

### FEATURES

- Single 3.3V power supply
- Up to 10.7Gbps operation
- 800mVp-p output swing with 30ps edge rates
- 28dB voltage gain with 5mVp-p input sensitivity
- On chip 50Ω I/O termination
- Programmable signal detect (SD and /SD) with 6dB hysteresis
- Chatter-free OC-TTL SD and /SD outputs with internal 5kΩ pull-up resistors can feedback to TTL enable (/EN) input
- Available in a tiny (3mm × 3mm) 16-pin MLF® package or die

### APPLICATIONS

- OC-192 SDH/SONET
- 10G Ethernet/Fibre Channel receivers
- Upto 10.7Gbps proprietary link
- XFP transceivers
- Line driver/receiver

### DESCRIPTION

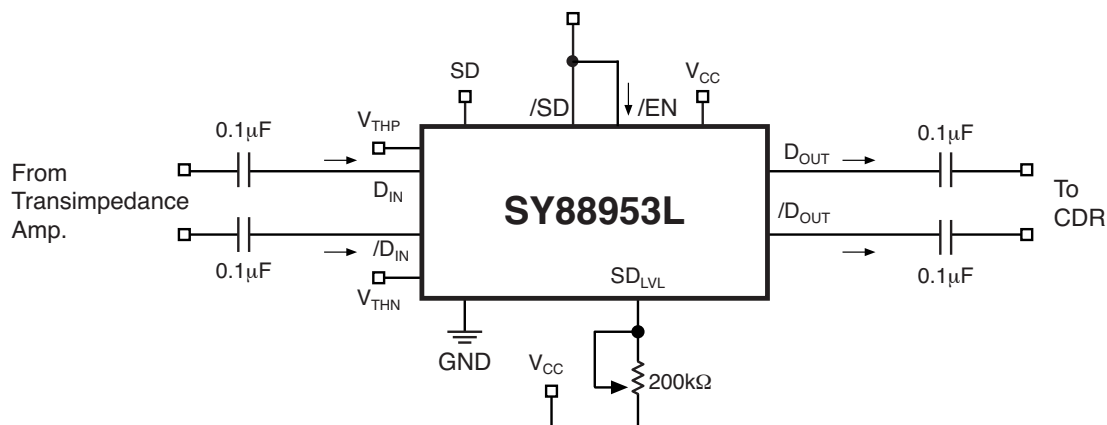
The SY88953L high-speed limiting post amplifier is designed for use in fiber-optic receivers. The device connects to typical transimpedance amplifiers (TIAs). The linear signal output from TIAs can contain significant amounts of noise and may vary in amplitude over time. The SY88953L quantizes these signals and outputs CML level waveforms.

The SY88953L operates from a single +3.3V power supply, over temperatures ranging from -40°C to +85°C. With its wide bandwidth and high gain, signals with data rates up to 10.7Gbps and as small as 5mVp-p can be amplified to drive devices with CML inputs.

The SY88953L outputs TTL signal-detect (SD and /SD) signals. A programmable signal-detect level set pin (SD<sub>LVL</sub>) sets the sensitivity of the input amplitude detection. SD asserts high if the input amplitude rises above the threshold set by SD<sub>LVL</sub> and deasserts low otherwise. /SD is the complementary output of SD. /SD can be feedback to the enable (/EN) input to maintain output stability under a loss of signal condition. /EN deasserts the true output signal without removing the input signal. Typically 6dB SD hysteresis is provided to prevent chattering.

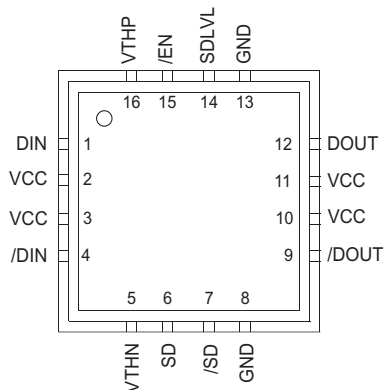
The SY88953L also includes an input threshold adjustment to correct pulsewidth distortion.

### TYPICAL APPLICATIONS CIRCUIT



**PACKAGE/ORDERING INFORMATION**

**Ordering Information**



**16-Pin MLF®**

| Part Number                 | Package Type | Operating Range | Package Marking                      | Lead Finish    |
|-----------------------------|--------------|-----------------|--------------------------------------|----------------|
| SY88953LMI                  | MLF-16       | Industrial      | 953L                                 | Sn-Pb          |
| SY88953LMITR <sup>(1)</sup> | MLF-16       | Industrial      | 953L                                 | Sn-Pb          |
| SY88953LMG                  | MLF-16       | Industrial      | 953L with Pb-Free bar-line indicator | Pb-Free NiPdAu |
| SY88953LMGTR <sup>(1)</sup> | MLF-16       | Industrial      | 953L with Pb-Free bar-line indicator | Pb-Free NiPdAu |

**Note:**

- 1. Tape and Reel.

**PIN DESCRIPTION**

| Pin Number   | Pin Name | Type   | Pin Function   |
|--------------|----------|--|--|
| 1            | DIN      | Data Input   | True data input w/50Ω resistor to V <sub>CC</sub> .  |
| 2, 3, 10, 11 | VCC      | Power Supply   | Positive power supply.   |
| 4            | /DIN     | Data Input   | Complementary data input w/50Ω resistor to V <sub>CC</sub> .   |
| 5            | VTHN     | Input  | /DIN DC threshold adjustment pin.  |
| 6            | SD       | Open-collector TTL output w/ internal 5kΩ pull-up resistor | Signal-Detect: Asserts high when the data input amplitude rises above the threshold set by SD <sub>LVL</sub> .                                     |
| 7            | /SD      | Open-collector TTL output w/ internal 5kΩ pull-up resistor | Inverted Signal-Detect: Asserts low when the data input amplitude rises above the threshold set by SD <sub>LVL</sub> .                             |
| 8, 13, EP    | GND      | Ground   | Device ground. Exposed pad must be soldered to PCB ground for proper electrical and thermal performance.   |
| 9            | /DOOUT   | CML Output   | Complementary data output.   |
| 12           | DOOUT    | CML Output   | True data output.  |
| 14           | SDLVL    | Input  | Signal-Detect Level Set: A resistor from this pin to V <sub>CC</sub> sets the threshold for the data input amplitude at which SD will be asserted. |
| 15           | /EN      | TTL Input: Default is high.                                | Enable: Deasserts true data output when high.  |
| 16           | VTHP     | Input  | DIN DC threshold adjustment pin.   |

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

|   |                               |
|---|-------------------------------|
| Supply Voltage ( $V_{CC}$ )   | -0.5V to +4.0V                |
| Data Input Voltage ( $D_{IN}, /D_{IN}$ ) ... ( $V_{CC}-1.0V$ ) to ( $V_{CC}+0.5V$ ) |                               |
| Data Output Voltage ( $D_{OUT}, /D_{OUT}$ )   |                               |
| ..... ( $V_{CC}-1.0V$ ) to ( $V_{CC}+0.5V$ )  |                               |
| Data Output Current ( $D_{OUT}, /D_{OUT}$ )   | 22mA                          |
| /EN Voltage   | 0 to $V_{CC}$                 |
| SD, /SD Current   | 5mA                           |
| SDLVL Voltage   | ( $V_{CC}-1.3V$ ) to $V_{CC}$ |
| 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 |
| Package Thermal Resistance <sup>(3)</sup> |                 |
| MLF <sup>®</sup>                          |                 |
| ( $\theta_{JA}$ ) Still-Air               | 59°C/W          |
| ( $\psi_{JB}$ ) Still-Air                 | 32°C/W          |

## DC ELECTRICAL CHARACTERISTICS

$V_{CC} = 3.0V$  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    |
|--------------|-------------------------------|-------------------------------------|----------------|----------------|----------------|----------|
| $I_{CC}$     | Power Supply Current          | no output load                      |                | 110            | 170            | mA       |
| $V_{SDLVL}$  | SDLVL Voltage                 |                                     | $V_{CC}-1.3$   |                | $V_{CC}$       | 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        | $V_{IN} = V_{CC}$                   |                |                | 20             | $\mu A$  |
| $I_{IL}$     | /EN Input LOW Current         | $V_{IN} = 0.5V$                     | -0.3           |                |                | mA       |
| $V_{OH}$     | SD, /SD Output HIGH Level     |                                     | 2.4            |                |                | V        |
| $V_{OL}$     | SD, /SD Output LOW Level      | $I_{OL} = +2mA$                     |                |                | 0.5            | V        |
| $V_{OH}$     | Output HIGH Voltage           | 50 $\Omega$ to $V_{CC}$ output load | $V_{CC}-0.020$ | $V_{CC}-0.005$ | $V_{CC}$       | V        |
| $V_{OL}$     | Output LOW Voltage            | 50 $\Omega$ to $V_{CC}$ output load | $V_{CC}-0.560$ | $V_{CC}-0.400$ | $V_{CC}-0.240$ | V        |
| $V_{OFFSET}$ | Differential Output Offset    |                                     |                |                | $\pm 80$       | mV       |
| $Z_O$        | Single-Ended Output Impedance |                                     | 40             | 50             | 60             | $\Omega$ |
| $Z_O$        | Single-Ended Input Impedance  |                                     | 40             | 50             | 60             | $\Omega$ |

**Note s:**

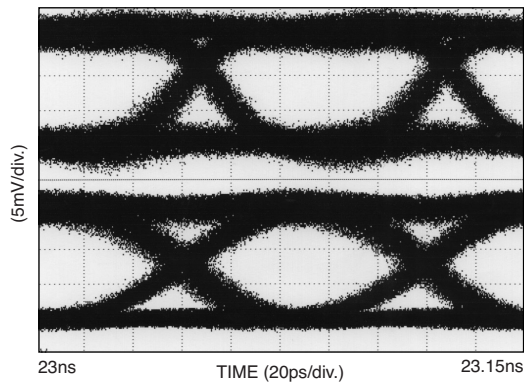
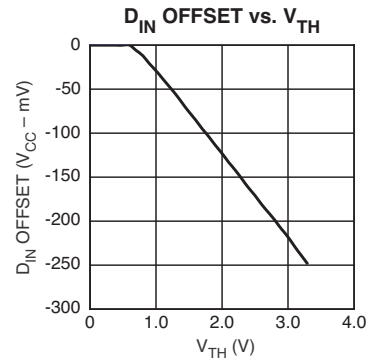
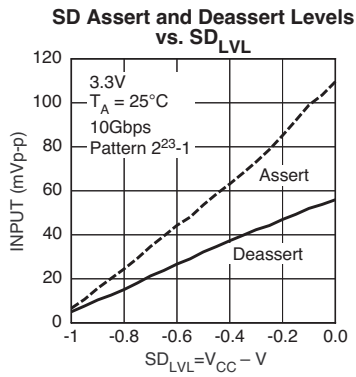
1. Permanent device damage may occur if absolute maximum ratings are exceeded. This is a stress rating only and functional operation is not implied at conditions other than those detailed in the operational sections of this data sheet. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.
2. The data sheet limits are not guaranteed if the device is operated beyond the operating ratings.
3. Exposed pad must be soldered to PCB's ground plane.

## AC ELECTRICAL CHARACTERISTICS

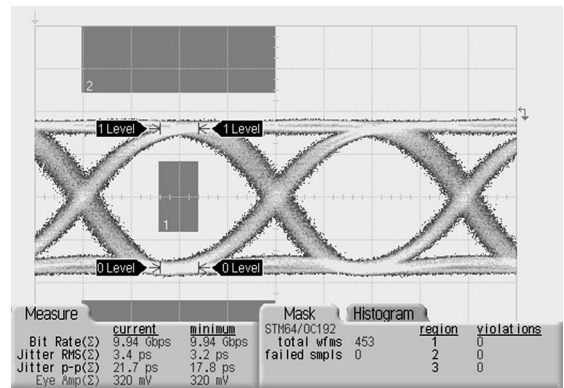
$V_{CC} = 3.0V$  to  $3.6V$ ;  $R_{LOAD} = 50\Omega$  to  $V_{CC}$ ;  $T_A = -40^\circ C$  to  $+85^\circ C$ ; typical values at  $V_{CC} = 3.3V$ ,  $T_A = 25^\circ C$

| Symbol        | Parameter                         | Condition               | Min | Typ | Max  | Units     |
|---------------|-----------------------------------|-------------------------|-----|-----|------|-----------|
| HYS           | SD Hysteresis                     | electrical signal       | 2   | 6   | 8    | dB        |
| PSRR          | Power Supply Rejection Ratio      |                         |     | 35  |      | dB        |
| $t_{OFF}$     | SD, /SD Release Time              |                         |     | 0.1 | 0.5  | $\mu s$   |
| $t_{ON}$      | SD, /SD Assert Time               |                         |     | 0.2 | 0.5  | $\mu s$   |
| $t_r, t_f$    | Output Rise/Fall Time             | $V_{ID} \geq 50mV_{PP}$ |     | 30  | 35   | ps        |
| $V_{ID}$      | Differential Input Voltage Swing  |                         | 5   |     | 1800 | $mV_{PP}$ |
| $V_{OD}$      | Differential Output Voltage Swing |                         | 480 | 800 | 1120 | $mV_{PP}$ |
| $V_{SR}$      | SD Sensitivity Range              |                         | 5   |     | 50   | $mV_{PP}$ |
| $A_{V(Diff)}$ | Differential Voltage Gain         |                         | 22  | 28  |      | dB        |
| $S_{21}$      | Single-Ended Small-Signal Gain    |                         | 16  | 22  |      | dB        |
| $B_{-3dB}$    | 3dB Bandwidth                     |                         |     | 7.5 |      | GHz       |

**TYPICAL OPERATING CHARACTERISTICS**



**Example of Using  $V_{TH}$  to Cancel Effect of Pulse Width Distortion**



**(3.3V, 27°C, 10Gbps)  
 30mV<sub>pp</sub> Differential Input**

## DETAILED DESCRIPTION

The SY88953L high-speed 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 up to 10.7Gbps and as small as 5mVp-p can be amplified. Figure 1 shows the allowed input voltage swing. The SY88953L generates SD and /SD outputs.  $\text{SD}_{\text{LVL}}$  sets the sensitivity of the input amplitude detection. The SY88953L also includes an input threshold adjustment to correct pulsewidth distortion

### Input Amplifier/Buffer

Figure 2 shows a simplified schematic of the SY88953L's input stage. The high-sensitivity of the input amplifier allows signals as small as 5mVp-p to be detected and amplified. The input amplifier allows input signals as large as 1800mVp-p. Input signals are linearly amplified with a typically 28dB differential voltage gain. Since it is a limiting amplifier, the SY88953L outputs typically 800mV<sub>PP</sub> voltage-limited waveforms for input signals that are greater than 32mVp-p. Applications requiring the SY88953L to operate with high-gain should have the upstream TIA placed as close as possible to the SY88953L's input pins to ensure the best performance of the device.

### Threshold Adjustment

The SY88953L's duty cycle can be controlled by forcing an offset at either input using  $V_{\text{THP}}$  or  $V_{\text{THN}}$ . Typically, only one of the inputs is required to be adjusted, depending on the required direction of the pulse width adjustment. The SY88953L implements current source based offset control of the inputs. "Typical Operating Characteristics" shows the offset applied to the input for a given  $V_{\text{TH}}$  voltage. This feature is disabled by simply setting  $V_{\text{TH}}$  to GND.

### Output Buffer

The SY88953L's CML output buffer is designed to drive 50 $\Omega$  lines. The output buffer requires appropriate termination for proper operation. An external 50 $\Omega$  resistor to  $V_{\text{CC}}$  for each output pin provides this. Figure 3 shows a simplified schematic of the output stage and includes an appropriate termination method. Of course, driving a downstream device that is internally terminated with 50 $\Omega$  to  $V_{\text{CC}}$  eliminates the need for external termination. As noted in the previous section, the amplifier outputs typically 800mVp-p waveforms across 25 $\Omega$  total loads. The output buffer thus switches typically 16mA tail-current.

### Signal-Detect

The SY88953L generates chatter-free signal-detect (SD and /SD) open-collector TTL outputs with internal 5k $\Omega$  pullup resistors as shown in Figure 4. SD is used to determine that the input amplitude is large enough to be considered a valid input. SD asserts high if the input amplitude rises above the threshold set by  $\text{SD}_{\text{LVL}}$  and deasserts low otherwise. /SD is the complementary output of SD. /SD asserts low if the input amplitude rises above the threshold set by  $\text{SD}_{\text{LVL}}$  and deasserts high otherwise. /SD can be fed back to the enable (/EN) input to maintain output stability under a loss of signal condition. /EN deasserts the true output signal without removing the input signals. Typically 6dB SD hysteresis is provided to prevent chattering.

### Signal-Detect Level Set

A programmable signal-detect level set pin ( $\text{SD}_{\text{LVL}}$ ) sets the threshold of the input amplitude detection. Connecting an external resistor between  $V_{\text{CC}}$  and  $\text{SD}_{\text{LVL}}$  sets the voltage at  $\text{SD}_{\text{LVL}}$ . 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. If desired, an appropriate external voltage may be applied rather than using a resistor. The smaller the external resistor, implying a smaller voltage difference from  $\text{SD}_{\text{LVL}}$  to  $V_{\text{CC}}$ , the smaller the SD sensitivity. Hence, larger input amplitude is required to assert SD. "Typical Operating Characteristics" shows the relationship between the input amplitude detection sensitivity and the  $\text{SD}_{\text{LVL}}$  voltage.

### Hysteresis

The SY88953L provides typically 6dB SD electrical hysteresis. By definition, a power ratio measured in dB is  $10\log(\text{power ratio})$ . Power is calculated as  $V_{\text{IN}}^2/R$  for an electrical signal. Hence the same ratio can be stated as  $20\log(\text{voltage ratio})$ . 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 SY88953L provides typically 3dB SD optical hysteresis. As the SY88953L is an electrical device, this datasheet refers to hysteresis in electrical terms. With 6dB SD hysteresis, a voltage factor of two is required to assert or deassert SD.

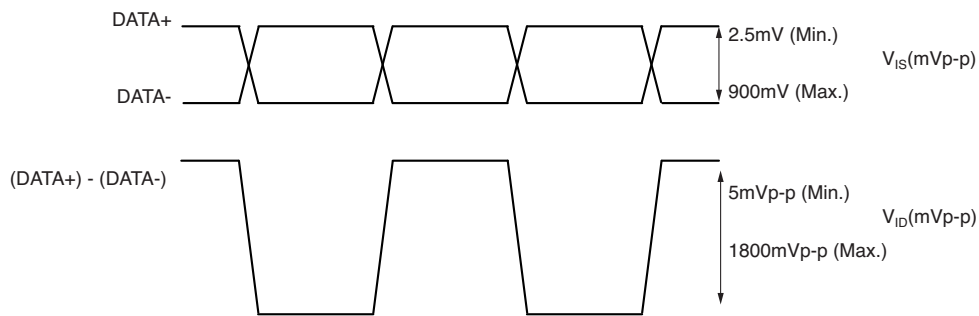


Figure 1.  $V_{IS}$  and  $V_{ID}$  Definitions

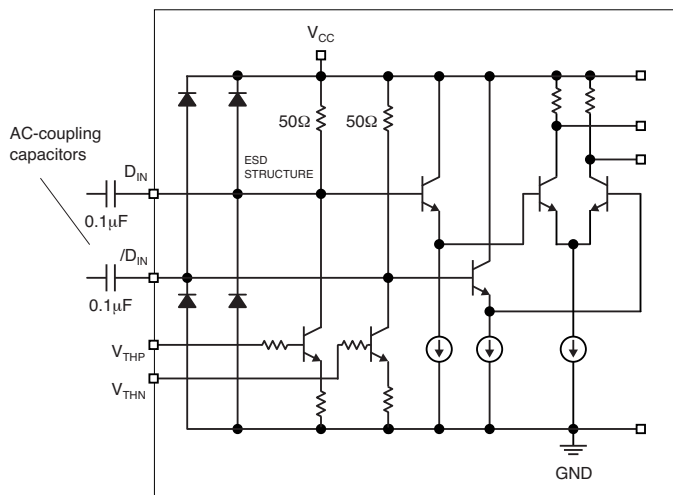


Figure 2. Input Structure

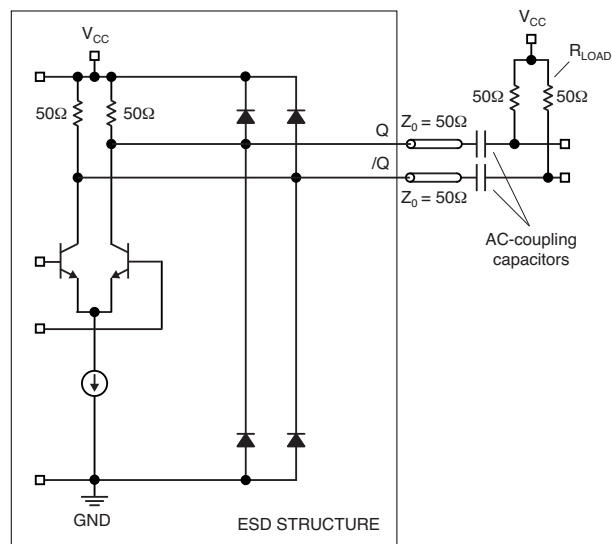


Figure 3. Output Structure

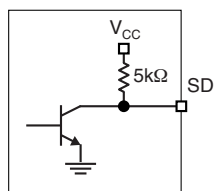


Figure 4. SD, /SD Output Structure

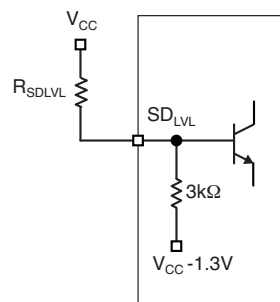
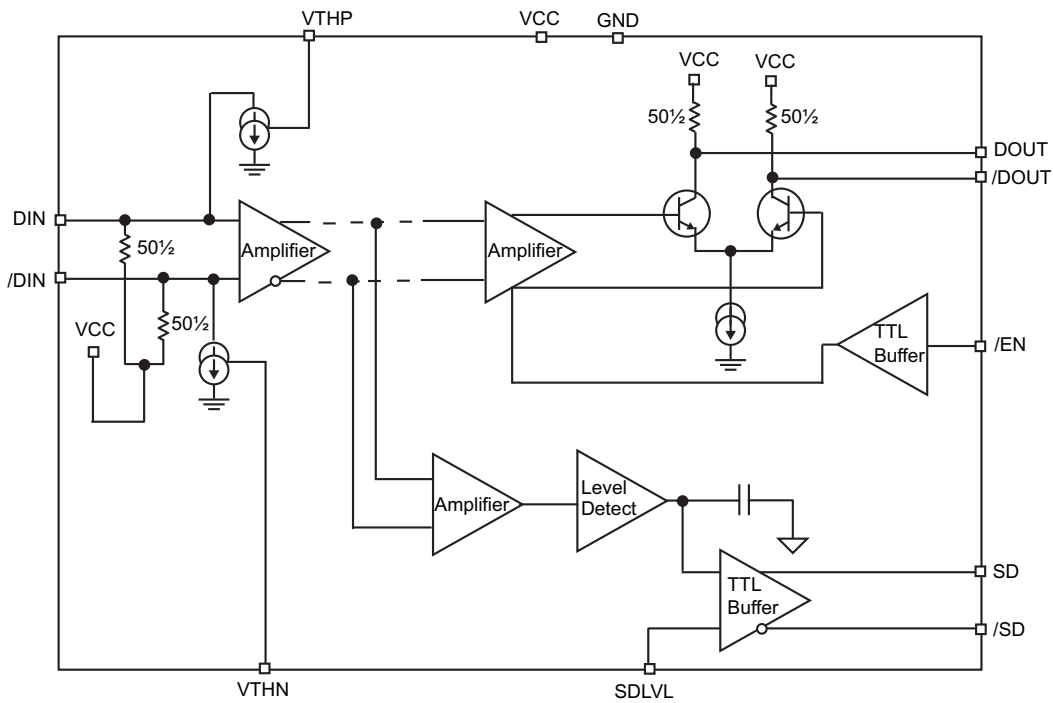


Figure 5.  $SD_{LVL}$  Setting Circuit

**FUNCTIONAL BLOCK DIAGRAM**



**DESIGN PROCEDURE**

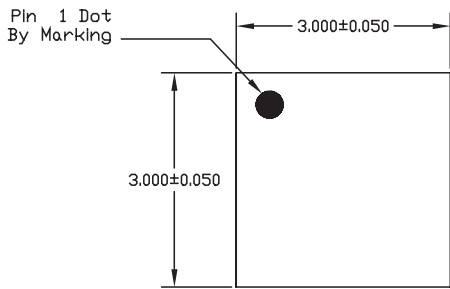
**Layout and PCB Design**

Since the SY88953L is a high-frequency component, performance can be largely determined by the board layout and design. A common problem with high-gain amplifiers is the feedback from the large swing outputs to the input via the power supply.

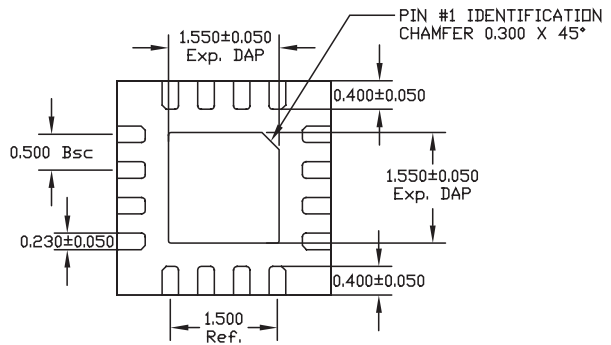
The SY88953L's ground pins should be connected to the circuit board ground. Use multiple PCB vias close to the part to connect to ground. Avoid long, inductive runs which can degrade performance.



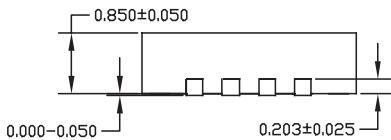
**16-PIN MicroLeadFrame® (MLF-16)**



TOP VIEW

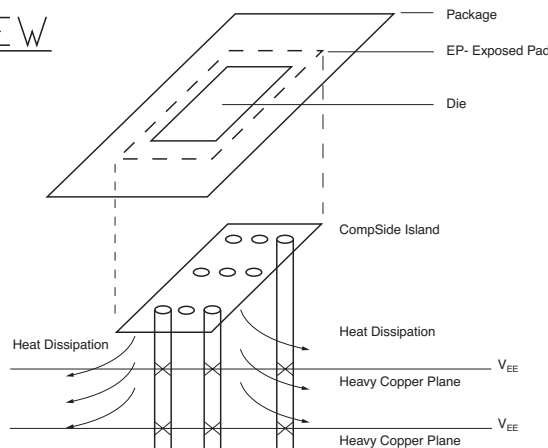


BOTTOM VIEW



SIDE VIEW

- NOTE:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
  2. MAX. PACKAGE WARPAGE IS 0.05 mm.
  3. MAXIMUM ALLOWABLE 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 100% baked and 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>

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