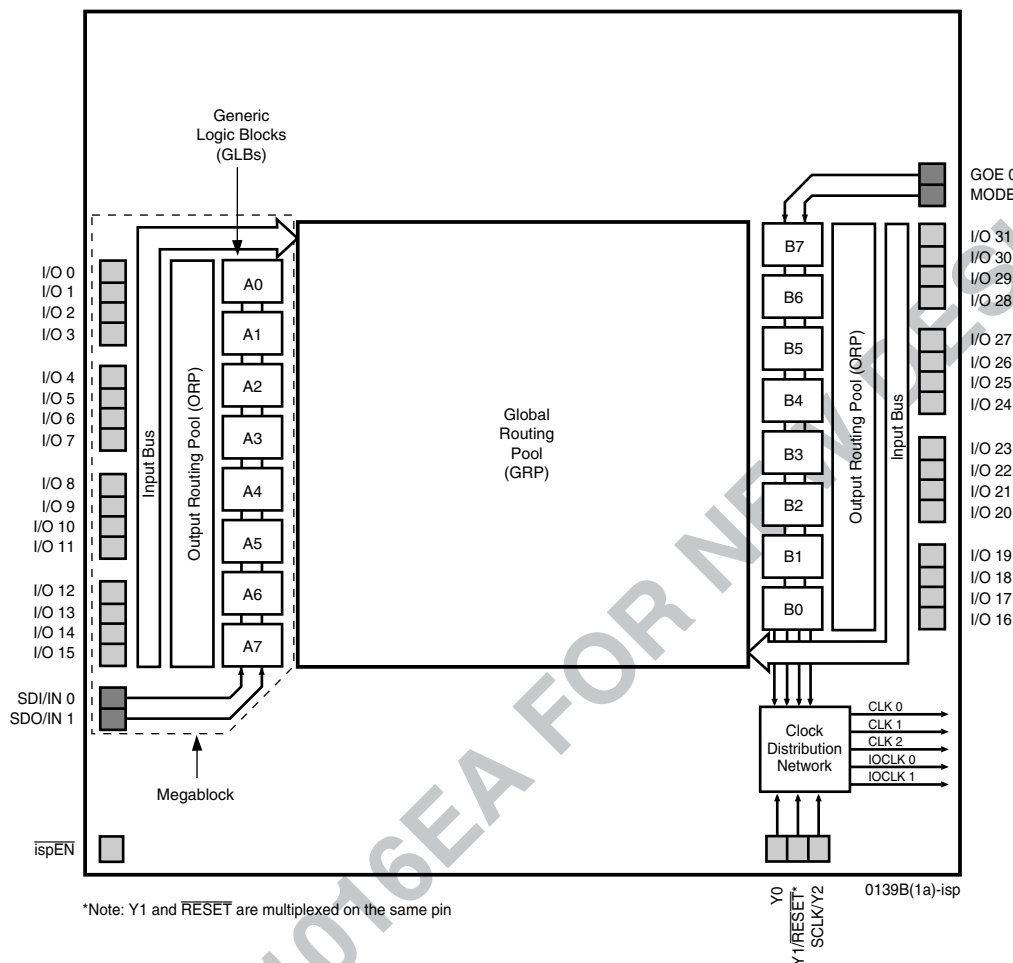




In-System Programmable High Density PLD

Functional Block Diagram

Figure 1. ispLSI 1016E Functional Block Diagram



The device also has 32 I/O cells, each of which is directly connected to an I/O pin. Each I/O cell can be individually programmed to be a combinatorial input, registered input, latched input, output or bi-directional I/O pin with 3-state control. The signal levels are TTL compatible voltages and the output drivers can source 4 mA or sink 8 mA. Each output can be programmed independently for fast or slow output slew rate to minimize overall output switching noise.

Eight GLBs, 16 I/O cells, two dedicated inputs and one ORP are connected together to make a Megablock (see Figure 1). The outputs of the eight GLBs are connected to a set of 16 universal I/O cells by the ORP. Each ispLSI 1016E device contains two Megablocks.

The GRP has, as its inputs, the outputs from all of the GLBs and all of the inputs from the bi-directional I/O cells. All of these signals are made available to the inputs of the GLBs. Delays through the GRP have been equalized to minimize timing skew.

Clocks in the ispLSI 1016E device are selected using the Clock Distribution Network. Three dedicated clock pins (Y0, Y1 and Y2) are brought into the distribution network, and five clock outputs (CLK 0, CLK 1, CLK 2, IOCLK 0 and IOCLK 1) are provided to route clocks to the GLBs and I/O cells. The Clock Distribution Network can also be driven from a special clock GLB (B0 on the ispLSI 1016E device). The logic of this GLB allows the user to create an internal clock from a combination of internal signals within the device.

Absolute Maximum Ratings ¹

Supply Voltage V_{CC} -0.5 to +7.0V
 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 Temp. with Power Applied -55 to 125°C
 Max. Junction Temp. (T_J) with Power Applied ... 150°C

1. Stresses above those listed under the "Absolute Maximum Ratings" may cause permanent damage to the device. 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 Recommended Operating Conditions

SYMBOL	PARAMETER		MIN.	MAX.	UNITS
V_{CC}	Supply Voltage	Commercial $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$	4.75	5.25	V
		Industrial $T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$	4.5	5.5	V
V_{IL}	Input Low Voltage		0	0.8	V
V_{IH}	Input High Voltage		2.0	$V_{CC} + 1$	V

Table 2-0005/1016E

Capacitance ($T_A = 25^\circ\text{C}$, $f = 1.0\text{ MHz}$)

SYMBOL	PARAMETER	TYPICAL	UNITS	TEST CONDITIONS
C_1	Dedicated Input, I/O, Y1, Y2, Y3, Clock Capacitance (Commercial/Industrial)	8	pf	$V_{CC} = 5.0V$, $V_{PIN} = 2.0V$
C_2	Y0 Clock Capacitance	12	pf	$V_{CC} = 5.0V$, $V_{PIN} = 2.0V$

Table 2-0006/1016E

Data Retention Specifications

PARAMETER	MINIMUM	MAXIMUM	UNITS
Data Retention	20	—	Years
Erase/Reprogram Cycles	10000	—	Cycles

Table 2-0008/1016E

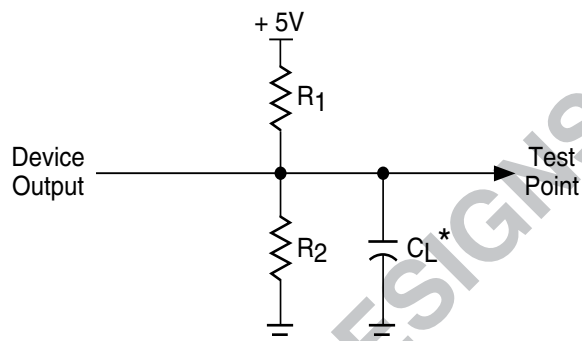
Switching Test Conditions

Input Pulse Levels	GND to 3.0V	
Input Rise and Fall Time 10% to 90%	-125	≤ 2 ns
	-100, -80	≤ 3 ns
Input Timing Reference Levels	1.5V	
Output Timing Reference Levels	1.5V	
Output Load	See Figure 2	

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

Table 2-0003/1016E

Figure 2. Test Load



*CL includes Test Fixture and Probe Capacitance.

0213a

Output Load Conditions (see Figure 2)

TEST CONDITION		R1	R2	CL
A		470Ω	390Ω	35pF
B	Active High	∞	390Ω	35pF
	Active Low	470Ω	390Ω	35pF
C	Active High to Z at $V_{OH}-0.5V$	∞	390Ω	5pF
	Active Low to Z at $V_{OL}+0.5V$	470Ω	390Ω	5pF

Table 2-0004/1016E

DC Electrical Characteristics

Over Recommended Operating Conditions

SYMBOL	PARAMETER	CONDITION	MIN.	TYP. ³	MAX.	UNITS
V_{OL}	Output Low Voltage	$I_{OL} = 8$ mA	—	—	0.4	V
V_{OH}	Output High Voltage	$I_{OH} = -4$ mA	2.4	—	—	V
I_{IL}	Input or I/O Low Leakage Current	$0V \leq V_{IN} \leq V_{IL}(\text{Max.})$	—	—	-10	μA
I_{IH}	Input or I/O High Leakage Current	$3.5V \leq V_{IN} \leq V_{CC}$	—	—	10	μA
I_{IL-isp}	ispEN Input Low Leakage Current	$0V \leq V_{IN} \leq V_{IL}$	—	—	-150	μA
I_{IL-PU}	I/O Active Pull-Up Current	$0V \leq V_{IN} \leq V_{IL}$	—	—	-150	μA
I_{OS}¹	Output Short Circuit Current	$V_{CC} = 5V, V_{OUT} = 0.5V$	—	—	-200	mA
I_{CC}^{2, 4}	Operating Power Supply Current	$V_{IL} = 0.5V, V_{IH} = 3.0V$ $f_{CLOCK} = 1$ MHz	Commercial	90	—	mA
			Industrial	90	—	mA

Table 2-0007/1016E

- One output at a time for a maximum duration of one second. $V_{OUT} = 0.5V$ was selected to avoid test problems by tester ground degradation. Characterized but not 100% tested.
- Measured using four 16-bit counters.
- Typical values are at $V_{CC} = 5V$ and $T_A = 25^\circ C$.
- Maximum I_{CC} varies widely with specific device configuration and operating frequency. Refer to the Power Consumption section of this data sheet and Thermal Management section of the Lattice Semiconductor Data Book or CD-ROM to estimate maximum I_{CC} .

External Timing Parameters

Over Recommended Operating Conditions

PARAMETER	TEST COND. ⁴	# ²	DESCRIPTION ¹	-125		-100		-80		UNITS
				MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	
t_{pd1}	A	1	Data Prop. Delay, 4PT Bypass, ORP Bypass	–	7.5	–	10.0	–	15.0	ns
t_{pd2}	A	2	Data Prop. Delay, Worst Case Path	–	10.0	–	13.0	–	18.5	ns
f_{max}	A	3	Clk. Frequency with Int. Feedback ³	125	–	100	–	84.0	–	MHz
f_{max} (Ext.)	–	4	Clk. Frequency with Ext. Feedback($\frac{1}{t_{su2} + t_{co1}}$)	100	–	77.0	–	57.0	–	MHz
f_{max} (Tog.)	–	5	Clk. Frequency, Max. Toggle($\frac{1}{t_{wh} + t_{wl}}$)	167	–	125	–	100	–	MHz
t_{su1}	–	6	GLB Reg. Setup Time before Clk., 4 PT Bypass	5.0	–	7.0	–	8.5	–	ns
t_{co1}	A	7	GLB Reg. Clk. to Output Delay, ORP Bypass	–	4.5	–	5.0	–	8.0	ns
t_{h1}	–	8	GLB Reg. Hold Time after Clk., 4 PT Bypass	0.0	–	0.0	–	0.0	–	ns
t_{su2}	–	9	GLB Reg. Setup Time before Clk.	5.5	–	8.0	–	9.5	–	ns
t_{co2}	–	10	GLB Reg. Clk. to Output Delay	–	5.5	–	6.0	–	9.5	ns
t_{h2}	–	11	GLB Reg. Hold Time after Clk.	0.0	–	0.0	–	0.0	–	ns
t_{r1}	A	12	Ext. Reset Pin to Output Delay	–	10.0	–	13.5	–	17.0	ns
t_{rw1}	–	13	Ext. Reset Pulse Duration	5.0	–	6.5	–	10.0	–	ns
t_{ptoen}	B	14	Input to Output Enable	–	12.0	–	15.0	–	20.0	ns
t_{ptoedis}	C	15	Input to Output Disable	–	12.0	–	15.0	–	20.0	ns
t_{goeen}	B	16	Global OE Output Enable	–	7.0	–	9.0	–	10.5	ns
t_{goedis}	C	17	Global OE Output Disable	–	7.0	–	9.0	–	10.5	ns
t_{wh}	–	18	Ext. Sync. Clk. Pulse Duration, High	3.0	–	4.0	–	5.0	–	ns
t_{wl}	–	19	Ext. Sync. Clk. Pulse Duration, Low	3.0	–	4.0	–	5.0	–	ns
t_{su3}	–	20	I/O Reg. Setup Time before Ext. Sync. Clk. (Y2, Y3)	3.0	–	3.5	–	4.5	–	ns
t_{h3}	–	21	I/O Reg. Hold Time after Ext. Sync. Clk. (Y2, Y3)	0.0	–	0.0	–	0.0	–	ns

1. Unless noted otherwise, all parameters use the GRP, 20 PTXOR path, ORP and Y0 clock.
2. Refer to Timing Model in this data sheet for further details.
3. Standard 16-bit counter using GRP feedback.
4. Reference Switching Test Conditions Section.

Table 2-0030-16/125,100, 80

Internal Timing Parameters¹

PARAMETER	# ²	DESCRIPTION	-125		-100		-80		UNITS
			MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	
Inputs									
t _{iobp}	22	I/O Register Bypass	–	0.3	–	0.4	–	0.6	ns
t _{iolat}	23	I/O Latch Delay	–	1.8	–	2.4	–	3.6	ns
t _{iosu}	24	I/O Register Setup Time before Clock	3.0	–	3.5	–	4.5	–	ns
t _{ioh}	25	I/O Register Hold Time after Clock	-0.3	–	-0.4	–	-0.6	–	ns
t _{ioco}	26	I/O Register Clock to Out Delay	–	4.0	–	5.0	–	7.5	ns
t _{ior}	27	I/O Register Reset to Out Delay	–	4.0	–	5.0	–	7.5	ns
t _{din}	28	Dedicated Input Delay	–	2.2	–	2.6	–	3.9	ns
GRP									
t _{grp1}	29	GRP Delay, 1 GLB Load	–	1.8	–	1.9	–	2.9	ns
t _{grp4}	30	GRP Delay, 4 GLB Loads	–	1.9	–	2.2	–	3.3	ns
t _{grp8}	31	GRP Delay, 8 GLB Loads	–	2.1	–	2.5	–	3.8	ns
t _{grp16}	32	GRP Delay, 16 GLB Loads	–	2.4	–	3.1	–	4.7	ns
GLB									
t _{4ptbpc}	34	4 Product Term Bypass Path Delay (Combinatorial)	–	3.9	–	5.7	–	8.1	ns
t _{4ptbpr}	35	4 Product Term Bypass Path Delay (Registered)	–	3.9	–	5.6	–	7.3	ns
t _{1ptxor}	36	1 Product Term/XOR Path Delay	–	4.4	–	6.1	–	7.1	ns
t _{20ptxor}	37	20 Product Term/XOR Path Delay	–	4.4	–	6.1	–	8.2	ns
t _{xoradj}	38	XOR Adjacent Path Delay ³	–	4.4	–	6.6	–	8.3	ns
t _{gbp}	39	GLB Register Bypass Delay	–	1.0	–	1.6	–	1.9	ns
t _{gsu}	40	GLB Register Setup Time before Clock	0.2	–	0.2	–	-0.6	–	ns
t _{gh}	41	GLB Register Hold Time after Clock	1.5	–	2.5	–	4.3	–	ns
t _{gco}	42	GLB Register Clock to Output Delay	–	1.8	–	1.9	–	2.9	ns
t _{gro}	43	GLB Register Reset to Output Delay	–	4.4	–	6.3	–	7.0	ns
t _{ptre}	44	GLB Product Term Reset to Register Delay	–	3.5	–	5.1	–	7.2	ns
t _{ptoe}	45	GLB Product Term Output Enable to I/O Cell Delay	–	5.5	–	7.1	–	9.7	ns
t _{ptck}	46	GLB Product Term Clock Delay	3.2	3.5	4.8	5.3	6.8	7.5	ns
ORP									
t _{orp}	47	ORP Delay	–	1.0	–	1.0	–	1.5	ns
t _{orpbp}	48	ORP Bypass Delay	–	0.0	–	0.0	–	0.0	ns

Table 2-0036-16/125,100, 80

1. Internal Timing Parameters are not tested and are for reference only.
2. Refer to Timing Model in this data sheet for further details.
3. The XOR Adjacent path can only be used by Lattice hard macros.

Internal Timing Parameters¹

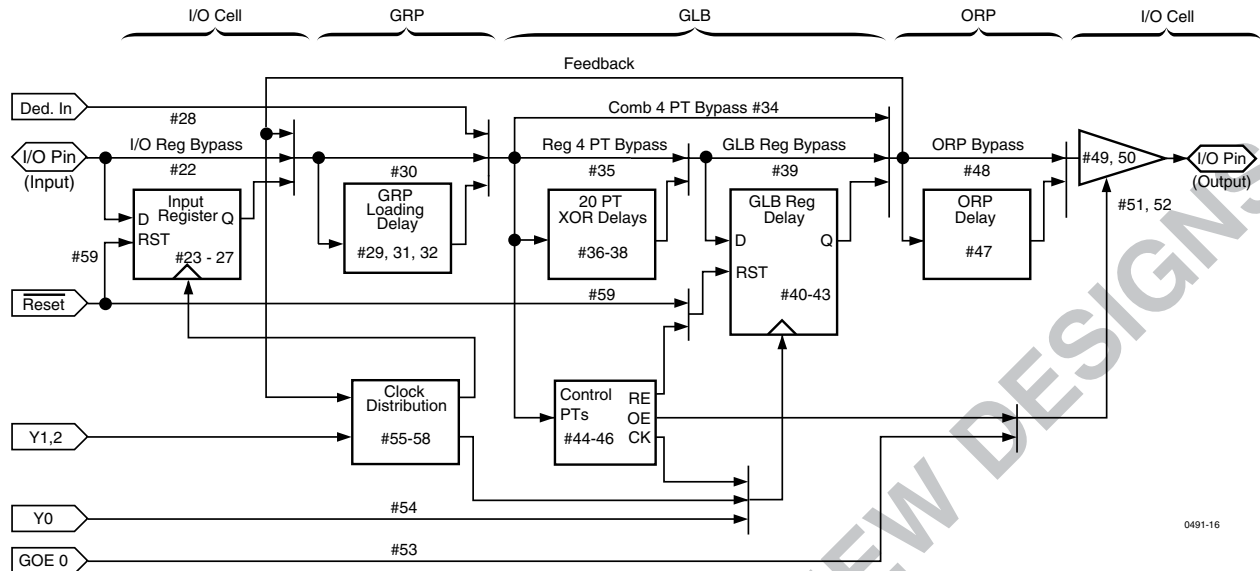
PARAMETER	# ²	DESCRIPTION	-125		-100		-80		UNITS
			MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	
Outputs									
tob	49	Output Buffer Delay	–	1.4	–	1.7	–	3.0	ns
tsl	50	Output Slew Limited Delay Adder	–	10.0	–	10.0	–	10.0	ns
toen	51	I/O Cell OE to Output Enabled	–	4.3	–	5.3	–	6.4	ns
todis	52	I/O Cell OE to Output Disabled	–	4.3	–	5.3	–	6.4	ns
tgoe	53	Global Output Enable	–	2.7	–	3.7	–	4.1	ns
Clocks									
tgy0	54	Clock Delay, Y0 to Global GLB Clock Line (Ref. clock)	1.3	1.3	1.4	1.4	2.1	2.1	ns
tgy1/2	55	Clock Delay, Y1 or Y2 to Global GLB Clock Line	2.3	2.7	2.4	2.9	3.6	4.4	ns
tgcp	56	Clock Delay, Clock GLB to Global GLB Clock Line	0.8	1.8	0.8	1.8	1.2	2.7	ns
tioy1/2	57	Clock Delay, Y1 or Y2 to I/O Cell Global Clock Line	0.0	0.3	0.0	0.4	0.0	0.6	ns
tiocp	58	Clock Delay, Clock GLB to I/O Cell Global Clock Line	0.8	1.8	0.8	1.8	1.2	2.7	ns
Global Reset									
tgr	59	Global Reset to GLB and I/O Registers	–	3.2	–	4.5	–	5.5	ns

1. Internal Timing Parameters are not tested and are for reference only.

Table 2-0037-16/125,100,80

2. Refer to Timing Model in this data sheet for further details.

ispLSI 1016E Timing Model



0491-16

Derivations of t_{su} , t_h and t_{co} from the Product Term Clock¹

$$\begin{aligned}
 t_{su} &= \text{Logic} + \text{Reg su} - \text{Clock (min)} \\
 &= (t_{iobp} + t_{grp4} + t_{20ptxor}) + (t_{gsu}) - (t_{iobp} + t_{grp4} + t_{ptck(min)}) \\
 &= (\#22 + \#30 + \#37) + (\#40) - (\#22 + \#30 + \#46) \\
 1.4 \text{ ns} &= (0.3 + 1.9 + 4.4) + (0.2) - (0.3 + 1.9 + 3.2) \\
 t_h &= \text{Clock (max)} + \text{Reg h} - \text{Logic} \\
 &= (t_{iobp} + t_{grp4} + t_{ptck(max)}) + (t_{gh}) - (t_{iobp} + t_{grp4} + t_{20ptxor}) \\
 &= (\#22 + \#30 + \#46) + (\#41) - (\#22 + \#30 + \#37) \\
 0.6 \text{ ns} &= (0.3 + 1.9 + 3.5) + (1.5) - (0.3 + 1.9 + 4.4) \\
 t_{co} &= \text{Clock (max)} + \text{Reg co} + \text{Output} \\
 &= (t_{iobp} + t_{grp4} + t_{ptck(max)}) + (t_{gco}) + (t_{orp} + t_{ob}) \\
 &= (\#22 + \#30 + \#46) + (\#42) + (\#47 + \#49) \\
 9.9 \text{ ns} &= (0.3 + 1.9 + 3.5) + (1.8) + (1.0 + 1.4)
 \end{aligned}$$

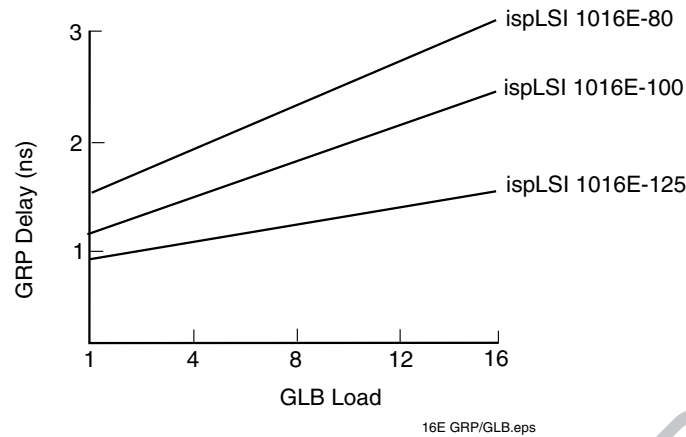
Derivations of t_{su} , t_h and t_{co} from the Clock GLB¹

$$\begin{aligned}
 t_{su} &= \text{Logic} + \text{Reg su} - \text{Clock (min)} \\
 &= (t_{iobp} + t_{grp4} + t_{20ptxor}) + (t_{gsu}) - (t_{gy0(min)} + t_{gco} + t_{gcp(min)}) \\
 &= (\#22 + \#30 + \#37) + (\#40) - (\#54 + \#42 + \#56) \\
 2.9 \text{ ns} &= (0.3 + 1.9 + 4.4) + (0.2) - (1.3 + 1.8 + 0.8) \\
 t_h &= \text{Clock (max)} + \text{Reg h} - \text{Logic} \\
 &= (t_{gy0(max)} + t_{gco} + t_{gcp(max)}) + (t_{gh}) - (t_{iobp} + t_{grp4} + t_{20ptxor}) \\
 &= (\#54 + \#42 + \#56) + (\#41) - (\#22 + \#30 + \#37) \\
 -0.2 \text{ ns} &= (1.3 + 1.8 + 1.8) + (1.5) - (0.3 + 1.9 + 4.4) \\
 t_{co} &= \text{Clock (max)} + \text{Reg co} + \text{Output} \\
 &= (t_{gy0(max)} + t_{gco} + t_{gcp(max)}) + (t_{gco}) + (t_{orp} + t_{ob}) \\
 &= (\#54 + \#42 + \#56) + (\#42) + (\#47 + \#49) \\
 9.1 \text{ ns} &= (1.3 + 1.8 + 1.8) + (1.8) + (1.0 + 1.4)
 \end{aligned}$$

Table 2-0042-16

1. Calculations are based upon timing specifications for the ispLSI 1016E-125

Maximum GRP Delay vs GLB Loads

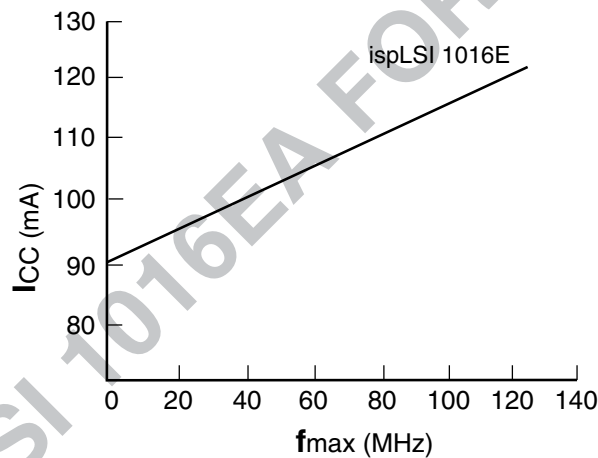


Power Consumption

Power consumption in the ispLSI 1016E device depends on two primary factors: the speed at which the device is operating and the number of Product Terms used.

Figure 3 shows the relationship between power and operating speed.

Figure 3. Typical Device Power Consumption vs fmax



Notes: Configuration of four 16-bit counters
Typical current at 5V, 25°C

I_{CC} can be estimated for the ispLSI 1016E using the following equation:

$$I_{CC}(\text{mA}) = 23 + (\# \text{ of PTs} * 0.52) + (\# \text{ of nets} * \text{max freq} * 0.004)$$

Where:

- # of PTs = Number of product terms used in design
- # of nets = Number of signals used in device
- Max freq = Highest clock frequency to the device (in MHz)

The I_{CC} estimate is based on typical conditions ($V_{CC} = 5.0\text{V}$, room temperature) and an assumption of four GLB loads on average exists and the device is filled with four 16-bit counters. These values are for estimates only. Since the value of I_{CC} is sensitive to operating conditions and the program in the device, the actual I_{CC} should be verified.

0127B-16-80-isp/1016

Pin Description

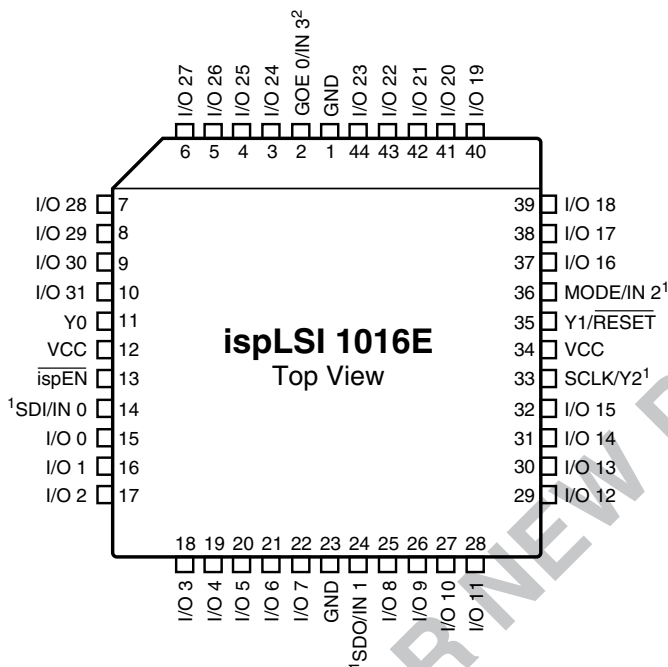
NAME	PLCC PIN NUMBERS	TQFP PIN NUMBERS	DESCRIPTION
I/O 0 - I/O 3 I/O 4 - I/O 7 I/O 8 - I/O 11 I/O 12 - I/O 15 I/O 16 - I/O 19 I/O 20 - I/O 23 I/O 24 - I/O 27 I/O 28 - I/O 31	15, 16, 17, 18, 19, 20, 21, 22, 25, 26, 27, 28, 29, 30, 31, 32, 37, 38, 39, 40, 41, 42, 43, 44, 3, 4, 5, 6, 7, 8, 9, 10	9, 10, 11, 12, 13, 14, 15, 16, 19, 20, 21, 22, 23, 24, 25, 26, 31, 32, 33, 34, 35, 36, 37, 38, 41, 42, 43, 44, 1, 2, 3, 4	Input/Output Pins - These are the general purpose I/O pins used by the logic array.
GOE 0/IN 3 ²	2	40	This is a dual function pin. It can be used either as Global Output Enable for all I/O cells or it can be used as a dedicated input pin.
$\overline{\text{ispEN}}$	13	7	Input - Dedicated in-system programming enable input pin. This pin is brought low to enable the programming mode. The MODE, SDI, SDO and SCLK controls become active.
SDI/IN 0 ¹	14	8	Input - This pin performs two functions. When $\overline{\text{ispEN}}$ is logic low, it functions as an input pin to load programming data into the device. It is a dedicated input pin when $\overline{\text{ispEN}}$ is logic high. SDI/INO also is used as one of the two control pins for the isp state machine.
MODE/IN 2 ¹	36	30	Input - This pin performs two functions. When $\overline{\text{ispEN}}$ is logic low, it functions as a pin to control the operation of the isp state machine. It is a dedicated input pin when $\overline{\text{ispEN}}$ is logic high.
SDO/IN 1 ¹	24	18	Output/Input - This pin performs two functions. When $\overline{\text{ispEN}}$ is logic low, it functions as an output pin to read serial shift register data. It is a dedicated input pin when $\overline{\text{ispEN}}$ is logic high.
SCLK/Y2 ¹	33	27	Input - This pin performs two functions. When $\overline{\text{ispEN}}$ is logic low, it functions as a clock pin for the Serial Shift Register. It is a dedicated clock input when $\overline{\text{ispEN}}$ is logic high. This clock input is brought into the Clock Distribution Network, and can optionally be routed to any GLB and/or I/O cell on the device.
Y0	11	5	Dedicated Clock input. This clock input is connected to one of the clock inputs of all the GLBs on the device.
Y1/RESET	35	29	This pin performs two functions: - Dedicated clock input. This clock input is brought into the Clock Distribution Network, and can optionally be routed to any GLB and/or I/O cell on the device. - Active Low (0) Reset pin which resets all of the GLB and I/O registers in the device.
GND	1, 23	17, 39	Ground (GND)
VCC	12, 34	6, 28	Vcc

Table 2-0002C-16-isp

1. Pins have dual function capability.
2. Pins have dual function capability which is software selectable.

Pin Configurations

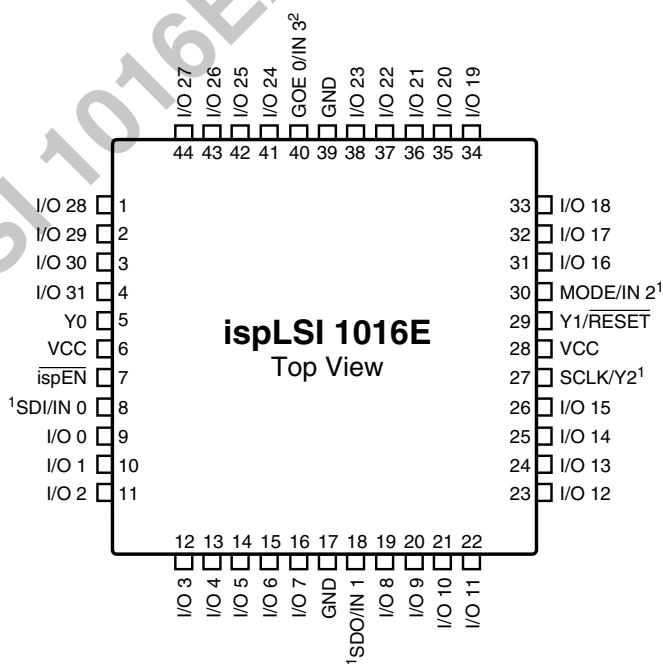
ispLSI 1016E 44-Pin PLCC Pinout Diagram



1. Pins have dual function capability.
2. Pins have dual function capability which is software selectable.

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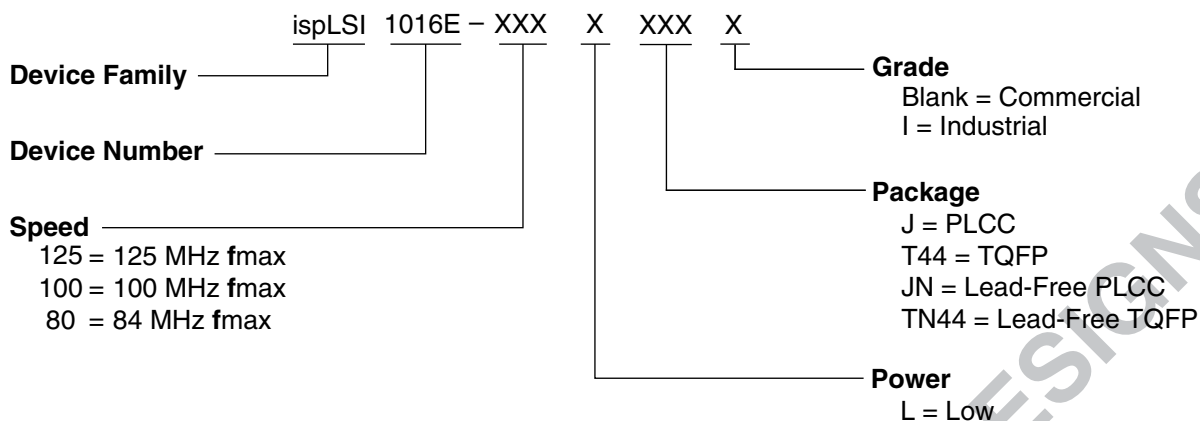
ispLSI 1016E 44-Pin TQFP Pinout Diagram



1. Pins have dual function capability.
2. Pins have dual function capability which is software selectable.

0851-16E/TQFP

Part Number Description



ispLSI 1016E Ordering Information

Conventional Packaging

COMMERCIAL

FAMILY	fmax (MHz)	tpd (ns)	ORDERING NUMBER	PACKAGE
ispLSI	125	7.5	ispLSI 1016E-125LJ	44-Pin PLCC
	125	7.5	ispLSI 1016E-125LT44	44-Pin TQFP
	100	10	ispLSI 1016E-100LJ	44-Pin PLCC
	100	10	ispLSI 1016E-100LT44	44-Pin TQFP
	84	15	ispLSI 1016E-80LJ	44-Pin PLCC
	84	15	ispLSI 1016E-80LT44	44-Pin TQFP

INDUSTRIAL

FAMILY	fmax (MHz)	tpd (ns)	ORDERING NUMBER	PACKAGE
ispLSI	84	15	ispLSI 1016E-80LJI	44-Pin PLCC
	84	15	ispLSI 1016E-80LT44I	44-Pin TQFP

Lead-Free Packaging

COMMERCIAL

FAMILY	fmax (MHz)	tpd (ns)	ORDERING NUMBER	PACKAGE
ispLSI	125	7.5	ispLSI 1016E-125LJN	Lead-Free 44-Pin PLCC
	125	7.5	ispLSI 1016E-125LTN44	Lead-Free 44-Pin TQFP
	100	10	ispLSI 1016E-100LJN	Lead-Free 44-Pin PLCC
	100	10	ispLSI 1016E-100LTN44	Lead-Free 44-Pin TQFP
	84	15	ispLSI 1016E-80LJN	Lead-Free 44-Pin PLCC
	84	15	ispLSI 1016E-80LTN44	Lead-Free 44-Pin TQFP

INDUSTRIAL

FAMILY	fmax (MHz)	tpd (ns)	ORDERING NUMBER	PACKAGE
ispLSI	84	15	ispLSI 1016E-80LJNI	Lead-Free 44-Pin PLCC
	84	15	ispLSI 1016E-80LTN44I	Lead-Free 44-Pin TQFP

Revision History

Date	Version	Change Summary
—	08	Previous Lattice release.
August 2006	09	Updated for lead-free package options.

USE ispLSI 1016EA FOR NEW DESIGNS