



## SY58604U

### 3.2Gbps Precision, LVPECL Buffer with Internal Termination and Fail Safe Input

## General Description

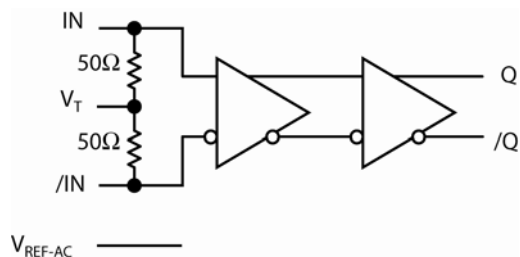
The SY58604U is a 2.5/3.3V, high-speed, fully differential LVPECL buffer optimized to provide only 108fs<sub>RMS</sub> phase jitter. The SY58604U can process clock signals as fast as 2.5GHz or data patterns up to 3.2Gbps.

The differential input includes Micrel's unique, 3-pin input termination architecture that interfaces to LVPECL, LVDS or CML differential signals, (AC- 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 800mV LVPECL, with extremely fast rise/fall times guaranteed to be less than 110ps.

The SY58604U operates from a 2.5V  $\pm$ 5% supply or 3.3V  $\pm$ 10% supply and is guaranteed over the full industrial temperature range (-40°C to +85°C). For applications that require CML or LVDS outputs, consider the SY58603U and the SY58605U, buffers with 400mV and 325mV output swings respectively. The SY58604U is part of Micrel's high-speed, Precision Edge<sup>®</sup> product line.

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

## Functional Block Diagram



Precision Edge<sup>®</sup>

## Features

- Precision 800mV LVPECL buffer
- Ultra-low jitter design
  - 108fs<sub>RMS</sub> phase jitter
- Guaranteed AC performance over temperature and voltage:
  - DC-to > 3.2Gbps throughput
  - <350ps typical propagation delay (IN-to-Q)
  - <110ps rise/fall times
- Fail Safe Input
  - Prevents output from oscillating when input is invalid
- High-speed LVPECL output
- 2.5V  $\pm$ 5% or 3.3V  $\pm$ 10% power supply operation
- Industrial temperature range: -40°C to +85°C
- Available in 8-pin (2mm x 2mm) DFN package

## Applications

- All SONET clock and data distribution
- Fibre Channel clock and data distribution
- Gigabit Ethernet clock and data distribution
- Backplane distribution

## Markets

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

United States Patent No. RE44,134

Precision Edge is a registered trademark of Micrel, Inc.

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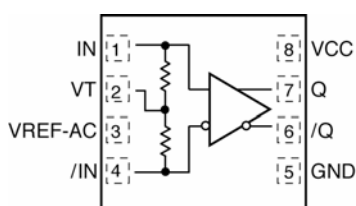
## Ordering Information<sup>(1)</sup>

Part Number	Package Type	Operating Range	Package Marking
SY58604UMG	DFN-8	Industrial	604 with Pb-Free bar-line indicator
SY58604UMGTR <sup>(2)</sup>	DFN-8	Industrial	604 with Pb-Free bar-line indicator

### Notes:

- Contact factory for die availability. Dice are guaranteed at  $T_A = 25^\circ\text{C}$ , DC Electricals only.
- 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” subsection for more details.
2	VT	Input Termination Center-Tap: Each input terminates to this pin. The VT pin provides a center-tap for each input (IN, /IN) to a termination network for maximum interface flexibility. See “Input Interface Applications” subsection.
3	VREF-AC	Reference Voltage: This output biases to $V_{CC}-1.2\text{V}$ . It is used for AC-coupling inputs IN and /IN. Connect VREF-AC directly to the VT pin. Bypass with 0.01μF low ESR capacitor to VCC. Maximum sink/source current is ±1.5mA. See “Input Interface Applications” subsection for more details.
5	GND, 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	LVPECL Differential Output Pair: Differential buffered output copy of the input signal. The output swing is typically 800mV. See “LVPECL Output Termination” subsection.
8	VCC	Positive Power Supply: Bypass with 0.1μF//0.01μF 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 $V_{CC}+0.5V$
LVPECL Output Current ( $I_{OUT}$ )	
Continuous	50mA
Surge	100mA
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 $V_{REF-AC}^{(4)}$	$\pm 1.5mA$
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>**

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

Symbol	Parameter	Condition	Min	Typ	Max	Units
$V_{CC}$	Power Supply Voltage Range		2.375 3.0	2.5 3.3	2.625 3.6	V
$I_{CC}$	Power Supply Current	No load, max. $V_{CC}$		30	45	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:**

- Permanent device damage may occur if absolute maximum ratings are exceeded. This is a stress rating only and functional operation is not implied at conditions other than those detailed in the operational sections of this data sheet. Exposure to absolute maximum ratings conditions for extended periods may affect device reliability.
- The data sheet limits are not guaranteed if the device is operated beyond the operating ratings.
- Package thermal resistance assumes exposed pad is soldered (or equivalent) to the 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.
- Due to the limited drive capability, use for input of the same package only.
- The circuit is designed to meet the DC specifications shown in the above table after thermal equilibrium has been established.
- $V_{IN}$  (max) is specified when  $V_T$  is floating.
- $V_{IH}$  (min) not lower than 1.2V.

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

$V_{CC} = +2.5V \pm 5\%$  or  $+3.3V \pm 10\%$ ,  $R_L = 50\Omega$  to  $V_{CC}-2V$ ;  $T_A = -40^\circ C$  to  $+85^\circ C$ , unless otherwise stated.

Symbol	Parameter	Condition	Min	Typ	Max	Units
$V_{OH}$	Output HIGH Voltage		$V_{CC}-1.145$		$V_{CC}-0.895$	V
$V_{OL}$	Output LOW Voltage		$V_{CC}-1.945$		$V_{CC}-1.695$	V
$V_{OUT}$	Output Voltage Swing	See Figure 3a	550	800	950	mV
$V_{DIFF\_OUT}$	Differential Output Voltage Swing	See Figure 3b	1100	1600		mV

### AC Electrical Characteristics

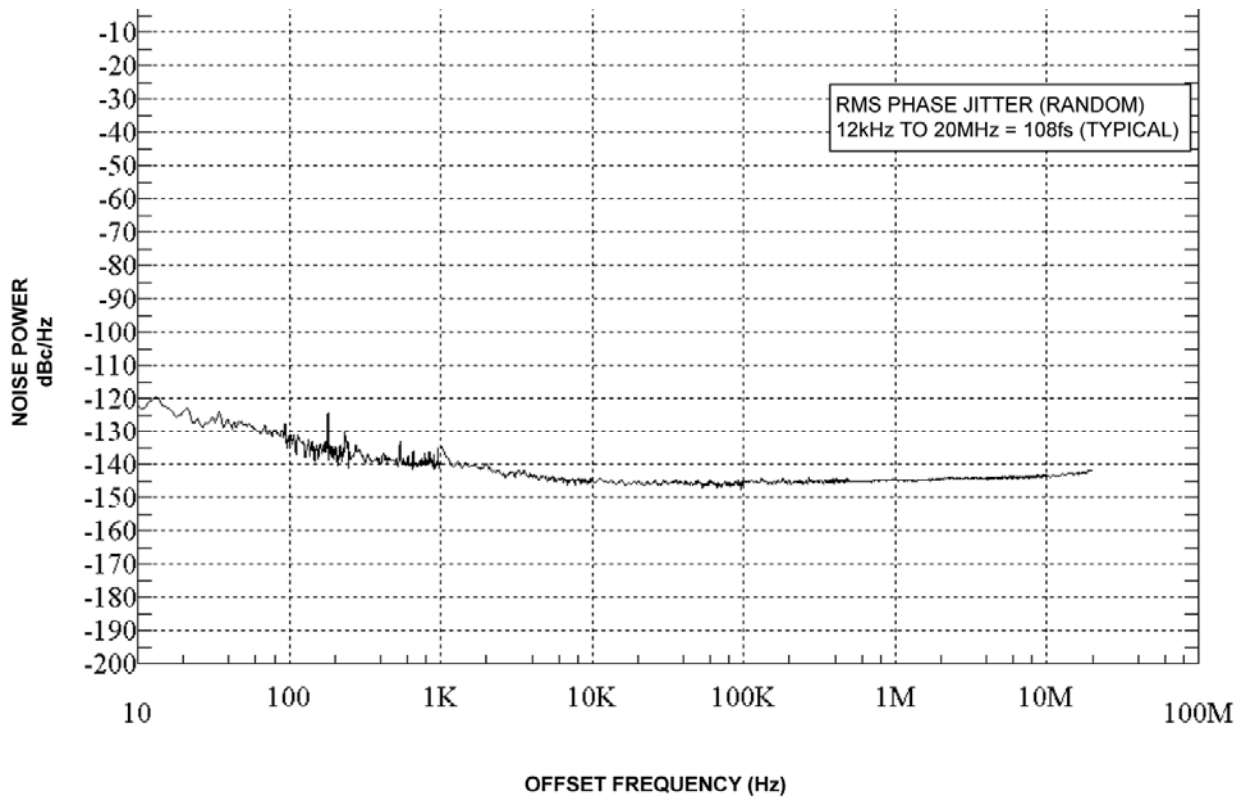
$V_{CC} = +2.5V \pm 5\%$  or  $+3.3V \pm 10\%$ ,  $R_L = 50\Omega$  to  $V_{CC}-2V$ , Input  $t_r/t_f: \leq 300ps$ ;  $T_A = -40^\circ C$  to  $+85^\circ C$ , unless otherwise stated.

Symbol	Parameter	Condition	Min	Typ	Max	Units
$f_{MAX}$	Maximum Frequency	NRZ Data	3.2	4.25		Gbps
		$V_{OUT} > 400mV$ Clock	2.5	3		GHz
$t_{PD}$	Propagation Delay IN-to-Q	$V_{IN}: 100mV-200mV$	180	320	450	ps
		$V_{IN}: 200mV-800mV$	150	230	350	ps
$t_{Skew}$	Part-to-Part Skew	Note 7			135	ps
$t_{Jitter}$	RMS Phase Jitter	Output = 622MHz Integration Range: 12kHz – 20MHz		108		$fs_{RMS}$
$t_r, t_f$	Output Rise/Fall Times (20% to 80%)	At full output swing.	40	75	110	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.

### Phase Noise Plot



PHASE NOISE PLOT: 622MHz @ 3.3V

## 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 outputs when there is no input signal present, or when the amplitude of the input signal drops sufficiently below  $100\text{mV}_{\text{PK}}$  ( $200\text{mV}_{\text{PP}}$ ), typically  $30\text{mV}_{\text{PK}}$ . Maximum frequency of SY58604U is limited by the FSI function.

### Input Clock Failure Case

If the input clock fails to a floating, static, or extremely low signal swing, then 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

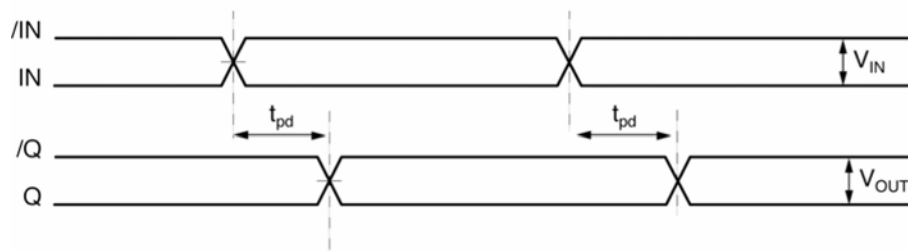


Figure 1a. Propagation Delay

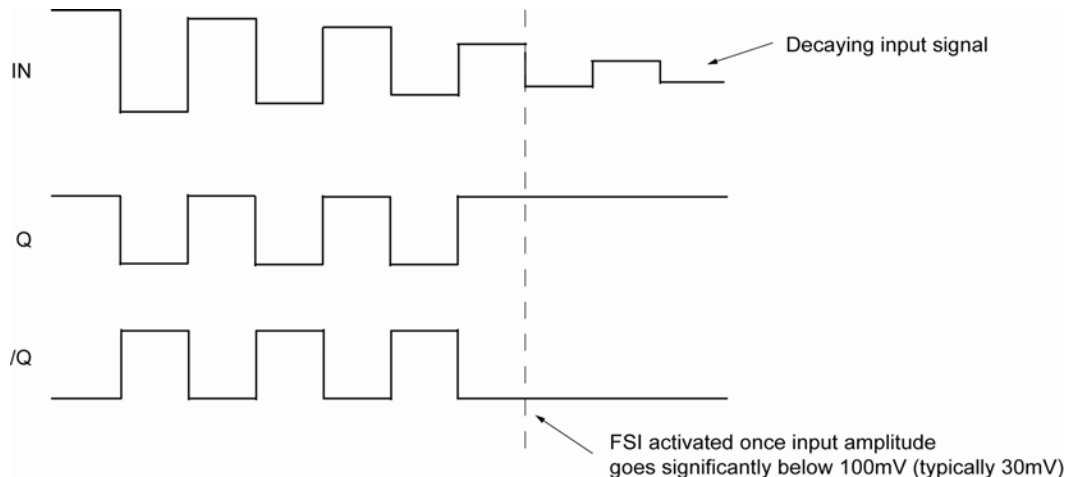
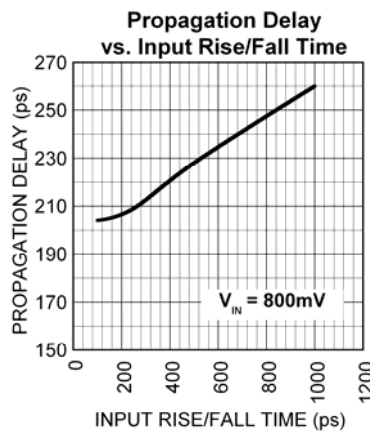
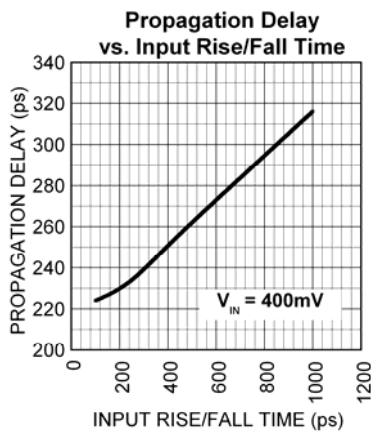
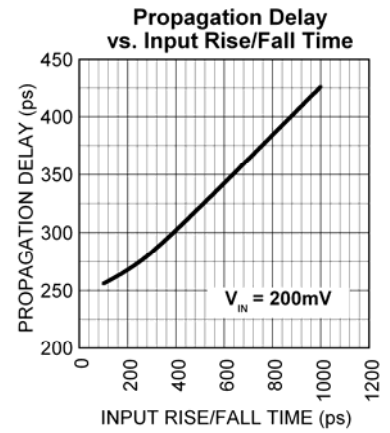
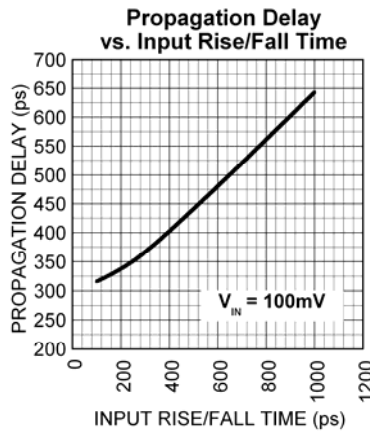
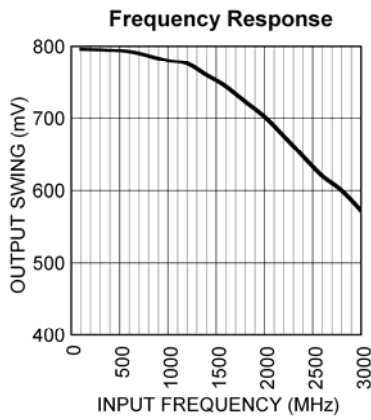


Figure 1b. Fail Safe Feature

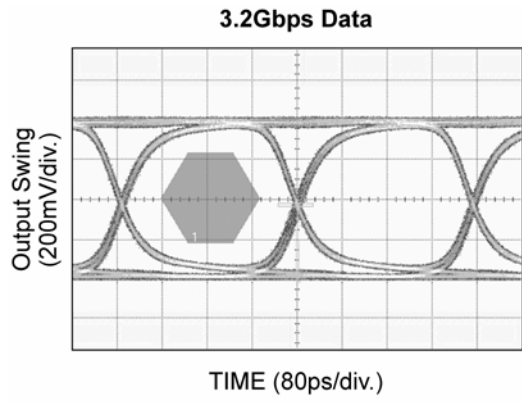
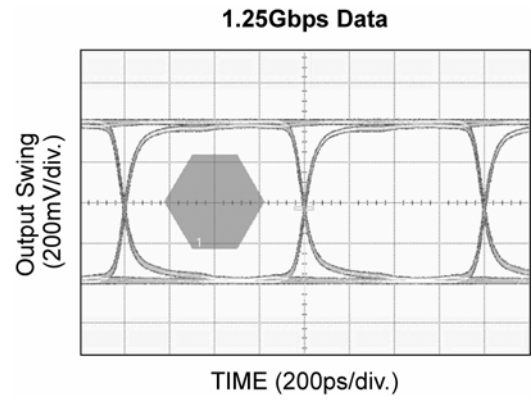
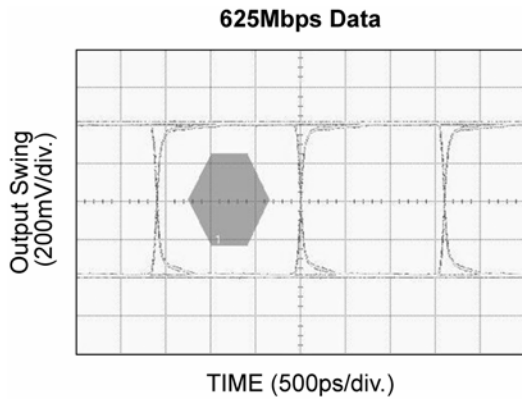
## Typical Characteristics

$V_{CC} = 3.3V$ ,  $GND = 0V$ ,  $V_{IN} = 100mV$ ,  $R_L = 50\Omega$  to  $V_{CC}-2V$ ,  $T_A = 25^\circ C$ , unless otherwise stated.



### Functional Characteristics

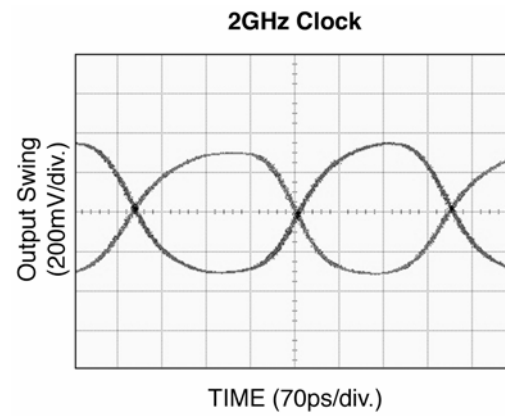
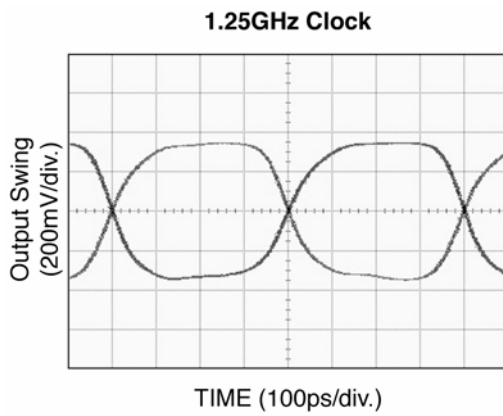
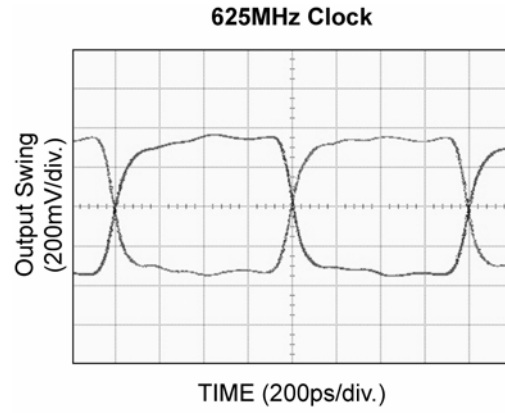
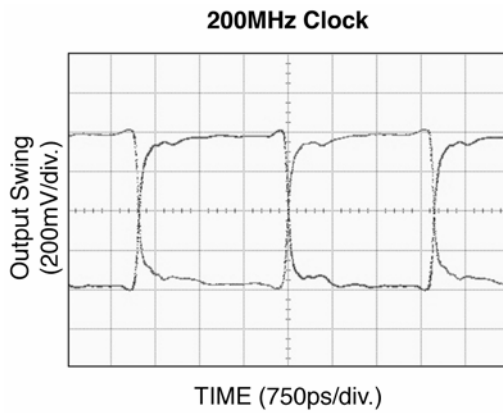
$V_{CC} = 3.3V$ ,  $GND = 0V$ ,  $V_{IN} = 400mV$ , Data Pattern:  $2^{23}-1$ ,  $R_L = 50\Omega$  to  $V_{CC}-2V$ ,  $T_A = 25^\circ C$ , unless otherwise stated.





### Functional Characteristics (continued)

$V_{CC} = 3.3V$ ,  $GND = 0V$ ,  $V_{IN} = 400mV$ ,  $R_L = 50\Omega$  to  $V_{CC}-2V$ ,  $T_A = 25^\circ C$ , unless otherwise stated.



### Input and Output Stage

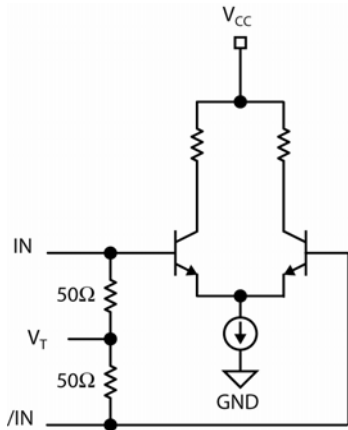


Figure 2a. Simplified Differential Input Buffer

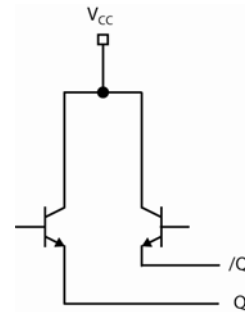


Figure 2b. Simplified LVPECL Output Buffer

### Single-Ended and Differential Swings



Figure 3a. Single-Ended Voltage Swing

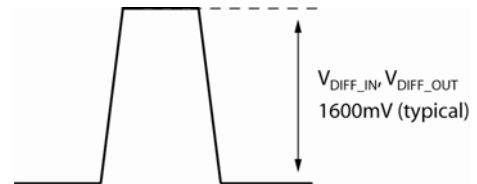
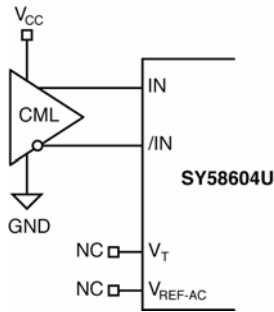


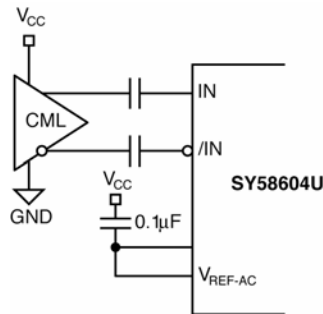
Figure 3b. Differential Voltage Swing

## Input Interface Applications

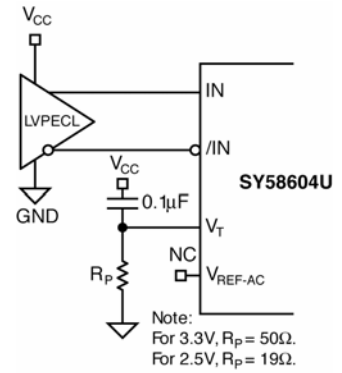


**Figure 4a. CML Interface (DC-Coupled)**

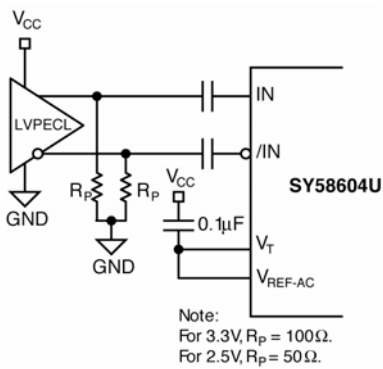
*Option: May connect  $V_T$  to  $V_{CC}$*



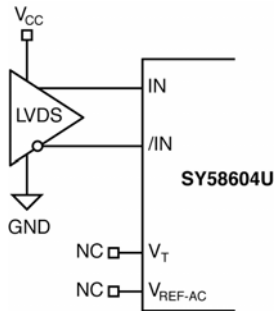
**Figure 4b. CML Interface (AC-Coupled)**



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



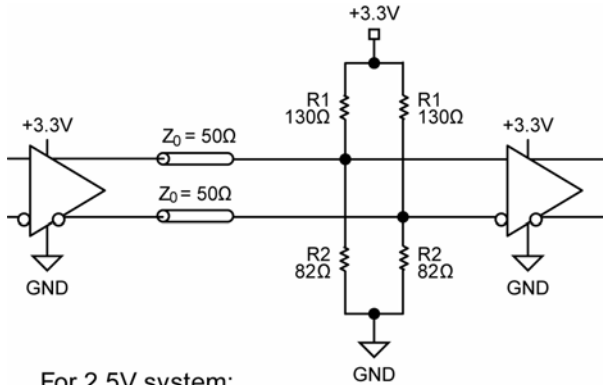
**Figure 4d. LVPECL Interface (AC-Coupled)**



**Figure 4e. LVDS Interface**

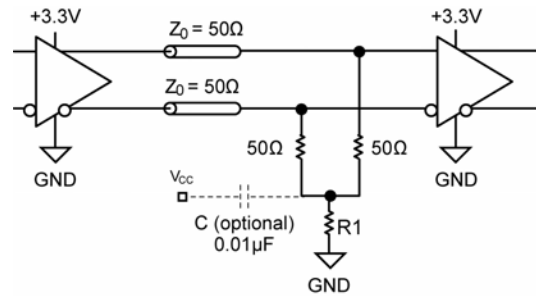
### LVPECL Output Termination

LVPECL outputs have very low output impedance (open emitter), and small signal swing which results in low EMI. LVPECL is ideal for driving 50Ω-and-100Ω-controlled impedance transmission lines. There are several techniques in terminating the LVPECL output, as shown in Figure 5a and 5b.



For 2.5V system:  
R1=250Ω, R2=62.5Ω

Figure 5a. Parallel Termination-Thevenin Equivalent



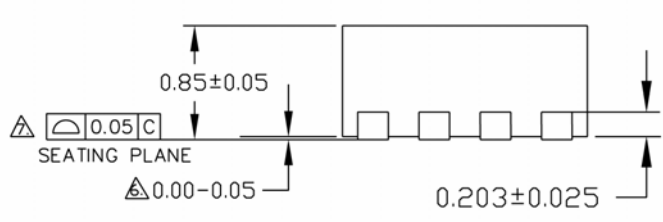
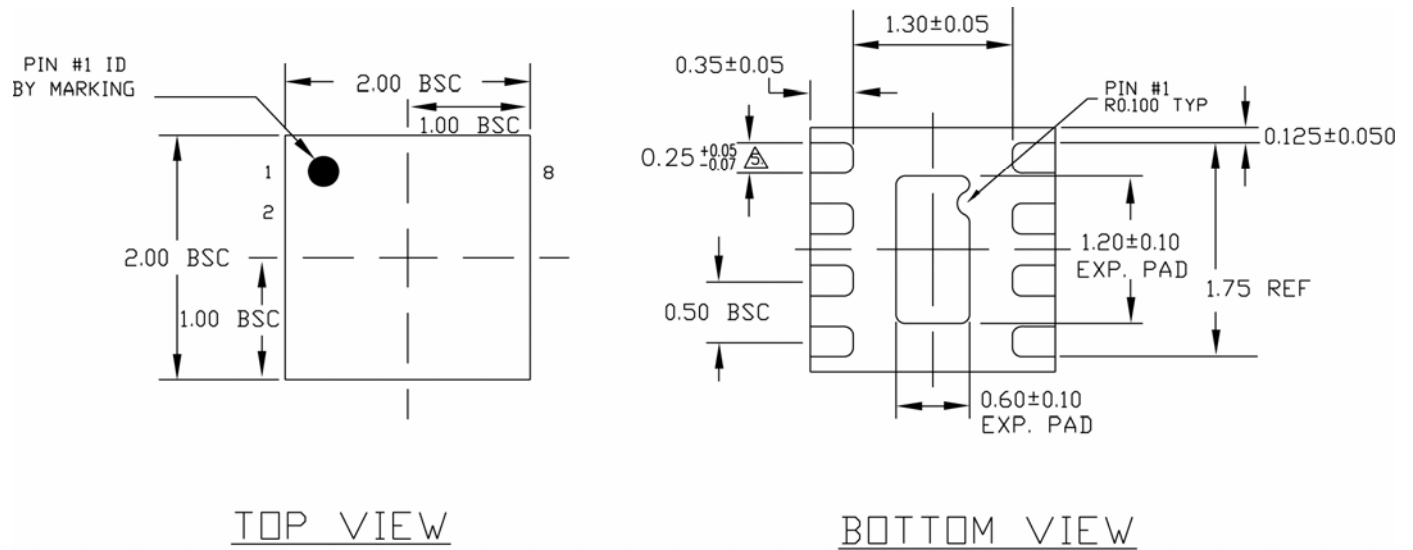
For 2.5V system: R1 = 19Ω.  
For 3.3V system: R1 = 50Ω.

Figure 5b. Three-Resistor “Y-Termination”

### Related Product and Support Documents

Part Number	Function	Data Sheet Link
SY58603U	4.25Gbps Precision CML Buffer with Internal Termination and Fail Safe Input	<a href="http://www.micrel.com/page.do?page=/product-info/products/sy58603u.shtml">http://www.micrel.com/page.do?page=/product-info/products/sy58603u.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/HBWolutions.shtml">http://www.micrel.com/page.do?page=/product-info/as/HBWolutions.shtml</a>

### Package Information



- 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.

Rev. B

SIDE VIEW

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

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