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**SY54016R**


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**Low Voltage 1.2V/1.8V CML Differential Line Driver/Receiver with Fail Safe Input**  
**3.2Gbps, 2.5GHz**


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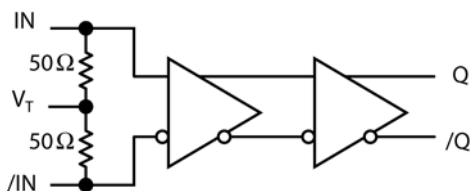
**General Description**

The SY54016R is a fully differential, low voltage 1.2V/1.8V CML Line Driver/Receiver with Fail-Safe Input. The SY54016R 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, 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 internal voltage reference is provided to bias the V<sub>T</sub> pin. The outputs are CML, with extremely fast rise/fall times guaranteed to be less than 95ps.

The SY54016R operates from a 2.5V ±5% core supply and a 1.8V or 1.2V ±5% output supply and is guaranteed over the full industrial temperature range (–40°C to +85°C). The SY54016R 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****Precision Edge<sup>®</sup>****Features**

- 1.2V/1.8V CML Line Driver/Receiver with Fail-Safe Input
- Guaranteed AC performance over temperature and voltage:
  - DC-to- > 3.2Gbps throughput
  - <370ps propagation delay (IN-to-Q)
  - <95ps rise/fall times
- Ultra-low jitter design
  - <1ps<sub>RMS</sub> random jitter
- High-speed CML outputs
- 2.5V ±5% , 1.8/1.2V ±5% power supply operation
- Industrial temperature range: –40°C to +85°C
- Available in 8-pin (2mm x 2mm) MLF<sup>®</sup> package

**Applications**

- Data Distribution: OC-48, OC-48+FEC
- 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
- Metro area network equipment

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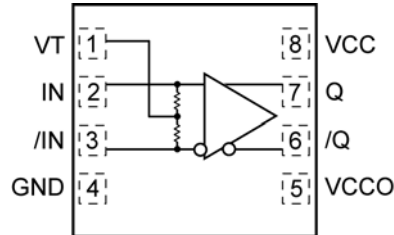
## Ordering Information<sup>(1)</sup>

Part Number	Package Type	Operating Range	Package Marking	Lead Finish
SY54016RMGTR <sup>(2)</sup>	MLF-8	Industrial	016R 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



8-Pin MLF<sup>®</sup> (MLF-8)

## Pin Description

Pin Number	Pin Name	Pin Function
2,3	IN, /IN	Differential Input: This input pair is the differential signal input to the device. Input accepts differential signals as small as 100mV (200mV <sub>PP</sub> ). Each input pin 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.
1	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. An internal high impedance resistor divider biases VT to allow input AC coupling. For AC-coupling, bypass VT with 0.1μF low ESR capacitor to VCC. See "Interface Applications" subsection and Figure 2a.
8	VCC	Positive Power Supply: Bypass with 0.1uF//0.01uF low ESR capacitors as close to the V <sub>CC</sub> pin as possible. Supplies input and core circuitry.
5	VCCO	Output Supply: Bypass with 0.1uF//0.01uF low ESR capacitors as close to the V <sub>CCO</sub> pin as possible. Supplies the output buffer.
4	GND, Exposed pad	Ground: Exposed pad must be connected to a ground plane that is the same potential as the ground pin.
7,6	Q, /Q	CML Differential Output Pair: Differential buffered copy of the input signal. The output swing is typically 390mV. See "Interface Applications" subsection for termination information.

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

Supply Voltage ( $V_{CC}$ ) ..... -0.5V to +3.0V  
 Supply Voltage ( $V_{CCO}$ ) ..... -0.5V to +2.7V  
 $V_{CC} - V_{CCO}$  ..... <1.8V  
 $V_{CCO} - V_{CC}$  ..... <0.5V  
 Input Voltage ( $V_{IN}$ ) ..... -0.5V to  $V_{CC}$   
 CML Output Voltage ( $V_{OUT}$ ) ..... 0.6V to  $V_{CCO}+0.5V$   
 Current ( $V_T$ )  
     Source or sink current on  $V_T$  pin .....  $\pm 100mA$   
 Input Current  
     Source or sink current on (IN, /IN) .....  $\pm 50mA$   
 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 2.625V  
 ( $V_{CCO}$ ) ..... 1.14V to 1.9V  
 Ambient Temperature ( $T_A$ ) ..... -40°C to +85°C  
 Package Thermal Resistance<sup>(3)</sup>  
 MLF<sup>®</sup>  
     Still-air ( $\theta_{JA}$ ) ..... 93°C/W  
     Junction-to-board ( $\theta_{JB}$ ) ..... 56°C/W

### DC Electrical Characteristics<sup>(4)</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	$V_{CC}$	2.375	2.5	2.625	V
		$V_{CCO}$	1.14	1.2	1.26	V
		$V_{CCO}$	1.7	1.8	1.9	V
$I_{CC}$	Power Supply Current	Max. $V_{CC}$		13	19	mA
$I_{CCO}$	Power Supply Current	No Load. Max. $V_{CCO}$		16	21	mA
$R_{IN}$	Input Resistance (IN-to- $V_T$ , /IN-to- $V_T$ )		45	50	55	$\Omega$
$R_{DIFF\_IN}$	Differential Input Resistance (IN-to-/IN)		90	100	110	$\Omega$
$V_{IH}$	Input HIGH Voltage (IN, /IN)	IN, /IN	1.2		$V_{CC}$	V
$V_{IL}$	Input LOW Voltage (IN, /IN)	$V_{IL}$ with $V_{IH} = 1.2V$	0.2		$V_{IH}-0.1$	V
$V_{IH}$	Input HIGH Voltage (IN, /IN)	IN, /IN	1.14		$V_{CC}$	V
$V_{IL}$	Input LOW Voltage (IN, /IN)	$V_{IL}$ with $V_{IH} = 1.14V, (1.2V-5\%)$	0.66		$V_{IH}-0.1$	V
$V_{IN}$	Input Voltage Swing (IN, /IN)	see Figure 3a	0.1		1.0	V
$V_{DIFF\_IN}$	Differential Input Voltage Swing ( IN - /IN )	see Figure 3b	0.2		2.0	V
$V_{IN\_FSI}$	Input Voltage Threshold that Triggers FSI			30	100	mV
$V_{T\_IN}$	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. The circuit is designed to meet the DC specifications shown in the above table after thermal equilibrium has been established.

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

$V_{CC0} = 1.14V$  to  $1.26V$   $R_L = 50\Omega$  to  $V_{CC0}$ ,

$V_{CC0} = 1.7V$  to  $1.9V$ ,  $R_L = 50\Omega$  to  $V_{CC0}$  or  $100\Omega$  across the outputs,

$V_{CC} = 2.375V$  to  $2.625V$ .  $T_A = -40^\circ C$  to  $+85^\circ C$ , unless otherwise stated.

Symbol	Parameter	Condition	Min	Typ	Max	Units
$V_{OH}$	Output HIGH Voltage	$R_L = 50\Omega$ to $V_{CC0}$	$V_{CC0}-0.020$	$V_{CC0}-0.010$	$V_{CC0}$	V
$V_{OUT}$	Output Voltage Swing	See Figure 3a	300	390	475	mV
$V_{DIFF\_OUT}$	Differential Output Voltage Swing	See Figure 3b	600	780	950	mV
$R_{OUT}$	Output Source Impedance		45	50	55	$\Omega$

### Note:

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

## AC Electrical Characteristics

$V_{CC0} = 1.14V$  to  $1.26V$   $R_L = 50\Omega$  to  $V_{CC0}$ ,

$V_{CC0} = 1.7V$  to  $1.9V$ ,  $R_L = 50\Omega$  to  $V_{CC0}$  or  $100\Omega$  across the outputs,

$V_{CC} = 2.375V$  to  $2.625V$ .  $T_A = -40^\circ C$  to  $+85^\circ C$ , unless otherwise stated.

Symbol	Parameter	Condition	Min	Typ	Max	Units
$f_{MAX}$	Maximum Frequency	NRZ Data	3.2			Gbps
		$V_{OUT} > 200mV$ Clock	2.5			GHz
$t_{PD}$	Propagation Delay IN-to-Q	$V_{IN}: 100mV-200mV$ , Note 6, Figure 1a	180	300	420	ps
		$V_{IN}: >200mV$ , Note 6, Figure 1a	170	250	370	ps
$t_{Skew}$	Part-to-Part Skew	Note 7			75	ps
$t_{Jitter}$	Random Jitter				1	$\mu s_{RMS}$
$t_R$ $t_F$	Output Rise/Fall Times (20% to 80%)	At full output swing.	30	60	95	ps
	Duty Cycle	Differential I/O	47		53	%

### Notes:

- Propagation delay is measured with input  $t_r/t_f \leq 300ps$  (20% to 80%).
- 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.  $V_{IN} > 200mV$  with input  $t_r/t_f \leq 300ps$  (20% to 80%).

## 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  $100\text{mV}_{\text{PK}}$  ( $200\text{mV}_{\text{PP}}$ ), typically  $30\text{mV}_{\text{PK}}$ . Maximum frequency of the SY54016R 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 close to the FSI threshold. 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

## Interface Applications

For Input Interface Applications see Figures 4a-f and for CML Output Termination see Figures 5a-d.

### CML Output Termination with VCCO 1.2V

For VCCO of 1.2V, Figure 5a, terminate the output with  $50\Omega$ -to-1.2V, DC-coupled, not  $100\Omega$  differentially across the outputs.

If AC-coupling is used, Figure 5d, terminate into  $50\Omega$ -to-1.2V before the coupling capacitor and then connect to a high value resistor to a reference voltage.

Do not AC couple with internally terminated receiver. For example,  $50\Omega$  ANY-IN input. AC-coupling will offset the output voltage by 200mV and this offset voltage will be too low for proper driver operation.

### CML Output Termination with VCCO 1.8V

For VCCO of 1.8V, Figure 5a and Figure b, terminate with either  $50\Omega$  to 1.8V or  $100\Omega$  differentially across the outputs. AC- or DC-coupling is fine.

### Input AC-Coupling

The SY54016R input can accept AC-coupling from any driver. Tie VT to VCC with a capacitor as shown in Figures 4c and 4d. VT has an internal high impedance resistor divider as shown in Figure 2a, to provide a bias voltage for AC-coupling.

## Timing Diagrams

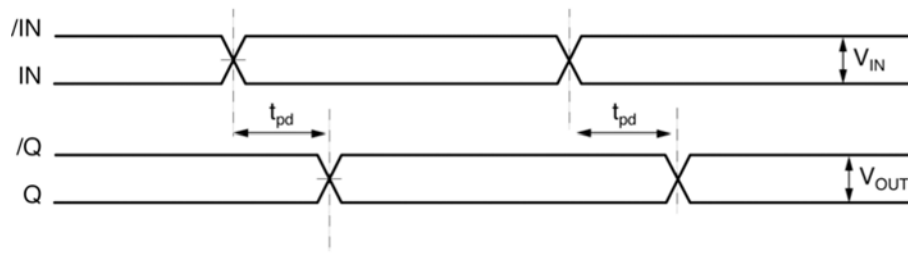


Figure 1a. Propagation Delay

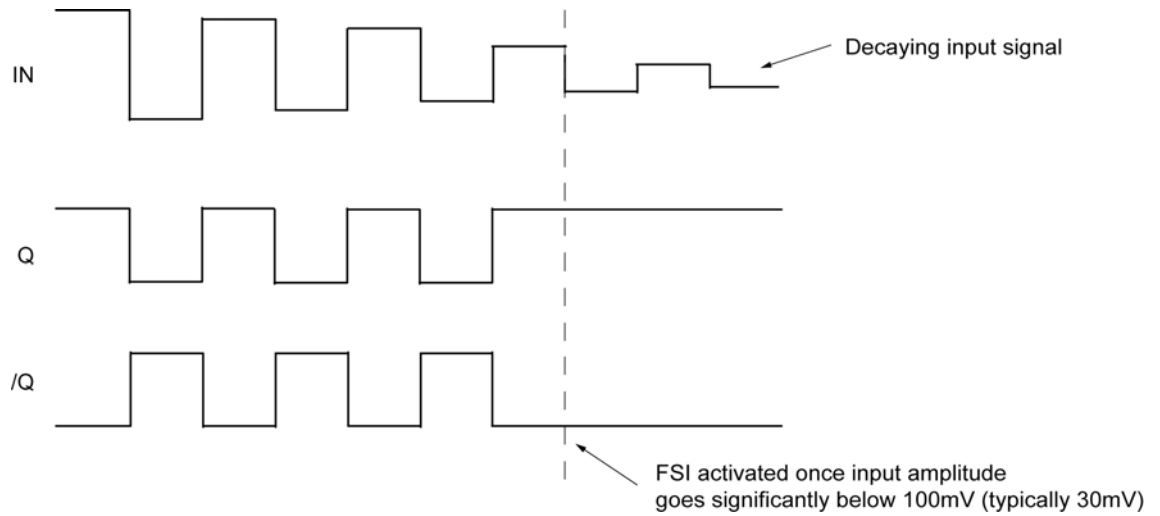
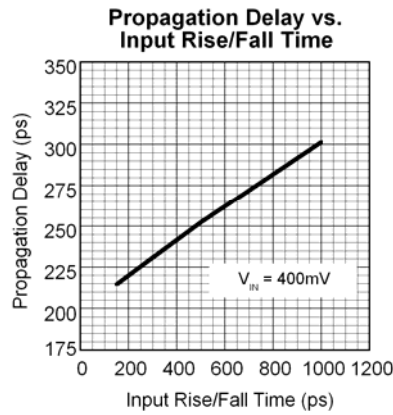
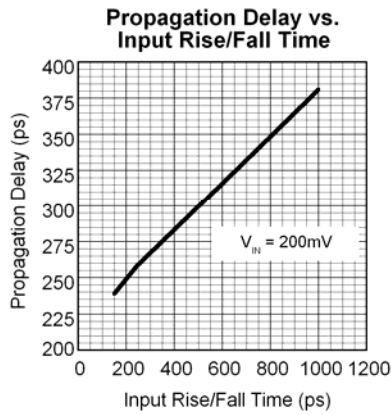
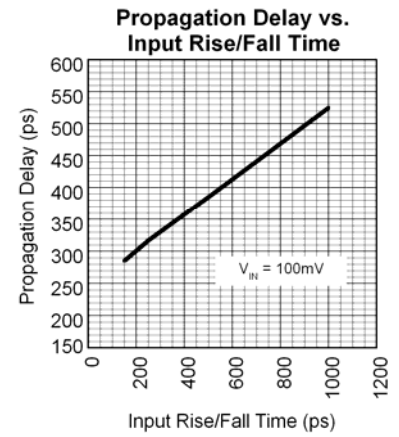
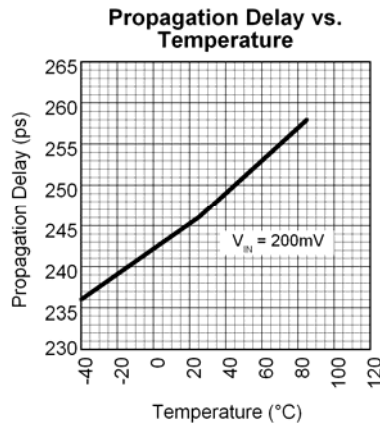
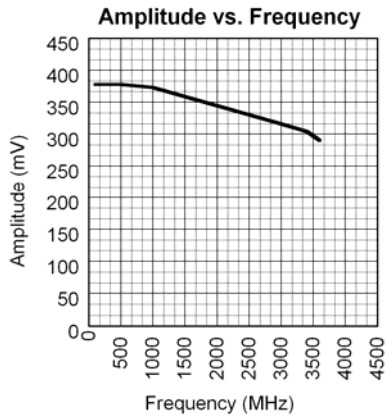


Figure 1b. Fail-Safe Feature

## Typical Characteristics

$V_{CC} = 2.5V$ ,  $GND = 0V$ ,  $R_L = 50\Omega$  to  $1.2V$ ,  $V_{IN} = 100mV$ ,  $T_A = 25^\circ C$ , unless otherwise stated.



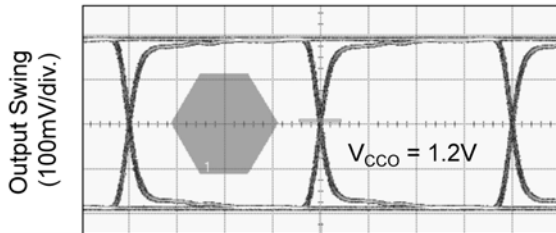


### Functional Characteristics

$V_{CC} = 2.5V$ ,  $GND = 0V$ ,  $V_{IN} = 400mV$ ,  $R_L = 50\Omega$  to  $V_{CCO}$ , Data Pattern:  $2^{23}-1$ ,  $T_A = 25^\circ C$ , unless otherwise stated.

**Output Eyes with  $V_{CCO} = 1.2V$**

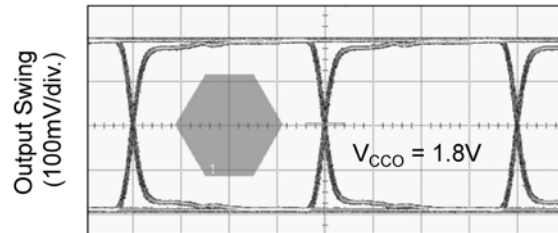
**1.25Gbps Data**



TIME (200ps/div.)

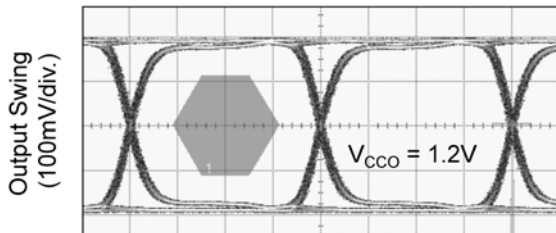
**Output Eyes with  $V_{CCO} = 1.8V$**

**1.25Gbps Data**



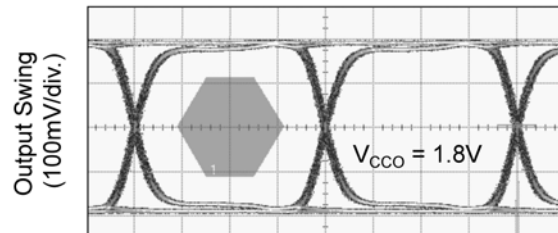
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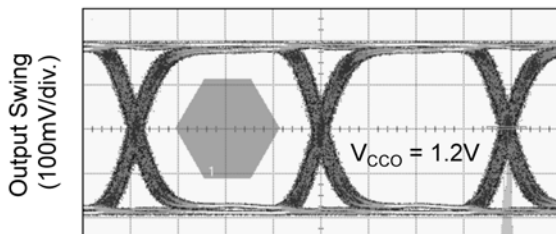
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**2.5Gbps Data**



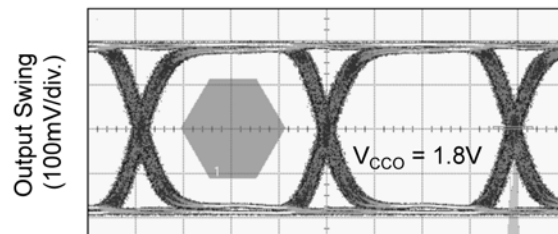
TIME (100ps/div.)

**3.2Gbps Data**



TIME (80ps/div.)

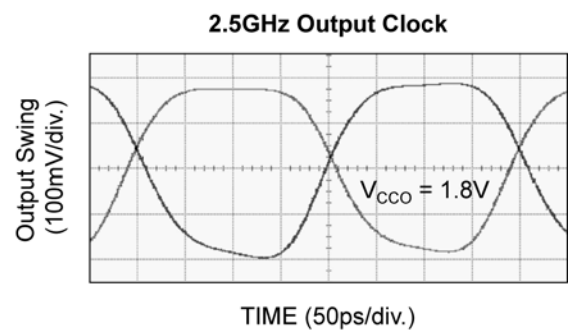
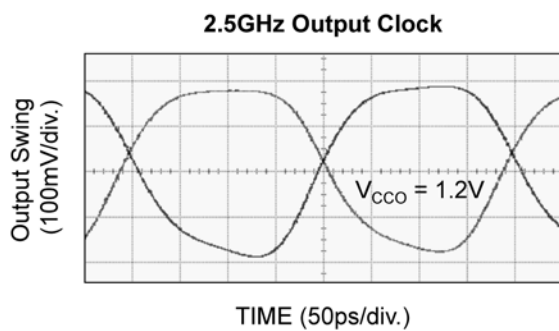
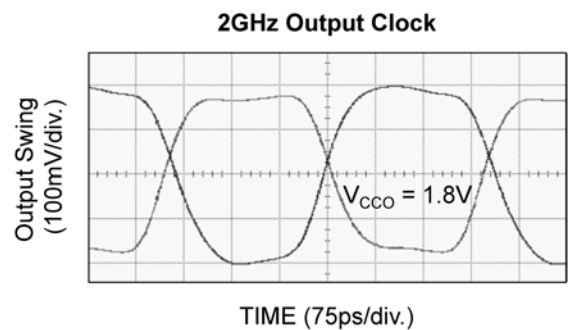
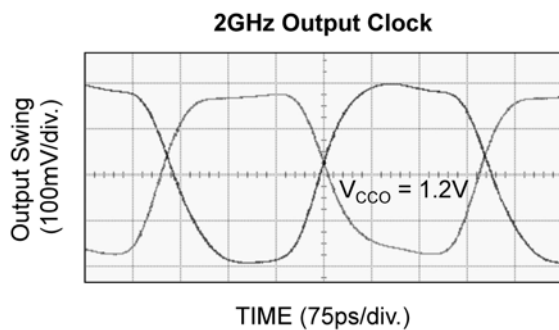
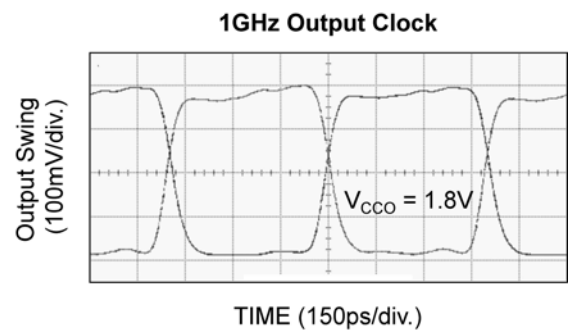
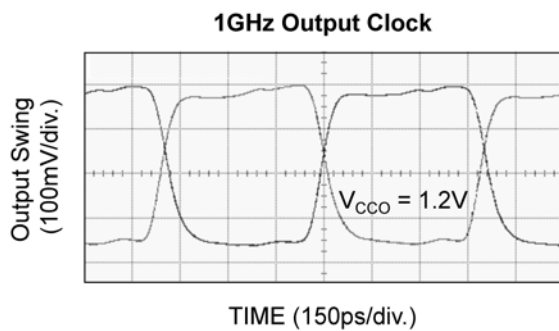
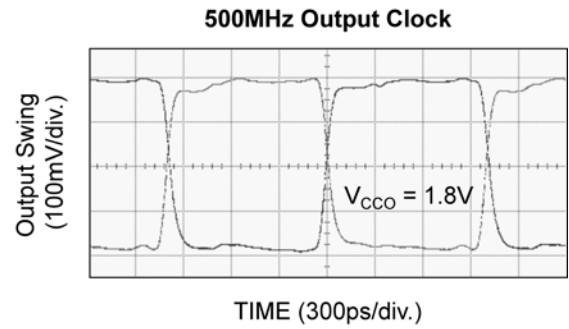
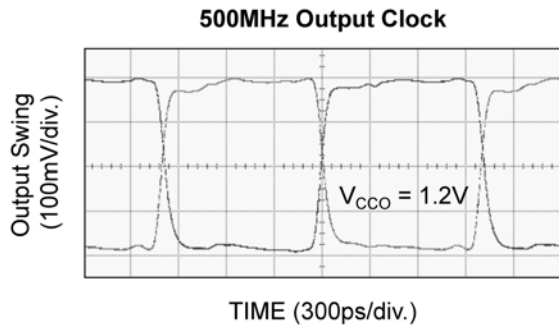
**3.2Gbps Data**



TIME (80ps/div.)

### Functional Characteristics

$V_{CC} = 2.5V$ ,  $GND = 0V$ ,  $V_{IN} = 400mV$ ,  $R_L = 50\Omega$  to  $V_{CCO}$ ,  $T_A = 25^\circ C$ , unless otherwise stated.



## Input and Output Stage

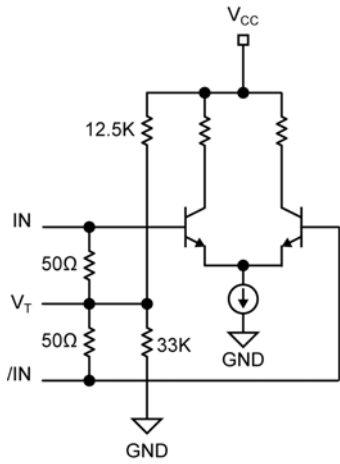


Figure 2a. Simplified Differential Input Buffer

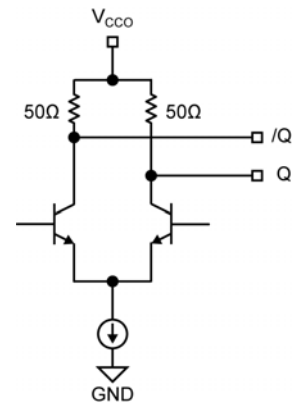


Figure 2b. Simplified CML Output Buffer

## Single-Ended and Differential Swings



Figure 3a. Single-Ended Swing

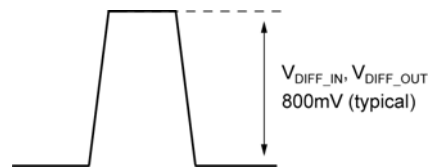
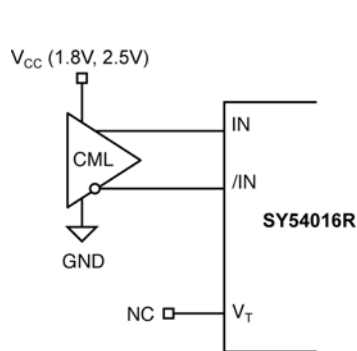
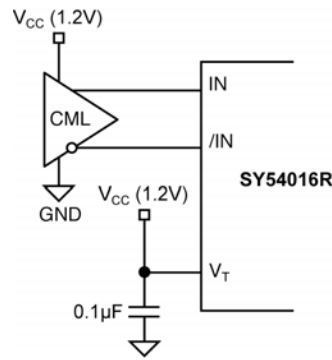


Figure 3b. Differential Swing

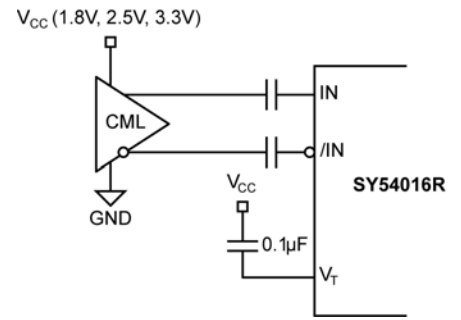
## Input Interface Applications



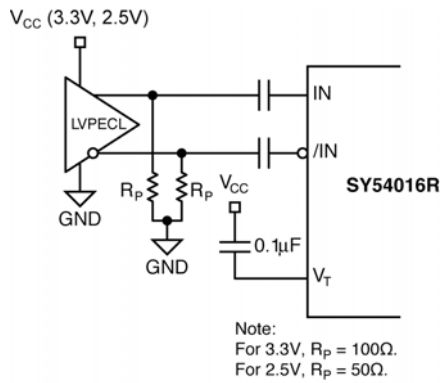
**Figure 4a. CML Interface (DC-Coupled, 1.8V, 2.5V)**



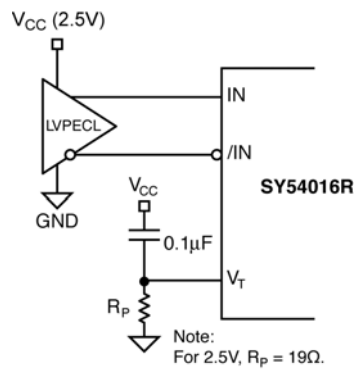
**Figure 4b. CML Interface (DC-Coupled, 1.2V)**



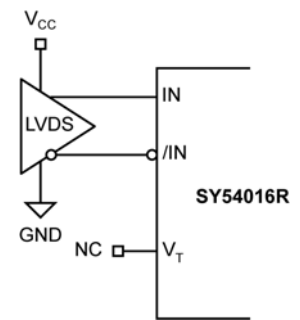
**Figure 4c. CML Interface (AC-Coupled)**



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



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



**Figure 4f. LVDS Interface**

### CML Output Termination

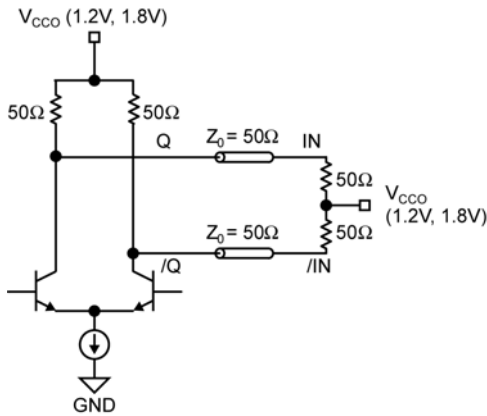


Figure 5a. 1.2 or 1.8V CML DC-Coupled Termination

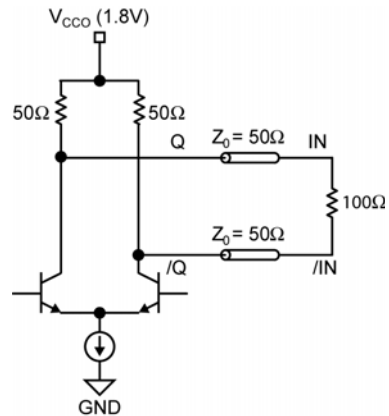


Figure 5b. 1.8V CML DC-Coupled Termination

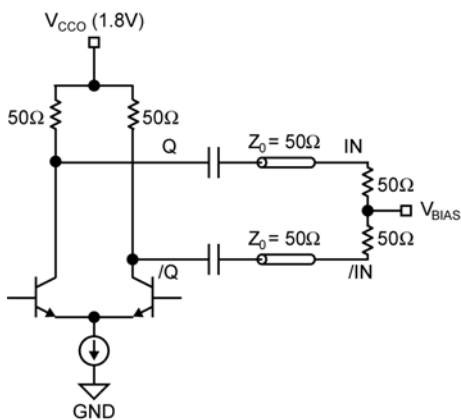


Figure 5c. CML AC-Coupled Termination (V<sub>CCO</sub> 1.8V Only)

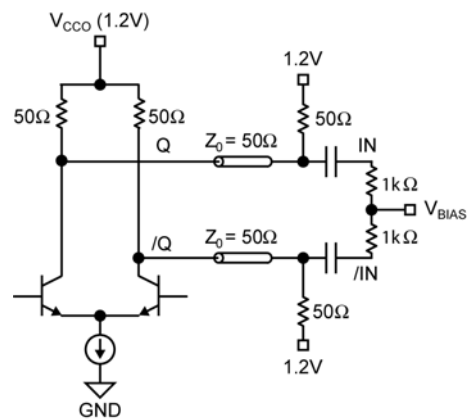
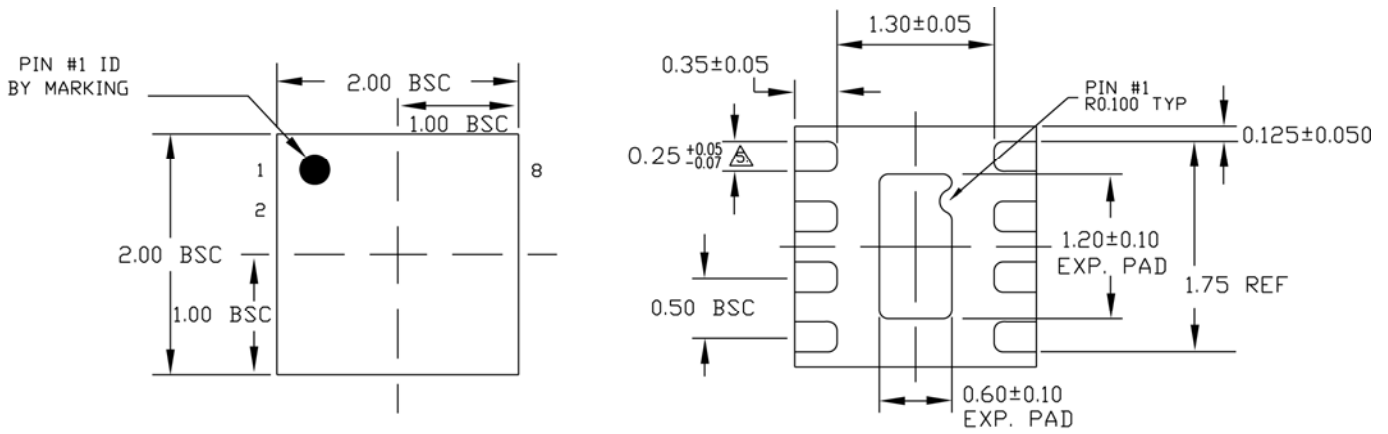


Figure 5d. CML AC-Coupled Termination (V<sub>CCO</sub> 1.2V Only)

### Related Product and Support Documents

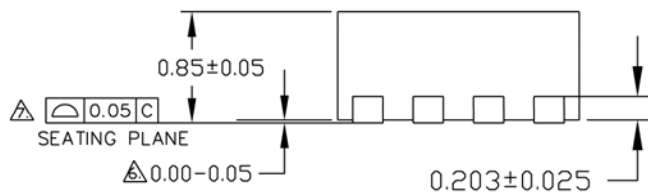
Part Number	Function	Datasheet Link
SY54016AR	3.2Gbps Precision, 1:1 Low Voltage CML Buffer with Internal Termination	<a href="http://www.micrel.com/page.do?page=/product-info/products/sy54016ar.shtml">http://www.micrel.com/page.do?page=/product-info/products/sy54016ar.shtml</a>
HBW Solutions	New Products 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 MLF<sup>®</sup> (2mm x 2mm) (MLF-8)**

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