

# SY56023R



## Low Voltage 1.2V/1.8V/2.5V CML 2x2 Crosspoint Switch 6.4Gbps with Equalization

### General Description

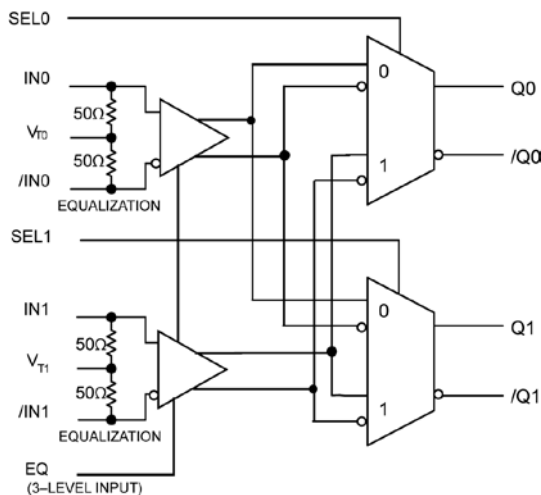
The SY56023R is a fully-differential, low-voltage 1.2V/1.8V/2.5V CML 2x2 crosspoint switch with input equalization. The SY56023R can process clock signals as fast as 5GHz or data patterns up to 6.4Gbps.

The differential input includes Micrel's unique, 3-pin input termination architecture that interfaces to CML differential signals, without any level-shifting or termination resistor networks in the signal path. The differential input can also accept AC-coupled LVPECL and LVDS signals. Input voltages as small as 200mV (400mV<sub>PP</sub>) are applied before the 9", 18" or 27" FR4 transmission line. 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 80ps.

The SY56023R operates from a 2.5V ±5% core supply and a 1.2V, 1.8V or 2.5V ±5% output supply and is guaranteed over the full industrial temperature range (-40°C to +85°C). The SY56023R 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



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Precision Edge<sup>®</sup>

### Features

- 1.2V/1.8V/2.5V CML 2x2 crosspoint switch
- Equalizes 9, 18, 27 inches of FR4
- Guaranteed AC performance over temperature and voltage:
  - DC-to > 6.4Gbps Data throughput
  - DC-to > 5GHz Clock throughput
  - <280 ps propagation delay (IN-to-Q)
  - <15 ps output skew
  - <80 ps rise/fall times
- Ultra-low jitter design
  - <1 pSRMS cycle-to-cycle jitter
- High-speed CML outputs
- 2.5V ±5% V<sub>CC</sub>, 1.2/1.8V/2.5V ±5% V<sub>CCO</sub> power supply operation
- Industrial temperature range: -40°C to +85°C
- Available in 16-pin (3mm x 3mm) QFN package

### Applications

- Data Distribution:
- SONET clock and data distribution
- Fiber 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

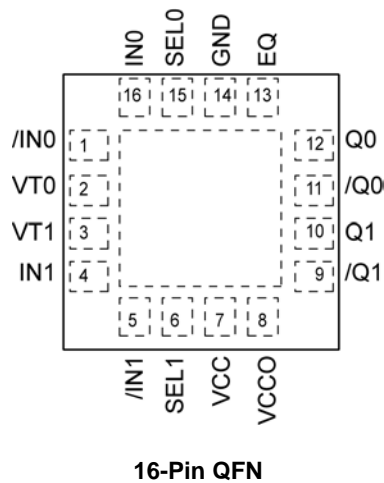
### Ordering Information<sup>(1)</sup>

Part Number	Package Type	Operating Range	Package Marking	Lead Finish
SY56023RMG	QFN-16	Industrial	R023 with Pb-Free Bar-Line Indicator	NiPdAu Pb-Free
SY56023RMGTR <sup>(2)</sup>	QFN-16	Industrial	R023 with Pb-Free Bar-Line Indicator	NiPdAu Pb-Free

**Notes:**

- Contact factory for die availability. Dice are guaranteed at T<sub>A</sub> = 25°C, DC Electricals only.
- Tape and Reel.

### Pin Configuration



### Truth Table

SEL0	SEL1	Q0	Q1
L	L	IN0	IN0
L	H	IN0	IN1
H	L	IN1	IN0
H	H	IN1	IN1

EQ	EQUALIZATION
LOW	27"
FLOAT	18"
HIGH	9"

## Pin Description

Pin Number	Pin Name	Pin Function
16,1 4,5	IN0, /IN0 IN1, /IN1	Differential Inputs: Signals as small as 200mV $V_{PK}$ (400mV <sub>PP</sub> ) applied to the input of 9, 18 or 27 inches 6 mil FR4 stripline transmission line are then terminated with the differential input. Each input pin internally terminates with 50Ω to the VT pin.
2 3	VT0 VT1	Input Termination Center-Tap: Each side of the differential input pair terminates to a 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.
13	EQ	Three level input for equalization control. High, float, low. EQ pin applies the same EQ setting to both inputs.
15 6	SEL0 SEL1	These single-ended TTL/CMOS-compatible inputs, selects inputs IN0 or IN1. Note that these inputs are internally connected to a 25kΩ pull-up resistor and will default to a logic HIGH state if left open.
7	VCC	Positive Power Supply: Bypass with 0.1μF//0.01μF low ESR capacitors as close to the V <sub>CC</sub> pins as possible. Supplies input and core circuitry.
8	VCCO	Output Supply: Bypass with 0.1μF//0.01μF low ESR capacitors as close to the V <sub>CCO</sub> pins as possible. Supplies the output buffers
14	GND, Exposed Pad	Ground: Exposed pad must be connected to a ground plane that is the same potential as the ground pins.
12,11 10,9	Q0, /Q0 Q1, /Q1	CML Differential Output Pairs: 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 +3.0V
$V_{CC} - V_{CCO}$	.....	<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 3.0V
Current ( $V_T$ )		
Source or sink on $V_T$ pin	.....	$\pm 100$ mA
Input Current		
Source or sink Current on (IN, /IN)	.....	$\pm 50$ mA
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 2.625V
Ambient Temperature ( $T_A$ )	.....	-40°C to +85°C
Package Thermal Resistance <sup>(3)</sup>		
QFN		
Still-air ( $\theta_{JA}$ )	.....	75°C/W
Junction-to-board ( $\psi_{JB}$ )	.....	33°C/W

### DC Electrical Characteristics<sup>(4)</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	$V_{CC}$	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
		$V_{CCO}$	2.375	2.5	2.625	V
$I_{CC}$	Power Supply Current	Max. $V_{CC}$		80	110	mA
$I_{CCO}$	Power Supply Current	No Load. $V_{CCO}$		32	42	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	1.42		$V_{CC}$	V
$V_{IL}$	Input LOW Voltage (IN, /IN)	IN, /IN 1.22V = 1.7-0.475	1.22		$V_{IH}-0.2$	V
$V_{IN}$	Input Voltage Swing (IN, /IN)	see Figure 3a, Note 5, applied to input of transmission line.	0.2		1.0	V
$V_{DIFF\_IN}$	Differential Input Voltage Swing ( IN - /IN )	see Figure 3b, Note 5, applied to input of transmission line.	0.4		2.0	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. The circuit is designed to meet the DC specifications shown in the above table after thermal equilibrium has been established.
5.  $V_{IN(max)}$  is specified when  $V_T$  is floating.

### CML Outputs DC Electrical Characteristics<sup>(6)</sup>

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

$V_{CCO} = 1.7V$  to  $1.9V$ ,  $2.375V$  to  $2.625V$ ,  $R_L = 50\Omega$  to  $V_{CCO}$  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 $V_{CCO}$	$V_{CC}-0.020$	$V_{CC}-0.010$	$V_{CC}$	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	$\Omega$

### LVTTL/CMOS DC Input Electrical Characteristics<sup>(6)</sup>

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

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

### Three Level EQ Input DC Electrical Characteristics<sup>(6)</sup>

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

Symbol	Parameter	Condition	Min	Typ	Max	Units
$V_{IH}$	Input HIGH Voltage		$V_{CC}-0.3$		$V_{CC}$	V
$V_{IL}$	Input LOW Voltage		0		$V_{EE}+0.3$	V
$I_{IH}$	Input HIGH Current	$V_{IH} = V_{CC}$			400	$\mu A$
$I_{IL}$	Input LOW Current	$V_{IL} = GND$	-480			$\mu A$

**Note:**

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

## AC Electrical Characteristics

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

$V_{CCO} = 1.7V$  to  $1.9V$ ,  $2.375V$  to  $2.625V$ ,  $R_L = 50\Omega$  to  $V_{CCO}$  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	6.4			Gbps
		$V_{OUT} = 100mV$ Clock	5			GHz
$t_{PD}$	Propagation Delay IN-to-Q SEL-to-Q	Note 7, Figure 1	100	180	280	ps
		Figure 1	90	210	350	ps
$t_{Skew}$	Input-to-Input Skew	Note 8		5	20	ps
	Output-to-Output Skew	Note 9		3	15	ps
	Part-to-Part Skew	Note 10			100	ps
$t_{Jitter}$	Random Jitter	Note 11			1	ps <sub>RMS</sub>
	Crosstalk Induced Jitter (Adjacent Channel)	Note 12			0.7	ps <sub>PP</sub>
$t_R$ $t_F$	Output Rise/Fall Time (20% to 80%)	At full output swing.	20	50	80	ps

### Notes:

7. Propagation delay is measured with no attenuating transmission line connected to the input.
8. Input-to-Input skew is the difference in time between both inputs and the output for the same temperature, voltage and transition.
9. Output-to-Output skew is the difference in time between both outputs under identical input transition, temperature and power supply
10. 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.
11. Random jitter is measured with a K28.7 pattern, measured at  $\leq f_{MAX}$ .
12. Crosstalk induced jitter is defined as the added jitter that results from signals applied to the adjacent channel. It is measured at the output while applying a similar, differential clock frequencies that are asynchronous with respect to each other at the adjacent input.

## Interface Applications

For Input Interface Applications see Figures 4a-e 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 Ohms to 1.2V, not 100 ohms differentially across the outputs. If AC coupling is used, Figure 5d, terminate into 50 ohms to 1.2V before the coupling capacitor and then connect to a high value resistor to a reference voltage. Any unused output pair needs to be terminated, do not leave floating.

### CML Output Termination with VCCO 1.8V

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

### Input Termination

1.8V CML driver: Terminate input with VT tied to 1.8V. Don't terminate 100 ohms differentially.

2.5V CML driver: Terminate input with either VT tied to 2.5V or 100 ohms differentially.

The input cannot be DC coupled from a 1.2V CML driver.

## Timing Diagrams

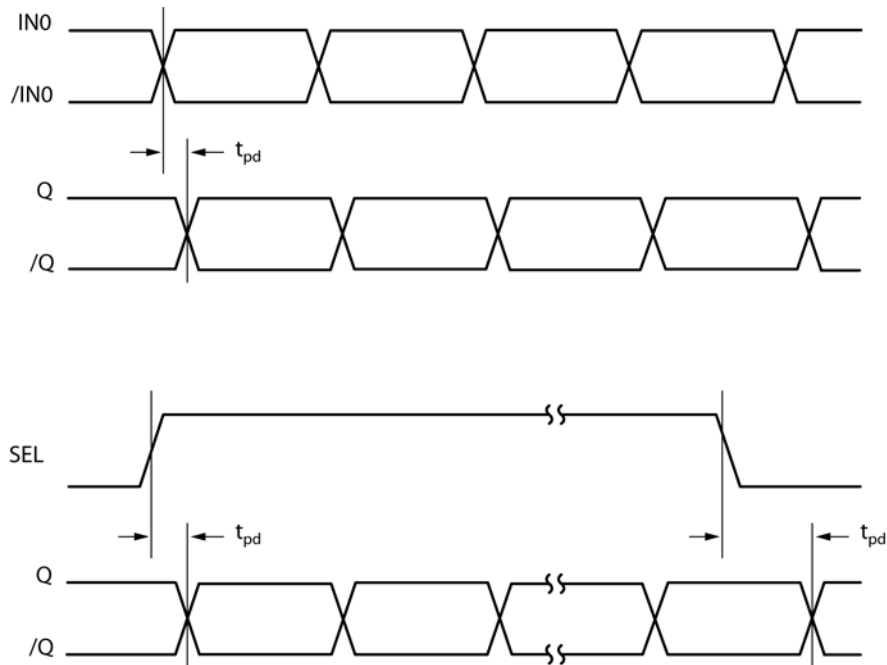
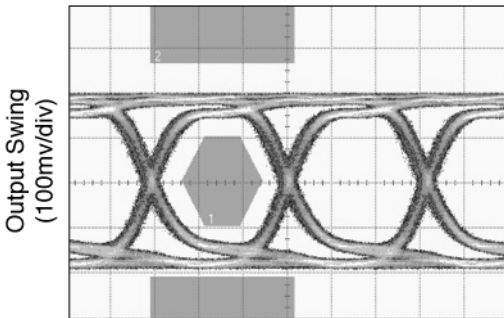


Figure 1. Propagation Delay

### Typical Characteristics

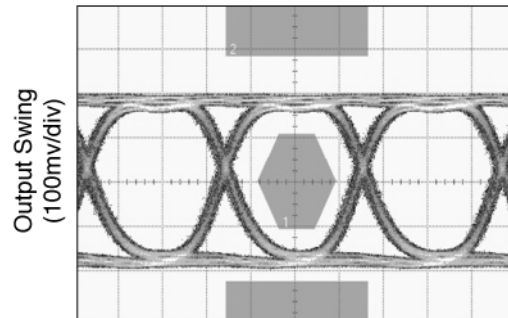
$V_{CC} = 2.5$ ,  $V_{CCO} = 1.2V$ ,  $GND = 0V$ ,  $V_{IN} = 400mV$ ,  $R_L = 50\Omega$  to  $1.2V$ , Data Pattern:  $2^{23}-1$ ,  $T_A = 25^\circ C$ , unless otherwise stated.

**6.4Gbps, 24 inch FR4**



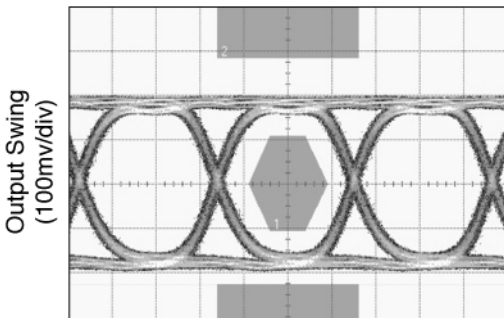
TIME (50ps/div.)

**6.4Gbps, 18 inch FR4**



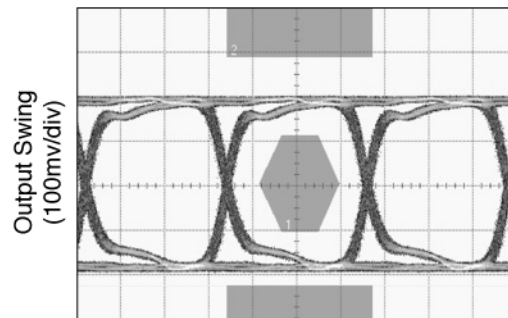
TIME (50ps/div.)

**6.4Gbps, 9 inch FR4**



TIME (50ps/div.)

**3.2Gbps, 24 inch FR4**



TIME (100ps/div.)



## Input and Output Stage

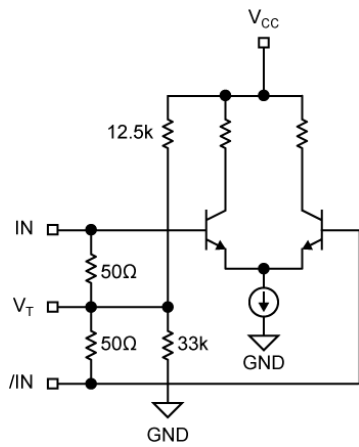


Figure 2a. Simplified Differential Input Buffer

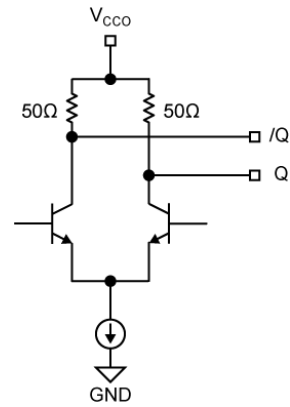


Figure 2b. Simplified CML Output Buffer

## Single-Ended and Differential Swings

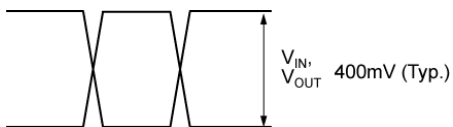


Figure 3a. Single-Ended Swing

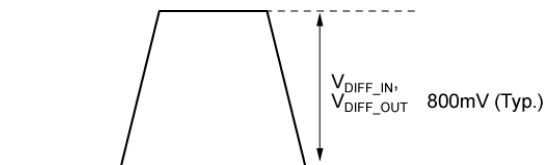


Figure 3b. Differential Swing

## Input Interface Applications

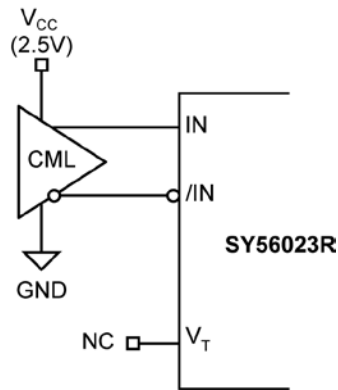


Figure 4a. CML Interface 100Ω Differential (DC-Coupled, 2.5V)

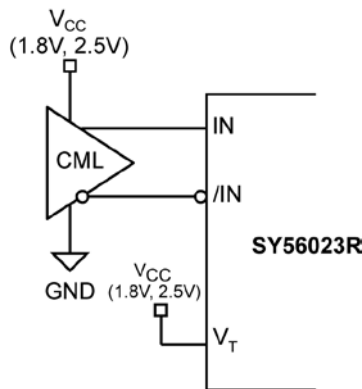


Figure 4b. CML Interface 50Ω to V<sub>CC</sub> (DC-Coupled, 1.8V, 2.5V)

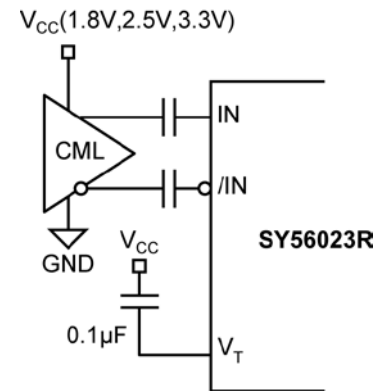


Figure 4c. CML Interface (AC-Coupled)

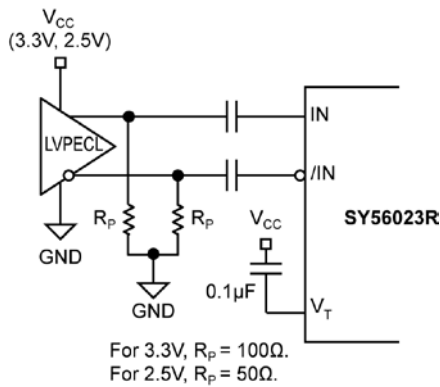


Figure 4d. LVPECL Interface (AC-Coupled)

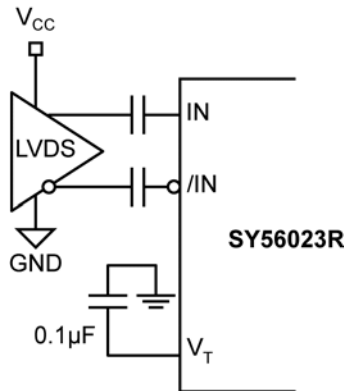


Figure 4e. LVDS Interface (AC-Coupled)

### CML Output Termination

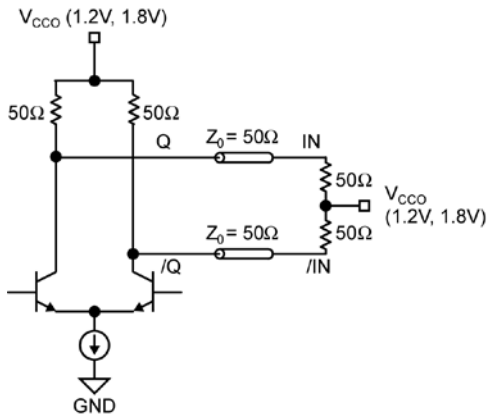


Figure 5a. 1.2V or 1.8V CML DC-Coupled Termination

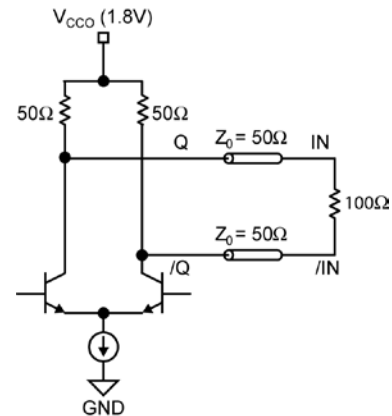


Figure 5b. 1.8V CML DC-Coupled Termination

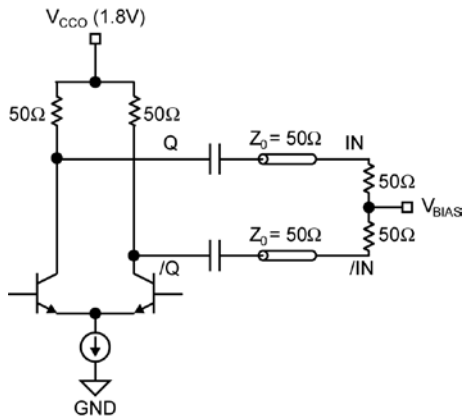


Figure 5c. CML AC-Coupled Termination  
Vcc0 1.8V Only

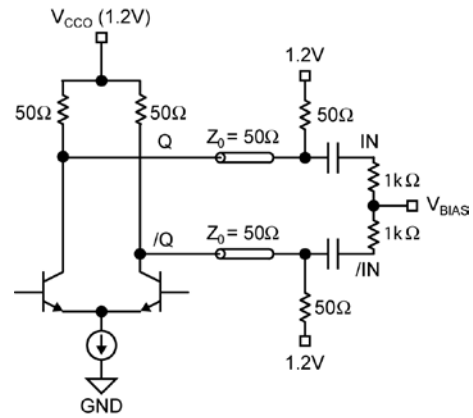
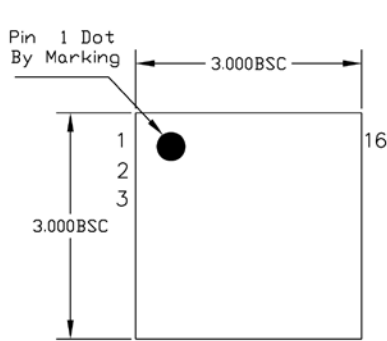


Figure 5d. CML AC-Coupled Termination  
Vcc0 1.2V Only

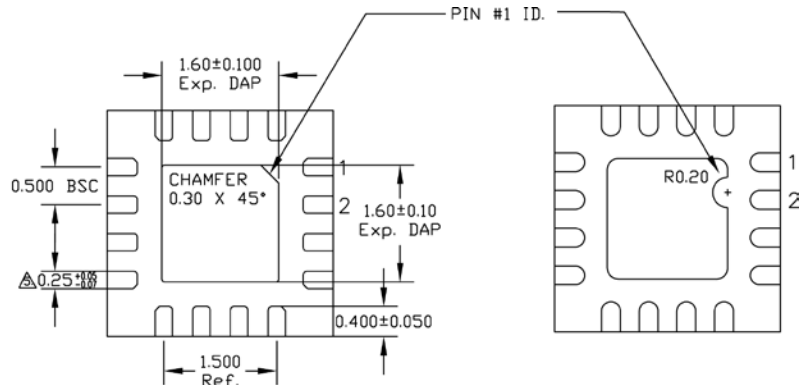
### Related Product and Support Documents

Part Number	Function	Datasheet Link
HBW Solutions	New Products and Termination Application Notes	<a href="http://www.micrel.com/page.do?page=/product-info/as/HBW/solutions.shtml">http://www.micrel.com/page.do?page=/product-info/as/HBW/solutions.shtml</a>

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



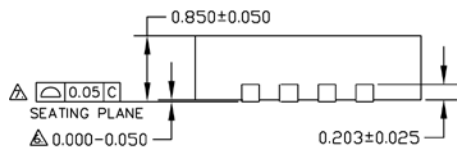
TOP VIEW



VARIATION A

VARIATION B

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.

## 16-Pin QFN

**Note:**

1. Package information is correct as of the publication date. For updates and most current information, go to [www.micrel.com](http://www.micrel.com).

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