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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	10 ns
Voltage Supply - Internal	4.75V ~ 5.25V
Number of Logic Elements/Blocks	-
Number of Macrocells	8
Number of Gates	-
Number of I/O	-
Operating Temperature	0°C ~ 75°C (TA)
Mounting Type	Surface Mount
Package / Case	28-LCC (J-Lead)
Supplier Device Package	28-PLCC (11.51x11.51)
Purchase URL	https://www.e-xfl.com/product-detail/lattice-semiconductor/gal20v8c-10lj



Product Line	Ordering Part Number	Product Status	Reference PCN
GAL20V8B (Cont'd)	GAL20V8B-25QJ	Discontinued	<u>PCN#13-10</u>
	GAL20V8B-25QJN		
	GAL20V8B-20QJI		<u>PCN#09-10</u>
	GAL20V8B-20QJNI		
	GAL20V8B-25QJI		<u>PCN#13-10</u>
	GAL20V8B-25QJNI		
GAL20V8C	GAL20V8C-5LJ		<u>PCN#06-07</u>
	GAL20V8C-5LJN		
	GAL20V8C-7LJ		<u>PCN#13-10</u>
	GAL20V8C-7LJN		
	GAL20V8C-10LJ		
	GAL20V8C-10LJN		
	GAL20V8C-10LJI		
	GAL20V8C-10LJNI		

GAL20V8 Ordering Information

Conventional Packaging Commercial Grade Specifications

Tpd (ns)	Tsu (ns)	Tco (ns)	Icc (mA)	Ordering #	Package
5	3	4	115	GAL20V8C-5LJ ¹	28-Lead PLCC
7.5	7	5	115	GAL20V8C-7LJ	28-Lead PLCC
			115	GAL20V8B-7LP ¹	24-Pin Plastic DIP
10	10	7	115	GAL20V8C-10LJ	28-Lead PLCC
			115	GAL20V8B-10LP	24-Pin Plastic DIP
15	12	10	55	GAL20V8B-15QP	24-Pin Plastic DIP
			55	GAL20V8B-15QJ	28-Lead PLCC
			90	GAL20V8B-15LP	24-Pin Plastic DIP
			90	GAL20V8B-15LJ	28-Lead PLCC
25	15	12	55	GAL20V8B-25QP	24-Pin Plastic DIP
			55	GAL20V8B-25QJ	28-Lead PLCC
			90	GAL20V8B-25LP	24-Pin Plastic DIP
			90	GAL20V8B-25LJ	28-Lead PLCC

Industrial Grade Specifications

Tpd (ns)	Tsu (ns)	Tco (ns)	Icc (mA)	Ordering #	Package
10	10	7	130	GAL20V8C-10LJI	28-Lead PLCC
			130	GAL20V8B-10LPI ¹	24-Pin Plastic DIP
			130	GAL20V8B-10LJI	28-Lead PLCC
15	12	10	130	GAL20V8B-15LPI	24-Pin Plastic DIP
			130	GAL20V8B-15LJI	28-Lead PLCC
20	13	11	65	GAL20V8B-20QPI	24-Pin Plastic DIP
			65	GAL20V8B-20QJI	28-Lead PLCC
25	15	12	65	GAL20V8B-25QPI	24-Pin Plastic DIP
			65	GAL20V8B-25QJI	28-Lead PLCC
			130	GAL20V8B-25LPI	24-Pin Plastic DIP
			130	GAL20V8B-25LJI	28-Lead PLCC

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

**Lead-Free Packaging
Commercial Grade Specifications**

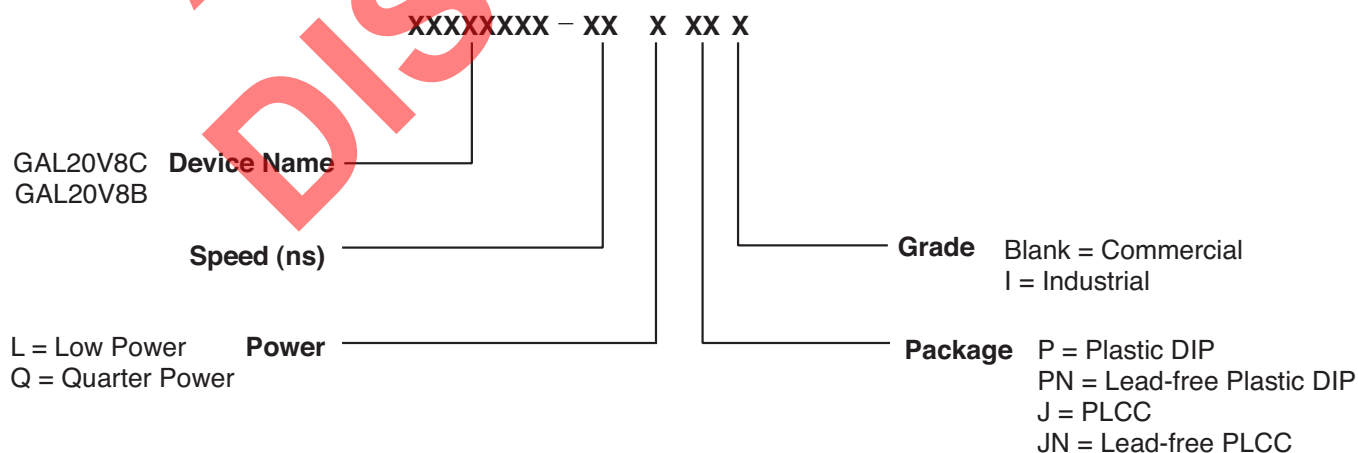
Tpd (ns)	Tsu (ns)	Tco (ns)	Icc (mA)	Ordering #	Package
5	3	4	115	GAL20V8C-5LJN ¹	Lead-Free 28-Lead PLCC
7.5	7	5	115	GAL20V8C-7LJN	Lead-Free 28-Lead PLCC
			115	GAL20V8B-7LPN ¹	Lead-Free 24-Pin Plastic DIP
10	10	7	115	GAL20V8C-10LJN	Lead-Free 28-Lead PLCC
			115	GAL20V8B-10LPN	Lead-Free 24-Pin Plastic DIP
15	12	10	55	GAL20V8B-15QJN	Lead-Free 28-Lead PLCC
			55	GAL20V8B-15QPN	Lead-Free 24-Pin Plastic DIP
			90	GAL20V8B-15LJN	Lead-Free 28-Lead PLCC
			90	GAL20V8B-15LPN	Lead-Free 24-Pin Plastic DIP
25	15	12	55	GAL20V8B-25QJN	Lead-Free 28-Lead PLCC
			55	GAL20V8B-25QPN	Lead-Free 24-Pin Plastic DIP
			90	GAL20V8B-25LJN	Lead-Free 28-Lead PLCC
			90	GAL20V8B-25LPN	Lead-Free 24-Pin Plastic DIP

Industrial Grade Specifications

Tpd (ns)	Tsu (ns)	Tco (ns)	Icc (mA)	Ordering #	Package
10	10	7	130	GAL20V8C-10LJN ¹	Lead-Free 28-Pin Plastic DIP
			130	GAL20V8B-10LPN ¹	Lead-Free 24-Pin Plastic DIP
15	12	10	130	GAL20V8B-15LJN ¹	Lead-Free 28-Lead PLCC
			130	GAL20V8B-15LPN ¹	Lead-Free 24-Pin Plastic DIP
20	13	11	65	GAL20V8B-20QJN ¹	Lead-Free 28-Lead PLCC
			65	GAL20V8B-20QPN ¹	Lead-Free 24-Pin Plastic DIP
25	15	12	65	GAL20V8B-25QJN ¹	Lead-Free 28-Lead PLCC
			65	GAL20V8B-25QPN ¹	Lead-Free 24-Pin Plastic DIP
			130	GAL20V8B-25LJN ¹	Lead-Free 28-Lead PLCC
			130	GAL20V8B-25LPN ¹	Lead-Free 24-Pin Plastic DIP

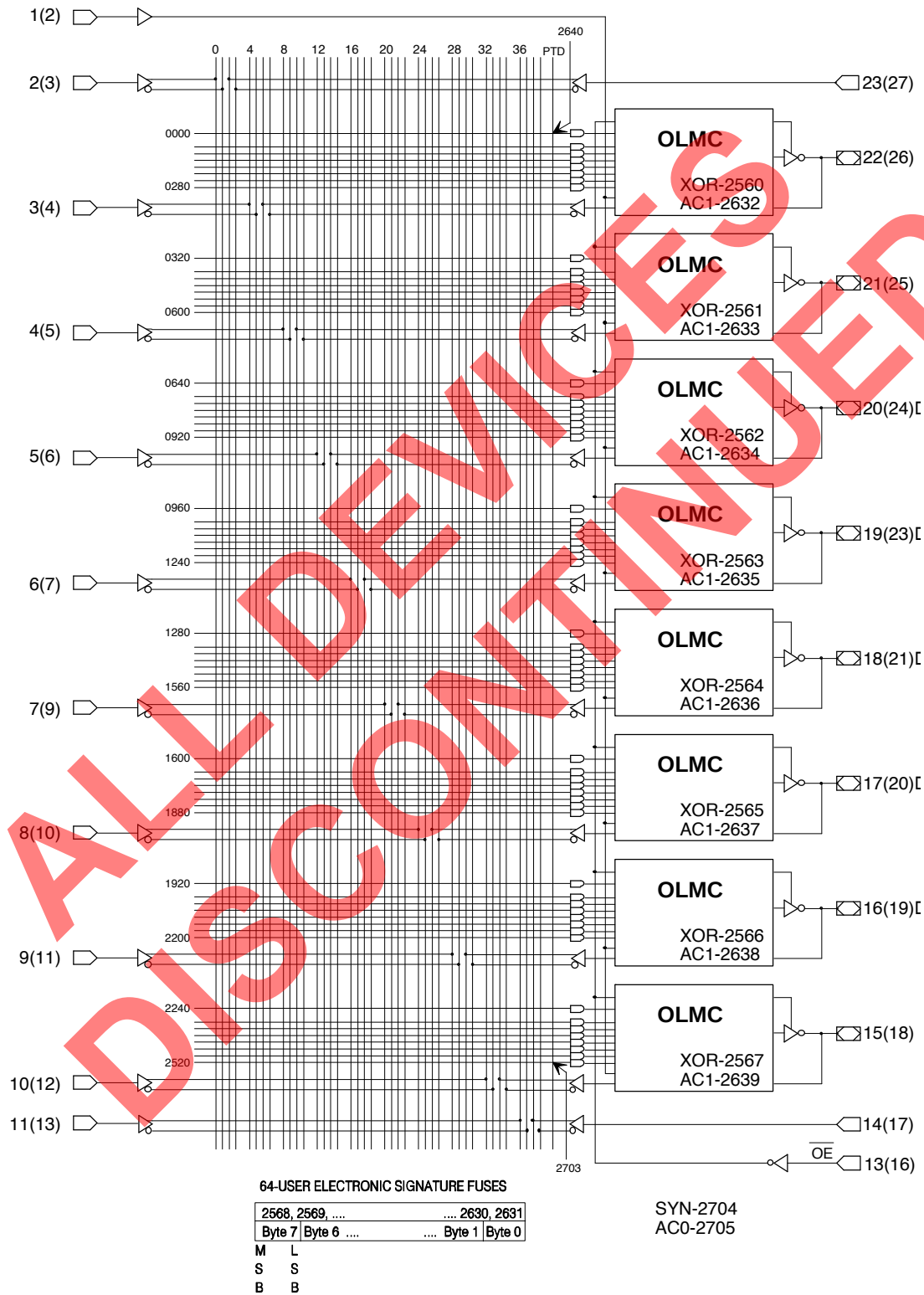
1. Discontinued per PCN #06-07. Contact Rochester Electronics for available inventory.

Part Number Description



Registered Mode Logic Diagram

DIP (PLCC) Package Pinouts



Complex Mode

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

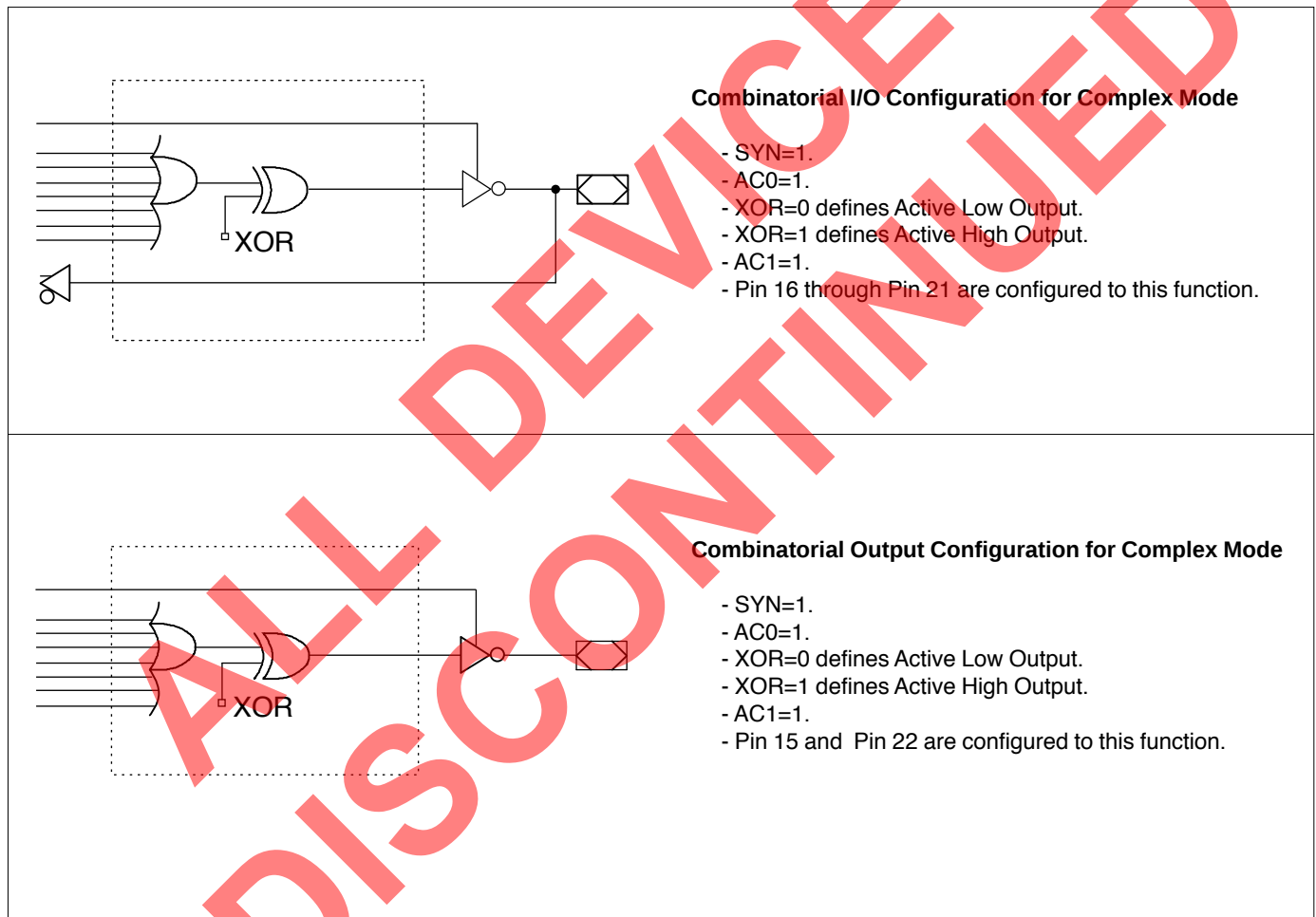
Architecture configurations available in this mode are similar to the common 20L8 and 20P8 devices with programmable polarity in each macrocell.

Up to six I/Os 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 15 & 22) do not have input capability. De-

signs requiring eight I/Os 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 13 are always available as data inputs into the AND array.

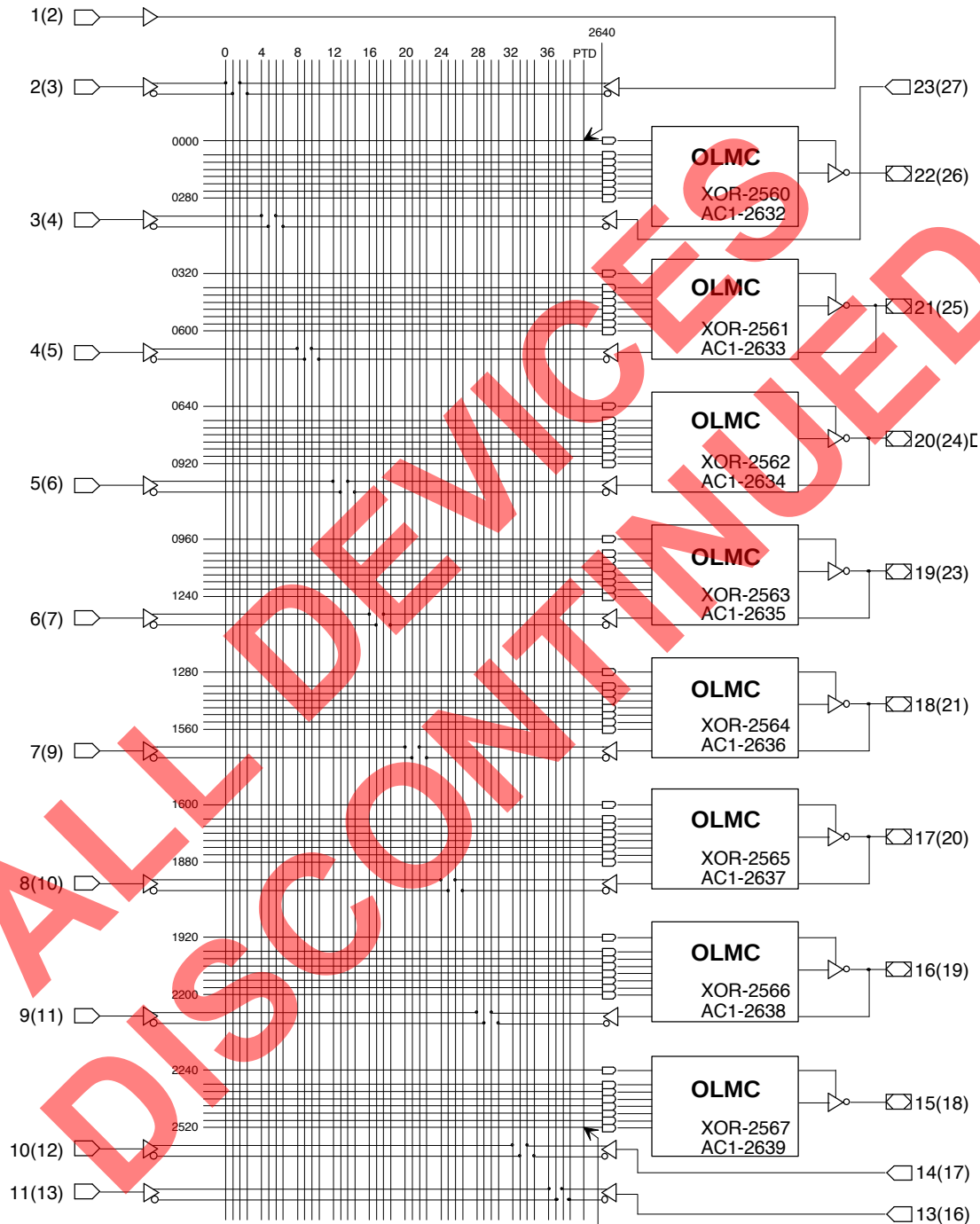
The JEDEC fuse numbers including the UES fuses and PTD fuses are shown on the logic diagram on the following page.



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

2568, 2569,	 2630, 2631
Byte 7 Byte 6	 Byte 1 Byte 0
M L	
S S	
B B	

SYN-2704
AC0-2705

Absolute Maximum Ratings⁽¹⁾

Supply voltage V_{CC} -0.5 to +7V
 Input voltage applied -2.5 to $V_{CC} + 1.0V$
 Off-state output voltage applied -2.5 to $V_{CC} + 1.0V$
 Storage Temperature -65 to 150°C
 Ambient Temperature with

Power Applied -55 to 125°C

1. Stresses above those listed under the "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress only ratings and functional operation of the device at these or at any other conditions above those indicated in the operational sections of this specification is not implied (while programming, follow the programming specifications).

Recommended Operating Conditions

Commercial Devices:

Ambient Temperature (T_A) 0 to 75°C
 Supply voltage (V_{CC})
 with Respect to Ground +4.75 to +5.25V

Industrial Devices:

Ambient Temperature (T_A) -40 to 85°C
 Supply voltage (V_{CC})
 with Respect to Ground +4.50 to +5.50V

DC Electrical Characteristics

Over Recommended Operating Conditions (Unless Otherwise Specified)

SYMBOL	PARAMETER	CONDITION	MIN.	TYP. ³	MAX.	UNITS
V_{IL}	Input Low Voltage		$V_{SS} - 0.5$	—	0.8	V
V_{IH}	Input High Voltage		2.0	—	$V_{CC} + 1$	V
I_{IL}^1	Input or I/O Low Leakage Current	$0V \leq V_{IN} \leq V_{IL} (MAX.)$	—	—	-100	μA
I_{IH}	Input or I/O High Leakage Current	$3.5V \leq V_{IN} \leq V_{CC}$	—	—	10	μA
V_{OL}	Output Low Voltage	$I_{OL} = MAX.$ $V_{IN} = V_{IL} \text{ or } V_{IH}$	—	—	0.5	V
V_{OH}	Output High Voltage	$I_{OH} = MAX.$ $V_{IN} = V_{IL} \text{ or } V_{IH}$	2.4	—	—	V
I_{OL}	Low Level Output Current		—	—	16	mA
I_{OH}	High Level Output Current		—	—	-3.2	mA
I_{OS}^2	Output Short Circuit Current	$V_{CC} = 5V$ $V_{OUT} = 0.5V$ $T_A = 25^\circ C$	-30	—	-150	mA

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I_{CC}	Operating Power Supply Current	$V_{IL} = 0.5V$ $V_{IH} = 3.0V$ $f_{toggle} = 15MHz$ Outputs Open	L -5/-7/-10	—	75	115	mA
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INDUSTRIAL

I_{CC}	Operating Power Supply Current	$V_{IL} = 0.5V$ $V_{IH} = 3.0V$ $f_{toggle} = 15MHz$ Outputs Open	L-10	—	75	130	mA
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1) The leakage current is due to the internal pull-up resistor on all pins. See **Input Buffer** section for more information.

2) One output at a time for a maximum duration of one second. $V_{out} = 0.5V$ was selected to avoid test problems caused by tester ground degradation. Characterized but not 100% tested.

3) Typical values are at $V_{CC} = 5V$ and $T_A = 25^\circ C$

AC Switching Characteristics

Over Recommended Operating Conditions

				COM		COM		COM/IND		
PARAMETER	TEST COND ¹ .	DESCRIPTION		-5		-7		-10		UNITS
				MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	
t_{pd}	A	Input or I/O to	8 outputs switching	1	5	3	7.5	3	10	ns
		Comb. Output	1 output switching	—	—	—	7	—	—	ns
t_{co}	A	Clock to Output Delay		1	4	2	5	2	7	ns
t_{cf}²	—	Clock to Feedback Delay		—	3	—	3	—	6	ns
t_{su}	—	Setup Time, Input or Feedback before Clock↑		3	—	5	—	7.5	—	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/(t _{su} + t _{co})		142.8	—	100	—	66.7	—	MHz
	A	Maximum Clock Frequency with Internal Feedback, 1/(t _{su} + t _{cf})		166	—	125	—	71.4	—	MHz
	A	Maximum Clock Frequency with No Feedback		166	—	125	—	83.3	—	MHz
t_{wh}	—	Clock Pulse Duration, High		3	—	4	—	6	—	ns
t_{wl}	—	Clock Pulse Duration, Low		3	—	4	—	6	—	ns
t_{en}	B	Input or I/O to Output Enabled		1	6	3	9	3	10	ns
	B	OE to Output Enabled		1	6	2	6	2	10	ns
t_{dis}	C	Input or I/O to Output Disabled		1	5	2	9	2	10	ns
	C	OE to Output Disabled		1	5	1.5	6	1.5	10	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 initially and after any design or process changes that may affect these parameters.

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

Absolute Maximum Ratings⁽¹⁾

Supply voltage V_{CC} -0.5 to +7V
 Input voltage applied -2.5 to $V_{CC} + 1.0V$
 Off-state output voltage applied -2.5 to $V_{CC} + 1.0V$
 Storage Temperature -65 to 150°C
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Power Applied -55 to 125°C

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Recommended Operating Conditions

Commercial Devices:

Ambient Temperature (T_A) 0 to 75°C

Supply voltage (V_{CC})

with Respect to Ground +4.75 to +5.25V

Industrial Devices:

Ambient Temperature (T_A) -40 to 85°C

Supply voltage (V_{CC})

with Respect to Ground +4.50 to +5.50V

DC Electrical Characteristics

Over Recommended Operating Conditions (Unless Otherwise Specified)

SYMBOL	PARAMETER	CONDITION	MIN.	TYP. ³	MAX.	UNITS
V_{IL}	Input Low Voltage		$V_{SS} - 0.5$	—	0.8	V
V_{IH}	Input High Voltage		2.0	—	$V_{CC} + 1$	V
I_{IL}¹	Input or I/O Low Leakage Current	$0V \leq V_{IN} \leq V_{IL} (MAX.)$	—	—	-100	μA
I_{IH}	Input or I/O High Leakage Current	$3.5V \leq V_{IN} \leq V_{CC}$	—	—	10	μA
V_{OL}	Output Low Voltage	$I_{OL} = MAX. V_{IN} = V_{IL} \text{ or } V_{IH}$	—	—	0.5	V
V_{OH}	Output High Voltage	$I_{OH} = MAX. V_{IN} = V_{IL} \text{ or } V_{IH}$	2.4	—	—	V
I_{OL}	Low Level Output Current		—	—	24	mA
I_{OH}	High Level Output Current		—	—	-3.2	mA
I_{OS}²	Output Short Circuit Current	$V_{CC} = 5V \quad V_{OUT} = 0.5V \quad T_A = 25^\circ C$	-30	—	-150	mA

COMMERCIAL

I_{CC}	Operating Power	$V_{IL} = 0.5V \quad V_{IH} = 3.0V$	L -7/-10	—	75	115	mA
	Supply Current	$f_{toggle} = 15MHz \quad \text{Outputs Open}$	L -15/-25	—	75	90	mA
			Q -15/-25	—	45	55	mA

INDUSTRIAL

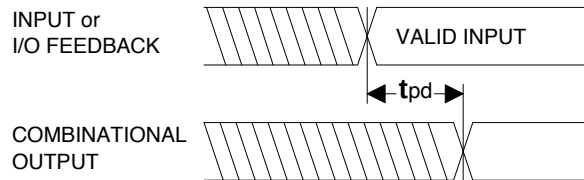
I_{CC}	Operating Power	$V_{IL} = 0.5V \quad V_{IH} = 3.0V$	L -10/-15/-25	—	75	130	mA
	Supply Current	$f_{toggle} = 15MHz \quad \text{Outputs Open}$	Q -20/-25	—	45	65	mA

1) The leakage current is due to the internal pull-up resistor on all pins. See **Input Buffer** section for more information.

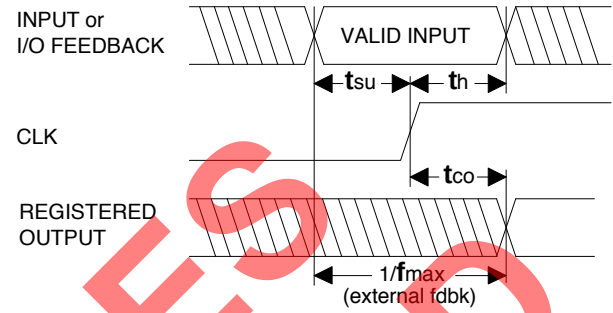
2) One output at a time for a maximum duration of one second. $V_{out} = 0.5V$ was selected to avoid test problems caused by tester ground degradation. Characterized but not 100% tested.

3) Typical values are at $V_{CC} = 5V$ and $T_A = 25^\circ C$

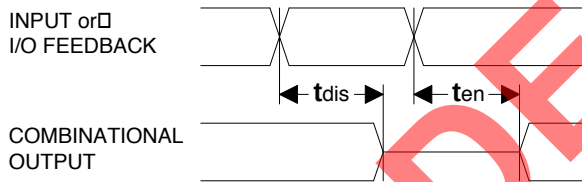
Switching Waveforms



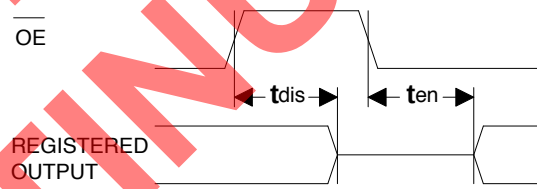
Combinatorial Output



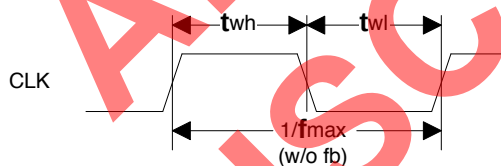
Registered Output



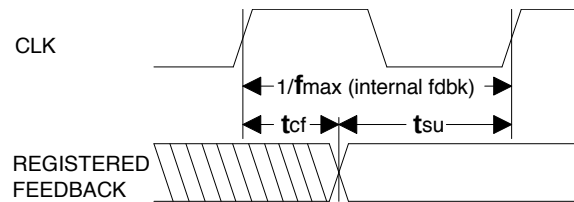
Input or I/O to Output Enable/Disable



OE to Output Enable/Disable

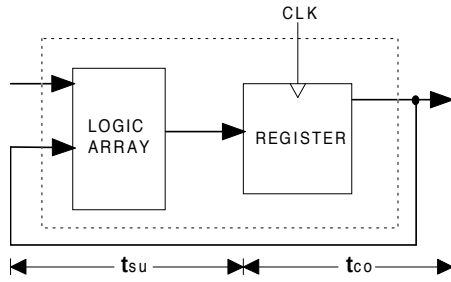


Clock Width



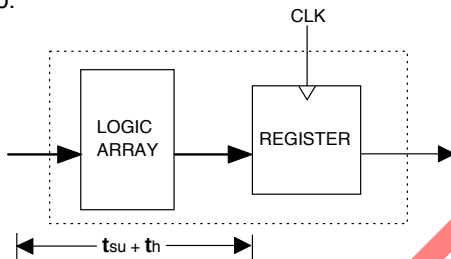
f_{max} with Feedback

fmax Descriptions



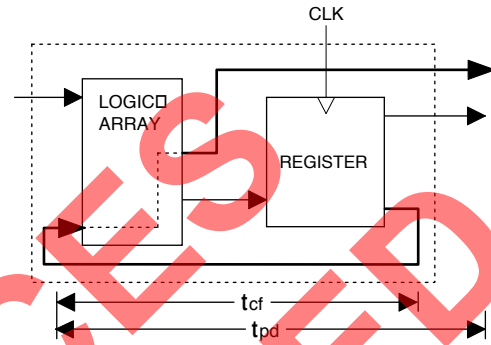
fmax with External Feedback $1/(t_{su}+t_{co})$

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



fmax with No Feedback

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%.



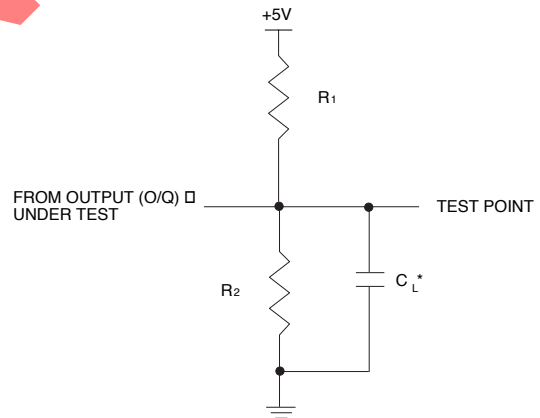
fmax with Internal Feedback $1/(t_{su}+t_{cf})$

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	GAL20V8B	2 – 3ns 10% – 90%
	GAL20V8C	1.5ns 10% – 90%
Input Timing Reference Levels		1.5V
Output Timing Reference Levels		1.5V
Output Load		See Figure

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



*CL INCLUDES TEST FIXTURE AND PROBE CAPACITANCE

GAL20V8B Output Load Conditions (see figure)

Test Condition	R1	R2	CL
A	200Ω	390Ω	50pF
B	∞	390Ω	50pF
C	200Ω	390Ω	5pF

GAL20V8C Output Load Conditions (see figure)

Test Condition	R1	R2	CL
A	200Ω	200Ω	50pF
B	∞	200Ω	50pF
C	200Ω	200Ω	5pF

Electronic Signature

An electronic signature is provided in every GAL20V8 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 GAL20V8 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

GAL20V8 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.

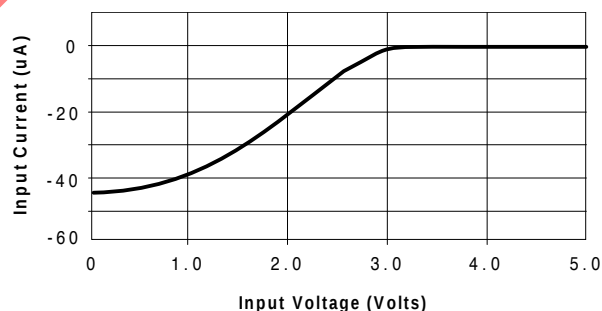
GAL20V8 devices include circuitry that allows each registered output to be synchronously set either high or low. Thus, any present state condition can be forced for test sequencing. If necessary, approved GAL programmers capable of executing test vectors perform output register preload automatically.

Input Buffers

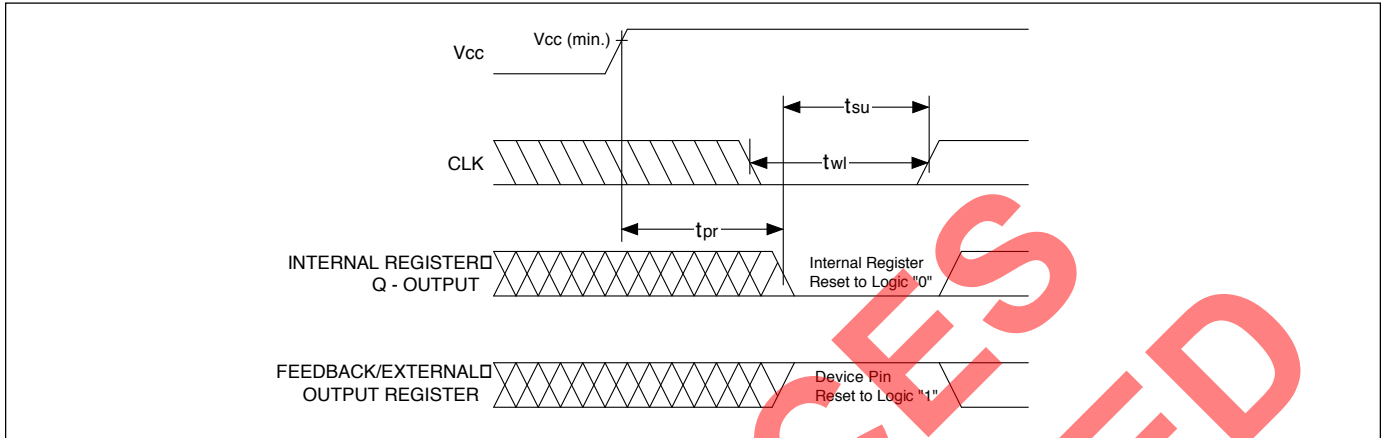
GAL20V8 devices are designed with TTL level compatible input buffers. These buffers have a characteristically high impedance, and present a much lighter load to the driving logic than bipolar TTL devices.

The GAL20V8 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



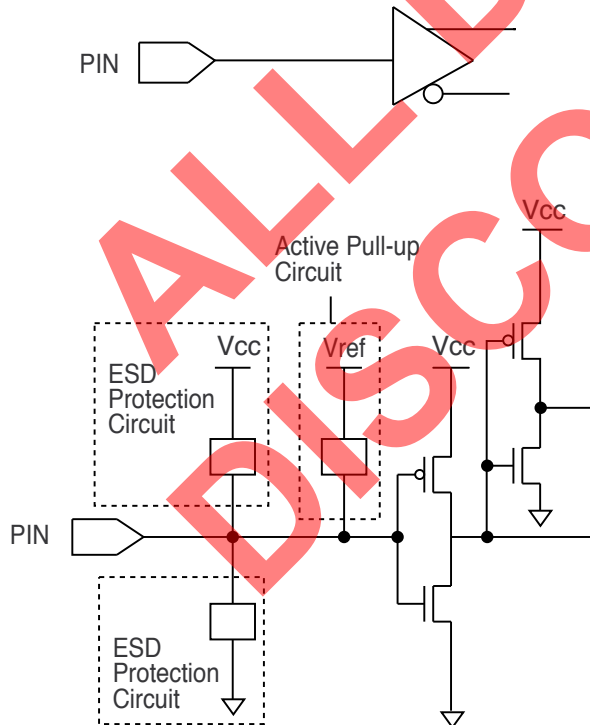
Power-Up Reset



Circuitry within the GAL20V8 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

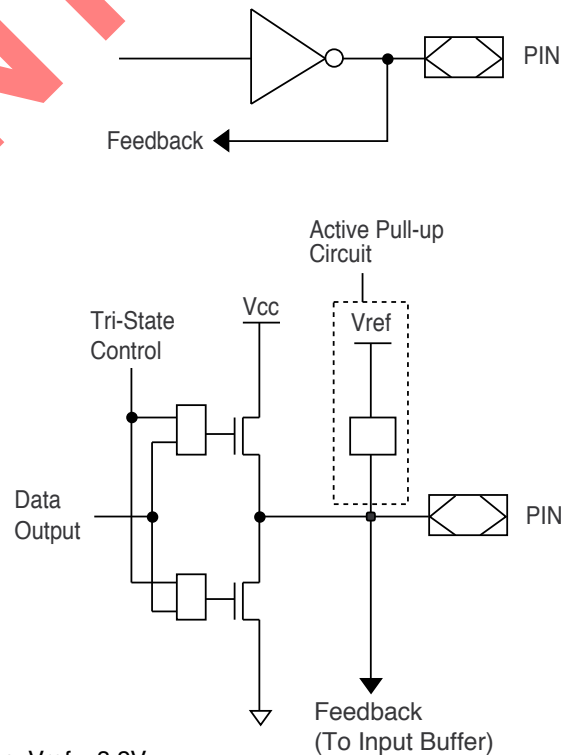
a valid power-up reset of the device. First, the V_{cc} rise must be monotonic. Second, the clock input must be at static TTL level as shown in the diagram during power up. The registers will reset within a maximum of t_{pr} time. As in normal system operation, avoid clocking the device until all input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

Input/Output Equivalent Schematics



Typ. $V_{ref} = 3.2V$

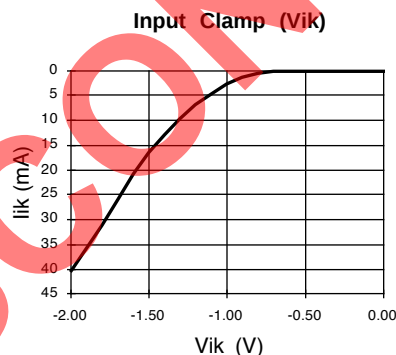
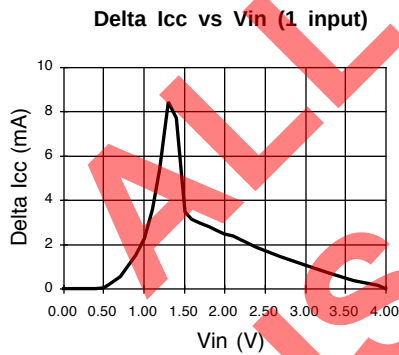
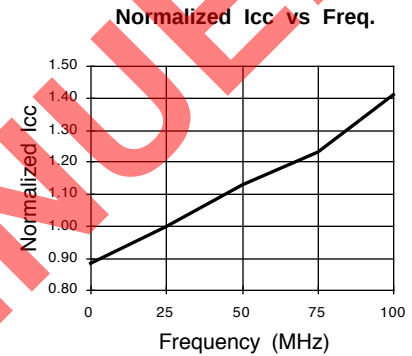
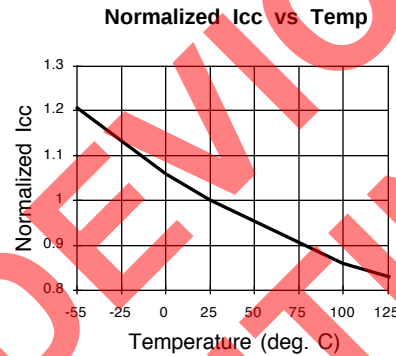
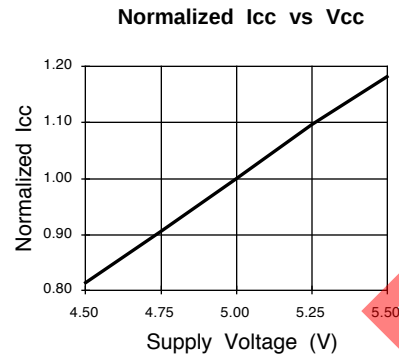
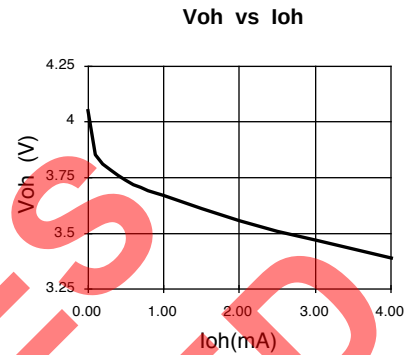
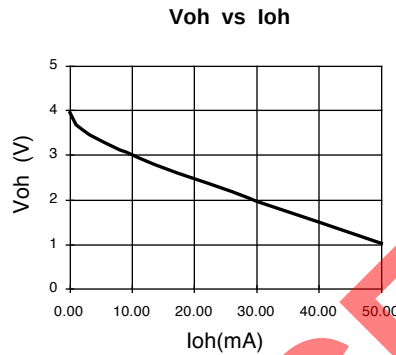
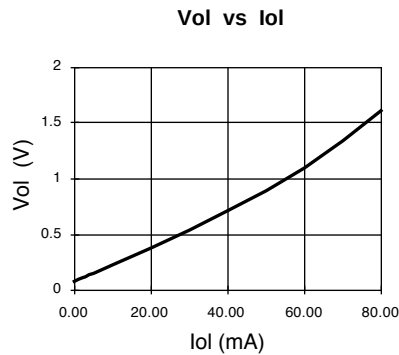
Typical Input



Typ. $V_{ref} = 3.2V$

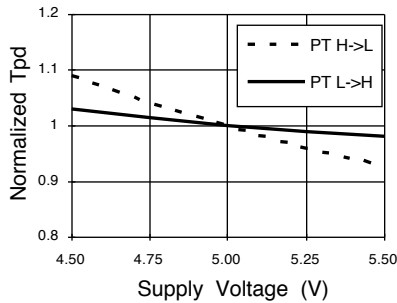
Typical Output

GAL20V8C: Typical AC and DC Characteristic Diagrams

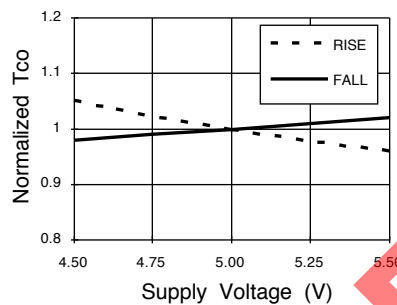


GAL20V8B-7/-10: Typical AC and DC Characteristic Diagrams

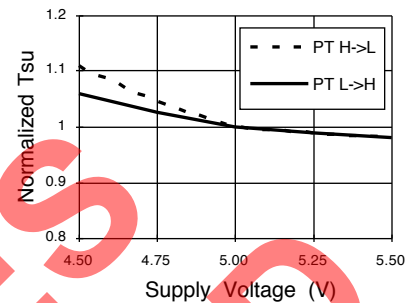
Normalized Tpd vs Vcc



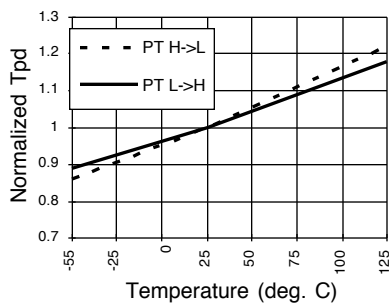
Normalized Tco vs Vcc



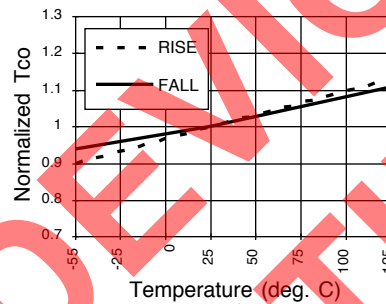
Normalized Tsu vs Vcc



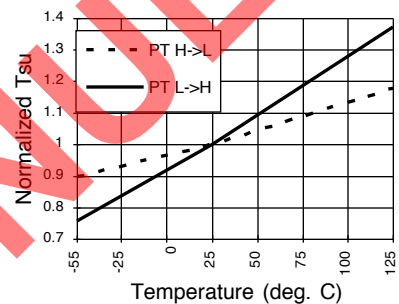
Normalized Tpd vs Temp



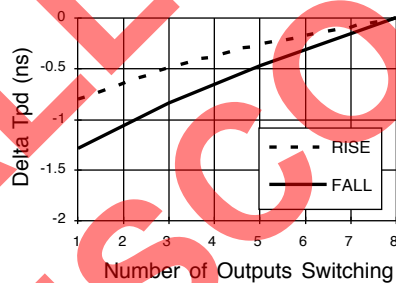
Normalized Tco vs Temp



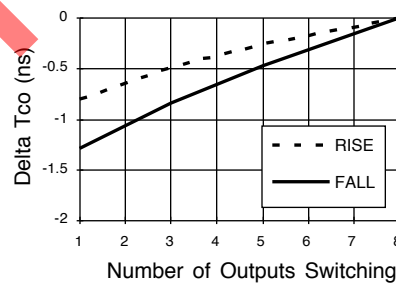
Normalized Tsu vs Temp



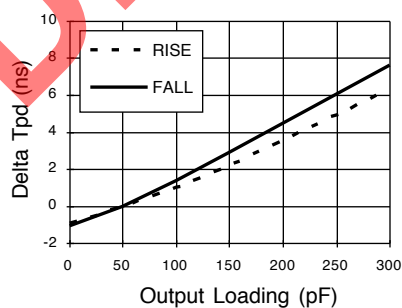
Delta Tpd vs # of Outputs Switching



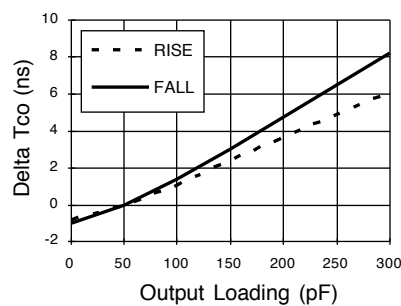
Delta Tco vs # of Outputs Switching



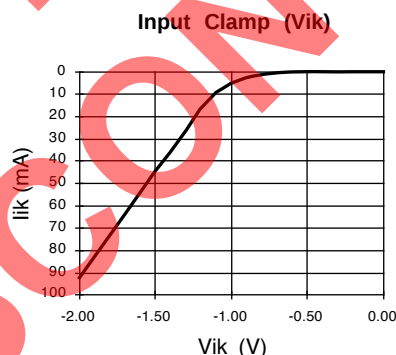
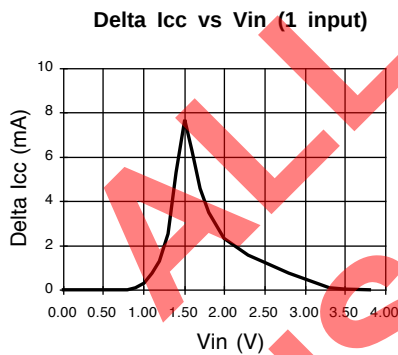
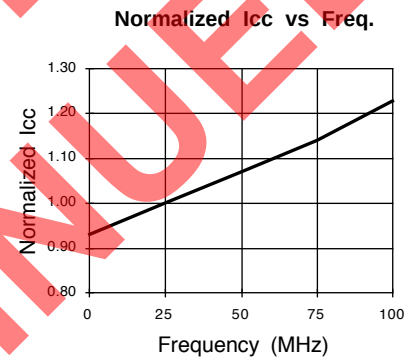
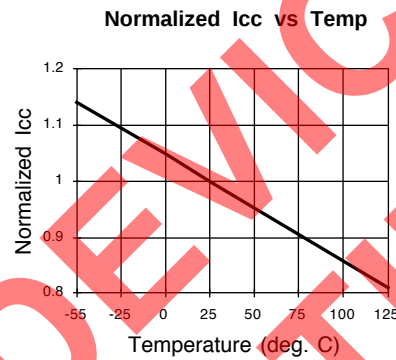
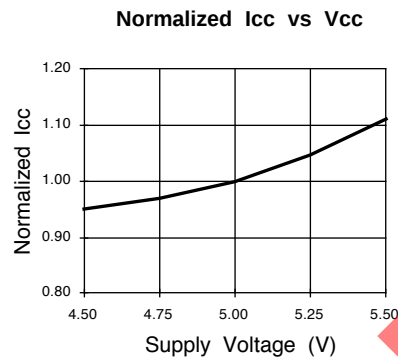
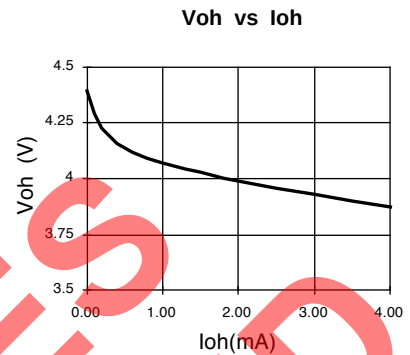
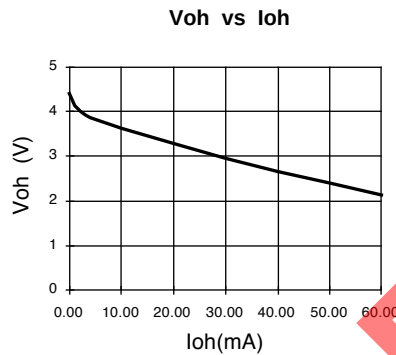
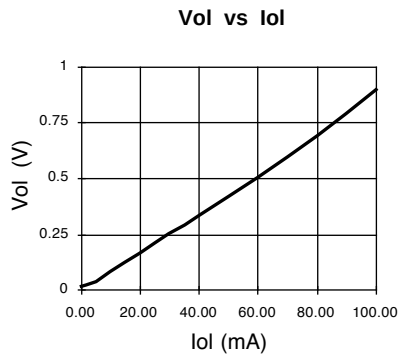
Delta Tpd vs Output Loading



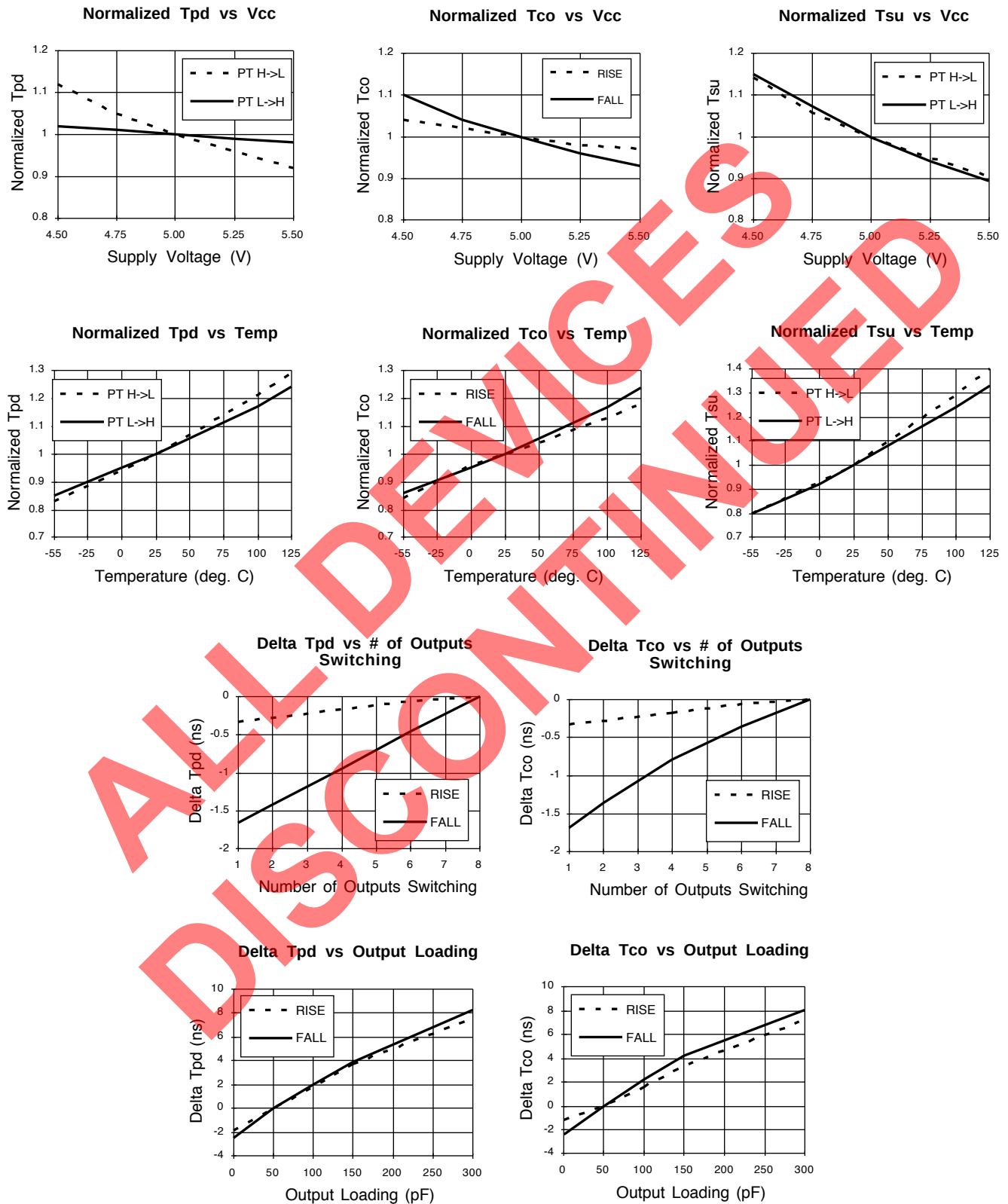
Delta Tco vs Output Loading



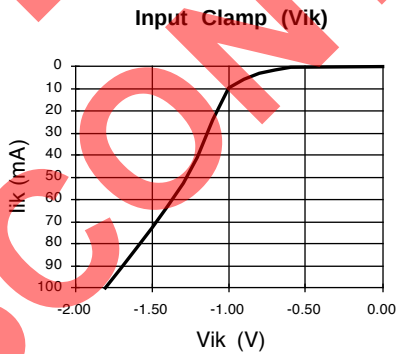
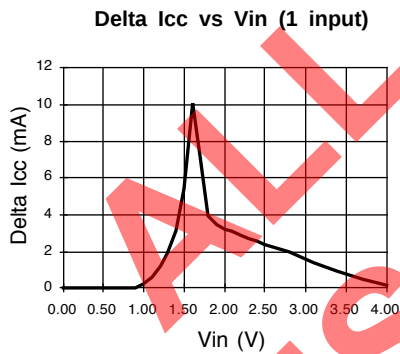
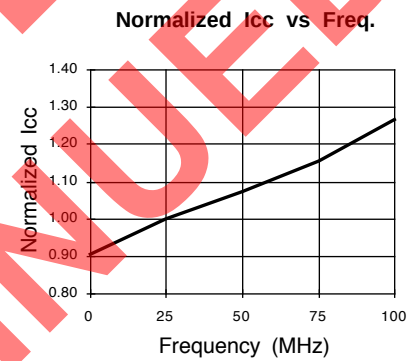
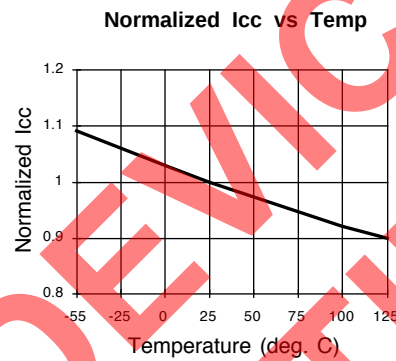
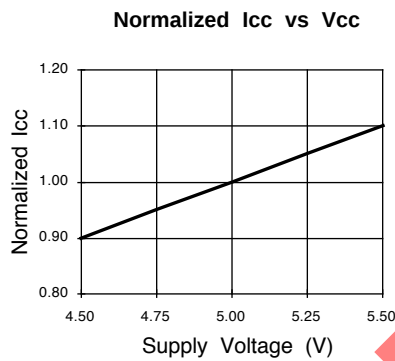
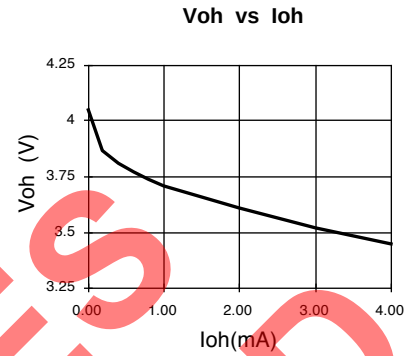
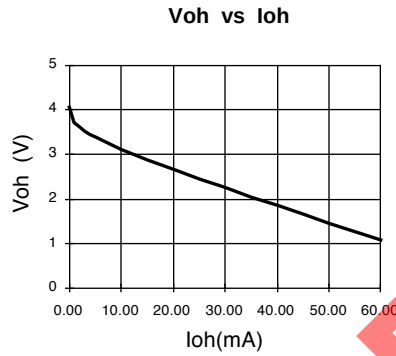
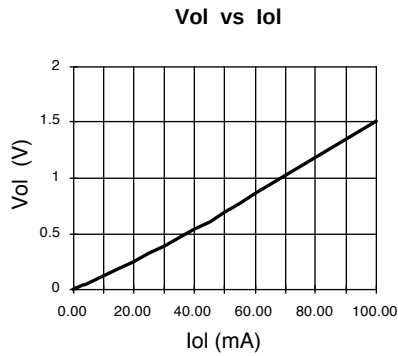
GAL20V8B-7/-10: Typical AC and DC Characteristic Diagrams



GAL20V8B-15/-25: Typical AC and DC Characteristic Diagrams



GAL20V8B-15/-25: Typical AC and DC Characteristic Diagrams



Revision History

Date	Version	Change Summary
-	20v8_06	Previous Lattice release.
August 2006	20v8_07	Updated for lead-free package options.

ALL DEVICES
DISCONTINUED