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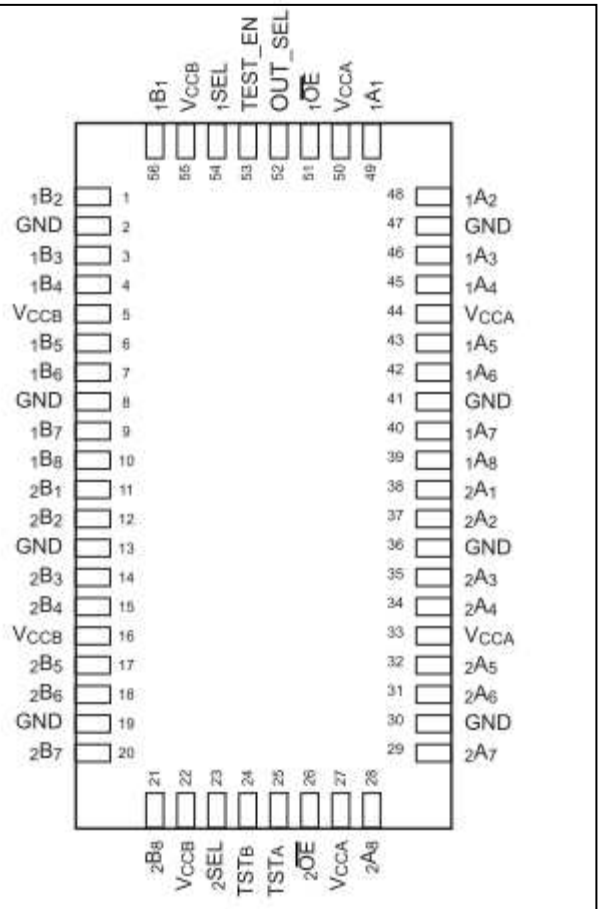
1.2V to 3.6V Universal Bidirectional Level Shifter with Automatic Direction Control

Features

- PI4ULS3V16 is designed for low voltage operation: 1.2V to 3.6V
- Universal bidirectional level shifting with automatic direction control
- Fast bus speeds up to 180 Mbps for push-pull application
- Drive Capability 12mA
- Independent translation of each bit
- Each supply rail is configurable over supply range
- ESD Protection exceeds JESD22
- - 2000V Human Body Model (A114-B)
- -200V Machine Model (A115-A)
- Latch-up performance exceeds 100mA per JESD 78
- Industrial operation at -40°C to +85°C
- Package: 56-contact plastic 197-mil TQFN

Pin Configuration



TQFN-56L(Top View)

Description

PI4ULS3V16, is a 16-bit (dual-octal) non-inverting bus transceiver with two separate supply rails: A port (VCCA) and B port (VCCB) are set to operate at 1.2V to 3.6V. This arrangement permits universal bidirectional translation of differential signal levels over the voltage ranges.

The PI4ULS3V16 is designed for asynchronous communication between data buses. Data is transmitted from the A bus to the B bus, or vice versa, without direction control. All AX, and BX are tri-stated when data is coming from both directions at the same time. The output-enable ($\overline{OE}$) input is used to disable outputs so buses are isolated.

The control pins xSEL, x$\overline{OE}$, TEST_EN and OUT_SEL are supplied by VCCB.

To ensure the high impedance state during power-up or power- down, the output-enable ($\overline{OE}$) input should be tied to VCC through a pull-up resistor: the minimum value of the resistor is determined by the current-sinking capability of the driver.

Applications

- Voltage Translation
- Bus Relay

Pin Description

Pin Name	Description
x$\overline{OE}$	3-State Output Enable Inputs (Active Low)
xSEL	Outputs Loading Selection
xAx	Side A Inputs/Outputs
xBx	Side B Inputs/Outputs
TEST_EN	Enable Test Mode
OUT_SEL	Output impedance select
GND	Ground
VccA,V_{CCB}	Power
TSTx	Internal test pins. For normal usage, please tie to ground

Block Diagram

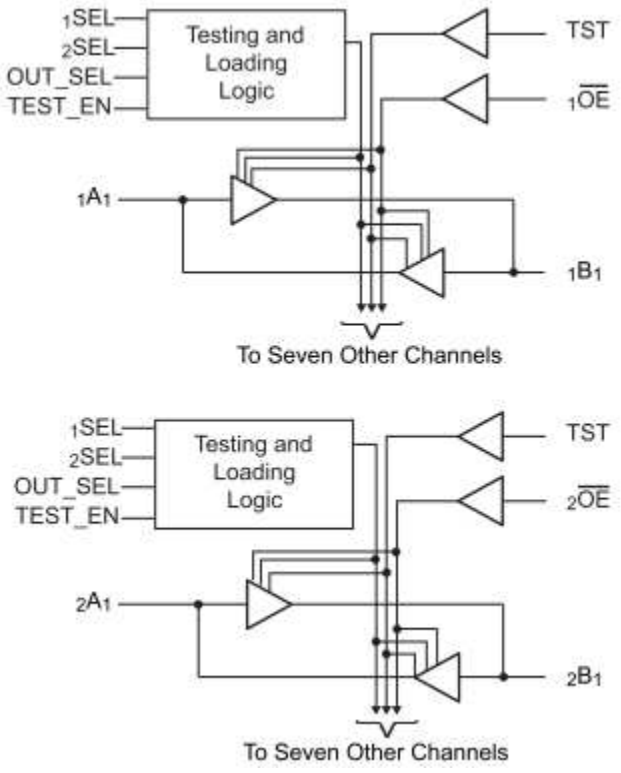


Figure 1: Block Diagram

Truth Table

Inputs			Outputs Loading(2)	Operation
xOE	2SEL	1SEL		
L	L	L	$C_L \leq 50pF$	Bus B data to Bus A, or Bus A data to Bus B
L	L	H	$C_L \leq 30pF$	
L	H	L	$C_L \leq 20pF$	
L	H	H	$C_L \leq 10pF$	
H	X	X		Z (Isolation)

Note:
1. H = HIGH Signal Level, L = LOW Signal Level
   X = Don't Care or Irrelevant, Z = High Impedance
2. Refer to Figure2for output Loading Chart

Test Mode / Output Impedance Select

TEST_EN	Out_SEL	Conditions
L	L	Normal Operation Low output impedance 300Ω
L	H	Normal Operation High output impedance 2.2KΩ
H	L	Test_MODE A → B
H	H	Test_MODE B → A

Maximum Ratings

Storage Temperature ..... -65°C to +150°C
DC Supply Voltage VCCA ..... -0.5V to +4.6V
DC Supply Voltage VCCB ..... -0.5V to +4.6V
Enable Control Pin DC Input Voltage ..... -0.5V to+4.6V
Voltage Range applied to any I/O pins in the high-impedance or Power-Off state VIOZ(A) ..... -0.5V to+4.6V
Voltage Range applied to any I/O pins in the high-impedance or Power-Off state VIOZ(B) ..... -0.5V to+4.6V
Voltage Range applied to any I/O pins in the high or Low state VIO(A) ..... -0.5V to VCCA+0.5V
Voltage Range applied to any I/O pins in the high or Low state VIO(B) ..... -0.5V to VCCB+0.5V
Input clamp Current (VI < 0) ..... -50mA
Ourput clamp current (VO < 0) ..... -50mA
Continuous output current ..... ±20mA
Continuous current through VCCA, VCCB or GND Pin ..... ±100mA
Package thermal impedance, 0_{JA}(3)
ZF package ..... 33°C/W

Note:
1 The input negative voltage and output voltage ratings may be exceeded if the input and output current ratings are observed.
2 This value is limited to 3.6V maximum.
3 Stresses greater than those listed under 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 above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

Recommended Operating Conditions

Parameter	Description		V_{CCI}	Min	Max	Units
V_{CCA}, V_{CCB}	Supply Voltage		-	1.2	3.6	V
V_{IH}	High-Level Input	I/O pins	1.2V to 1.95V	0.65 x V_{CCI}	-	
			2.3V to 2.7V	1.7	-	
			2.7V to 3.6V	2		
V_{IL}	Low-Level Input	I/O pins	1.2V to 1.95V	-	0.35 x V_{CCI}	
			2.3V to 2.7V	-	0.7	
			2.7V to 3.6V	-	0.8	
V_{IHB}	High-Level Input Voltage	Control Inputs ($\overline{OE}$ and SEL)	1.2V to 1.95V	0.65 x V_{CCB}	-	
			2.3V to 2.7V	1.7	-	
			2.7V to 3.6V	2	-	
V_{ILB}	Low-Level Input Voltage	Control Inputs ($\overline{OE}$ and SEL)	1.2V to 1.95V	-	0.35 x V_{CCB}	
			2.3V to 2.7V	-	0.7	
			2.7V to 3.6V	-	0.8	
V_I	Input Voltage	I/O pins and Control	-	0	3.6	
V_O	Output Voltage	I/O pins and Control	-	0	3.6	
I_{OH}	High-Level Output	I/O pins	V_{CCO} = 1.2V	-	-3	mA
			V_{CCO} = 1.4V	-	-5	
			V_{CCO} = 1.65V	-	-8	
			V_{CCO} = 2.3V	-	-9	
			V_{CCO} = 3.0V	-	-12	
I_{OL}	Low-Level Output	I/O pins	V_{CCO} = 1.2V	-	3	
			V_{CCO} = 1.4V	-	5	
			V_{CCO} = 1.65V	-	8	
			V_{CCO} = 2.3V	-	9	
			V_{CCO} = 3.0V	-	12	
$\Delta V/\Delta t$	Input Transition rise or fall rate		-	-	10	V/ns
T_A	Operating Free-Air Temperature		-	-40	85	°C

Notes:
1. V_{CCI} is the V_{CC} associated with the data input port.
2. V_{CCO} is the V_{CC} associated with the data output port.
3. To ensure proper device operation, all unused device inputs must be held at V_{CCI} or GND.

Electrical Characteristics

(Over recommended free-air temperature range, unless otherwise noted.)

Parameter	Description	Test Conditions	V_{CCA}/V_{CCB}	Min	Typ (1)	Max	Units
V_{OH}	High-Level Output Voltage	I_{OH} = -100µA	1.2V to 3.6V	V_{CCO} - 0.1V	-	-	V
		I_{OH} = -2mA	1.2V	-	0.8	-	
		I_{OH} = -4mA	1.4V	1	-	-	
		I_{OH} = -7mA	1.65V	1.2	-	-	
		I_{OH} = -9mA	2.3V	1.8	-	-	
		I_{OH} = -12mA	3.0V	2.4	-	-	
V_{OL}	Low-Level Output Voltage	I_{OL} = 100µA	1.2V to 3.6V	-	-	0.2	
		I_{OL} = 2mA	1.2V	-	0.1		
		I_{OL} = 4mA	1.4V	-	-	0.4	
		I_{OL} = 7mA	1.65V	-	-	0.4	
		I_{OL} = 9mA	2.3V	-	-	0.4	
		I_{OL} = 12mA	3.0V	-	-	0.4	
I_{CC}	Quiescent Supply Current	$V_I = V_{CCI}$ or GND, I_O = 0	1.2V to 3.6V	-	-	10	µA
I_I	Control Inputs ($\overline{OE}$ and SEL)	$V_I = V_{CCB}$ or GND	1.2V to 3.6V	-	-	±5	
I_{OZ} (2)	3-State Output Current	$V_O = V_{CCO}$ or GND	1.2V to 3.6V	-	-	±10	
C_{IN}	Control Input Capacitance	$V_I = V_{CCB}$ or GND	-	-	3	-	pF
C_{IO}	I/O Capacitance	$V_I = V_{CCA/B}$ or GND	-	-	5	-	

Notes:
1. All typical values are at T_A = 25°C.
2. For I/O ports, the parameter I_{OZ} includes the input leakage current.
3. Parameters are specified under test mode conditions.

Timing Characteristics

(V_{CCA} = 1.5V±0.1V, Over recommended free-air temperature range, unless otherwise noted.)

Parameter	From (Input)	To (Output)	V_{CCB} = 1.2V	V_{CCB} = 1.5V ±0.1V		V_{CCB} = 1.8V ±0.15V		V_{CCB} = 2.5V ±0.2V		V_{CCB} = 3.3V ±0.3V		Units
			Typ	Min	Max	Min	Max	Min	Max	Min	Max	
t_{PD}	A	B	8	1.0	7.0	1.0	6.5	1.0	6.0	1.0	5.0	ns
	B	A	6	1.0	7.0	1.0	6.5	1.0	6.0	1.0	5.5	
tsk(a)(1)	-		-	-	0.3	-	0.3	-	0.3	-	0.3	
tsk(b)(1)	-		-	-	0.25	-	0.25	-	0.25	-	0.25	
f_{max} 10pF load	B	A	25	30	-	40	-	50	-	60	-	MHz
	A	B	30	30	-	35	-	40	-	40	-	

(V_{CCA} = 1.8V±0.15V, Over recommended free-air temperature range, unless otherwise noted.)

Parameter	From (Input)	To (Output)	V_{CCB} = 1.2V	V_{CCB} = 1.5V ±0.1V		V_{CCB} = 1.8V ±0.15V		V_{CCB} = 2.5V ±0.2V		V_{CCB} = 3.3V ±0.3V		Units
			Typ	Min	Max	Min	Max	Min	Max	Min	Max	
t_{PD}	A	B	8	1.0	6.0	0.5	5.5	0.5	5.0	0.5	4.5	ns
	B	A	6	1.0	6.0	0.5	5.5	0.5	5.0	0.5	4.5	
tsk(a)(1)	-		-	-	0.25	-	0.25	-	0.25	-	0.25	
tsk(b)(1)	-		-	-	0.2	-	0.2	-	0.2	-	0.2	
f_{max} 10pF load	B	A	25	35	-	45	-	55	-	65	-	MHz
	A	B	30	40	-	45	-	50	-	55	-	

(V_{CCA} = 2.5V±0.2V, Over recommended free-air temperature range, unless otherwise noted.)

Parameter	From (Input)	To (Output)	V_{CCB} = 1.2V	V_{CCB} = 1.5V ±0.1V		V_{CCB} = 1.8V ±0.15V		V_{CCB} = 2.5V ±0.2V		V_{CCB} = 3.3V ±0.3V		Units
			Typ	Min	Max	Min	Max	Min	Max	Min	Max	
t_{PD}	A	B	8	1.0	5.5	0.5	5.0	0.5	4.5	0.5	4.0	ns
	B	A	6	1.0	5.5	0.5	5.0	0.5	4.5	0.5	4.0	
tsk(a)(1)	-		-	-	0.25	-	0.25	-	0.25	-	0.25	
tsk(b)(1)	-		-	-	0.2	-	0.2	-	0.2	-	0.2	
f_{max} 10pF load	B	A	30	40	-	50	-	75	-	80	-	MHz
	A	B	40	50	-	55	-	75	-	80	-	

(V_{CCA} = 3.3V±0.3V, Over recommended free-air temperature range, unless otherwise noted.)

Parameter	From (Input)	To (Output)	V_{CCB} = 1.2V	V_{CCB} = 1.5V ±0.1V		V_{CCB} = 1.8V ±0.15V		V_{CCB} = 2.5V ±0.2V		V_{CCB} = 3.3V ±0.3V		Units
			Typ	Min	Max	Min	Max	Min	Max	Min	Max	
t_{PD}	A	B	7	1.0	5.0	0.5	4.5	0.5	4.0	0.5	3.5	ns
	B	A	6	1.0	5.0	0.05	4.5	0.5	4.0	0.5	3.5	
tsk(a)(1)	-		-	-	0.25	-	0.25	-	0.25	-	0.25	
tsk(b)(1)	-		-	-	0.2	-	0.2	-	0.2	-	0.2	
f_{max} 10pF load	B	A	30	40	-	55	-	80	-	90	-	MHz
	A	B	40	60	-	65	-	80	-	90	-	

Note:

1. This is the skew between any two outputs of the same package, and switching in the same direction. For tsk(a), Output 1 and Output 2 are any two outputs. For tsk(b), Output 1 and Output 2 are in the same bank. These parameters are warranted but not production tested.

Operating Characteristics

(V_{CCA} and V_{CCB} = 2.5V; T_A = 25°C)

Parameter			Test Conditions	Typ	Units
Cpd (1) (V_{CCA})	Power Dissipation Capacitance A to B	Outputs Enabled	C_L = 0 f = 10 MHz	15	pF
		Outputs Disabled		2	
	Power Dissipation Capacitance B to A	Outputs Enabled		30	
		Outputs Disabled		10	
Cpd (1) (V_{CCB})	Power Dissipation Capacitance A to B	Outputs Enabled	C_L = 0 f = 10 MHz	30	pF
		Outputs Disabled		10	
	Power Dissipation Capacitance B to A	Outputs Enabled		15	
		Outputs Disabled		2	

Notes:
1. This parameter is specified under test mode conditions.

Parameter Measurement Information

V_{CCA}/V_{CCB}	C_L
1.2V ~ 1.6V	10pF
1.8V ±0.15V	20pF
2.5V ±0.2V	30pF
3.3V ±0.3V	50pF

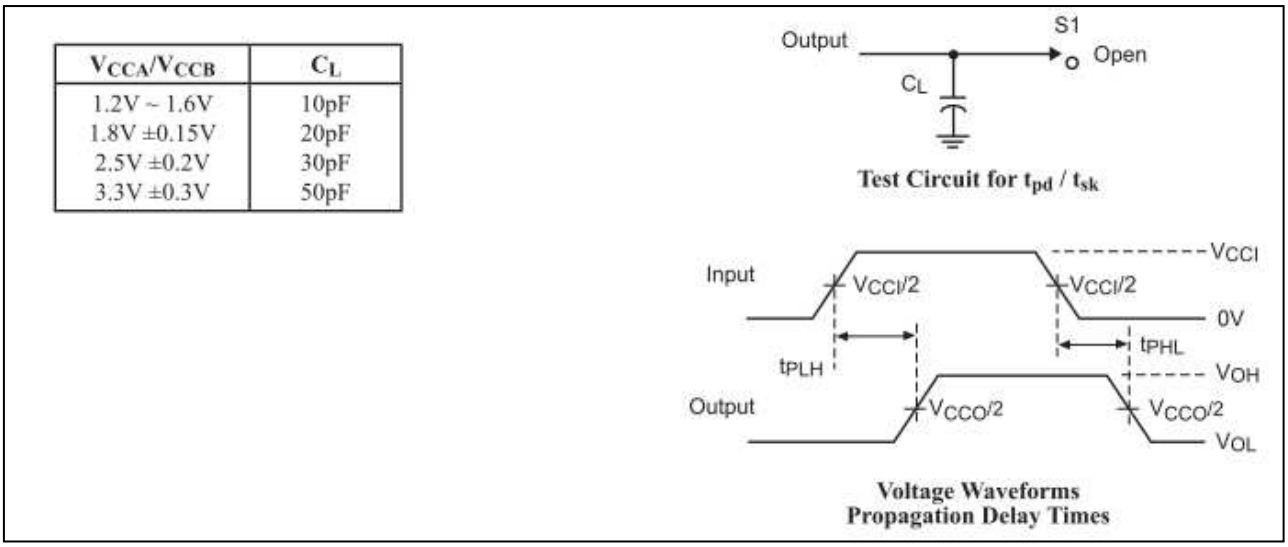
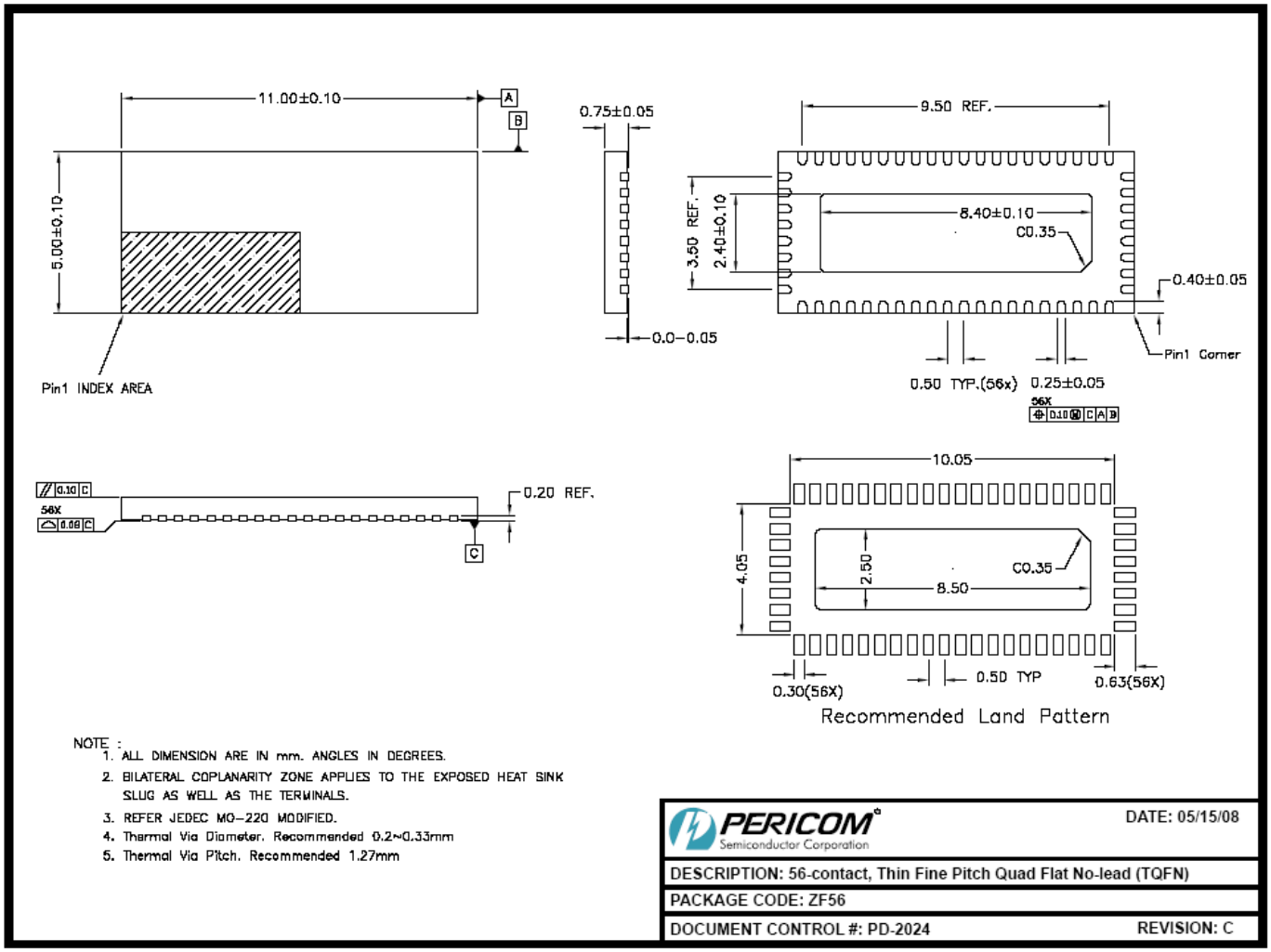


Figure 2. Load Circuit and Voltage Waveforms

Notes:
1. C_L includes probe and jig capacitance.
2. All input pulses are supplied by generators having the following characteristics: PRR≤ 10Mz, Z_O=50Ω, tr ≤ 2.5ns, tf ≤ 2.5ns.
3. The outputs are measured one at a time with one transition per measurement.
4. V_{CCI} defines the input port (V_{CCA} or V_{CCB}).
5. V_{CCO} defines the output port (V_{CCA} or V_{CCB}).

Mechanical Information

TQFN 5x11-56L



Ordering Information

Part No.	Package Code	Package
PI4ULS3V16ZFE	ZF	Lead free and Green 56-pin TQFN 5x11

Note:

- E = Pb-free
- Adding X Suffix= Tape/Reel

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