

## 2.5 GHz, Any-In to LVPECL, Programmable Clock Divider/Fanout Buffer with Internal Termination

### Features

- Integrated Programmable Clock Divider and 1:2 Fanout Buffer
- Guaranteed AC Performance over Temperature and Voltage:
  - >2.5 GHz  $f_{MAX}$
  - <250 ps  $t_r/t_f$
  - <5 ps Within-Device Skew
- Low-Jitter Design:
  - <10 ps<sub>pp</sub> Total Jitter
  - <1 ps<sub>RMS</sub> Cycle-to-Cycle Jitter
- Unique Input Termination and VT Pin for DC-Coupled and AC-Coupled Inputs; LVCMOS, LVTTTL, CML, PECL, LVDS, and HSTL
- TTL/CMOS Inputs for Select and Reset
- 100k EP-Compatible LVPECL Outputs
- Parallel Programming Capability
- Programmable Divider Ratios of 1, 2, 4, 8, and 16
- Low Voltage Operation 2.5V or 3.3V
- Output Disable Function
- -40°C to +85°C Temperature Range
- Available in 16-Pin (3 mm x 3 mm) QFN Package

### Applications

- SONET/SDH Line Cards
- Transponders
- High-End Multiprocessor Sensors

### General Description

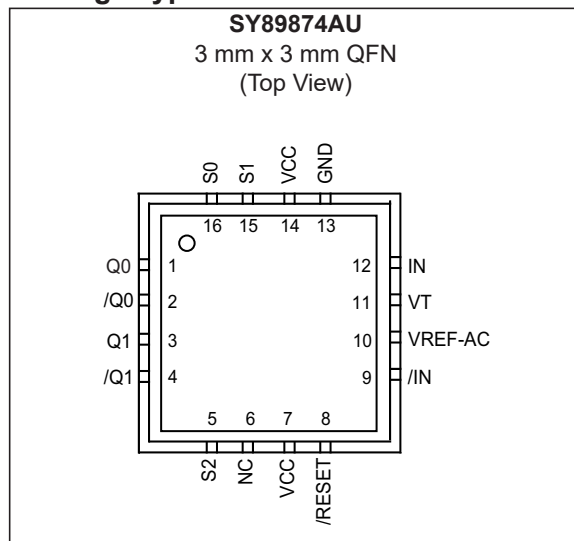
This low-skew, low-jitter device can accept a high-speed (622 MHz or higher) LVTTTL, LVCMOS, CML, LVPECL, LVDS, or HSTL clock input signal and divide down the frequency using a programmable divider ratio to create a frequency-locked, lower speed version of the input clock. Available divider ratios are 2, 4, 8, and 16, or straight pass-through. In a typical 622 MHz clock system this would provide availability of 311 MHz, 155 MHz, 77 MHz, or 38 MHz auxiliary clock components.

The differential input buffer has a unique internal termination design that allows access to the termination network through a VT pin. This feature allows the device to easily interface to different logic standards. A  $V_{REF-AC}$  reference is included for AC-coupled applications.

The /RESET input asynchronously resets the divider. In the pass-through function (divide by 1) the /RESET synchronously enables or disables the outputs on the next falling edge of IN (rising edge of /IN).

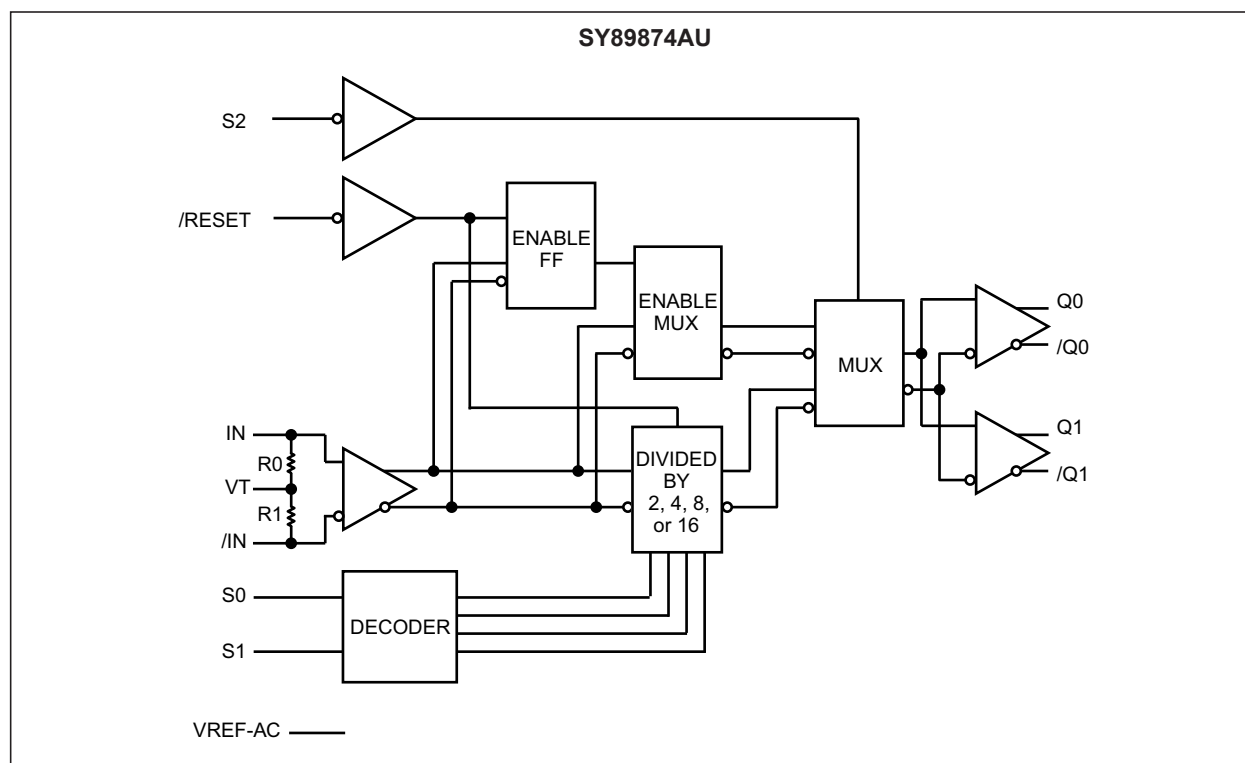
Use the SY89874U version, which has a wider input range, to DC-couple low offset differential signals.

### Package Type



# SY89874AU

## Functional Block Diagram



## Truth Table

TABLE 0-1: TRUTH TABLE

/RESET	S2	S1	S0	Outputs
1	0	X	X	Reference clock (pass through)
1	1	0	0	Reference clock ÷ 2
1	1	0	1	Reference clock ÷ 4
1	1	1	0	Reference clock ÷ 8
1	1	1	1	Reference clock ÷ 16
0	1	X	X	Q = Low, /Q = High, Clock disable

## 1.0 ELECTRICAL CHARACTERISTICS

### Absolute Maximum Ratings †

Supply Voltage ( $V_{CC}$ )	.....	-0.5V to +4.0V
Input Voltage ( $V_{IN}$ )	.....	-0.5V to $V_{CC}+0.3V$
ECL Output Current ( $I_{OUT}$ )		
Continuous	.....	50 mA
Surge	.....	100 mA
Input Current $I_N$ , /IN ( $I_{IN}$ )	.....	±50 mA
VT Current ( $I_{VT}$ )	.....	±100 mA
VREF-AC Sink/Source Current ( $I_{VREF-AC}$ ) (Note 1)	.....	±2 mA

### Operating Ratings ‡

Supply Voltage ( $V_{CC}$ )	.....	3.3V ±10% or 2.5V ±5%
-----------------------------	-------	-----------------------

† **Notice:** Permanent device damage can 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 rating conditions for extended periods may affect device reliability.

‡ **Notice:** The data sheet limits are not guaranteed if the device is operated beyond the operating ratings.

**Note 1:** Due to the limited drive capability, use for input of the same package only.

## DC ELECTRICAL CHARACTERISTICS

Electrical Characteristics: $T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$ unless otherwise noted. Note 1						
Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Power Supply	$V_{CC}$	2.375	—	3.63	V	—
Power Supply Current	$I_{CC}$	—	50	75	mA	No load, maximum $V_{CC}$
Differential Input Resistance (IN-to-/IN)	$R_{IN}$	90	100	110	$\Omega$	—
Input High Voltage (IN, /IN)	$V_{IH}$	0.8	—	$V_{CC} + 0.3$	V	Note 2
Input Low Voltage (IN, /IN)	$V_{IL}$	-0.3	—	$V_{IH} - 0.1$	V	Note 2
Input Voltage Swing	$V_{IN}$	0.1	—	$V_{CC}$	V	Note 2, Note 3
Differential Input Voltage Swing	$V_{DIFF\_IN}$	0.2	—	—	V	Note 2, Note 4
Input Current (IN, /IN)	$ I_{IN} $	—	—	45	mA	Note 2
Reference Voltage	$V_{REF-AC}$	$V_{CC} - 1.525$	$V_{CC} - 1.425$	$V_{CC} - 1.325$	V	Note 5

**Note 1:** The circuit is designed to meet the DC specifications in this table after thermal equilibrium has been established. For a wider input range, use the SY89874U device.

- Due to the internal termination (see the Input Buffer Structure), the input current depends on the applied voltages at the IN, /IN, and VT inputs. Do not apply a combination of voltages that cause the input current to exceed the maximum limit.
- See the Timing Diagram or Definition of Single-Ended and Differential Swing sections for  $V_{IN}$  definition.  $V_{IN}$  (maximum) is specified when VT is floating.
- See the Definition of Single-Ended and Differential Swing section for  $V_{DIFF}$  definition.
- Operation using  $V_{REF-AC}$  is limited to AC-coupled PECL or CML applications only. Connect directly to the VT pin.

# SY89874AU

## LVPECL (100KEP) DC ELECTRICAL CHARACTERISTICS

**Electrical Characteristics:** 3.3V  $\pm$ 10% or 2.5V  $\pm$ 5%;  $T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ ,  $R_L = 50\Omega$  to  $V_{CC} - 2V$  unless otherwise stated. [Note 1](#).

Parameter	Symbol	Min.	Typ.	Max.	Units	Condition
Output High Voltage	$V_{OH}$	$V_{CC} - 1.145$	$V_{CC} - 1.020$	$V_{CC} - 0.895$	V	—
Output Low Voltage	$V_{OL}$	$V_{CC} - 1.945$	$V_{CC} - 1.820$	$V_{CC} - 1.695$	V	—
Output Voltage Swing	$V_{OUT}$	550	800	1050	mV	—
Differential Output Voltage Swing	$V_{DIFF\_OUT}$	1.10	1.60	2.10	V	—

**Note 1:** The circuit is designed to meet the DC specifications shown in this table after thermal equilibrium has been established. For a wider differential input range, use the SY89874U device.

## LVTTTL/CMOS DC ELECTRICAL CHARACTERISTICS

**Electrical Characteristics:** 3.3V  $\pm$ 10% or 2.5V  $\pm$ 5%;  $T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$  unless otherwise stated. [Note 1](#).

Parameter	Symbol	Min.	Typ.	Max.	Units	Condition
Input High Voltage	$V_{IH}$	2.0	—	—	V	—
Input Low Voltage	$V_{IL}$	—	—	0.8	V	—
Input High Current	$I_{IH}$	-125	—	20	$\mu\text{A}$	—
Input Low Current	$I_{IL}$	-300	—	—	$\mu\text{A}$	—

**Note 1:** The circuit is designed to meet the DC specifications shown in this table after thermal equilibrium has been established.

## AC ELECTRICAL CHARACTERISTICS

**Electrical Characteristics:** 3.3V  $\pm$ 10% or 2.5V  $\pm$ 5%;  $T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$  unless otherwise stated. [Note 1](#), [Note 2](#).

Parameter	Symbol	Min.	Typ.	Max.	Units	Condition
Maximum Output Toggle Frequency	$f_{MAX}$	2.5	—	—	GHz	Output Swing $\geq$ 400 mV
Maximum Input Frequency		3.2	—	—		Divide by 2, 4, 8, 16
Differential Propagation Delay, IN-to-Q	$t_{PD}$	510	620	760	ps	Input Swing < 400 mV
		450	570	700		Input Swing $\geq$ 400 mV
Within-Device Skew (Differential) Q0 - Q1	$t_{SKEW}$	—	7	15	ps	<a href="#">Note 3</a>
Part-to-Part Skew (Differential)		—	—	250		<a href="#">Note 3</a>
Reset Recovery Time	$t_{RR}$	600	—	—	ps	<a href="#">Note 4</a>
Cycle-to-Cycle Jitter	$t_{JITTER}$	—	—	1	ps <sub>RMS</sub>	<a href="#">Note 5</a>
Total Jitter		—	—	10	ps <sub>pp</sub>	<a href="#">Note 6</a>
Rise/Fall Time (20% to 80%)	$t_r/t_f$	70	150	250	ps	—

**Note 1:** Specification for packaged product only.

**2:** Measured with 400 mV input signal, 50% duty cycle, all outputs loaded with  $50\Omega$  to  $V_{CC} - 2V$ , unless otherwise stated.

**3:** Skew is measured between outputs under identical transitions.

**4:** See the "Timing Diagram" section.

**5:** Cycle-to-cycle Jitter Definition: The variation in 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.

**6:** Total Jitter Definition: With an ideal clock input, of frequency  $\leq f_{MAX}$  (device), no more than one output edge in  $10^{12}$  output edges will deviate by more than the specified peak-to-peak jitter value.

## TEMPERATURE SPECIFICATIONS (Note 1)

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
<b>Temperature Ranges</b>						
Lead Temperature	—	—	—	+260	°C	Soldering, 20 sec.
Ambient Operating Temperature	T <sub>A</sub>	-40	—	+85	°C	—
Storage Temperature	T <sub>A</sub>	-65	—	+150	°C	—
Maximum Junction Temperature	T <sub>J</sub>	—	—	+125	°C	—
<b>Package Thermal Resistance</b>						
Thermal Resistance, QFN 16-Ld	θ <sub>JA</sub>	—	60	—	°C/W	Still-Air
	θ <sub>JA</sub>	—	54	—	°C/W	500 lfpm
	Ψ <sub>JB</sub>	—	32	—	°C/W	Junction-to-board, <a href="#">Note 2</a>

**Note 1:** The maximum allowable power dissipation is a function of ambient temperature, the maximum allowable junction temperature and the thermal resistance from junction to air (i.e., T<sub>A</sub>, T<sub>J</sub>, θ<sub>JA</sub>). Exceeding the maximum allowable power dissipation will cause the device operating junction temperature to exceed the maximum +125°C rating. Sustained junction temperatures above +125°C can impact the device reliability.

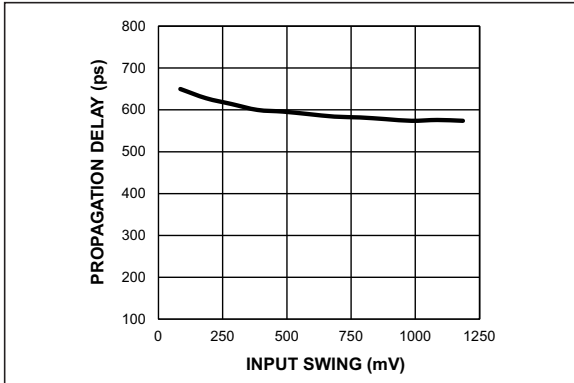
**2:** Junction-to-board resistance assumes that the exposed pad is soldered (or equivalent) to the device's most negative potential on the PCB.

# SY89874AU

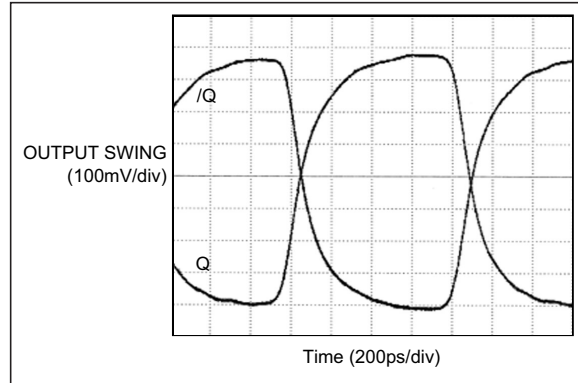
## 2.0 TYPICAL PERFORMANCE CURVES

**Note:** The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

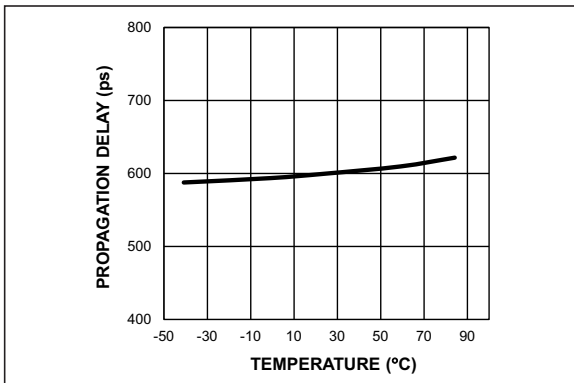
$V_{CC} = 3.3V$ ,  $V_{IN} = 400\text{ mV}$ ,  $T_A = +25^\circ\text{C}$ , unless otherwise stated.



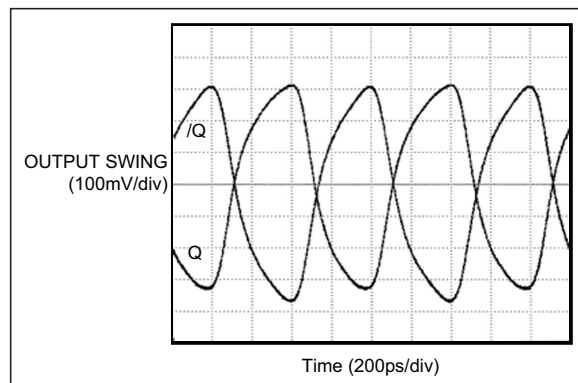
**FIGURE 2-1:** IN-to-Q Propagation Delay vs. Input Swing.



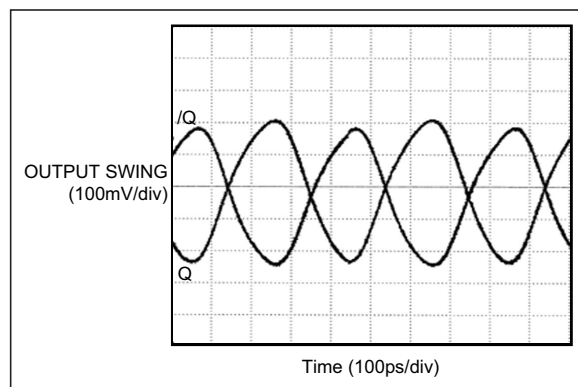
**FIGURE 2-3:** 622 MHz Output.



**FIGURE 2-2:** IN-to-Q Propagation Delay vs. Temperature.

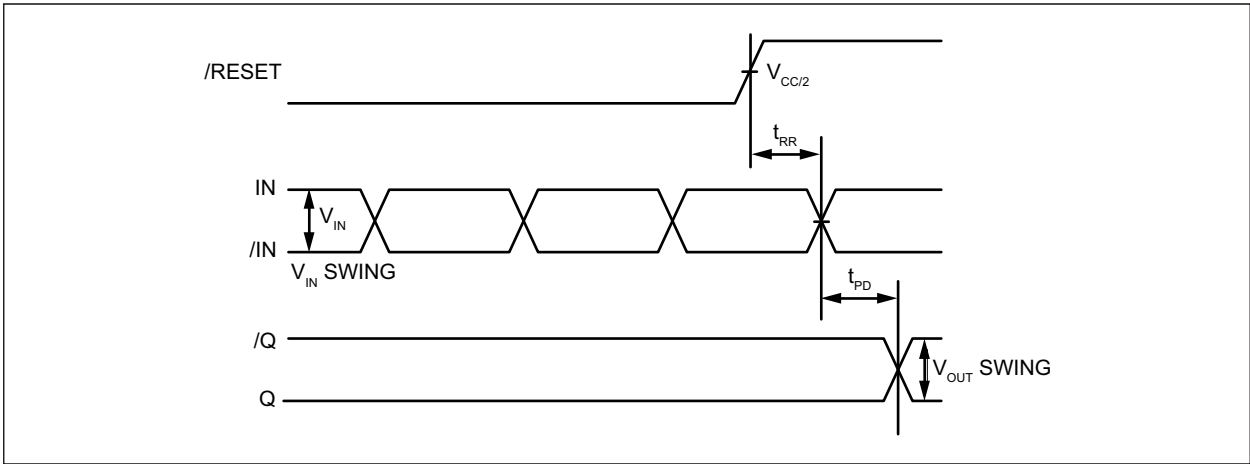


**FIGURE 2-4:** 1.25 GHz Output.

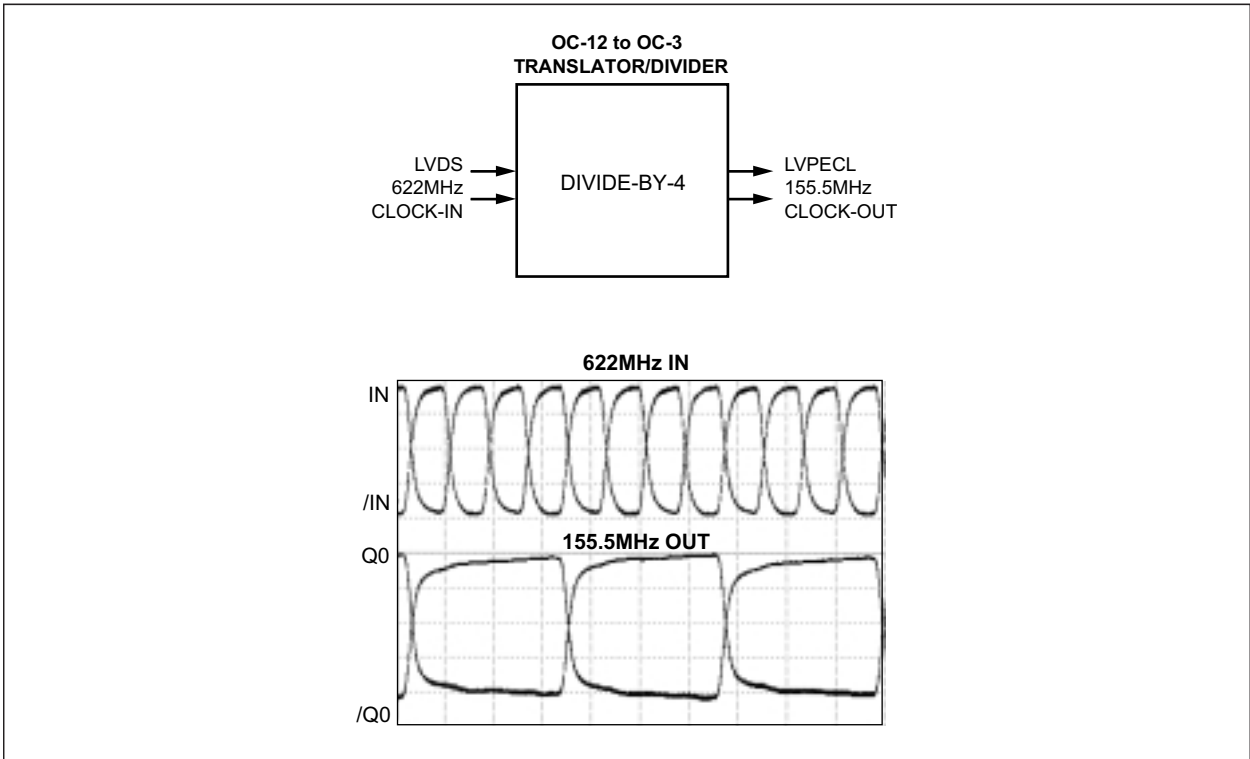


**FIGURE 2-5:** 2.5 GHz Output.

Timing Diagram



Typical Performance



# SY89874AU

## 3.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in [Table 3-1](#).

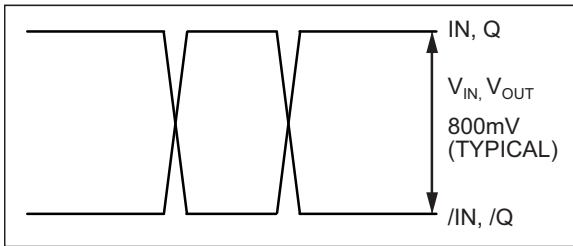
**TABLE 3-1: PIN FUNCTION TABLE**

Pin Number	Pin Name	Description
1, 2, 3, 4	Q0, /Q0 Q1, /Q1	Differential Buffered LVPECL Outputs. Divided by 1, 2, 4, 8, or 16. See the <a href="#">Truth Table</a> . Unused PECL outputs may be left floating with no impact on jitter performance.
16, 15, 5	S0, S1, S2	Select Pins. See the <a href="#">Truth Table</a> . LVTTTL/CMOS logic levels. Internal 25 k $\Omega$ pull-up resistor. Logic high if left unconnected (divided by 16 mode). Input threshold is $V_{CC}/2$ .
6	NC	No connect.
7, 14	VCC	Positive Power Supply. Bypass with 0.1 $\mu$ F/0.01 $\mu$ F low-ESR capacitor.
8	/RESET /DISABLE	LVTTTL/CMOS Logic Levels. Internal 25 k $\Omega$ pull-up resistor. Logic high if left unconnected. Apply low to reset the divider (divided by 2, 4, 8, or 16 mode). Also acts as a synchronous disable/enable function. The reset and disable function occurs on the next high-to-low clock input transition. Input threshold is $V_{CC}/2$ .
12, 9	IN, /IN	Input. Internal 50 $\Omega$ termination resistors to VT input. Flexible input accepts any input. See the "Input Interface Applications" section.
10	VREF-AC	Reference Voltage. Equal to $V_{CC} - 1.4V$ (approximately). Used for AC-coupled applications only. Decouple the VREF-AC pin with a 0.01 $\mu$ F capacitor. See the "Input Interface Applications" section.
11	VT	Termination Center Tap. For CML or LVDS inputs, leave this floating. Otherwise, see the figures in the "Input Interface Applications" section.
13	GND	Ground.



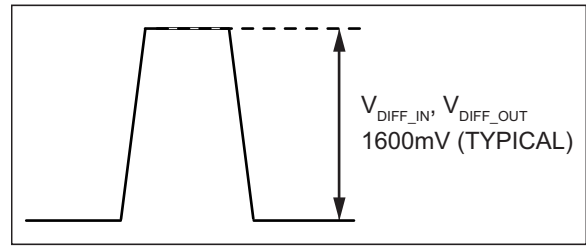
## 4.0 DIAGRAMS

### 4.1 Definition of Single-Ended and Differential Swing



**FIGURE 4-1:** Single-Ended Swing.

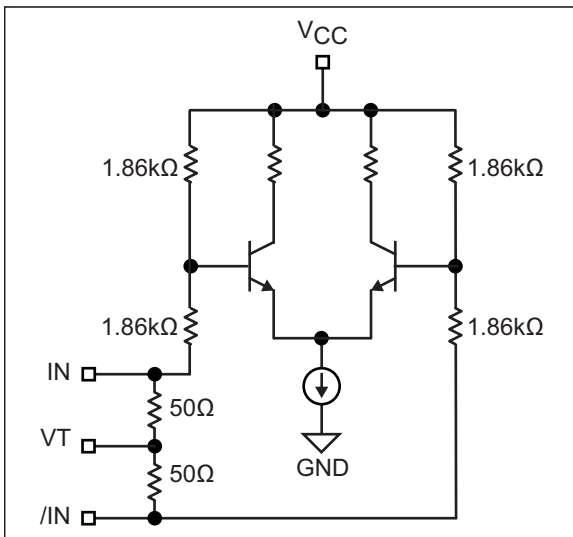
Single-ended swing is the amplitude of the signal when driven differentially.



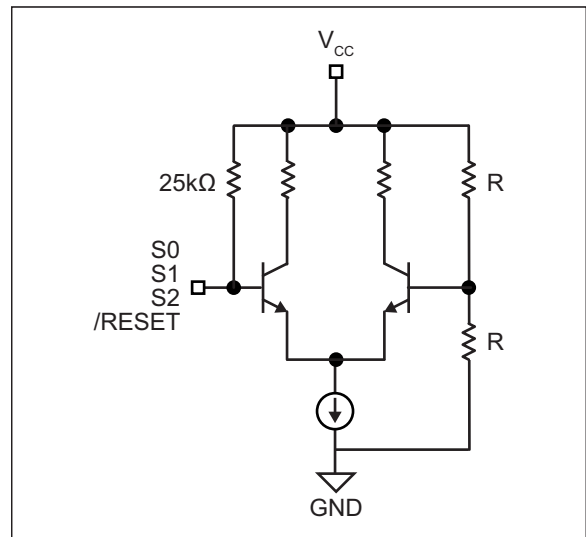
**FIGURE 4-2:** Differential Swing.

Differential swing is defined as  $IN - /IN$  (or  $Q - /Q$ ).

### 4.2 Input Buffer Structure



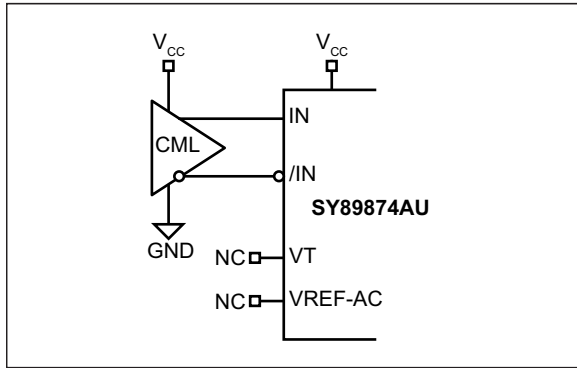
**FIGURE 4-3:** Single-Ended Input Structure.



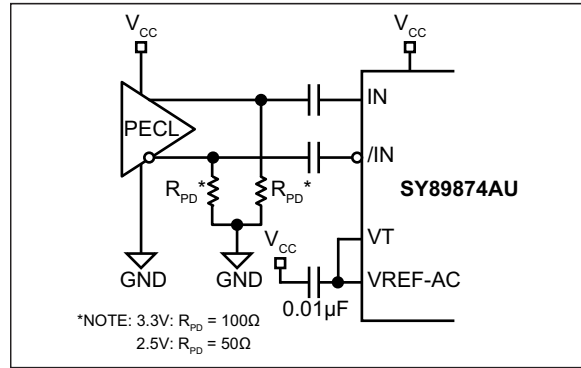
**FIGURE 4-4:** Differential Input Structure.

# SY89874AU

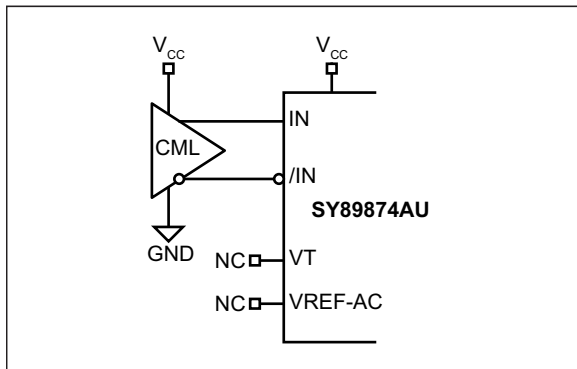
## 5.0 DIFFERENTIAL INPUT INTERFACE APPLICATIONS



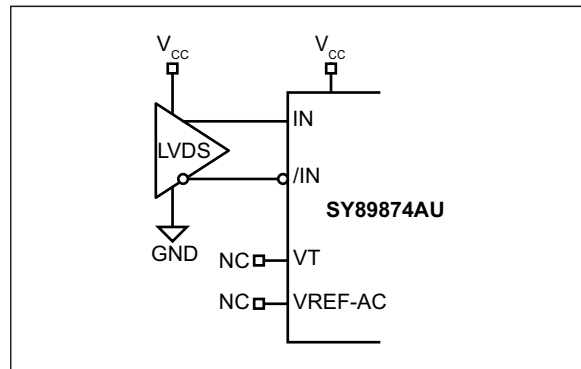
**FIGURE 5-1:** DC-Coupled CML Input Interface.



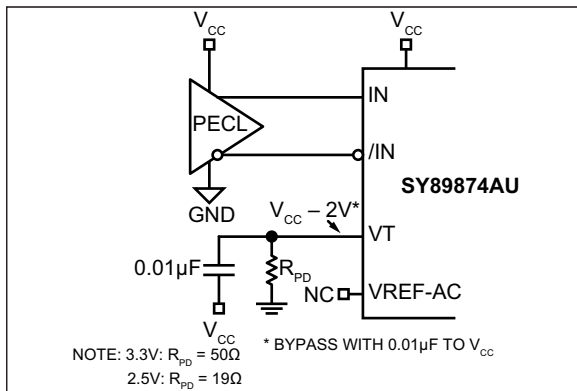
**FIGURE 5-4:** AC-Coupled PECL Input Interface.



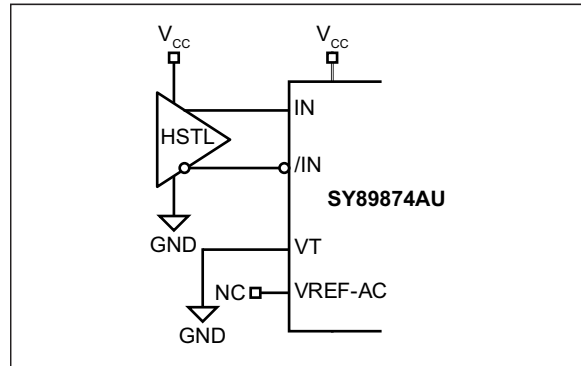
**FIGURE 5-2:** AC-Coupled CML Input Interface.



**FIGURE 5-5:** LVDS Input Interface.

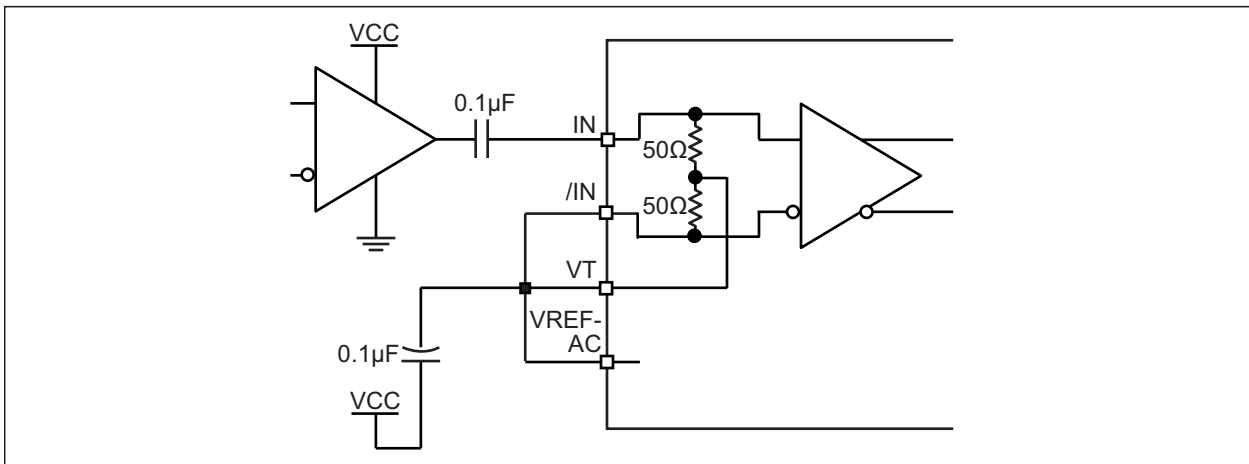


**FIGURE 5-3:** DC-Coupled PECL Input Interface.

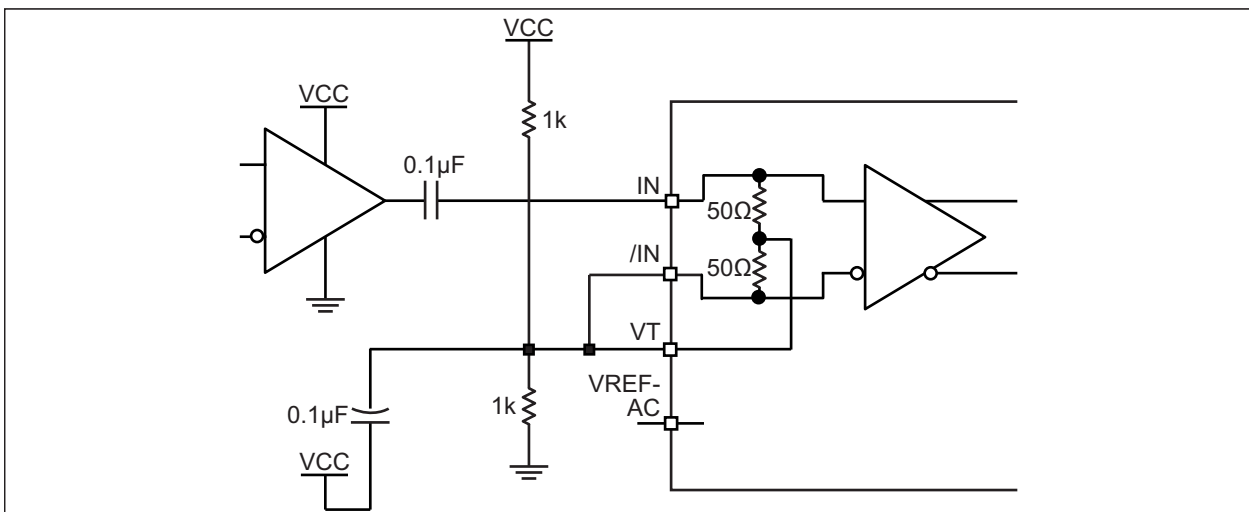


**FIGURE 5-6:** HSTL Input Interface.

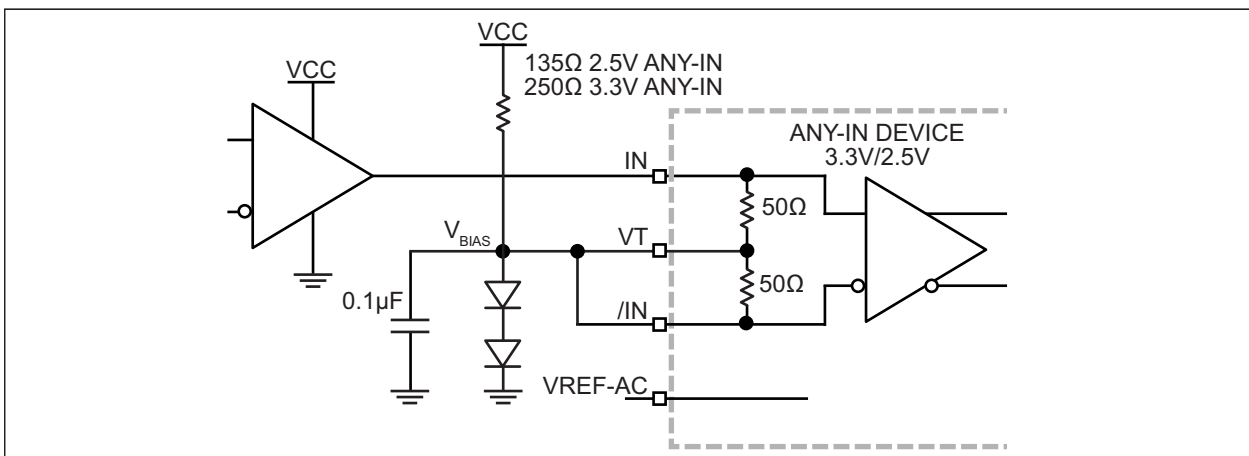
## 6.0 SINGLE-ENDED INPUT INTERFACE APPLICATIONS



**FIGURE 6-1:** AC-Coupled LVTTTL CLK Termination.



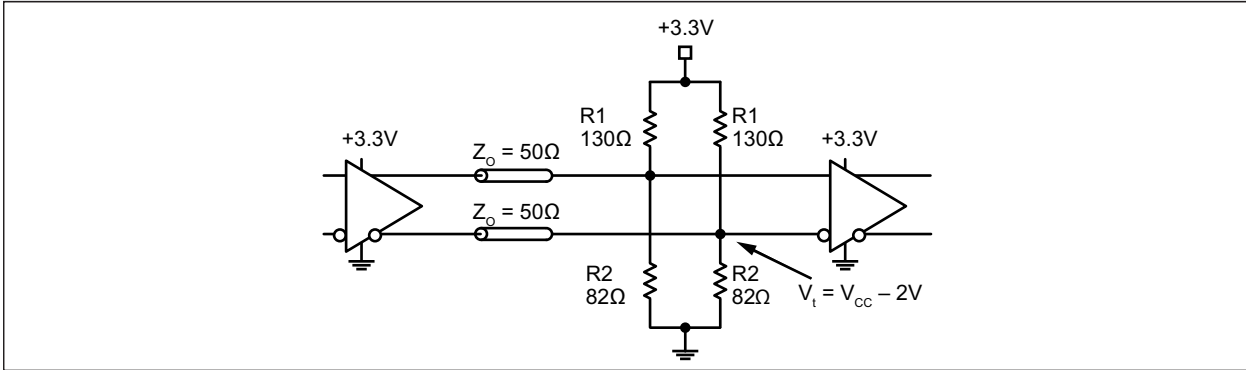
**FIGURE 6-2:** AC-Coupled CMOS CLK Termination.



**FIGURE 6-3:** DC-Coupled CLK Termination.

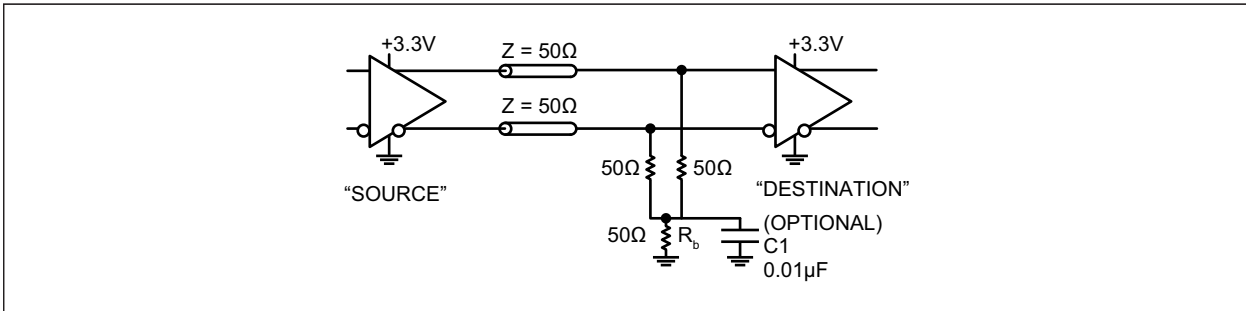
# SY89874AU

## 7.0 LVPECL OUTPUT TERMINATION RECOMMENDATIONS



**FIGURE 7-1:** Parallel Termination-Thevenin Equivalent.

**Note:** For +2.5V systems: R1 = 250Ω, R2 = 62.5Ω.



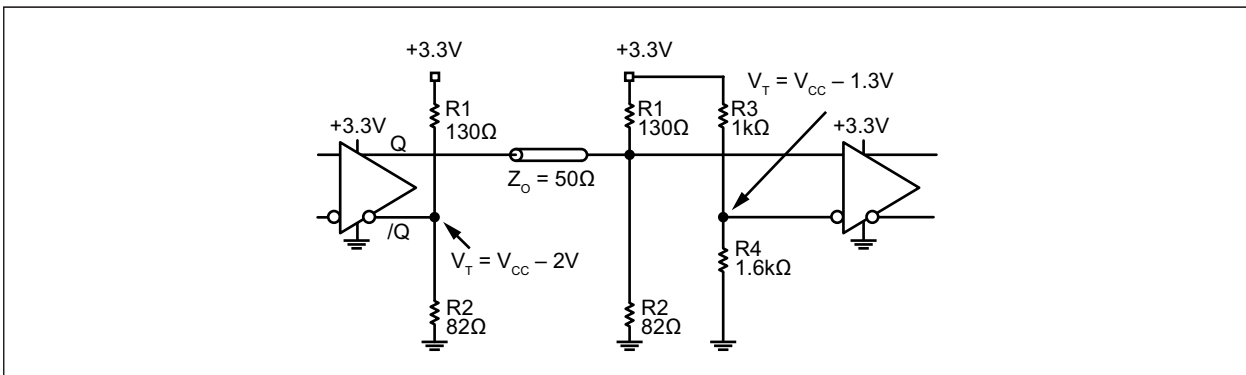
**FIGURE 7-2:** Three-Resistor "Y Termination".

**Note 1:** Power-saving alternative to Thevenin termination.

**2:** Place termination resistors as close to destination inputs as possible.

**3:** The  $R_b$  resistor sets the DC bias voltage, equal to  $V_T$ . For +3.3V systems:  $R_b = 46\Omega$  to  $50\Omega$ . For +2.5V systems:  $R_b = 19\Omega$ .

**4:** C1 is an optional bypass capacitor that compensates for any  $t_r/t_f$  mismatches.



**FIGURE 7-3:** Terminating Unused I/O.

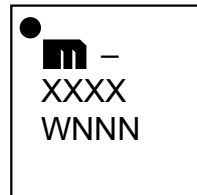
**Note 1:** Unused output (/Q) must be terminated to balance the output.

**2:** For +2.5V systems: R1 = 250Ω, R2 = 62.5Ω, R3 = 1.25 kΩ, R4 = 1.2 kΩ.

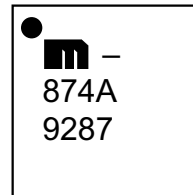
## 8.0 PACKAGING INFORMATION

### 8.1 Package Marking Information

16-Lead QFN\*



Example



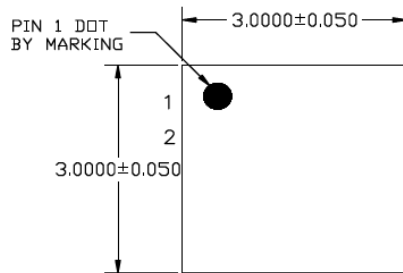
<b>Legend:</b>	XX...X	Product code or customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week '01')
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC® designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator ((e3)) can be found on the outer packaging for this package.
	•, ▲, ▼	Pin one index is identified by a dot, delta up, or delta down (triangle mark).
<b>Note:</b>	In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information. Package may or may not include the corporate logo.	
	Underbar ( _ ) and/or Overbar ( ¯ ) symbol may not be to scale.	

# SY89874AU

## TITLE

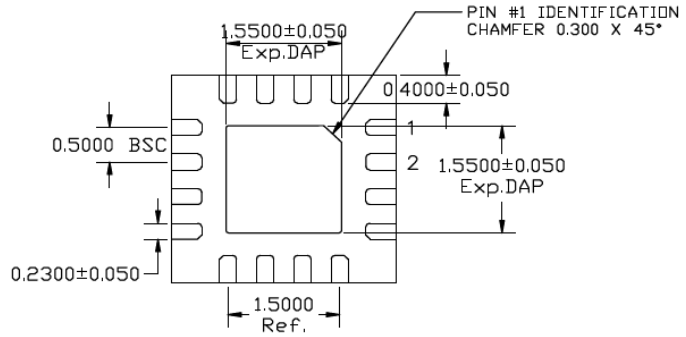
16 LEAD QFN 3x3mm PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

DRAWING #	QFN33-16LD-PL-1	UNIT	MM
-----------	-----------------	------	----



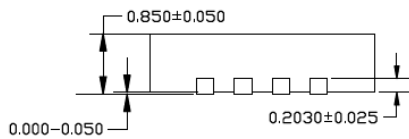
TOP VIEW

NOTE: 1, 2, 3



BOTTOM VIEW

NOTE: 1, 2, 3



SIDE VIEW

NOTE: 1, 2, 3

### NOTE:

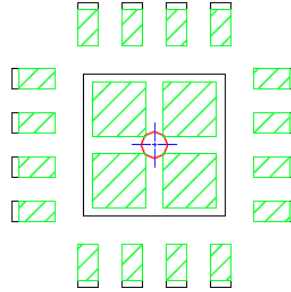
1. MAX PACKAGE WARPAGE IS 0.05 MM
2. MAX ALLOWABLE BURR IS 0.076 MM IN ALL DIRECTIONS
3. PIN #1 IS ON TOP WILL BE LASER MARKED
4. RED CIRCLE IN LAND PATTERN INDICATE THERMAL VIA. SIZE SHOULD BE 0.30-0.35 MM IN DIAMETER AND SHOULD BE CONNECTED TO GND FOR MAX THERMAL PERFORMANCE
5. GREEN RECTANGLES (SHADED AREA) indicate SOLDER STENCIL OPENING ON EXPOSED PAD AREA. SIZE SHOULD BE 0.60x0.60 MM IN SIZE, 0.20 MM SPACING.

Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>.

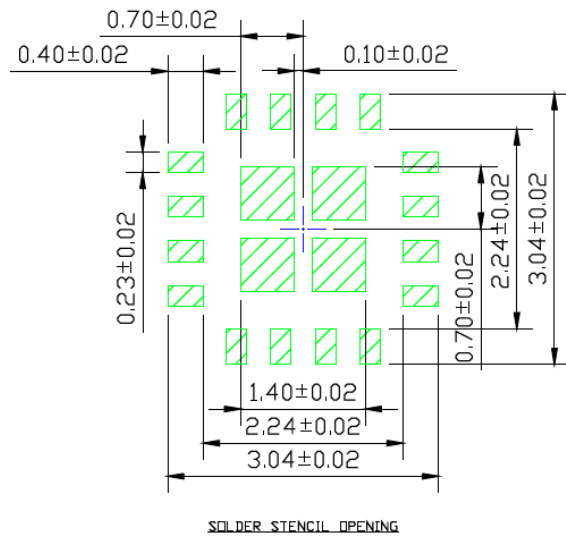
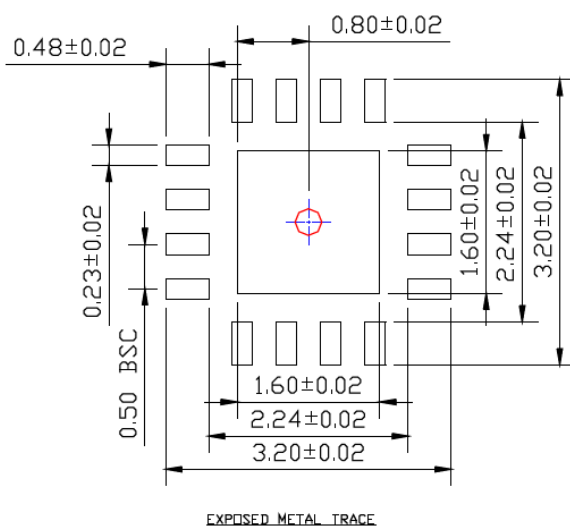
POD-Land Pattern drawing # QFN33-16LD-PL-1

## RECOMMENDED LAND PATTERN

NOTE: 4, 5



STACKED-UP



Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packageing>.

# SY89874AU

---

NOTES:



## APPENDIX A: REVISION HISTORY

### Revision A (June 2019)

- Converted Micrel document SY89874AU to Microchip data sheet DS20006200A.
- Minor text changes throughout.

# SY89874AU

---

NOTES:

## PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, contact your local Microchip representative or sales office.

<u>Part No.</u>	<u>X</u>	<u>X</u>	<u>X</u>	<u>-XX</u>	<b>Examples:</b>
Device	Supply Voltage	Package	Temp. Range	Packing	
<b>Device:</b>	SY89874A:	2.5 GHz, Any-In to LVPECL, Programmable Clock Divider/Fanout Buffer with Internal Termination			a) SY89874AUMG: SY89874A, 2.5V/3.3V Supply Voltage, 16-Lead QFN, -40°C to +85°C Temperature Range, 110/Tube  b) SY89874AUMG-TR: SY89874A, 2.5V/3.3V Supply Voltage, 16-Lead QFN, -40°C to +85°C Temperature Range, 1,000/Reel
<b>Supply Voltage:</b>	U	=	2.5V/3.3V		<b>Note 1:</b> Tape and Reel identifier only appears in the catalog part number description. This identifier is used for ordering purposes and is not printed on the device package. Check with your Microchip Sales Office for package availability with the Tape and Reel option.
<b>Package:</b>	M	=	16-Lead 3 mm x 3 mm QFN		
<b>Temperature Range:</b>	G	=	-40°C to +85°C (NiPdAu Lead-Free)		
<b>Tape and Reel:</b>	<blank>	=	110/Tube		
	TR	=	1,000/Reel		

# SY89874AU

---

NOTES:

---

**Note the following details of the code protection feature on Microchip devices:**

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as “unbreakable.”

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

---

Information contained in this publication regarding device applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION, INCLUDING BUT NOT LIMITED TO ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR PURPOSE. Microchip disclaims all liability arising from this information and its use. Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights unless otherwise stated.

### Trademarks

The Microchip name and logo, the Microchip logo, Adaptec, AnyRate, AVR, AVR logo, AVR Freaks, BesTime, BitCloud, chipKIT, chipKIT logo, CryptoMemory, CryptoRF, dsPIC, FlashFlex, flexPWR, HELDO, IGLOO, JukeBlox, KeeLoq, Klear, LANCheck, LinkMD, maXStylus, maXTouch, MediaLB, megaAVR, Microsemi, Microsemi logo, MOST, MOST logo, MPLAB, OptoLyzer, PackeTime, PIC, picoPower, PICSTART, PIC32 logo, PolarFire, Prochip Designer, QTouch, SAM-BA, SenGenuity, SpyNIC, SST, SST Logo, SuperFlash, Symmetricom, SyncServer, Tachyon, TempTrackr, TimeSource, tinyAVR, UNI/O, Vectron, and XMEGA are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

APT, ClockWorks, The Embedded Control Solutions Company, EtherSynch, FlashTec, Hyper Speed Control, HyperLight Load, IntelliMOS, Libero, motorBench, mTouch, Powermite 3, Precision Edge, ProASIC, ProASIC Plus, ProASIC Plus logo, Quiet-Wire, SmartFusion, SyncWorld, Temux, TimeCesium, TimeHub, TimePictra, TimeProvider, Vite, WinPath, and ZL are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Adjacent Key Suppression, AKS, Analog-for-the-Digital Age, Any Capacitor, AnyIn, AnyOut, BlueSky, BodyCom, CodeGuard, CryptoAuthentication, CryptoAutomotive, CryptoCompanion, CryptoController, dsPICDEM, dsPICDEM.net, Dynamic Average Matching, DAM, ECAN, EtherGREEN, In-Circuit Serial Programming, ICSP, INICnet, Inter-Chip Connectivity, JitterBlocker, KlearNet, KlearNet logo, memBrain, Mindi, MiWi, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, MultiTRAK, NetDetach, Omniscient Code Generation, PICDEM, PICDEM.net, PICKit, PICtail, PowerSmart, PureSilicon, QMatrix, REAL ICE, Ripple Blocker, SAM-ICE, Serial Quad I/O, SMART-I.S., SQI, SuperSwitcher, SuperSwitcher II, Total Endurance, TSHARC, USBCheck, VariSense, ViewSpan, WiperLock, Wireless DNA, and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

The Adaptec logo, Frequency on Demand, Silicon Storage Technology, and Symmcom are registered trademarks of Microchip Technology Inc. in other countries.

GestIC is a registered trademark of Microchip Technology Germany II GmbH & Co. KG, a subsidiary of Microchip Technology Inc., in other countries.

All other trademarks mentioned herein are property of their respective companies.

© 2019, Microchip Technology Incorporated, All Rights Reserved.

ISBN: 978-1-5224-4707-8

For information regarding Microchip's Quality Management Systems, please visit [www.microchip.com/quality](http://www.microchip.com/quality).



# MICROCHIP

## Worldwide Sales and Service

### AMERICAS

**Corporate Office**  
2355 West Chandler Blvd.  
Chandler, AZ 85224-6199  
Tel: 480-792-7200  
Fax: 480-792-7277  
Technical Support:  
<http://www.microchip.com/support>  
Web Address:  
[www.microchip.com](http://www.microchip.com)

#### Atlanta

Duluth, GA  
Tel: 678-957-9614  
Fax: 678-957-1455

#### Austin, TX

Tel: 512-257-3370

#### Boston

Westborough, MA  
Tel: 774-760-0087  
Fax: 774-760-0088

#### Chicago

Itasca, IL  
Tel: 630-285-0071  
Fax: 630-285-0075

#### Dallas

Addison, TX  
Tel: 972-818-7423  
Fax: 972-818-2924

#### Detroit

Novi, MI  
Tel: 248-848-4000

#### Houston, TX

Tel: 281-894-5983

#### Indianapolis

Noblesville, IN  
Tel: 317-773-8323  
Fax: 317-773-5453  
Tel: 317-536-2380

#### Los Angeles

Mission Viejo, CA  
Tel: 949-462-9523  
Fax: 949-462-9608  
Tel: 951-273-7800

#### Raleigh, NC

Tel: 919-844-7510

#### New York, NY

Tel: 631-435-6000

#### San Jose, CA

Tel: 408-735-9110  
Tel: 408-436-4270

#### Canada - Toronto

Tel: 905-695-1980  
Fax: 905-695-2078

### ASIA/PACIFIC

**Australia - Sydney**  
Tel: 61-2-9868-6733

**China - Beijing**  
Tel: 86-10-8569-7000

**China - Chengdu**  
Tel: 86-28-8665-5511

**China - Chongqing**  
Tel: 86-23-8980-9588

**China - Dongguan**  
Tel: 86-769-8702-9880

**China - Guangzhou**  
Tel: 86-20-8755-8029

**China - Hangzhou**  
Tel: 86-571-8792-8115

**China - Hong Kong SAR**  
Tel: 852-2943-5100

**China - Nanjing**  
Tel: 86-25-8473-2460

**China - Qingdao**  
Tel: 86-532-8502-7355

**China - Shanghai**  
Tel: 86-21-3326-8000

**China - Shenyang**  
Tel: 86-24-2334-2829

**China - Shenzhen**  
Tel: 86-755-8864-2200

**China - Suzhou**  
Tel: 86-186-6233-1526

**China - Wuhan**  
Tel: 86-27-5980-5300

**China - Xian**  
Tel: 86-29-8833-7252

**China - Xiamen**  
Tel: 86-592-2388138

**China - Zhuhai**  
Tel: 86-756-3210040

### ASIA/PACIFIC

**India - Bangalore**  
Tel: 91-80-3090-4444

**India - New Delhi**  
Tel: 91-11-4160-8631

**India - Pune**  
Tel: 91-20-4121-0141

**Japan - Osaka**  
Tel: 81-6-6152-7160

**Japan - Tokyo**  
Tel: 81-3-6880-3770

**Korea - Daegu**  
Tel: 82-53-744-4301

**Korea - Seoul**  
Tel: 82-2-554-7200

**Malaysia - Kuala Lumpur**  
Tel: 60-3-7651-7906

**Malaysia - Penang**  
Tel: 60-4-227-8870

**Philippines - Manila**  
Tel: 63-2-634-9065

**Singapore**  
Tel: 65-6334-8870

**Taiwan - Hsin Chu**  
Tel: 886-3-577-8366

**Taiwan - Kaohsiung**  
Tel: 886-7-213-7830

**Taiwan - Taipei**  
Tel: 886-2-2508-8600

**Thailand - Bangkok**  
Tel: 66-2-694-1351

**Vietnam - Ho Chi Minh**  
Tel: 84-28-5448-2100

### EUROPE

**Austria - Wels**  
Tel: 43-7242-2244-39  
Fax: 43-7242-2244-393

**Denmark - Copenhagen**  
Tel: 45-4450-2828  
Fax: 45-4485-2829

**Finland - Espoo**  
Tel: 358-9-4520-820

**France - Paris**  
Tel: 33-1-69-53-63-20  
Fax: 33-1-69-30-90-79

**Germany - Garching**  
Tel: 49-8931-9700

**Germany - Haan**  
Tel: 49-2129-3766400

**Germany - Heilbronn**  
Tel: 49-7131-72400

**Germany - Karlsruhe**  
Tel: 49-721-625370

**Germany - Munich**  
Tel: 49-89-627-144-0  
Fax: 49-89-627-144-44

**Germany - Rosenheim**  
Tel: 49-8031-354-560

**Israel - Ra'anana**  
Tel: 972-9-744-7705

**Italy - Milan**  
Tel: 39-0331-742611  
Fax: 39-0331-466781

**Italy - Padova**  
Tel: 39-049-7625286

**Netherlands - Drunen**  
Tel: 31-416-690399  
Fax: 31-416-690340

**Norway - Trondheim**  
Tel: 47-7288-4388

**Poland - Warsaw**  
Tel: 48-22-3325737

**Romania - Bucharest**  
Tel: 40-21-407-87-50

**Spain - Madrid**  
Tel: 34-91-708-08-90  
Fax: 34-91-708-08-91

**Sweden - Gothenberg**  
Tel: 46-31-704-60-40

**Sweden - Stockholm**  
Tel: 46-8-5090-4654

**UK - Wokingham**  
Tel: 44-118-921-5800  
Fax: 44-118-921-5820