

### TEST AND MEASUREMENT PRODUCTS

#### Description

The Edge629 is a monolithic timing delay and signal fanout solution manufactured in a high-performance bipolar process. In Automatic Test Equipment (ATE) applications, the Edge629 buffers, distributes, and aligns timing signals across multiple channels (typically found inside Memory Test Systems). It is also suitable for per pin deskew in Logic Testers.

The Edge629 supports:

- Minimum pulse width = 330 ps with Falling Edge Adjust disabled, 500 ps with Falling Edge Adjust enabled
- Net usable delay span  $\geq 4.0$  ns
- Falling Edge Adjust  $\pm 250$  ps
- On Board DACs to generate 5 ps resolution

With a maximum operating frequency of 1 GHz, the Edge629 is optimized for extremely high speed, high accuracy testers, particularly those aimed to test memory devices.

The Edge629 solves several difficult problems associated with aligning multiple timing signals because it can:

- delay very narrow pulses over a long timing span
- adjust the falling edge independently from the overall propagation delay
- maintain extreme timing accuracy for very narrow (sub-ns) pulses
- maintain tight timing accuracy over changes in frequency, duty cycle, and pattern.

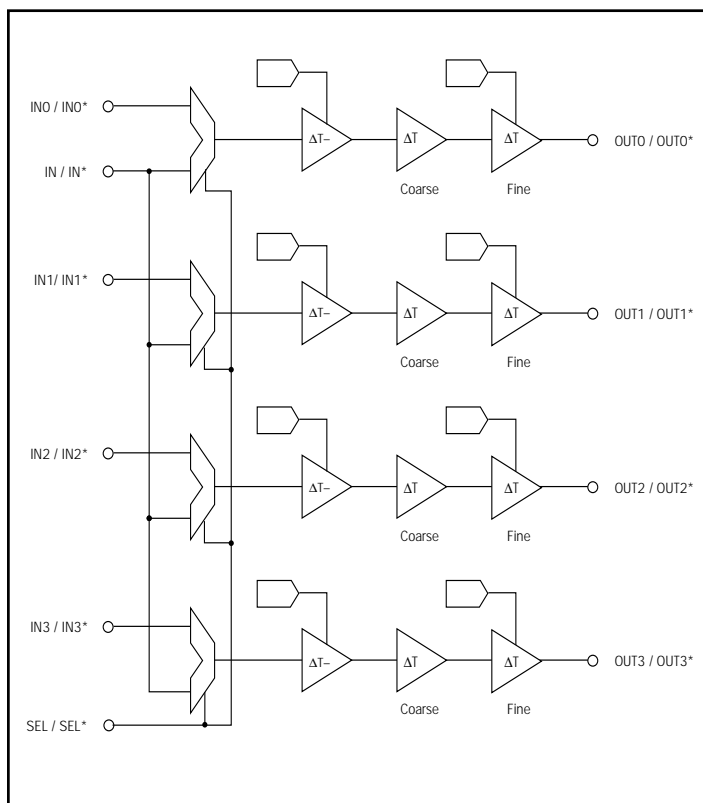
#### Applications

- Memory Test Equipment
  - Data Fanout
  - Channel Deskew
- Logic Testers
  - Per Pin Deskew
- Clock / Signal Fanout

#### Features

- $F_{max} \geq 1$  GHz
- Independent Falling Edge Adjust
- Small Footprint (10 mm x 10 mm)
- Excellent Timing Accuracy
- Very Stable Timing Delays
- 5 ps Resolution
- ECL, CMOS Compatible Inputs

#### Functional Block Diagram



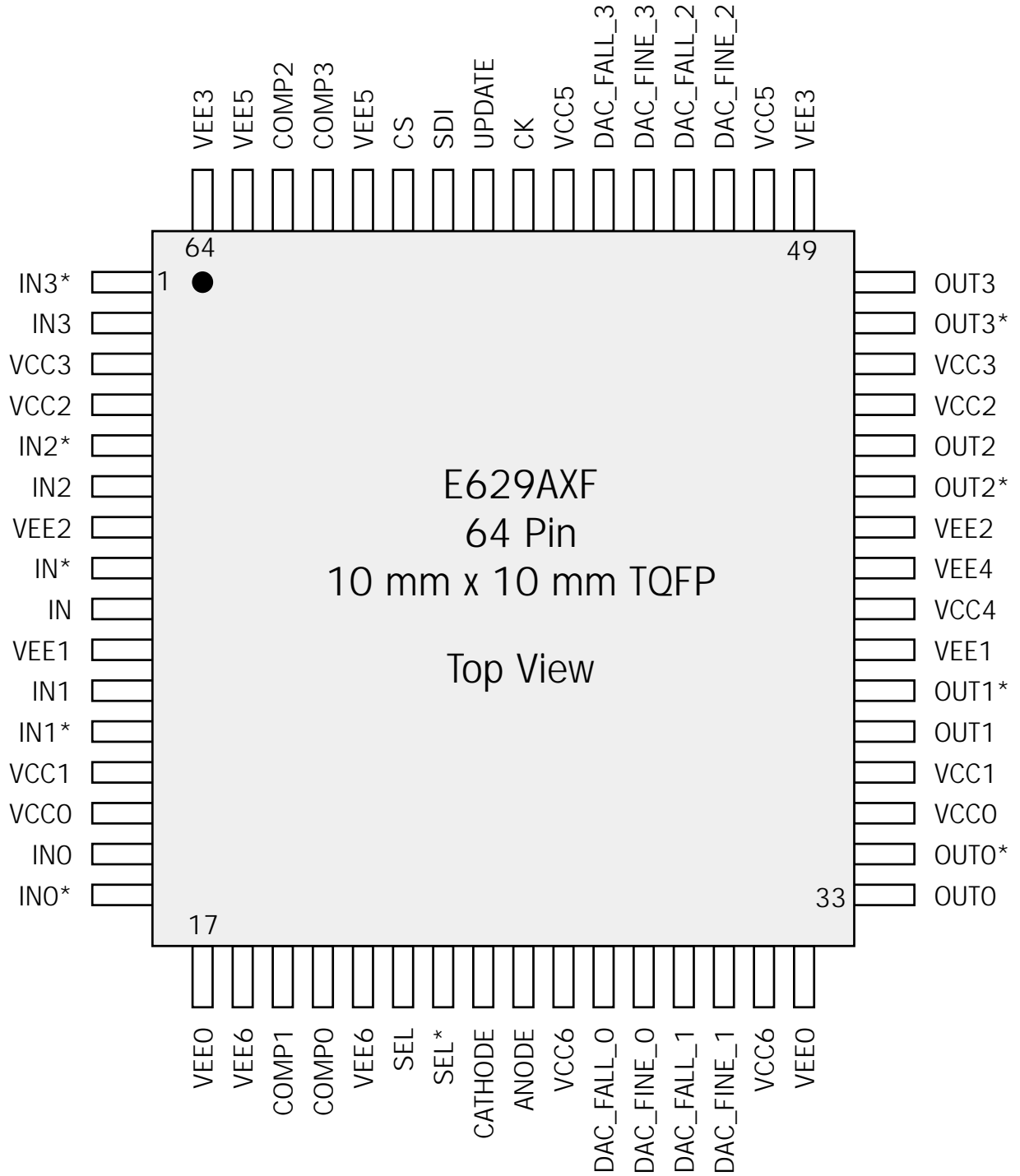
## TEST AND MEASUREMENT PRODUCTS

## PIN Description

Pin Name	Pin #	Description
IN/IN*	9, 8	Differential input signal used for 1:4 signal fanout.
INO, IN0*	15, 16	Differential input signals used for 1:1 signal fanout.
IN1/IN1*	11, 12	
IN2/IN2*	6, 5	
IN3/IN3*	2, 1	
OUT0/OUT0*	33, 34	Differential output signals.
OUT1/OUT1*	37, 38	
OUT2/OUT2*	44, 43	
OUT3/OUT3*	48, 47	
SEL/SEL*	22, 23	Differential input signals used to select the input signal source.
SDI	58	Serial data input.
CK	56	Clock used to latch in SDI.
CS	59	Chip select.
UPDATE	57	Digital input which loads the delay registers.
CATHODE, ANODE	24, 25	Terminals of an on-chip thermal diode string.
COMPO-3	20, 19, 62, 61	External op amp compensation pins.
DAC_FALL_(0-3)	27, 29, 52, 54	Falling edge adjust DAC outputs. For test purposes only; nothing should be connected to these pins.
DAC_FINE_(0-3)	28, 30, 51, 53	Fine delay DAC outputs. For test purposes only; nothing should be connected to these pins.
VCC	3, 4, 13, 14, 26, 31, 35, 36, 40, 45, 46, 50, 55	Positive power supply.
VEE	7, 10, 17, 18, 21, 32, 39, 41, 42, 49, 60, 63, 64	Negative power supply.

TEST AND MEASUREMENT PRODUCTS

PIN Description (continued)



#### Introduction

The Edge629 is a quad channel delay element with 2 basic operating modes:

- 1) Fanout – 1 signal in, 4 signals out
- 2) Pass Through – 4 signals in, 4 signals out

In all modes, each channel supports 3 delay functions:

- 1) Coarse timing delay
- 2) Fine timing delay
- 3) Falling edge adjust

All 3 delay functions are independent of each other, and independent for each channel.

The programming of the delay functions is done using a 16 bit register, loaded serially, which contains both a delay and an address value.

#### Coarse Delay

Coarse propagation delay adjustment is accomplished using a series of gate delays and multiplexers (see Figure 1). Coarse delay provides a total delay span of:

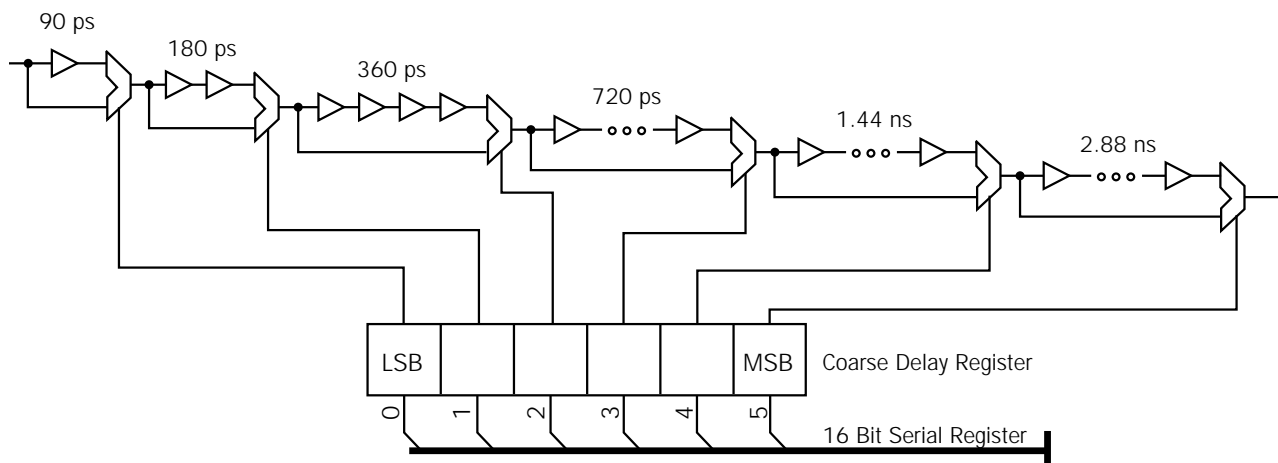
- 1 Coarse LSB = 90 ps
- 2 Coarse LSB = 180 ps
- 4 Coarse LSB = 360 ps
- 8 Coarse LSB = 720 ps
- 16 Coarse LSB = 1.44 ns
- 32 Coarse LSB = 2.88 ns

$$0 \text{ ns} \leq \text{Coarse Delay Range} \leq 5.67 \text{ ns}$$

Each channel has its own unique coarse delay setting and may be programmed independently from all other channels. The coarse delay of any channel will not affect the fine delay of that channel, nor will it affect the overall delay of any other channel.

The propagation delay of a rising edge and falling edge will track each other over the entire coarse delay span. (Adding or subtracting coarse delay does not cause pulse width distortion.)

Delay Code		
000000	Minimum Delay	0.0 ns
111111	Maximum Delay	5.67 ns



**Figure 1. Coarse Delay Architecture**

**Fine Delay**

Fine delay is accomplished using an analog delay cell and an on-chip 6 bit DAC (see Figure 2). The fine delay range is designed to be ~2X the coarse delay resolution.

Fine delay provides a total delay span of:

LSB	1 Fine LSB	=	2.5 ps (see note)
	2 Fine LSB	=	5 ps
	4 Fine LSB	=	10 ps
	8 Fine LSB	=	20 ps
	16 Fine LSB	=	40 ps
MSP	32 Fine LSB	=	80 ps
<hr/>			
	0 ns ≤ Fine Delay Range ≤		157.5 ps.

*Note:* Because the transfer function is non-linear, some LSB steps could be as large as 5 ps.

Each channel has its own unique delay setting and may be programmed independently from all other channels. The fine delay of any channel will not affect the coarse delay of that channel, nor will it affect the overall delay of any other channel.

The propagation delay of a rising and falling edge will track each other over the entire span of fine delay. (Adding or subtracting fine delay will not cause pulse width distortion.)

**Fine Delay Select**

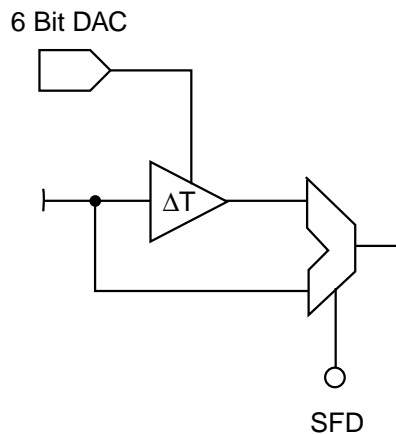
The fine delay section may be selected or bypassed by a multiplexer (see Figure 2). If SFD (Select Fine Delay) is high, Fine Delay will be used. If SFD is low, Fine Delay will be bypassed.

DAC Code	SFD	Delay
XXXXXX	0	Fine Delay Bypassed
000000	1	Minimum Delay (0.0 ns)
111111	1	Maximum Delay (157 ps)

**Fine Delay DAC Outputs**

DAC\_FINE\_(0-3) are analog voltage outputs from the on-board DACs which program the fine delay elements of each channel.

DAC\_FINE\_(0-3) pins are for test purposes only. Nothing should be connected to these pins.



**Figure 2. Fine Delay Architecture**

## TEST AND MEASUREMENT PRODUCTS

### Circuit Description *(continued)*

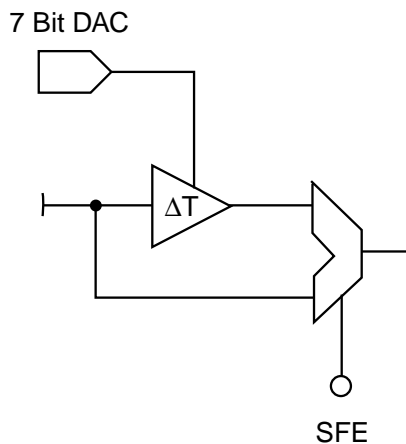
#### Falling Edge Adjustment

The falling edge of a signal may be adjusted to compensate for any system level pulse width distortion that may occur. Falling edge adjust (FEA) is accomplished using an analog delay cell and an on-chip 7 bit DAC (see Figure 3).

FEA may be bypassed completely by a multiplexer. Also, FEA affects only the propagation delay of the falling edge. It has no effect on the propagation delay of a rising edge.

Each channel has its own unique FEA setting and may be programmed independently from all other channels. The FEA of any channel will not affect the propagation delay of any other channel, nor will FEA affect the propagation delay of a rising edge.

SFE	DAC Code	Falling Edge Delay	Resolution
0	XXXXXXX	FEA Bypassed	N/A
1	0000000	-250 ps	2.5 ps
1	1111111	+250 ps	2.5 ps



**Figure 3. Falling Edge Adjust Architecture**

There is a limitation on FEA range vs. pulse width.

Input Pulse Width	FEA Range
1.0 ns	±250 ps
900 ps	±250 ps
800 ps	±250 ps
700 ps	±250 ps
600 ps	±200 ps
500 ps	±100 ps

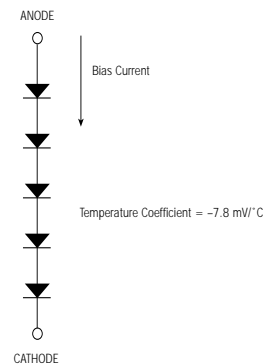
#### Falling Edge Adjust DAC Outputs

DAC\_FALL\_(0-3) are analog voltage outputs from the on-board DACs which program the falling edge delay elements of each channel.

DAC\_FALL\_(0-3) pins are for test purposes only. Nothing should be connected to these pins.

#### Thermal Monitor

The Edge629 features a thermal diode string consisting of 5 diodes as shown in Figure 4 below. This string allows accurate die temperature measurements.



**Figure 4. Thermal Diode String**

When an external bias current of up to 100  $\mu$ A is injected through the string, the voltage measured across the ANODE and CATHODE pins maps directly to the Edge629 junction temperature (see Figure 5).

## TEST AND MEASUREMENT PRODUCTS

### Circuit Description (continued)

#### Programming

The Edge629 is programmed serially with 3 control lines:

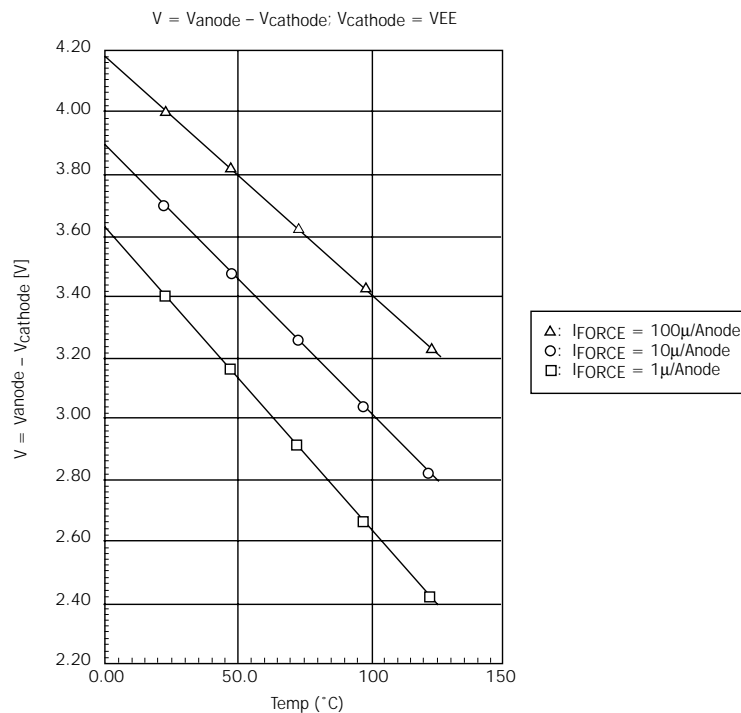
- SDI – serial data input
- CS – chip select
- UPDATE – register update

which are all synchronous with CK. With CS valid (high), rising edge of CK will load SDI into the 16 bit shift register.

With CS valid and UPDATE valid (high), CK high will make the selected latch go transparent. The falling edge of CK will then latch the data (see Figures 6 and 7).

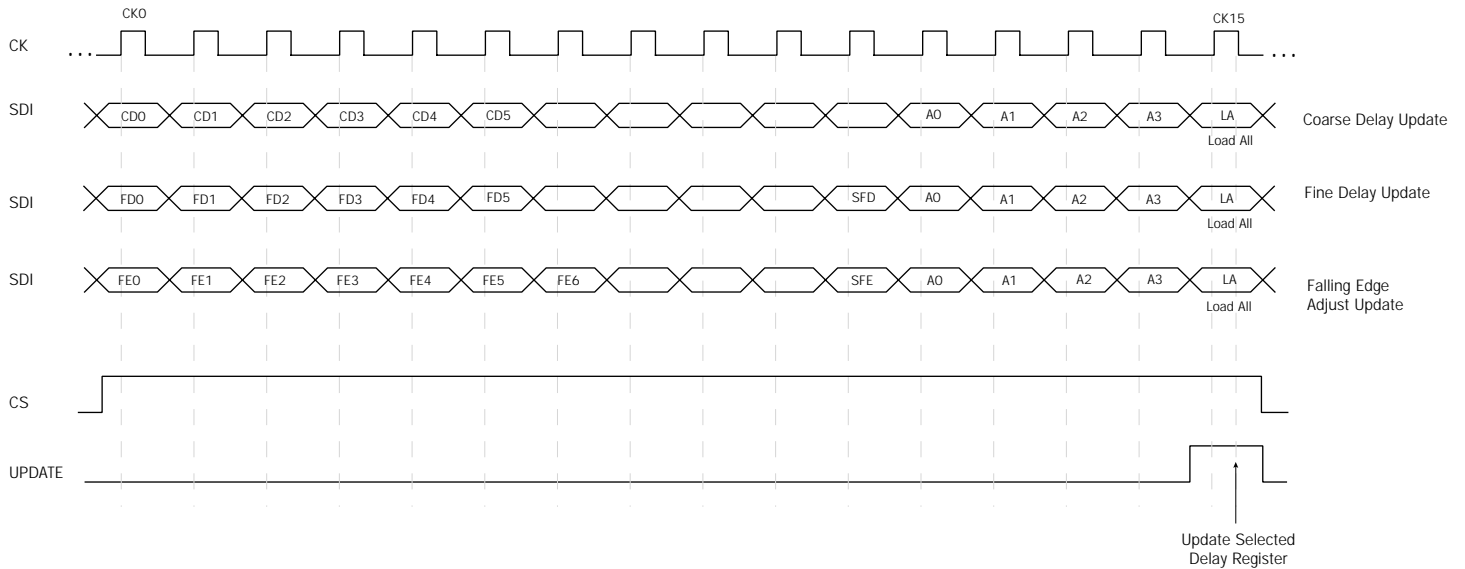
Data and address information are combined in the 16 bit word. Bits 0–6 are used for data, bits 11–15 for address. Bits 11–14 select 1 of 16 destinations, bit 15, if high, selects all 16 locations to be loaded simultaneously (useful for preloading all registers to a default state).

Bit	15	14	13	12	11	10	
Ad-dr	LA	A3	A2	A1	A0		Delay Function
0	0	0	0	0	0	X	Channel 0, Coarse Delay
1	0	0	0	0	1	1	Channel 0, Fine Delay
2	0	0	0	1	0	1	Channel 0, Falling Edge Adjust
3	0	0	0	1	1	X	Not Used
4	0	0	1	0	0	X	Channel 1, Coarse Delay
5	0	0	1	0	1	1	Channel 1, Fine Delay
6	0	0	1	1	0	1	Channel 1, Falling Edge Adjust
7	0	0	1	1	1	X	Not Used
8	0	1	0	0	0	X	Channel 2, Coarse Delay
9	0	1	0	0	1	1	Channel 2, Fine Delay
A	0	1	0	1	0	1	Channel 2, Falling Edge Adjust
B	0	1	0	1	1	X	Not Used
C	0	1	1	0	0	X	Channel 3, Coarse Delay
D	0	1	1	0	1	1	Channel 3, Fine Delay
E	0	1	1	1	0	1	Channel 3, Falling Edge Adjust
F	0	1	1	1	1	X	Not Used
X	1	X	X	X	X	0	All Channels, Coarse Delay
X	1	X	X	X	X	1	All Channels, All Functions



**Figure 5. Voltage vs. Temperature for Thermal Diode String**

629 Digital Interface Timing  
16 Bit Loads



**Figure 6. Synchronous Loading**



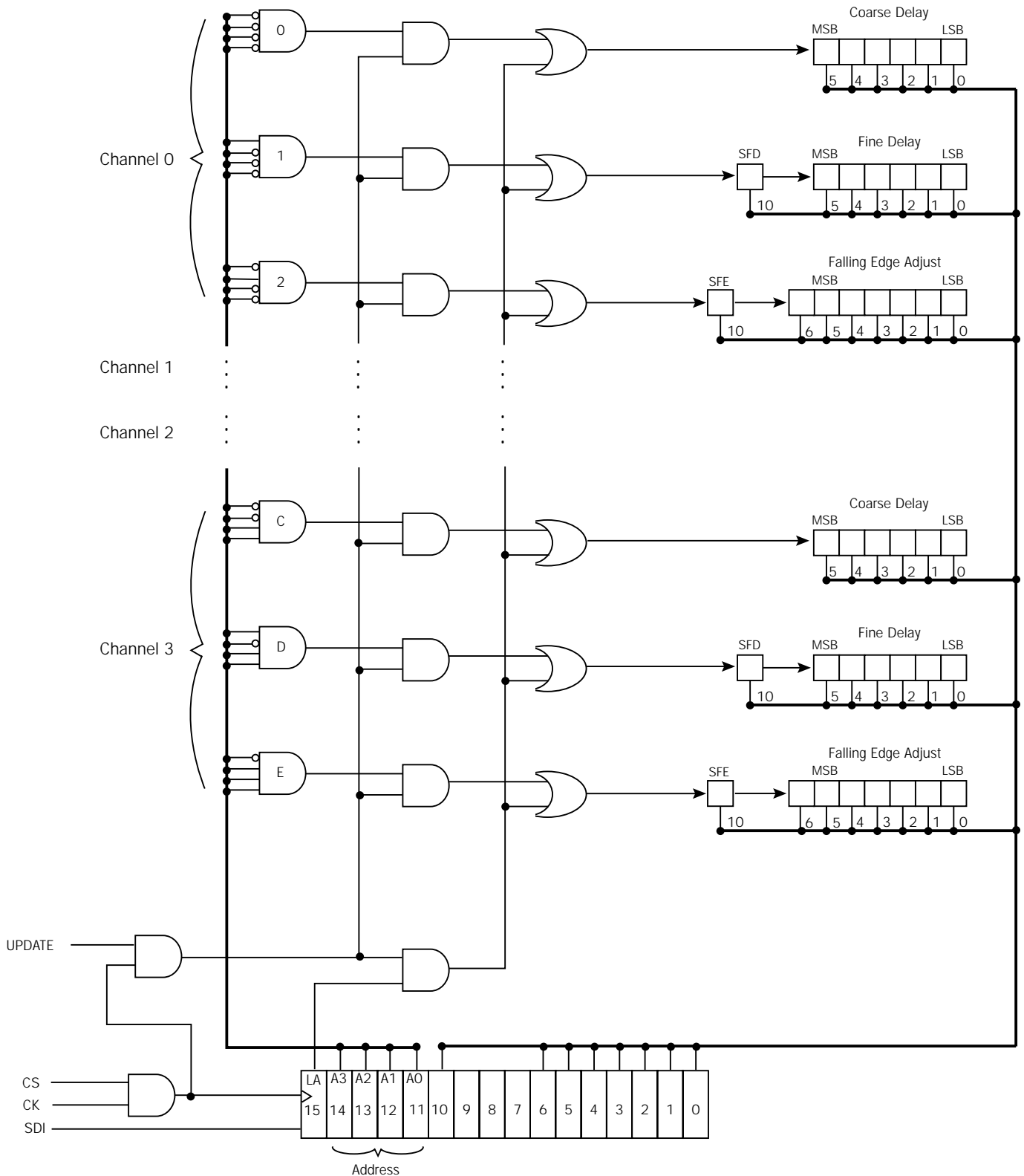


Figure 7. Data Interface

#### Timing Inputs

IN/IN\* and INO/INO\* – IN3/IN3\* are high speed differential inputs which require >300 mV of differential input voltage for reliable switching.

These inputs may receive differential input signals with amplitudes up to 3.3V. This wide range input voltage compliance allows CMOS signals to drive the Edge629 directly.

The inputs may go all the way up to VCC and still not cause any saturation. The Edge629 will operate at full performance under these input conditions.

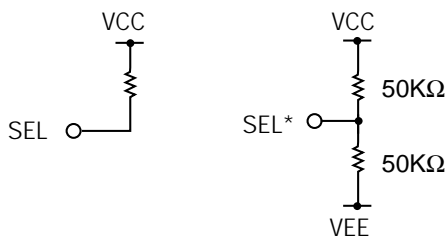
Do not leave any differential inputs floating as they will be in an indeterminate state. All unused inputs must be tied to either a high or low level. Connecting unused timing inputs to VCC is an acceptable method to make an input high. However, to make an input low, it must be connected to VEE + 2.0V or higher.

#### Input Mux Select

Each delay channel can select its input from one of two sources. If Mux Select is high (SEL > SEL\*), IN/IN\* will be selected for all four channels. If Mux Select is low (SEL < SEL\*), INO/INO\* – IN3/IN3\* will be selected for each channel.

SEL/SEL*	Input Source	Mode
0	INO/INO* – IN3/IN3*	Pass Through
1	IN/IN*	Fanout

SEL/SEL\* have internal pull-up/pull-down resistors which, when left floating, place the chip in fanout mode.



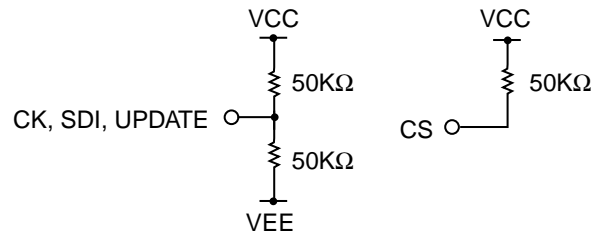
#### Data Interface Digital Inputs

All data digital inputs are standard, single ended ECL inputs with  $V_{bb} = -1.3V$  relative to VCC. However, all digital inputs may receive input signals anywhere between VCC and VEE. This wide input voltage compliance allows CMOS signals to program the Edge629 without causing saturation problems.

**All digital interface inputs are "3.3V rail to rail" CMOS compatible provided VCC = +3.3V and VEE = -2V.**

CK, SDI, and UPDATE all have an internal pull-down resistor network to establish a default condition of a logical 0 when left floating. CS has a large (~50 KΩ) internal pull-up resistor to VCC to establish a default condition of a logical 1 when left floating.

For optimal performance, all data interface digital inputs should be static when the Edge 629 is actively delaying signals. (However, it is acceptable if CK continues to run.)



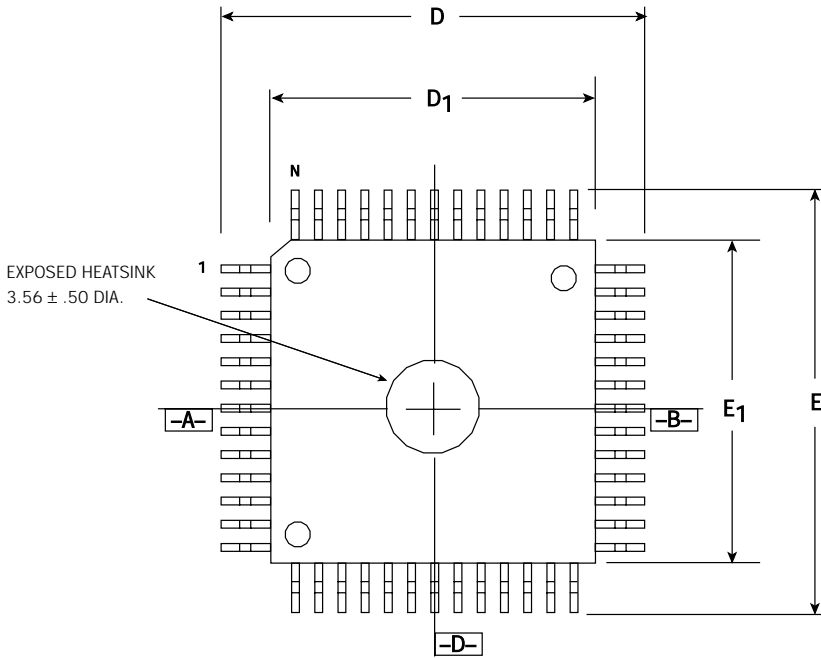
#### Timing Outputs

OUT0/OUT0\* – OUT3/OUT3\* are standard differential ECL open emitter outputs.

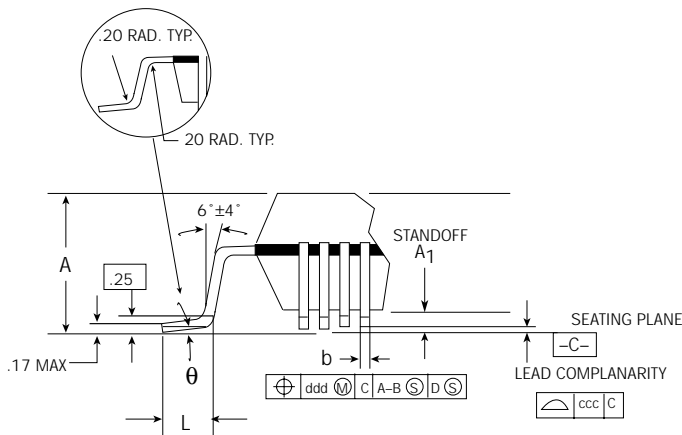
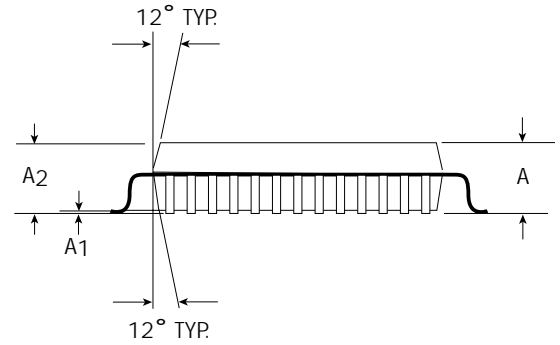
#### Compensation Pins

COMP0, COMP1, COMP2, and COMP3 are op amp compensation pins requiring external 100 pF capacitors to VEE.

64-Pin TQFP  
10 mm x 10 mm x 1.4 mm



Top View



Dims.	Tolerance	Value
A	MAX.	1.60
A1		.05 min. / .15 max
A2	±.05	1.40
D	±.20	12.00
D1	±.10	10.00
E	±.20	12.00
E1	±.10	10.00
L	+.15 / -.10	.60
e	BASIC	.50
b	±.05	.22
θ		0° - 7°
ddd	MAX.	.08
ccc	MAX.	.08
Package Thickness		1.40
Footprint		Body + 2 mm

Notes:

1. All dimensions in millimeters.
2. Dimensions shown are nominal with tolerances as indicated.
3. L/F: EFTEC 64T copper or equivalent, 0.127mm (.005") or 0.15mm (.006") thick.
4. Foot length "L" is measured at gage plane, at 0.25 above the seating plane.

**TEST AND MEASUREMENT PRODUCTS**
**Recommended Operating Conditions**

Parameter	Symbol	Min	Typ	Max	Units
Total Power Supply	VCC – VEE	4.2	5.2	+5.5	V
Junction Temperature	TJ	0		+100	°C

**Absolute Maximum Ratings**

Parameter	Symbol	Min	Typ	Max	Units
Power Supply	VCC – VEE	0		7.0	V
Voltage on any Digital Input Pin		VEE – 0.5		VCC + 0.5	V
Voltage on any Analog Input Pin		VEE – 0.5		VCC + 0.5	V
Output Current		–50			mA
Storage Temperature	TS	–65		+150	°C
Junction Temperature	TJ			+150	°C
Soldering Temperature (5 seconds, .25" from the pin)	TSOL			+260	°C
$\theta_{JC}$ (to top of case)	$\theta_{JC}$		1.5		°C
$\theta_{JA}$ (@ still air)	$\theta_{JA}$		28		°C
$\theta_{JA}$ (@ 400 LFPM)	$\theta_{JA}$		21		°C

Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only, and functional operation of the device at these, or any other conditions beyond those listed, is not implied. Exposure to absolute maximum conditions for extended periods may affect device reliability.

## TEST AND MEASUREMENT PRODUCTS

## DC Characteristics

Parameter	Symbol	Min	Typ	Max	Units
<b>Timing Inputs (IN/IN*, INO/INO* – IN3/IN3*)</b>					
Differential Input Voltage	$ IN - IN^* $	.3		VCC – VEE	V
Input High Voltage Range	VIH	VEE + 2.0		VCC	V
Input Low Voltage Range	VIL	VEE + 2.0		VIH – .3	V
Input High Current	I <sub>IH</sub>	–100		+100	μA
Input Low Current	I <sub>IL</sub>	–100		+100	μA
<b>Select Input (SEL/SEL*)</b>					
Input High Voltage	SEL – SEL*	.3		VCC – VEE	V
Input Low Voltage	SEL* – SEL	.3		VCC – VEE	V
Input High Common Mode Range	VIH	VEE + 2.0		VCC	V
Input Low Common Mode Range	VIL	VEE + 2.0		VIH – .3	V
Input High Current	I <sub>IH</sub>			250	μA
Input Low Current	I <sub>IL</sub>			250	μA
<b>Programming Inputs (CK, UPDATE, CS, SDI)</b>					
Input High Voltage	VIH	VCC – 1.1		VCC	V
Input Low Voltage	VIL	VEE + 2.0		VCC – 1.5	V
Input High Current	I <sub>IH</sub>			250	μA
Input Low Current	I <sub>IL</sub>			250	μA
<b>Digital Outputs</b>					
Digital Output High Voltage	OUT – OUT*	600	690		mV
Digital Output Low Voltage	OUT* – OUT	600	690		mV
Output Common Mode Range	$\frac{OUT + OUT^*}{2}$	VCC – 1.5	VCC – 1.3	VCC – 1.1	V
Output Current	I <sub>out</sub>			30	mA
<b>Power Supply Current</b>					
VCC – VEE = 4.2V	IEE		561	900	mA
VCC – VEE = 5.2V	IEE		604	900	mA
VCC – VEE = 5.5V	IEE		613	900	mA

## TEST AND MEASUREMENT PRODUCTS

## AC Characteristics

Parameter	Symbol	Min	Typ	Max	Units
<b>Timing Inputs/Outputs</b>					
Minimum Propagation Delay (Note 2)					
IN to OUT (0,3)	Tpd Min	1.282	1.357	1.432	ns
INO, 3 to OUT (0,3)	Tpd Min	1.406	1.481	1.556	ns
$\Delta$ Tpd, FD Disabled to FD=0	$\Delta$ Tpd		320		ps
$\Delta$ Tpd, FEA Disabled to FEA=0	$\Delta$ Tpd		950		ps
Rising Edge/Falling Edge Propagation Delay Difference (FEA disabled)	Tpd+ - Tpd-		3	10	ps
Channel-to-Channel Skew (Note 2)					
IN to OUT (0,3) (Fanout Mode)	Tskew1		10	45	ps
IN (0,3) to OUT (0,3)	Tskew2		15	50	ps
Programmable Delay (Note 2)					
Coarse Delay	Tspan_Coarse	5.5	6.0	6.5	ns
Fine Delay	Tspan_Fine	110	150	180	ps
Falling Edge Adjust (SFE = 1) (Note 1)	FEA	$\pm$ 200	$\pm$ 250	$\pm$ 300	ps
Programmable Delay Step Size (Note 3)					
Coarse Delay	Tstep_Coarse	1.0	95	110	ps
Fine Delay	Tstep_Fine	1.0	5	7	ps
Falling Edge Adjust	Tstep_FEA	1.0	5	7	ps
Maximum Operating Frequency (FEA Enabled)	Fmax	1.0			GHz
Maximum Operating Frequency (FEA Disabled)	Fmax	1.3			GHz
Minimum Pulse Width (at outputs)	PW min	350			ps
Output Rise and Fall Times (20% - 80%)	Tr/Tf		110	150	ps
Temperature Coefficient (vs. Die Temp)	$\Delta$ Tpd/ $\Delta$ T				
CD = Min, FD & FEA Disabled				2.4	ps/ $^{\circ}$ C
CD = Max, FD & FEA Disabled				13.3	ps/ $^{\circ}$ C
CD & FD = Min, FEA Disabled				3.3	ps/ $^{\circ}$ C
CD & FD = Max, FEA Disabled				15.1	ps/ $^{\circ}$ C
CD, FD, & FEA = Min				5.2	ps/ $^{\circ}$ C
CD, FD, & FEA = Max				18.8	ps/ $^{\circ}$ C
<b>Total Timing Error</b>					
$\Delta$ Tpd vs. Frequency			20		ps
Channel-to-Channel Crosstalk			2	10	ps
$\Delta$ Tpd vs. Duty Cycle			20		ps
Jitter @ Minimum Delay				1	ps
Jitter @ Maximum Delay				5	ps

Test Conditions (unless otherwise specified): "Recommended Operating Conditions."

TEST AND MEASUREMENT PRODUCTS

AC Characteristics (continued)

Test Conditions (unless otherwise specified): "Recommended Operating Conditions."

Note 1: Tested with an input pulse = 50 ns. This parameter is guaranteed by characterization for input pulse widths  $\geq 700$  ps.

Note 2: Coarse Delay = 0, Fine Delay and Falling Edge Adjust disabled. Case Temperature = 50°C.

Note 3: Coarse Delay is monotonic. Fine Delay is Monotonic. Since the fine delay spans close to 2 LSBs of coarse delay, the summation of digital codes for coarse and fine delays is not monotonic. Proper binary searching using both the coarse and fine delays is achieved first with the coarse (with SFD=1), and then with the fine delays as separate searches.

Parameter	Symbol	Min	Typ	Max	Units
<b>Data Interface</b>					
Set Up Time					
SDI to CK $\uparrow$	Tsu	10			ns
CS to CK $\uparrow$	Tsu	10			ns
UPDATE to CK $\downarrow$	Tsu	20			ns
Hold Time					
CK $\uparrow$ to SDI	Th	4			ns
CK $\uparrow$ to CS	Th	4			ns
CK $\downarrow$ to UPDATE	Th	4			ns
Minimum Pulse Widths					
CK High		13			ns
CK Low		13			ns
CK Period	T	30			ns
DAC Settling Time				1	$\mu$ s

Test Conditions (unless otherwise specified): "Recommended Operating Conditions."

AC Characteristics are guaranteed by design and characterization. Not production tested.

**TEST AND MEASUREMENT PRODUCTS**

## Ordering Information

Model Number	Package
E629AXF	10 x 10 x 1.4mm TQFP w/Exposed Heatsink on Top
EVM629AXF	Edge629 Evaluation Board

## Contact Information

Semtech Corporation  
Test and Measurement Division  
10021 Willow Creek Rd., San Diego, CA 92131  
Phone: (858)695-1808 FAX (858)695-2633