

### Features

- **HIGH PERFORMANCE E<sup>2</sup>CMOS® TECHNOLOGY**
  - 7.5 ns Maximum Propagation Delay
  - F<sub>max</sub> = 100 MHz
  - 6 ns Maximum from Clock Input to Data Output
  - TTL Compatible 12 mA Outputs
  - UltraMOS® Advanced CMOS Technology
- **50% REDUCTION IN POWER FROM BIPOLAR**
  - 75mA Typ I<sub>cc</sub>
- **ACTIVE PULL-UPS ON ALL PINS (GAL16V8D-7 and GAL16V8D-10)**
- **E<sup>2</sup> 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**

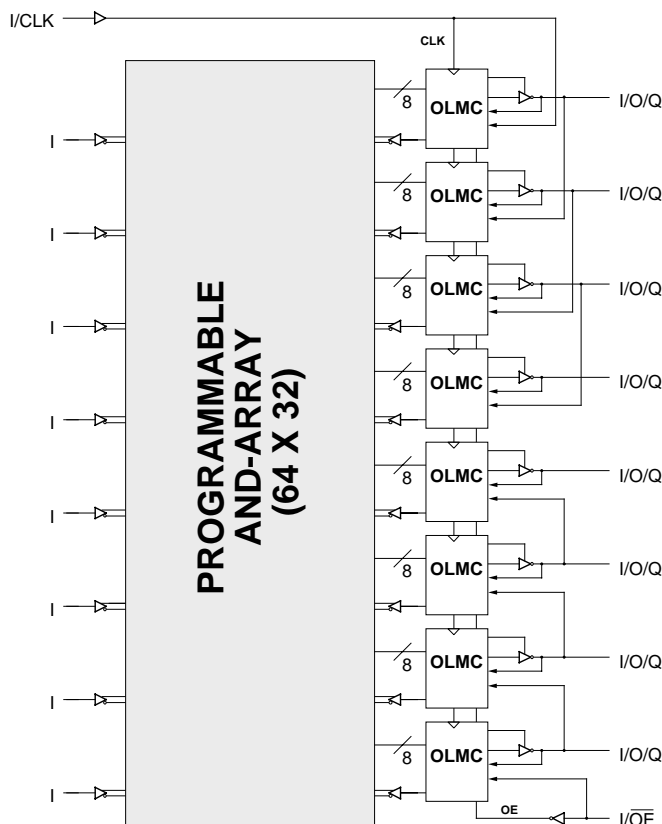
### Description

The GAL16V8/883 is a high performance E<sup>2</sup>CMOS programmable logic device processed in full compliance to MIL-STD-883. This military grade device combines a high performance CMOS process with Electrically Erasable (E<sup>2</sup>) floating gate technology to provide the highest speed/power performance available in the 883 qualified PLD market. The GAL16V8D/883, at 7.5ns maximum propagation delay time, is the world's fastest military qualified CMOS PLD.

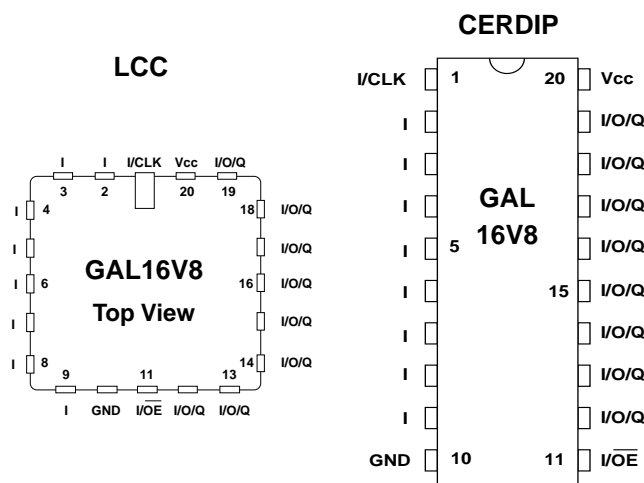
The generic GAL architecture provides maximum design flexibility by allowing the Output Logic Macrocell (OLMC) to be configured by the user. The GAL16V8/883 is capable of emulating all standard 20-pin PAL® devices with full function/fuse map/parametric compatibility.

Unique test circuitry and reprogrammable cells allow complete AC, DC, and functional testing during manufacture. Therefore, 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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## Absolute Maximum Ratings<sup>(1)</sup>

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  
 Case Temperature with  
 Power Applied ..... -55 to 125°C

## Recommended Operating Conditions

Case Temperature ( $T_C$ ) ..... -55 to 125°C  
 Supply voltage ( $V_{CC}$ )  
 with Respect to Ground ..... +4.50 to +5.50V

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).

## DC Electrical Characteristics

Over Recommended Operating Conditions (Unless Otherwise Specified)

SYMBOL	PARAMETER	CONDITION	MIN.	TYP. <sup>3</sup>	MAX.	UNITS	
<b>V<sub>IL</sub></b>	Input Low Voltage		$V_{SS} - 0.5$	—	0.8	V	
<b>V<sub>IH</sub></b>	Input High Voltage		2.0	—	$V_{CC} + 1$	V	
<b>I<sub>IL</sub><sup>1</sup></b>	Input or I/O Low Leakage Current	$0V \leq V_{IN} \leq V_{IL} (MAX.)$	—	—	-100	μA	
<b>I<sub>IH</sub></b>	Input or I/O High Leakage Current	$3.5V \leq V_{IN} \leq V_{CC}$	—	—	10	μA	
<b>V<sub>OL</sub></b>	Output Low Voltage	$I_{OL} = MAX. V_{in} = V_{IL} \text{ or } V_{IH}$	—	—	0.5	V	
<b>V<sub>OH</sub></b>	Output High Voltage	$I_{OH} = MAX. V_{in} = V_{IL} \text{ or } V_{IH}$	2.4	—	—	V	
<b>I<sub>OL</sub></b>	Low Level Output Current		—	—	12	mA	
<b>I<sub>OH</sub></b>	High Level Output Current		—	—	-2	mA	
<b>I<sub>OS</sub><sup>2</sup></b>	Output Short Circuit Current	$V_{CC} = 5V \quad V_{OUT} = 0.5V \quad T_A = 25^\circ C$	-30	—	-150	mA	
<b>I<sub>CC</sub></b>	Operating Power Supply Current	$V_{IL} = 0.5V \quad V_{IH} = 3.0V$ $f_{toggle} = 15MHz \text{ Outputs Open}$		L-7/-10	—	75 130	mA

1) The leakage current is due to the internal pull-up 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

PARAMETER	TEST COND <sup>1</sup> .	DESCRIPTION	-7		-10		UNITS
			MIN.	MAX.	MIN.	MAX.	
<b>t<sub>pd</sub></b>	A	Input or I/O to Combinational Output	1	7.5	2	10	ns
<b>t<sub>co</sub></b>	A	Clock to Output Delay	1	6	1	7	ns
<b>t<sub>cf</sub><sup>2</sup></b>	—	Clock to Feedback Delay	—	6	—	7	ns
<b>t<sub>su</sub></b>	—	Setup Time, Input or Feedback before Clock <sup>↑</sup>	7	—	10	—	ns
<b>t<sub>h</sub></b>	—	Hold Time, Input or Feedback after Clock <sup>↑</sup>	0	—	0	—	ns
<b>f<sub>max</sub><sup>3</sup></b>	A	Maximum Clock Frequency with External Feedback, 1/(t <sub>su</sub> + t <sub>co</sub> )	76.9	—	58.8	—	MHz
	A	Maximum Clock Frequency with Internal Feedback, 1/(t <sub>su</sub> + t <sub>cf</sub> )	76.9	—	58.8	—	MHz
	A	Maximum Clock Frequency with No Feedback	100	—	62.5	—	MHz
<b>t<sub>wh</sub></b>	—	Clock Pulse Duration, High	5	—	8	—	ns
<b>t<sub>wl</sub></b>	—	Clock Pulse Duration, Low	5	—	8	—	ns
<b>t<sub>en</sub></b>	B	Input or I/O to Output Enabled	1	9	—	10	ns
	B	$\overline{OE}$ to Output Enabled	1	7	—	10	ns
<b>t<sub>dis</sub></b>	C	Input or I/O to Output Disabled	1	9	—	10	ns
	C	$\overline{OE}$ to Output Disabled	1	7	—	10	ns

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

2) Calculated from f<sub>max</sub> with internal feedback. Refer to **f<sub>max</sub> Descriptions** section.

3) Refer to **f<sub>max</sub> Descriptions** section.

## Capacitance (T<sub>A</sub> = 25°C, f = 1.0 MHz)

SYMBOL	PARAMETER	MAXIMUM*	UNITS	TEST CONDITIONS
C <sub>I</sub>	Input Capacitance	10	pF	V <sub>CC</sub> = 5.0V, V <sub>I</sub> = 2.0V
C <sub>I/O</sub>	I/O Capacitance	10	pF	V <sub>CC</sub> = 5.0V, V <sub>I/O</sub> = 2.0V

\*Characterized but not 100% tested.

## Absolute Maximum Ratings<sup>(1)</sup>

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  
 Case 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

Case Temperature ( $T_C$ ) ..... -55 to 125°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. <sup>2</sup>	MAX.	UNITS
<b>V<sub>IL</sub></b>	Input Low Voltage		$V_{SS} - 0.5$	—	0.8	V
<b>V<sub>IH</sub></b>	Input High Voltage		2.0	—	$V_{CC} + 1$	V
<b>I<sub>IL</sub></b>	Input or I/O Low Leakage Current	$0V \leq V_{IN} \leq V_{IL} (MAX.)$	—	—	-10	μA
<b>I<sub>IH</sub></b>	Input or I/O High Leakage Current	$3.5V \leq V_{IN} \leq V_{CC}$	—	—	10	μA
<b>V<sub>OL</sub></b>	Output Low Voltage	$I_{OL} = MAX. V_{in} = V_{IL} \text{ or } V_{IH}$	—	—	0.5	V
<b>V<sub>OH</sub></b>	Output High Voltage	$I_{OH} = MAX. V_{in} = V_{IL} \text{ or } V_{IH}$	2.4	—	—	V
<b>I<sub>OL</sub></b>	Low Level Output Current		—	—	12	mA
<b>I<sub>OH</sub></b>	High Level Output Current		—	—	-2	mA
<b>I<sub>OS</sub><sup>1</sup></b>	Output Short Circuit Current	$V_{CC} = 5V \quad V_{OUT} = 0.5V \quad T_A = 25^\circ C$	-30	—	-150	mA
<b>I<sub>CC</sub></b>	Operating Power Supply Current	$V_{IL} = 0.5V \quad V_{IH} = 3.0V$ $f_{toggle} = 15MHz$ Outputs Open				
		L -15/ -20/-30	—	75	130	mA

1) 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

PARAMETER	TEST COND <sup>1</sup> .	DESCRIPTION	-15		-20		-30		UNITS
			MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	
<b>t<sub>pd</sub></b>	A	Input or I/O to Combinational Output	3	15	3	20	3	30	ns
<b>t<sub>co</sub></b>	A	Clock to Output Delay	2	12	2	15	2	20	ns
<b>t<sub>cf</sub><sup>2</sup></b>	—	Clock to Feedback Delay	—	12	—	15	—	20	ns
<b>t<sub>su</sub></b>	—	Setup Time, Input or Feedback before Clock <sup>↑</sup>	12	—	15	—	25	—	ns
<b>t<sub>h</sub></b>	—	Hold Time, Input or Feedback after Clock <sup>↑</sup>	0	—	0	—	0	—	ns
<b>f<sub>max</sub><sup>3</sup></b>	A	Maximum Clock Frequency with External Feedback, 1/(t <sub>su</sub> + t <sub>co</sub> )	41.6	—	33.3	—	22.2	—	MHz
	A	Maximum Clock Frequency with Internal Feedback, 1/(t <sub>su</sub> + t <sub>cf</sub> )	41.6	—	33.3	—	22.2	—	MHz
	A	Maximum Clock Frequency with No Feedback	50	—	41.6	—	33.3	—	MHz
<b>t<sub>wh</sub></b>	—	Clock Pulse Duration, High	10	—	12	—	15	—	ns
<b>t<sub>wl</sub></b>	—	Clock Pulse Duration, Low	10	—	12	—	15	—	ns
<b>t<sub>en</sub></b>	B	Input or I/O to Output Enabled	—	15	—	20	—	30	ns
	B	OE to Output Enabled	—	15	—	18	—	25	ns
<b>t<sub>dis</sub></b>	C	Input or I/O to Output Disabled	—	15	—	20	—	30	ns
	C	OE to Output Disabled	—	15	—	18	—	25	ns

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

2) Calculated from f<sub>max</sub> with internal feedback. Refer to **f<sub>max</sub> Descriptions** section.

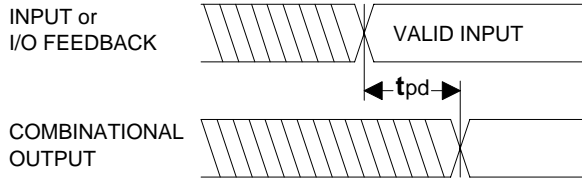
3) Refer to **f<sub>max</sub> Descriptions** section.

## Capacitance (T<sub>A</sub> = 25°C, f = 1.0 MHz)

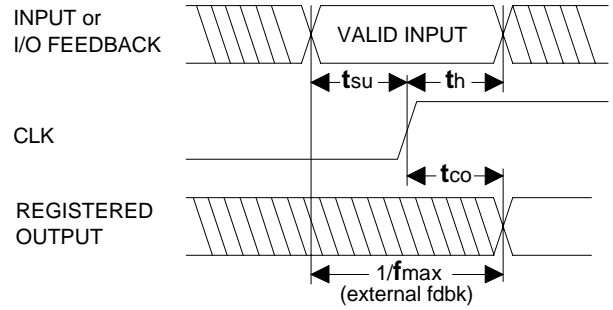
SYMBOL	PARAMETER	MAXIMUM*	UNITS	TEST CONDITIONS
C <sub>I</sub>	Input Capacitance	10	pF	V <sub>CC</sub> = 5.0V, V <sub>I</sub> = 2.0V
C <sub>I/O</sub>	I/O Capacitance	10	pF	V <sub>CC</sub> = 5.0V, V <sub>I/O</sub> = 2.0V

\*Characterized but not 100% tested.

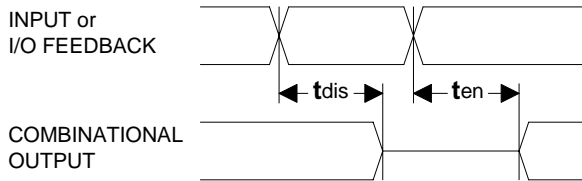
## Switching Waveforms



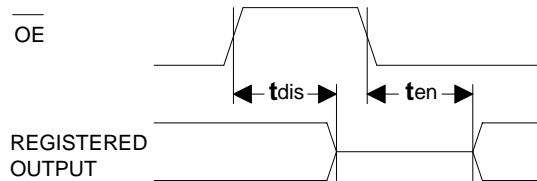
**Combinatorial Output**



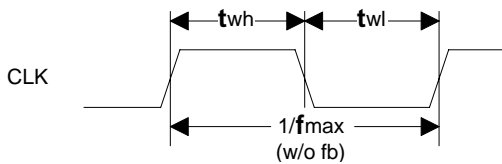
**Registered Output**



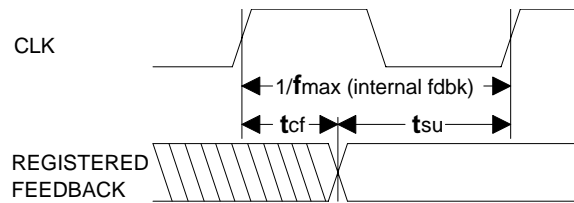
**Input or I/O to Output Enable/Disable**



**OE to Output Enable/Disable**

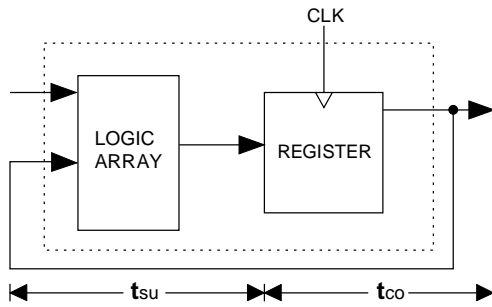


**Clock Width**



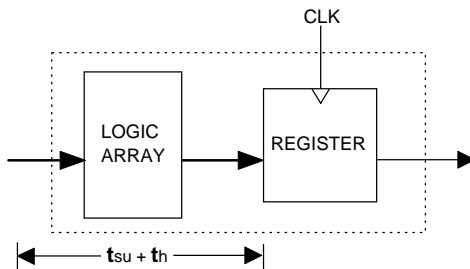
**$f_{max}$  with Feedback**

## fmax Descriptions



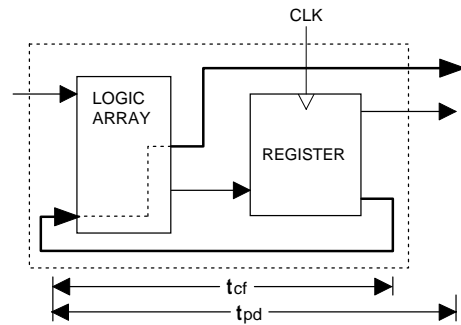
**fmax with External Feedback  $1/(tsu+tco)$**

**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  $1/(twh + twl)$ . This is to allow for a clock duty cycle of other than 50%.



**fmax with Internal Feedback  $1/(tsu+tcf)$**

**Note:** tcf is a calculated value, derived by subtracting tsu from the period of fmax w/internal feedback ( $tcf = 1/fmax - tsu$ ). 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  $tcf + tpd$ .

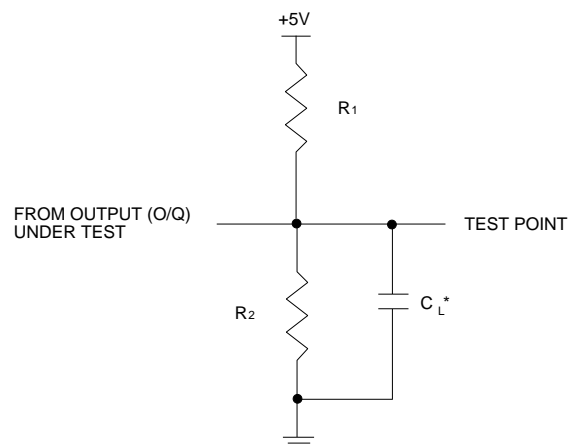
## Switching Test Conditions

Input Pulse Levels	GND to 3.0V
Input Rise and Fall Times	3ns 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.

### Output Load Conditions (see figure)

Test Condition	R1	R2	CL
A	390Ω	750Ω	50pF
B	Active High	∞	750Ω
	Active Low	390Ω	750Ω
C	Active High	∞	5pF
	Active Low	390Ω	750Ω



\*CL INCLUDES TEST FIXTURE AND PROBE CAPACITANCE

## GAL16V8 Ordering Information (MIL-STD-883 and SMD)

Tpd (ns)	Tsu (ns)	Tco (ns)	Icc (mA)	Package	Ordering #	
					MIL-STD-883	SMD #
7.5	7	6	130	20-Pin Cerdip	GAL16V8D-7LD/883	5962-8983907RA
			130	20-Pin LCC	GAL16V8D-7LR/883	5962-89839072A
10	10	7	130	20-Pin Cerdip	GAL16V8D-10LD/883	5962-8983904RA
			130	20-Pin LCC	GAL16V8D-10LR/883	5962-89839042A
15	12	12	130	20-Pin Cerdip	GAL16V8D-15LD/883	5962-8983903RA
			130	20-Pin LCC	GAL16V8D-15LR/883	5962-89839032A
20	15	15	130	20-Pin Cerdip	GAL16V8D-20LD/883	5962-8983902RA
			130	20-Pin LCC	GAL16V8D-20LR/883	5962-89839022A
30	25	20	130	20-Pin Cerdip	GAL16V8D-30LD/883	5962-8983901RA

**Note:** Lattice Semiconductor recognizes the trend in military device procurement towards using SMD compliant devices, as such, ordering by this number is recommended.

## Part Number Description

