



## SY58603U

### 4.25Gbps Precision CML Buffer with Internal Termination and Fail Safe Input

## General Description

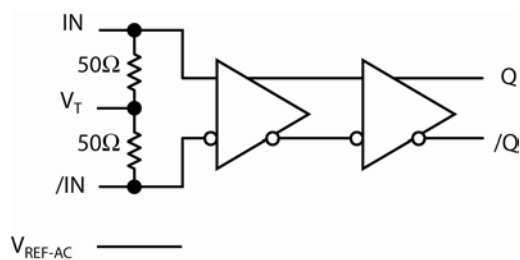
The SY58603U is a 2.5/3.3V, high-speed, fully differential CML buffer optimized to provide less than 10ps<sub>pp</sub> total jitter. The SY58603U can process clock signals as fast as 2.5GHz or data patterns up to 4.25Gbps.

The differential input includes Micrel's unique, 3-pin input termination architecture that interfaces to LVPECL, LVDS or CML differential signals, (AC-coupled or DC-coupled) as small as 100mV (200mV<sub>pp</sub>) without any level-shifting or termination resistor networks in the signal path. For AC-coupled input interface applications, an integrated voltage reference ( $V_{REF-AC}$ ) is provided to bias the  $V_T$  pin. The output is 400mV CML, with extremely fast rise/fall times guaranteed to be less than 85ps.

The SY58603U operates from a 2.5V  $\pm 5\%$  supply or 3.3V  $\pm 10\%$  supply and is guaranteed over the full industrial temperature range ( $-40^\circ\text{C}$  to  $+85^\circ\text{C}$ ). For applications that require LVPECL or LVDS outputs, consider the SY58604U and SY58605U, buffers with 800mV and 325mV output swings respectively. The SY58603U is part of Micrel's high-speed, Precision Edge<sup>®</sup> product line.

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

## Functional Block Diagram



United States Patent No. RE44,134

Precision Edge is a registered trademark of Micrel, Inc.

Micrel Inc. • 2180 Fortune Drive • San Jose, CA 95131 • USA • tel +1 (408) 944-0800 • fax + 1 (408) 474-1000 • <http://www.micrel.com>

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[hbwhelp@micrel.com](mailto:hbwhelp@micrel.com) or (408) 955-1690

## Precision Edge<sup>®</sup>

### Features

- Precision 400mV CML buffer
- Guaranteed AC performance over temperature and voltage:
  - DC-to >4.25Gbps throughput
  - <300ps propagation delay (IN-to-Q)
  - <85ps rise/fall times
- Fail Safe Input
  - Prevents output from oscillating when input is invalid
- Ultra-low jitter design
  - <1ps<sub>RMS</sub> cycle-to-cycle jitter
  - <10ps<sub>pp</sub> total jitter
  - <1ps<sub>RMS</sub> random jitter
  - <10ps<sub>pp</sub> deterministic jitter
- High-speed CML output
- 2.5V  $\pm 5\%$  or 3.3V  $\pm 10\%$  power supply operation
- Industrial temperature range:  $-40^\circ\text{C}$  to  $+85^\circ\text{C}$
- Available in 8-pin (2mm x 2mm) DFN package

### Applications

- Data Distribution: OC-48, OC-48+FEC, XAUI
- Backplane Buffering
- SONET clock or data distribution
- Fibre Channel clock or data distribution
- Gigabit Ethernet clock or data distribution

### Markets

- Storage
- ATE
- Test and measurement
- Enterprise networking equipment
- High-end servers
- Access
- Metro area network equipment

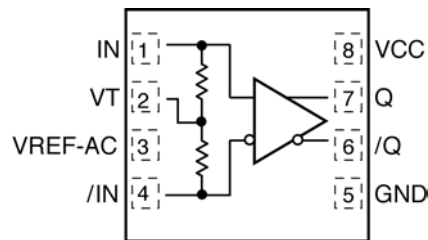
## Ordering Information<sup>(1)</sup>

| Part Number                 | Package Type | Operating Range | Package Marking                     | Lead Finish       |
|-----------------------------|--------------|-----------------|-------------------------------------|-------------------|
| SY58603UMG                  | DFN-8        | Industrial      | 603 with Pb-Free bar-line indicator | NiPdAu<br>Pb-Free |
| SY58603UMGTR <sup>(2)</sup> | DFN-8        | Industrial      | 603 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



8-Pin DFN

## Pin Description

| Pin Number | Pin Name           | Pin Function  |
|------------|--------------------|---|
| 1, 4       | IN, /IN            | Differential Input: This input pair is the differential signal input to the device. Input accepts DC-Coupled differential signals as small as 100mV (200mVpp). Each pin of this pair internally terminates with 50Ω to the VT pin. If the input swing falls below a certain threshold (typical 30mV), the Fail Safe Input (FSI) feature will guarantee a stable output by latching the output to its last valid state. See “Input Interface Applications” section for more details. |
| 2          | VT                 | Input Termination Center-Tap: Each side of the differential input pair terminates to VT pin. This pin provides a center-tap to a termination network for maximum interface flexibility. See “Input Interface Applications” section.   |
| 3          | VREF-AC            | Reference Voltage: This output biases to $V_{CC}-1.2\text{V}$ . It is used for AC-coupling input IN and /IN. Connect VREF-AC directly to the corresponding VT pin. Bypass with 0.01μF low ESR capacitor to VCC. Maximum sink/source current is ±1.5mA. Please refer to the “Input Interface Applications” section for more details.   |
| 5          | GND<br>Exposed pad | Ground: Exposed pad must be connected to a ground plane that is the same potential as the ground pin.   |
| 6, 7       | /Q, Q              | CML Differential Output Pair: Differential buffered output copy of the input signal. The output swing is typically 400mV. See “CML Output Termination” section.   |
| 8          | VCC                | Positive Power Supply: Bypass with 0.1uF//0.01uF low ESR capacitors as close to the VCC pin as possible.  |

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

Supply Voltage ( $V_{CC}$ ) ..... -0.5V to +4.0V  
 Input Voltage ( $V_{IN}$ ) ..... -0.5V to  $V_{CC}$   
 CML Output Voltage ( $V_{OUT}$ ) .....  $V_{CC}-1.0V$  to  $V_{CC}+0.5V$   
 Current ( $V_T$ )  
     Source or sink on  $V_T$  pin .....  $\pm 100mA$   
 Input Current  
     Source or sink Current on ( $I_N$ ,  $/I_N$ ) .....  $\pm 50mA$   
 Current ( $V_{REF}$ )  
     Source or sink current on  $V_{REF-AC}$ <sup>(4)</sup> .....  $\pm 1.5mA$   
 Maximum operating Junction Temperature ..... 125°C  
 Lead Temperature (soldering, 20sec.) ..... 260°C  
 Storage Temperature ( $T_s$ ) ..... -65°C to +150°C

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

Supply Voltage ( $V_{IN}$ ) ..... +2.375V to +3.60V  
 Ambient Temperature ( $T_A$ ) ..... -40°C to +85°C  
 Package Thermal Resistance<sup>(3)</sup>  
 DFN  
     Still-air ( $\theta_{JA}$ ) ..... 93°C/W  
     Junction-to-board ( $\psi_{JB}$ ) ..... 56°C/W

### DC Electrical Characteristics<sup>(5)</sup>

$T_A = -40^\circ C$  to  $+85^\circ C$ , unless otherwise stated.

| Symbol         | Parameter   | Condition              | Min          | Typ          | Max          | Units    |
|----------------|---|------------------------|--------------|--------------|--------------|----------|
| $V_{CC}$       | Power Supply Voltage Range                          |                        | 2.375<br>3.0 | 2.5<br>3.3   | 2.625<br>3.6 | V        |
| $I_{CC}$       | Power Supply Current                                | No load, max. $V_{CC}$ |              | 39           | 50           | mA       |
| $R_{DIFF\_IN}$ | Differential Input Resistance (IN-to- $/I_N$ )      |                        | 90           | 100          | 110          | $\Omega$ |
| $V_{IH}$       | Input HIGH Voltage (IN, $/I_N$ )                    | IN, $/I_N$ , Note 7    | $V_{CC}-1.6$ |              | $V_{CC}$     | V        |
| $V_{IL}$       | Input LOW Voltage (IN, $/I_N$ )                     | IN, $/I_N$             | 0            |              | $V_{IH}-0.1$ | V        |
| $V_{IN}$       | Input Voltage Swing (IN, $/I_N$ )                   | see Figure 3a, Note 6  | 0.1          |              | 1.7          | V        |
| $V_{DIFF\_IN}$ | Differential Input Voltage Swing ( $ I_N - /I_N $ ) | see Figure 3b          | 0.2          |              |              | V        |
| $V_{IN\_FSI}$  | Input Voltage Threshold that Triggers FSI           |                        |              | 30           | 100          | mV       |
| $V_{REF-AC}$   | Output Reference Voltage                            |                        | $V_{CC}-1.3$ | $V_{CC}-1.2$ | $V_{CC}-1.1$ | V        |
| $V_{T\_IN}$    | Voltage from Input to $V_T$                         |                        |              |              | 1.28         | 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 device's most negative potential on the PCB.  $\psi_{JB}$  and  $\theta_{JA}$  values are determined for a 4-layer board in still-air number, unless otherwise stated.
4. Due to the limited drive capability, use for input of the same package only.
5. The circuit is designed to meet the DC specifications shown in the above table after thermal equilibrium has been established.
6.  $V_{IN}$  (max) is specified when  $V_T$  is floating.
7.  $V_{IH}$  (min) not lower than 1.2V.

## CML Output DC Electrical Characteristics<sup>(7)</sup>

$V_{CC} = +2.5V \pm 5\%$  or  $+3.3V \pm 10\%$ ,  $R_L = 100\Omega$  across the outputs;  $T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ , unless otherwise stated.

| Symbol          | Parameter                         | Condition                    | Min            | Typ            | Max      | Units    |
|-----------------|-----------------------------------|------------------------------|----------------|----------------|----------|----------|
| $V_{OH}$        | Output HIGH Voltage               | $R_L = 50\Omega$ to $V_{CC}$ | $V_{CC}-0.020$ | $V_{CC}-0.010$ | $V_{CC}$ | V        |
| $V_{OUT}$       | Output Voltage Swing              | See Figure 3a                | 325            | 400            |          | mV       |
| $V_{DIFF\_OUT}$ | Differential Output Voltage Swing | See Figure 3b                | 650            | 800            |          | mV       |
| $R_{OUT}$       | Output Source Impedance           |                              | 45             | 50             | 55       | $\Omega$ |

**Note:**

7. The circuit is designed to meet the DC specifications shown in the above table after thermal equilibrium has been established.

## AC Electrical Characteristics

$V_{CC} = +2.5V \pm 5\%$  or  $+3.3V \pm 10\%$ ,  $R_L = 100\Omega$  across the outputs, Input  $t_r/t_f: \leq 300ps$ ;  $T_A = -40^\circ C$  to  $+85^\circ C$ , unless otherwise stated.

| Symbol       | Parameter                           | Condition               | Min  | Typ | Max | Units      |
|--------------|-------------------------------------|-------------------------|------|-----|-----|------------|
| $f_{MAX}$    | Maximum Frequency                   | NRZ Data                | 4.25 |     |     | Gbps       |
|              |                                     | $V_{OUT} > 200mV$ Clock | 2.5  | 3   |     | GHz        |
| $t_{PD}$     | Propagation Delay IN-to-Q           | $V_{IN}: 100mV-200mV$   | 150  | 250 | 350 | ps         |
|              |                                     | $V_{IN}: 200mV-800mV$   | 120  | 190 | 300 | ps         |
| $t_{Skew}$   | Part-to-Part Skew                   | Note 8                  |      |     | 100 | ps         |
| $t_{Jitter}$ | Data Random Jitter                  | Note 9                  |      |     | 1   | $\mu SRMS$ |
|              | Deterministic Jitter                | Note 10                 |      |     | 10  | $\mu SPP$  |
|              | Clock Cycle-to-Cycle Jitter         | Note 11                 |      |     | 1   | $\mu SRMS$ |
|              | Total Jitter                        | Note 12                 |      |     | 10  | $\mu SPP$  |
| $t_r, t_f$   | Output Rise/Fall Times (20% to 80%) | At full output swing.   | 30   | 50  | 85  | ps         |
|              | Duty Cycle                          | Differential I/O        | 47   |     | 53  | %          |

### Notes:

- Part-to-part skew is defined for two parts with identical power supply voltages at the same temperature and no skew at the edges at the respective inputs.
- Random jitter is measured with a K28.7 pattern, measured at  $\leq f_{MAX}$ .
- Deterministic jitter is measured at 2.5Gbps with both K28.5 and  $2^{23}-1$  PRBS pattern.
- Cycle-to-cycle jitter definition: the variation period between adjacent cycles over a random sample of adjacent cycle pairs.  $t_{JITTER\_CC} = T_n - T_{n+1}$ , where T is the time between rising edges of the output signal.
- Total jitter definition: with an ideal clock input frequency of  $\leq f_{MAX}$  (device), no more than one output edge in  $10^{12}$  output edges will deviate by more than the specified peak-to-peak jitter value.

## Functional Description

### Fail-Safe Input (FSI)

The input includes a special failsafe circuit to sense the amplitude of the input signal and to latch the output when there is no input signal present, or when the amplitude of the input signal drops sufficiently below  $100mV_{PK}$  ( $200mV_{PP}$ ), typically  $30mV_{PK}$ . Maximum frequency of SY58603U is limited by the FSI function.

### Input Clock Failure Case

If the input clock fails to a floating, static, or extremely low signal swing, the FSI function will eliminate a metastable condition and guarantee a stable output. No ringing and no undetermined state will occur at the output under these conditions.

Note that the FSI function will not prevent duty cycle distortion in case of a slowly deteriorating (but still toggling) input signal. Due to the FSI function, the propagation delay will depend on rise and fall time of the input signal and on its amplitude. Refer to "Typical Characteristics" for detailed information.

## Timing Diagrams

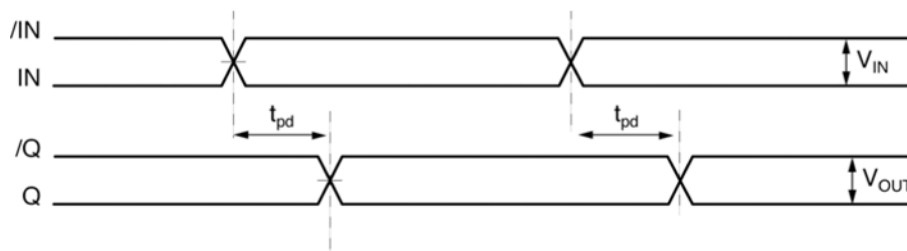


Figure 1a. Propagation Delay

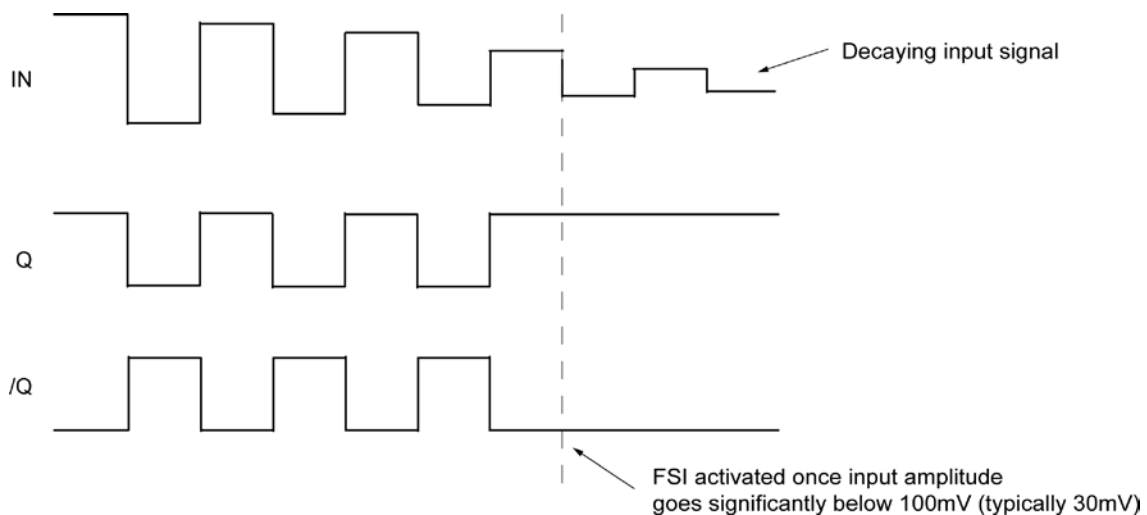
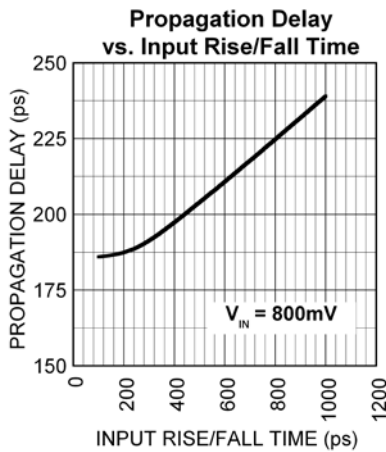
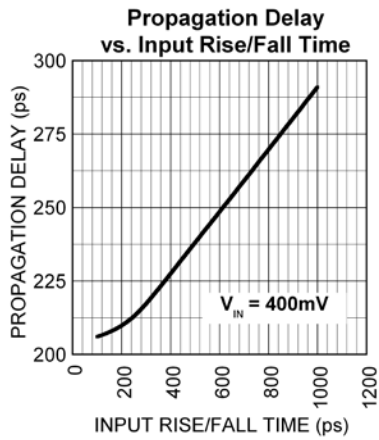
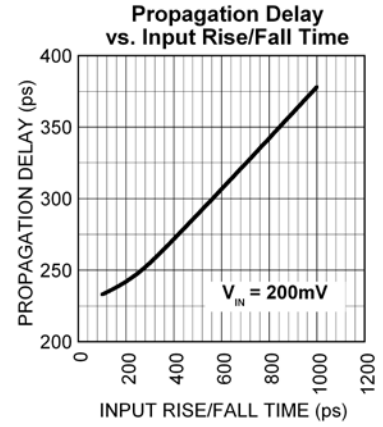
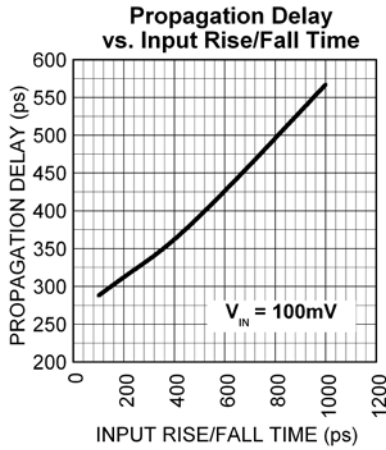
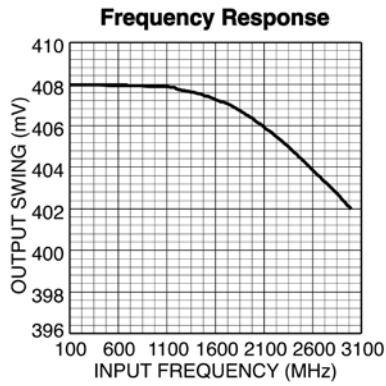


Figure 1b. Fail Safe Feature

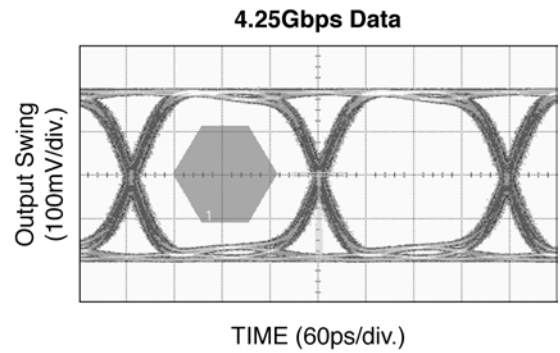
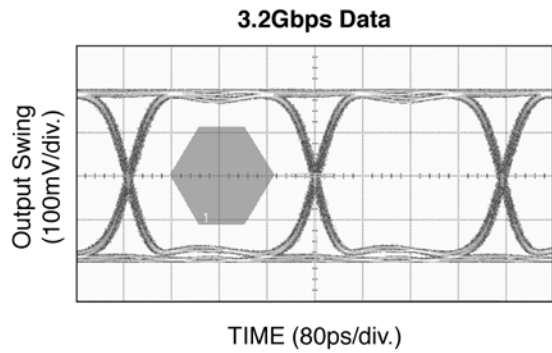
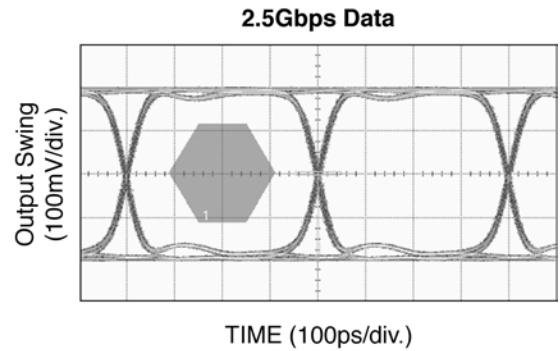
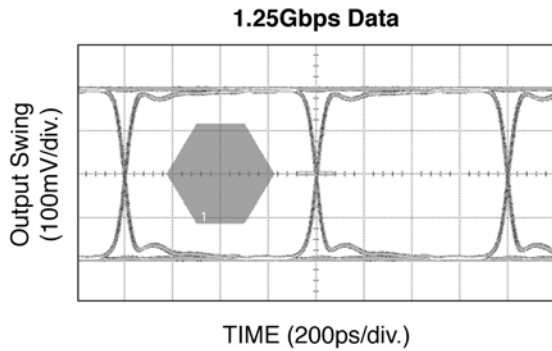
## Typical Characteristics

$V_{CC} = 2.5V$ ,  $GND = 0V$ ,  $V_{IN} = 100mV$ ,  $R_L = 100\Omega$  across the outputs,  $T_A = 25^\circ C$ , unless otherwise stated.



### Functional Characteristics

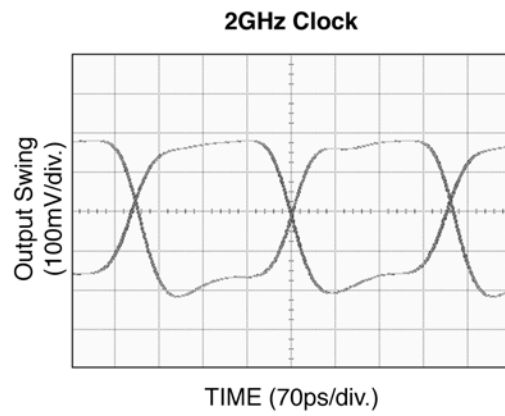
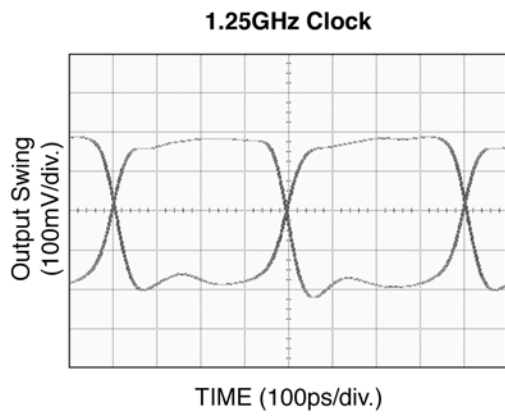
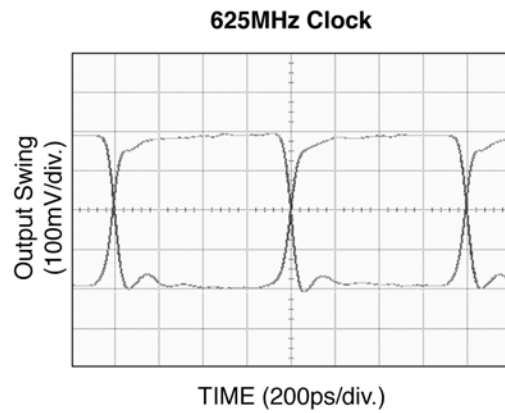
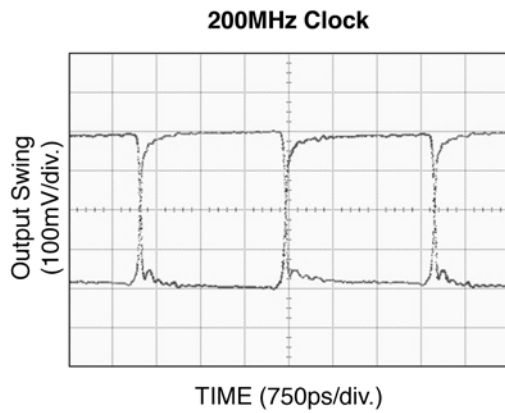
$V_{CC} = 2.5V$ ,  $GND = 0V$ ,  $V_{IN} = 325mV$ , Data Pattern:  $2^{23}-1$ ,  $R_L = 100\Omega$  across the outputs,  $T_A = 25^\circ C$ , unless otherwise stated.





### Functional Characteristics (continued)

$V_{CC} = 2.5V$ ,  $GND = 0V$ ,  $V_{IN} = 325mV$ ,  $R_L = 100\Omega$  across the outputs,  $T_A = 25^\circ C$ , unless otherwise stated.



### Input and Output Stage

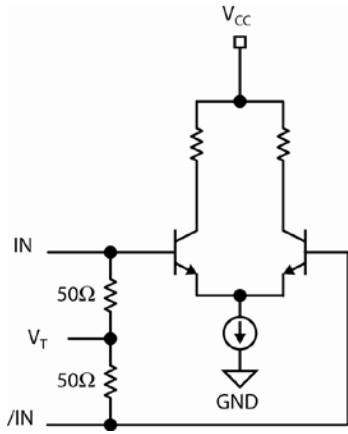


Figure 2a. Simplified Differential Input Buffer

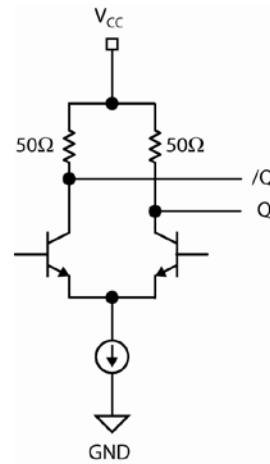


Figure 2b. Simplified CML Output Buffer

### Single-ended and Differential Swings



Figure 3a. Single-Ended Swing

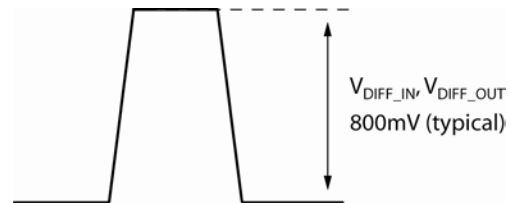
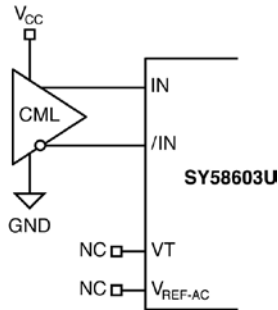


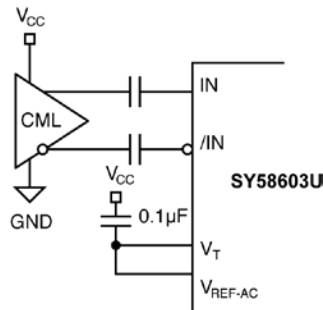
Figure 3b. Differential Swing

## Input Interface Applications

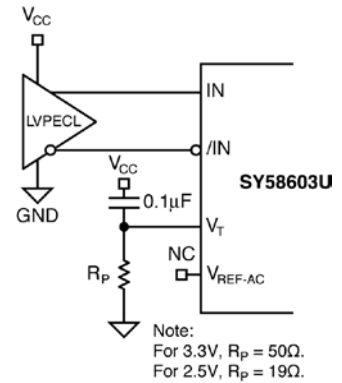


**Figure 4a. CML Interface (DC-Coupled)**

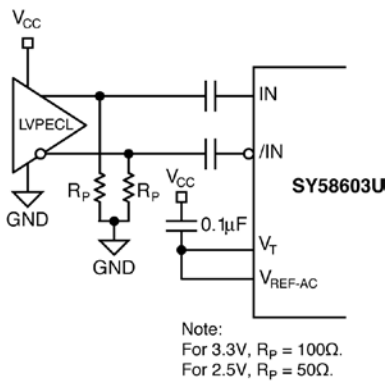
*Option: May connect  $V_T$  to  $V_{CC}$*



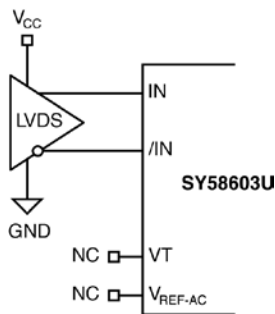
**Figure 4b. CML Interface (AC-Coupled)**



**Figure 4c. LVPECL Interface (DC-Coupled)**



**Figure 4d. LVPECL Interface (AC-Coupled)**



**Figure 4e. LVDS Interface**

### CML Output Termination

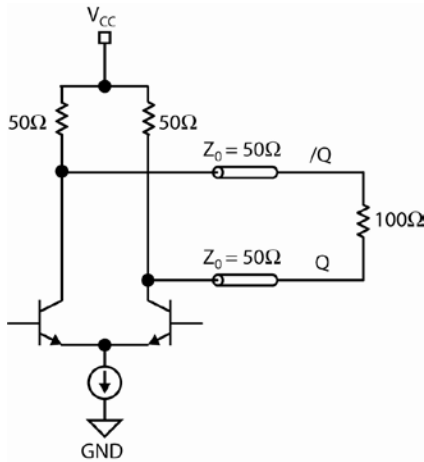


Figure 5a. CML DC-Coupled Termination

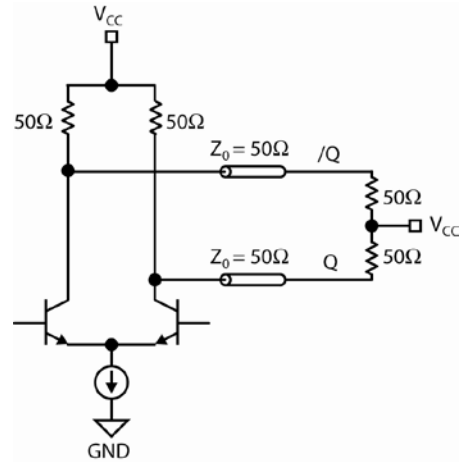


Figure 5b. CML DC-Coupled Termination

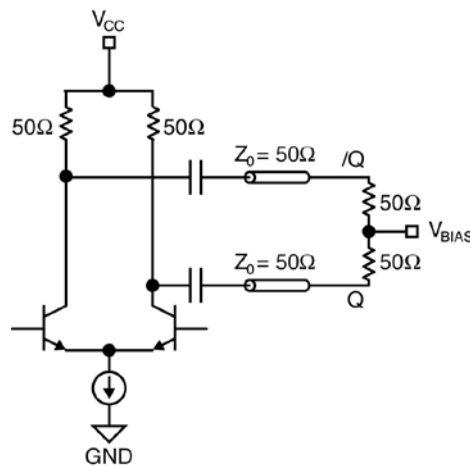
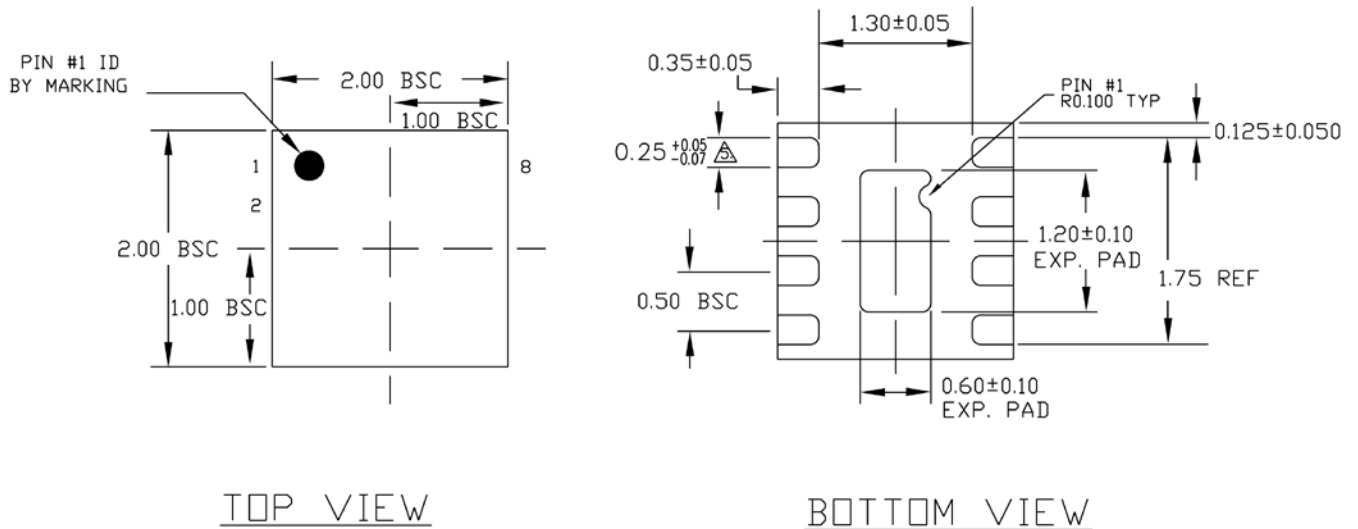


Figure 5c. CML AC-Coupled Termination

### Related Product and Support Documents

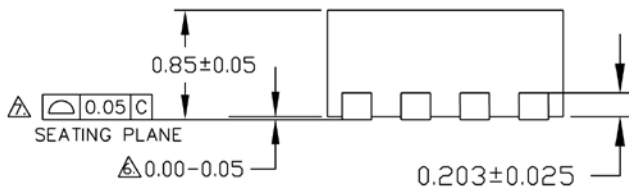
| Part Number   | Function  | Data Sheet Link   |
|---------------|---|---|
| SY58604U      | 3.2Gbps Precision LVPECL Buffer with Internal Termination and Fail Safe Input | <a href="http://www.micrel.com/page.do?page=/product-info/products/sy58604u.shtml">http://www.micrel.com/page.do?page=/product-info/products/sy58604u.shtml</a> |
| SY58605U      | 3.2Gbps Precision LVDS Buffer with Internal Termination and Fail Safe Input   | <a href="http://www.micrel.com/page.do?page=/product-info/products/sy58605u.shtml">http://www.micrel.com/page.do?page=/product-info/products/sy58605u.shtml</a> |
| HBW Solutions | New Products and Termination Application Notes                                | <a href="http://www.micrel.com/page.do?page=/product-info/as/HBWsolutions.shtml">http://www.micrel.com/page.do?page=/product-info/as/HBWsolutions.shtml</a>     |

### Package Information



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.
- △ DIMENSION APPLIES TO METALIZED TERMINAL AND IS MEASURED BETWEEN 0.20 AND 0.25 mm FROM TERMINAL TIP.
- △ APPLIED ONLY FOR TERMINALS.
- △ APPLIED FOR EXPOSED PAD AND TERMINALS.

#### 8-Pin DFN (2mm x 2mm)

**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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