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SY89296U

2.5V/3.3V 1.5GHz Precision LVPECL Programmable Delay with Fine Tune Control

Precision Edge®

General Description

The SY89296U is a programmable delay line that delays the input signal using a digital control signal. The delay can vary from 3.2ns to 14.8ns in 10ps increments. Further, the delay may be varied continuously in about 40ps range by setting the voltage at the FTUNE pin. In addition, the input signal is LVPECL, uses either a 2.5V ±5% or 3.3V ±10% power supply, and is guaranteed over the full industrial temperature range (–40°C to +85°C).

The delay varies in discrete steps based on a control word. The control word is 10-bits long and controls the delay in 10ps increments. The eleventh bit is D[10] and is used to simultaneously cascade the SY89296U for a larger delay range. In addition, the input pins IN and /IN default to an equivalent low state when left floating. Further, for maximum flexibility, the control register interface accepts CMOS or TTL level signals.

For applications that do not require an analog delay input, see the SY89295U. The SY89295U and SY89296U are part of Micrel's high-speed, Precision Edge® product line.

Data sheets and support documentation can be found on Micrel's web site at: www.micrel.com.

Precision Edge®

Features

- Precision LVPECL programmable delay time
- Guaranteed AC performance over temperature and voltage:
  - >1.5GHz f_{MAX}
  - <160ps rise/fall times
- Low jitter design:
  - <10ps$_{PP}$ total jitter
  - <2ps$_{RMS}$ cycle-to-cycle jitter
  - <1ps$_{RMS}$ random jitter
- Programmable delay range: 3.2ns to 14.8ns in 10ps increments
- Increased monotonicity over the MC100EP195
- ±10ps INL
- VBB output reference voltage
- Parallel inputs accept LVPECL or CMOS/LVTTL
- 40ps/V fine tune range
- Low voltage operation: 2.5V ±5% and 3.3V ±10%
- Industrial –40°C to +85°C temperature range
- Available in 32-pin (5mm × 5mm) MLF® package or 32-pin TQFP package

Applications

- Clock de-skewing
- Timing adjustments
- Aperture centering

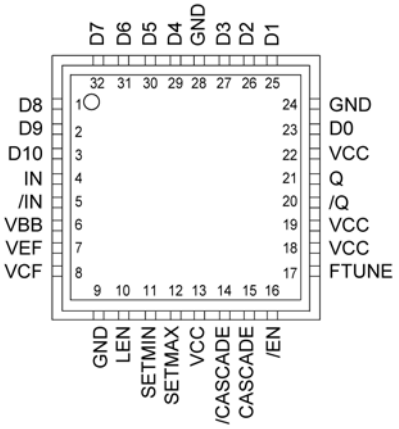
Ordering Information[1]

Part Number	Package Type	Operating Range	Package Marking	Lead Finish
SY89296UMI	MLF-32	–40°C to +85°C	SY89296U	Sn-Pb
SY89296UMITR[2]	MLF-32	–40°C to +85°C	SY89296U	Sn-Pb
SY89296UTI	T32-1	–40°C to +85°C	SY89296U	Sn-Pb
SY89296UTITR[2]	T32-1	–40°C to +85°C	SY89296U	Sn-Pb
SY89296UMG[3]	MLF-32	–40°C to +85°C	SY89296U with Pb-Free bar-line indicator	Pb-Free NiPdAu
SY89296UMGTR[2, 3]	MLF-32	–40°C to +85°C	SY89296U with Pb-Free bar-line indicator	Pb-Free NiPdAu
SY89296UTG[3]	T32-1	–40°C to +85°C	SY89296U with Pb-Free bar-line indicator	Pb-Free NiPdAu
SY89296UTGTR[2, 3]	T32-1	–40°C to +85°C	SY89296U with Pb-Free bar-line indicator	Pb-Free NiPdAu

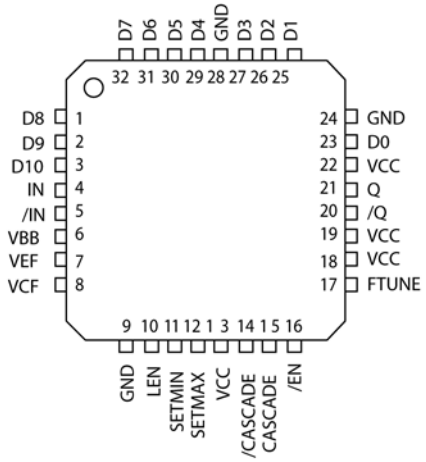
Notes:

1. Contact factory for die availability. Dice are guaranteed at T_A = 25°C, DC electricals only.
2. Tape and Reel.
3. Pb-Free package recommended for new designs.

Pin Configuration



32-Pin MLF® (MLF-32)



32-Pin TQFP (T32-1)

hbwhelp@micrel.com or (408) 955-1690

Pin Description

Pin Number	Pin Name	Pin Function	
23, 25, 26, 27, 29, 30, 31, 32, 1, 2	D[9:0]	CMOS, ECL, or TTL Control Bits: These control signals adjust the delay from IN to Q. See "AC Electrical Characteristics" for delay values. In addition, see "Interface Applications" section which illustrates the proper interfacing techniques for different logic standards. D[9:0] contains pull-downs and defaults LOW when left floating. D0 (LSB), and D9 (MSB). See "Typical Operating Characteristics" for delay information.	
3	D10	CMOS, ECL, or TTL Control Bit: This bit is used to cascade devices for an extended delay range. In addition, it drives CASCADE and /CASCADE. Further, D[10] contains a pull-down and defaults LOW when left floating.	
4, 5	IN, /IN	LVPECL/ECL Signal Input: Input signal to be delayed. IN contains a 75kΩ pull-down and will default to a logic LOW if left floating.	
6	VBB[1]	Reference Voltage Output: When using a single-ended input signal source to IN or /IN, connect the unused input of the differential pair to this pin. This pin can also be used to rebias AC-coupled inputs to IN and /IN. When used, de-couple to V_{CC} using a 0.01µF capacitor, otherwise leave floating if not used. Maximum sink/source is ±0.5mA.	
7	VEF	Reference Voltage Output: Connect this pin to V_{CF} when D[9:0], and D[10] is ECL.	
		Logic Standard	**V_{CF} Connects to:**
		LVPECL	V_{EF}**(1)**
		CMOS	No Connect
		TTL	1.5V Source
8	VCF	Reference Voltage Input: The voltage driven on VCF sets the logic transition threshold for D[9:0], and D[10].	
9, 24, 28	GND, Exposed Pad[2]	Negative Supply: For MLF® package, exposed pad must be connected to a ground plane that is the same potential as the ground pin.	
10	LEN	ECL Control Input: When HIGH latches the D[9:0] and D[10] bits. When LOW, the D[9:0] and D[10] latches are transparent.	
11	SETMIN	ECL Control Input: When HIGH, D[9:0] registers are reset. When LOW, the delay is set by SETMAX or D[9:0] and D[10]. SETMIN contains a pull-down and defaults LOW when left floating.	
12	SETMAX	ECL Control Input: When SETMAX is set HIGH and SETMIN is set LOW, D[9:0] = 1111111111. When SETMAX is LOW, the delay is set by SETMIN or D[9:0] and D[10]. SETMAX contains a pull-down and defaults LOW when left floating.	
13, 18, 19, 22	VCC	Positive Power Supply: Bypass with 0.1µF and 0.01µF low ESR capacitors.	
14, 15	/Cascade, Cascade	LVPECL Differential Output: The outputs are used when cascading two or more SY89296U to extend the delay range.	
16	/EN	LVPECL Single-Ended Control Input: When LOW, Q is delayed from IN. When HIGH, Q is a differential LOW. /EN contains a pull-down and defaults LOW when left floating.	
20, 21	/Q, Q	LVPECL Differential Output: Q is a delayed version of IN, Always terminates the output with 50Ω to VCC – 2V. See "Output Interface Applications" section.	
17	FTUNE	Voltage Control Input: By varying the voltage, the delay is fine tuned, see the graph, "Propagation Delay vs. FTUNE Voltage." Leave pin floating if not used.	

Notes:

1. Single-ended operation is only functional at 3.3V.
2. MLF® package only.

Truth Tables

Input/Output

Inputs		Outputs	
IN	/IN	OUT	/OUT
0	1	0	1
1	0	1	0

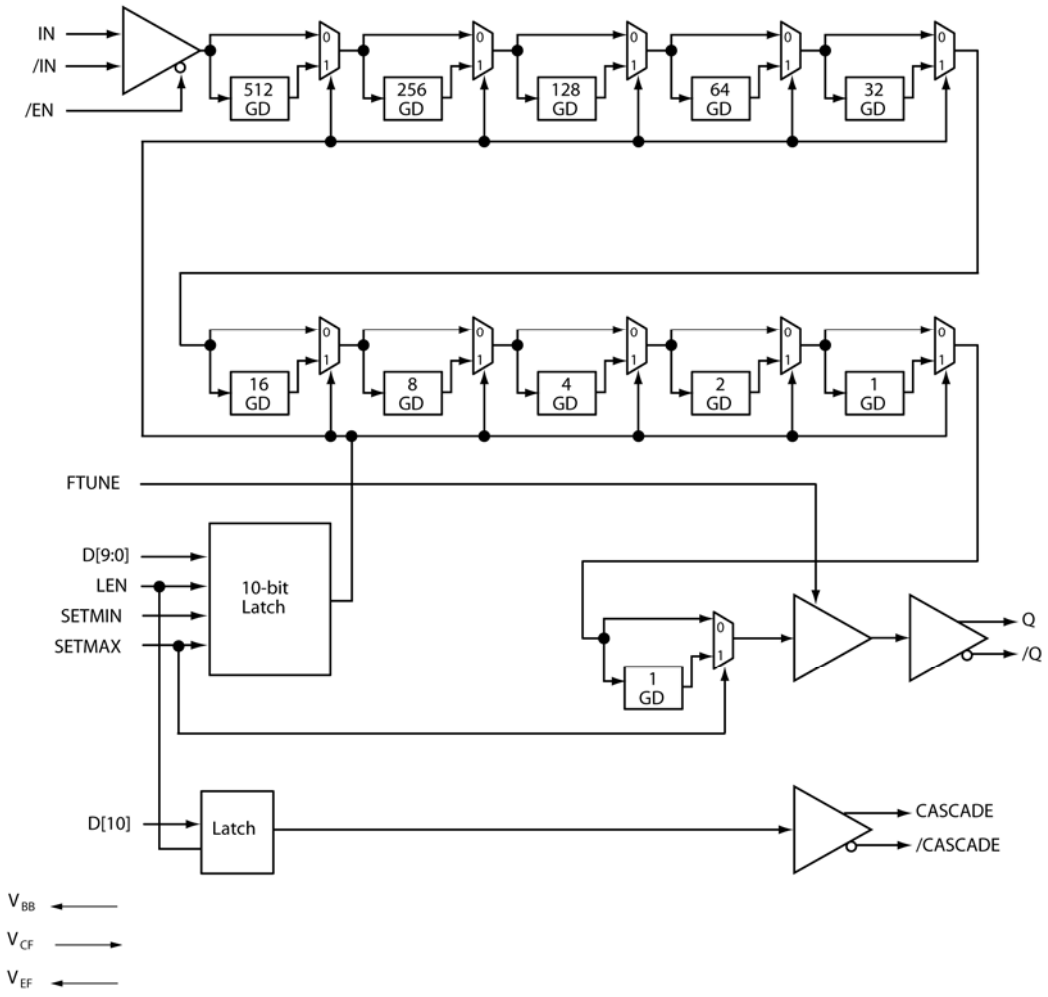
Digital Control Latch

LEN	Latch Action
0	Pass Through D[10:0]
1	Latched D[10:0]

Input Enable

/EN	Q, /Q
0	IN, /IN Delayed
1	Latched D[10:0]

Functional Block Diagram



SY89296U Block Diagram

Absolute Maximum Ratings[1]

Supply Voltage (V_{CC}) ..... –0.5V to +4.0V
Input Voltage (V_{IN}) ..... –0.5V to V_{CC}
LVPECL Output Current (I_{OUT})
  Continuous 50mA
  Surge 100mA
Lead Temperature (soldering, 20sec.) ..... +260°C
Storage Temperature (T_s) ..... –65°C to +150°C

Operating Ratings[2]

Supply Voltage (V_{IN}) ..... +2.375V to +3.6V
Ambient Temperature (T_A) ..... –40°C to +85°C
Package Thermal Resistance
  MLF® (θ_{JA})
    Still-Air ..... 35°C/W
  MLF® (Ψ_{JB})
    Junction-to-Board ..... 28°C/W
  TQFP (θ_{JA})
    Still-Air ..... 28°C/W
  TQFP (Ψ_{JB})
    Junction-to-Board ..... 20°C/W

DC Electrical Characteristics[4]

T_A = –40°C to +85°C, unless otherwise stated.

Symbol	Parameter	Condition	Min.	Typ.	Max.	Units
VCC	Power Supply	VCC = 2.5V	2.375	2.5	2.625	V
		VCC = 3.3V	3	3.3	3.6	
IEE	Power Supply Current	No load, max. VCC			220	mA
VIN	Input Voltage Swing (IN, /IN)	See Figure 1a.	150		1200	mV
VDIFF_IN	Differential Input Voltage Swing (IN, /IN)	See Figure 1b.	300		2400	mV
VIHCMR	Input High Common Mode Range	IN, /IN	VEE + 1.2		VCC	V

V_{CC} = 3.3V, T_A = –40°C to +85°C, unless otherwise stated.

Symbol	Parameter	Condition	Min.	Typ.	Max.	Units
V_{IH}	Input High Voltage (IN, /IN)		2.075		2.420	V
V_{IL}	Input Low High Voltage (IN, /IN)		1.355		1.675	V
V_{BB}	Output Voltage Reference		1.775	1.875	1.975	V
V_{EF}	Mode Connection		1.9	2.0	2.1	V
V_{CF}	Input Select Voltage		1.55	1.65	1.75	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 Rating” 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. Thermal performance on MLF® packages assumes exposed pad is soldered (or equivalent) to the device most negative potential (GND).
4. The circuit is designed to meet the DC specifications shown in the table above after thermal equilibrium has been established. Input and output parameters vary 1:1 with V_{CC}, with the exception of V^{CF}.

DC Electrical Characteristics[4] (Continued)

V_{CC} = 2.5V, T_A = –40°C to +85°C, unless otherwise stated.

Symbol	Parameter	Condition	Min.	Typ.	Max.	Units
V_{IH}	Input High Voltage (IN, /IN)		1.275		1.62	V
V_{IL}	Input Low High Voltage (IN, /IN)		0.555		0.875	V
V_{BB}	Output Voltage Reference		0.925	1.075	1.175	V
V_{EF}	Mode Connection		1.10	1.20	1.30	V
V_{CF}	Input Select Voltage		1.15	1.25	1.35	V

LVPECL Outputs DC Electrical Characteristics[5]

V_{CC} = 3.3V, T_A = –40°C to +85°C; R_{LOAD} = 500Ω to V_{CC} – 2V, unless noted.

Symbol	Parameter	Condition	Min.	Typ.	Max.	Units
V_{OH}	Output HIGH Voltage (Q, /Q)		2.155	2.280	2.405	V
V_{OL}	Output LOW Voltage (Q, /Q)		1.355	1.480	1.605	V
V_{OUT}	Output Voltage Swing (Q, /Q)	See Figure 1a.	550	800		mV
V_{DIFF_OUT}	Differential Output Voltage Swing (Q, /Q)	See Figure 1b.	1.1	1.6		V

V_{CC} = 2.5V, T_A = –40°C to +85°C; R_{LOAD} = 50Ω to V_{CC} – 2V, unless noted.

Symbol	Parameter	Condition	Min.	Typ.	Max.	Units
V_{OH}	Output HIGH Voltage (Q, /Q)		1.355	1.48	1.605	V
V_{OL}	Output LOW Voltage (Q, /Q)		0.555	0.680	0.805	V
V_{OUT}	Output Voltage Swing (Q, /Q)	See Figure 1a.	550	800		mV
V_{DIFF_OUT}	Differential Output Voltage Swing (Q, /Q)	See Figure 1b.	1.1	1.6		V

LVTTL/CMOS Outputs DC Electrical Characteristics[6]

V_{CC} = 2.5V ±5% or 3.3V ±10%; T_A = –40°C to +85°C; unless noted.

Symbol	Parameter	Condition	Min.	Typ.	Max.	Units
VCC	Power Supply	VCC = 2.5V	2.375	2.5	2.625	V
		VCC = 3.3V	3	3.3	3.6	
IEE	Power Supply Current	No load, max. VCC			220	mA
VIN	Input Voltage Swing (IN, /IN)	See Figure 1a.	150		1200	mV
VDIFF_IN	Differential Input Voltage Swing (IN, /IN)	See Figure 1b.	300		2400	mV

Notes:

5. The circuit is designed to meet the DC specifications shown in the table above after thermal equilibrium has been established. V_{OH} and V_{OL} parameters vary 1:1 with V_{CC}.
6. The circuit is designed to meet the DC specifications shown in the table above after thermal equilibrium has been established

AC Electrical Characteristics[7]

T_A = –40°C to +85°C, unless otherwise stated.

Symbol	Parameter	Condition	Min.	Typ.	Max.	Units
f_{MAX}	Maximum Operating Frequency	Clock	1.5			GHz
t_{PD}	Propagation Delay					ps
	IN to Q; D[0–10]=0		3200		4200	
	IN to Q; D[0–10]=1023		11500		14800	
	/EN to Q: D[0–10]=0		3400		4400	
	D10 to CASCADE		350		670	
t_{RANGE}	Programmable Range t_{pd} (max.) – t_{pd} (min.)		8300			ps
t_{SKEW}	Duty Cycle Skew $t_{PHL} – t_{PLH}$	**Note 8**			25	ps
Δt	Step Delay					ps
	D0 High			10		
	D1 High			15		
	D2 High			35		
	D3 High			70		
	D4 High			145		
	D5 High			290		
	D6 High			575		
	D7 High			1150		
	D8 High			2300		
	D9 High			4610		
	D0 – D9 High			9220		
INL	Integral Non-Linearity	**Note 9**		±10		ps

Notes:

7. High-frequency AC electricals are guaranteed by design and characterization.
8. Duty cycle skew guaranteed only for differential operation measured from the crosspoint of the input to the crosspoint of the output.
9. INL (Integral Non-Linearity) is defined from its corresponding point on the ideal delay vs. D[9:0] curve as the deviation from its ideal delay. The maximum difference is the INL. Theoretical Ideal Linearity (TIL) = measured maximum delay – measured minimum delay) ÷ 1024. INL = measured delay – measured minimum delay + (step number × TIL).

AC Electrical Characteristics[7] (Continued)

T_A = –40°C to +85°C, unless otherwise stated.

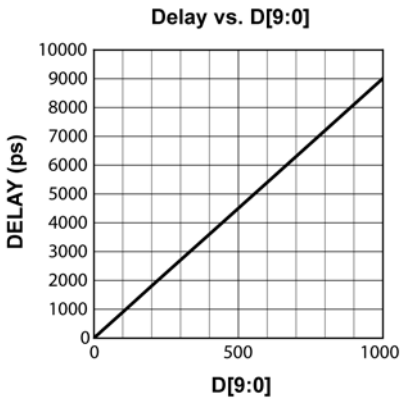
Symbol	Parameter	Condition	Min.	Typ.	Max.	Units
t_S	Set-Up Time					ps
	D t+o LEN	**Note 10**	200			
	D to IN	**Note 11**	350			
	/EN to IN		300			
t_H	Hold Time					ps
	LEN to D		200			
	IN to /EN	**Note 12**	400			
t_R	Release Time					ps
	/EN to IN		500			
	SETMAX to LEN		500			
	SETMIN to LEN		450			
t_{JITTER}	Cycle-to-Cycle Jitter	**Note 13**			2	ps_{RMS}
	Total Jitter	**Note 14**			10	ps_{PP}
	Random Jitter	**Note 15**			1	ps_{RMS}
t_r, t_f	Output Rise/Fall Time	20% to 80% (Q)	50	85	160	ps
		20% to 80% (CASCADE)	90		300	ps
	Duty Cycle		45		55	%
f_T	F_{TUNE}	$0 \le F_{TUNE} \le 1.25V$		47	52	Ps/V

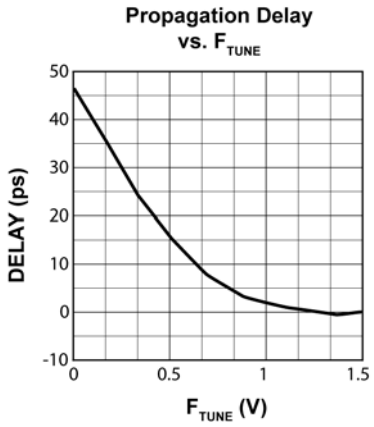
Notes:

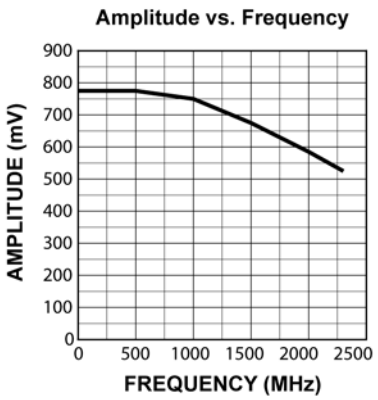
10. This setup time defines the amount of time prior to the input signal. The delay tap of the device must be set.
11. This setup time defines the amount of the time that /EN must be asserted prior to the next transition of IN, /IN to prevent an output response greater than ±75mV to the IN, /IN transition.
12. Hold time is the minimum time that /EN must remain asserted after a negative going IN or a positive going /IN to prevent an output response greater than ±75mV to that IN, /IN transition .
13. Cycle-to-cycle jitter definition: the variation of periods 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.
14. Total jitter definition: with an ideal clock input, no more than one output edge in 10^{12} output edges will deviate by more than the specified peak-to-peak jitter value.
15. Random jitter definition: jitter that is characterized by a Gaussian distribution, unbounded and is quantified by its standard deviation and mean. Random jitter is measured with a K28.7 comma defect pattern, measured at 1.5Gbps.

Typical Operating Characteristics

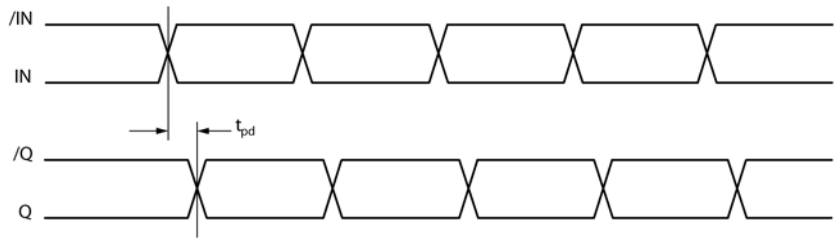
V_{CC} = 3.3V, GND = 0, D_{IN} = 100mV, T_A = 25°C, unless otherwise noted.







Timing Diagram



Single-Ended and Differential Swings

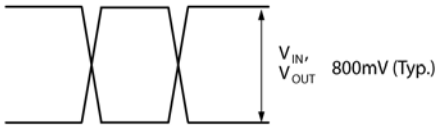


Figure 1a. Single-Ended Voltage Swing

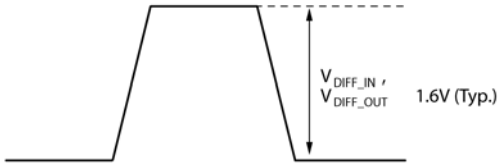


Figure 1b. Differential Voltage Swing

Input and Output Stages

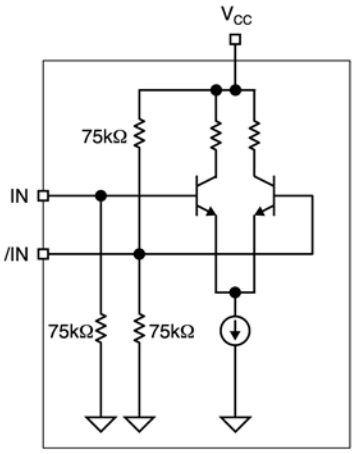


Figure 2a. Differential Input Stage

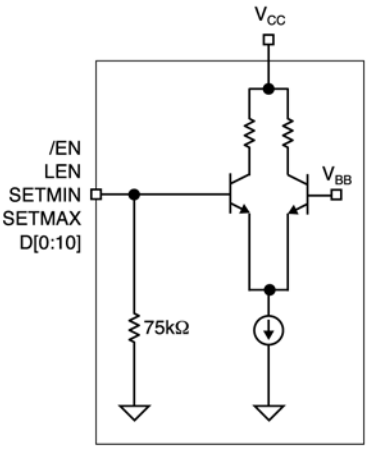


Figure 2b. Single-Ended Input Stage

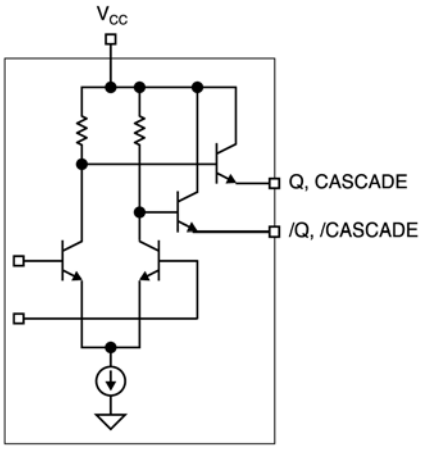


Figure 3. LVPECL Output Stage

Output Interface Applications

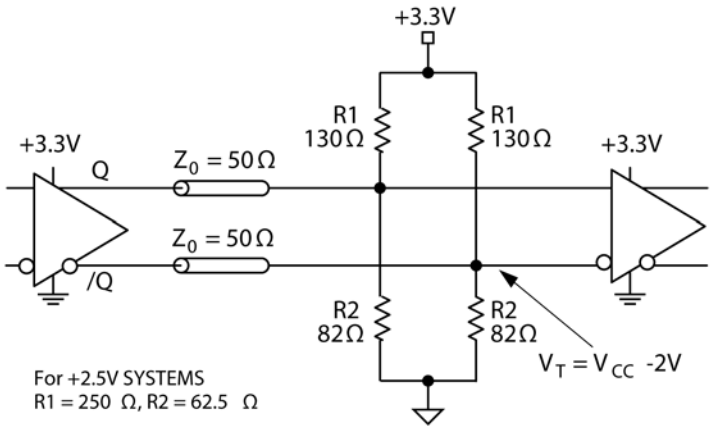


Figure 4. Parallel Termination

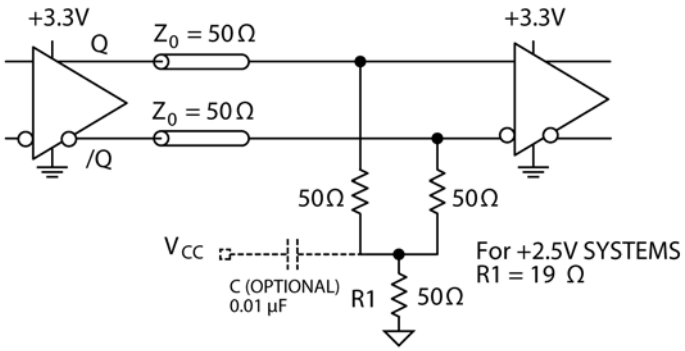


Figure 5. Y-Termination

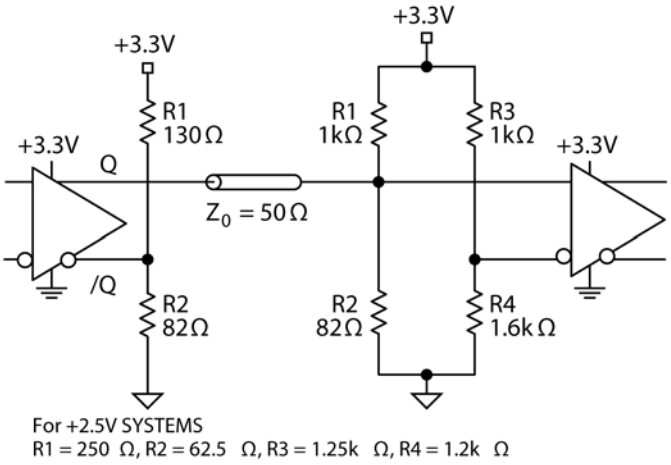


Figure 6. Terminating Unused I/O

hbwhelp@micrel.com or (408) 955-1690

Application Information

For best performance, use good high frequency layout techniques, filter V_{CC} supplies, and keep ground connections short. Use multiple vias where possible. Also, use controlled impedance transmission lines to interface with the SY89296U data inputs and outputs.

V_{BB} Reference

The VBB pin is an internally generated reference and is available for use only by the SY89296U. When unused, this pin should be left unconnected. The two common uses for V_{BB} are to handle a single-ended PECL input, and to re-bias inputs for AC-coupling applications.

If either IN or /IN is driven by a single-ended output, V_{BB} is used to bias the unused input. Please refer to Figure 10. The PECL signal driving the SY89296U may optionally be inverted in this case.

When the signal is AC-coupled, V_{BB} is used, as shown in Figure 13, to re-bias IN and/or /IN. This ensures that SY89296U inputs are within acceptable common mode range.

In all cases, V_{BB} current sinking or sourcing must be limited to 0.5mA or less.

Setting D Input Logic Thresholds

In all designs where the SY89296U GND supply is at zero volts, the D inputs can accommodate CMOS and TTL level signals, as well as PECL or LVPECL. Figures 11, 12, and 14 show how to connect VCF and VEF for all possible cases.

Cascading

Two or more SY89296U may be cascaded in order to extend the range of delays permitted. Each additional SY89296U adds about 3.2ns to the minimum delay and adds another 10240ps to the delay range.

Internal cascade circuitry has been included in the SY89296U. Using this internal circuitry, the SY89296U may be cascaded without any external gating.

Examples of cascading 2, 3, or 4 SY89296U appear in Figures 7, 8, and 9.

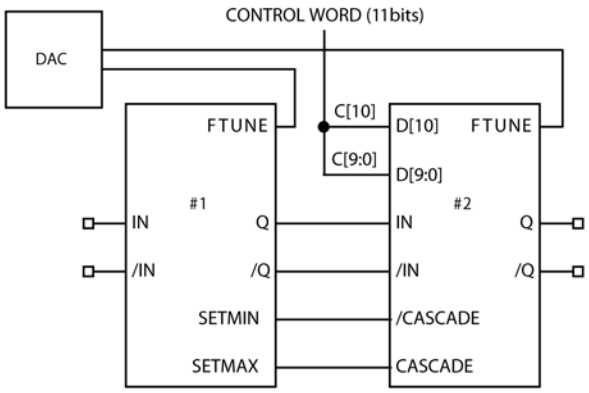


Figure 7. Cascading Two SY89296U

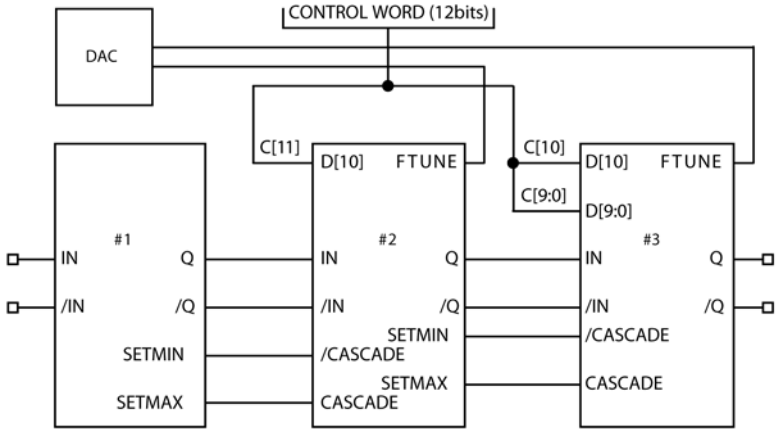


Figure 8. Cascading Three SY89296U

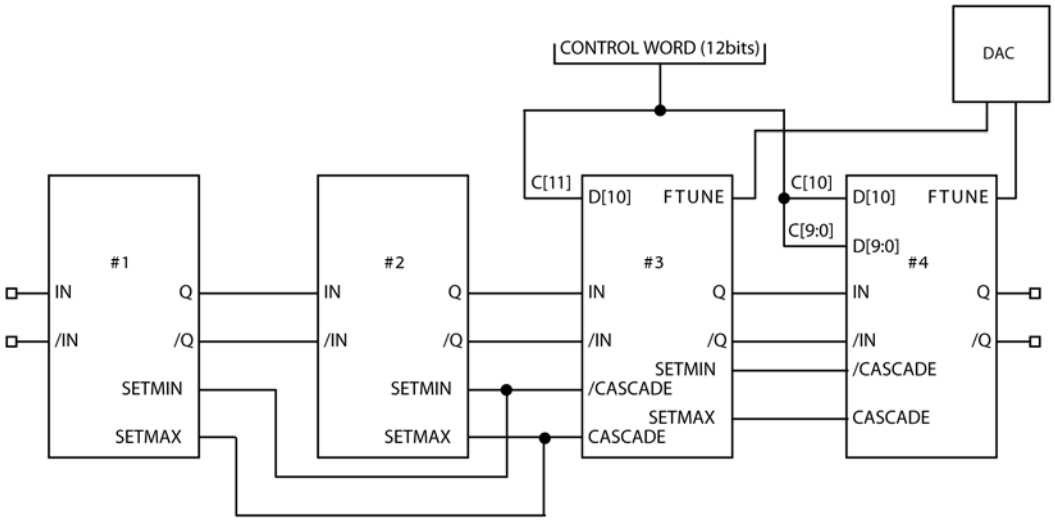


Figure 9. Cascading Four SY896296U

hbwhelp@micrel.com or (408) 955-1690

Interface Applications

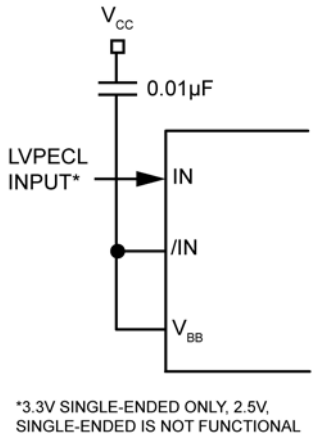


Figure 10. Interfacing to a Single-Ended LVPECL Signal
To invert the signal, connect the LVPECL input to /IN and connect V_{CC} to IN

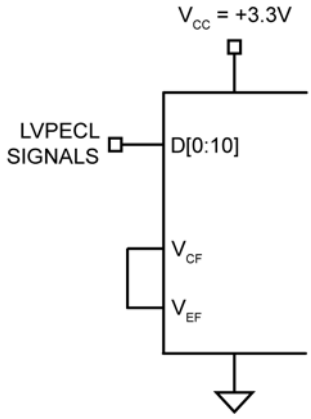


Figure 11. V_{CF} / V_{EF} Biasing for LVPECL Control (D) Input

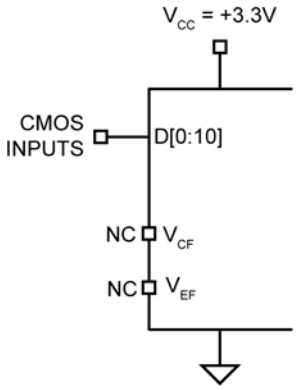


Figure 12. V_{CF} / V_{EF} Biasing for CMOS Control (D) Input

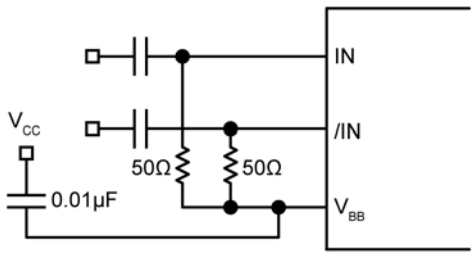


Figure 13. Re-Biasing an AC-Coupled Signal

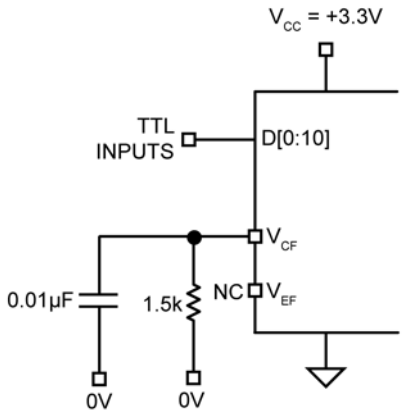
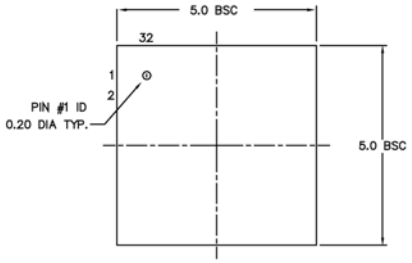


Figure 14. V_{CF} / V_{EF} Biasing for LVTTL Control (D) Input

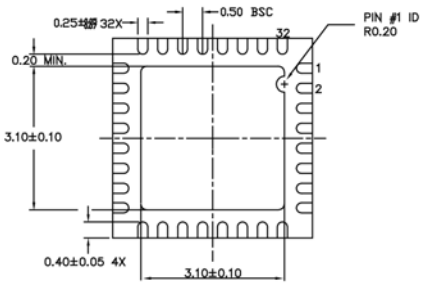
Related Product and Support Documentation

Part Number	Function	Data Sheet Link
SY89295U	2.5/3.3V 1.5GHz Precision LVPECL Programmable Delay	www.micrel.com/product-info/products/sy89295u.shtml
SY89296U	2.5/3.3V 1.5GHz Precision LVPECL Programmable Delay with Fine Tune Control	www.micrel.com/product-info/products/sy89296u.shtml
	16-MLF® Manufacturing Guidelines Exposed Pad Application Note	www.amkor.com/products/notes_papers/MLF_appnote_0902.pdf
	HBW Solutions	www.micrel.com/product-info/as/solutions.shtml

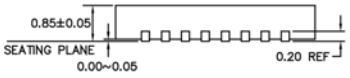
Package Information



TOP VIEW

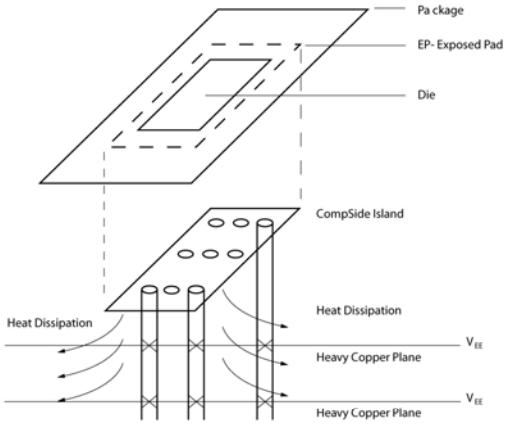


BOTTOM VIEW



SIDE VIEW

NOTE:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. MAX. PACKAGE WARPAGE IS 0.05 mm.
3. MAXIMUM ALLOWABE BURRS IS 0.076 mm IN ALL DIRECTIONS.
4. PIN #1 ID ON TOP WILL BE LASER/INK MARKED.

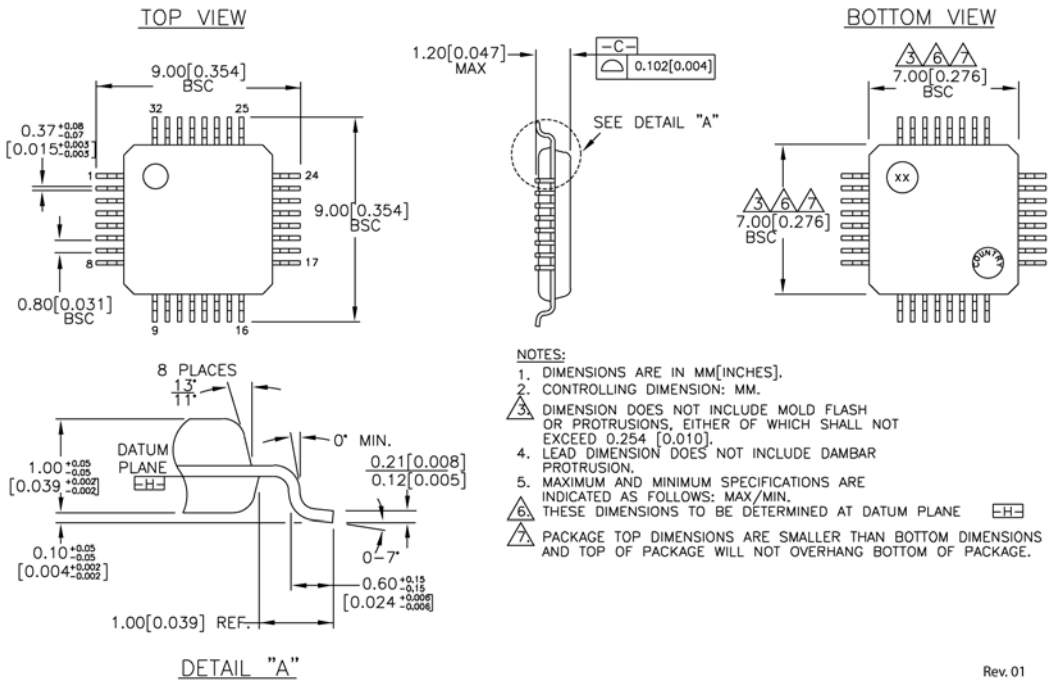


PCB Thermal Consideration for 32-Pin MLF * Package
(Always solder, or equivalent, the exposed pad to the PCB)

Package Notes:
1. Package meets Level 2 qualification.
2. All parts are dry-packaged before shipment.
3. Exposed pads must be soldered to a ground for proper thermal management.

32-Pin MLF® (MLF-32)

Package Information (Continued)



32-Pin TQFP (T32-1)

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