



## SY54020AR

Low Voltage 1.2V/1.8V/2.5V CML 1:4 Fanout  
Buffer with /EN 3.2Gbps, 3.2GHz

### General Description

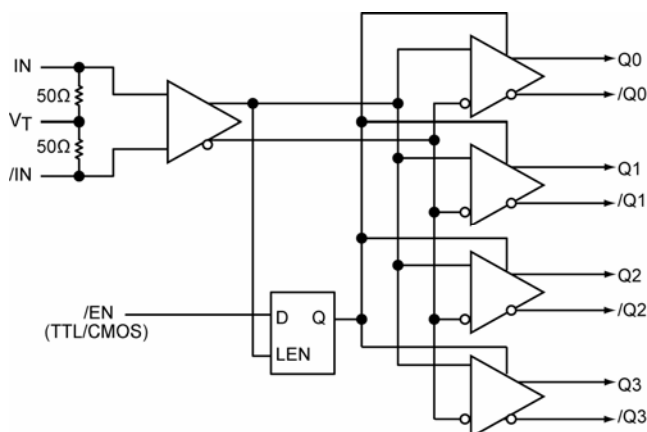
The SY54020AR is a fully differential, low voltage 1.2V/1.8V/2.5V CML 1:4 Fanout Buffer with active-low Enable (/EN). The Enable is synchronous so that the outputs will only be enabled/disabled when they are already in the LOW state. This avoids any chance of generating a runt clock pulse when the device is enabled/disabled as can happen with an asynchronous control. When this device is used as a clock fanout, disabling the downstream clock may reduce system power. The SY54020AR can process clock signals as fast as 3.2 GHz 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 100ps.

The SY54020AR operates from a 2.5V  $\pm$ 5% core supply and a 1.2V, 1.8V or 2.5V  $\pm$ 5% output supply and is guaranteed over the full industrial temperature range (–40°C to +85°C).

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®

### Features

- 1.2V/1.8V/2.5V CML 1:4 Fanout Buffer
- Active-low Enable (/EN) input to disable the outputs
- Guaranteed AC performance over temperature and voltage:
  - DC-to > 3.2Gbps Data throughput
  - DC-to > 3.2GHz Clock throughput
  - <320 ps propagation delay (IN-to-Q)
  - <20ps within-device skew
  - <100 ps rise/fall times
- Ultra-low jitter design
  - <1ps<sub>RMS</sub> cycle-to-cycle jitter
- High-speed CML outputs
- 2.5V  $\pm$ 5% V<sub>CC</sub>, 1.2/1.8V/2.5V  $\pm$ 5% V<sub>CCO</sub> power supply operation
- Industrial temperature range: –40°C to +85°C
- Available in 16-pin (3mm x 3mm) MLF® package

### Applications

- 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
- Metro area network equipment

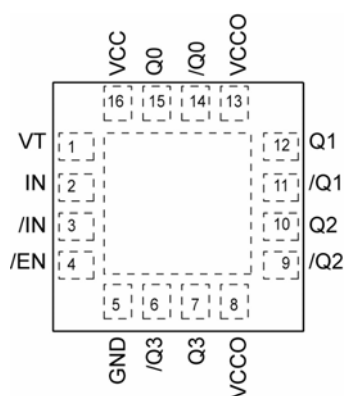
## Ordering Information<sup>(1)</sup>

| Part Number                  | Package Type | Operating Range | Package Marking                      | Lead Finish    |
|------------------------------|--------------|-----------------|--------------------------------------|----------------|
| SY54020ARMG                  | MLF-16       | Industrial      | 020A with Pb-Free bar-line indicator | NiPdAu Pb-Free |
| SY54020ARMGTR <sup>(2)</sup> | MLF-16       | Industrial      | 020A with Pb-Free bar-line indicator | NiPdAu 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



16-Pin MLF<sup>®</sup> (MLF-16)

## 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. It accepts differential signals as small as 100mV (200mV <sub>PP</sub> ). Each input pin internally terminates with 50Ω to the VT pin. Note that this input will default to an indeterminate state if left open. Please refer to the "Interface Applications" section for more details.                                                                                        |
| 1                             | VT                                       | 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. 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.                                                               |
| 4                             | /EN                                      | Single-ended TTL/CMOS-compatible input functions as a synchronous output enable. The synchronous enable ensures that enable/disable will only occur when the outputs are in a logic LOW state. The input switching threshold is V <sub>CC</sub> /2. Note that this input is internally connected to a 25kΩ pull-down resistor and will default to a logic LOW state (Enabled) if left open. Outputs are disabled when /EN is high. See Figure 1b for more details. |
| 16                            | VCC                                      | Positive Power Supply: Bypass with 0.1μF//0.01μF low ESR capacitors as close to the V <sub>CC</sub> pin as possible. Supplies input and core circuitry.                                                                                                                                                                                                                                                                                                            |
| 8,13                          | 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.                                                                                                                                                                                                                                                                                                                        |
| 5                             | GND,<br>Exposed pad                      | Ground: Exposed pad must be connected to a ground plane that is the same potential as the ground pin.                                                                                                                                                                                                                                                                                                                                                              |
| 15,14<br>12,11<br>10,9<br>7,6 | Q0, /Q0<br>Q1, /Q1<br>Q2, /Q2<br>Q3, /Q3 | CML Differential Output Pairs: Differential buffered copy of the input signal. The output swing is typically 390mV. See "Interface Applications" subsection for termination information.                                                                                                                                                                                                                                                                           |

## Truth Table

| IN | /IN | /EN | Q                | /Q               |
|----|-----|-----|------------------|------------------|
| 0  | 1   | 0   | 0                | 1                |
| 1  | 0   | 0   | 1                | 0                |
| X  | X   | 1   | 0 <sup>(1)</sup> | 1 <sup>(1)</sup> |

**Note:**

1. See timing diagram, Figure 1b.

**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 $V_{CC} + 0.5V$ |
| CML Output Voltage ( $V_{OUT}$ )       | 0.6V to $V_{CCO} + 0.5V$ |
| Current ( $V_T$ )                      |                          |
| Source or sink current on VT pin       | ±100mA                   |
| Input Current                          |                          |
| Source or sink current on (IN, /IN)    | ±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 2.625V  |
| Ambient Temperature ( $T_A$ )             | –40°C to +85°C   |
| Package Thermal Resistance <sup>(3)</sup> |                  |
| MLF <sup>®</sup>                          |                  |
| 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. $V_{CC}$                              |       | 40  | 56             | mA       |
| $I_{CCO}$      | Power Supply Current                                | No Load. $V_{CCO}$                         |       | 64  | 84             | mA       |
| $R_{IN}$       | Input Resistance<br>(IN-to- $V_T$ , /IN-to- $V_T$ ) |                                            | 45    | 50  | 55             | $\Omega$ |
| $R_{DIFF\_IN}$ | Differential Input Resistance<br>(IN-to-/IN)        |                                            | 90    | 100 | 110            | $\Omega$ |
| $V_{IH}$       | Input HIGH Voltage<br>(IN, /IN)                     | IN, /IN                                    | 1.2   |     | $V_{CC}$       | V        |
| $V_{IL}$       | Input LOW Voltage<br>(IN, /IN)                      | Min. $V_{IL}$ with $V_{IH} = 1.2V$         | 0.2   |     | $V_{IH} - 0.1$ | V        |
| $V_{IH}$       | Input HIGH Voltage<br>(IN, /IN)                     | IN, /IN                                    | 1.14  |     | $V_{CC}$       | V        |
| $V_{IL}$       | Input LOW Voltage<br>(IN, /IN)                      | $V_{IL}$ with $V_{IH} = 1.14V$ , (1.2V-5%) | 0.66  |     | $V_{IH} - 0.1$ | V        |
| $V_{IN}$       | Input Voltage Swing<br>(IN, /IN)                    | See Figure 3a                              | 0.1   |     | 1.0            | V        |
| $V_{DIFF\_IN}$ | Differential Input Voltage Swing<br>( IN - /IN )    | See Figure 3b                              | 0.2   |     | 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 datasheet. 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>

$V_{CCO} = 1.14V$  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 $V_{CCO}$ | $V_{CCO}-0.020$ | $V_{CCO}-0.010$ | $V_{CCO}$ | 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 Electrical Characteristics<sup>(5)</sup>

$V_{CC} = 2.5V \pm 5\%$ ,  $T_A = -40^\circ C$  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 | $V_{IH} = V_{CC}$ |     |     | 200      | $\mu A$ |
| $I_{IL}$ | Input LOW Current  | $V_{IL} = 0V$     | -5  |     | 75       | $\mu A$ |

### 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

$V_{CCO} = 1.14V$  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 Data Rate/ Frequency        | NRZ Data                                        | 3.2      |     |          | Gbps  |
|              |                                     | $V_{OUT} > 200mV$ Clock                         | 3.2      |     |          | GHz   |
| $t_{PD}$     | Propagation Delay IN-to-Q           | $V_{IN} > 200mV$ , Note 6, Figure 1a            | 150      | 220 | 320      | ps    |
| $t_S$        | Setup Time /EN                      |                                                 |          | 200 |          | ps    |
| $t_H$        | Hold Time /EN                       |                                                 |          | 100 |          | ps    |
| $t_{SKEW}$   | Output-to-Output Skew               | Note 7                                          |          | 8   | 20       | ps    |
|              | Part-to-Part Skew                   | Note 8                                          |          |     | 75       | ps    |
| $t_{Jitter}$ | Data Random Jitter                  | Note 9                                          |          |     | 1        | pSRMS |
|              | Deterministic Jitter                | Note 10                                         |          |     | 10       | pSPP  |
|              | Clock Cycle-to-Cycle Jitter         | Note 11                                         |          |     | 1        | pSRMS |
|              | Total Jitter                        | Note 12                                         |          |     | 10       | pSPP  |
| $t_R, t_F$   | Output Rise/Fall Times (20% to 80%) | At full output swing.                           | 35       | 60  | 100      | ps    |
|              | Duty Cycle                          | Differential I/O $\leq 2.5GHz$<br>$\leq 3.2GHz$ | 47<br>45 |     | 53<br>55 | %     |

### Notes:

- Propagation delay is measured with input  $t_r/t_f \leq 300$  ps (20% to 80%)
- Output-to-Output skew is the difference in time between both outputs, receiving data from the same input, for the same temperature, voltage and transition.
- Part-to-part skew is defined for two parts with identical power supply voltages at the same temperature and no skew at the edges of 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.

## Interface Applications

For Input Interface Applications, see Figures 4a through 4f. For CML Output Termination, see Figures 5a through 5d.

### 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, such as 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. Any unused output pair needs to be terminated when VCCO is 1.2V. Do not leave floating.

### CML Output Termination with VCCO 1.8V, 2.5V

For VCCO of 1.8V and 2.5V, Figure 5a and Figure 5b, terminate with either 50 $\Omega$  to VCCO or 100 $\Omega$  differentially across the outputs. See Figure 5c for AC-coupling.

### Input AC-Coupling

The SY54020AR input can accept AC coupling from any driver. Bypass VT with a 0.1 $\mu$ F low ESR capacitor to VCC 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

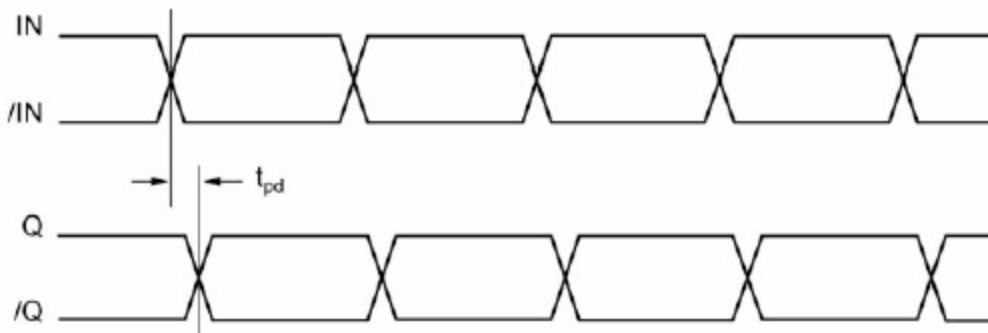


Figure 1a. Propagation Delay

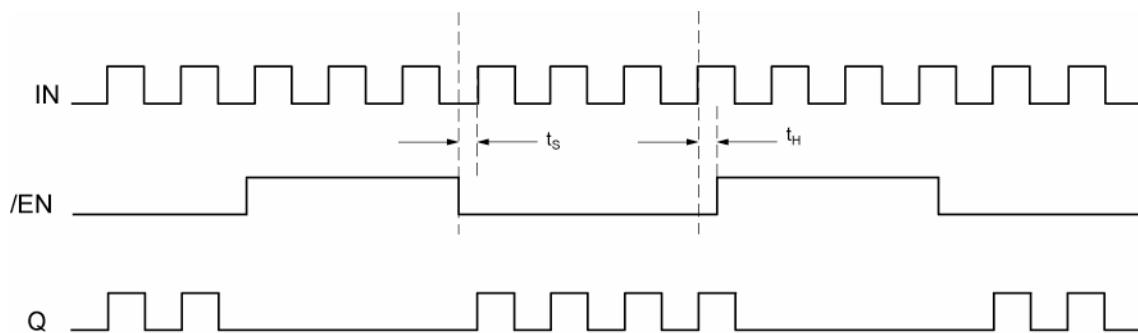
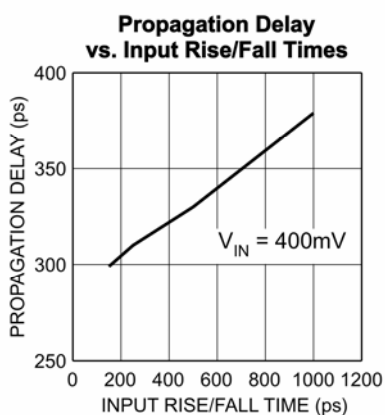
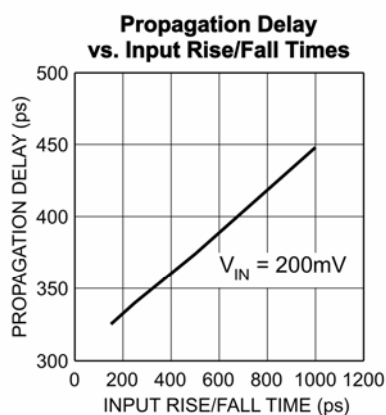
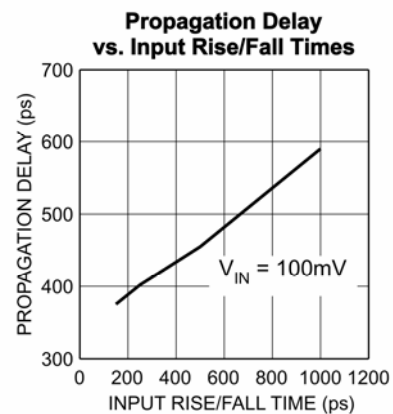
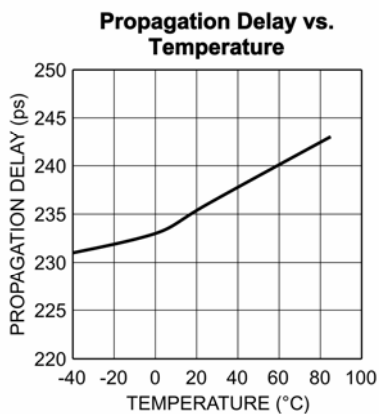
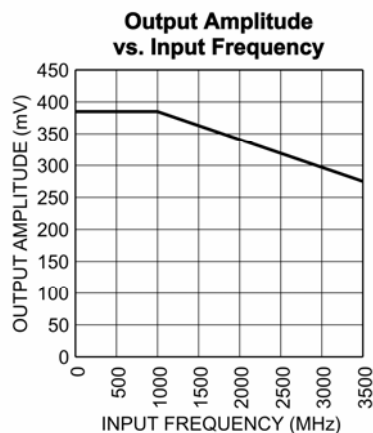


Figure 1b. Output Enable/Disable Timing Diagram

## Typical Characteristics

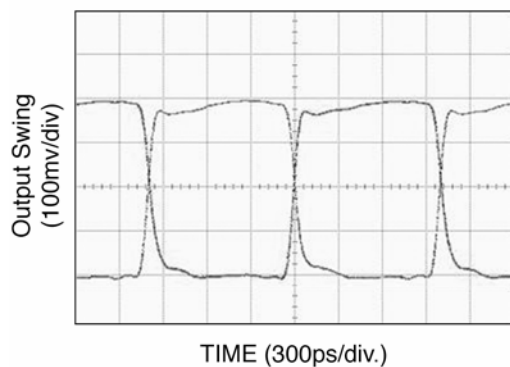
$V_{CC} = 2.5V$ ,  $V_{CC0} = 1.2V$ ,  $GND = 0V$ ,  $V_{IN} = 400mV$ ,  $R_L = 50\Omega$  to  $1.2V$ ,  $T_A = 25^\circ C$ , unless otherwise stated.



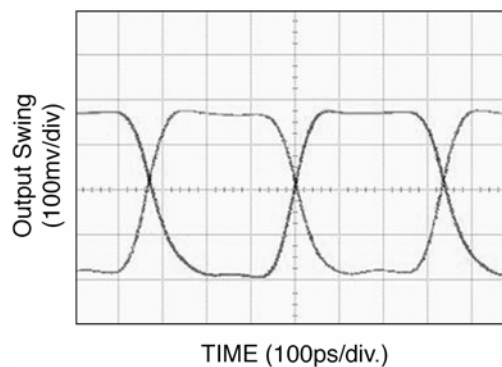
## Functional Characteristics

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

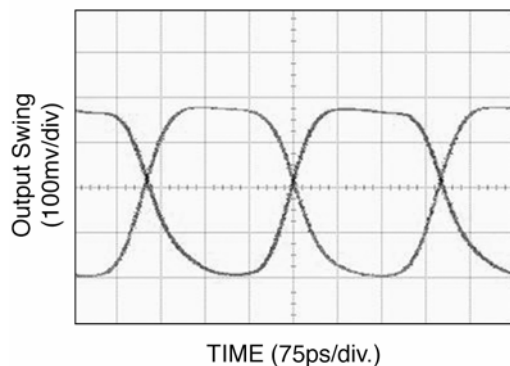
**500MHz Output**



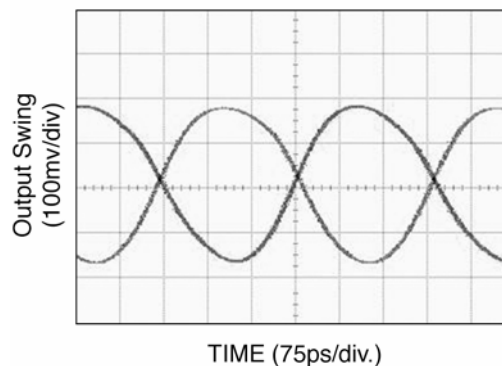
**1.5GHz Output**



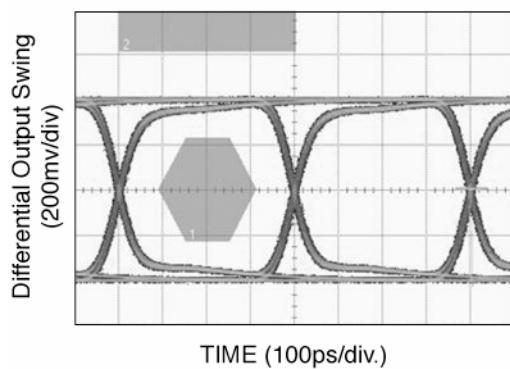
**2GHz Output**



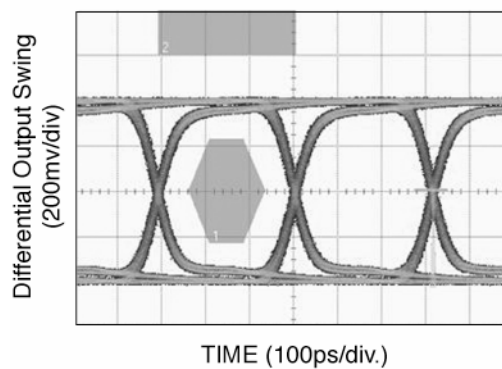
**3.2GHz Output**



**2.5Gbps Output**



**3.2Gbps Output**



## Input and Output Stage

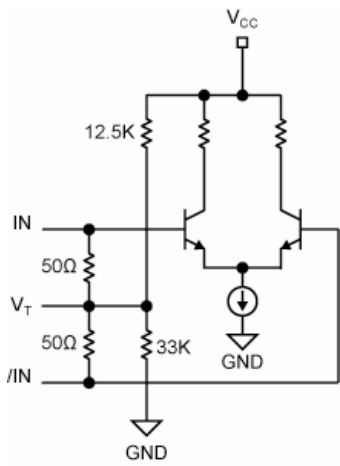


Figure 2a. Simplified Differential Input Buffer

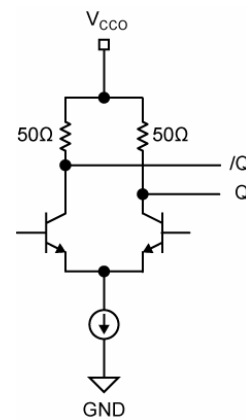


Figure 2b. Simplified CML Output Buffer

## Single-Ended and Differential Swings



Figure 3a. Single-Ended Swing

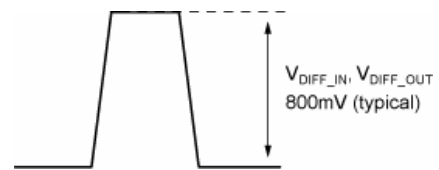
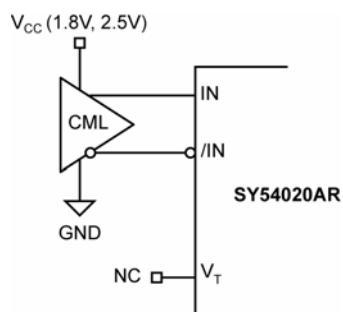


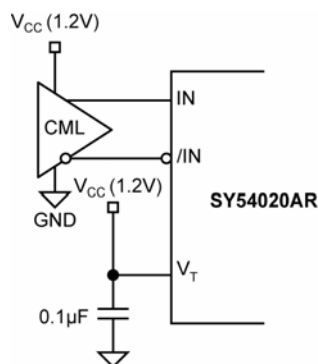
Figure 3b. Differential Swing

## Input Interface Applications

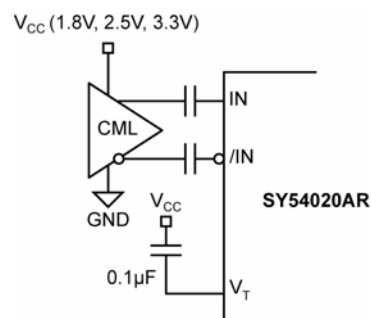


**Figure 4a. CML Interface  
(DC-Coupled, 1.8V, 2.5V)**

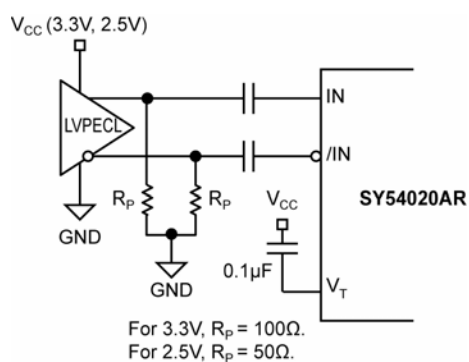
*Option: may connect  $V_T$  to  $V_{CC}$*



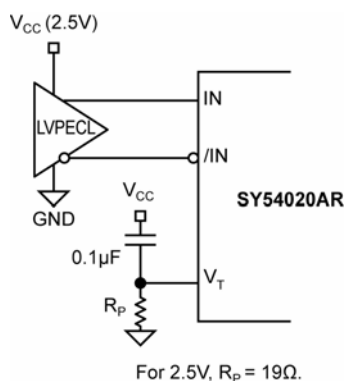
**Figure 4b. CML Interface  
(DC-Coupled, 1.2V)**



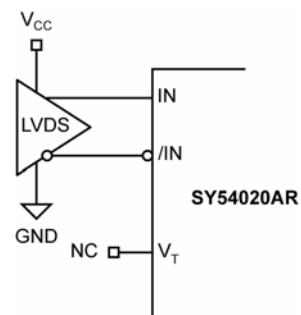
**Figure 4c. CML Interface  
(AC-Coupled)**



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



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



**Figure 4f. LVDS Interface**

## CML Output Termination

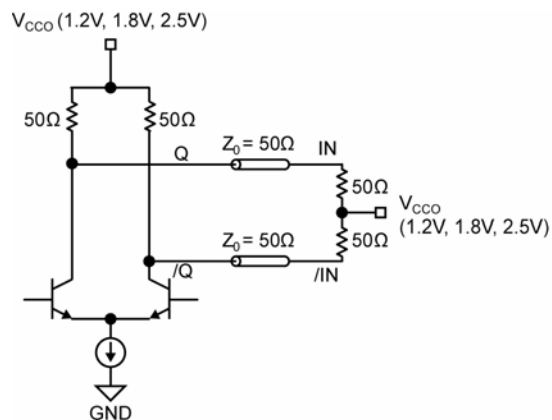


Figure 5a. 1.2V, 1.8V or 2.5V  
CML DC-Coupled Termination

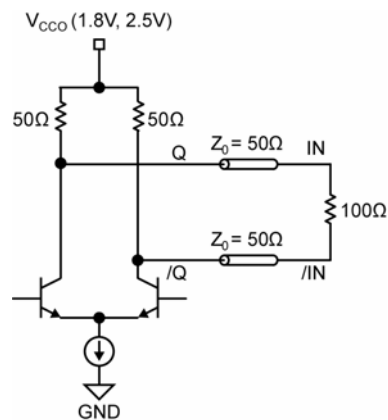


Figure 5b. 1.8V or 2.5V  
CML DC-Coupled Termination

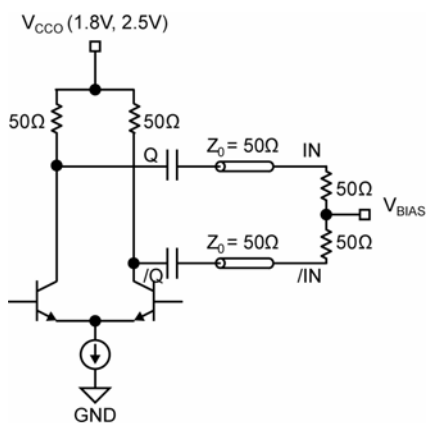


Figure 5c. CML AC-Coupled Termination  
( $V_{CCO}$  1.8V or 2.5V )

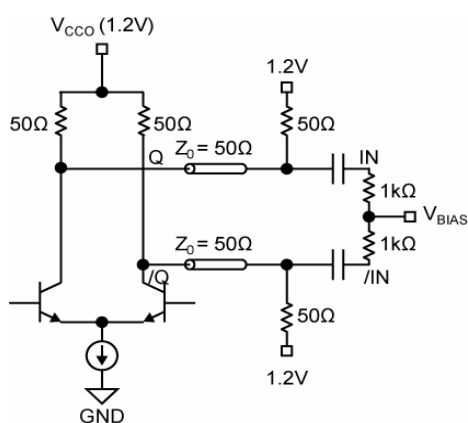
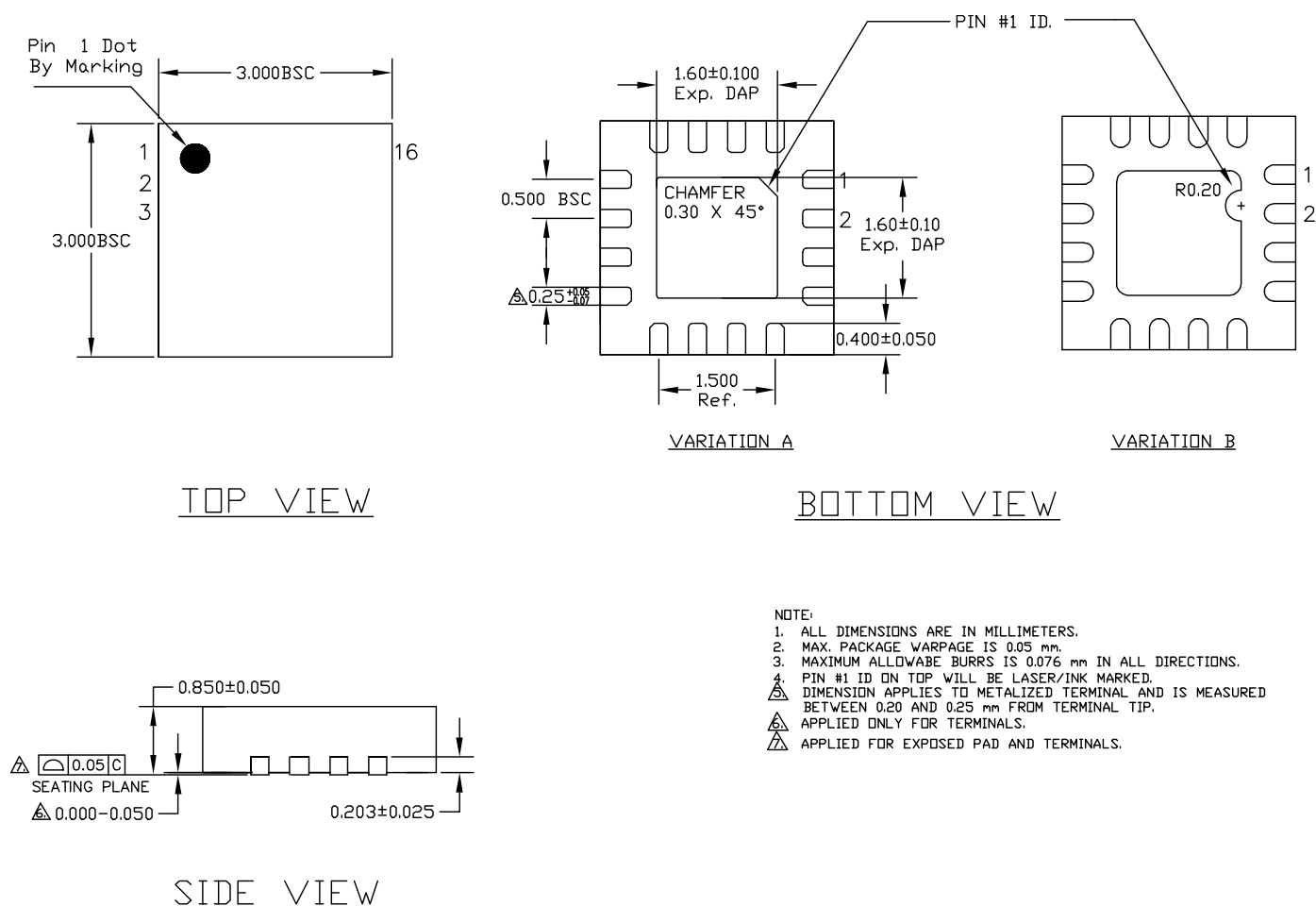


Figure 5d. CML AC-Coupled Termination  
( $V_{CCO}$  1.2V only)

## Package Information



**16-Pin MLF<sup>®</sup> (3mm x3mm) (MLF-16)**

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