



## Features

- No Direction-Control
- Max Data Rates  
24Mbps (Push-Pull, 12MHz)  
1.2Mbps (Open-Drain, 0.6MHz)
- 1.1V to 5.5V on A ports and 1.1V to 5.5V on B Ports ( $V_{CCA} \leq V_{CCB}$ )
- VCC Isolation: If Either VCC is at GND, Both Ports are in the High-Impedance State
- No Power-Supply Sequencing Required: VCCA or VCCB can be Ramped First
- Ioff Supports Partial Power-Down-Mode Operation
- ESD protection exceeds 4000V HBM
- Extended Temperature: -40°C to +125°C

## Application

- I2C/SMBus, MDIO, SPI Interface
- Low-Voltage ASIC Level Translation
- Cell phone, Tablet, PC
- Server, Telecommunication

## Description

The RS7LSX104 is a 4-bit configurable dual supply bidirectional auto sensing translator that does not require a directional control pin. The A and B ports are designed to track two different power supply rails, VCCA and VCCB respectively.

A port supporting operating voltages from 1.1V to 5.5V while it tracks the VCCA supply, and the B ports supporting operating voltages from 1.1V to 5.5V while it tracks the VCCB supply. This allows the support of both lower and higher logic signal levels while providing bidirectional translation capabilities between any of the 1.2V, 1.8V, 2.5V, 3.3V and 5V voltage nodes

The translator has integrated pull-up resistors on the I/O lines. The integrated pull-up resistors are used to pull-up the I/O lines to either VCCA or VCCB. The RS7LSX104 is an excellent match for open-drain applications such as the I2C communication bus.

When the output-enable (EN) input is low, all outputs are placed in the high-impedance state. To ensure the high-impedance state during power up or power down, EN should be tied to GND through a pulldown resistor; the minimum value of the resistor is determined by the current-sourcing capability of the driver.

## Ordering Information

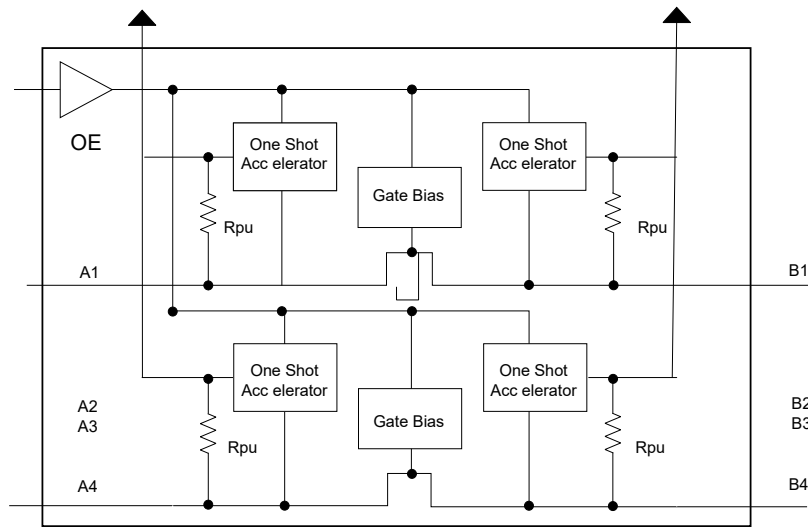
| Part Number | Package | Description |
|-------------|---------|-------------|
| RS7LSX104L  | TSSOP14 | 5 x 4.4 mm  |
| RS7LSX104ZM | UQFN-12 | 1.7x2.0 mm  |
| RS7LSX104ZB | TQFN-14 | 3.5x3.5 mm  |

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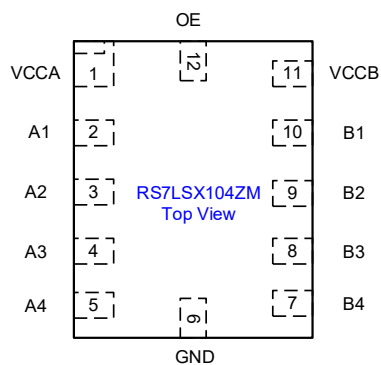
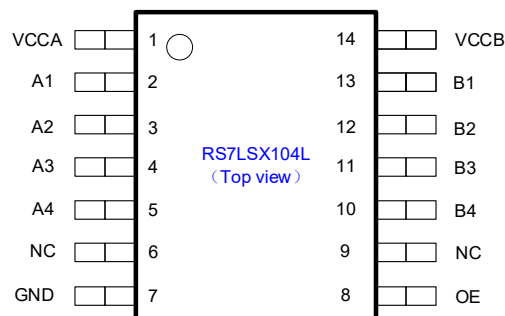
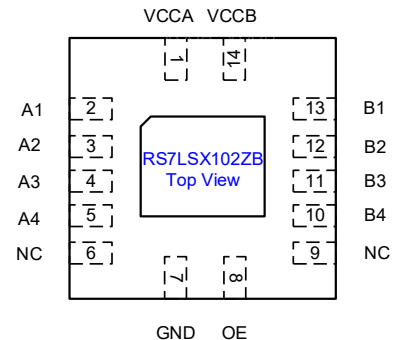
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**RS7LSX104**Bi-directional Level Translator for  
Open-drain and Push-Pull Applications

## Block Diagram

**Figure 1: Block Diagram**

## Pin Configuration

**UQFN-12 (Top view)****TSSOP14 (Top view)****TQFN-14 (Top view)**

| Pin Name | UQFN-12 | TSSOP-14 | TQFN-14 | Description                                                                        |
|----------|---------|----------|---------|------------------------------------------------------------------------------------|
| VCCA     | 1       | 1        | 1       | A-port supply voltage. $1.1V \leq VCCA \leq 5.5V$                                  |
| A1       | 2       | 2        | 2       | Input/output A. Referenced to VCCA.                                                |
| A2       | 3       | 3        | 3       | Input/output A. Referenced to VCCA                                                 |
| A3       | 4       | 4        | 4       | Input/output A. Referenced to VCCA                                                 |
| A4       | 5       | 5        | 5       | Input/output A. Referenced to VCCA                                                 |
| GND      | 6       | 7        | 7       | Ground.                                                                            |
| OE       | 12      | 8        | 8       | Output enables (active High).<br>Pull OE low to place all outputs in 3-state mode. |
| B4       | 7       | 10       | 10      | Input/output B. Referenced to VCCB                                                 |
| B3       | 8       | 11       | 11      | Input/output B. Referenced to VCCB                                                 |
| B2       | 9       | 12       | 12      | Input/output B. Referenced to VCCB                                                 |
| B1       | 10      | 13       | 13      | Input/output B. Referenced to VCCB                                                 |
| VCCB     | 11      | 14       | 14      | B-port supply voltage. $1.1V \leq VCCB \leq 5.5V$                                  |
| NC       | /       | 6,9      | 6,9     | Not Connect                                                                        |



## Absolute Maximum Ratings

| Symbol | Parameter                                  | MIN  | TYP | MAX  | Unit |
|--------|--------------------------------------------|------|-----|------|------|
| Tstore | Storage Temperature                        | -65  | -   | +150 | °C   |
| VCCA   | DC Supply Voltage port B                   | -0.3 | -   | 6.5  | V    |
| VCCB   | DC Supply Voltage port A                   | -0.3 | -   | 6.5  | V    |
| VIOB   | Vi(A) referenced DC Input / Output Voltage | -0.3 | -   | 6.5  | V    |
| VIOB   | Vi(B) referenced DC Input / Output Voltage | -0.3 | -   | 6.5  | V    |
| VOE    | Enable Control Pin DC Input Voltage        | -0.3 | -   | 6.5  | V    |
| Ishort | Short circuit duration (I/O to GND)        |      |     | 50   | mA   |

**Notes:**

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 |
|-----------------------|------------------------------------|-----|-----|------|------|
| VCCA                  | VCCA Positive DC Supply Voltage    | 1.1 | -   | 5.5  | V    |
| VCCB                  | VCCB Positive DC Supply Voltage    | 1.1 | -   | 5.5  | V    |
| VOE                   | Enable Control Pin Voltage         | GND | -   | 5.5  | V    |
| VIO                   | I/O Pin Voltage                    | GND | -   | 5.5  | V    |
| $\Delta t / \Delta V$ | Input transition rise or fall time | -   | -   | 10   | ns/V |
| TA                    | Operating Temperature Range        | -40 | -   | +125 | °C   |

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**RS7LSX104**Bi-directional Level Translator for  
Open-drain and Push-Pull Applications**DC Electrical Characteristics**Unless otherwise specified,  $-40^{\circ}\text{C} \leq T_A \leq 125^{\circ}\text{C}$ ,  $1.1\text{V} \leq V_{CCA} \leq 5.5\text{V}$ ,  $1.1\text{V} \leq V_{CCB} \leq 5.5\text{V}$ 

| Symbol          | Parameter                                 | Test Conditions* <sup>1</sup>                                               |                                                                                  | MIN              | TYP | MAX              | Unit          |
|-----------------|-------------------------------------------|-----------------------------------------------------------------------------|----------------------------------------------------------------------------------|------------------|-----|------------------|---------------|
| VIHA            | A port Input HIGH Voltage                 | $1.1\text{V} \leq V_{CCA} \leq 1.95$                                        |                                                                                  | $V_{CCA} - 0.2$  |     |                  | V             |
|                 |                                           | $1.95 < V_{CCA} \leq 5.5\text{V}$                                           |                                                                                  | $V_{CCA} - 0.4$  |     |                  | V             |
| VILA            | A port Input LOW Voltage                  | $1.1\text{V} \leq V_{CCA} \leq 5.5\text{V}$                                 |                                                                                  | -                | -   | 0.15             | V             |
| VIHB            | B port Input HIGH Voltage                 | $1.1\text{V} \leq V_{CCA} \leq 1.95$                                        |                                                                                  | $V_{CCA} - 0.2$  | -   | -                | V             |
|                 |                                           | $1.95 < V_{CCA} \leq 5.5\text{V}$                                           |                                                                                  | $V_{CCA} - 0.4$  |     |                  |               |
| VILB            | B port Input LOW Voltage                  | $1.1\text{V} \leq V_{CCA} \leq 5.5\text{V}$                                 |                                                                                  | -                | -   | 0.15             | V             |
| VIH(EN)         | Control Pin Input HIGH Voltage            | $1.1\text{V} \leq V_{CCA} \leq 5.5\text{V}$                                 |                                                                                  | $0.65 * V_{CCA}$ | -   | -                | V             |
| VIL(EN)         | Control Pin Input LOW Voltage             | $1.95\text{V} \leq V_{CCA} \leq 5.5\text{V}$                                |                                                                                  | -                | -   | $0.35 * V_{CCA}$ | V             |
|                 |                                           | $1.1\text{V} \leq V_{CCA} < 1.95\text{V}$                                   |                                                                                  |                  |     | 0.15             |               |
| VOHA            | A port Output HIGH Voltage                | $\text{IOH} = -20 \mu\text{A}$ $1.1\text{V} \leq V_{CCA} \leq 5.5\text{V}$  |                                                                                  | $0.67 * V_{CCA}$ | -   | -                | V             |
| VOLA            | A port Output LOW Voltage                 | $\text{IOH} = 180 \mu\text{A}$ $1.1\text{V} \leq V_{CCA} \leq 1.65\text{V}$ |                                                                                  | -                | -   | 0.55             | V             |
|                 |                                           | $\text{IOH} = 220 \mu\text{A}$ $1.65\text{V} \leq V_{CCA} \leq 2.3\text{V}$ |                                                                                  |                  |     |                  |               |
|                 |                                           | $\text{IOH} = 300 \mu\text{A}$ $2.3\text{V} \leq V_{CCA} \leq 3\text{V}$    |                                                                                  |                  |     |                  |               |
|                 |                                           | $\text{IOH} = 400 \mu\text{A}$ $3\text{V} \leq V_{CCA} \leq 4.5\text{V}$    |                                                                                  |                  |     |                  |               |
|                 |                                           | $\text{IOH} = 620 \mu\text{A}$ $4.5\text{V} \leq V_{CCA} \leq 5.5\text{V}$  |                                                                                  |                  |     |                  |               |
| VOHB            | B port Output HIGH Voltage                | $\text{IOH} = -20 \mu\text{A}$ $1.1\text{V} \leq V_{CCB} \leq 5.5\text{V}$  |                                                                                  | $0.67 * V_{CCB}$ | -   | -                | V             |
| VOLB            | B port Output LOW Voltage                 | $\text{IOH} = 180 \mu\text{A}$ $1.1\text{V} \leq V_{CCB} \leq 1.65\text{V}$ |                                                                                  | -                | -   | 0.55             | V             |
|                 |                                           | $\text{IOH} = 220 \mu\text{A}$ $1.65\text{V} \leq V_{CCB} \leq 2.3\text{V}$ |                                                                                  |                  |     |                  |               |
|                 |                                           | $\text{IOH} = 300 \mu\text{A}$ $2.3\text{V} \leq V_{CCB} \leq 3\text{V}$    |                                                                                  |                  |     |                  |               |
|                 |                                           | $\text{IOH} = 400 \mu\text{A}$ $3\text{V} \leq V_{CCB} \leq 4.5\text{V}$    |                                                                                  |                  |     |                  |               |
|                 |                                           | $\text{IOH} = 620 \mu\text{A}$ $4.5\text{V} \leq V_{CCB} \leq 5.5\text{V}$  |                                                                                  |                  |     |                  |               |
| ICCA            | VCCA Supply Current                       | EN=High                                                                     | $V_{CCA}=1.1\text{V to } 5.5\text{V}$ ,<br>$V_{CCB}=1.1\text{V to } 5.5\text{V}$ | -                |     | 6                | $\mu\text{A}$ |
|                 |                                           |                                                                             | $V_{CCA}= 5.5\text{V}$ , $V_{CCB}= 0\text{V}$                                    | -                | -   | 6                | $\mu\text{A}$ |
|                 |                                           |                                                                             | $V_{CCA}= 0\text{V}$ , $V_{CCB}=5.5\text{V}$                                     | -                |     | -2               | $\mu\text{A}$ |
| ICCB            | VCCB Supply Current                       | EN=High                                                                     | $V_{CCA}=1.1\text{V to } 5.5\text{V}$ ,<br>$V_{CCB}=1.1\text{V to } 5.5\text{V}$ | -                |     | 6                | $\mu\text{A}$ |
|                 |                                           |                                                                             | $V_{CCA}= 5.5\text{V}$ , $V_{CCB}= 0\text{V}$                                    | -                |     | -2               | $\mu\text{A}$ |
|                 |                                           |                                                                             | $V_{CCA}= 0\text{V}$ , $V_{CCB}=5.5\text{V}$                                     | -                |     | 6                | $\mu\text{A}$ |
| ICCA+ICCB       | Combined supply current                   | EN=High                                                                     | $V_{CCA}=1.1\text{V to } 5.5\text{V}$ ,<br>$V_{CCB}=1.1\text{V to } 5.5\text{V}$ |                  |     | 12               | $\mu\text{A}$ |
| ICCZA           | Static supply current VCCA                | EN=Low                                                                      | $V_{CCA}=1.1\text{V to } 5.5\text{V}$ ,<br>$V_{CCB}=1.1\text{V to } 5.5\text{V}$ |                  |     | 6                | $\mu\text{A}$ |
| ICCZB           | Static supply current VCCB                |                                                                             |                                                                                  |                  |     | 6                | $\mu\text{A}$ |
| I <sub>OZ</sub> | I/O Tri-state Output Mode Leakage Current | A or B port<br>EN=Low                                                       | $V_{CCA}=1.1\text{V to } 5.5\text{V}$ ,<br>$V_{CCB}=1.1\text{V to } 5.5\text{V}$ |                  |     | $\pm 2$          | $\mu\text{A}$ |
| IOFF            | Partial power down current                | A port                                                                      | $V_{CCA}=0\text{V}$ ,<br>$V_{CCB}=0\text{V to } 5.5\text{V}$                     |                  |     | $\pm 5$          | $\mu\text{A}$ |
|                 |                                           | B port                                                                      | $V_{CCA}=0\text{V to } 5.5\text{V}$<br>$V_{CCB}=0\text{V}$                       |                  |     | $\pm 5$          | $\mu\text{A}$ |
| II-EN           | Control pin leakage Current               | $V_I = V_{CCI} \text{ or } \text{GND}$                                      |                                                                                  | -                | -   | $\pm 2$          | $\mu\text{A}$ |

**Note:**

- All units are production tested at  $T_A = +25^{\circ}\text{C}$ . Limits over the operating temperature range are guaranteed by design. Typical values are for  $V_{CCB} = +5\text{V}$ ,  $V_{CCA} = +3.3\text{V}$  and  $T_A = +25^{\circ}\text{C}$ .

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**RS7LSX104**Bi-directional Level Translator for  
Open-drain and Push-Pull Applications**AC Electrical characteristics**

Timing Characteristics

(C<sub>LOAD</sub> = 15pF, driver output impedance ≤ 50Ω, R<sub>LOAD</sub> = 1 MΩ, T<sub>A</sub> = -40°C to 125°C)**V<sub>CCA</sub> = 1.2V±0.1V**

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

| Symbol  | Parameter                  | Test Conditions | VCCB = 2.5V |     | VCCB = 3.3V |     | Unit |
|---------|----------------------------|-----------------|-------------|-----|-------------|-----|------|
|         |                            |                 | MIN         | MAX | MIN         | MAX |      |
| tPHL_AB | Propagation Delay<br>A → B | Push-pull       |             | 10  |             | 10  | ns   |
|         |                            | Open-drain      |             | 30  |             | 30  | ns   |
| tPLH_AB | Propagation Delay<br>A → B | Push-pull       |             | 15  |             | 15  | ns   |
|         |                            | Open-drain      |             | 130 |             | 110 | ns   |
| tPHL_BA | Propagation Delay<br>B → A | Push-pull       |             | 10  |             | 10  | ns   |
|         |                            | Open-drain      |             | 140 |             | 130 | ns   |
| tPLH_BA | Propagation Delay<br>B → A | Push-pull       |             | 15  |             | 15  | ns   |
|         |                            | Open-drain      |             | 50  |             | 50  | ns   |
| tEN     | Enable Time                | EN to A or B    |             | 200 |             | 200 | ns   |
| tDIS    | Disable Time               | EN to A or B    |             | 200 |             | 200 | ns   |
| tRA     | A port Rise Time           | Push-pull       |             | 30  |             | 30  | ns   |
|         |                            | Open-drain      |             | 800 |             | 600 | ns   |
| tRB     | B port Rise Time           | Push-pull       |             | 30  |             | 30  | ns   |
|         |                            | Open-drain      |             | 800 |             | 600 | ns   |
| tFA     | A port Fall Time           | Push-pull       |             | 20  |             | 25  | ns   |
|         |                            | Open-drain      |             | 30  |             | 30  | ns   |
| tFB     | B port Fall Time           | Push-pull       |             | 20  |             | 25  | ns   |
|         |                            | Open-drain      |             | 30  |             | 30  | ns   |
| tSKEW   | Channel to Channel Skew    |                 |             | 1   |             | 1   | 1    |
| MDR     | Maximum Data Rate          | Push-pull       |             | 24  |             | 24  | Mbps |
|         |                            | Open-drain      |             | 0.8 |             | 0.8 | Mbps |

\* Conversion from 1.2V to 1.8V or 5V is not advised.

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**RS7LSX104**Bi-directional Level Translator for  
Open-drain and Push-Pull Applications**V<sub>CCA</sub> = 1.8V±0.15V**

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

| Symbol  | Parameter               | Test Conditions | VCCB= 2.5V |     | VCCB = 3.3V |     | VCCB= 5V |     | Unit |
|---------|-------------------------|-----------------|------------|-----|-------------|-----|----------|-----|------|
|         |                         |                 | MIN        | MAX | MIN         | MAX | MIN      | MAX |      |
| tPHL_AB | Propagation Delay A → B | Push-pull       |            | 10  |             | 9   |          | 9   | ns   |
|         |                         | Open-drain      |            | 30  |             | 30  |          | 30  | ns   |
| tPLH_AB | Propagation Delay A → B | Push-pull       |            | 12  |             | 11  |          | 11  | ns   |
|         |                         | Open-drain      |            | 100 |             | 100 |          | 100 | ns   |
| tPHL_BA | Propagation Delay B → A | Push-pull       |            | 9   |             | 9   |          | 9   | ns   |
|         |                         | Open-drain      |            | 30  |             | 30  |          | 30  | ns   |
| tPLH_BA | Propagation Delay B → A | Push-pull       |            | 14  |             | 12  |          | 12  | ns   |
|         |                         | Open-drain      |            | 100 |             | 100 |          | 100 | ns   |
| tEN     | Enable Time             | EN to A or B    |            | 200 |             | 200 |          | 200 | ns   |
| tDIS    | Disable Time            | EN to A or B    |            | 300 |             | 300 |          | 300 | ns   |
| tRA     | A port Rise Time        | Push-pull       |            | 30  |             | 30  |          | 30  | ns   |
|         |                         | Open-drain      |            | 900 |             | 750 |          | 600 | ns   |
| tRB     | B port Rise Time        | Push-pull       |            | 30  |             | 30  |          | 30  | ns   |
|         |                         | Open-drain      |            | 900 |             | 750 |          | 600 | ns   |
| tFA     | A port Fall Time        | Push-pull       |            | 20  |             | 25  |          | 25  | ns   |
|         |                         | Open-drain      |            | 30  |             | 30  |          | 30  | ns   |
| tFB     | B port Fall Time        | Push-pull       |            | 25  |             | 30  |          | 30  | ns   |
|         |                         | Open-drain      |            | 30  |             | 30  |          | 30  | ns   |
| tSKEW   | Channel to Channel Skew |                 |            | 1   |             | 1   |          | 1   | ns   |
| MDR     | Maximum Data Rate       | Push-pull       |            | 24  |             | 24  |          | 24  | Mbps |
|         |                         | Open-drain      |            | 0.8 |             | 0.8 |          | 1   | Mbps |

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**RS7LSX104**Bi-directional Level Translator for  
Open-drain and Push-Pull Applications **$V_{CCA} = 2.5V \pm 0.2V$** 

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

| Symbol  | Parameter               | Test Conditions | VCCB= 2.5V |      | VCCB = 3.3V |     | VCCB= 5V |     | Unit |
|---------|-------------------------|-----------------|------------|------|-------------|-----|----------|-----|------|
|         |                         |                 | MIN        | MAX  | MIN         | MAX | MIN      | MAX |      |
| tPHL_AB | Propagation Delay A → B | Push-pull       |            | 10   |             | 9   |          | 9   | ns   |
|         |                         | Open-drain      |            | 30   |             | 30  |          | 30  | ns   |
| tPLH_AB | Propagation Delay A → B | Push-pull       |            | 12   |             | 10  |          | 10  | ns   |
|         |                         | Open-drain      |            | 70   |             | 70  |          | 70  | ns   |
| tPHL_BA | Propagation Delay B → A | Push-pull       |            | 9    |             | 9   |          | 9   | ns   |
|         |                         | Open-drain      |            | 30   |             | 30  |          | 30  | ns   |
| tPLH_BA | Propagation Delay B → A | Push-pull       |            | 14   |             | 12  |          | 12  | ns   |
|         |                         | Open-drain      |            | 70   |             | 70  |          | 70  | ns   |
| tEN     | Enable Time             | EN to A or B    |            | 200  |             | 200 |          | 200 | ns   |
| tDIS    | Disable Time            | EN to A or B    |            | 300  |             | 300 |          | 300 | ns   |
| tRA     | A port Rise Time        | Push-pull       |            | 30   |             | 30  |          | 30  | ns   |
|         |                         | Open-drain      |            | 1000 |             | 850 |          | 600 | ns   |
| tRB     | B port Rise Time        | Push-pull       |            | 30   |             | 30  |          | 30  | ns   |
|         |                         | Open-drain      |            | 1000 |             | 850 |          | 600 | ns   |
| tFA     | A port Fall Time        | Push-pull       |            | 20   |             | 30  |          | 30  | ns   |
|         |                         | Open-drain      |            | 30   |             | 30  |          | 30  | ns   |
| tFB     | B port Fall Time        | Push-pull       |            | 25   |             | 25  |          | 25  | ns   |
|         |                         | Open-drain      |            | 30   |             | 30  |          | 30  | ns   |
| tSKEW   | Channel to Channel Skew |                 |            | 1    |             | 1   |          | 1   | ns   |
| MDR     | Maximum Data Rate       | Push-pull       |            | 24   |             | 24  |          | 24  | Mbps |
|         |                         | Open-drain      |            | 0.8  |             | 0.8 |          | 1   | Mbps |

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**RS7LSX104**Bi-directional Level Translator for  
Open-drain and Push-Pull Applications **$V_{CCA} = 3.3V \pm 0.3V$** 

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

| Symbol  | Parameter               | Test Conditions | VCCB = 3.3V |     | VCCB= 5V |     | Unit |
|---------|-------------------------|-----------------|-------------|-----|----------|-----|------|
|         |                         |                 | MIN         | MAX | MIN      | MAX |      |
| tPHL_AB | Propagation Delay A → B | Push-pull       |             | 9   |          | 9   | ns   |
|         |                         | Open-drain      |             | 30  |          | 30  | ns   |
| tPLH_AB | Propagation Delay A → B | Push-pull       |             | 12  |          | 12  | ns   |
|         |                         | Open-drain      |             | 50  |          | 30  | ns   |
| tPHL_BA | Propagation Delay B → A | Push-pull       |             | 9   |          | 9   | ns   |
|         |                         | Open-drain      |             | 30  |          | 30  | ns   |
| tPLH_BA | Propagation Delay B → A | Push-pull       |             | 11  |          | 10  | ns   |
|         |                         | Open-drain      |             | 50  |          | 50  | ns   |
| tEN     | Enable Time             | EN to A or B    |             | 200 |          | 200 | ns   |
| tDIS    | Disable Time            | EN to A or B    |             | 300 |          | 300 | ns   |
| tRA     | A port Rise Time        | Push-pull       |             | 30  |          | 30  | ns   |
|         |                         | Open-drain      |             | 120 |          | 120 | ns   |
| tRB     | B port Rise Time        | Push-pull       |             | 30  |          | 30  | ns   |
|         |                         | Open-drain      |             | 900 |          | 700 | ns   |
| tFA     | A port Fall Time        | Push-pull       |             | 25  |          | 25  | ns   |
|         |                         | Open-drain      |             | 900 |          | 700 | ns   |
| tFB     | B port Fall Time        | Push-pull       |             | 25  |          | 25  | ns   |
|         |                         | Open-drain      |             | 30  |          | 30  | ns   |
| tSKEW   | Channel to Channel Skew |                 |             | 1   |          | 1   | ns   |
| MDR     | Maximum Data Rate       | Push-pull       |             | 24  |          | 24  | Mbps |
|         |                         | Open-drain      |             | 0.8 |          | 1.2 | Mbps |





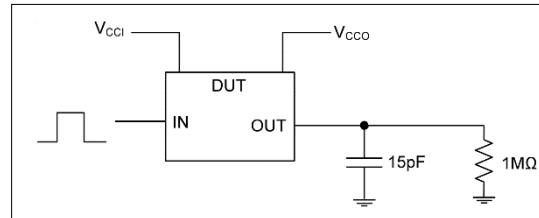
**$V_{CCA} = 5V \pm 0.5V$**

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

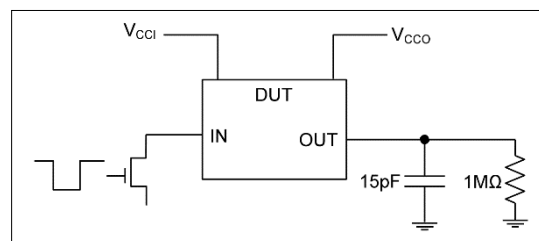
| Symbol  | Parameter               | Test Conditions | VCCB= 5V |     | Unit |
|---------|-------------------------|-----------------|----------|-----|------|
|         |                         |                 | MIN      | MAX |      |
| tPHL_AB | Propagation Delay A → B | Push-pull       |          | 9   | ns   |
|         |                         | Open-drain      |          | 30  | ns   |
| tPLH_AB | Propagation Delay A → B | Push-pull       |          | 12  | ns   |
|         |                         | Open-drain      |          | 30  | ns   |
| tPHL_BA | Propagation Delay B → A | Push-pull       |          | 9   | ns   |
|         |                         | Open-drain      |          | 30  | ns   |
| tPLH_BA | Propagation Delay B → A | Push-pull       |          | 10  | ns   |
|         |                         | Open-drain      |          | 50  | ns   |
| tEN     | Enable Time             | EN to A or B    |          | 200 | ns   |
| tDIS    | Disable Time            | EN to A or B    |          | 300 | ns   |
| tRA     | A port Rise Time        | Push-pull       |          | 30  | ns   |
|         |                         | Open-drain      |          | 750 | ns   |
| tRB     | B port Rise Time        | Push-pull       |          | 30  | ns   |
|         |                         | Open-drain      |          | 750 | ns   |
| tFA     | A port Fall Time        | Push-pull       |          | 25  | ns   |
|         |                         | Open-drain      |          | 30  | ns   |
| tFB     | B port Fall Time        | Push-pull       |          | 25  | ns   |
|         |                         | Open-drain      |          | 30  | ns   |
| tSKEW   | Channel to Channel Skew |                 |          | 1   | ns   |
| MDR     | Maximum Data Rate       | Push-pull       |          | 24  | Mbps |
|         |                         | Open-drain      |          | 1.2 | Mbps |



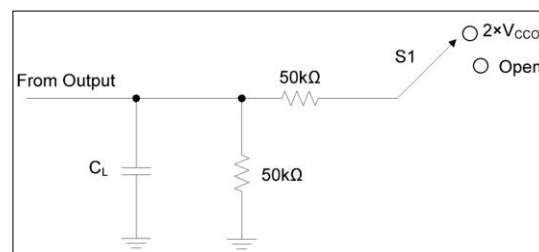
## Test Circuits



**Figure 2 Data Rate, Pulse Duration, Propagation Delay, Output Rise-Time and Fall-Time Measurement  
Using a Push-Pull Driver**



**Figure 3 Data Rate, Pulse Duration, Propagation Delay, Output Rise-Time and Fall-Time Measurement  
Using an Open-Drain Driver**



| TEST                                | S1                 |
|-------------------------------------|--------------------|
| $t_{PZL}, t_{PLZ}$<br>( $t_{dis}$ ) | $2 \times V_{CCO}$ |
| $t_{PHZ}, t_{PZH}$<br>( $t_{en}$ )  | Open               |

**Figure 4 Load Circuit for Enable-Time and Disable-Time Measurement**

### Notes:

1.  $C_L$  includes probe and jig capacitance.
2.  $t_{en}$  is the same as  $t_{PZL}$  and  $t_{PZH}$ .  $t_{dis}$  is the same as  $t_{PLZ}$  and  $t_{PHZ}$ .
3.  $V_{CCI}$  is the supply voltage associated with the input.
4.  $V_{CCO}$  is the supply voltage associated with the output.



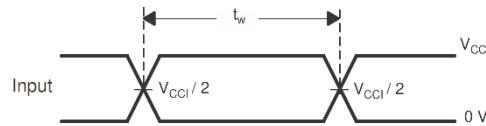
## Voltage Waveforms

The outputs are measured one at a time, with one transition per measurement. All input pulses are supplied by generators that have the following characteristics:

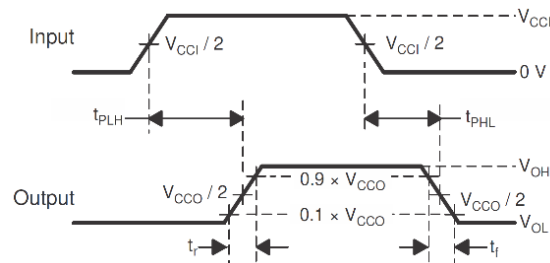
PRR  $\leq 10$  MHz

$Z_O = 50 \Omega$

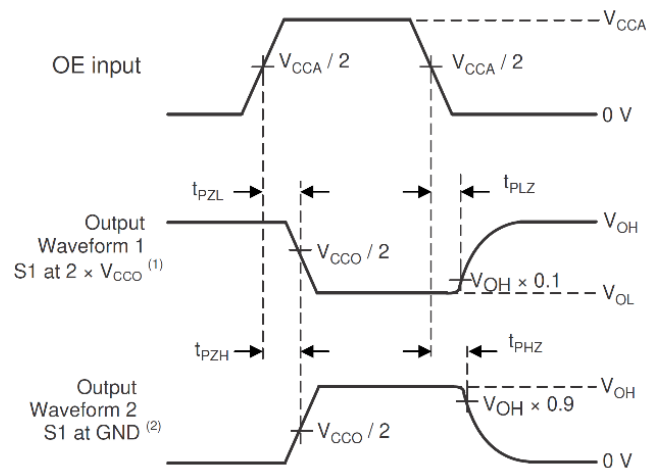
$dv/dt \geq 1$  V/ns



**Figure 5 Pulse Duration**



**Figure 6 Propagation Delay Times**



**Figure 7 Enable and Disable Times**

1. Waveform 1 is for an output with internal such that the output is high, except when OE is high.
2. Waveform 2 is for an output with conditions such that the output is low, except when OE is high.



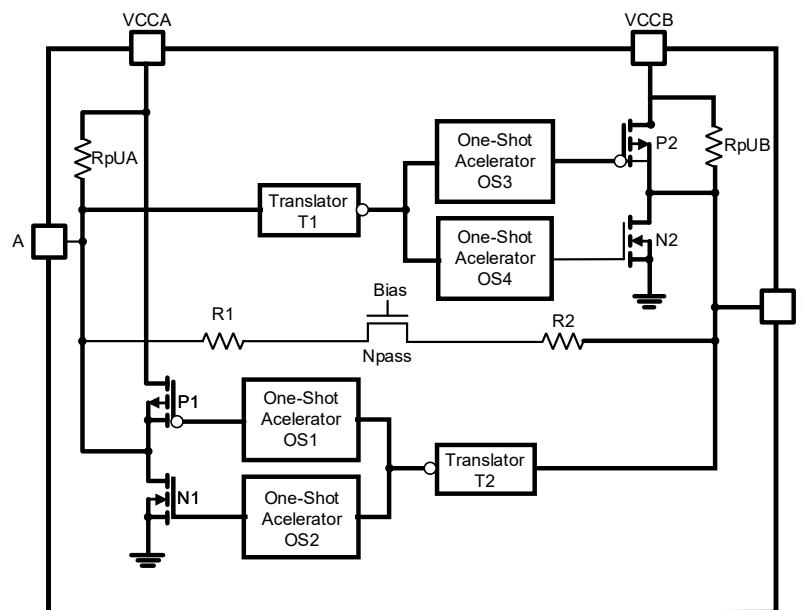
## Functional Description

The RS7LSX104 device is a directionless voltage-level translator specifically designed for translating logic voltage levels. The A-port accepts I/O voltages ranging from 1.1 V to 5.5 V. The B-port accepts I/O voltages from 1.1 V to 5.5 V. The device uses pass gate architecture with edge rate accelerators (one shots) to improve the overall data rate. The pull-up resistors, commonly used in open-drain applications, have been conveniently integrated so that an external resistor is not needed. While this device is designed for open-drain applications, the device can also translate push-pull CMOS logic outputs.

Each A-port I/O has a pull-up resistor (RPUA) to VCCA and each B-port I/O has a pull-up resistor (RPUB) to VCCB. RPUA and RPUB have a value of 40 k $\Omega$  when the output is driving low. RPUA and RPUB have a value of 4 k $\Omega$  when the output is driving high. RPUA and RPUB are disabled when OE = Low.

## Architecture

Figure 8 describes semi-buffered architecture design this application requires for both push-pull and open-drain mode. This application uses edge-rate accelerator circuitry (for both the high-to-low and low-to-high edges), a high-on-resistance N-channel pass-gate transistor (on the order of 300  $\Omega$  to 500  $\Omega$ ) and pull-up resistors (to provide DC-bias and drive capabilities) to meet these requirements. This design needs no direction-control signal (to control the direction of data flow from A to B or from B to A). The resulting implementation supports both low-speed open-drain operation as well as high-speed push-pull operation.



**Figure 8 Level Shifter Architecture**

When transmitting data from A-ports to B-ports, during a rising edge the one-shot circuit (OS3) turns on the PMOS transistor (P2) for a short-duration which reduces the low-to-high transition time. Similarly, during a falling edge, when transmitting data from A to B, the one-shot circuit (OS4) turns on the N-channel MOSFET transistor (N2) for a short-duration which speeds up the high-to-low transition. The B-port edge-rate accelerator consists of one-shot circuits OS3 and OS4. Transistors P2 and N2 and serves to rapidly force the B port high or low when a corresponding transition is detected on the A port.



When transmitting data from B- to A-ports, during a rising edge the one-shot circuit (OS1) turns on the PMOS transistor (P1) for a short-duration which reduces the low-to-high transition time. Similarly, during a falling edge, when transmitting data from B to A, the one-shot circuit (OS2) turns on NMOS transistor (N1) for a short-duration and these speeds up the high-to-low transition. The A-port edge-rate accelerator consists of one-shots OS1 and OS2, transistors P1 and N1 components and form the edge-rate accelerator and serves to rapidly force the A port high or low when a corresponding transition is detected on the B port.

### Input Driver Requirements

The continuous DC-current sinking capability is determined by the external system-level open-drain (or push- pull) drivers that are interfaced to the RS7LSX104 I/O pins. Because the high bandwidth of these bidirectional I/O circuits is used to facilitate this fast change from an input to an output and an output to an input, they have a modest DC-current sourcing capability of hundreds of micro-amperes, as determined by the internal pull-up resistors.

The fall time ( $t_{fA}$ ,  $t_{fB}$ ) of a signal depends on the edge-rate and output impedance of the external device driving RS7LSX104 data I/Os, as well as the capacitive loading on the data lines.

Similarly, the  $t_{PHL}$  and maximum data rates also depend on the output impedance of the external driver. The values for  $t_{fA}$ ,  $t_{fB}$ ,  $t_{PHL}$ , and maximum data rates in the data sheet assume that the output impedance of the external driver is less than 50  $\Omega$ .

### Output Load Considerations

Raystar recommends careful PCB layout practices with short PCB trace lengths to avoid excessive capacitive loading and to ensure that proper one-shot triggering takes place. PCB signal trace-lengths should be kept short enough such that the round-trip delay of any reflection is less than the one-shot duration. This improves signal integrity by ensuring that any reflection sees a low impedance at the driver. The one-shot circuits have been designed to stay on for approximately 15 ns. The maximum capacitance of the lumped load that can be driven also depends directly on the one-shot duration. With very heavy capacitive loads, the one-shot can time-out before the signal is driven fully to the positive rail. The one-shot duration has been set to best optimize trade-offs between dynamic ICC, load driving capability, and maximum bit-rate considerations. Both PCB trace length and connectors add to the capacitance of the RS7LSX104 output. Therefore, Raystar recommends that this lumped-load capacitance is considered in order to avoid one-shot retriggering, bus contention, output signal oscillations, or other adverse system-level affects.

### Enable and Disable

The RS7LSX104 has an OE pin input that is used to disable the device by setting the OE pin low, which places all I/Os in the Hi-Z state. The disable time ( $t_{dis}$ ) indicates the delay between the time when the OE pin goes low and when the outputs actually get disabled (Hi-Z). The enable time ( $t_{en}$ ) indicates the amount of time the design must allow for the one-shot circuitry to become operational after the OE pin goes high.

### Pull-up or Pull-down Resistors on I/O Lines

The RS7LSX104 has the smart pull-up resistors dynamically change value based on whether a low or a high is being passed through the I/O line. Each A-port I/O has a pull-up resistor (RPUA) to VCCA and each B-port I/O has a pull-up resistor (RPUB) to VCCB. RPUA and RPUB have a value of 40 k $\Omega$  when the output is driving low. RPUA and RPUB have a value of 4 k $\Omega$  when the output is driving high. RPUA and RPUB are disabled when OE = Low. This feature provides lower static power consumption (when the I/Os are passing a low), and supports lower VOL values for the same size pass-gate transistor, and helps improve simultaneous switching performance.



## Device Functional Modes

The RS7LSX104 device has two functional modes, enabled and disabled. To disable the device set the OE pin input low, which places all I/Os in a high impedance state. Setting the OE pin input high enables the device.

## Application Information

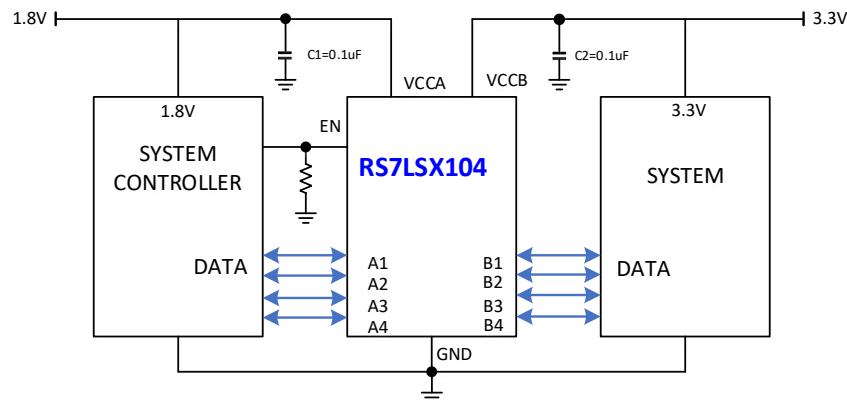


Figure 10 Application Circuit

## Design Requirements

To begin the design process, determine the following:

Use the supply voltage of the device that is driving the RS7LSX104 device to determine the input and output voltage range. For a valid logic high the value must exceed the  $V_{IH}$  of the input port. For a valid logic low the value must be less than the  $V_{IL}$  of the input port.

The RS7LSX104 device has smart internal pull-up resistors. The max data rate under open-drain mode is 1.2Mbps. If a higher data rate is required, 10 k $\Omega$  pull-up resistors can be added on external I/Os.

External pull-up resistors can be added to reduce the total RC of a signal trace if necessary. An external pull-down resistor decreases the output  $V_{OH}$  and  $V_{OL}$ . Use Equation 1 to calculate the  $V_{OH}$  as a result of an external pull-down resistor.

$$V_{OH} = V_{CCX} \times R_{PD} / (R_{PD} + 4 \text{ k}\Omega)$$

## Power Supply Recommendations

During operation, ensure that  $V_{CCA} \leq V_{CCB}$  at all times. The sequencing of each power supply will not damage the device during the power up operation, so either power supply can be ramped up first. The output-enable (OE) input circuit is designed so that it is supplied by  $V_{CCA}$  and when the (OE) input is low, all outputs are placed in the high-impedance state. To ensure the high-impedance state of the outputs during power up or power down, the OE input pin must be tied to GND through a pull-down resistor and must not be enabled until  $V_{CCA}$  and  $V_{CCB}$  are fully ramped and stable. The minimum value of the pull-down resistor to ground is determined by the current-sourcing capability of the driver.

**Layout Guidelines**

To ensure reliability of the device, following common printed-circuit board layout guidelines is recommended.

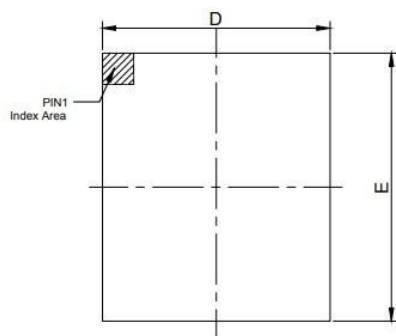
Bypass capacitors should be used on power supplies. Place the capacitors as close as possible to the VCCA, VCCB pin and GND pin.

Short trace lengths should be used to avoid excessive loading.

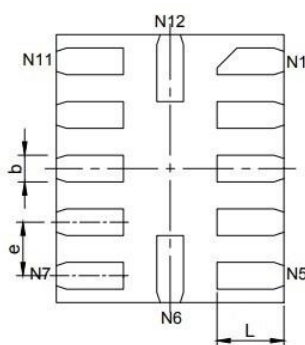
PCB signal trace-lengths must be kept short enough so that the round-trip delay of any reflection is less than the one-shot duration, approximately 15 ns, ensuring that any reflection encounters low impedance at the source driver.

**RSM**

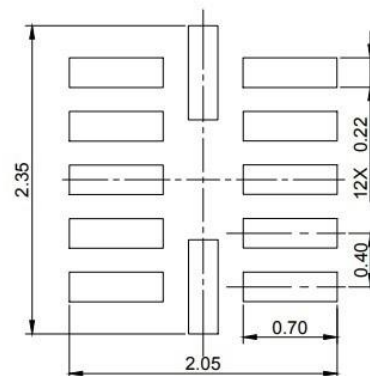
www.raystar-tek.com

**RS7LSX104**Bi-directional Level Translator for  
Open-drain and Push-Pull Applications**Package Information****UQFN 1.7x2.0-12L**

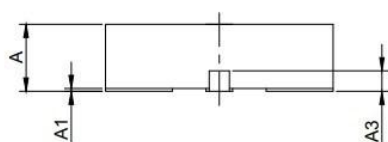
TOP VIEW



BOTTOM VIEW



RECOMMENDED LAND PATTERN



SIDE VIEW

| PKG. DIMENSIONS(MM) |          |      |
|---------------------|----------|------|
| SYMBOL              | Min      | Max  |
| A                   | 0.45     | 0.55 |
| A1                  | 0.00     | 0.05 |
| A3                  | 0.15 REF |      |
| D                   | 1.65     | 1.75 |
| E                   | 1.95     | 2.05 |
| b                   | 0.15     | 0.25 |
| e                   | 0.40 TYP |      |
| L                   | 0.45     | 0.55 |

**Note:**

- 1.All dimensions are in mm.
- 2.Dimensions exclude burrs, mold flash or protrusions.
- 3.Refer Jedec MO-287A
4. Recommended land pattern is for reference only.

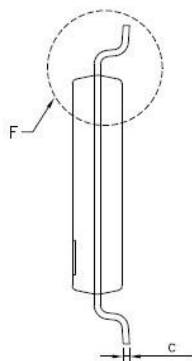
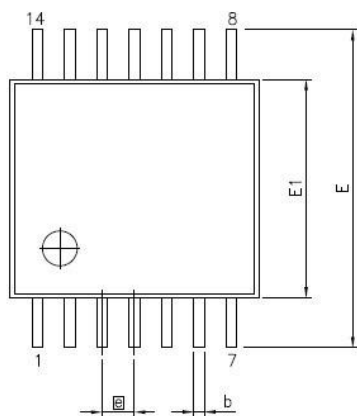
**Raystar Microelectronics Technology Inc.**

UQFN1.7X2.0-12L (ZM12) POD Rev.0

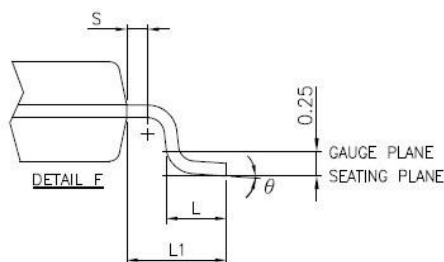
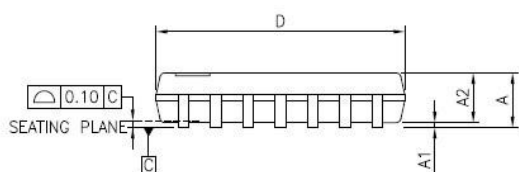


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**RS7LSX104**Bi-directional Level Translator for  
Open-drain and Push-Pull Applications**TSSOP-14L**

| SYMBOLS  | MIN.     | NOM. | MAX. |
|----------|----------|------|------|
| A        | —        | —    | 1.20 |
| A1       | 0.05     | —    | 0.15 |
| A2       | 0.80     | 1.00 | 1.05 |
| b        | 0.19     | —    | 0.30 |
| c        | 0.09     | —    | 0.20 |
| D        | 4.90     | 5.00 | 5.10 |
| E1       | 4.30     | 4.40 | 4.50 |
| E        | 6.20     | 6.40 | 6.60 |
| e        | 0.65 BSC |      |      |
| L1       | 1.00 REF |      |      |
| L        | 0.45     | 0.60 | 0.75 |
| S        | 0.20     | —    | —    |
| $\theta$ | 0°       | —    | 8°   |

**Note:**

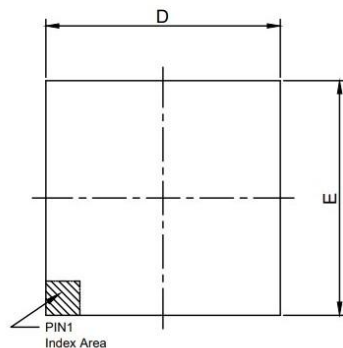
- 1.All dimensions are in mm. Angels in degrees.
- 2.Dimensions exclude burrs, mold flash or protrusions.
- 3.Refer Jedec MO-153F
4. Recommended land pattern is for reference only.

**Raystar Microelectronics Technology Inc.**

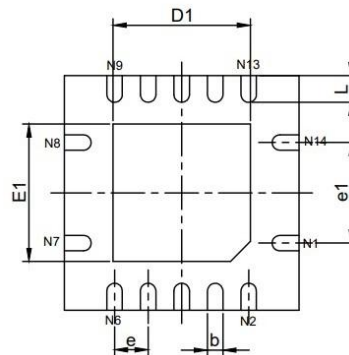
TSSOP14 POD Rev.0

**RSM**

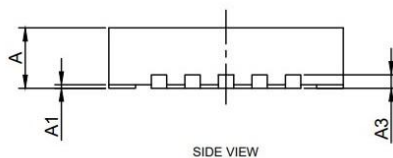
www.raystar-tek.com

**RS7LSX104**Bi-directional Level Translator for  
Open-drain and Push-Pull Applications**TQFN3.5X3.5-14L (ZB14)**

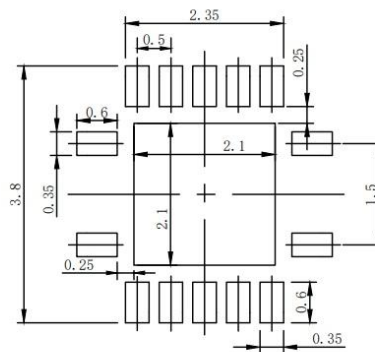
TOP VIEW



BOTTOM VIEW



SIDE VIEW



RECOMMENDED LAND PATTERN(unit:mm)

| PKG. DIMENSIONS(MM) |          |      |
|---------------------|----------|------|
| SYMBOL              | Min      | Max  |
| A                   | 0.80     | 0.90 |
| A1                  | 0.00     | 0.05 |
| A3                  | 0.20 REF |      |
| D                   | 3.42     | 3.58 |
| E                   | 3.42     | 3.58 |
| D1                  | 1.95     | 2.15 |
| E1                  | 1.95     | 2.15 |
| b                   | 0.20     | 0.30 |
| e                   | 0.50 TYP |      |
| e1                  | 1.50 TYP |      |
| L                   | 0.32     | 0.48 |

**Note:**

- 1.All dimensions are in mm.
- 2.Dimensions exclude burrs, mold flash or protrusions.
- 3.Refer Jedec MO-220
4. Recommended land pattern is for reference only.

TQFN 3.5X3.5-14L POD Rev.0  
**Raystar Microelectronics Technology Inc.**

**RSM**

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**RS7LSX104**Bi-directional Level Translator for  
Open-drain and Push-Pull Applications**Revision History**

| Revision | Description                                                  | Date      |
|----------|--------------------------------------------------------------|-----------|
| 0.9      | Preliminary                                                  | 2026/3/3  |
| 1.0      | Initial Release                                              | 2026/4/22 |
| 1.1      | Revise the architecture and application circuit description. | 2026/8/13 |