rates up to 12.5Gbps, and as small as  $15\text{mV}_{\text{pp}}$ , can be amplified. Figure 1 shows the allowed input voltage swing. The SY88053AL generates a LOS output signal that can be fed back to /EN for output stability in the absence of a signal at the input.  $\text{LOS}_{\text{LVL}}$  sets the sensitivity of the input amplitude detection. In the situations where the noise is not evenly distributed between the high and the low levels of the signal, such as in links using EDFA amplifiers, the offset of the signal can be adjusted, using VTHN and VTHP pins to optimize the performance of the link.

### Input Amplifier/Buffer

Figure 2 shows a simplified schematic of the input stage. The high-sensitivity of the input amplifier allows signals as small as  $15\text{mV}_{\text{pp}}$  to be detected and amplified. The input amplifier allows input signals as large as  $1800\text{mV}_{\text{pp}}$ . Input signals are amplified with a typically 38dB differential voltage gain. Since it is a limiting amplifier, the SY88053AL outputs typically  $700\text{mV}_{\text{pp}}$  voltage-limited waveforms for input signals that are greater than  $10\text{mV}_{\text{pp}}$ .

### Output Buffer

The SY88053AL's CML output buffer is designed to drive  $50\Omega$  lines and is internally terminated with  $50\Omega$  to VCC. Figure 3 shows a schematic of the output stage.

### Loss-of-Signal

The SY88053AL generates a chatter-free loss-of-signal (LOS) open-collector TTL output as shown in Figure 4. LOS is used to determine that the input amplitude is too small to be considered as a valid input. LOS asserts high if the input amplitude falls below the threshold set by  $\text{LOS}_{\text{LVL}}$  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, 3dB LOS hysteresis is provided to prevent chattering.

### Loss-of-Signal-Level Set

A programmable LOS level set pin ( $\text{LOS}_{\text{LVL}}$ ) sets the threshold of the input amplitude detection. Connecting an external resistor between  $V_{\text{CC}}$  and  $\text{LOS}_{\text{LVL}}$  sets the voltage at  $\text{LOS}_{\text{LVL}}$ . 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.

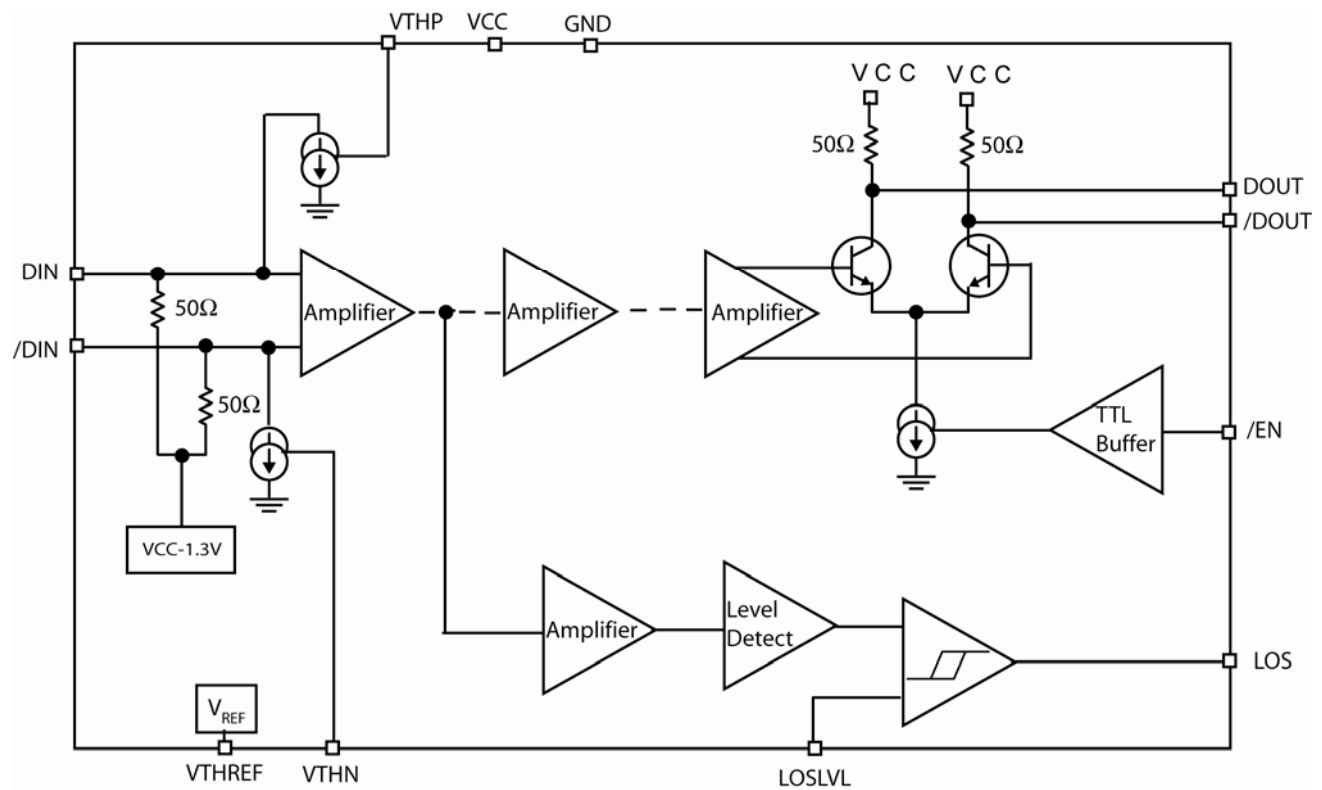
### Hysteresis

The SY88053AL provides typically 3dB LOS electrical hysteresis, which is defined as  $20\log(V_{\text{IN}_{\text{LOS-Assert}}} / V_{\text{IN}_{\text{LOS-De-Assert}}})$ . Since the relationship between the voltage out of the ROSA to optical power at its input is linear, the optical hysteresis will be typically half of the electrical hysteresis reported in the datasheet, but in practice the ratio between electrical and optical hysteresis is found to be within the range 1.5-1.8. Thus 3dB electrical hysteresis will correspond to an optical hysteresis within the range 1.7dB - 2dB.

### Signal Crossing Adjustment

In order to optimize the BER of the optical link where the noise is unevenly distributed between the high and the low levels, the SY88053AL provides two pins for output signal crossing control. The output crossing can be adjusted by connecting pins VTHN and VTHREF together while applying a DC voltage at VTHP pin. By varying the DC signal at VTHP from 1V to 1.5V while the input signal to the post amplifier is less than  $60\text{mV}_{\text{pp}}$ , the crossing of the output signal will change from 20% to 80%. The output crossing is at 50% when  $V_{\text{THP}} = 1.25\text{V}$ . If the crossing control function is not needed, VTHN and VTHP should be connected to ground.

## Functional Block Diagram



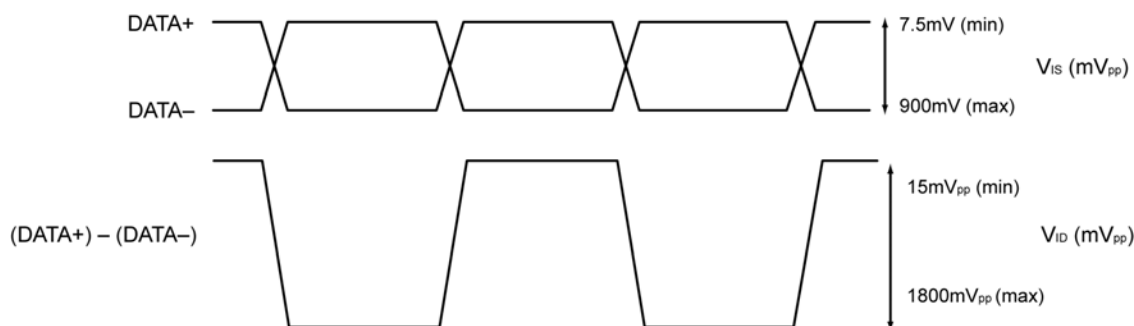
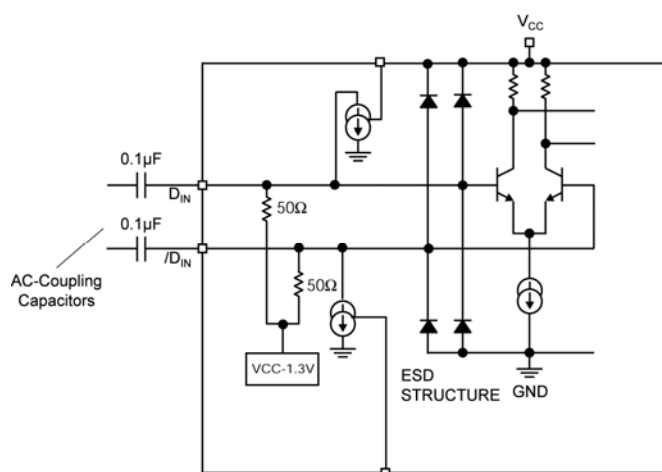
Figure 1.  $V_{IS}$  and  $V_{ID}$  Definition

Figure 2. Input Structure

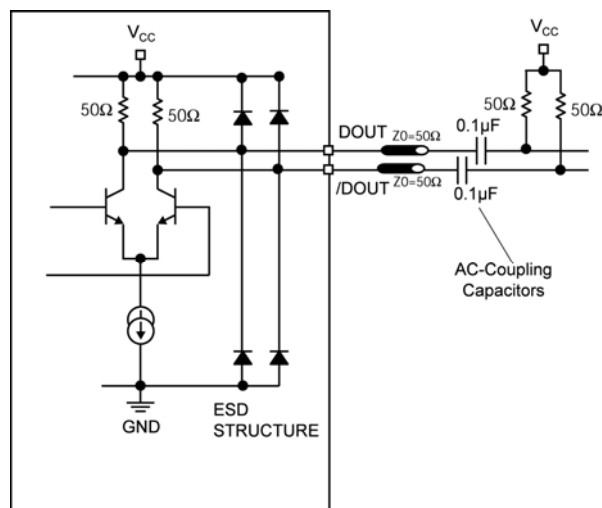


Figure 3. Output Structure

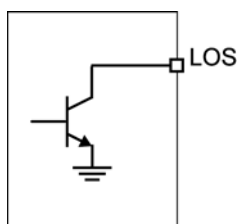
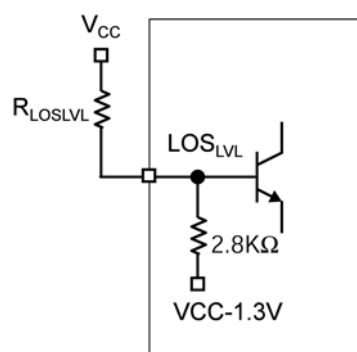


Figure 4. LOS Output Structure

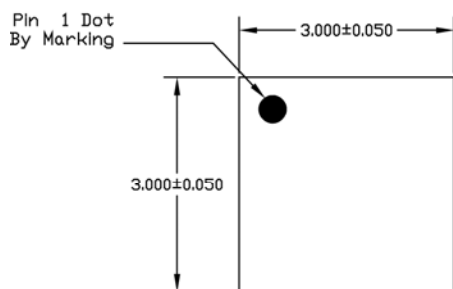
Figure 5.  $LOS_{LVL}$  Setting Circuit

Note: Recommended value for  $R_{LOSLVL}$  is 15kΩ or less.

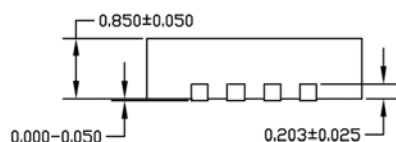
**Related Product and Support Documentation**

| 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> |

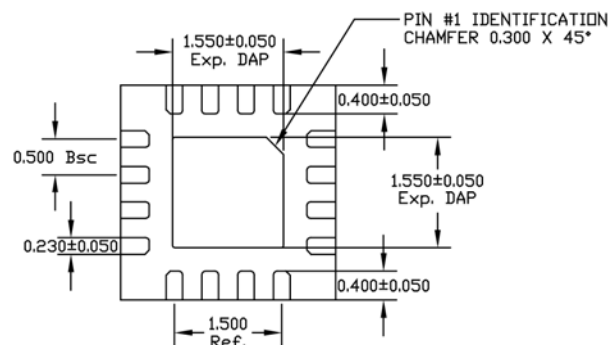
## Package Information



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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