



#### Automotive Qualified 140Mb/s Bi-directional Level Translator for Push-Pull Applications

#### **Features**

- → Qualified for Automotive Applications
- → AEC-Q100 Qualified with the Following Results
  - Device Temperature Grade 1: -40°C to +125°C
     Ambient Operating Temperature Range
- → 0.9V to 2.0V on A Port and 1.65V to 3.6V on B Port
- → VCCA may be greater than, equal to, or less than VCCB
- → High-Speed with 140 Mb/s Guaranteed Date Rate
- → 100 pF Capacitive Drive Capability
- → Low Bit-to-Bit Skew
- → Overvoltage Tolerant Enable and I/O Pins
- → Non-preferential Power-Up Sequencing
- → Power-Off Protection
- → Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)
- → Halogen and Antimony Free. "Green" Device (Note 3)
- → The PI4ULS3V304AQ is suitable for automotive applications requiring specific change control; this part is AEC-Q 100 qualified, PPAP capable, and manufactured in IATF 16949 certified facilities.

https://www.diodes.com/quality/product-definitions/

→ Package: UQFN-12(ZMA)

## **Applications**

- → Mobile Phones, PDAs
- → Other Portable Devices
- → Automotive

### **Description**

The PI4ULS3V304AQ is an automotive qualified 4-bit configurable dual-supply autosensing bidirectional level translator that does not require a direction control pin. The B and A ports are designed to track two different power supply rails, VCCB and VCCA respectively.

The PI4ULS3V304AQ offers the feature that the values of the VCCB and VCCA supplies are independent. Design flexibility is maximized because VCCA can be set to a value either greater than or less than the VCCB supply.

The PI4ULS3V304AQ has high output current capability, which allows the translator to drive high capacitive loads such as most high frequency EMI filters. Another feature of the PI4ULS3V304AQ is that each An and Bn channel can function as either an input or an output.

An Output Enable (EN) input is available to reduce the power consumption. The EN pin can be used to disable both I/O ports by putting them in 3-state which significantly reduces the supply current.

The PI4ULS3V304AQ is capable of 2 kV System-Level ESD.

## **Block Diagram**

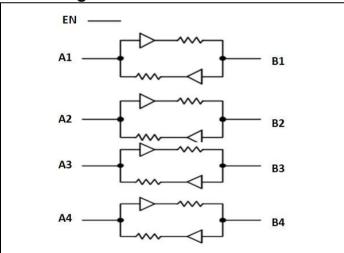


Figure 1: Block Diagram

#### Notes

<sup>1.</sup> No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.

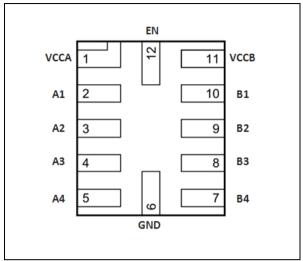
<sup>2.</sup> See https://www.diodes.com/quality/lead-free/ for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.

3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.





# **Pin Configuration**

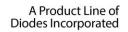


UQFN (Top View)

# **Pin Description**

| Pin# | Pin Name | Type  | Description  |
|------|----------|-------|--|
| 1    | VccA     | Power | A-port supply voltage. $0.9V \le VCCA \le 2.0V$                                |
| 2    | A1       | I/O   | Input/output A. Referenced to VCCA.  |
| 3    | A2       | I/O   | Input/output A. Referenced to VCCA   |
| 4    | A3       | I/O   | Input/output A. Referenced to VCCA.  |
| 5    | A4       | I/O   | Input/output A. Referenced to VCCA   |
| 6    | GND      | GND   | Ground.  |
| 7    | B4       | I/O   | Input/output B. Referenced to VCCB   |
| 8    | В3       | I/O   | Input/output B. Referenced to VCCB   |
| 9    | B2       | I/O   | Input/output B. Referenced to VCCB   |
| 10   | B1       | I/O   | Input/output B. Referenced to VCCB   |
| 11   | VccB     | Power | B-port supply voltage. $1.65V \le VCCB \le 3.6V$                               |
| 12   | EN       | Input | Output enable (active High). Pull EN low to place all outputs in 3-state mode. |







## **Maximum Ratings**

| Storage Temperature   | 65°C to +150°C |
|---|----------------|
| Junction Temperature, Tj  | 125°C          |
| DC Supply Voltage port B  | 0.5V to +4.0V  |
| DC Supply Voltage port A  | 0.5V to+2.6V   |
| Vi(A) referenced DC Input / Output Voltage                                | 0.5V to +2.6V  |
| Vi(B) referenced DC Input / Output Voltage                                | 0.5V to+4.0V   |
| Enable Control Pin DC Input Voltage                                       | 0.5V to+2.6V   |
| DC Input Diode Current (V <sub>1</sub> <gnd)< td=""><td>50mA</td></gnd)<> | 50mA           |
| DC Output Diode Current (Vo <gnd)< td=""><td>50mA</td></gnd)<>            | 50mA           |
| DC Supply Current through V <sub>CCB</sub>                                | ±100mA         |
| DC Supply Current through V <sub>CCA</sub>                                | ±100mA         |
| DC Ground Current through Ground Pin                                      |                |

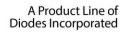
#### Note

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 Operation Conditions** 

| Symbol      | Parameter                                      | Min.  | Typ. | Max. | Unit |    |
|-------------|--|---|------|------|------|----|
| $V_{CCA}$   | A-side Positive DC Supply Vol                  | A-side Positive DC Supply Voltage   |      |      | 2.0  | V  |
| $V_{CCB}$   | B-side Positive DC Supply Vol                  | B-side Positive DC Supply Voltage   |      |      | 3.6  | V  |
| $V_{\rm I}$ | Enable Control Pin Voltage                     |   | GND  | _    | 2.0  | V  |
| x 7         | Bus Input/Output Pin Voltage                   | I/O A   | GND  | _    | 2.0  | V  |
| $V_{IO}$    |  | I/O B   | GND  | _    | 3.6  | V  |
| $T_A$       | Operating Temperature Range                    |   | -40  | _    | +125 | °C |
| At/Av       | Input Transition Rise or Rate, V 3.3 V ± 0.3 V | $V_{\rm I}$ , $V_{\rm IO}$ from 30% to 70% of $V_{\rm CC}$ ; $V_{\rm CC}$ = | 0    | _    | 10   | ns |







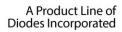
#### **DC Electrical Characteristics**

|                       |   | *1   | ${ m V_{CCB}}^{*2}$ | V <sub>CCA</sub> *3 | -4                   | <b>T</b> T 1. |                      |      |
|-----------------------|---|--|---------------------|---------------------|----------------------|---------------|----------------------|------|
| Symbol                | Parameter                                     | Test Conditions*1  | (V)                 | (V)                 | Min.                 | Typ.*4        | Max.                 | Unit |
| ${ m V}_{ m IHB}$     | B port Input HIGH Voltage                     | _  | 1.65-3.6            | 0.9-2.0             | 2/3*V <sub>CCB</sub> | _             | _                    | V    |
| $V_{_{\rm ILB}}$      | B port Input LOW Voltage                      | _  | 1.65-3.6            | 0.9-2.0             | _                    | _             | 1/3*V <sub>CCB</sub> | V    |
| V                     | A port Input HIGH Voltage                     |  | 1.65-3.6            | 0.9-1.1             | 3/4*V <sub>CCA</sub> | _             | _                    | V    |
| $V_{_{\mathrm{IHA}}}$ | A port iliput filofi voltage                  | _  | 1.65-3.6            | 1.1-2.0             | 2/3*V <sub>CCA</sub> | _             |                      | V    |
| $V_{_{\rm ILA}}$      | A port Input LOW Voltage                      |  | 1.65-3.6            | 0.9-1.1             | _                    | _             | 1/4*V <sub>CCA</sub> | V    |
| V ILA                 | A port input LOW voltage                      | _  | 1.65-3.6            | 1.1-2.0             | _                    | _             | 1/3*V <sub>CCA</sub> | V    |
| $ m V_{IH}$           | Control Pin Input HIGH                        |  | 1.65-3.6            | 0.9-1.1             | 3/4*V <sub>CCA</sub> |               | _                    | V    |
| * IH                  | Voltage                                       | _  | 1.65-3.6            | 1.1-2.0             | 2/3*V <sub>CCA</sub> | _             |                      | V    |
| V                     | Control Pin Input LOW                         |  | 1.65-3.6            | 0.9-1.1             | _                    | _             | 1/4*V <sub>CCA</sub> | V    |
| $V_{IL}$              | Voltage                                       | _  | 1.65-3.6            | 1.1-2.0             | _                    | _             | 1/3*V <sub>CCA</sub> | V    |
| $V_{OHB}$             | B port Output HIGH<br>Voltage                 | B port source current = $20\mu$ A  | 1.65-3.6            | 0.9-2.0             | 0.9*V <sub>CCB</sub> | _             | _                    | V    |
| $V_{OLB}$             | B port Output LOW<br>Voltage                  | B port sink current = $20\mu$ A  | 1.65-3.6            | 0.9-2.0             | _                    | _             | 0.2                  | V    |
| $V_{OHA}$             | A port Output HIGH<br>Voltage                 | A port source current= 20μA  | 1.65-3.6            | 0.9-2.0             | 0.9*V <sub>CCA</sub> | _             | _                    | V    |
| $V_{OLA}$             | A port Output LOW<br>Voltage                  | A port sink current = 20μA   | 1.65-3.6            | 0.9-2.0             | _                    | _             | 0.2                  | V    |
| ${ m I}_{ m QVB}$     | V <sub>CCB</sub> Supply Current               | $EN = V_{CCA}, I_O = 0A,$  | 1.65-3.6            | 0.9-2.0             | _                    | 0.1           | 6                    | μΑ   |
| ${ m I}_{ m QVA}$     | V <sub>CCA</sub> Supply Current               | (I/O_B= 0V or $V_{CCB}$ , I/O_A= float) or (I/O_B = float, I/O_A = 0V or $V_{CCA}$ ) | 1.65-3.6            | 0.9-2.0             |                      | 0.2           | 30                   | μА   |
| ${\rm I}_{{ m TS-B}}$ | B port Tristate Output Mode<br>Supply Current | $(I/O_B = 0V \text{ or } V_{CCB}, I/O_A$   | 1.65-3.6            | 0.9-2.0             |                      | 0.1           | 6                    | μΑ   |
| ${ m I}_{ m TS-A}$    | A port Tristate Output Mode<br>Supply Current | = float) or<br>( $I/O_B$ = float, $I/O_A$ = 0V<br>or $V_{CCA}$ )                     | 1.65-3.6            | 0.9-2.0             | _                    | 0.2           | 30                   | μΑ   |
| I <sub>oz</sub>       | I/O Tristate Output Mode<br>Leakage Current   | EN=0V  | 1.65-3.6            | 0.9-2.0             | _                    | _             | ±6                   | μΑ   |
| $I_{I}$               | Control Pin Input Current                     |  | 1.65-3.6            | 0.9-2.0             |                      |               | ±1                   | μA   |
|                       |   | 1/0 D 0 / 2 (7/ 1/0 / )  | 0                   | 0                   | _                    | _             | 15                   |      |
| $I_{OFF}$             | Power Off Leakage Current                     | $I/O_B = 0$ to 3.6V, $I/O_A = 0$ to 2.0V   | 1.65-3.6            | 0                   |                      |               | 30                   | μΑ   |
|                       |   | IO 2.0 V   | 0                   | 0.9-2.0             |                      |               | 15                   |      |
| Note:                 |   |  |                     |                     |                      |               |                      |      |

#### Note:

- Normal test conditions are V<sub>I</sub> = 0V, C<sub>IOB</sub> ≤ 15pF and C<sub>IOA</sub> ≤ 15pF, unless otherwise specified.
   V<sub>CCB</sub> is the supply voltage associated with the I/O B port, and B range from +1.65 V to 3.6 V under normal operating conditions.
   V<sub>CCA</sub> is the supply voltage associated with the I/O A port, and A range from +0.9 V to 2.0V under normal operating conditions.
   Typical values are tested at T<sub>A</sub> = +25°C. Limits over the operating temperature range are guaranteed by design.
   When VCCA <1.0V, VIH is 0.75\*V<sub>CCA</sub> (Min), VIL is 0.25\*V<sub>CCA</sub> (Max)



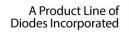




**Timing Characteristics** 

| Symbol                | Parameter                             | Test Conditions*1                                    | $V_{CCB}^{*2}(V)$      | V *3(V)           | -40  |          | -40°C to +125°C |       |  |
|-----------------------|---------------------------------------|--|------------------------|-------------------|------|----------|-----------------|-------|--|
| Symbol                | ा वा वागारास                          |  | V <sub>CCB</sub> - (V) | $V_{CCA}^{*3}(V)$ | Min. | Typ.*4   | Max.            | Unit  |  |
| f                     | B port Rise Time                      | $C_{IOB} = 15 \text{ pF}$                            | 1.65-3.6               | 0.9-2.0           | _    | 3        | 8               | ns    |  |
| R-B                   | B port Rise Time                      | C <sub>IOB</sub> = 13 pt                             | 2.25-3.6               | 1.65-2.0          |      | 0.8      | 4               | 113   |  |
| f                     | B port Fall Time                      | $C_{IOB} = 15 \text{ pF}$                            | 1.65-3.6               | 0.9-2.0           |      | 0.6      | 3               | ne    |  |
| F-B                   | B port ran Time                       | $C_{IOB} = 13 \text{ pr}$                            | 2.25-3.6               | 1.65-2.0          |      | 0.5      | 3               | ns    |  |
| f                     | A port Rise Time                      | $C_{IOA} = 15 \text{ pF}$                            | 1.65-3.6               | 0.9-2.0           | _    | 4        | 12              | ne    |  |
| l <sub>R-A</sub>      | A port Rise Time                      | C <sub>IOA</sub> = 13 pr                             | 2.25-3.6               | 1.65-2.0          |      | 0.7      | 4               | ns    |  |
| t                     | A port Fall Time                      | $C_{IOA} = 15 \text{ pF}$                            | 1.65-3.6               | 0.9-2.0           |      | 0.8      | 4               | ne    |  |
| L <sub>F-A</sub>      | A port Tan Time                       | C <sub>IOA</sub> = 13 pr                             | 2.25-3.6               | 1.65-2.0          |      | 0.5      | 3               | ns    |  |
|                       | B port One-Shot                       | One-Shot   | Shot 1.8               |                   |      |          | 37              |       |  |
| $Z_{OB}$              | Output Impedance                      | *5   | 2.5                    | 0.9-2.0           | _    | 20       |                 | Ω     |  |
|                       | output impedance                      |  | 3.6                    |                   |      | 15       |                 |       |  |
| _                     | A port One-Shot Out- put              |  |                        | 0.9               |      | 52       |                 |       |  |
| $Z_{OA}$              | Impedance                             | *5   | 1.8-3.3                | 1.8               | _    | 17       |                 | Ω     |  |
|                       |                                       |  |                        | 2.0               |      | 15       |                 |       |  |
|                       |                                       | $C_{IOB} = 15 \text{ pF}$                            | 1.65-3.6               | 0.9-2.0           |      | 9.8      | 35              | _     |  |
|                       |                                       | Olob 10 bi   | 2.25-3.6               | 1.65-2.0          |      | 2.3      | 10              | _     |  |
|                       |                                       | $C_{IOB} = 30 \text{ pF}$                            | 1.65-3.6               | 0.9-2.0           |      | 10       | 35              | 4     |  |
| t <sub>PD_A-B</sub>   | Propagation Delay                     | Clob 20 bi   | 2.25-3.6               | 1.65-2.0          |      | 2.5      | 10              | ns    |  |
| PD_A-B                | (Driving B port )                     | $C_{IOB} = 50 \text{ pF}$                            | 1.65-3.6               | 0.9-2.0           |      | 10.4     | 37              |       |  |
|                       |                                       | CIOB CO PT   | 2.25-3.6               | 1.65-2.0          |      | 2.7      | 11              |       |  |
|                       |                                       | $C_{IOB} = 100 \text{ pF}$                           | 1.65-3.6               | 0.9-2.0           |      | 10.9     | 40              |       |  |
|                       |                                       |  | 2.25-3.6               | 1.65-2.0          |      | 3.3      | 13              |       |  |
|                       | Propagation Delay<br>(Driving A port) | $C_{IOA} = 15 \text{ pF}$                            | 1.65-3.6               | 0.9-2.0           |      | 9.4      | 35              | ns ns |  |
| t                     |                                       | TIOA F-  | 2.25-3.6               | 1.65-2.0          |      | 1.6      | 10              |       |  |
|                       |                                       | $C_{IOA} = 30 \text{ pF}$                            | 1.65-3.6               | 0.9-2.0           |      | 9.6      | 35              |       |  |
|                       |                                       | CIOA SO PI   | 2.25-3.6               | 1.65-2.0          |      | 1.8      | 10              |       |  |
| PD_B-A                |                                       | $C_{IOA} = 50 \text{ pF}$ $C_{IOA} = 100 \text{ pF}$ | 1.65-3.6               | 0.9-2.0           |      | 10       | 37              |       |  |
|                       |                                       |  | 2.25-3.6               | 1.65-2.0          |      | 2        | 11              |       |  |
|                       |                                       |  | 1.65-3.6               | 0.9-2.0           |      | 11.2     | 40              |       |  |
|                       |                                       | Cloa 100 pr  | 2.25-3.6               | 1.65-2.0          | _    | 2.6      | 13              |       |  |
| t <sub>sk</sub>       | Channel-to-Channel<br>Skew            | $C_{IOB} = 15pF, C_{IOA} = 15pF^{*5}$                | 1.65-3.6               | 0.9-2.0           |      | -        | 0.15            | ns    |  |
| t (t)                 |                                       | $C_{IOB} = 15 pF, I/O_A = V_{CCA}$                   | 1.65-3.6               | 0.9-2.0           |      | 120      | 250             |       |  |
| $t_{EN-B}(t_{PZH})$   | B port Output Enable Time             | $C_{IOB} = 13$ pF, $I/O_A = V_{CCA}$                 | 2.25-3.6               | 1.65-2.0          | _    | 40       | 160             | ]     |  |
| t (t )                | B port Output Enable Time             | $C_{IOB} = 15 pF, I/O_A = 0V$                        | 1.65-3.6               | 0.9-2.0           |      | 80       | 200             | ns    |  |
| $t_{EN-B}(t_{PZL})$   |                                       | $C_{IOB} = 13$ pr, $I/O_A = 0$                       | 2.25-3.6               | 1.65-2.0          | _    | 40       | 160             | 1     |  |
| t (t )                |                                       | $C_{IOA} = 15$ pF, I/O_B = $V_{CCB}$                 | 1.65-3.6               | 0.9-2.0           |      | 120      | 250             |       |  |
| $t_{EN-A} (t_{PZH})$  | A port Output Enable Time             | $C_{IOA} = 13$ pF, $I/O_B = V_{CCB}$                 | 2.25-3.6               | 1.65-2.0          |      | 40       | 160             | ]     |  |
| t (t )                | A port Output Enable Time             | C <sub>IOA</sub> = 15 pF, I/O_B = 0 V                | 1.65-3.6               | 0.9-2.0           |      | 50       | 200             | ns    |  |
| $t_{EN-A}(t_{PZL})$   |                                       | $C_{IOA} = 13 \text{ pr}, 1/O\_B = 0 \text{ V}$      | 2.25-3.6               | 1.65-2.0          |      | 30       | 160             | 1     |  |
| t (t )                |                                       | $C_{IOB} = 15$ pF, I/O_A = $V_{CCA}$                 | 1.65-3.6               | 0.9-2.0           | _    | 200      | 400             |       |  |
| $t_{DIS-B}(t_{PHZ})$  | Day of O to A Diville Time            | $C_{IOB} = 13$ pr, $I/O_A = V_{CCA}$                 | 2.25-3.6               | 1.65-2.0          | _    | 200      | 400             | 1     |  |
| + (+ )                | B port Output Disable Time            | $C_{IOB} = 15$ pF, I/O_A = 0V                        | 1.65-3.6               | 0.9-2.0           | _    | 60       | 175             | ns    |  |
| $t_{DIS-B}(t_{PLZ})$  |                                       | $C_{IOB} = 13 \text{pr}, 1/O\_A = 0 \text{ V}$       | 2.25-3.6               | 1.65-2.0          | _    | 60       | 175             | 1     |  |
| · (+ `                |                                       | C 15-E 1/O A W                                       | 1.65-3.6               | 0.9-2.0           | _    | 180      | 400             |       |  |
| $t_{DIS-A} (t_{PHZ})$ |                                       | $C_{IOB} = 15pF$ , $I/O\_A = V_{CCA}$                | 2.25-3.6               | 1.65-2.0          | _    | 100      | 400             | 1     |  |
| t (t )                | A port Output Disable Time            | C = 15  pe  I/O = A = OV                             | 1.65-3.6               | 0.9-2.0           | _    | 50       | 175             | ns    |  |
| $t_{DIS-A}(t_{PLZ})$  | '                                     | $C_{IOB} = 15 pF, I/O_A = 0V$                        | 2.25-3.6               | 1.65-2.0          | _    | 50       | 175             | 1     |  |
|                       |                                       | C - 15nE   | 1.65-3.6               | 0.9-2.0           | 50   | _        | _               |       |  |
|                       |                                       | $C_{IO} = 15pF$                                      | 2.25-3.6               | 1.65-2.0          | 140  | _        | _               | 1     |  |
| $M_{\rm IDR}$         | Maximum Data Rate                     | C 20E  | 1.65-3.6               | 0.9-2.0           | 40   | _        | _               | mbps  |  |
|                       |                                       | $C_{IO} = 30pF$                                      | 2.25-3.6               | 1.65-2.0          | 120  | _        | _               | 1     |  |
|                       |                                       | $C_{IO} = 50pF$                                      | 1.65-3.6               | 0.9-2.0           | 30   | <u> </u> |                 | mbps  |  |







|  |                         | 2.25-3.6 | 1.65-2.0 | 100 | _ | _ |  |
|--|-------------------------|----------|----------|-----|---|---|--|
|  | $C_{10} = 100 pF$       | 1.65-3.6 | 0.9-2.0  | 20  | _ | _ |  |
|  | C <sub>IO</sub> = 100pr | 2.25-3.6 | 1.65-2.0 | 60  | _ | _ |  |

#### Notes:

- Normal test conditions are V<sub>I</sub> = 0 V, C<sub>IOB</sub> ≤ 15pF and C<sub>IOA</sub> ≤ 15pF, unless otherwise specified.
   V<sub>CCB</sub> is the supply voltage associated with the I/O B port, and B ranges from +1.65 V to 3.6 V under normal operating conditions.
   V<sub>CCA</sub> is the supply voltage associated with the I/O A port, and A ranges from +0.9 V to 2.0V under normal operating conditions.
   Typical value are tested at T<sub>A</sub> = +25°C. Limits over the operating temperature range are guaranteed by design.

- 5. Guaranteed by design







**Power Consumption** (T<sub>A</sub>=+25°C)

| Symbol <sup>(1)</sup> | Parameter                       | <b>Test Conditions</b>           | $V_{CCB}^{*2}(V)$ | $V_{\text{CCA}}^{*3}(V)$ | Тур. | Unit |
|-----------------------|---------------------------------|----------------------------------|-------------------|--------------------------|------|------|
| $C_{PD\_VCCA}$        | A = Input port, B = Output Port | $C_{Load} = 0$ , $f = 1MHz$ ,    | 1.65-3.6          | 0.9-2.0                  | 40   | pF   |
| OPD_VCCA              | B = Input port, A = Output Port | $EN = V_{CCA}$ (outputs enabled) | 1.05 5.0          | 0.5 2.0                  | 10   | PI   |
| $C_{PD\ VCCB}$        | A = Input port, B = Output Port | $C_{Load} = 0$ , $f = 1MHz$ ,    | 1.65-3.6          | 0.9-2.0                  | 40   | ņ₽   |
|                       | B = Input port, A = Output Port | $EN = V_{CCA}$ (outputs enabled) | 1.03-3.0          | 0.9-2.0                  | 40   | pF   |
| C                     | A = Input port, B = Output Port | $C_{Load} = 0$ , $f = 1MHz$ ,    | 1.65-3.6          | 0.9-2.0                  | 1    | pF   |
| $C_{PD\_VCCA}$        | B = Input port, A = Output Port | EN = GND(outputs disabled)       | 1.03-3.0          | 0.9-2.0                  | 1    | pr.  |
| $C_{PD\ VCCB}$        | A = Input port, B = Output Port | $C_{Load} = 0$ , $f = 1MHz$ ,    | 1.65-3.6          | 0.9-2.0                  | 1    | ηE   |
|                       | B = Input port, A = Output Port | EN = GND(outputs disabled)       | 1.03-3.0          | 0.9-2.0                  | 1    | pF   |

#### Notes:

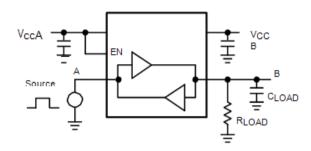
<sup>2.</sup>  $V_{CCB}$  is the supply voltage associated with the I/O B port, and  $V_{CCB}$  ranges from +1.65V to 3.6V under normal operating conditions.

<sup>3.</sup>  $V_{\text{CCA}}$  is the supply voltage associated with the I/O A port, and  $V_{\text{CCA}}$  range from +0.9 V to 2.0V under normal operating conditions.

<sup>4.</sup> Typical values are tested at  $T_A = +25$  °C. Limits over the operating temperature range are guaranteed by design.



### **Test Circuits**



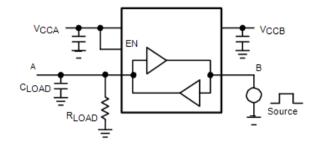


Figure 2. Driving A Test Circuit

Figure 3. Driving B Test Circuit

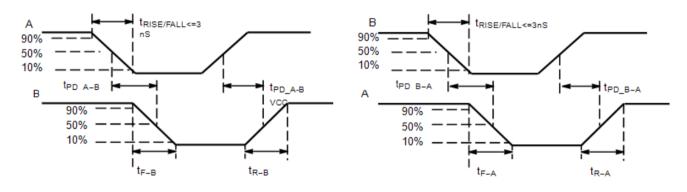
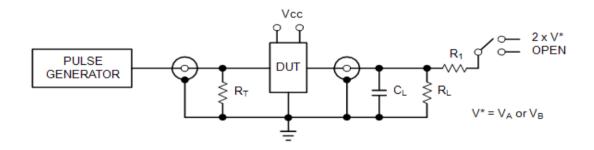


Figure 4. Definition of Timing Specification Parameters



| Test                                | Switch |
|-------------------------------------|--------|
| t <sub>PZH</sub> , t <sub>PHZ</sub> | Open   |
| t <sub>PZL</sub> , t <sub>PLZ</sub> | 2 x V* |

 $C_L$  = 15 pF or equivalent (Includes jig and probe capacitance)  $R_L$  =  $R_1$  = 50 k  $\Omega$  or equivalent  $R_T$  =  $Z_{OUT}$  of pulse generator (typically 50  $\Omega$ )  $V^*$  =  $V_A$  or  $V_B$  for A or B measurements, respectively.

Figure 5. Test Circuit for Enable/Disable Time Measurement







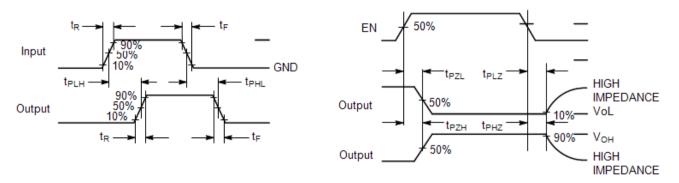


Figure 6. Timing Definitions for Propagation Delays and Enable/Disable Measurement

## **Functional Description**

The PI4ULS3V304AQ is a 4-bit configurable dual-supply autosensing bidirectional level translator that does not require a direction control pin. The B and A ports are designed to track two different power supply rails, VCCB and VCCA respectively. The PI4ULS3V304AQ offers the feature that the values of the VCCB and  $V_{CCA}$  supplies are independent. Design flexibility is maximized because VCCA can be set to a value either greater than or less than the VCCB supply.

The PI4ULS3V304AQ has high output current capability, which allows the translator to drive high capacitive loads such as most high frequency EMI filters. Another feature of the PI4ULS3V304AQ is that each An and Bn channel can function as either an input or an output.

An Output Enable (EN) input is available to reduce the power consumption. The EN pin can be used to disable both I/O ports by putting them in 3-state which significantly reduces the supply current.

## **Application Information**

#### **Level Translator Architecture**

The PI4ULS3V304AQ auto-sense translator provides bi-directional logic voltage level shifting to transfer data in multiple supply voltage systems. These level translators have two supply voltages,  $V_{CCA}$  and  $V_{CCB}$ , which set the logic levels on the input and output sides of the translator. When used to transfer data from the I/O  $V_{CCA}$  to the I/O  $V_{CCB}$  ports, input signals referenced to the  $V_{CCA}$  supply are translated to output signals with a logic level matched to VCCB. In a similar manner, the I/O  $V_{CCB}$  to I/O  $V_{CCA}$  translation shifts input signals with a logic level compatible to  $V_{CCB}$  to an output signal matched to  $V_{CCA}$ . The PI4ULS3V304AQ translator consists of bi-directional channels that independently determine the direction of the data flow without requiring a directional pin. One-shot circuits are used to detect the rising or falling input signals. In addition, the one-shots decrease the rise and fall times of the output signal for high-to-low and low-to-high transitions.

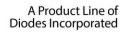
#### **Input Driver Requirements**

Auto-sense translators such as the PI4ULS3V304AQ have a wide bandwidth, but a relatively small DC output current rating. The high bandwidth of the bi-directional I/O circuit is used to quickly transform from an input to an output driver and vice versa. The I/O ports have a modest DC current output specification so that the output driver can be over driven when data is sent in the opposite direction. For proper operation, the input driver to the auto-sense translator should be capable of driving 3mA of peak output current. The bi-directional configuration of the translator results in both input stages being active for a very short time period. Although the peak current from the input signal circuit is relatively large, the average current is small and consistent with a standard CMOS input stage. Enable Input (EN) The PI4ULS3V304AQ translator has an Enable pin (EN) that provides tri–state operation at the I/O pins. Driving the Enable pin to a low logic level minimizes the power consumption of the device and drives the I/O  $V_{\rm CCB}$  and I/O  $V_{\rm CCB}$  pins to a high impedance state. Normal translation operation occurs when the EN pin is equal to a logic high signal. The EN pin is referenced to the  $V_{\rm CCB}$  supply and has Over-Voltage Tolerant (OVT) protection.

#### **Uni-Directional versus Bi-Directional Translation**

The PI4ULS3V304AQ translator can function as a non-inverting uni-directional translator. One advantage of using the translator as a uni-directional device is that each I/O pin can be configured as either an input or output. The configurable input or output







feature is especially useful in applications such as SPI that use multiple uni-directional I/O lines to send data to and from a device. The flexible I/O port of the auto sense translator simplifies the trace connections on the PCB.

### **Power Supply Guidelines**

The values of the  $V_{CCA}$  and  $V_{CCB}$  supplies can be set to anywhere in range 0.9-2.0V and 1.65-3.6V. Design flexibility is maximized because  $V_{CCA}$  may be either greater than or less than the  $V_{CCB}$  supply. In contrast, the majority of the competitive auto sense translators has a restriction that the value of the  $V_{CCA}$  supply must be equal to less than ( $V_{CCB}$  - 0.4) V. The sequencing of the power supplies will not damage the device during power-up operation. In addition, the I/O  $V_{CCB}$  and I/O  $V_{CCA}$  pins are in the high impedance state if either supply voltage is equal to 0V. For optimal performance, 0.01 to 0.1 $\mu$ F decoupling capacitors should be used on the  $V_{CCA}$  and  $V_{CCB}$  power supply pins. Ceramic capacitors are a good design choice to filter and bypass any noise signals on the voltage lines to the ground plane of the PCB. The noise immunity will be maximized by placing the capacitors as close as possible to the supply and ground pins, along with minimizing the PCB connection traces. The PI4ULS3V304AQ translators have a power down feature that provides design flexibility. The output ports are disabled when either power supply is off ( $V_{CCA}$  or  $V_{CCB}$  = 0V). This feature causes all of the I/O pins to be in the power saving high impedance state.

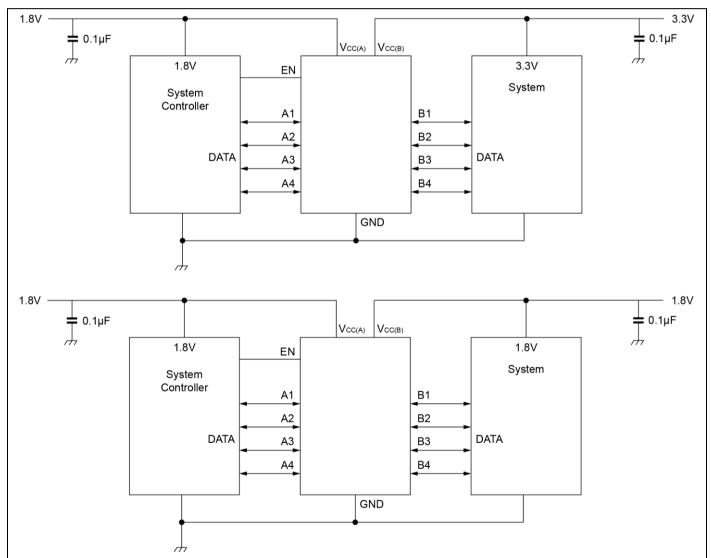


Figure 7. Typical Application





### **Part Marking**

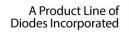
wZ YW

wZ: PI4ULS3V304AQ1ZMAE

Y: Date Code (Year)

W: Date Code (Workweek)

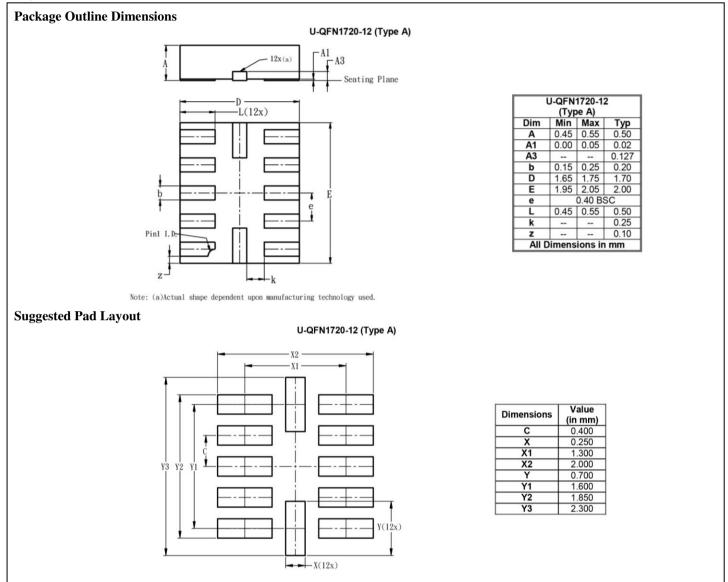






# **Packaging Mechanical**

UQFN-12 (ZMA)



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## **Ordering Information**

| Part Numbers        | Package Code | Description   |
|---------------------|--------------|---------------|
| PI4ULS3V304AQ1ZMAEX | ZMA          | 12-Pin (UQFN) |

#### Notes:

- 1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
- 2. See https://www.diodes.com/quality/lead-free/ for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
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- 7. X suffix = Tape/Reel





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