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Understanding [Embedded - CPLDs \(Complex Programmable Logic Devices\)](#)

Embedded - CPLDs, or Complex Programmable Logic Devices, are highly versatile digital logic devices used in electronic systems. These programmable components are designed to perform complex logical operations and can be customized for specific applications. Unlike fixed-function ICs, CPLDs offer the flexibility to reprogram their configuration, making them an ideal choice for various embedded systems. They consist of a set of logic gates and programmable interconnects, allowing designers to implement complex logic circuits without needing custom hardware.

Applications of Embedded - CPLDs

Details

Product Status	Obsolete
Programmable Type	EE PLD
Delay Time tpd(1) Max	20 ns
Voltage Supply - Internal	4.5V ~ 5.5V
Number of Logic Elements/Blocks	-
Number of Macrocells	8
Number of Gates	-
Number of I/O	-
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	20-LCC (J-Lead)
Supplier Device Package	20-PLCC (9x9)
Purchase URL	https://www.e-xfl.com/product-detail/lattice-semiconductor/gal16v8d-20qjni



Product Line	Ordering Part Number	Product Status	Reference PCN
GAL16V8D (Cont'd)	GAL16V8D-7LJ	Discontinued	<u>PCN#13-10</u>
	GAL16V8D-7LJN		
	GAL16V8D-10LJ		
	GAL16V8D-10LJN		
	GAL16V8D-15LJ		
	GAL16V8D-15LJN		
	GAL16V8D-25LJ		
	GAL16V8D-25LJN		
	GAL16V8D-7LJI		<u>PCN#09-10</u>
	GAL16V8D-7LJNI		
	GAL16V8D-10LJI		
	GAL16V8D-10LJNI		<u>PCN#13-10</u>
	GAL16V8D-15LJI		
	GAL16V8D-15LJNI		
	GAL16V8D-25LJI		
	GAL16V8D-25LJNI		
	GAL16V8D-10QJ		
	GAL16V8D-10QJN		
	GAL16V8D-15QJ		
	GAL16V8D-15QJN		
	GAL16V8D-25QJ		
	GAL16V8D-25QJN		
	GAL16V8D-20QJI		
	GAL16V8D-20QJNI		
	GAL16V8D-25QJI		
	GAL16V8D-25QJNI		
	GAL16V8D-7LS		<u>PCN#06-07</u>
	GAL16V8D-10LS		
	GAL16V8D-15LS		
	GAL16V8D-25LS		

Features

- **HIGH PERFORMANCE E²CMOS® TECHNOLOGY**
 - 3.5 ns Maximum Propagation Delay
 - $F_{max} = 250$ MHz
 - 3.0 ns Maximum from Clock Input to Data Output
 - UltraMOS® Advanced CMOS Technology
- **50% to 75% REDUCTION IN POWER FROM BIPOLAR**
 - 75mA Typ I_{cc} on Low Power Device
 - 45mA Typ I_{cc} on Quarter Power Device
- **ACTIVE PULL-UPS ON ALL PINS**
- **E² CELL TECHNOLOGY**
 - Reconfigurable Logic
 - Reprogrammable Cells
 - 100% Tested/100% Yields
 - High Speed Electrical Erasure (<100ms)
 - 20 Year Data Retention
- **EIGHT OUTPUT LOGIC MACROCELLS**
 - Maximum Flexibility for Complex Logic Designs
 - Programmable Output Polarity
 - Also Emulates 20-pin PAL® Devices with Full Function/Fuse Map/Parametric Compatibility
- **PRELOAD AND POWER-ON RESET OF ALL REGISTERS**
 - 100% Functional Testability
- **APPLICATIONS INCLUDE:**
 - DMA Control
 - State Machine Control
 - High Speed Graphics Processing
 - Standard Logic Speed Upgrade
- **ELECTRONIC SIGNATURE FOR IDENTIFICATION**
- **LEAD-FREE PACKAGE OPTIONS**

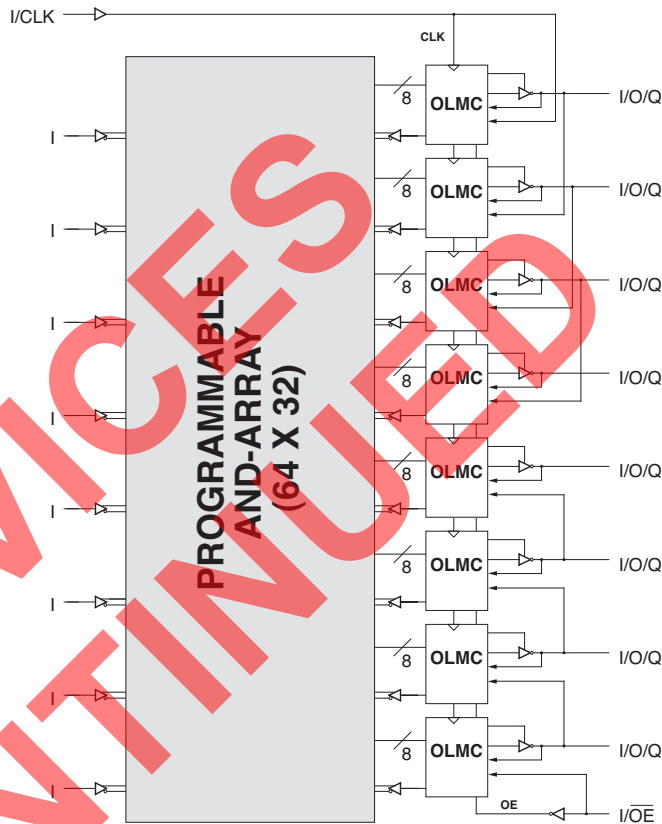
Description

The GAL16V8, at 3.5 ns maximum propagation delay time, combines a high performance CMOS process with Electrically Erasable (E²) floating gate technology to provide the highest speed performance available in the PLD market. High speed erase times (<100ms) allow the devices to be reprogrammed quickly and efficiently.

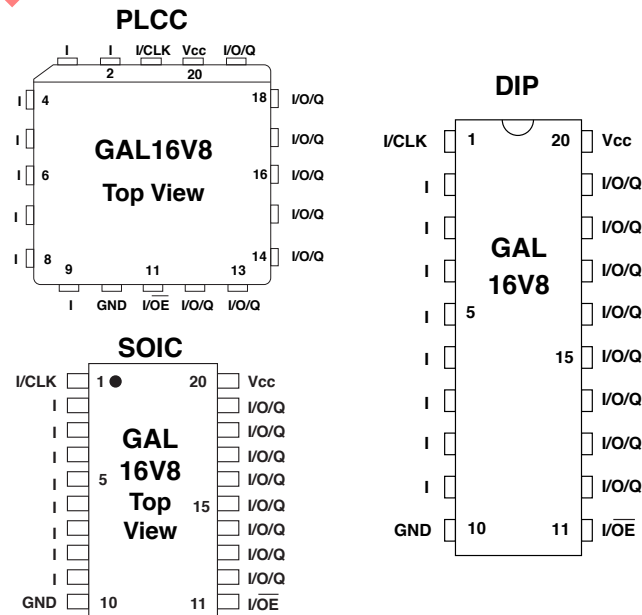
The generic architecture provides maximum design flexibility by allowing the Output Logic Macrocell (OLMC) to be configured by the user. An important subset of the many architecture configurations possible with the GAL16V8 are the PAL architectures listed in the table of the macrocell description section. GAL16V8 devices are capable of emulating any of these PAL architectures with full function/fuse map/parametric compatibility.

Unique test circuitry and reprogrammable cells allow complete AC, DC, and functional testing during manufacture. As a result, Lattice Semiconductor delivers 100% field programmability and functionality of all GAL products. In addition, 100 erase/write cycles and data retention in excess of 20 years are specified.

Functional Block Diagram



Pin Configuration



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August 2006

GAL16V8 Ordering Information

Conventional Packaging Commercial Grade Specifications

Tpd (ns)	Tsu (ns)	Tco (ns)	Icc (mA)	Ordering #	Package
3.5	2.5	3.0	115	GAL16V8D-3LJ ¹	20-Lead PLCC
5	3	4	115	GAL16V8C-5LP ¹	20-Pin Plastic DIP
			115	GAL16V8D-5LJ	20-Lead PLCC
7.5	7	5	115	GAL16V8D-7LP	20-Pin Plastic DIP
			115	GAL16V8C-7LP ¹	20-Pin Plastic DIP
			115	GAL16V8D-7LJ	20-Lead PLCC
			115	GAL16V8D-7LS ¹	20-Pin SOIC
10	10	7	55	GAL16V8D-10QP	20-Pin Plastic DIP
			55	GAL16V8D-10QJ	20-Lead PLCC
			115	GAL16V8D-10LP	20-Pin Plastic DIP
			115	GAL16V8D-10LJ	20-Lead PLCC
			115	GAL16V8D-10LS ¹	20-Pin SOIC
15	12	10	55	GAL16V8D-15QP	20-Pin Plastic DIP
			55	GAL16V8D-15QJ	20-Lead PLCC
			90	GAL16V8D-15LP	20-Pin Plastic DIP
			90	GAL16V8D-15LJ	20-Lead PLCC
			90	GAL16V8D-15LS ¹	20-Pin SOIC
25	15	12	55	GAL16V8D-25QP	20-Pin Plastic DIP
			55	GAL16V8D-25QJ	20-Lead PLCC
			90	GAL16V8D-25LP	20-Pin Plastic DIP
			90	GAL16V8D-25LJ	20-Lead PLCC
			90	GAL16V8D-25LS ¹	20-Pin SOIC

1. Discontinued per PCN #06-07. Contact Rochester Electronics for available inventory.

Industrial Grade Specifications

Tpd (ns)	Tsu (ns)	Tco (ns)	Icc (mA)	Ordering #	Package
7.5	7	5	130	GAL16V8D-7LPI	20-Pin Plastic DIP
			130	GAL16V8D-7LJI	20-Lead PLCC
10	10	7	130	GAL16V8D-10LPI	20-Pin Plastic DIP
			130	GAL16V8D-10LJI	20-Lead PLCC
15	12	10	130	GAL16V8D-15LPI	20-Pin Plastic DIP
			130	GAL16V8D-15LJI	20-Lead PLCC
20	13	11	65	GAL16V8D-20QPI	20-Pin Plastic DIP
			65	GAL16V8D-20QJI	20-Lead PLCC
25	15	12	65	GAL16V8D-25QPI	20-Pin Plastic DIP
			65	GAL16V8D-25QJI	20-Lead PLCC
			130	GAL16V8D-25LPI	20-Pin Plastic DIP
			130	GAL16V8D-25LJI	20-Lead PLCC

Lead-Free Packaging

Commercial Grade Specifications

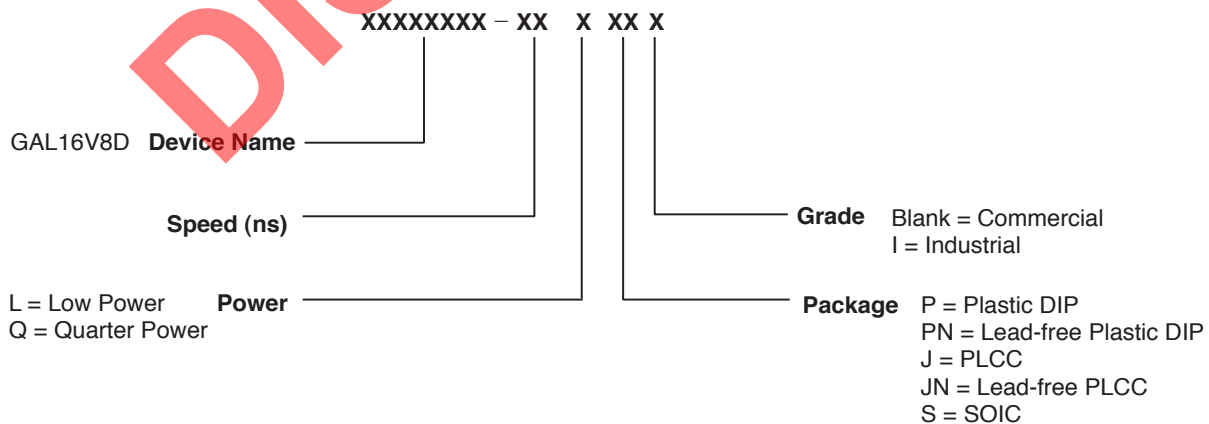
Tpd (ns)	Tsu (ns)	Tco (ns)	Icc (mA)	Ordering #	Package
3.5	2.5	3.0	115	GAL16V8D-3LJN ¹	Lead-Free 20-Lead PLCC
5	3	4	115	GAL16V8D-5LJN	Lead-Free 20-Lead PLCC
7.5	7	5	115	GAL16V8D-7LPN	Lead-Free 20-Pin Plastic DIP
			115	GAL16V8D-7LJN	Lead-Free 20-Lead PLCC
10	10	7	55	GAL16V8D-10QPN	Lead-Free 20-Pin Plastic DIP
			55	GAL16V8D-10QJN	Lead-Free 20-Lead PLCC
			115	GAL16V8D-10LPN	Lead-Free 20-Pin Plastic DIP
			115	GAL16V8D-10LJN	Lead-Free 20-Lead PLCC
15	12	10	55	GAL16V8D-15QPN	Lead-Free 20-Pin Plastic DIP
			55	GAL16V8D-15QJN	Lead-Free 20-Lead PLCC
			90	GAL16V8D-15LPN	Lead-Free 20-Pin Plastic DIP
			90	GAL16V8D-15LJN	Lead-Free 20-Lead PLCC
25	15	12	55	GAL16V8D-25QPN	Lead-Free 20-Pin Plastic DIP
			55	GAL16V8D-25QJN	Lead-Free 20-Lead PLCC
			90	GAL16V8D-25LPN	Lead-Free 20-Pin Plastic DIP
			90	GAL16V8D-25LJN	Lead-Free 20-Lead PLCC

1. Discontinued per PCN #06-07. Contact Rochester Electronics for available inventory.

Industrial Grade Specifications

Tpd (ns)	Tsu (ns)	Tco (ns)	Icc (mA)	Ordering #	Package
7.5	7	5	130	GAL16V8D-7LJNI	Lead-Free 20-Lead PLCC
			130	GAL16V8D-7LPNI	Lead-Free 20-Pin Plastic DIP
10	10	7	130	GAL16V8D-10LJNI	Lead-Free 20-Lead PLCC
			130	GAL16V8D-10LPNI	Lead-Free 20-Pin Plastic DIP
15	12	10	130	GAL16V8D-15LJNI	Lead-Free 20-Lead PLCC
			130	GAL16V8D-15LPNI	Lead-Free 20-Pin Plastic DIP
20	13	11	65	GAL16V8D-20QJNI	Lead-Free 20-Lead PLCC
			65	GAL16V8D-20QPNI	Lead-Free 20-Pin Plastic DIP
25	15	12	65	GAL16V8D-25QJNI	Lead-Free 20-Lead PLCC
			65	GAL16V8D-25QPNI	Lead-Free 20-Pin Plastic DIP
			130	GAL16V8D-25LJNI	Lead-Free 20-Lead PLCC
			130	GAL16V8D-25LPNI	Lead-Free 20-Pin Plastic DIP

Part Number Description



Registered Mode

In the Registered mode, macrocells are configured as dedicated registered outputs or as I/O functions.

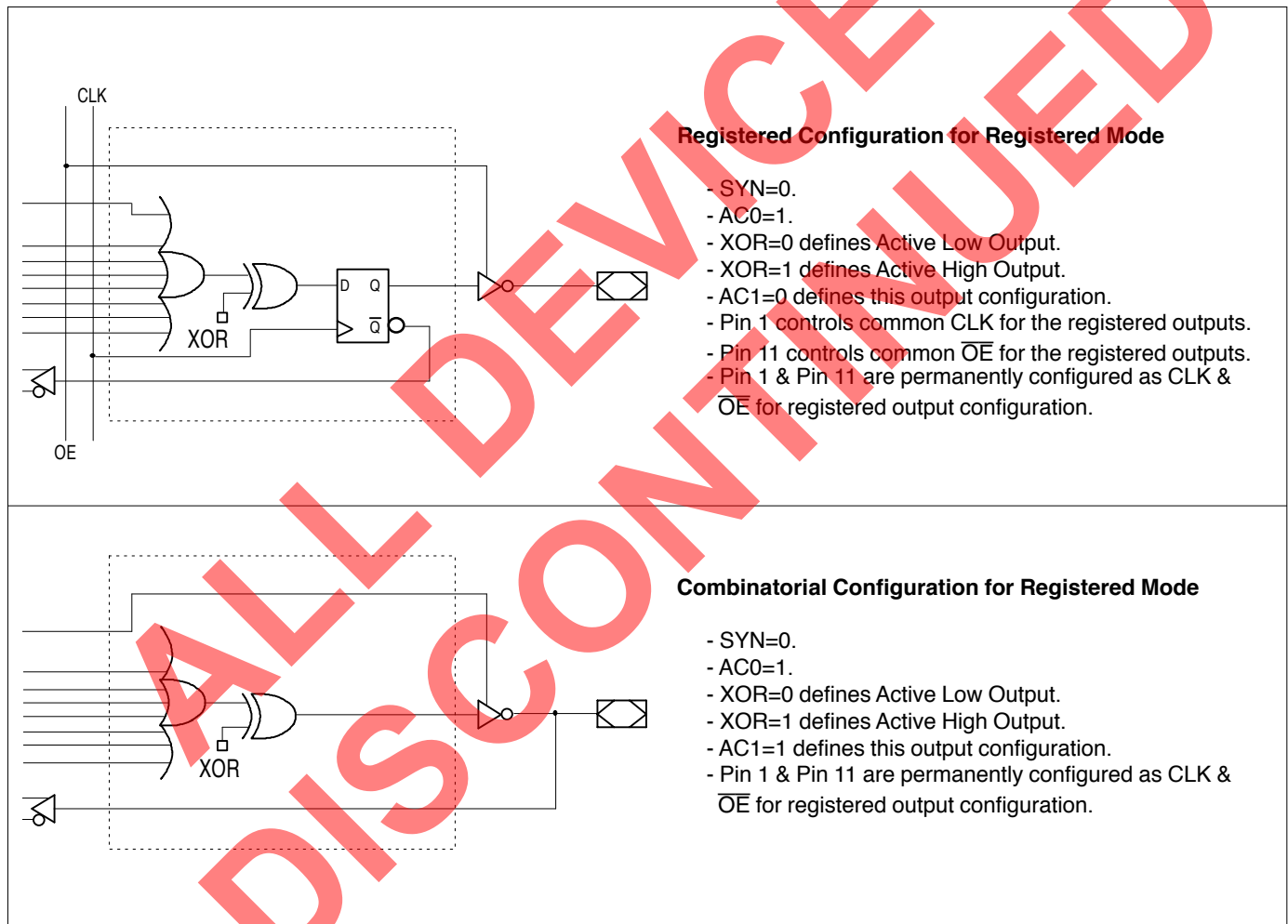
Architecture configurations available in this mode are similar to the common 16R8 and 16RP4 devices with various permutations of polarity, I/O and register placement.

All registered macrocells share common clock and output enable control pins. Any macrocell can be configured as registered or I/O. Up to eight registers or up to eight I/O's are possible in this mode.

Dedicated input or output functions can be implemented as subsets of the I/O function.

Registered outputs have eight product terms per output. I/O's have seven product terms per output.

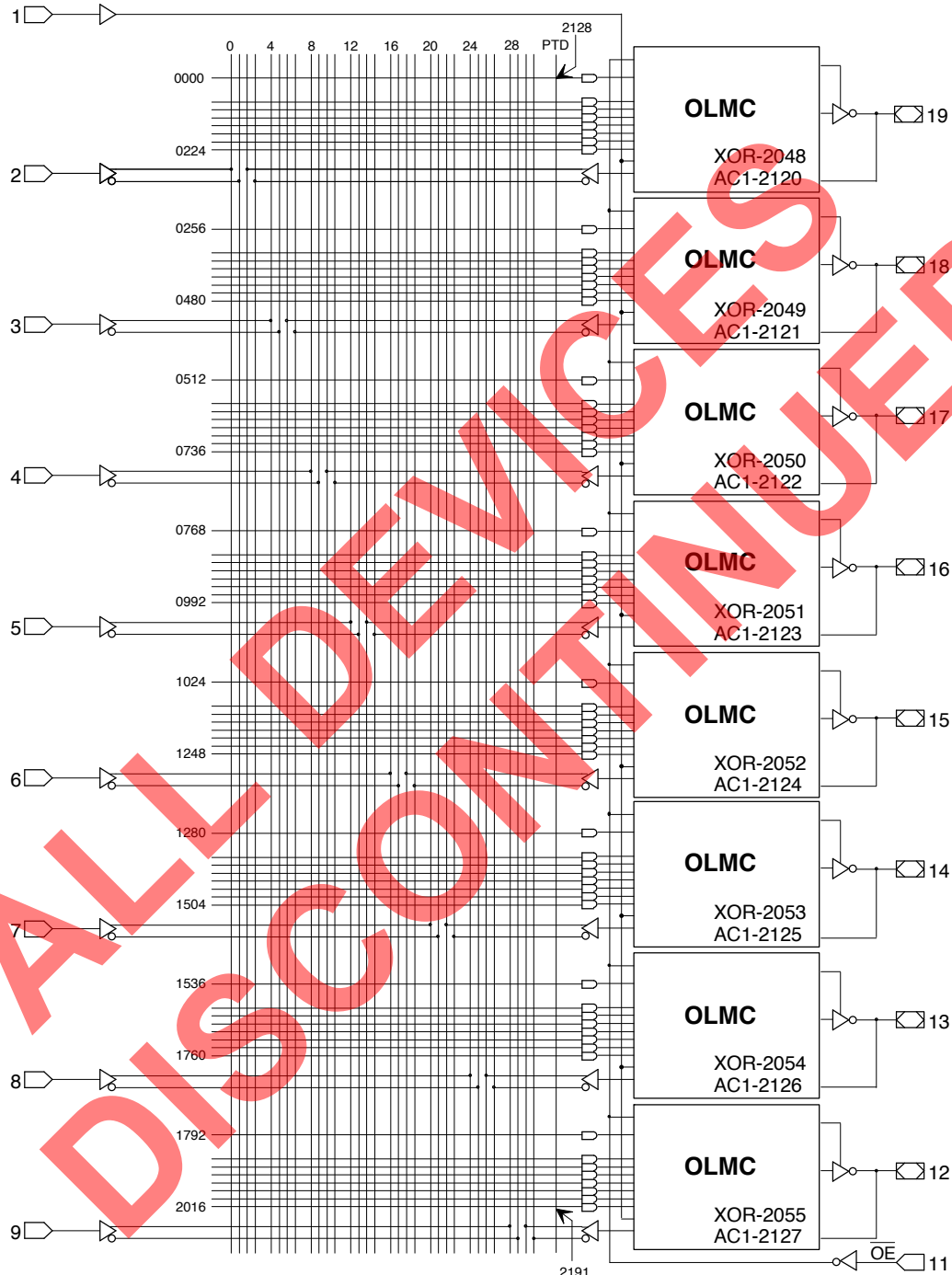
The JEDEC fuse numbers, including the User Electronic Signature (UES) fuses and the Product Term Disable (PTD) fuses, are shown on the logic diagram on the following page.



Note: The development software configures all of the architecture control bits and checks for proper pin usage automatically.

Registered Mode Logic Diagram

DIP & PLCC Package Pinouts



Complex Mode

In the Complex mode, macrocells are configured as output only or I/O functions.

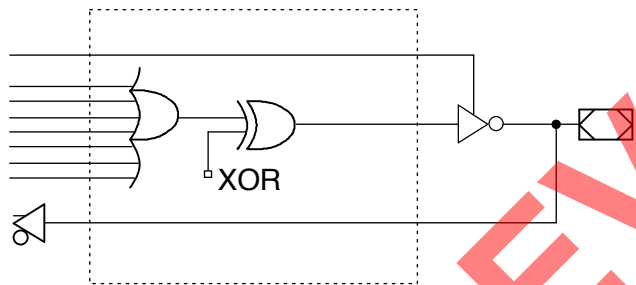
Architecture configurations available in this mode are similar to the common 16L8 and 16P8 devices with programmable polarity in each macrocell.

Up to six I/O's are possible in this mode. Dedicated inputs or outputs can be implemented as subsets of the I/O function. The two outer most macrocells (pins 12 & 19) do not have input capa-

bility. Designs requiring eight I/O's can be implemented in the Registered mode.

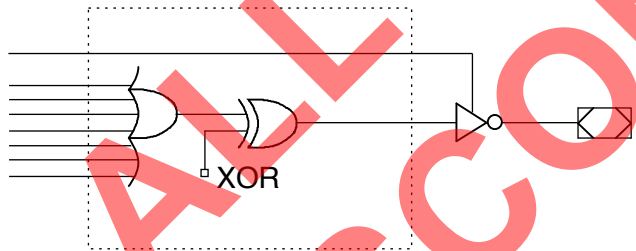
All macrocells have seven product terms per output. One product term is used for programmable output enable control. Pins 1 and 11 are always available as data inputs into the AND array.

The JEDEC fuse numbers including the UES fuses and PTD fuses are shown on the logic diagram on the following page.



Combinatorial I/O Configuration for Complex Mode

- SYN=1.
- AC0=1.
- XOR=0 defines Active Low Output.
- XOR=1 defines Active High Output.
- AC1=1.
- Pin 13 through Pin 18 are configured to this function.



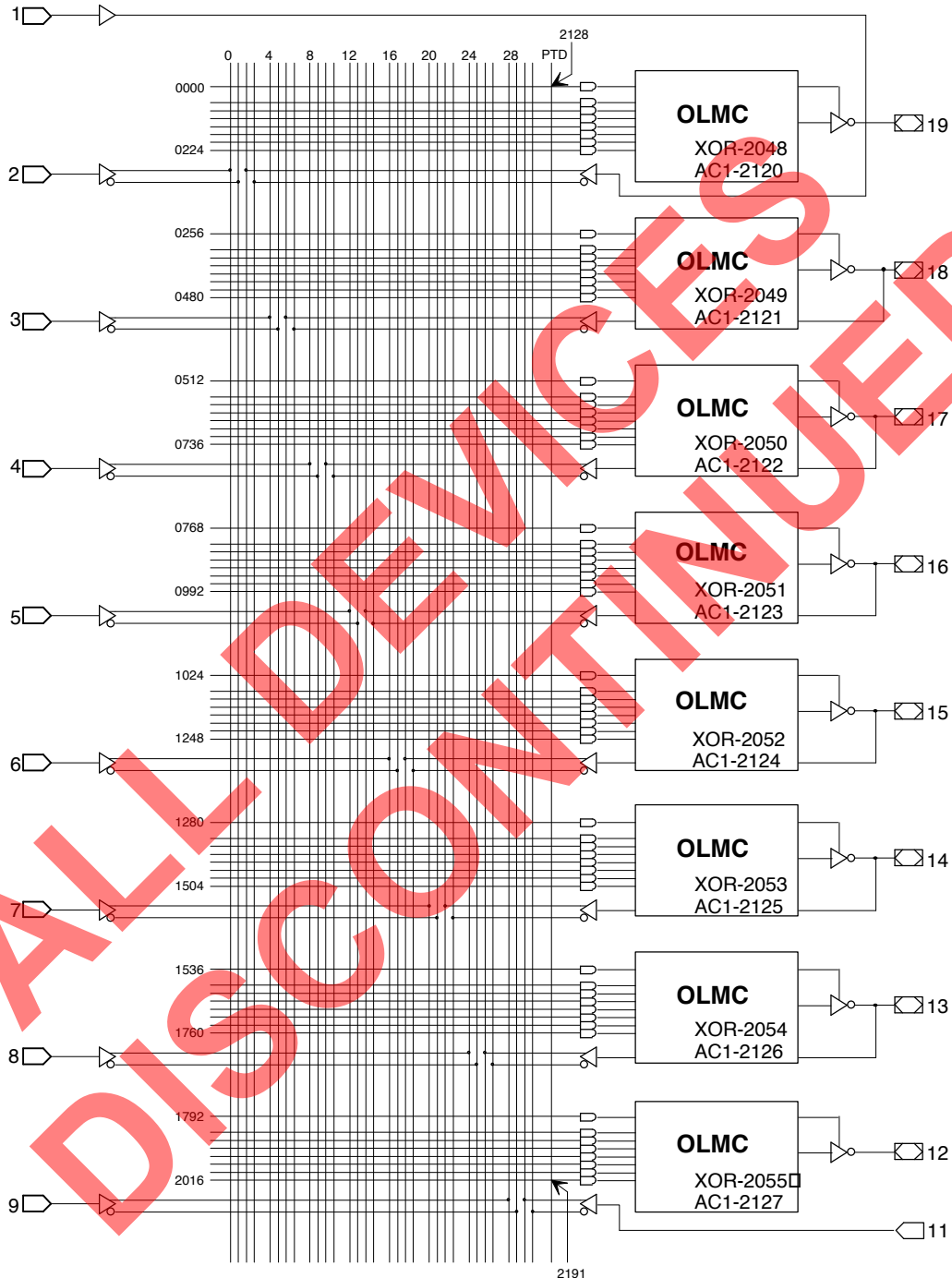
Combinatorial Output Configuration for Complex Mode

- SYN=1.
- AC0=1.
- XOR=0 defines Active Low Output.
- XOR=1 defines Active High Output.
- AC1=1.
- Pin 12 and Pin 19 are configured to this function.

Note: The development software configures all of the architecture control bits and checks for proper pin usage automatically.

Complex Mode Logic Diagram

DIP & PLCC Package Pinouts



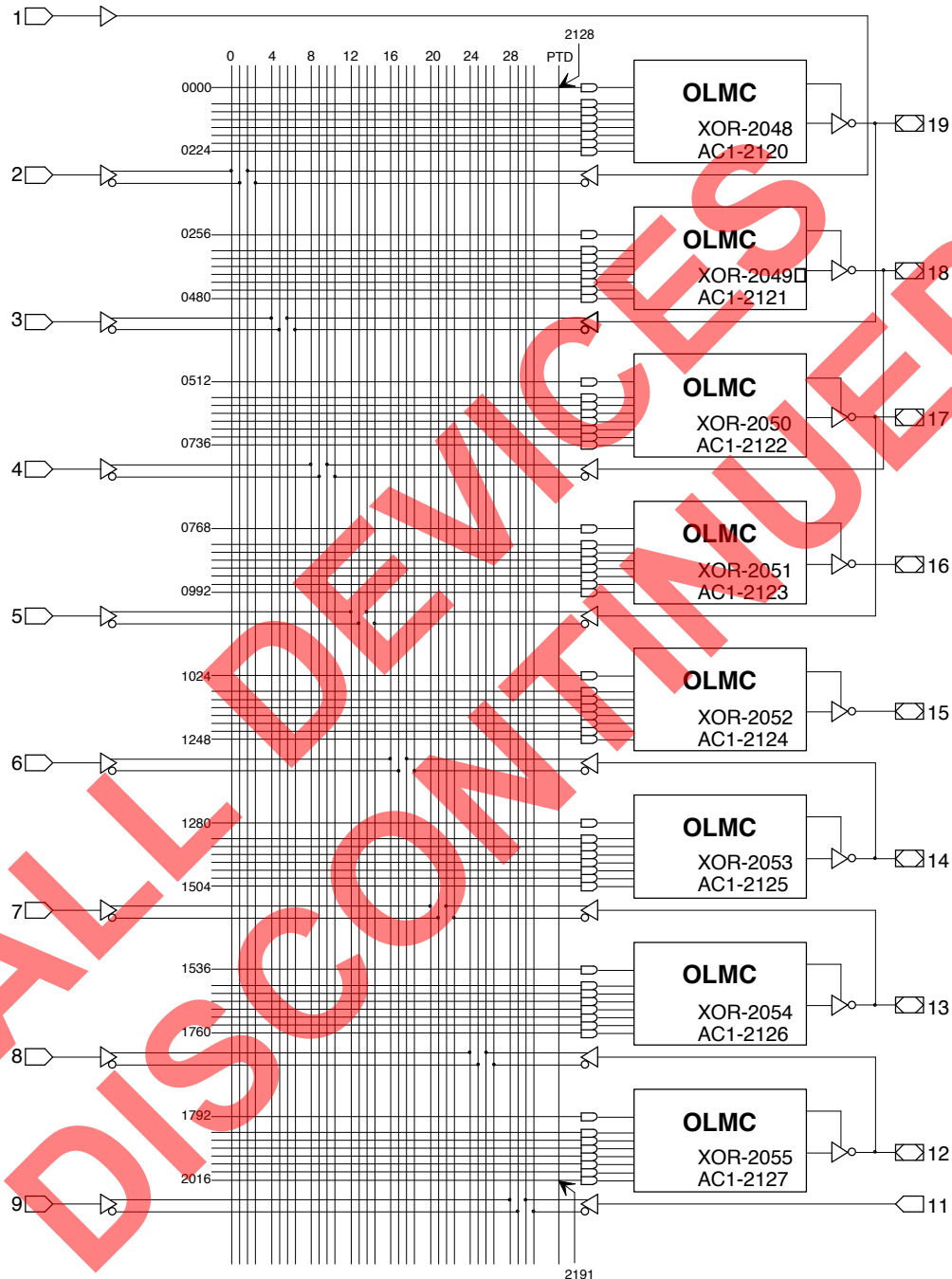
64-USER ELECTRONIC SIGNATURE FUSES

2056, 2057,	 2118, 2119
Byte 7 Byte 6 	 Byte 1 Byte 0
M	L
S	S
B	B

SYN-2192
AC0-2193

Simple Mode Logic Diagram

DIP & PLCC Package Pinouts



64-USER ELECTRONIC SIGNATURE FUSES

2056, 2057,	 2118, 2119
Byte 7 Byte 6	 Byte 1 Byte 0

M L
S S
B B

SYN-2192
AC0-2193

AC Switching Characteristics

Over Recommended Operating Conditions

			COM		COM		COM / IND		
PARAMETER	TEST COND ¹ .	DESCRIPTION	-3		-5		-7		UNITS
			MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	
t _{pd}	A	Input or I/O to Comb. Output	1	3.5	1	5	1	7.5	ns
t _{co}	A	Clock to Output Delay	1	3	1	4	1	5	ns
t _{cf} ²	—	Clock to Feedback Delay	—	2.5	—	3	—	3	ns
t _{su}	—	Setup Time, Input or Feedback before Clock↑	2.5	—	3	—	5	—	ns
t _h	—	Hold Time, Input or Feedback after Clock↑	0	—	0	—	0	—	ns
f _{max} ³	A	Maximum Clock Frequency with External Feedback, 1/(tsu + tco)	182	—	142.8	—	100	—	MHz
	A	Maximum Clock Frequency with Internal Feedback, 1/(tsu + tcf)	200	—	166	—	125	—	MHz
	A	Maximum Clock Frequency with No Feedback	250	—	166	—	125	—	MHz
t _{wh}	—	Clock Pulse Duration, High	2 ⁴	—	3 ⁴	—	4	—	ns
t _{wl}	—	Clock Pulse Duration, Low	2 ⁴	—	3 ⁴	—	4	—	ns
t _{en}	B	Input or I/O to Output Enabled	—	4.5	1	6	1	9	ns
	B	OE to Output Enabled	—	4.5	1	6	1	6	ns
t _{dis}	C	Input or I/O to Output Disabled	—	4.5	1	5	1	9	ns
	C	OE to Output Disabled	—	4.5	1	5	1	6	ns

1) Refer to **Switching Test Conditions** section.

2) Calculated from f_{max} with internal feedback. Refer to **f_{max} Descriptions** section.

3) Refer to **f_{max} Descriptions** section. Characterized but not 100% tested.

4) Characterized but not 100% tested.

Capacitance (T_A = 25°C, f = 1.0 MHz)

SYMBOL	PARAMETER	MAXIMUM*	UNITS	TEST CONDITIONS
C _I	Input Capacitance	8	pF	V _{CC} = 5.0V, V _I = 2.0V
C _{I/O}	I/O Capacitance	8	pF	V _{CC} = 5.0V, V _{I/O} = 2.0V

*Characterized but not 100% tested.

AC Switching Characteristics

Over Recommended Operating Conditions

PARAM.	TEST COND ¹ .	DESCRIPTION	COM / IND		COM / IND		IND		COM / IND		UNITS
			-10		-15		-20		-25		
			MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	
t _{pd}	A	Input or I/O to Comb. Output	3	10	3	15	3	20	3	25	ns
t _{co}	A	Clock to Output Delay	2	7	2	10	2	11	2	12	ns
t _{cf} ²	—	Clock to Feedback Delay	—	6	—	8	—	9	—	10	ns
t _{su}	—	Setup Time, Input or Fdbk before Clk↑	7.5	—	12	—	13	—	15	—	ns
t _h	—	Hold Time, Input or Fdbk after Clk↑	0	—	0	—	0	—	0	—	ns
f _{max} ³	A	Maximum Clock Frequency with External Feedback, 1/(tsu + tco)	66.7	—	45.5	—	41.6	—	37	—	MHz
	A	Maximum Clock Frequency with Internal Feedback, 1/(tsu + tcf)	71.4	—	50	—	45.4	—	40	—	MHz
	A	Maximum Clock Frequency with No Feedback	83.3	—	62.5	—	50	—	41.6	—	MHz
t _{wh}	—	Clock Pulse Duration, High	6	—	8	—	10	—	12	—	ns
t _{wl}	—	Clock Pulse Duration, Low	6	—	8	—	10	—	12	—	ns
t _{en}	B	Input or I/O to Output Enabled	1	10	—	15	—	18	—	20	ns
	B	OE to Output Enabled	1	10	—	15	—	18	—	20	ns
t _{dis}	C	Input or I/O to Output Disabled	1	10	—	15	—	18	—	20	ns
	C	OE to Output Disabled	1	10	—	15	—	18	—	20	ns

1) Refer to **Switching Test Conditions** section.

2) Calculated from **f_{max}** with internal feedback. Refer to **f_{max} Descriptions** section.

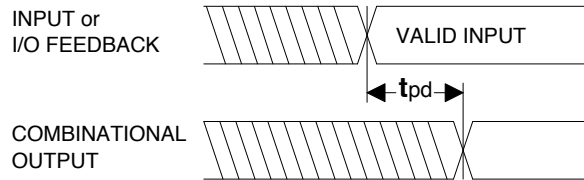
3) Refer to **f_{max} Descriptions** section. Characterized but not 100% tested.

Capacitance (T_A = 25°C, f = 1.0 MHz)

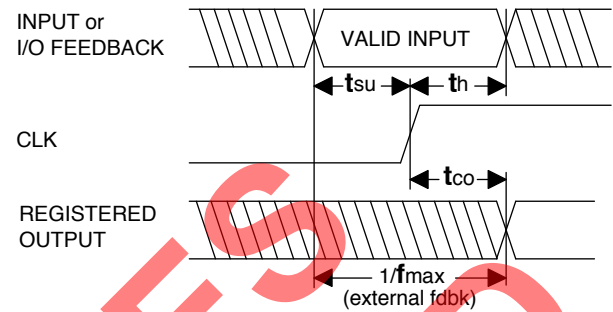
SYMBOL	PARAMETER	MAXIMUM*	UNITS	TEST CONDITIONS
C _I	Input Capacitance	8	pF	V _{CC} = 5.0V, V _I = 2.0V
C _{I/O}	I/O Capacitance	8	pF	V _{CC} = 5.0V, V _{I/O} = 2.0V

*Characterized but not 100% tested.

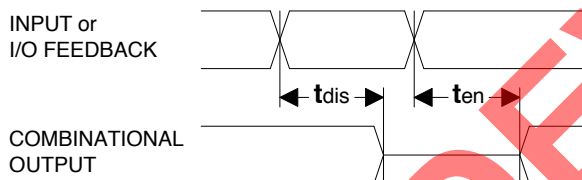
Switching Waveforms



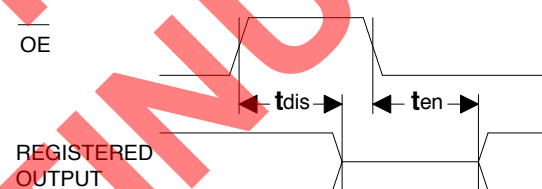
Combinatorial Output



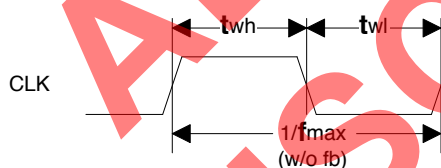
Registered Output



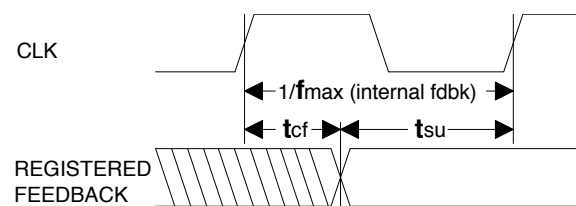
Input or I/O to Output Enable/Disable



OE to Output Enable/Disable

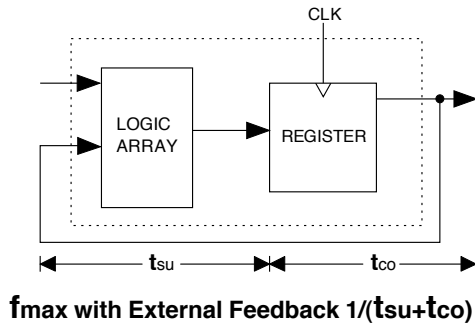


Clock Width

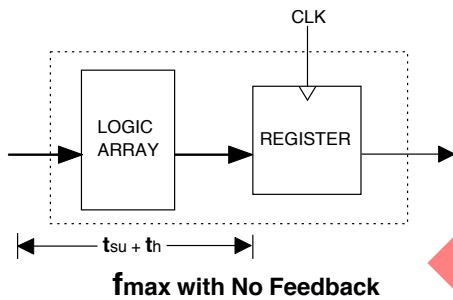


f_{max} with Feedback

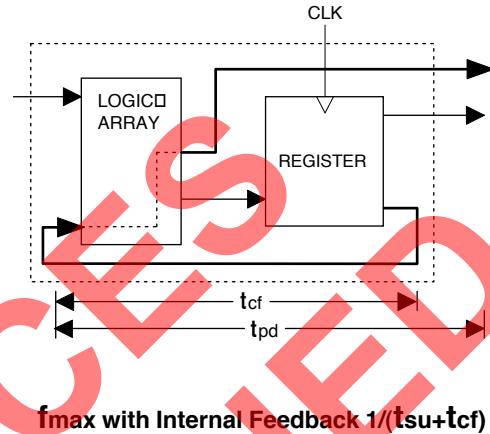
fmax Descriptions



Note: fmax with external feedback is calculated from measured tsu and tco.



Note: fmax with no feedback may be less than $1/(t_{wh} + t_{wl})$. This is to allow for a clock duty cycle of other than 50%.



Note: tcf is a calculated value, derived by subtracting tsu from the period of fmax w/internal feedback ($t_{cf} = 1/f_{max} - t_{su}$). The value of tcf is used primarily when calculating the delay from clocking a register to a combinational output (through registered feedback), as shown above. For example, the timing from clock to a combinational output is equal to $t_{cf} + t_{pd}$.

Switching Test Conditions

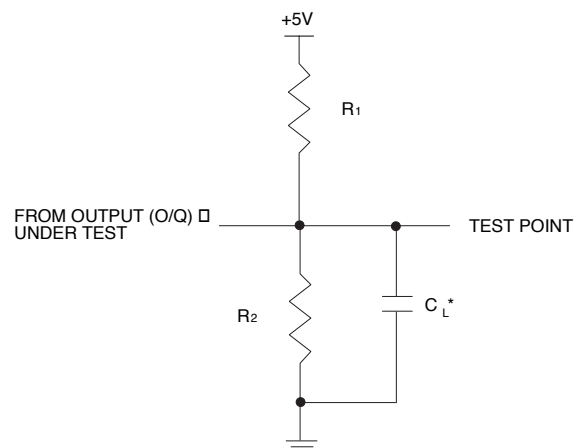
Input Pulse Levels		GND to 3.0V
Input Rise and Fall Times	GAL16V8D-10 (and slower)	2 – 3ns 10% – 90%
	GAL16V8D-3/-5/-7	1.5ns 10% – 90%
Input Timing Reference Levels		1.5V
Output Timing Reference Levels		1.5V
Output Load		See figure at right

3-state levels are measured 0.5V from steady-state active level.

Table 2-0003/16V8

GAL16V8D (except -3) Output Load Conditions (see figure above)

Test Condition	R ₁	R ₂	C _L
A	200Ω	390Ω	50pF
B	∞	390Ω	50pF
C	200Ω	390Ω	5pF

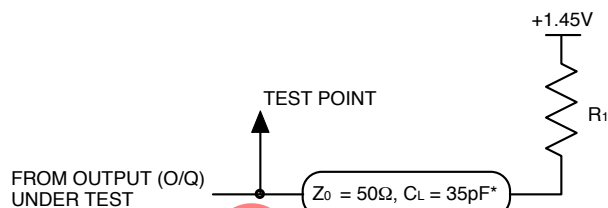


*C_L INCLUDES TEST FIXTURE AND PROBE CAPACITANCE

Switching Test Conditions (Continued)

GAL16V8D-3 Output Load Conditions (see figure at right)

Test Condition	R ₁	C _L
A	50Ω	35pF
B	50Ω	High Z to Active High at 1.9V
		High Z to Active Low at 1.0V
C	50Ω	Active High to High Z at 1.9V
		Active Low to High Z at 1.0V
	50Ω	35pF



*C_L includes test fixture and probe capacitance.

Electronic Signature

An electronic signature is provided in every GAL16V8 device. It contains 64 bits of reprogrammable memory that can contain user defined data. Some uses include user ID codes, revision numbers, or inventory control. The signature data is always available to the user independent of the state of the security cell.

NOTE: The electronic signature is included in checksum calculations. Changing the electronic signature will alter the checksum.

Security Cell

A security cell is provided in the GAL16V8 devices to prevent unauthorized copying of the array patterns. Once programmed, this cell prevents further read access to the functional bits in the device. This cell can only be erased by re-programming the device, so the original configuration can never be examined once this cell is programmed. The Electronic Signature is always available to the user, regardless of the state of this control cell.

Latch-Up Protection

GAL16V8 devices are designed with an on-board charge pump to negatively bias the substrate. The negative bias minimizes the potential of latch-up caused by negative input undershoots. Additionally, outputs are designed with n-channel pull-ups instead of the traditional p-channel pull-ups in order to eliminate latch-up due to output overshoots.

Device Programming

GAL devices are programmed using a Lattice Semiconductor-approved Logic Programmer, available from a number of manufacturers. Complete programming of the device takes only a few seconds. Erasing of the device is transparent to the user, and is done automatically as part of the programming cycle.

Output Register Preload

When testing state machine designs, all possible states and state transitions must be verified in the design, not just those required in the normal machine operations. This is because, in system operation, certain events occur that may throw the logic into an illegal state (power-up, line voltage glitches, brown-outs, etc.). To test a design for proper treatment of these conditions, a way must be provided to break the feedback paths, and force any desired (i.e., illegal) state into the registers. Then the machine can be sequenced and the outputs tested for correct next state conditions.

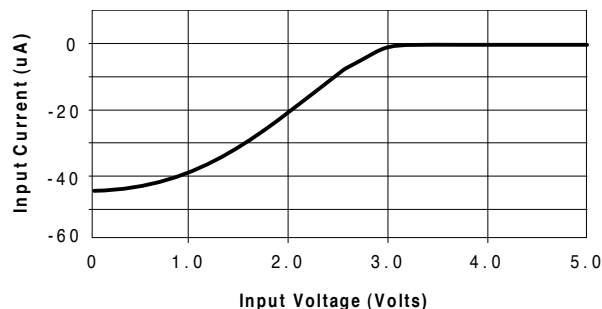
GAL16V8 devices include circuitry that allows each registered output to be synchronously set either high or low. Thus, any present state condition can be forced for test sequencing. If necessary, approved GAL programmers capable of executing text vectors perform output register preload automatically.

Input Buffers

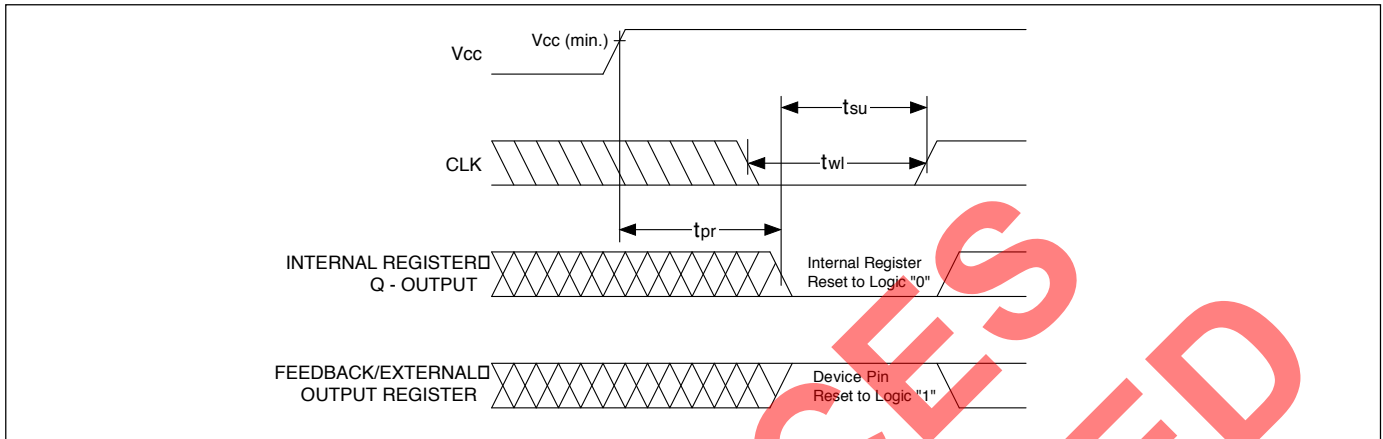
GAL16V8 devices are designed with TTL level compatible input buffers. These buffers have a characteristically high impedance, and present a much lighter load to the driving logic than bipolar TTL devices.

The GAL16V8 input and I/O pins have built-in active pull-ups. As a result, unused inputs and I/O's will float to a TTL "high" (logical "1"). Lattice Semiconductor recommends that all unused inputs and tri-stated I/O pins be connected to another active input, V_{CC}, or Ground. Doing this will tend to improve noise immunity and reduce I_{CC} for the device.

Typical Input Pull-up Characteristic



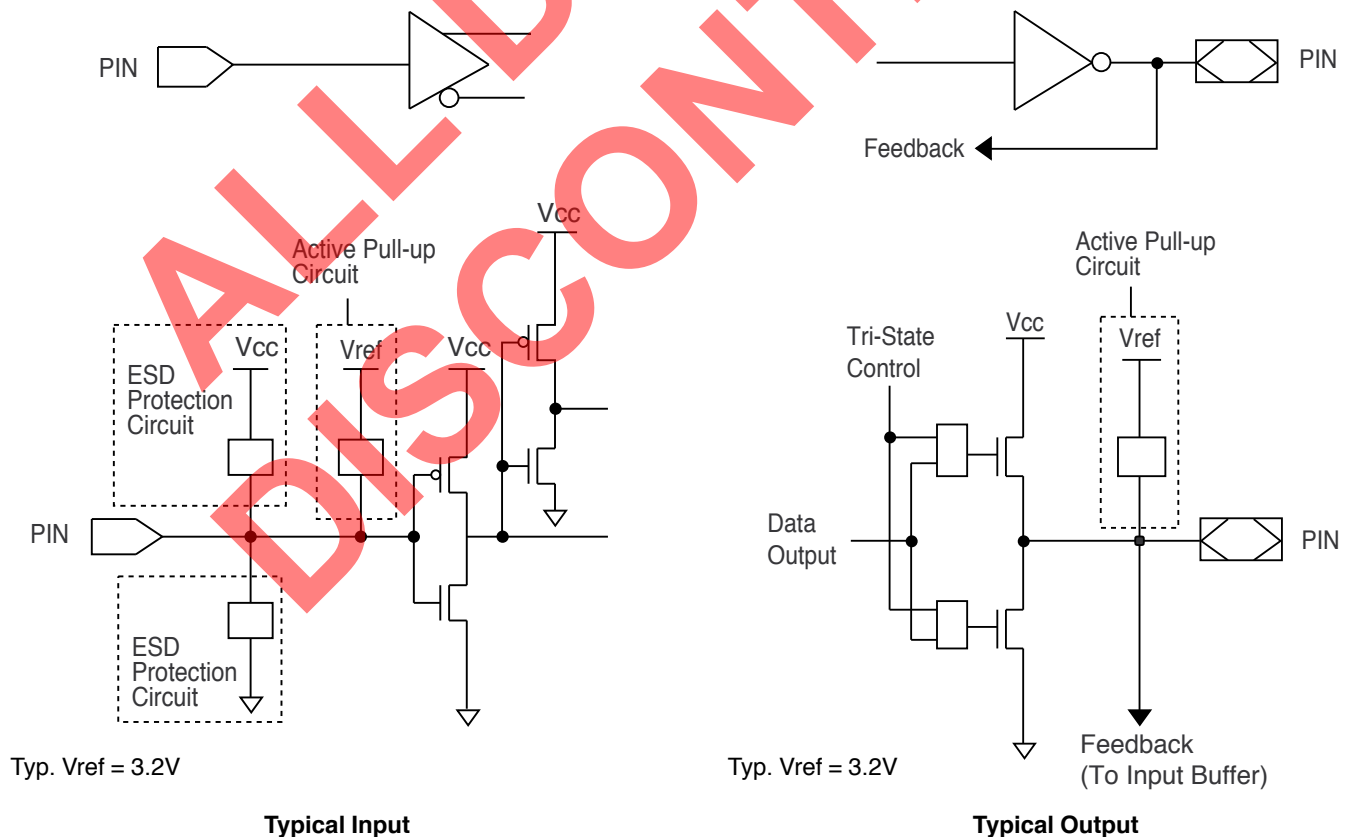
Power-Up Reset



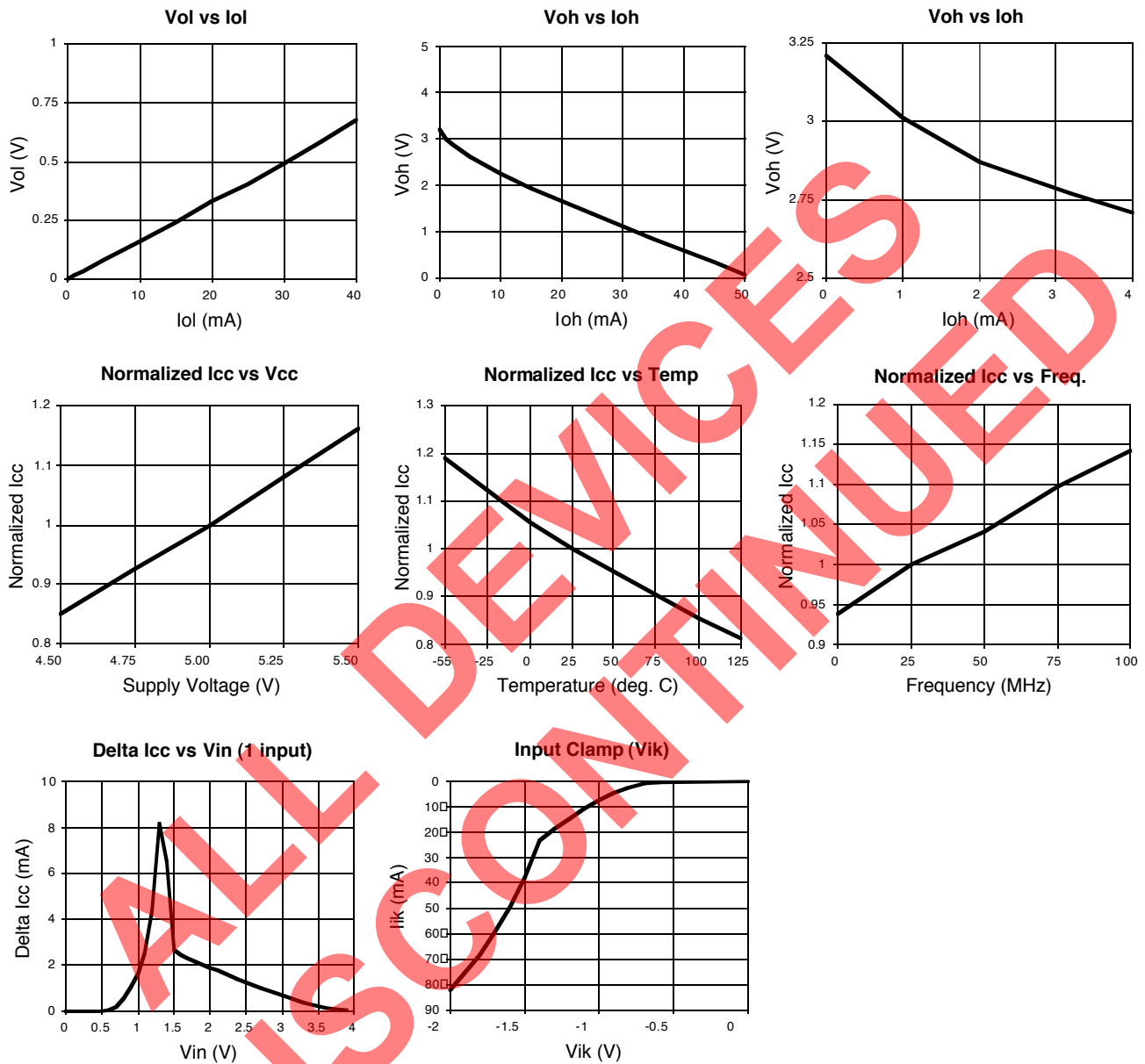
Circuitry within the GAL16V8 provides a reset signal to all registers during power-up. All internal registers will have their Q outputs set low after a specified time (t_{pr} , 1 μ s MAX). As a result, the state on the registered output pins (if they are enabled) will always be high on power-up, regardless of the programmed polarity of the output pins. This feature can greatly simplify state machine design by providing a known state on power-up. Because of the asynchronous nature of system power-up, some

conditions must be met to provide a valid power-up reset of the device. First, the V_{cc} rise must be monotonic. Second, the clock input must be at static TTL level as shown in the diagram during power up. The registers will reset within a maximum of t_{pr} time. As in normal system operation, avoid clocking the device until all input and feedback path setup times have been met. The clock must also meet the minimum pulse width requirements.

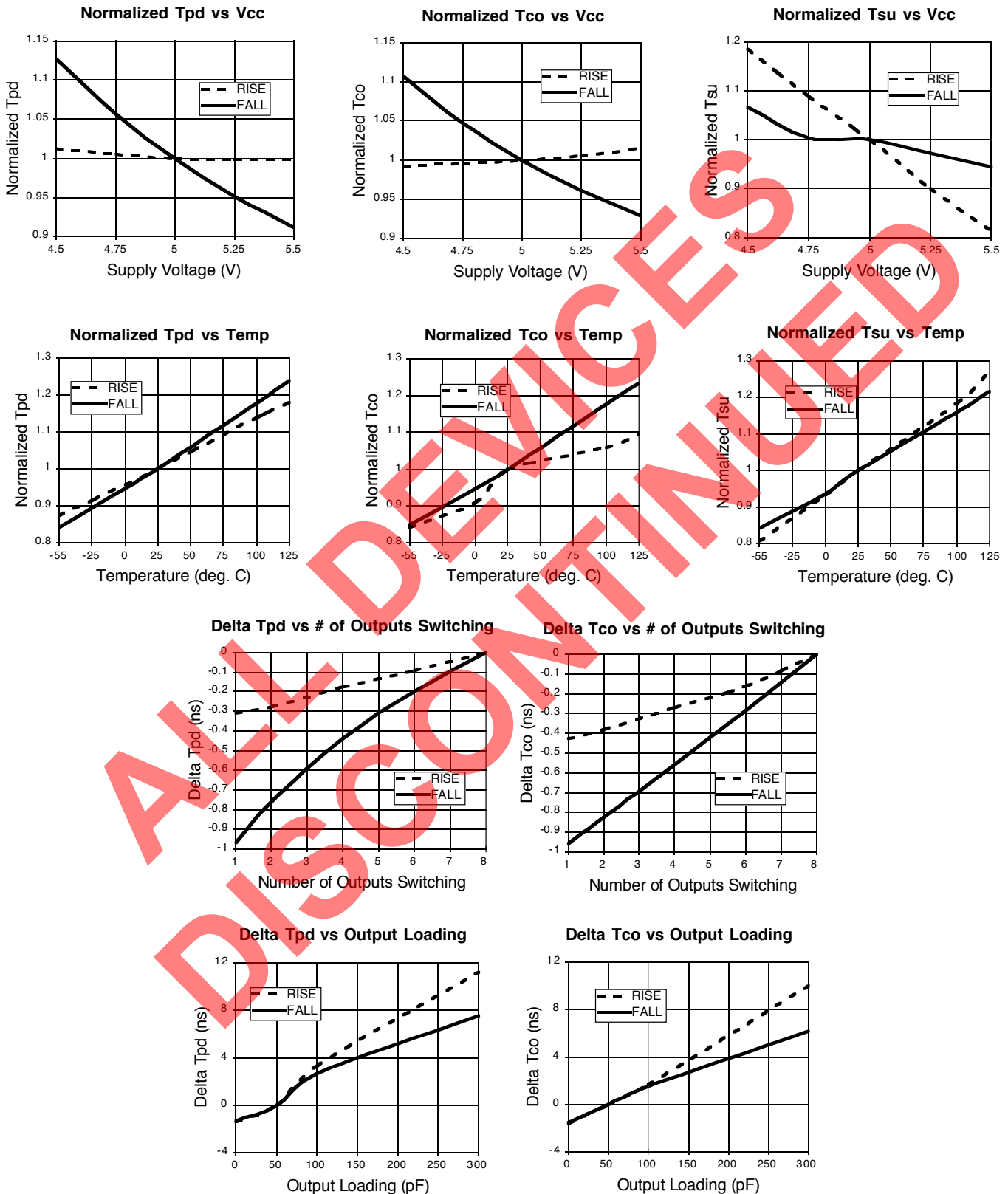
Input/Output Equivalent Schematics



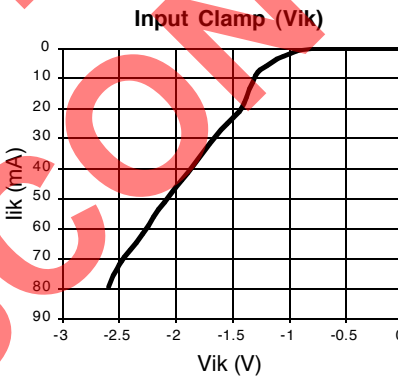
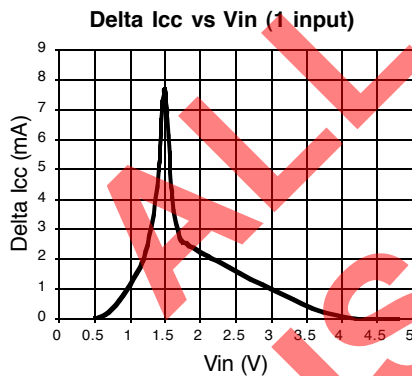
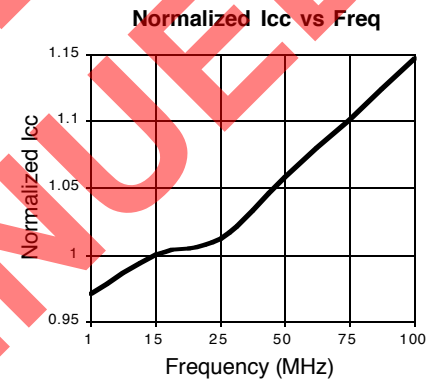
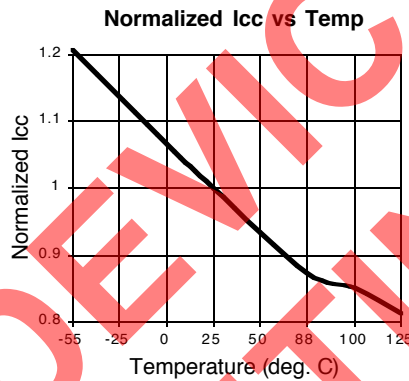
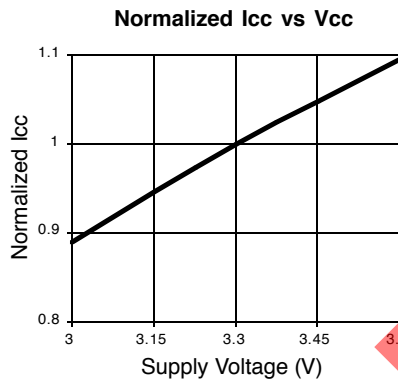
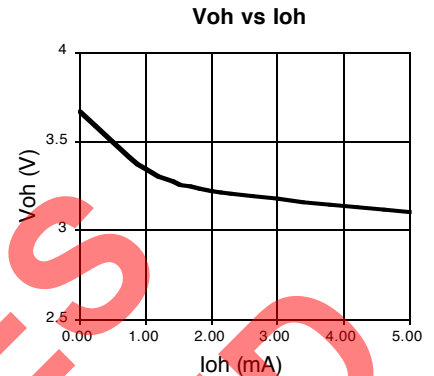
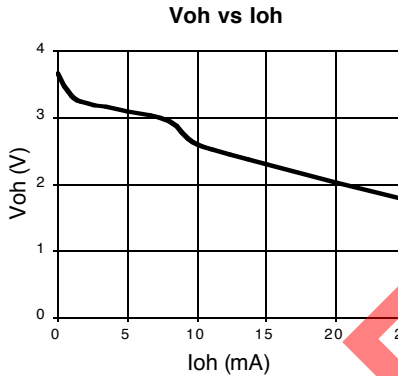
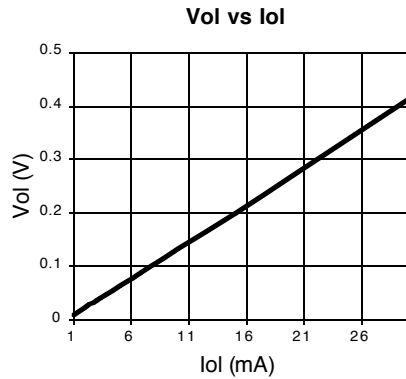
GAL16V8D-3/-5/-7 (IND PLCC): Typical AC and DC Characteristic Diagrams



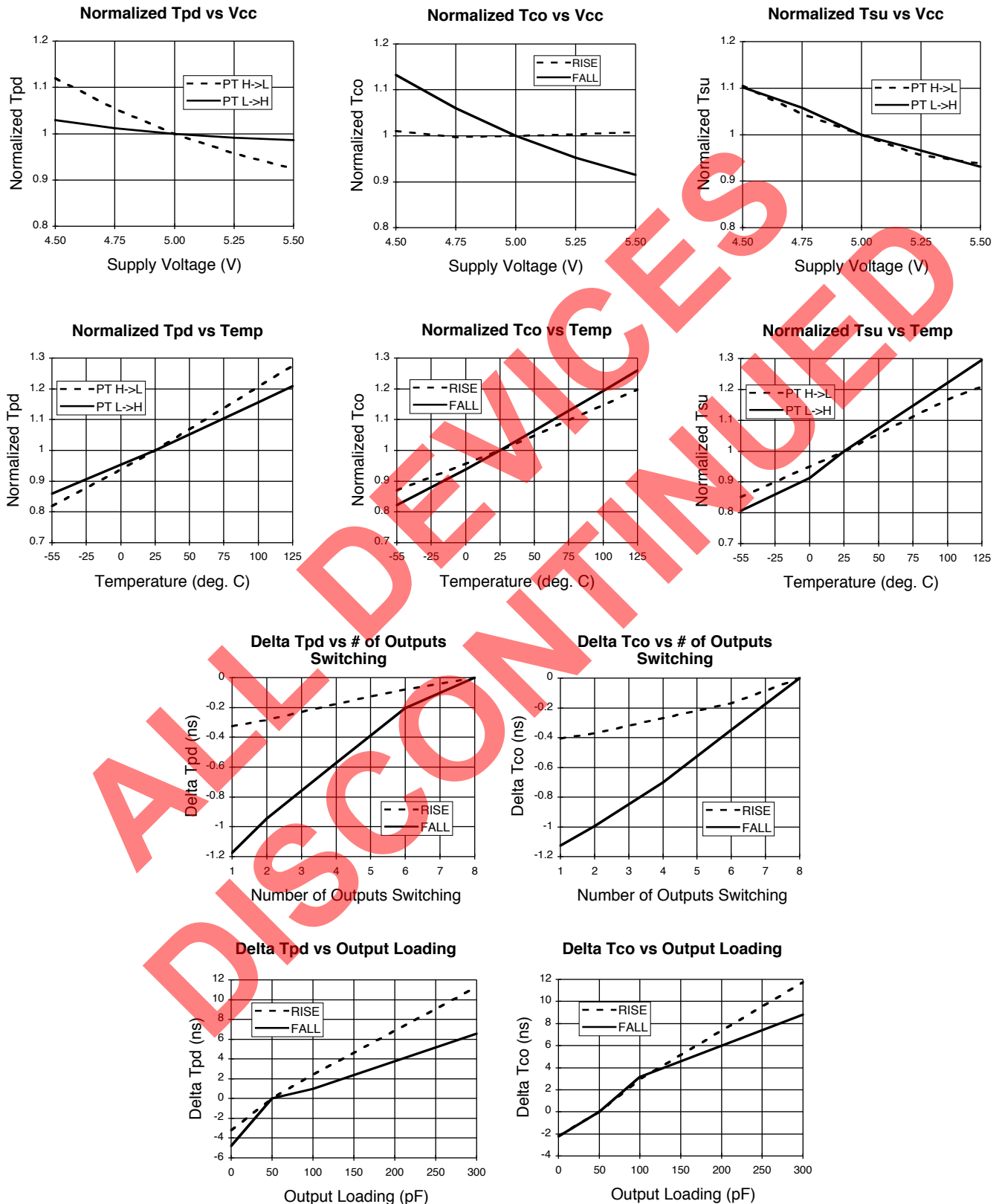
GAL16V8D-7 (Except IND PLCC)/-10L: Typical AC and DC Characteristic Diagrams



GAL16V8D-7 (Except IND PLCC)/-10L: Typical AC and DC Characteristic Diagrams



GAL16V8D-10Q (and Slower): Typical AC and DC Characteristic Diagrams



GAL16V8D-10Q (and Slower): Typical AC and DC Characteristic Diagrams

