



# SY58609U

## 4.25Gbps Precision, CML 2:1 MUX with Internal Termination and Fail Safe Input

### General Description

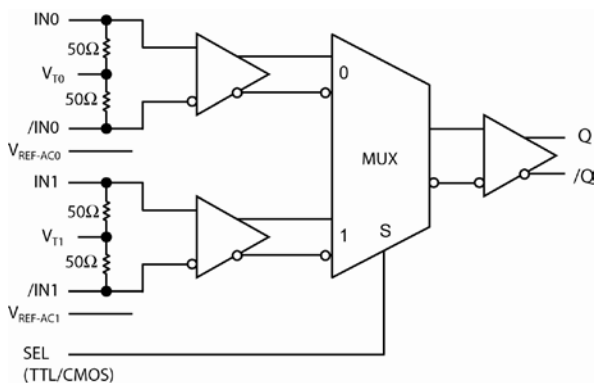
The SY58609U is a 2.5/3.3V, high-speed, fully differential CML 2:1 MUX capable of processing clock signals up to 2.5GHz and data patterns up to 4.25Gbps. The SY58609U is optimized to provide a buffered output of the selected input with less than 20ps of skew and less than 10ps<sub>pp</sub> total jitter.

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 reference voltage ( $V_{REF-AC}$ ) is provided to bias the  $V_T$  pin. The outputs are 400mV CML, with extremely fast rise/fall times guaranteed to be less than 90ps.

The SY58609U 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 Micrel's SY58610U and SY58611U, 2:1 MUX with 800mV and 325mV output swings, respectively. The SY58609U 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



United States Patent No. RE44,134

Precision Edge is a registered trademark of Micrel, Inc.



Precision Edge<sup>®</sup>

### Features

- Precision 400mV CML 2:1 MUX
- Guaranteed AC performance over temperature and voltage:
  - DC-to > 4.25Gbps throughput
  - <370ps propagation delay (IN-to-Q)
  - <90ps rise/fall times
- Fail Safe Input
  - Prevents outputs from oscillating when input is invalid
- Unique, patented MUX input isolation design minimizes adjacent channel crosstalk
- Ultra-low jitter design
  - <1ps<sub>RMS</sub> cycle-to-cycle jitter
  - <10ps<sub>SP</sub> total jitter
  - <1ps<sub>RMS</sub> random jitter
  - <10ps<sub>SP</sub> deterministic jitter
- High-speed CML outputs
- 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 16-pin (3mm x 3mm) QFN package

### Applications

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

### Markets

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

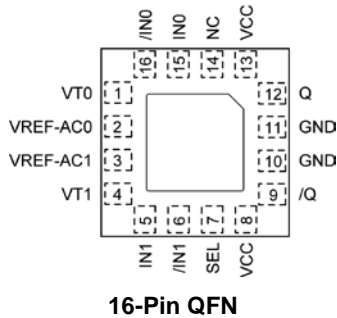
## Ordering Information<sup>(1)</sup>

Part Number	Package Type	Operating Range	Package Marking	Lead Finish
SY58609UMG	QFN-16	Industrial	609U with Pb-Free bar-line indicator	NiPdAu Pb-Free
SY58609UMGTR <sup>(2)</sup>	QFN-16	Industrial	609U with Pb-Free bar-line indicator	NiPdAu Pb-Free

**Notes:**

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

## Pin Configuration



## Truth Table

SEL	Output
0	IN0 Selected
1	IN1 Selected

## Pin Description

Pin Number	Pin Name	Pin Function
1, 4	VT0, VT1	Input Termination Center-Tap: Each side of the differential input pair terminates to the VT pin. This pin provides a center-tap to a termination network for maximum interface flexibility. See "Input Interface Applications" subsection.
2, 3	VREF-AC0, VREF-AC1	Reference Voltage: These outputs bias to $V_{CC}-1.2\text{V}$ . They are used for AC-coupling inputs IN and /IN. Connect VREF-AC directly to the corresponding VT pin. Bypass with $0.01\mu\text{F}$ low ESR capacitor to VCC. Due to limited drive capability, the VREF-AC pin is only intended to drive its respective VT pin. Maximum sink/source current is $\pm 0.5\text{mA}$ . See "Input Interface Applications" subsection.
5, 6 15, 16	IN1, /IN1 IN0, /IN0	Differential Inputs: These input pairs are the differential signal inputs to the device. Inputs accept DC-Coupled differential signals as small as $100\text{mV}$ ( $200\text{mVpp}$ ). Each pin of the pairs internally terminates with $50\Omega$ to the VT pin. If the input swing falls below a certain threshold (typical $30\text{mV}$ ), 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.
7	SEL	Single-Ended Input: This single-ended TTL/CMOS-compatible input selects the inputs to the multiplexer. Note that this input is internally connected to a $25\text{k}\Omega$ pull-up resistor and will default to logic HIGH state if left open. The input-switching threshold is $V_{CC}/2$ .
8, 13	VCC	Positive Power Supply: Bypass with $0.1\mu\text{F}/0.01\mu\text{F}$ low ESR capacitors as close to the VCC pins as possible.
9, 12	/Q, Q	CML Differential Output Pair: Differential buffered output copy of the selected input signal. The output swing is typically $400\text{mV}$ . Normally terminate with $100\Omega$ across Q and /Q. Unused output pair may be left floating with no impact on jitter. See "CML Output Termination" subsection.
10, 11	GND	Ground. Exposed pad must be connected to a ground plane that is the same potential as the ground pins.
14	NC	No connect.

**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>	.....	$\pm 0.5mA$
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 ( $V_{CC}$ )	.....	+2.375V to +3.60V
Ambient Temperature ( $T_A$ )	.....	-40°C to +85°C
Package Thermal Resistance <sup>(3)</sup>		
QFN		
Still-air ( $\theta_{JA}$ )	.....	60°C/W
Junction-to-board ( $\psi_{JB}$ )	.....	33°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. $V_{CC}$		50	60	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, $/I_N$	0.2		$V_{IH}-0.1$	V
$V_{IN}$	Input Voltage Swing (IN, $/I_N$ )	see Figure 3a, Note 6	0.1		1.0	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
$V_{REF-AC}$	AC Reference Voltage		$V_{CC}-1.3$		$V_{CC}-1.0$	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 Outputs DC Electrical Characteristics<sup>(7)</sup>

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

## LVTTL/CMOS DC Electrical Characteristics<sup>(7)</sup>

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

Symbol	Parameter	Condition	Min	Typ	Max	Units
$V_{IH}$	Input HIGH Voltage		2.0			V
$V_{IL}$	Input LOW Voltage				0.8	V
$I_{IH}$	Input HIGH Current		-125		30	$\mu A$
$I_{IL}$	Input LOW Current		-300			$\mu A$

### Notes:

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

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

$V_{CC} = +2.5V \pm 5\%$  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	$V_{IN}: 100mV-200mV$	180	330	450	ps
		$V_{IN}: >200mV$	140	270	370	ps
	SEL-to-Q		150		450	ps
$t_{Skew}$	Input-to-Input Skew	Note 9, 10		5	20	ps
	Part-to-Part Skew	Note 11			150	ps
$t_{Jitter}$	Data Random Jitter	Note 12			1	ps <sub>RMS</sub>
	Deterministic Jitter	Note 13			10	ps <sub>PP</sub>
	Clock Cycle-to-Cycle Jitter	Note 14			1	ps <sub>RMS</sub>
	Total Jitter	Note 15			10	ps <sub>PP</sub>
$t_R, t_F$	Output Rise/Fall Times (20% to 80%)	At full output swing.	35	50	90	ps
	Duty Cycle	Differential I/O	47		53	%

### Notes:

8. High-frequency AC-parameters are guaranteed by design and characterization.
9. Input-to-Input skew is the time difference between the two inputs and one output, under identical input transitions.
9. Input-to-Input Skew is included in IN-to-Q propagation delay.
11. Part-to-part skew is defined for two parts with identical power supply voltages at the same temperature, same transition edge, and no skew at the edges at the respective inputs.
12. Random jitter is measured with a K28.7 pattern, measured at  $\leq f_{MAX}$ .
13. Deterministic jitter is measured at 2.5Gbps with both K28.5 and  $2^{23}-1$  PRBS pattern.
14. 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.
15. 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 outputs when there is no input signal present, or when the amplitude of the input signal drops sufficiently below  $100\text{mV}_{PK}$  ( $200\text{mV}_{PP}$ ), typically  $30\text{mV}_{PK}$ . Maximum frequency of the SY58609U 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

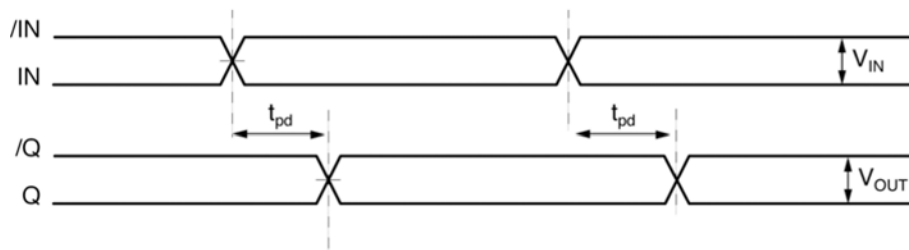


Figure 1a. Propagation Delay

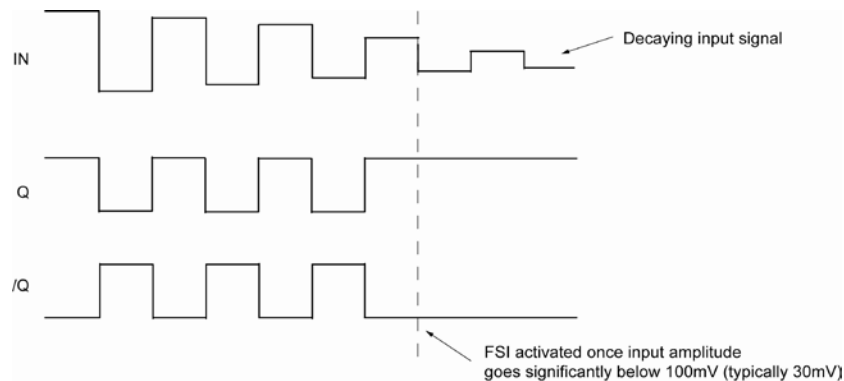


Figure 1b. Fail Safe Feature

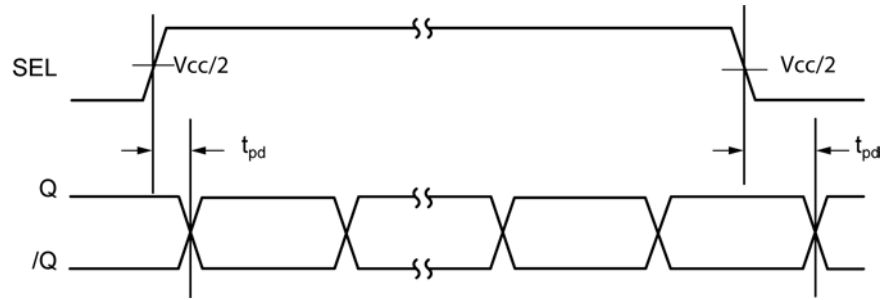
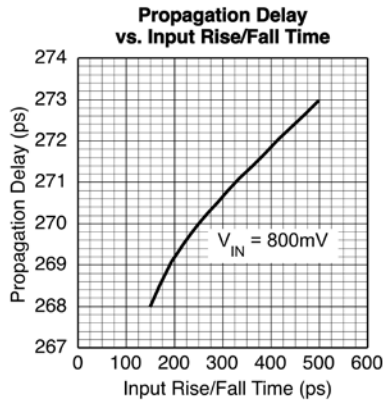
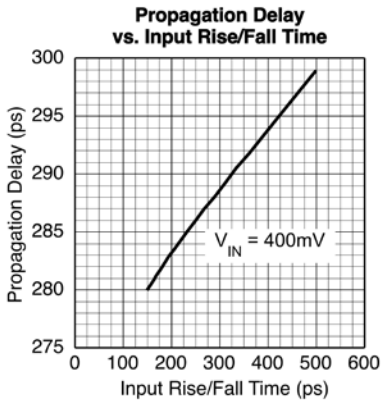
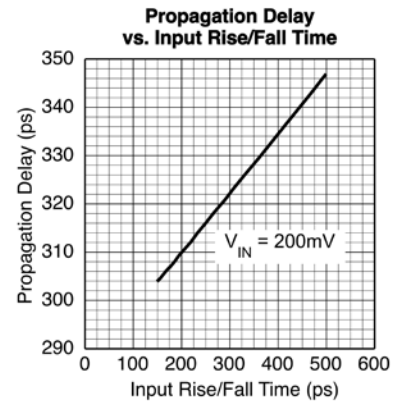
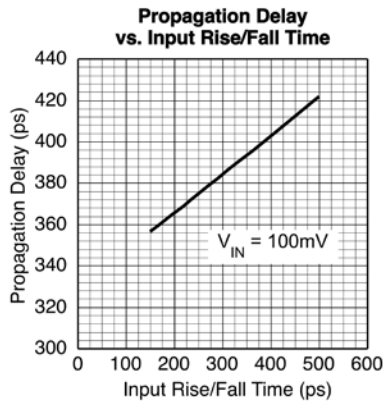
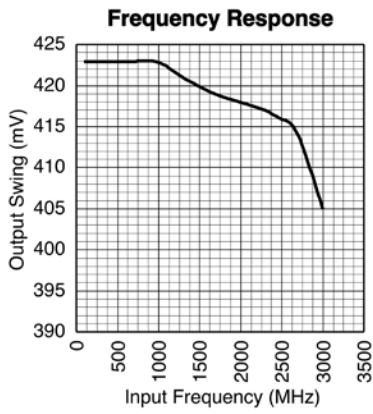


Figure 1c. SEL-to-Q Delay

### Typical Characteristics

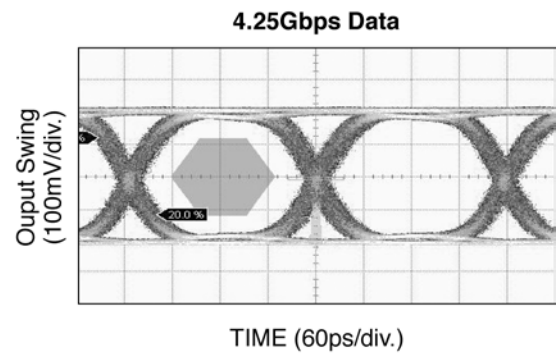
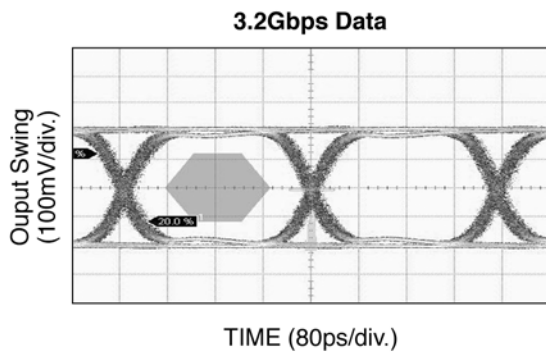
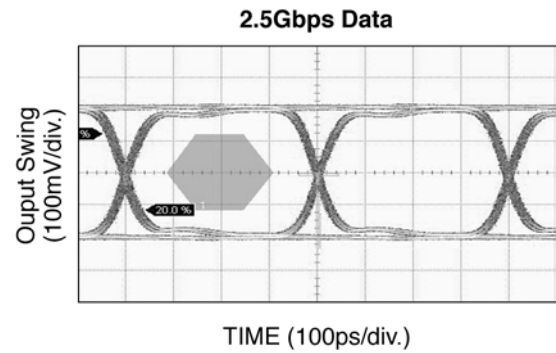
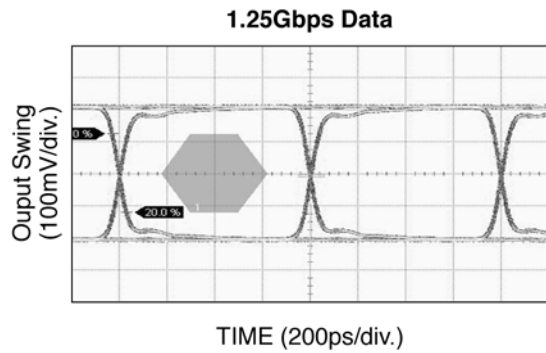
$V_{CC} = 2.5V$ ,  $GND = 0V$ ,  $V_{IN} = 100mV$ ,  $R_L = 100\Omega$  across the outputs,  $T_A = 25^\circ C$ , unless otherwise stated.





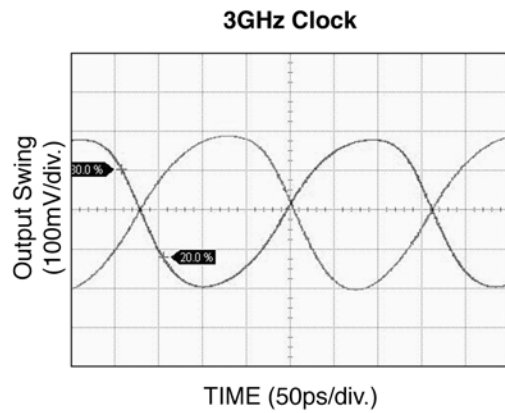
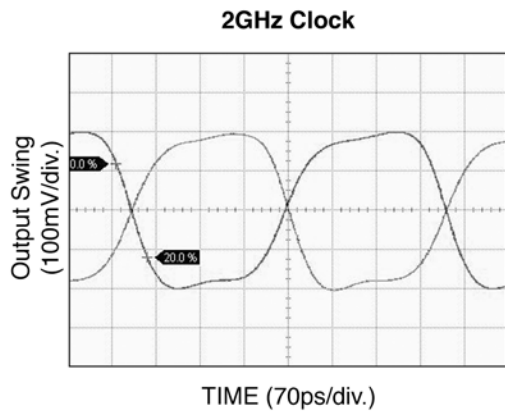
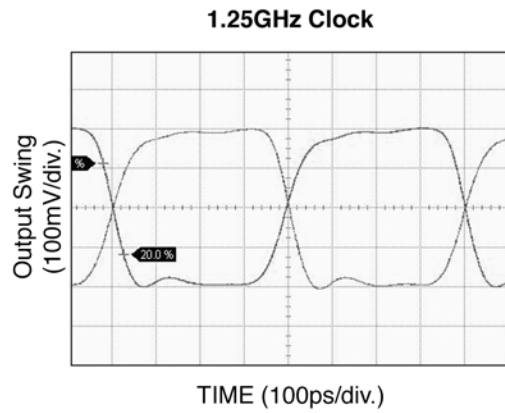
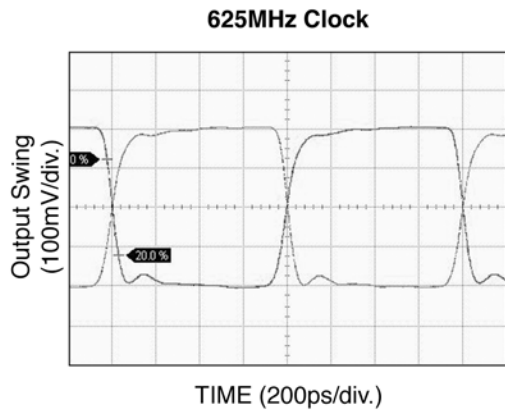
### Functional Characteristics

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



### Functional Characteristics

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



## Input and Output Stage

## Single-Ended and Differential Swings

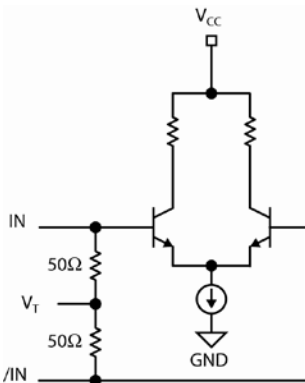


Figure 2a. Simplified Differential Input Buffer

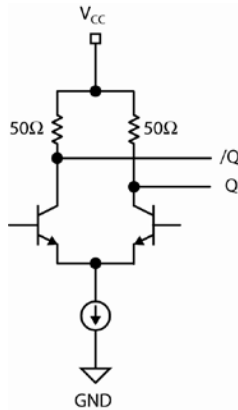


Figure 2b. Simplified CML Output Buffer



Figure 3a. Single-Ended Voltage Swing

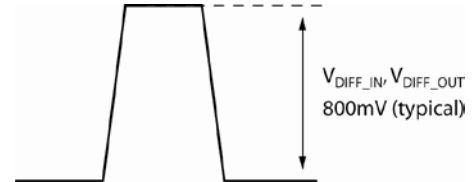
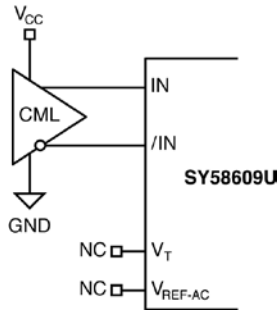


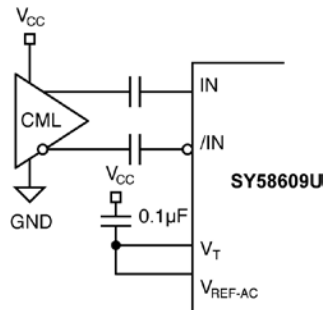
Figure 3b. Differential Voltage Swing

## Input Interface Applications

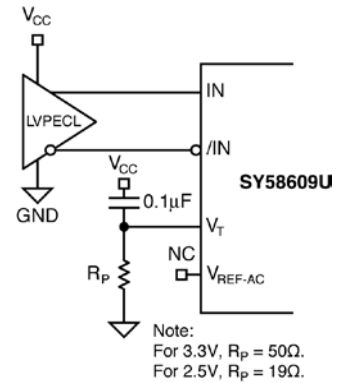


**Figure 4a. CML Interface (DC-Coupled)**

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

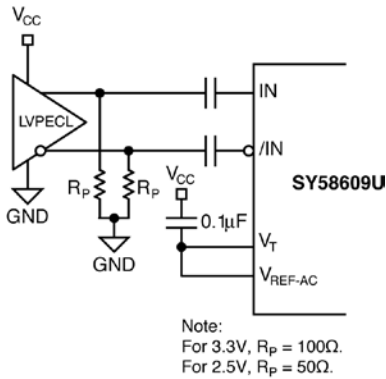


**Figure 4b. CML Interface (AC-Coupled)**



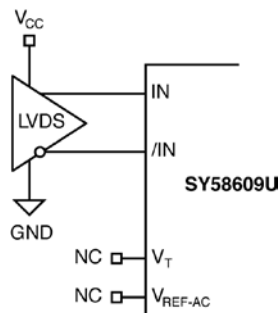
**Figure 4c. LVPECL Interface (DC-Coupled)**

Note:  
For 3.3V,  $R_p = 50\Omega$ .  
For 2.5V,  $R_p = 19\Omega$ .



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

Note:  
For 3.3V,  $R_p = 100\Omega$ .  
For 2.5V,  $R_p = 50\Omega$ .



**Figure 4e. LVDS Interface**

## CML Output Termination

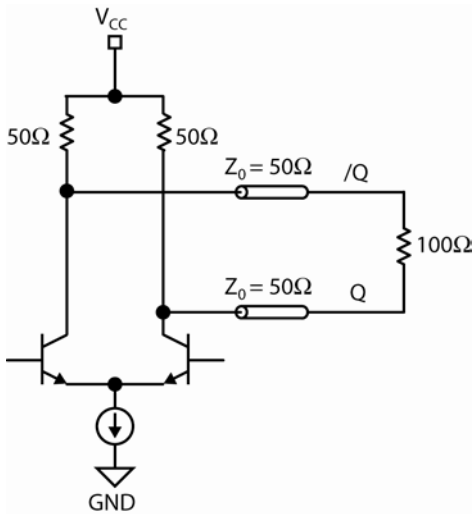


Figure 5a. CML DC-Coupled Termination

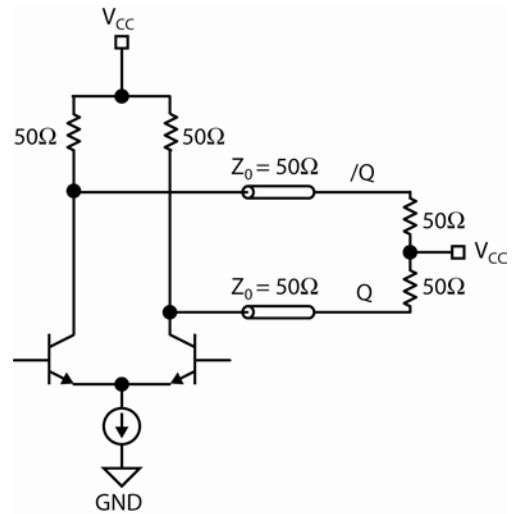


Figure 5b. CML DC-Coupled Termination

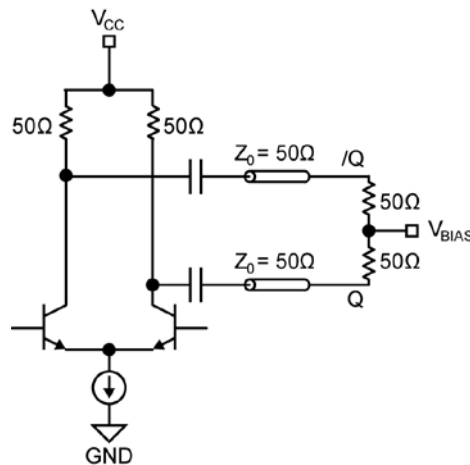
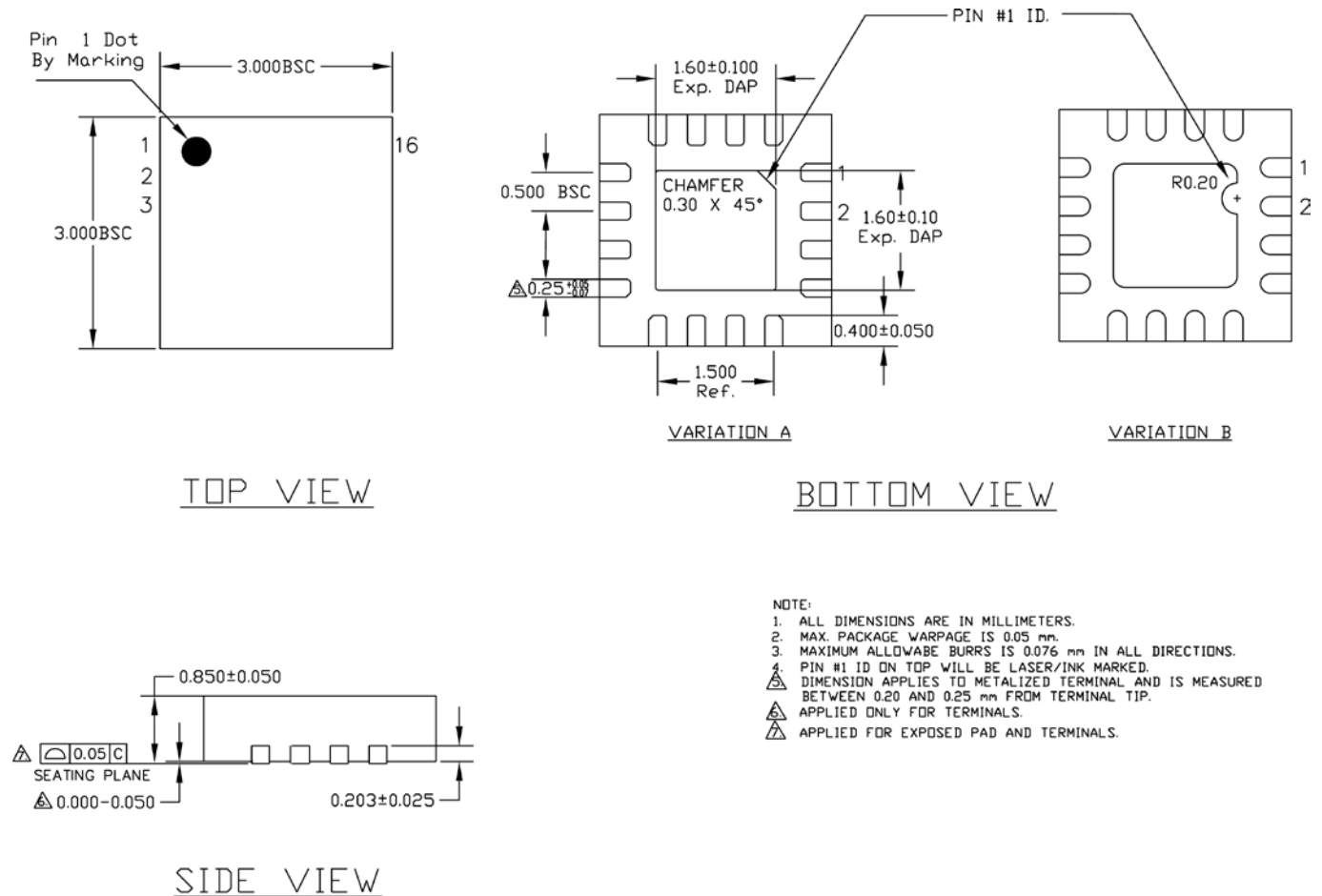


Figure 5c. CML AC-Coupled Termination

## Related Product and Support Documents

Part Number	Function	Datasheet Link
SY58610U	3.2Gbps Precision, LVPECL 2:1 MUX with Internal Termination and Fail Safe Input	<a href="http://www.micrel.com/_PDF/HBW/sy58610u.pdf">http://www.micrel.com/_PDF/HBW/sy58610u.pdf</a>
SY58611U	3.2Gbps Precision, LVDS 2:1 MUX with Internal Termination and Fail Safe Input	<a href="http://www.micrel.com/_PDF/HBW/sy58611u.pdf">http://www.micrel.com/_PDF/HBW/sy58611u.pdf</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



16-Pin (3mm x 3mm) QFN

**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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