



## SY58620L

### Precision 4.25Gbps CML Backplane Transceiver with Integrated Loopback



Precision Edge®

## General Description

The SY58620L is a low jitter, high-speed transceiver with a variable swing CML transmitter buffer and a CML high-gain receiver optimized for precision telecom and enterprise server transmission line and backplane data management. The SY58620L distributes data to 4.25Gbps guaranteed over temperature and voltage.

The SY58620L transmitter differential input includes Micrel's unique, 3-pin input termination architecture that directly interfaces to any (AC- or DC-coupled) differential signal as small as 100mV (200mV<sub>PP</sub>) without any termination resistor network in the signal path. The receiver differential input is optimized to interface directly to AC-coupled signals as small as 10mV (20mV<sub>PP</sub>). The outputs are 50Ω source-terminated CML with extremely fast rise/fall time.

To support remote self-testing, the SY58620L features a high-speed loopback test mode. The input control signal LOOPBACK enables an internal loopback path from the transmitter input to the receiver output.

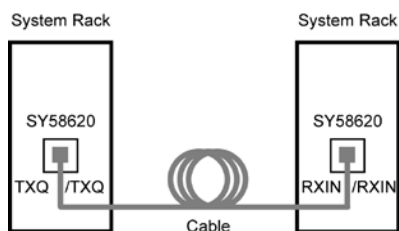
The SY58620L operates from a 3.3V ±10% supply and is guaranteed over the full industrial temperature range of -40°C to +85°C. The SY58620L is part of Micrel's high-speed, Precision Edge® product line.

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

## Applications

- Backplane management
- Active cable transceivers
- SONET/SDH data/clock applications
- 4X Fibre Channel applications

## Typical Applications



## Features

- Guaranteed AC performance over temperature and voltage:
  - Maximum Throughput 4.25Gbps
  - <120ps t<sub>r</sub>/t<sub>f</sub> time
- Transmitter
  - Patented input termination directly interfaces to AC- or DC-coupled differential inputs
  - Variable swing CML output
- Receiver
  - 32dB high-gain Input
  - Internal 50Ω input termination
  - Accepts AC-coupled input signals as small as 10mV (20mV<sub>PP</sub>)
  - 400mV (800mV<sub>PP</sub>) differential CML output swing
- Loss-of-Signal (LOS)
  - High-gain, TTL-compatible LOS output with internal 4.75kΩ pull-up
  - Programmable LOS level set
- Ultra-low jitter design
  - <5ps<sub>RMS</sub> random jitter
- Patent-pending MUX isolates the receiver and the transmitter channels minimizing on crosstalk
- Selectable loopback diagnostic mode
- Output enable
- Power supply +3.3V ±10%
- Industrial temperature range -40°C to +85°C
- Available in 24-pin (4mm x 4mm) QFN

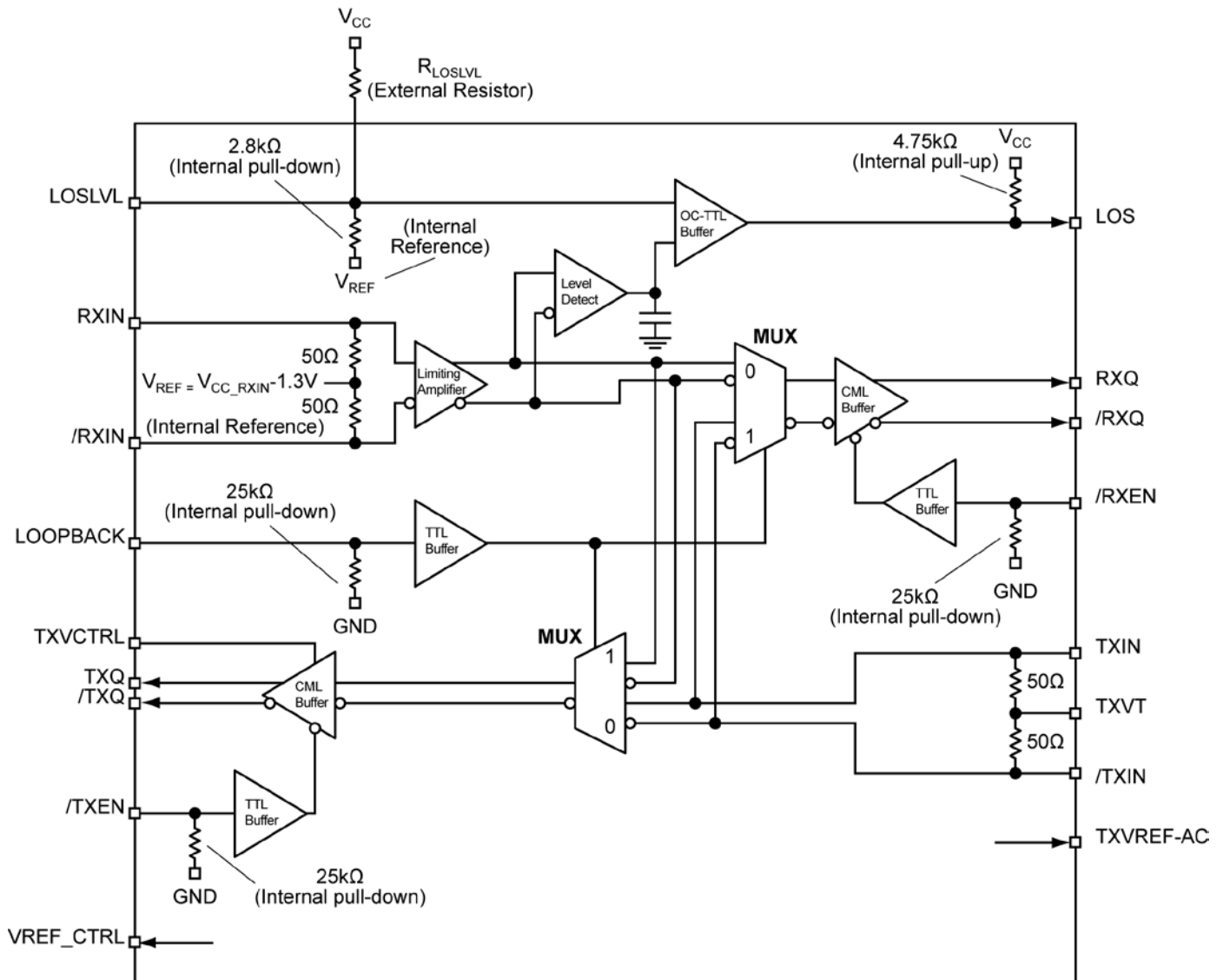
## Markets

- Precision telecom
- Enterprise server
- ATE
- Test and measurement

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## Functional Block Diagram



**Note:**

It is recommended that  $R_{LOSLVL} \leq 10k\Omega$ . See the "Typical Operating Characteristics" section for more details.

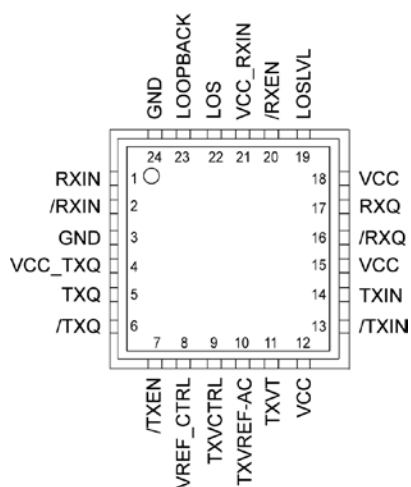
## Ordering Information<sup>(1)</sup>

| Part Number                 | Package Type | Operating Range | Package Marking                      | Lead Finish       |
|-----------------------------|--------------|-----------------|--------------------------------------|-------------------|
| SY58620LMG                  | QFN-24       | Industrial      | 620L with Pb-Free bar-line indicator | NiPdAu<br>Pb-Free |
| SY58620LMGTR <sup>(2)</sup> | QFN-24       | Industrial      | 620L with Pb-Free bar-line indicator | NiPdAu<br>Pb-Free |

### Notes:

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

## Pin Configuration



24-Pin QFN

## Pin Description

### Inputs

| Pin Number | Pin Name    | Pin Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|------------|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 23         | LOOPBACK    | LOOPBACK Mode Control. TTL/CMOS control input. LOOPBACK is an active HIGH signal used to control the LOOPBACK MUX. LOOPBACK is internally connected to a 25k $\Omega$ pull-down resistor and will default to a LOW state if left open. $V_{TH} = V_{CC}/2$ .                                                                                                                                                                                                                                              |
| 20         | /RXEN       | Receiver Output Control. TTL/CMOS control input. /RXEN is an active LOW signal used to enable the receiver outputs. /RXEN is internally connected to a 25k $\Omega$ pull-down resistor and will default to a LOW state if left open. $V_{TH} = V_{CC}/2$ .                                                                                                                                                                                                                                                |
| 1, 2       | RXIN, /RXIN | Receiver Differential Input. Input accepts AC differential signals as small as 10mV (20mV <sub>PP</sub> ). Each pin internally terminates to $V_{CC\_RXIN}-1.3V$ (internal voltage reference) through 50 $\Omega$ . Input will default to an indeterminate state if RXIN inputs are left open. See figure 6b.                                                                                                                                                                                             |
| 7          | /TXEN       | Transmitter Output Control. TTL/CMOS control input. /TXEN is an active LOW signal used to enable the transmitter output. /TXEN is internally connected to a 25k $\Omega$ pull-down resistor and will default to a LOW state if left open. $V_{TH} = V_{CC}/2$ .                                                                                                                                                                                                                                           |
| 14, 13     | TXIN, /TXIN | Transmitter Differential Input. Input accepts AC- or DC-coupled differential signals as small as 100mV (200mV <sub>PP</sub> ). Each pin terminates to the TXVT pin through 50 $\Omega$ . Input will default to an indeterminate state if TXIN inputs are left open. See figure 6a.                                                                                                                                                                                                                        |
| 9          | TXVCTRL     | Transmitter Output Swing Control. Input that controls the output amplitude of the transmitter. The operating range of the control input is from $V_{REF\_CTRL}$ (max swing) to $V_{CC}$ (min swing). Control of the output swing is obtained with a variable resistor between $V_{REF\_CTRL}$ and $V_{CC\_TXQ}$ through a wiper driving TXVCTRL. Setting TXVCTRL to $V_{CC\_TXQ}$ sets the output swing to min swing. Refer to the "Interface Applications" and "Output Stage" sections for more details. |
| 11         | TXVT        | Input Termination Center-Tap. Each side of the transmitter differential input pair terminates to the TXVT pin. The TXVT pin provides a center-tap to a termination network for maximum interface flexibility. Refer to the "Input Stage" section for more details.                                                                                                                                                                                                                                        |

## Outputs

| Pin Number | Pin Name  | Pin Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|------------|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 22         | LOS       | Loss-of-Signal Output. TTL-compatible output with internal 4.75k $\Omega$ pull-up resistor. Loss-of-Signal asserts to logic HIGH when the receiver input amplitudes falls below the threshold set by LOSLVL.                                                                                                                                                                                                                                                                                               |
| 19         | LOSLVL    | RX Loss-of-Signal Level Set. A resistor (R <sub>LOSLVL</sub> ) connected between LOSLVL and V <sub>CC</sub> sets the threshold for the data input amplitude at which the LOS output is asserted. Default is max sensitivity. LOSLVL is used to set the Loss-of-Signal (LOS) voltage. It is internally connected to a 2.8k $\Omega$ pull-down resistor to an internal V <sub>REF</sub> voltage source. See "Typical Operating Characteristics," and "Application Implementation" sections for more details. |
| 17, 16     | RXQ, /RXQ | Receiver Differential Output. Output is CML compatible. Refer to the "Truth Table" and "Output Stage" sections for more details. Unused output pair may be left open. The output is designed to drive 400mV (800mV <sub>PP</sub> ) into 50 $\Omega$ to V <sub>CC</sub> or 100 $\Omega$ across the pair.                                                                                                                                                                                                    |
| 5, 6       | TXQ, /TXQ | Transmitter Differential Variable Swing Output. Output is CML compatible. Please refer to the "Truth Table" and "Output Stage" sections for more details. Unused output pair may be left open. The output is designed to drive 80mV (160mV <sub>PP</sub> ) min swing to 400mV (800mV <sub>PP</sub> ) typ. swing into 50 $\Omega$ to V <sub>CC_TXQ</sub> or drive 100 $\Omega$ across the pair depending on TXVCTRL.                                                                                        |
| 8          | VREF_CTRL | Transmitter Output Reference Voltage. Output biases to V <sub>CC_TXQ</sub> -1.3V. Connecting V <sub>REF_CTRL</sub> to TXVCTRL sets the transmitter output swing to max swing.                                                                                                                                                                                                                                                                                                                              |
| 10         | TXVREF-AC | Transmitter Input Reference Voltage. This output biases to V <sub>CC</sub> -1.3V. It is used when AC coupling the transmitter input. For AC-coupled applications, connect TXVREF-AC to the TXVT pin and bypass with a 0.01 $\mu$ F low ESR capacitors to V <sub>CC</sub> . See "Input Stage" section for more details. Maximum sink/source current is $\pm 1.5$ mA.                                                                                                                                        |

## Power Pins

| Pin Number | Pin Name            | Pin Description                                                                                                                                                                                                                                                          |
|------------|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3, 24      | GND,<br>Exposed Pad | Ground. GND pins and exposed pad must be connected to the same ground plane.                                                                                                                                                                                             |
| 12, 15, 18 | VCC                 | 3.3V $\pm 10\%$ Positive Power Supply. Bypass with 0.1 $\mu$ F//0.01 $\mu$ F low ESR capacitors and place as close to each V <sub>CC</sub> pins as possible. Power pins are not connected internally and must be connected to the same power supply externally.          |
| 21         | VCC_RXIN            | 3.3V $\pm 10\%$ Receive Input Power Supply. Bypass with 0.1 $\mu$ F//0.01 $\mu$ F low ESR capacitors and place as close to the V <sub>CC_RXIN</sub> pin as possible. Power pins are not connected internally and must be connected to the same power supply externally.  |
| 4          | VCC_TXQ             | 3.3V $\pm 10\%$ Output Transmit Power Supply. Bypass with 0.1 $\mu$ F//0.01 $\mu$ F low ESR capacitors and place as close to the V <sub>CC_TXQ</sub> pin as possible. Power pins are not connected internally and must be connected to the same power supply externally. |

## Truth Table

| LOOPBACK | RXQ  | TXQ  |
|----------|------|------|
| 0        | RXIN | TXIN |
| 1        | TXIN | RXIN |

**Absolute Maximum Ratings<sup>(1)</sup>****Supply Voltage**(V<sub>CC</sub>, V<sub>CC\_TXQ</sub>, V<sub>CC\_RXIN</sub>) ..... -0.5V to +4.0V**Input Voltage**LOSLVL ..... V<sub>REF</sub> -1.2V to V<sub>CC</sub>LOOPBACK ..... -0.5V to V<sub>CC</sub>/TXEN, /RXEN ..... -0.5V to V<sub>CC</sub>TXVCTRL ..... VREF\_CTRL-1.2V to V<sub>CC</sub>TXIN, /TXIN ..... -0.5V to V<sub>CC</sub>**Source or Sink Current on**

TXVT ..... ±100mA

LOS ..... ±5mA

RXQ, /RXQ ..... ±25mA

TXQ, /TXQ ..... ±25mA

RXIN, /RXIN ..... ±10mA

TXIN, /TXIN ..... ±50mA

TXVREF-AC, VREF-CTRL ..... ±2mA

Lead Temperature (soldering, 20sec.) ..... 260°C

Storage Temperature (T<sub>s</sub>) ..... -65°C to +150°C**Operating Ratings<sup>(2)</sup>****Supply Voltage**(V<sub>CC</sub>, V<sub>CC\_TXQ</sub>, V<sub>CC\_RXIN</sub>) ..... +3.0V to +3.6VAmbient Temperature (T<sub>A</sub>) ..... -40°C to +85°CPackage Thermal Resistance<sup>(3)</sup>QFN (θ<sub>JA</sub>)

Still-Air ..... 50°C/W

QFN (ψ<sub>JB</sub>)

Junction-to-Board ..... 30°C/W

**DC Electrical Characteristics<sup>(4)</sup>**T<sub>A</sub> = -40°C to +85°C, unless otherwise stated.

| Symbol               | Parameter             | Condition                     | Min | Typ | Max | Units |
|----------------------|-----------------------|-------------------------------|-----|-----|-----|-------|
| V <sub>CC</sub>      | Power Supply          |                               | 3   | 3.3 | 3.6 | V     |
| V <sub>CC_TXQ</sub>  | Transmit Power Supply |                               | 3   | 3.3 | 3.6 | V     |
| V <sub>CC_RXIN</sub> | Receive Power Supply  |                               | 3   | 3.3 | 3.6 | V     |
| I <sub>CC</sub>      | Power Supply Current  | No load, max. V <sub>CC</sub> |     | 100 | 150 | mA    |

**Receiver Input DC Electrical Characteristics**V<sub>CC\_RXIN</sub> = 3.3V ±10%; T<sub>A</sub> = -40°C to +85°C, unless otherwise stated.

| Symbol               | Parameter                                      | Condition                   | Min                           | Typ                           | Max                           | Units |
|----------------------|------------------------------------------------|-----------------------------|-------------------------------|-------------------------------|-------------------------------|-------|
| R <sub>IN</sub>      | Input Resistance (RXIN to VREF)                |                             | 45                            | 50                            | 55                            | Ω     |
| R <sub>DIFF_IN</sub> | Input Resistance (RXIN to /RXIN)               |                             | 90                            | 100                           | 110                           | Ω     |
| V <sub>IN</sub>      | Input Voltage Swing (RXIN, /RXIN)              | See Figure 5a<br>AC-coupled | 10                            |                               | 900                           | mV    |
| V <sub>DIFF_IN</sub> | Differential Input Voltage Swing  RXIN - /RXIN | See Figure 5b<br>AC-coupled | 20                            |                               | 1800                          | mV    |
| V <sub>REF</sub>     | Internal Reference Voltage                     |                             | V <sub>CC_RXIN</sub><br>-1.48 | V <sub>CC_RXIN</sub><br>-1.32 | V <sub>CC_RXIN</sub><br>-1.16 | V     |

**Notes:**

1. Permanent device damage may occur if absolute maximum ratings are exceeded. This is a stress rating only and functional operation is not implied at conditions other than those detailed in the operational sections of this data sheet. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.
2. The data sheet limits are not guaranteed if the device is operated beyond the operating ratings.
3. Package thermal resistance assumes exposed pad is soldered (or equivalent) to the devices most negative potential on the PCB. θ<sub>JA</sub> and ψ<sub>JB</sub> values are determined for a 4-layer board in still-air, unless otherwise stated.
4. The circuit is designed to meet the DC specifications shown in the above table after thermal equilibrium has been established.

## Receiver Output DC Electrical Characteristics

$V_{CC} = 3.3V \pm 10\%$ ,  $R_L = 100\Omega$  across the outputs;  $T_A = -40^\circ C$  to  $+85^\circ C$ , unless otherwise stated.

| Symbol          | Parameter                                     | Condition                                    | Min              | Typ              | Max      | Units    |
|-----------------|-----------------------------------------------|----------------------------------------------|------------------|------------------|----------|----------|
| $V_{OH}$        | Output HIGH Voltage (RXQ, /RXQ)               | $R_L = 50\Omega$ to $V_{CC}$                 | $V_{CC} - 0.020$ | $V_{CC} - 0.010$ | $V_{CC}$ | V        |
| $V_{OUT}$       | Output Voltage Swing (RXQ, /RXQ)              | See Figure 5a                                | 325              | 400              | 500      | mV       |
| $V_{DIFF\_OUT}$ | Differential Output Voltage Swing (RXQ, /RXQ) | See Figure 5b                                | 650              | 800              | 1000     | mV       |
| $R_{OUT}$       | Single-Ended Output Impedance                 |                                              | 45               | 50               | 55       | $\Omega$ |
| $R_{DIFF\_OUT}$ | Differential Output Impedance                 |                                              | 90               | 100              | 110      | $\Omega$ |
| $V_{OFFSET}$    | Differential Output Offset                    | $R_L = 50\Omega$ to $V_{CC}$ , limiting mode | -140             |                  | +140     | mV       |

## Transmitter Input DC Electrical Characteristics

$V_{CC} = 3.3V \pm 10\%$ ;  $T_A = -40^\circ C$  to  $+85^\circ C$ , unless otherwise stated.

| Symbol           | Parameter                                      | Condition     | Min             | Typ            | Max            | Units    |
|------------------|------------------------------------------------|---------------|-----------------|----------------|----------------|----------|
| $R_{IN}$         | Input Resistance (TXIN to TXVT)                |               | 45              | 50             | 55             | $\Omega$ |
| $R_{DIFF\_IN}$   | Differential Input Resistance (TXIN to /TXIN)  |               | 90              | 100            | 110            | $\Omega$ |
| $V_{IH}$         | Input HIGH Voltage (TXIN, /TXIN)               |               | 1.2             |                | $V_{CC}$       | V        |
| $V_{IL}$         | Input LOW Voltage (TXIN, /TXIN)                |               | 0               |                | $V_{IH} - 0.1$ | V        |
| $V_{IN}$         | Input Voltage Swing (TXIN, /TXIN)              | See Figure 5a | 0.1             |                | $V_{CC}$       | V        |
| $V_{DIFF\_IN}$   | Differential Input Voltage Swing  TXIN - /TXIN | See Figure 5b | 0.2             |                |                | V        |
| $V_{T\_IN}$      | TXIN, /TXIN to VT                              |               |                 |                | 1.28           | V        |
| $V_{TXVREF\_AC}$ | Output Reference Voltage                       |               | $V_{CC} - 1.4$  | $V_{CC} - 1.3$ | $V_{CC} - 1.2$ | V        |
| $V_{REF\_CTRL}$  | Output Reference Voltage                       |               | $V_{CC} - 1.4$  | $V_{CC} - 1.3$ | $V_{CC} - 1.2$ | V        |
| $V_{TXVCTRL}$    | Input Voltage (TXVCTRL)                        |               | $V_{REF\_CTRL}$ |                | $V_{CC}$       | V        |

## Transmitter Output DC Electrical Characteristics

$V_{CC\_TXQ} = 3.3V \pm 10\%$ ,  $R_L = 100\Omega$  across the outputs;  $T_A = -40^\circ C$  to  $+85^\circ C$ , unless otherwise stated.

| Symbol          | Parameter                                     | Condition                                  | Min                   | Typ                   | Max           | Units    |
|-----------------|-----------------------------------------------|--------------------------------------------|-----------------------|-----------------------|---------------|----------|
| $V_{OH}$        | Output HIGH Voltage (TXQ, /TXQ)               | $R_L = 50\Omega$ to $V_{CC\_TXQ}$          | $V_{CC\_TXQ} - 0.020$ | $V_{CC\_TXQ} - 0.005$ | $V_{CC\_TXQ}$ | V        |
| $V_{OUT}$       | Output Voltage Swing (TXQ, /TXQ)              | TXVCTRL = $V_{REF\_CTRL}$<br>See Figure 5a | 325                   | 400                   |               | mV       |
|                 |                                               | TXVCTRL = $V_{CC\_TXQ}$<br>See Figure 5a   |                       | 80                    |               | mV       |
| $V_{DIFF\_OUT}$ | Differential Output Voltage Swing (TXQ, /TXQ) | TXVCTRL = $V_{REF\_CTRL}$<br>See Figure 5b | 650                   | 800                   |               | mV       |
|                 |                                               | TXVCTRL = $V_{CC\_TXQ}$<br>See Figure 5b   |                       | 160                   |               | mV       |
| $R_{OUT}$       | Single-Ended Output Impedance                 |                                            | 45                    | 50                    | 55            | $\Omega$ |
| $R_{DIFF\_OUT}$ | Differential Output Impedance                 |                                            | 90                    | 100                   | 110           | $\Omega$ |

## LVTTTL/CMOS INPUT DC Electrical Characteristics<sup>(5)</sup>

$V_{CC} = 3.3V \pm 10\%$ ;  $T_A = -40^\circ C$  to  $+85^\circ C$ , unless otherwise stated.

| Symbol   | Parameter              | Condition                | Min | Typ | Max | Units   |
|----------|------------------------|--------------------------|-----|-----|-----|---------|
| $V_{IL}$ | /TXEN, /RXEN, LOOPBACK |                          |     |     | 0.8 | V       |
| $V_{IH}$ | /TXEN, /RXEN, LOOPBACK |                          | 2   |     |     | V       |
| $I_{IL}$ | /TXEN, /RXEN, LOOPBACK | $I_{IL}@V_{IN} = 0.5V$   | 0   |     | 50  | $\mu A$ |
| $I_{IH}$ | /TXEN, /RXEN, LOOPBACK | $I_{IH}@V_{IN} = V_{CC}$ |     |     | 300 | $\mu A$ |

**Note:**

5. /TXEN, /RXEN, and LOOPBACK have an internal pull-down 25k $\Omega$  resistor.

## LOS DC Electrical Characteristics

$V_{CC} = 3.3V \pm 10\%$ ;  $T_A = -40^\circ C$  to  $+85^\circ C$ .

| Symbol            | Parameter                  | Condition                                                                                | Min       | Typ | Max      | Units            |
|-------------------|----------------------------|------------------------------------------------------------------------------------------|-----------|-----|----------|------------------|
| $V_{LOSLVL}$      | LOSLVL Voltage Range       |                                                                                          | $V_{REF}$ |     | $V_{CC}$ | V                |
| $V_{OH}$          | Output HIGH Voltage        | $I_{SOURCE} = -100\mu A$ ; $V_{CC} \geq 3.3V$                                            | 2.4       |     |          | V                |
| $V_{OL}$          | Output LOW Voltage         | $I_{OL} = 2mA$                                                                           |           |     | 0.5      | V                |
| VSR               | LOS Sensitivity Range      |                                                                                          | 7         |     | 35       | mV <sub>PP</sub> |
| LOS <sub>AL</sub> | Low LOS Assert Level       | $R_{LOSLVL} = 10k\Omega$<br>2 <sup>7</sup> -1 Data Pattern, Note 7                       |           |     |          |                  |
|                   |                            | 622Mbps                                                                                  |           | 15  |          | mV               |
|                   |                            | 4.25Gbps                                                                                 |           | 10  |          | mV               |
| LOS <sub>DL</sub> | Low LOS De-assert Level    | $R_{LOSLVL} = 10k\Omega$<br>2 <sup>7</sup> -1 Data Pattern, Note 7                       |           |     |          |                  |
|                   |                            | 622Mbps                                                                                  |           | 20  |          | mV               |
|                   |                            | 4.25Gbps                                                                                 |           | 15  |          | mV               |
| HYS <sub>L</sub>  | Low LOS Hysteresis         | $R_{LOSLVL} = 10k\Omega$ , limiting mode<br>2 <sup>7</sup> -1 Data Pattern, Note 6 and 7 |           |     |          |                  |
|                   |                            | 622Mbps                                                                                  |           | 3   |          | dB               |
|                   |                            | 4.25Gbps                                                                                 |           | 5.5 |          | dB               |
| LOS <sub>AM</sub> | Medium LOS Assert Level    | $R_{LOSLVL} = 5k\Omega$<br>2 <sup>7</sup> -1 Data Pattern, Note 7                        |           |     |          |                  |
|                   |                            | 622Mbps                                                                                  |           | 20  |          | mV               |
|                   |                            | 4.25Gbps                                                                                 |           | 15  |          | mV               |
| LOS <sub>DM</sub> | Medium LOS De-assert Level | $R_{LOSLVL} = 5k\Omega$<br>2 <sup>7</sup> -1 Data Pattern, Note 7                        |           |     |          |                  |
|                   |                            | 622Mbps                                                                                  |           | 30  |          | mV               |
|                   |                            | 4.25Gbps                                                                                 |           | 25  |          | mV               |
| HYS <sub>M</sub>  | Medium LOS Hysteresis      | $R_{LOSLVL} = 5k\Omega$ , limiting mode<br>2 <sup>7</sup> -1 Data Pattern, Note 6 and 7  |           |     |          |                  |
|                   |                            | 622Mbps                                                                                  |           | 4   |          | dB               |
|                   |                            | 4.25Gbps                                                                                 |           | 5.5 |          | dB               |
| LOS <sub>AH</sub> | High LOS Assert Level      | $R_{LOSLVL} = 1k\Omega$<br>2 <sup>7</sup> -1 Data Pattern, Note 7                        |           |     |          |                  |
|                   |                            | 622Mbps                                                                                  |           | 35  |          | mV               |
|                   |                            | 4.25Gbps                                                                                 |           | 30  |          | mV               |
| LOS <sub>DH</sub> | High LOS De-assert Level   | $R_{LOSLVL} = 1k\Omega$<br>2 <sup>7</sup> -1 Data Pattern, Note 7                        |           |     |          |                  |
|                   |                            | 622Mbps                                                                                  |           | 60  |          | mV               |
|                   |                            | 4.25Gbps                                                                                 |           | 55  |          | mV               |
| HYS <sub>H</sub>  | High LOS Hysteresis        | $R_{LOSLVL} = 1k\Omega$ , limiting mode<br>2 <sup>7</sup> -1 Data Pattern, Note 6 and 7  |           |     |          |                  |
|                   |                            | 622Mbps                                                                                  |           | 5   |          | dB               |
|                   |                            | 4.25Gbps                                                                                 |           | 5.5 |          | dB               |

### Notes:

6. Hysteresis is defined as:  $20\log_{10} \left( \frac{SD\_AssertVoltage}{SD\_De - assertVoltage} \right) dB$ .

7. See the "Typical Operating Characteristics" section for more details on  $R_{LOSLVL}$  and its associated LOS assert and de-assert amplitudes for a 2<sup>7</sup>-1 PRBS data pattern. See the "PRBS Discussion" section for more details on the 2<sup>7</sup>-1 PRBS data pattern.

## AC Electrical Characteristics<sup>(8)</sup>

$V_{CC} = V_{CC\_TXQ} = V_{CC\_RXIN} = 3.3V \pm 10\%$ ,  $R_L = 100\Omega$  across the outputs;  $T_A = -40^\circ C$  to  $+85^\circ C$ , unless otherwise stated.

### Receiver and Transmitter

| Symbol       | Parameter                 | Condition | Min | Typ | Max     | Units             |
|--------------|---------------------------|-----------|-----|-----|---------|-------------------|
| $t_{JITTER}$ | Deterministic Jitter (DJ) | Note 9    |     |     | Note 13 | pS <sub>PP</sub>  |
|              | Random Jitter (RJ)        | Note 10   |     | 0.7 | 5       | pS <sub>RMS</sub> |
|              | Crosstalk-Induced Jitter  | Note 11   |     |     | 1.2     | pS <sub>RMS</sub> |

### Receiver

| Symbol                    | Parameter                             | Condition                                  | Min   | Typ | Max  | Units   |
|---------------------------|---------------------------------------|--------------------------------------------|-------|-----|------|---------|
| $F_{MAX}$                 | Maximum Operating Frequency           | $V_{RXIN} \geq 10mV$ (20mV <sub>PP</sub> ) | 4.25  |     |      | Gbps    |
| BW                        | -3dB                                  | $V_{RXIN} \geq 10mV$ (20mV <sub>PP</sub> ) |       | 2.5 |      | GHz     |
| $S_{21}$                  | Single-Ended Gain                     | Linear mode                                |       | 32  |      | dB      |
| $A_{V(DIFF)}$             | Differential Voltage Gain             | Linear mode                                |       | 38  |      | dB      |
| $t_r, t_f$                | Output Rise/Fall Time<br>(20% to 80%) | Limiting mode                              |       | 60  | 120  | ps      |
| LOS<br>Frequency<br>Range | LOS Operating Frequency<br>Range      | Note 12                                    | 0.622 |     | 4.25 | Gbps    |
| $t_{OFF}$                 | LOS De-assert Time                    |                                            |       | 0.1 | 0.5  | $\mu s$ |
| $t_{ON}$                  | LOS Assert Time                       |                                            |       | 0.2 | 0.5  | $\mu s$ |

### Transmitter

| Symbol     | Parameter                             | Condition                                    | Min  | Typ | Max | Units |
|------------|---------------------------------------|----------------------------------------------|------|-----|-----|-------|
| $F_{MAX}$  | Maximum Operating Frequency           | $V_{TXIN} \geq 100mV$ (200mV <sub>PP</sub> ) | 4.25 |     |     | Gbps  |
| BW         | -3dB                                  | $V_{REF\_CTRL} \leq TXCTRL \leq V_{CC\_TXQ}$ |      | 3.5 |     | GHz   |
| $t_r, t_f$ | Output Rise/Fall Time<br>(20% to 80%) | $V_{TXVCTRL} = V_{REF\_CTRL}$                |      | 50  | 120 | ps    |

#### Notes:

8. High-frequency AC-parameters are guaranteed by design and characterization.
9. Deterministic jitter is measured with both K28.5 and 2<sup>23</sup>-1 PRBS data-pattern, measured at  $<f_{MAX}$ .  $V_{IN} = 10mV$  (20mV<sub>PP</sub>) RX, 100mV (200mV<sub>PP</sub>) TX. See the "PRBS Discussion" section for more details on the K28.5 and 2<sup>23</sup> - 1 PRBS data pattern.
10. Random jitter is measured with a K28.7 comma detect character pattern, measured at  $<f_{MAX}$ .  $V_{IN} = 10mV$  (20mV<sub>PP</sub>) RX, 100mV (200mV<sub>PP</sub>) TX. See the "PRBS Discussion" section for more details on the K28.7 PRBS data pattern.
11. Crosstalk is measured at the output while applying two similar differential clock frequencies that are asynchronous with respect to each other at the inputs.
12. LOS is guaranteed to be chatter-free at  $f_{MAX} \geq 622Mbps$  or  $f_{MAX} \geq 311MHz$  with  $V_{RXIN} \geq 10mV$  (20mV<sub>PP</sub>) with a 2<sup>7</sup>-1 PRBS data pattern.
13. Contact factory for limits.

## Detailed Description

### Receiver

The receiver AC-coupled differential input distributes data to 4.25Gbps with signals as small as 10mV (20mV<sub>PP</sub>) or as large as 900mV (1.8V<sub>PP</sub>). The receiver input features an internal 50Ω input termination connected to an internal reference which optimizes the inputs for AC-coupled signals. Input signals are linearly amplified with 38dB of differential gain and the output signal is limited to 400mV (800mV<sub>PP</sub>).

The receiver output buffer features 50Ω source termination resistors and a current source that provides 400mV (800mV<sub>PP</sub>) swing into 50Ω termination. The output buffer terminates to standard CML loads (100Ω across the output pair or equivalent). See the "Output Stage Receiver" section for more details.

### Transmitter

The transmitter differential input includes Micrel's unique, patented 3-pin input termination architecture that directly interfaces to any (AC- or DC-coupled) differential signal as small as 100mV (200mV<sub>PP</sub>) without any termination resistor network in the signal path.

The transmitter output buffer terminates to standard CML loads (100Ω across the output pair, or equivalent). The output buffer is a special variable swing CML buffer controlled by TXVCTRL. The output buffer features 50Ω source termination and a current source that provides 400mV (800mV<sub>PP</sub>) swing into 50Ω transmission lines. See the next section and Figures 1a and 1b for more details on how to control the variable output swing feature.

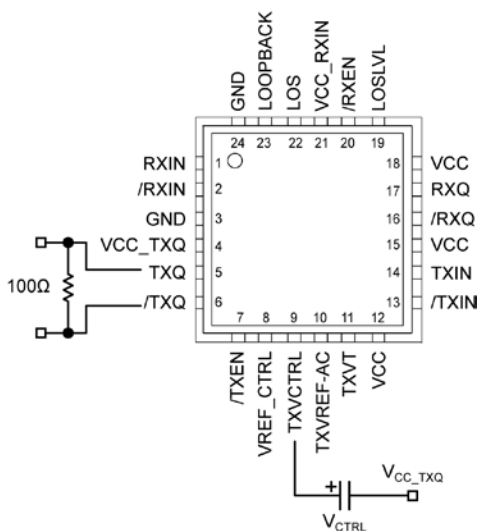


Figure 1a. Voltage Source Implementation

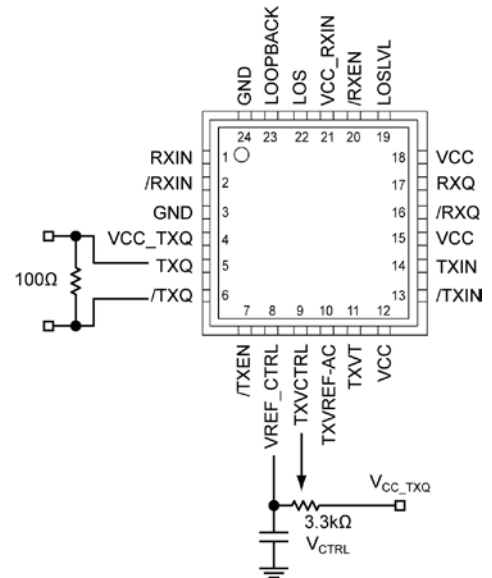


Figure 1b. Alternative Implementation

### Transmitter CML Variable-Swing Output Buffer

- Connecting  $V_{REF\_CTRL}$  to TXVCTRL sets the transmitter output buffer to maximum swing
- Setting TXVCTRL to  $V_{CC\_TXQ}$ , sets the transmitter output buffer to minimum swing
- Control of the transmitter output buffer swing can be obtained by using a variable resistor connected between  $V_{REF\_CTRL}$  and  $V_{CC\_TXQ}$  with a wiper connected to TXVCTRL as shown in Figure 1b

### Receiver LOS

The SY58620L features a chatter-free Loss-of-Signal (LOS) TTL compatible output with an internal 4.75kΩ pull-up resistor. LOS circuitry monitors the input receiver signal and asserts a signal when the input signal falls below the threshold set by the programmable LOS level set pin (LOSLVL). When the amplitude of the receiver input signal falls below the threshold, LOS is asserted HIGH with a response time of ~0.2μs. LOS can be fed into /RXEN to maintain output stability by disabling the output during a Loss-of-Signal condition. Figure 2a and 2b shows the LOS connection to /RXEN. When /RXEN is HIGH, the output signal RXQ is held LOW and /RXQ is held HIGH. Typically, 2dB of LOS hysteresis is adequate to prevent the receiver output from chattering. LOS operation is optimized for data rates ≥622Mbps with an input receiver amplitude of at least 10mV (20mV<sub>PP</sub>). Due to the long time constant in slower data rates below 622Mbps, the SY58620L LOS function does not guarantee chatter-free operation for low amplitude signals.

LOSLVL sets the threshold of the LOS input amplitude detection. Connecting an external resistor,  $R_{LOSLVL}$ , between VCC and LOSLVL sets the input amplitude

LOS detection trip-point by setting up a voltage divider between  $V_{CC}$  and  $V_{REF}$  (an internal voltage source set at  $V_{CC}-1.3V$ ), since there is a  $2.8k\Omega$  internal resistor connected between  $LOSLVL$  and  $V_{REF}$ . The input voltage range of  $LOSLVL$  ranges from  $V_{CC}$  to  $V_{REF}$ . See the “Functional Block Diagram” section and Figures 2a and 2b, to see how  $R_{LOSLVL}$  sets up a voltage divider between  $V_{CC}$  and  $V_{REF}$ . Refer to the “LOS Output DC Electrical Characteristics” table and “Typical Operating Characteristics” section to see how different  $R_{LOSLVL}$  values affect LOS sensitivity.

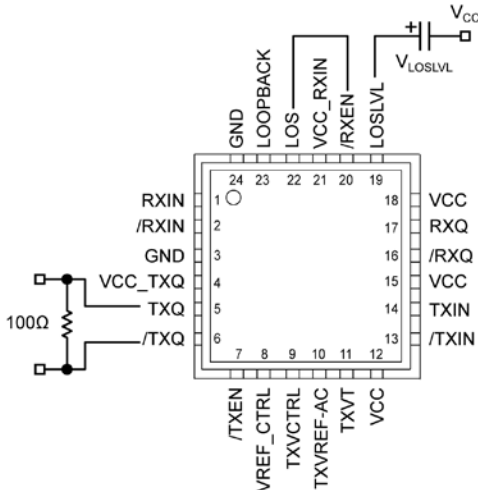


Figure 2a. Voltage Source Implementation

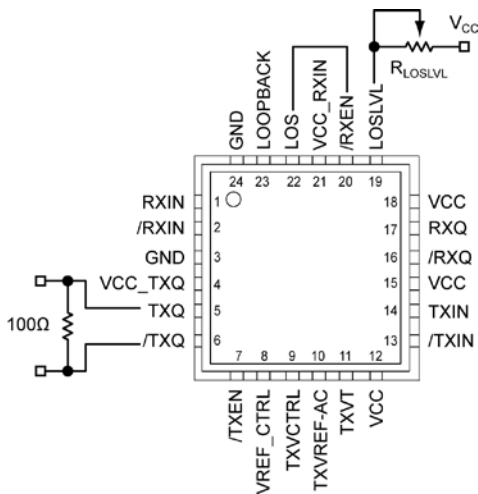


Figure 2b. Alternative Implementation

### LOS Output

- Connecting the input  $/RXEN$  to the LOS output as shown in Figures 2a and 2b, maintains receiver output stability under a Loss-of-Signal condition
- Sensitivity of the LOS signal can be programmed using the  $LOSLVL$  input by using a variable resistor connected to  $V_{CC}$  with a wiper connected to  $LOSLVL$ , as shown in Figure 2b

- $\geq 2dB$  hysteresis is insured if  $R_{LOSLVL} \leq 10k\Omega$ .
- LOS is guaranteed chatter-free at  $f \geq 622Mbps$  (311MHz)

### Hysteresis

The SY58620L provides a minimum of 2dB of LOS hysteresis, see the Figure 3 for more details.

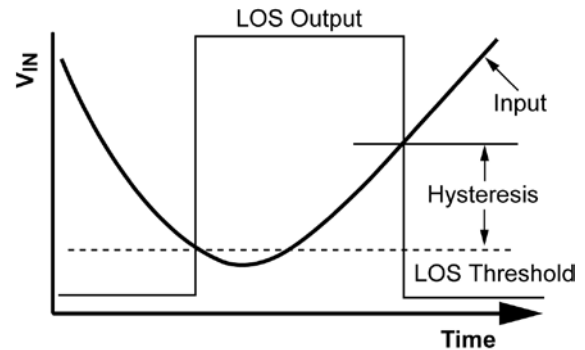


Figure 3. LOS Hysteresis Assert/De-assert

Hysteresis is defined as:  $20\log_{10}\left(\frac{SD\_AssertVoltage}{SD\_De - assertVoltage}\right)dB$ .

### Loopback

To support diagnostic system testing, the SY58620L features a loopback test mode, activated by setting  $LOOPBACK$  to logic HIGH. Loopback mode enables an internal loopback path from the transmitter input to the receiver output and supports the full 4.25Gbps data rate throughput.

### Crosstalk

The SY58620 features a patent-pending isolation between the receiver and transmitter channels. The following guide lines can be used to minimize on layout induced crosstalk:

#### 1. Ground Stripping

Ground stripping is an effective method to reduce crosstalk. Ground stripping involves running a ground trace between the receiver and transmitter channels.

#### 2. Vertical and Horizontal Traces

Another way to reduce crosstalk is to route the receiver and transmitter channels on separate layers with an embedded ground or power supply layer between the layers. When routing the traces on different layers, run the receiver traces horizontal to the transmitter traces and route the transmitter traces vertical to the receiver traces.

PRBS Discussion

LOS Testing

The LOS function is tested with a  $2^7-1$  PRBS (Pseudo Random Bit Stream) data pattern. A PRBS data pattern of  $2^7-1$  is used because it is a good approximation to an 8b10b-encoded NRZ data stream. 8b10b encodes 8 bits of data and replaces it with 10 bits of symbol. The extra bits are added to improve transition density and the BER (Bit Error Rate) of the system.

Deterministic Jitter Testing and the K28.5 Pattern

The K28.5 (11000001010011111010) and  $2^{23}-1$  PRBS data patterns are used to characterize DJ because both data patterns have lower spectral frequency content which provides a best approximation to scrambled NRZ data streams.

Random Jitter Testing and the K28.7 Pattern

The K28.7 (1111100000...) data pattern is used to measure RJ since the pattern is free of DJ. In addition, because the K28.7 data pattern can be used to compare the  $T_N$  ( $N^{th}$  period) to the  $T_0$  ( $1^{st}$  period), low frequency jitter components can be accumulated.

Power Supply Filtering

Although the SY58620L is fully differential, it is recommended that the power supplies are filtered as shown in Figure 4.

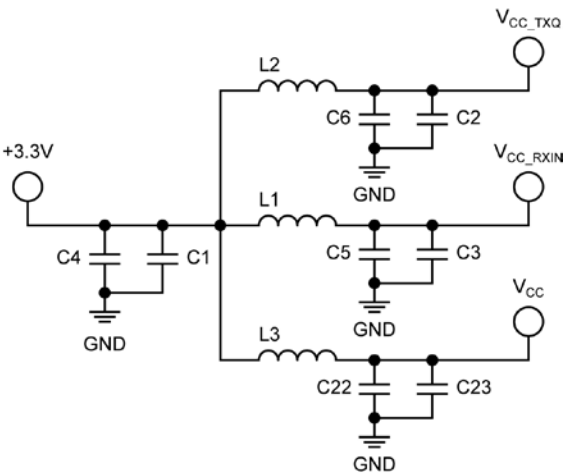


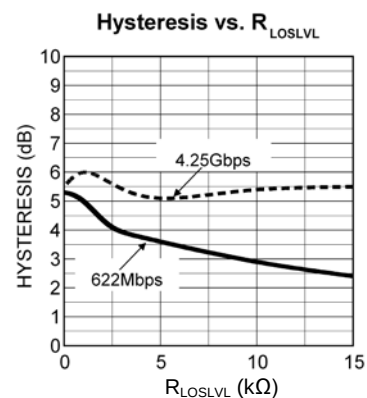
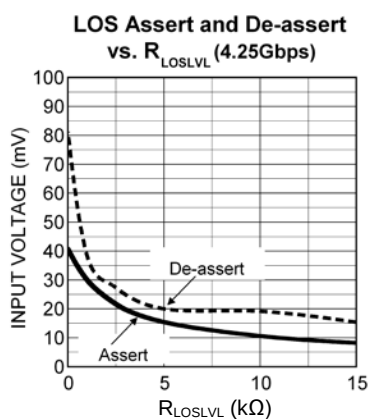
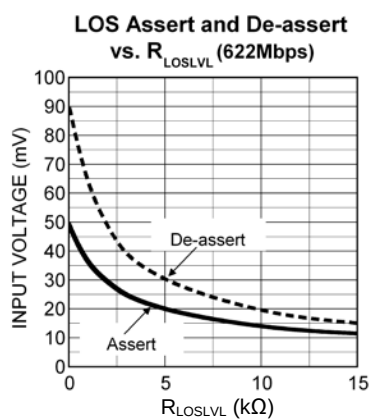
Figure 4. Power Supply Filtering Scheme

| Item            | Description                 |
|-----------------|-----------------------------|
| C1, C2, C3, C23 | 0.1µF Capacitor             |
| C4, C5, C6, C22 | 0.01µF Capacitor            |
| L1, L2, L3      | 1.2µH Ferrite Bead Inductor |

Table 1. Bill of Materials

## Typical Operating Characteristics

$V_{CC} = V_{CC\_TXQ} = V_{CC\_RXIN} = 3.3V \pm 10\%$ ,  $R_L = 100\Omega$  across the outputs;  $T_A = 25^\circ C$ , unless otherwise stated.



## Single-Ended and Differential Swings



Figure 5a. Single-Ended Voltage Swing

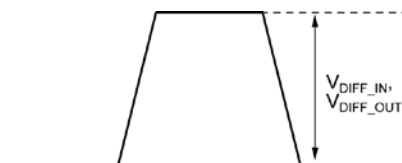


Figure 5b. Differential Voltage Swing

## Differential Input Stage

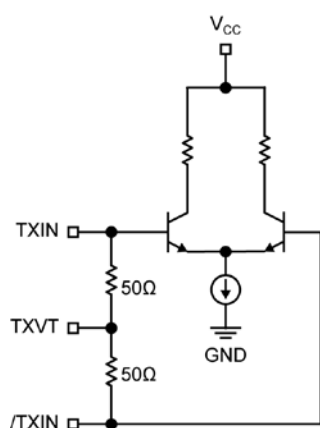


Figure 6a. TX Simplified Differential Input Stage

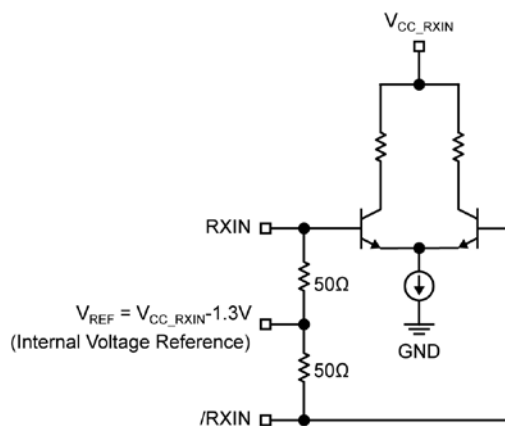


Figure 6b. RX Simplified Differential Input Stage

## Output Stage

### Receiver

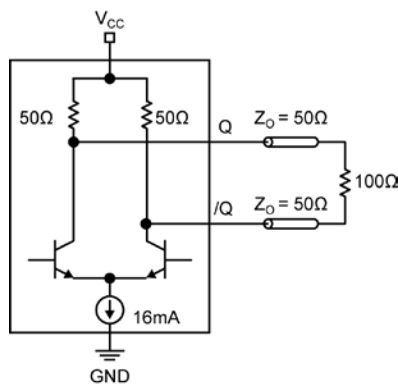


Figure 7a. Receiver CML  
DC-Coupled Output

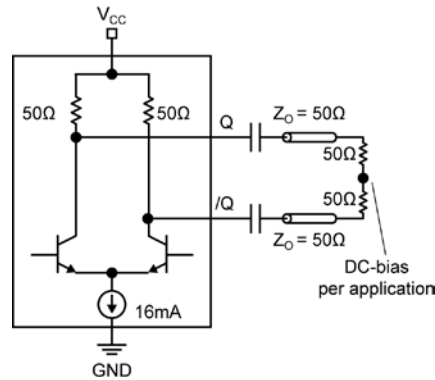


Figure 7b. Receiver CML  
AC-Coupled Output

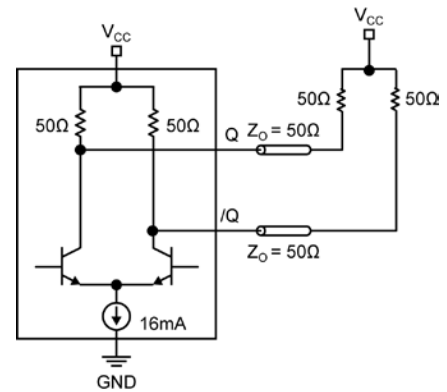


Figure 7c. Receiver CML  
DC-Coupled Output (50Ω to  $V_{CC}$ )

### Transmitter

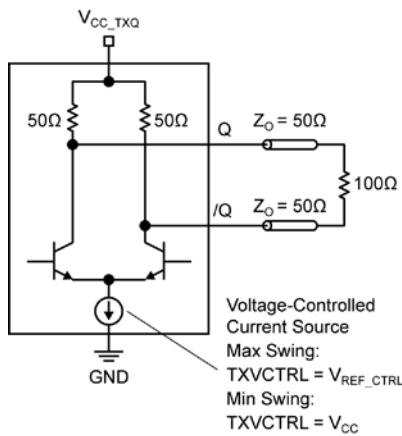


Figure 7d. Transmitter CML  
DC-Coupled Output

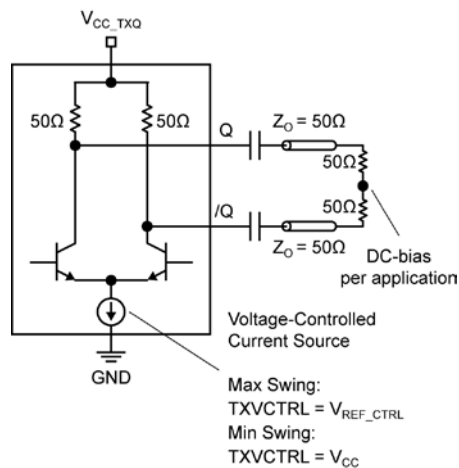


Figure 7e. Transmitter CML  
AC-Coupled Output

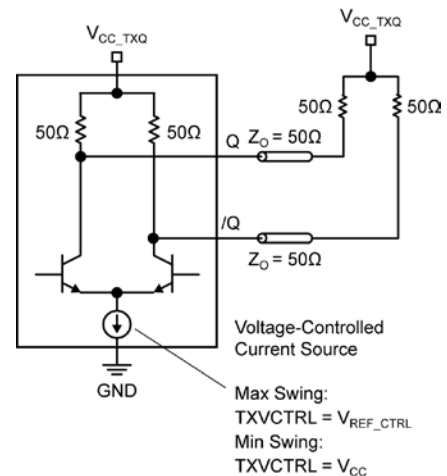
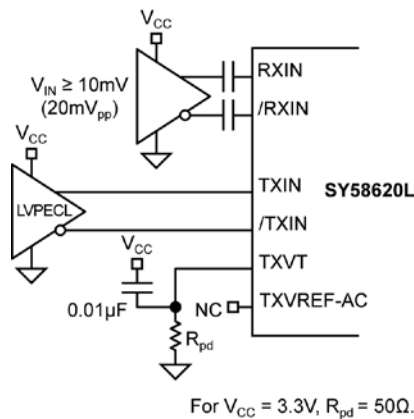
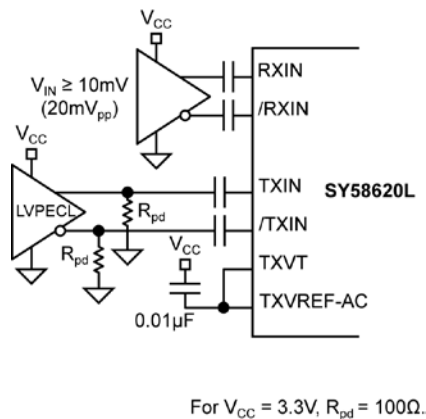


Figure 7f. Transmitter CML  
DC-Coupled Output (50Ω to  $V_{CC}$ )

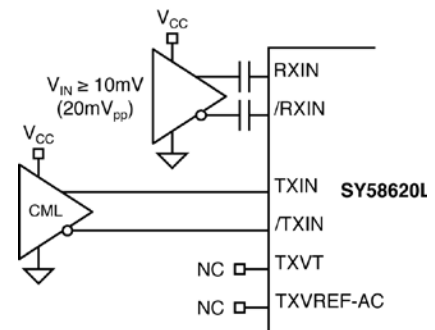
## Interface Applications



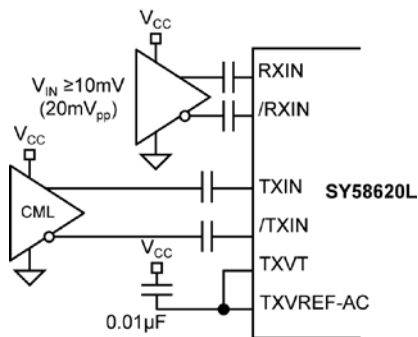
**Figure 8a. LVPECL Interface  
(TX DC-Coupled/RX AC-Coupled)**



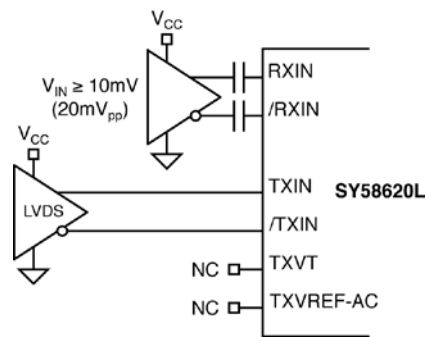
**Figure 8b. LVPECL Interface  
(TX AC-Coupled/RX AC-Coupled)**



**Figure 8c. CML Interface  
(TX DC-Coupled/RX AC-Coupled)**



**Figure 8d. CML Interface  
(TX AC-Coupled/RX AC-Coupled)**

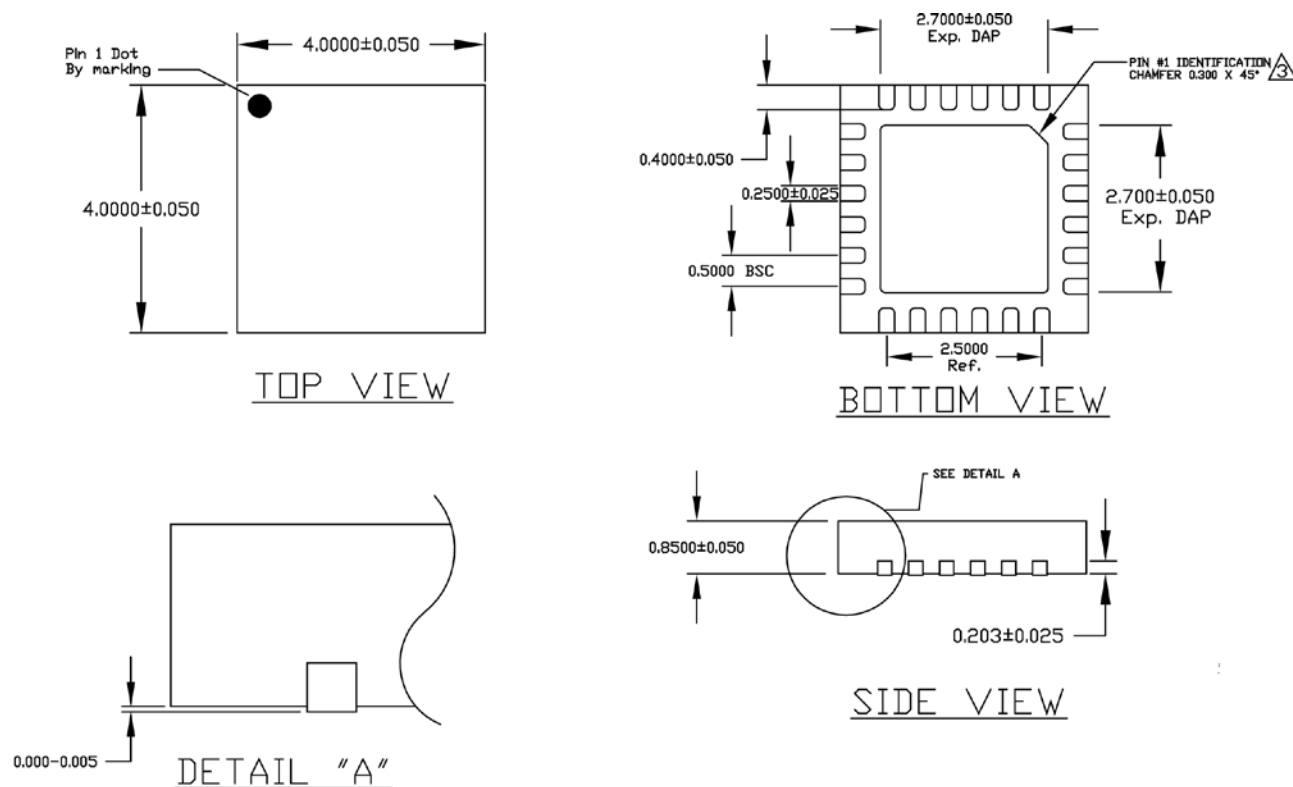


**Figure 8e. LVDS Interface  
(TX DC-Coupled/RX AC-Coupled)**

## Related Product and Support Documentation

| Part Number   | Function                                                           | Data Sheet Link                                                                                                                |
|---------------|--------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|
| SY58621L      | Precision 3.2 Gbps CML/LVPECL Transceiver with Integrated Loopback | <a href="http://www.micrel.com/product-info/products/sy58621l.shtml">www.micrel.com/product-info/products/sy58621l.shtml</a>   |
| HBW Solutions | New Products and Applications                                      | <a href="http://www.micrel.com/product-info/products/solutions.shtml">www.micrel.com/product-info/products/solutions.shtml</a> |

## Package Information



### NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETERS (mm).
2. THE PIN#1 IDENTIFIER MUST EXIST ON THE TOP SURFACE OF PACKAGE BY USING IDENTIFICATION MARK OR OTHER FEATURE OF PACKAGE BODY.
3. CHAMFER STYLE PIN 1 IDENTIFIER ON BOTTOM SIDE

### 24-Pin QFN

**MICREL, INC. 2180 FORTUNE DRIVE SAN JOSE, CA 95131 USA**

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