



# +1.2V to +3.6V, 0.1μA, 100Mbps, 8-Channel Level Translators

## General Description

The MAX3013–MAX3022 8-channel level translators provide the level shifting necessary to allow 100Mbps data transfer in a multivoltage system. Externally applied voltages,  $V_{CC}$  and  $V_L$ , set the logic levels on either side of the device. Logic signals present on the  $V_L$  side of the device appear as a higher voltage logic signal on the  $V_{CC}$  side of the device, and vice-versa.

The MAX3013–MAX3022 feature an EN input that, when at logic low, places all inputs/outputs on both sides in tristate and reduces the  $V_{CC}$  and  $V_L$  supply currents to 0.1μA. These devices operate at a guaranteed data rate of 100Mbps for  $V_L > 1.8V$ .

The MAX3013–MAX3022 accept a  $V_{CC}$  voltage from +1.65V to +3.6V and a  $V_L$  voltage from +1.2V to ( $V_{CC} - 0.4V$ ), making them ideal for data transfer between low-voltage ASICs/PLDs and higher voltage systems. The MAX3013–MAX3022 are available in 5 x 4 UCSP™, 20-pin 5mm x 5mm QFN, and 20-pin TSSOP packages.

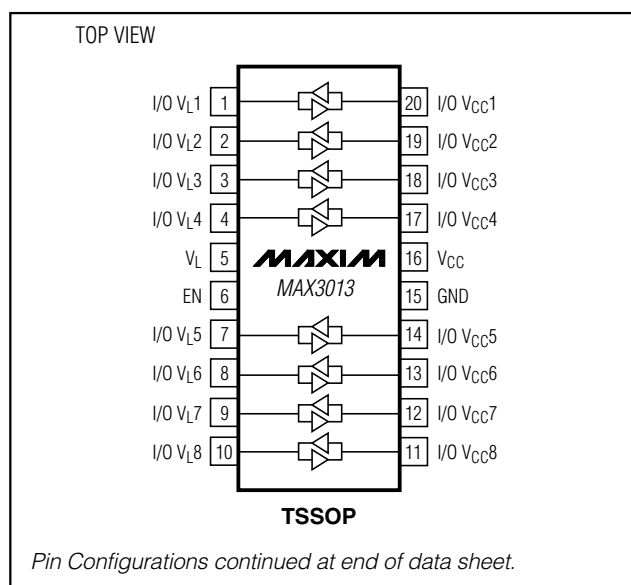
## Applications

Low-Voltage ASIC Level Translation  
Cell Phones  
SPI™, MICROWIRE™ Level Translation  
Portable POS Systems  
Portable Communication Devices  
GPS  
Telecommunications Equipment

## Features

- ◆ 100Mbps Guaranteed Data Rate
- ◆ Bidirectional Level Translation (MAX3013)
- ◆ Unidirectional Level Translation (MAX3014–MAX3022)
- ◆  $V_L$  Operation Down to +1.2V
- ◆ Ultra-Low 0.1μA Supply Current in Shutdown
- ◆ Low-Quiescent Current (0.1μA)
- ◆ UCSP, QFN, and TSSOP Packages

## Pin Configurations



UCSP is a trademark of Maxim Integrated Products, Inc.  
SPI is a trademark of Motorola, Inc.  
MICROWIRE is a trademark of National Semiconductor Corp.

Typical Operating Circuit appears at end of data sheet.

## Ordering Information

| PART         | TEMP RANGE     | PIN-PACKAGE | NUMBER OF<br>$V_L \rightarrow V_{CC}$<br>TRANSLATORS | NUMBER OF<br>$V_L \leftarrow V_{CC}$<br>TRANSLATORS | DATA RATE<br>(Mbps) |
|--------------|----------------|-------------|------------------------------------------------------|-----------------------------------------------------|---------------------|
| MAX3013EUP   | -40°C to +85°C | 20 TSSOP    | 8                                                    | 8                                                   | 100                 |
| MAX3013EBP-T | -40°C to +85°C | 5 x 4 UCSP  | 8                                                    | 8                                                   | 100                 |
| MAX3013EGP   | -40°C to +85°C | 20 QFN-EP*  | 8                                                    | 8                                                   | 100                 |

\*EP = Exposed paddle.

Ordering Information continued at end of data sheet.



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For pricing, delivery, and ordering information, please contact Maxim/Dallas Direct! at 1-888-629-4642, or visit Maxim's website at [www.maxim-ic.com](http://www.maxim-ic.com).

MAX3013–MAX3022

# +1.2V to +3.6V, 0.1 $\mu$ A, 100Mbps, 8-Channel Level Translators

## ABSOLUTE MAXIMUM RATINGS

(All voltages referenced to GND.)

|                                                                              |                                   |
|------------------------------------------------------------------------------|-----------------------------------|
| V <sub>CC</sub> .....                                                        | -0.3V to +4V                      |
| V <sub>L</sub> .....                                                         | -0.3V to +4V                      |
| I/O V <sub>CC</sub> .....                                                    | -0.3V to (V <sub>CC</sub> + 0.3V) |
| I/O V <sub>L</sub> .....                                                     | -0.3V to (V <sub>L</sub> + 0.3V)  |
| EN .....                                                                     | -0.3V to (V <sub>L</sub> + 0.3V)  |
| Short-Circuit Duration I/O V <sub>L</sub> , I/O V <sub>CC</sub> to GND ..... | Continuous                        |

Continuous Power Dissipation (T<sub>A</sub> = +70°C)

|                                                 |                 |
|-------------------------------------------------|-----------------|
| 20-Pin TSSOP (derate 11mW/°C above +70°C) ..... | 879mW           |
| 5 x 4 UCSP (derate 10mW/°C above +70°C) .....   | 800mW           |
| 20-Pin QFN (derate 20.0mW/°C above +70°C) ..... | 1.60W           |
| Operating Temperature Range .....               | -40°C to +85°C  |
| Junction Temperature .....                      | +150°C          |
| Storage Temperature Range .....                 | -65°C to +150°C |
| Lead Temperature (soldering, 10s) .....         | +300°C          |

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## ELECTRICAL CHARACTERISTICS

(V<sub>CC</sub> = +1.65V to +3.6V, V<sub>L</sub> = +1.2V to (V<sub>CC</sub> - 0.4V) (Note 1), EN = V<sub>L</sub>, C<sub>IOV<sub>L</sub></sub> ≤ 15pF, C<sub>IOV<sub>CC</sub></sub> ≤ 40pF, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>. Typical values are at V<sub>CC</sub> = +3.3V, V<sub>L</sub> = +1.8V, T<sub>A</sub> = +25°C.) (Note 2)

| PARAMETER                                           | SYMBOL              | CONDITIONS                                                                                                                                                                          | MIN                   | TYP                   | MAX                   | UNITS |
|-----------------------------------------------------|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------|-----------------------|-------|
| POWER SUPPLIES                                      |                     |                                                                                                                                                                                     |                       |                       |                       |       |
| V <sub>L</sub> Supply Range                         | V <sub>L</sub>      |                                                                                                                                                                                     | 1.2                   |                       | V <sub>CC</sub> - 0.4 | V     |
| V <sub>CC</sub> Supply Range                        | V <sub>CC</sub>     |                                                                                                                                                                                     | 1.65                  |                       | 3.6                   | V     |
| Supply Current from V <sub>CC</sub>                 | I <sub>QVCC</sub>   | I/O V <sub>CC</sub> _ = 0, I/O V <sub>L</sub> _ = 0 or I/O V <sub>CC</sub> _ = V <sub>CC</sub> ,<br>I/O V <sub>L</sub> _ = V <sub>L</sub>                                           |                       | 0.1                   | 1                     | μA    |
| Supply Current from V <sub>L</sub>                  | I <sub>QVL</sub>    | I/O V <sub>CC</sub> _ = 0, I/O V <sub>L</sub> _ = 0 or I/O V <sub>CC</sub> _ = V <sub>CC</sub> ,<br>I/O V <sub>L</sub> _ = V <sub>L</sub>                                           |                       | 0.1                   | 4                     | μA    |
|                                                     |                     | I/O V <sub>CC</sub> _ = 0, I/O V <sub>L</sub> _ = 0 or I/O V <sub>CC</sub> _ = V <sub>CC</sub> ,<br>I/O V <sub>L</sub> _ = V <sub>L</sub> , V <sub>L</sub> < V <sub>CC</sub> - 0.2V |                       | 0.1                   | 100                   |       |
| V <sub>CC</sub> Tristate Output Mode Supply Current | I <sub>TS-VCC</sub> | T <sub>A</sub> = +25°C, EN = 0                                                                                                                                                      |                       | 0.03                  | 1                     | μA    |
| V <sub>L</sub> Tristate Output Mode Supply Current  | I <sub>TS-VL</sub>  | T <sub>A</sub> = +25°C, EN = 0                                                                                                                                                      |                       | 0.1                   | 0.2                   | μA    |
|                                                     |                     | T <sub>A</sub> = +25°C, EN = 0, V <sub>L</sub> = V <sub>CC</sub> - 0.2V                                                                                                             |                       | 1                     | 2                     |       |
| I/O Tristate Output Mode Leakage Current            |                     | T <sub>A</sub> = +25°C, EN = 0,                                                                                                                                                     |                       |                       | 0.15                  | μA    |
|                                                     |                     | T <sub>A</sub> = +25°C, EN = 0, V <sub>L</sub> = V <sub>CC</sub> - 0.2V                                                                                                             |                       |                       | 30                    |       |
| LOGIC-LEVEL THRESHOLDS                              |                     |                                                                                                                                                                                     |                       |                       |                       |       |
| I/O V <sub>L</sub> _ Input-Voltage High             | V <sub>IHL</sub>    |                                                                                                                                                                                     | 2/3 x V <sub>L</sub>  |                       |                       | V     |
| I/O V <sub>L</sub> _ Input-Voltage Low              | V <sub>ILL</sub>    |                                                                                                                                                                                     |                       | 1/3 x V <sub>L</sub>  |                       | V     |
| I/O V <sub>CC</sub> _ Input-Voltage High            | V <sub>IHC</sub>    |                                                                                                                                                                                     | 2/3 x V <sub>CC</sub> |                       |                       | V     |
| I/O V <sub>CC</sub> _ Input-Voltage Low             | V <sub>ILC</sub>    |                                                                                                                                                                                     |                       | 1/3 x V <sub>CC</sub> |                       | V     |
| EN Input-Voltage High                               | V <sub>IH</sub>     | T <sub>A</sub> = +25°C                                                                                                                                                              | 2/3 x V <sub>L</sub>  |                       |                       | V     |

# **+1.2V to +3.6V, 0.1μA, 100Mbps, 8-Channel Level Translators**

**MAX3013-MAX3022**

## **ELECTRICAL CHARACTERISTICS (continued)**

(V<sub>CC</sub> = +1.65V to +3.6V, V<sub>L</sub> = +1.2V to (V<sub>CC</sub> - 0.4V) (Note 1), EN = V<sub>L</sub>, C<sub>IOVL</sub> ≤ 15pF, C<sub>IOVCC</sub> ≤ 40pF, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>. Typical values are at V<sub>CC</sub> = +3.3V, V<sub>L</sub> = +1.8V, T<sub>A</sub> = +25°C.) (Note 2)

| PARAMETER                                 | SYMBOL           | CONDITIONS                                  | MIN                   | TYP | MAX                   | UNITS |
|-------------------------------------------|------------------|---------------------------------------------|-----------------------|-----|-----------------------|-------|
| EN Input-Voltage Low                      | V <sub>IL</sub>  | T <sub>A</sub> = +25°C                      |                       |     | 1/3 x V <sub>L</sub>  | V     |
| EN Input Current                          |                  | T <sub>A</sub> = +25°C                      |                       |     | ±5                    | μA    |
| I/O V <sub>L</sub> _ Output-Voltage High  | V <sub>OHL</sub> | I/O V <sub>L</sub> _ source current = 20μA  | 2/3 x V <sub>L</sub>  |     |                       | V     |
| I/O V <sub>L</sub> _ Output-Voltage Low   | V <sub>OLL</sub> | I/O V <sub>L</sub> _ sink current = 20μA    |                       |     | 1/3 x V <sub>L</sub>  | V     |
| I/O V <sub>CC</sub> _ Output-Voltage High | V <sub>OHC</sub> | I/O V <sub>CC</sub> _ source current = 20μA | 2/3 x V <sub>CC</sub> |     |                       | V     |
| I/O V <sub>CC</sub> _ Output-Voltage Low  | V <sub>OLC</sub> | I/O V <sub>CC</sub> _ sink current = 20μA   |                       |     | 1/3 x V <sub>CC</sub> | V     |

## **TIMING CHARACTERISTICS**

(V<sub>CC</sub> = +1.65V to +3.6V, V<sub>L</sub> = +1.2V to (V<sub>CC</sub> - 0.4V) (Note 1), EN = V<sub>L</sub>, C<sub>IOVL</sub> ≤ 15pF, C<sub>IOVCC</sub> ≤ 40pF, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>. Typical values are at V<sub>CC</sub> = +3.3V, V<sub>L</sub> = +1.8V, T<sub>A</sub> = +25°C.) (Note 2)

| PARAMETER                                       | SYMBOL                | CONDITIONS                          | MIN | TYP | MAX  | UNITS |
|-------------------------------------------------|-----------------------|-------------------------------------|-----|-----|------|-------|
| I/O V <sub>CC</sub> _ Rise Time                 | t <sub>rvcc</sub>     | C <sub>IOVCC</sub> = 15pF, Figure 1 |     |     | 2.5  | ns    |
|                                                 |                       | C <sub>IOVCC</sub> = 20pF, Figure 1 |     |     | 3    |       |
|                                                 |                       | C <sub>IOVCC</sub> = 40pF, Figure 1 |     |     | 4    |       |
| I/O V <sub>CC</sub> _ Fall Time                 | t <sub>fvcc</sub>     | C <sub>IOVCC</sub> = 15pF, Figure 1 |     |     | 2.5  | ns    |
|                                                 |                       | C <sub>IOVCC</sub> = 20pF, Figure 1 |     |     | 3    |       |
|                                                 |                       | C <sub>IOVCC</sub> = 40pF, Figure 1 |     |     | 4    |       |
| I/O V <sub>CC</sub> _ One-Shot Output           |                       |                                     |     |     | 18.5 | Ω     |
| I/O V <sub>L</sub> _ Rise Time                  | t <sub>rvl</sub>      | C <sub>IOVL</sub> = 15pF, Figure 2  |     |     | 2.5  | ns    |
| I/O V <sub>L</sub> _ Fall Time                  | t <sub>fvL</sub>      | C <sub>IOVL</sub> = 15pF, Figure 2  |     |     | 2.5  | ns    |
| I/O V <sub>L</sub> _ One-Shot Output Impedance  |                       |                                     |     |     | 12.5 | Ω     |
| Propagation Delay (Driving I/O V <sub>L</sub> ) | I/O <sub>VL-VCC</sub> | C <sub>IOVCC</sub> = 15pF, Figure 1 |     |     | 6.5  | ns    |

# **+1.2V to +3.6V, 0.1 $\mu$ A, 100Mbps, 8-Channel Level Translators**

## **TIMING CHARACTERISTICS (continued)**

( $V_{CC}$  = +1.65V to +3.6V,  $V_L$  = +1.2V to ( $V_{CC}$  - 0.4V) (Note 1), EN =  $V_L$ ,  $C_{IOVL} \leq 15$ pF,  $C_{IOVCC} \leq 40$ pF,  $T_A$  =  $T_{MIN}$  to  $T_{MAX}$ . Typical values are at  $V_{CC}$  = +3.3V,  $V_L$  = +1.8V,  $T_A$  = +25°C.) (Note 2)

| PARAMETER                                                   | SYMBOL               | CONDITIONS                                                                    | MIN | TYP | MAX  | UNITS |
|-------------------------------------------------------------|----------------------|-------------------------------------------------------------------------------|-----|-----|------|-------|
| Propagation Delay (Driving I/O $V_{CC\_}$ )                 | I/O $V_{CC}$ - $V_L$ | $C_{IOVL}$ = 15pF, Figure 2                                                   |     |     | 6    | ns    |
| Part-to-Part Skew                                           | t <sub>PPSKEW</sub>  | $C_{IOVCC}$ = 15pF, $C_{IOVL}$ = 15pF, $V_{CC}$ = 2.5V, $V_L$ = 1.8V (Note 3) |     |     | 4    | ns    |
| Propagation Delay from I/O $V_L$ to I/O $V_{CC\_}$ after EN | t <sub>EN-VCC</sub>  | $C_{IOVCC}$ = 15pF, Figure 3                                                  |     |     | 1000 | ns    |
| Propagation Delay from I/O $V_{CC\_}$ to I/O $V_L$ after EN | t <sub>EN-VL</sub>   | $C_{IOVL}$ = 15pF, Figure 4                                                   |     |     | 1000 | ns    |
| Maximum Data Rate                                           |                      | $C_{IOVCC}$ = 15pF, $C_{IOVL}$ = 15pF, $V_L$ > 1.8V                           | 100 |     |      | Mbps  |
|                                                             |                      | $C_{IOVCC}$ = 15pF, $C_{IOVL}$ = 15pF, $V_L$ > 1.2V                           | 80  |     |      |       |

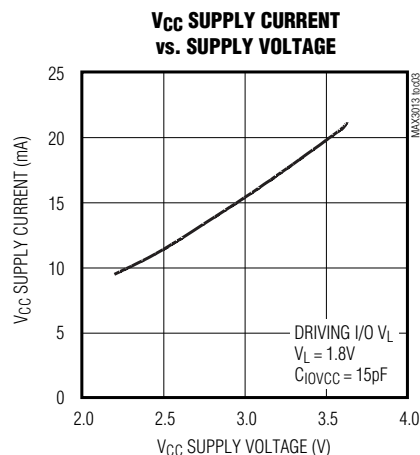
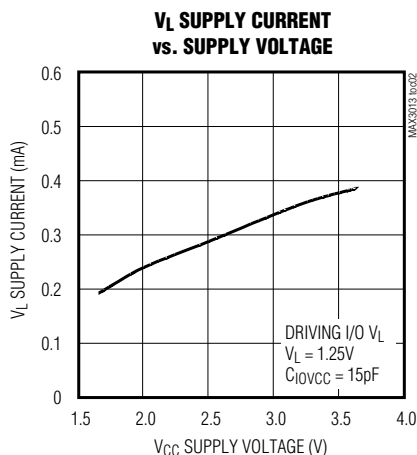
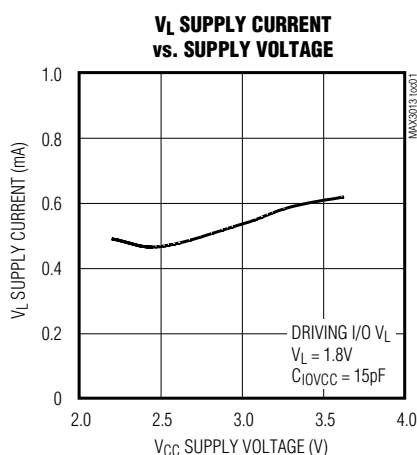
**Note 1:**  $V_L$  must be less than or equal to  $V_{CC}$  - 0.4V during normal operation. However,  $V_L$  can be greater than  $V_{CC}$  - 0.4V during starting up and shutting down conditions.

**Note 2:** All units are 100% production tested at  $T_A$  = +25°C. Limits over the operating temperature range are guaranteed by design and not production tested.

**Note 3:** Not production tested. Guaranteed by design.

## **Typical Operating Characteristics**

(Data rate = 100Mbps,  $V_{CC}$  = 3.3V,  $V_L$  = 1.8V,  $T_A$  = +25°C, unless otherwise noted.)

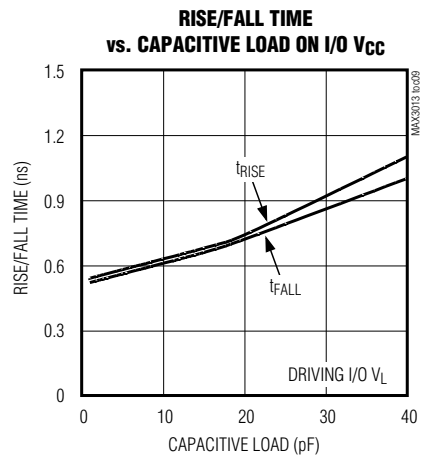
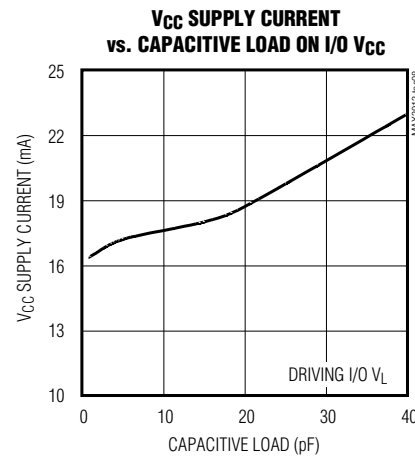
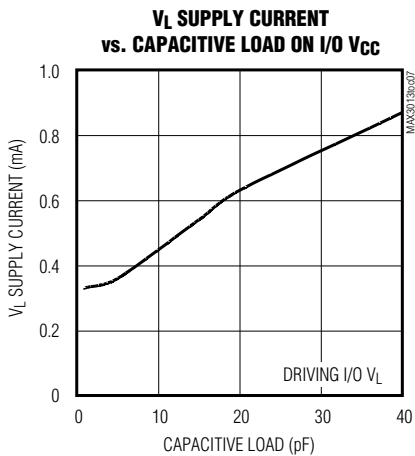
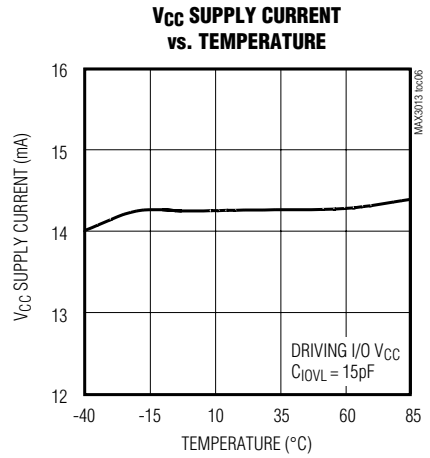
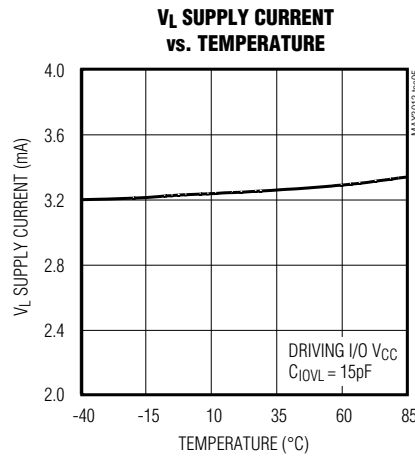
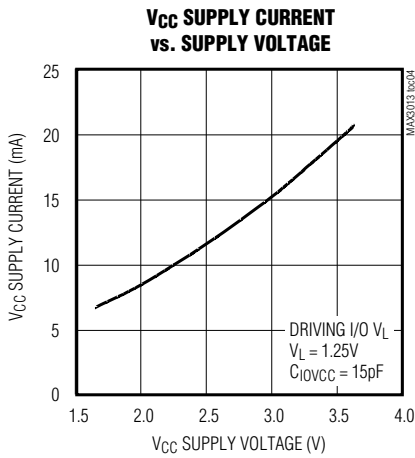


# +1.2V to +3.6V, 0.1 $\mu$ A, 100Mbps, 8-Channel Level Translators

## Typical Operating Characteristics (continued)

(Data rate = 100Mbps,  $V_{CC}$  = 3.3V,  $V_L$  = 1.8V,  $T_A$  = +25°C, unless otherwise noted.)

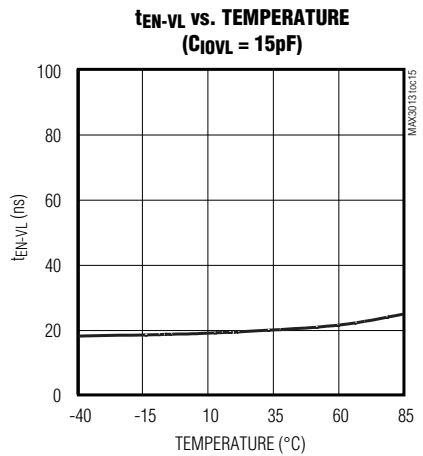
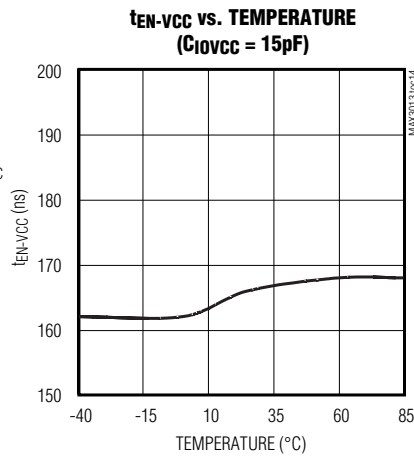
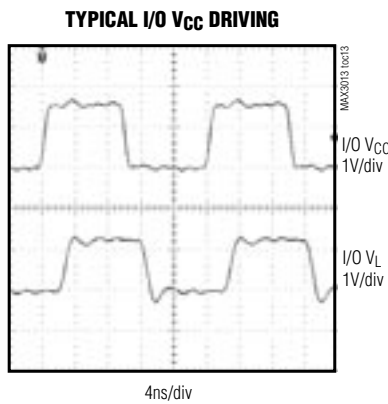
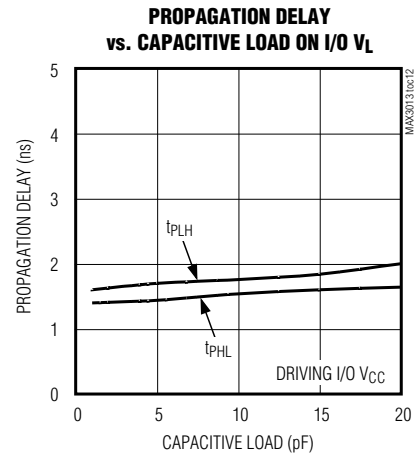
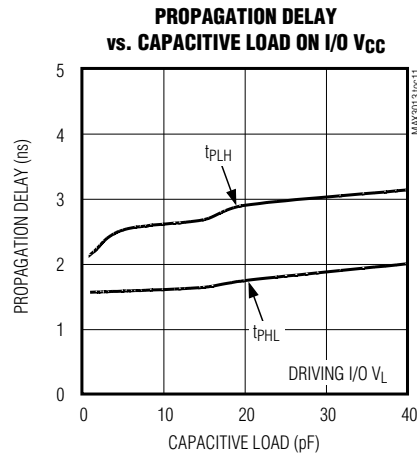
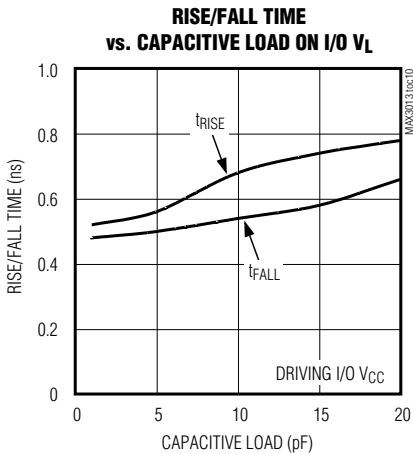
MAX3013-MAX3022



# +1.2V to +3.6V, 0.1 $\mu$ A, 100Mbps, 8-Channel Level Translators

## Typical Operating Characteristics (continued)

(Data rate = 100Mbps,  $V_{CC} = 3.3V$ ,  $V_L = 1.8V$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



# +1.2V to +3.6V, 0.1μA, 100Mbps, 8-Channel Level Translators

MAX3013-MAX3022

## Pin Description (MAX3013)

| PIN   |     |      | NAME                  | FUNCTION                                                                                                                              |
|-------|-----|------|-----------------------|---------------------------------------------------------------------------------------------------------------------------------------|
| TSSOP | QFN | UCSP |                       |                                                                                                                                       |
| 1     | 18  | B1   | I/O V <sub>L</sub> 1  | Input/Output 1, Referenced to V <sub>L</sub>                                                                                          |
| 2     | 19  | A1   | I/O V <sub>L</sub> 2  | Input/Output 2, Referenced to V <sub>L</sub>                                                                                          |
| 3     | 20  | B2   | I/O V <sub>L</sub> 3  | Input/Output 3, Referenced to V <sub>L</sub>                                                                                          |
| 4     | 1   | A2   | I/O V <sub>L</sub> 4  | Input/Output 4, Referenced to V <sub>L</sub>                                                                                          |
| 5     | 2   | A3   | V <sub>L</sub>        | V <sub>L</sub> Input Voltage, +1.2V ≤ V <sub>L</sub> ≤ (V <sub>CC</sub> - 0.4V). Bypass V <sub>L</sub> to GND with a 0.1μF capacitor. |
| 6     | 3   | A4   | EN                    | Enable Input. If EN is pulled low, all inputs/outputs are in tristate. Drive EN high (V <sub>L</sub> ) for normal operation.          |
| 7     | 4   | B3   | I/O V <sub>L</sub> 5  | Input/Output 5, Referenced to V <sub>L</sub>                                                                                          |
| 8     | 5   | A5   | I/O V <sub>L</sub> 6  | Input/Output 6, Referenced to V <sub>L</sub>                                                                                          |
| 9     | 6   | B4   | I/O V <sub>L</sub> 7  | Input/Output 7, Referenced to V <sub>L</sub>                                                                                          |
| 10    | 7   | B5   | I/O V <sub>L</sub> 8  | Input/Output 7, Referenced to V <sub>L</sub>                                                                                          |
| 11    | 8   | C5   | I/O V <sub>CC</sub> 8 | Input/Output 8, Referenced to V <sub>CC</sub>                                                                                         |
| 12    | 9   | C4   | I/O V <sub>CC</sub> 7 | Input/Output 7, Referenced to V <sub>CC</sub>                                                                                         |
| 13    | 10  | D5   | I/O V <sub>CC</sub> 6 | Input/Output 6, Referenced to V <sub>CC</sub>                                                                                         |
| 14    | 11  | C3   | I/O V <sub>CC</sub> 5 | Input/Output 5, Referenced to V <sub>CC</sub>                                                                                         |
| 15    | 12  | D4   | GND                   | Ground                                                                                                                                |
| 16    | 13  | D3   | V <sub>CC</sub>       | V <sub>CC</sub> Input Voltage, +1.65V ≤ V <sub>CC</sub> ≤ +3.6V. Bypass V <sub>CC</sub> to GND with a 0.1μF capacitor.                |
| 17    | 14  | D2   | I/O V <sub>CC</sub> 4 | Input/Output 4, Referenced to V <sub>CC</sub>                                                                                         |
| 18    | 15  | C2   | I/O V <sub>CC</sub> 3 | Input/Output 3, Referenced to V <sub>CC</sub>                                                                                         |
| 19    | 16  | D1   | I/O V <sub>CC</sub> 2 | Input/Output 2, Referenced to V <sub>CC</sub>                                                                                         |
| 20    | 17  | C1   | I/O V <sub>CC</sub> 1 | Input/Output 1, Referenced to V <sub>CC</sub>                                                                                         |

## Pin Description (MAX3014-MAX3022)

| NAME                                  | FUNCTION (Note 4)                                                                                                                   |
|---------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| V <sub>CC</sub>                       | V <sub>CC</sub> Input Voltage, +1.65V ≤ V <sub>CC</sub> ≤ +3.6V. Bypass V <sub>CC</sub> to GND with a 0.1μF capacitor.              |
| V <sub>L</sub>                        | V <sub>L</sub> Input Voltage, +1.2V ≤ V <sub>L</sub> ≤ V <sub>CC</sub> - 0.4V. Bypass V <sub>L</sub> to GND with a 0.1μF capacitor. |
| GND                                   | Ground                                                                                                                              |
| EN                                    | Enable Input. If EN is pulled low, all inputs/outputs are in tristate. Drive EN high (V <sub>L</sub> ) for normal operation.        |
| IV <sub>L</sub> 1-IV <sub>L</sub> 8   | Inputs Referenced to V <sub>L</sub> , Numbers 1 to 8                                                                                |
| OV <sub>L</sub> 1-OV <sub>L</sub> 8   | Outputs Referenced to V <sub>L</sub> , Numbers 1 to 8                                                                               |
| IV <sub>CC</sub> 1-IV <sub>CC</sub> 8 | Inputs Referenced to V <sub>CC</sub> , Numbers 1 to 8                                                                               |
| OV <sub>CC</sub> 1-OV <sub>CC</sub> 8 | Outputs Referenced to V <sub>CC</sub> , Numbers 1 to 8                                                                              |

**Note 4:** For specific pin numbers, see the *Pin Configurations* for more information.

# **+1.2V to +3.6V, 0.1 $\mu$ A, 100Mbps, 8-Channel Level Translators**

## **Test Circuits/Timing Diagrams**

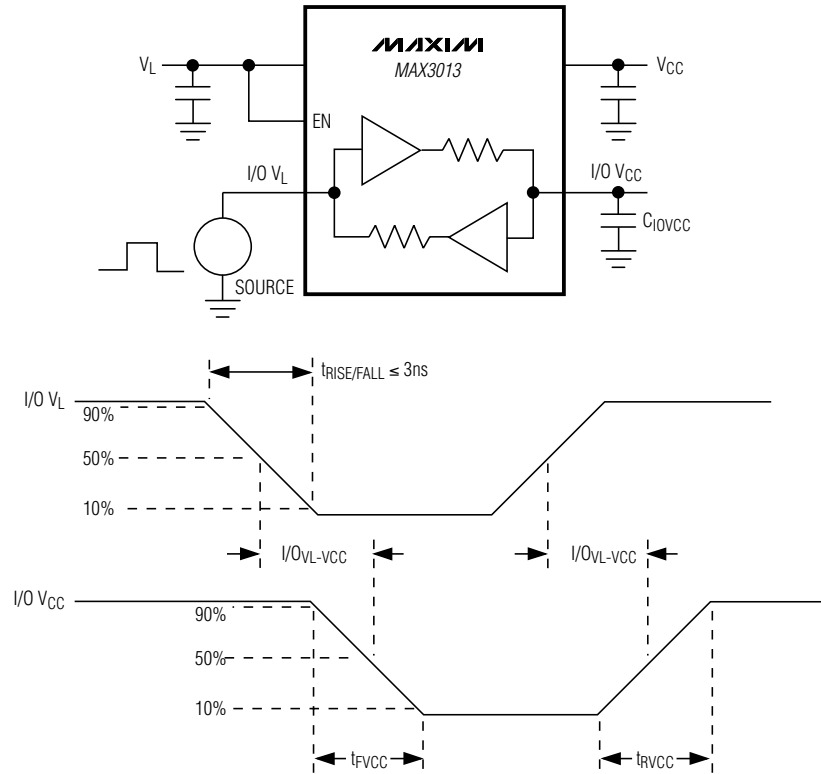


Figure 1. Driving I/O  $V_L$  Test Circuit and Timing



# **+1.2V to +3.6V, 0.1 $\mu$ A, 100Mbps, 8-Channel Level Translators**

## **Test Circuits/Timing Diagrams (continued)**

**MAX3013-MAX3022**

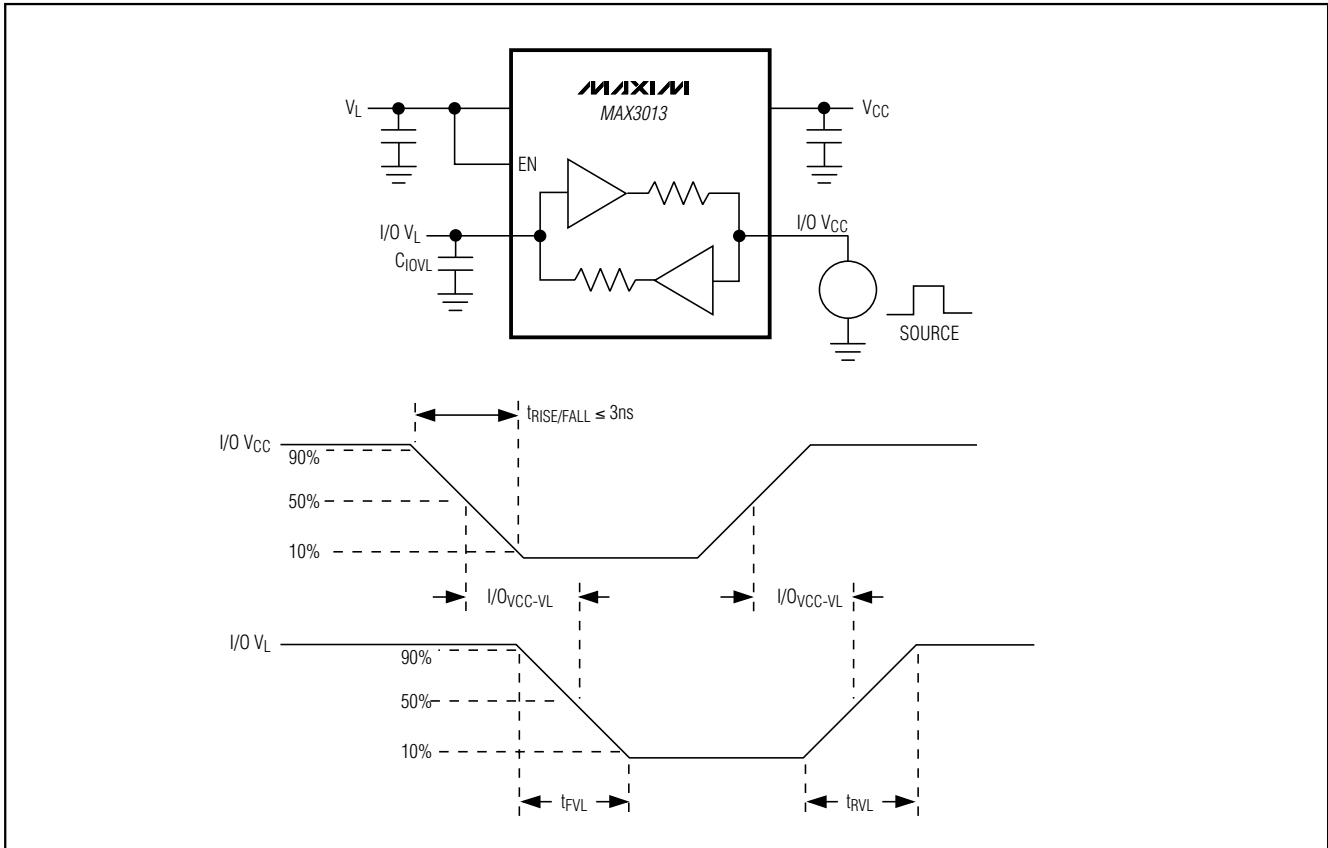


Figure 2. Driving I/O V<sub>CC</sub> Test Circuit and Timing

# **+1.2V to +3.6V, 0.1 $\mu$ A, 100Mbps, 8-Channel Level Translators**

## **Test Circuits/Timing Diagrams (continued)**

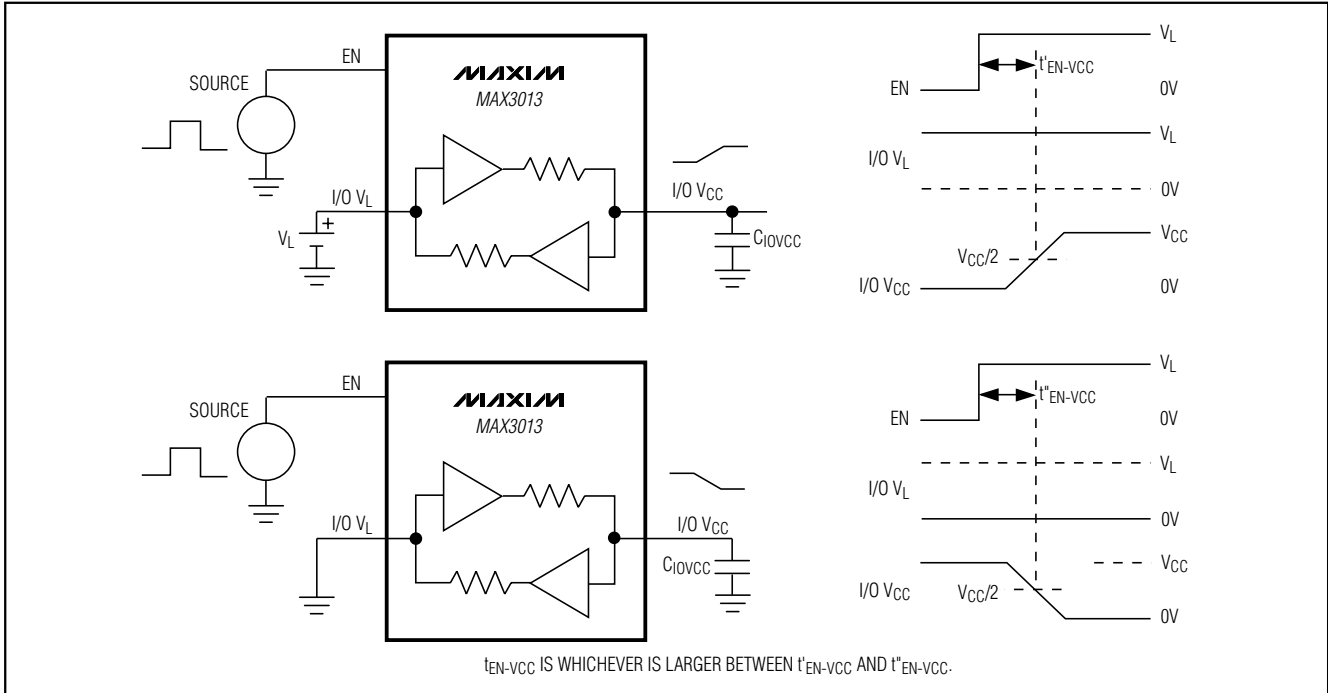


Figure 3. Propagation Delay from I/O V<sub>L</sub> to I/O V<sub>CC</sub> after EN

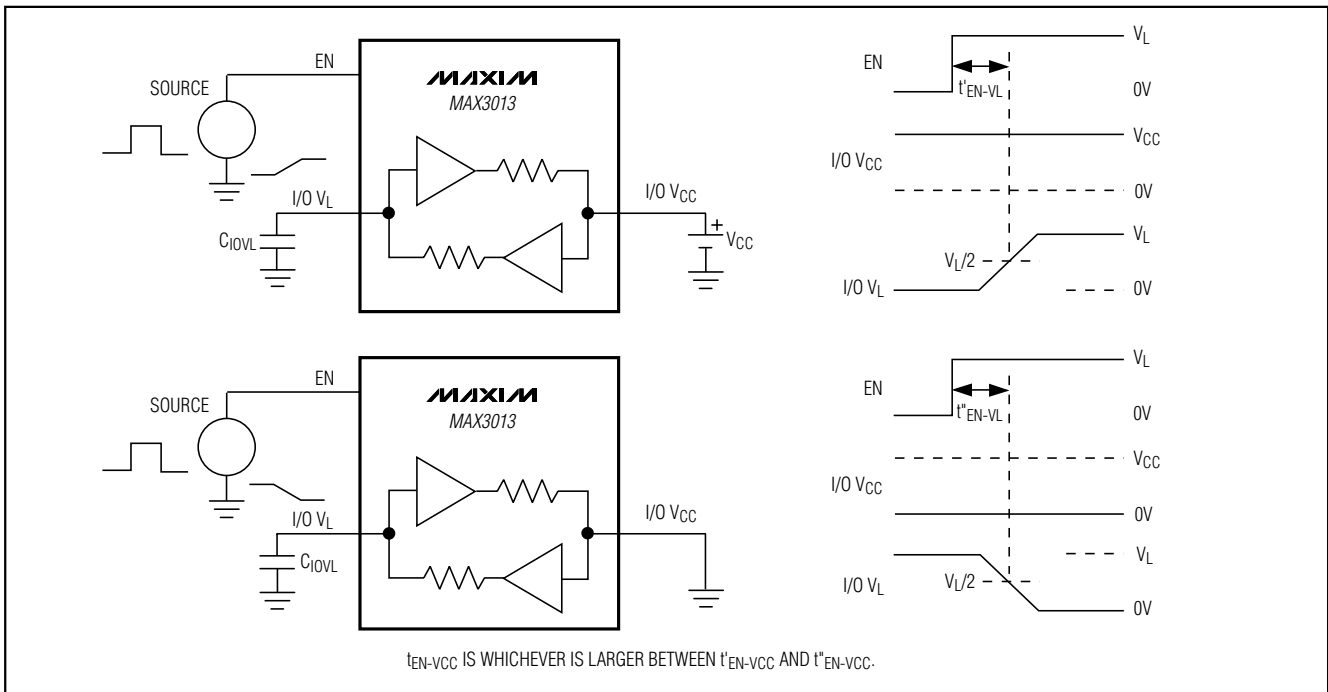


Figure 4. Propagation Delay from I/O V<sub>CC</sub> to I/O V<sub>L</sub> after EN

# +1.2V to +3.6V, 0.1μA, 100Mbps, 8-Channel Level Translators

## Detailed Description

The MAX3013–MAX3022 logic-level translators provide the level shifting necessary to allow 100Mbps data transfer in a multivoltage system. Externally applied voltages,  $V_{CC}$  and  $V_L$ , set the logic levels on either side of the device. Logic signals present on the  $V_L$  side of the device appear as a higher voltage logic signal on the  $V_{CC}$  side of the device, and vice-versa. The MAX3013 bidirectional level translator allows data translation in either direction ( $V_L \leftrightarrow V_{CC}$ ) on any single data line. The MAX3014–MAX3022 unidirectional translators level-shift data in one direction ( $V_L \rightarrow V_{CC}$  or  $V_{CC} \rightarrow V_L$ ) on any single data line. The MAX3013–MAX3022 accept  $V_L$  from +1.2V to ( $V_{CC} - 0.4V$ ) and operate with  $V_{CC}$  from +1.65V to +3.6V, making them ideal for data transfer between low-voltage ASICs/PLDs and higher voltage systems.

The MAX3013–MAX3022 feature an input enable mode (EN) that reduces  $V_{CC}$  and  $V_L$  supply currents to 0.1μA, when in tristate mode. These devices operate at a guaranteed data rate of 100Mbps for  $V_L > +1.8V$ .

## Level Translation

For proper operation, ensure that  $+1.65V \leq V_{CC} \leq +3.6V$ ,  $+1.2V \leq V_L \leq (V_{CC} - 0.4V)$ . During power-up sequencing,  $V_L \geq V_{CC}$  does not damage the device. During power-supply sequencing, when  $V_{CC}$  is floating and  $V_L$  is powering up, up to 40mA current can be sourced to each load on the  $V_L$  side, yet the device does not latch up. The maximum data rate depends heavily on the load capacitance (see the *Typical Operating Characteristics*, Rise/Fall Times), output impedance of the driver, and the operating voltage range (see the *Timing Characteristics*).

## Input Driver Requirements

The MAX3013–MAX3022 architecture is based on a one-shot accelerator output stage (see Figure 5). Accelerator output stages are always in tristate mode except when there is a transition on any of the translators on the input side, either I/O  $V_L$  or I/O  $V_{CC}$ . Then, a short pulse is generated during which the accelerator output stages become active and charge/discharge the capacitances at the I/Os. Due to its bidirectional nature, both input stages become active during the one-shot pulse. This can lead to some current feeding into the external source that is driving the translator. However, this behavior helps to speed up the transition on the driven side.

For proper operation, the external driver must meet the following conditions:  $<25\Omega$  output impedance and  $>20mA$  output current. Figure 6 shows a graph of Typical Input Current vs. Input Voltage.

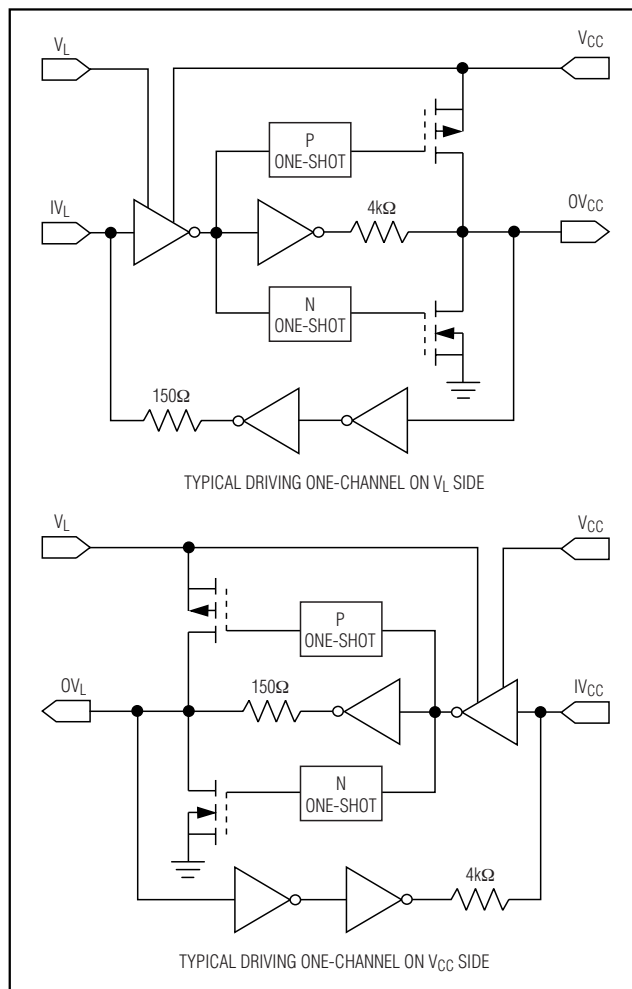


Figure 5. MAX3013–MAX3022 Simplified Diagram (1 I/O line)

## Output Load Requirements

The MAX3013–MAX3022 I/O were designed to drive CMOS inputs. Do not load the I/O lines with a resistive load less than 25kΩ. Also, do not place an RC circuit at the input of the MAX3013–MAX3022 to slow down the edges. If a slower data rate is required, please see the MAX3000E/MAX3001E logic-level translator.

For I<sup>2</sup>C™ level translation, please refer to the MAX3372E–MAX3379E/MAX3390E–MAX3393E data sheet.

*I<sup>2</sup>C is a trademark of Philips Corp. Purchase of I<sup>2</sup>C components of Maxim Integrated Products, Inc. or one of its sublicensed Associated Companies, conveys a license under the Philips I<sup>2</sup>C Patent Rights to use these components in an I<sup>2</sup>C system, provided that the system conforms to the I<sup>2</sup>C Standard Specification as defined by Philips.*

# **+1.2V to +3.6V, 0.1μA, 100Mbps, 8-Channel Level Translators**

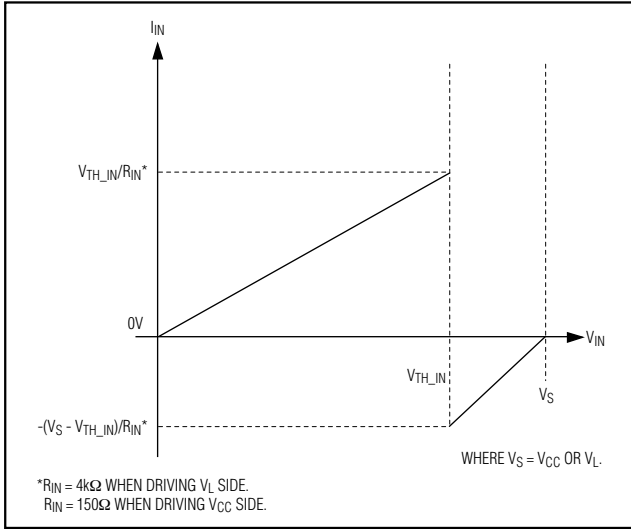


Figure 6. Typical  $I_{IN}$  vs.  $V_{IN}$

## **Enable Input (EN)**

The MAX3013-MAX3022 feature an EN input. Pull EN low to set the MAX3013-MAX3022's I/O on both sides in tristate output mode. Drive EN to logic high ( $V_L$ ) for normal operation.

## **Applications Information**

### **Power-Supply Decoupling**

To reduce ripple and the chance of introducing data errors, bypass  $V_L$  and  $V_{CC}$  to ground with a 0.1μF ceramic capacitor. Place the bypass capacitors as close to the power-supply input pins as possible.

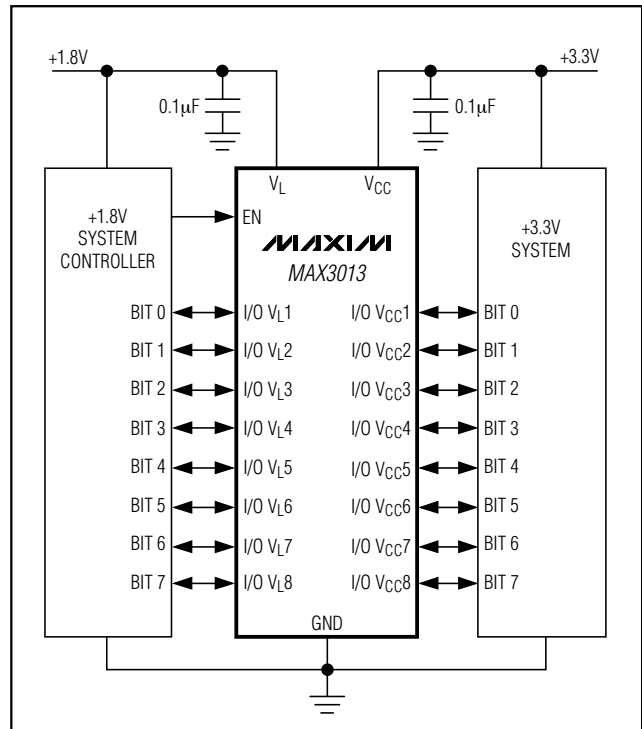
## **8-Bit Bus Translation**

The MAX3013-MAX3022 level-shift the data present on the I/O line between +1.2V to +3.6V, making them ideal for level translation between a low-voltage ASIC and a higher voltage system. The *Typical Operating Circuit* shows the MAX3013 bidirectional translator in an 8-bit bus level translation from a 1.8V system to a 3.3V system and vice versa.

## **Unidirectional vs. Bidirectional Level Translator**

The MAX3013 bidirectional translator can operate as a unidirectional device to translate signals without inversion. The MAX3014-MAX3022 unidirectional translators level-shift data in one direction ( $V_L \rightarrow V_{CC}$  or  $V_{CC} \rightarrow V_L$ ) on any single data line (see the *Ordering Information*). These devices provide the smallest solution (UCSP package) for unidirectional level translation without inversion.

## **Typical Operating Circuit**



## **Chip Information**

TRANSISTOR COUNT: 1447

PROCESS: BiCMOS

# **+1.2V to +3.6V, 0.1μA, 100Mbps, 8-Channel Level Translators**

## **Ordering Information (continued)**

| PART                | TEMP RANGE     | PIN-PACKAGE | NUMBER OF<br>V <sub>L</sub> → V <sub>CC</sub><br>TRANSLATORS | NUMBER OF<br>V <sub>L</sub> ← V <sub>CC</sub><br>TRANSLATORS | DATA RATE<br>(Mbps) |
|---------------------|----------------|-------------|--------------------------------------------------------------|--------------------------------------------------------------|---------------------|
| <b>MAX3014</b> EUP* | -40°C to +85°C | 20 TSSOP    | 8                                                            | 0                                                            | 100                 |
| MAX3014EBP-T*       | -40°C to +85°C | 5 x 4 UCSP  | 8                                                            | 0                                                            | 100                 |
| MAX3014EGP*         | -40°C to +85°C | 20 QFN-EP** | 8                                                            | 0                                                            | 100                 |
| <b>MAX3015</b> EUP* | -40°C to +85°C | 20 TSSOP    | 7                                                            | 1                                                            | 100                 |
| MAX3015EBP-T*       | -40°C to +85°C | 5 x 4 UCSP  | 7                                                            | 1                                                            | 100                 |
| MAX3015EGP*         | -40°C to +85°C | 20 QFN-EP** | 7                                                            | 1                                                            | 100                 |
| <b>MAX3016</b> EUP* | -40°C to +85°C | 20 TSSOP    | 6                                                            | 2                                                            | 100                 |
| MAX3016EBP-T*       | -40°C to +85°C | 5 x 4 UCSP  | 6                                                            | 2                                                            | 100                 |
| MAX3016EGP*         | -40°C to +85°C | 20 QFN-EP** | 6                                                            | 2                                                            | 100                 |
| <b>MAX3017</b> EUP* | -40°C to +85°C | 20 TSSOP    | 5                                                            | 3                                                            | 100                 |
| MAX3017EBP-T*       | -40°C to +85°C | 5 x 4 UCSP  | 5                                                            | 3                                                            | 100                 |
| MAX3017EGP*         | -40°C to +85°C | 20 QFN-EP** | 5                                                            | 3                                                            | 100                 |
| <b>MAX3018</b> EUP* | -40°C to +85°C | 20 TSSOP    | 4                                                            | 4                                                            | 100                 |
| MAX3018EBP-T*       | -40°C to +85°C | 5 x 4 UCSP  | 4                                                            | 4                                                            | 100                 |
| MAX3018EGP*         | -40°C to +85°C | 20 QFN-EP** | 4                                                            | 4                                                            | 100                 |
| <b>MAX3019</b> EUP* | -40°C to +85°C | 20 TSSOP    | 3                                                            | 5                                                            | 100                 |
| MAX3019EBP-T*       | -40°C to +85°C | 5 x 4 UCSP  | 3                                                            | 5                                                            | 100                 |
| MAX3019EGP*         | -40°C to +85°C | 20 QFN-EP** | 3                                                            | 5                                                            | 100                 |
| <b>MAX3020</b> EUP* | -40°C to +85°C | 20 TSSOP    | 2                                                            | 6                                                            | 100                 |
| MAX3020EBP-T*       | -40°C to +85°C | 5 x 4 UCSP  | 2                                                            | 6                                                            | 100                 |
| MAX3020EGP*         | -40°C to +85°C | 20 QFN-EP** | 2                                                            | 6                                                            | 100                 |
| <b>MAX3021</b> EUP* | -40°C to +85°C | 20 TSSOP    | 1                                                            | 7                                                            | 100                 |
| MAX3021EBP-T*       | -40°C to +85°C | 5 x 4 UCSP  | 1                                                            | 7                                                            | 100                 |
| MAX3021EGP*         | -40°C to +85°C | 20 QFN-EP** | 1                                                            | 7                                                            | 100                 |
| <b>MAX3022</b> EUP* | -40°C to +85°C | 20 TSSOP    | 0                                                            | 8                                                            | 100                 |
| MAX3022EBP-T*       | -40°C to +85°C | 5 x 4 UCSP  | 0                                                            | 8                                                            | 100                 |
| MAX3022EGP*         | -40°C to +85°C | 20 QFN-EP** | 0                                                            | 8                                                            | 100                 |

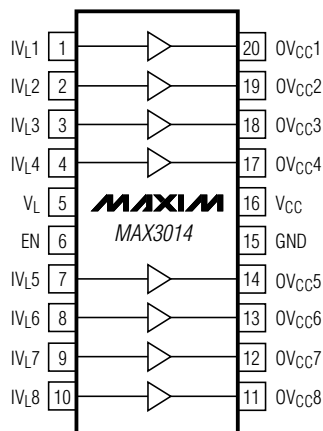
\*Future Product—Contact factory for availability.

\*\*EP = Exposed paddle.

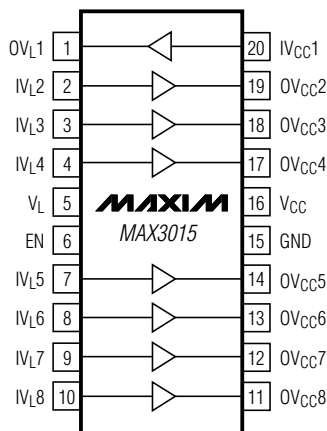
**MAX3013-MAX3022**

# **+1.2V to +3.6V, 0.1 $\mu$ A, 100Mbps, 8-Channel Level Translators**

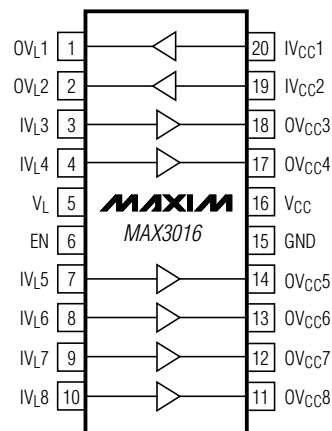
## **Pin Configurations (continued)**



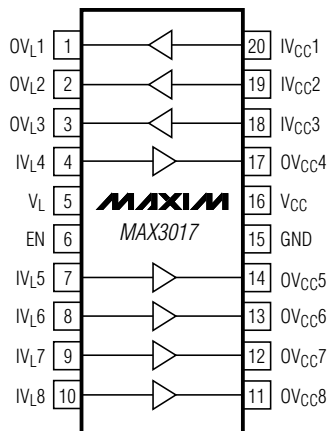
TSSOP



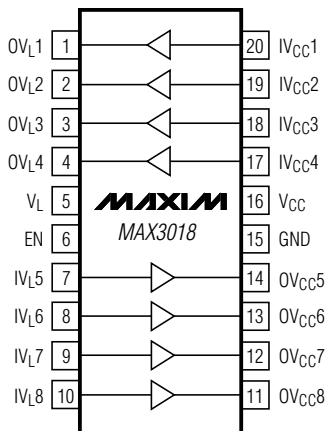
TSSOP



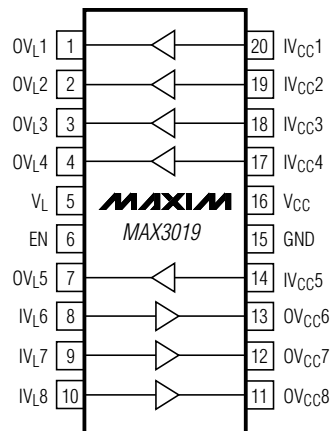
TSSOP



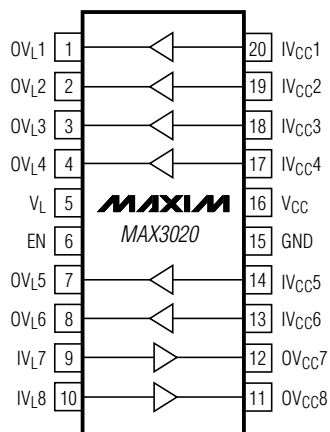
TSSOP



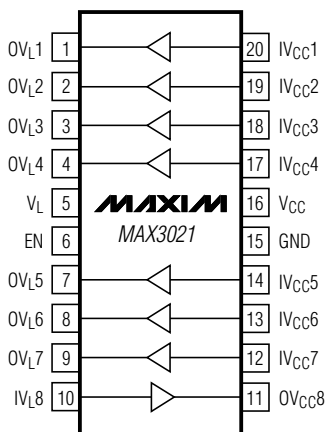
TSSOP



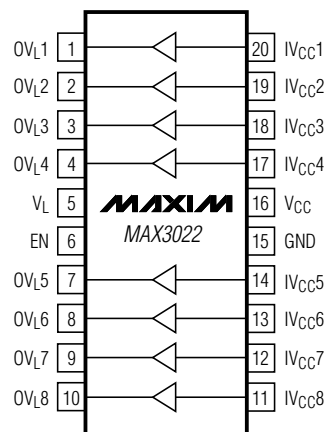
TSSOP



TSSOP



TSSOP



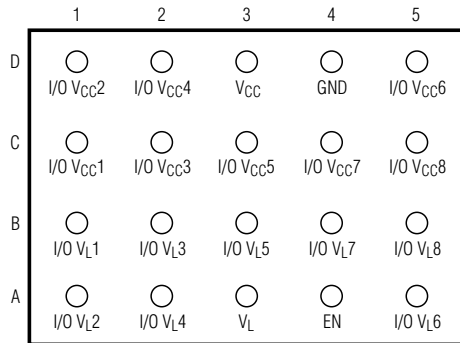
TSSOP

# **+1.2V to +3.6V, 0.1μA, 100Mbps, 8-Channel Level Translators**

## **Pin Configurations (continued)**

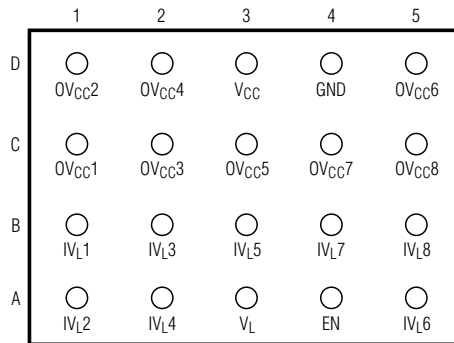
**MAX3013-MAX3022**

**MAXIM**  
MAX3013



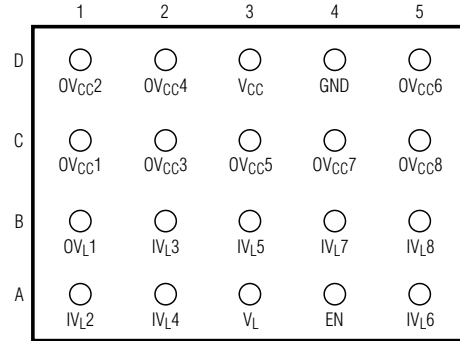
**20 UCSP  
(BOTTOM VIEW)**

**MAXIM**  
MAX3014



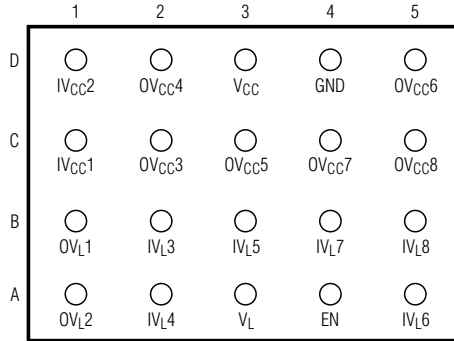
**20 UCSP  
(BOTTOM VIEW)**

**MAXIM**  
MAX3015



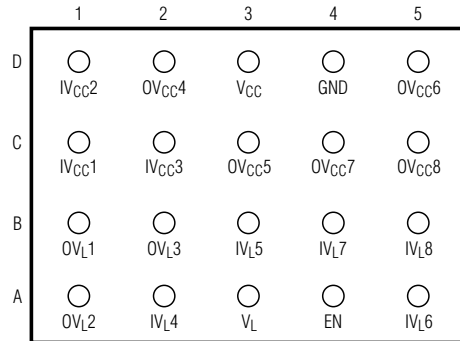
**20 UCSP  
(BOTTOM VIEW)**

**MAXIM**  
MAX3016



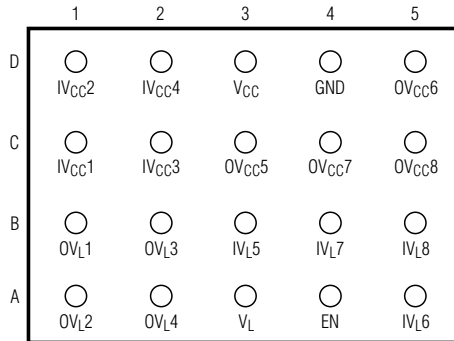
**20 UCSP  
(BOTTOM VIEW)**

**MAXIM**  
MAX3017



**20 UCSP  
(BOTTOM VIEW)**

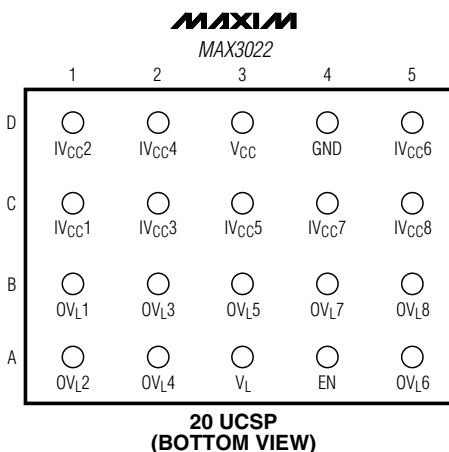
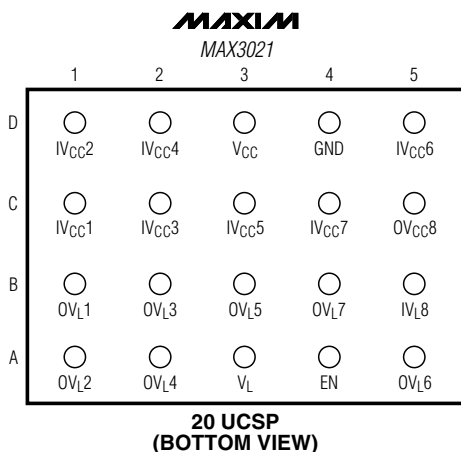
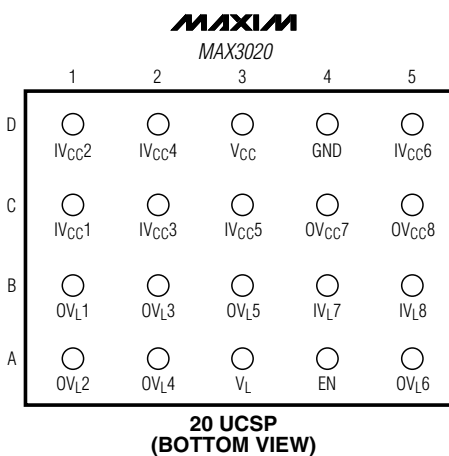
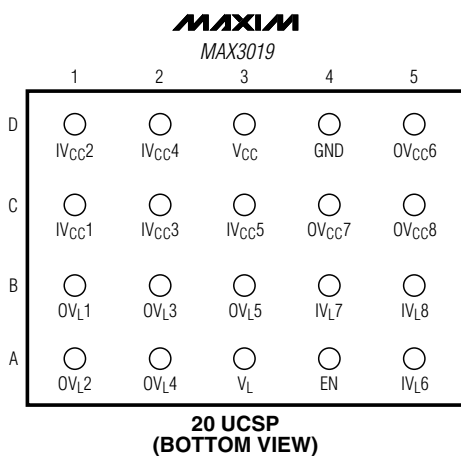
**MAXIM**  
MAX3018



**20 UCSP  
(BOTTOM VIEW)**

# **+1.2V to +3.6V, 0.1 $\mu$ A, 100Mbps, 8-Channel Level Translators**

## **Pin Configurations (continued)**

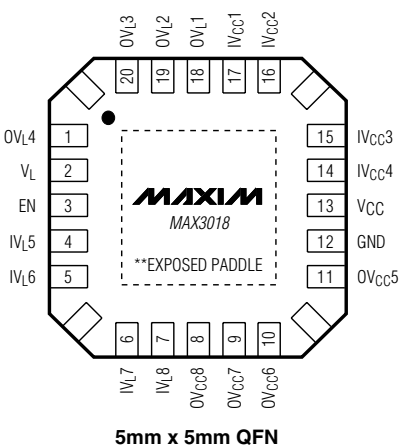
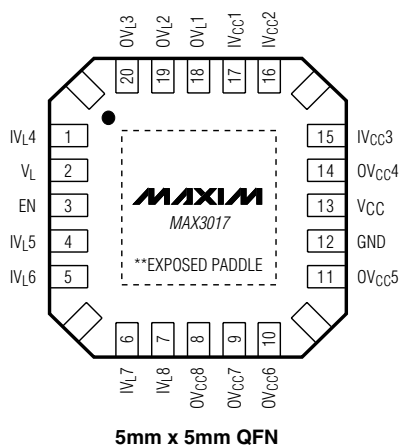
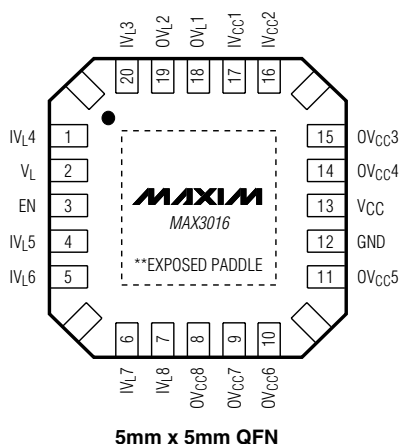
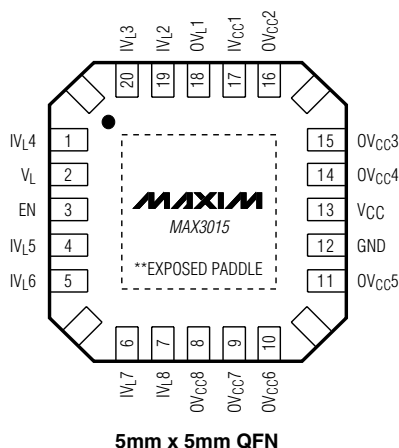
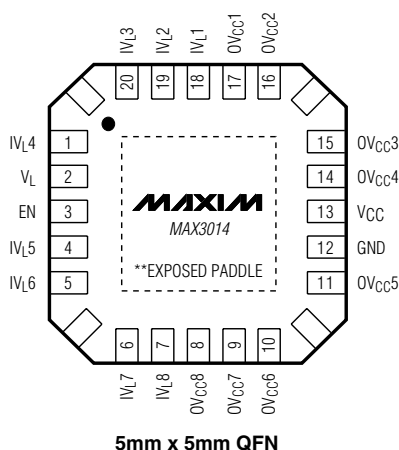
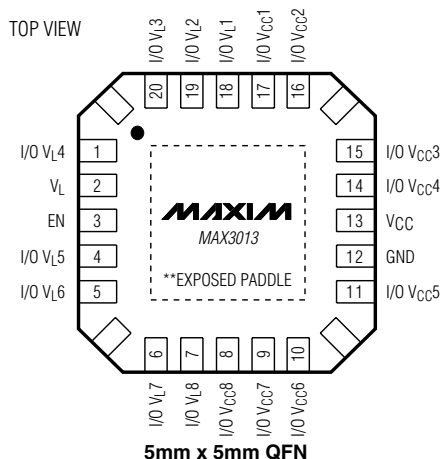




# +1.2V to +3.6V, 0.1μA, 100Mbps, 8-Channel Level Translators

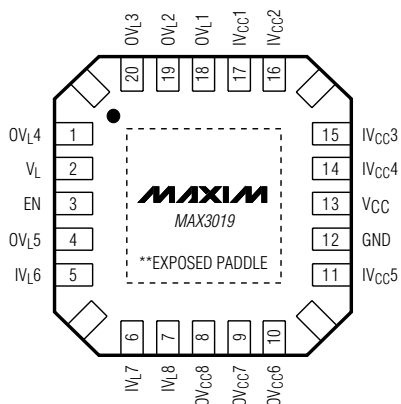
## Pin Configurations (continued)

MAX3013-MAX3022

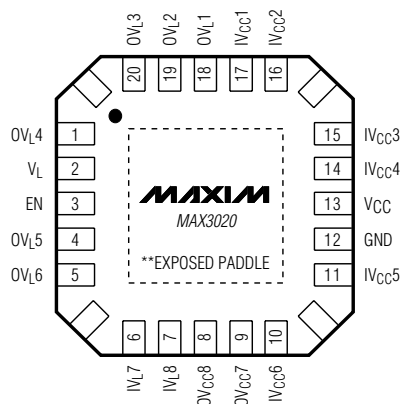


# **+1.2V to +3.6V, 0.1μA, 100Mbps, 8-Channel Level Translators**

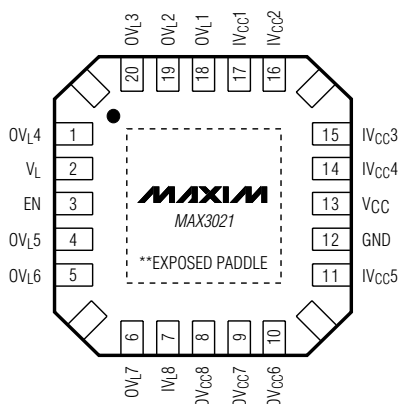
## **Pin Configurations (continued)**



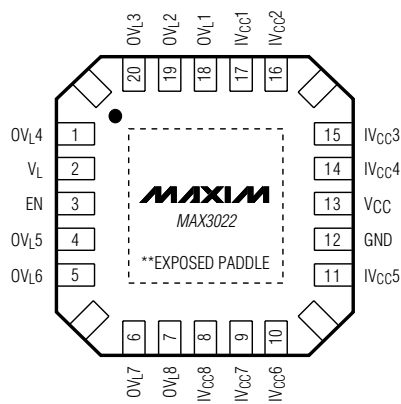
**5mm x 5mm QFN**



**5mm x 5mm QFN**



**5mm x 5mm QFN**



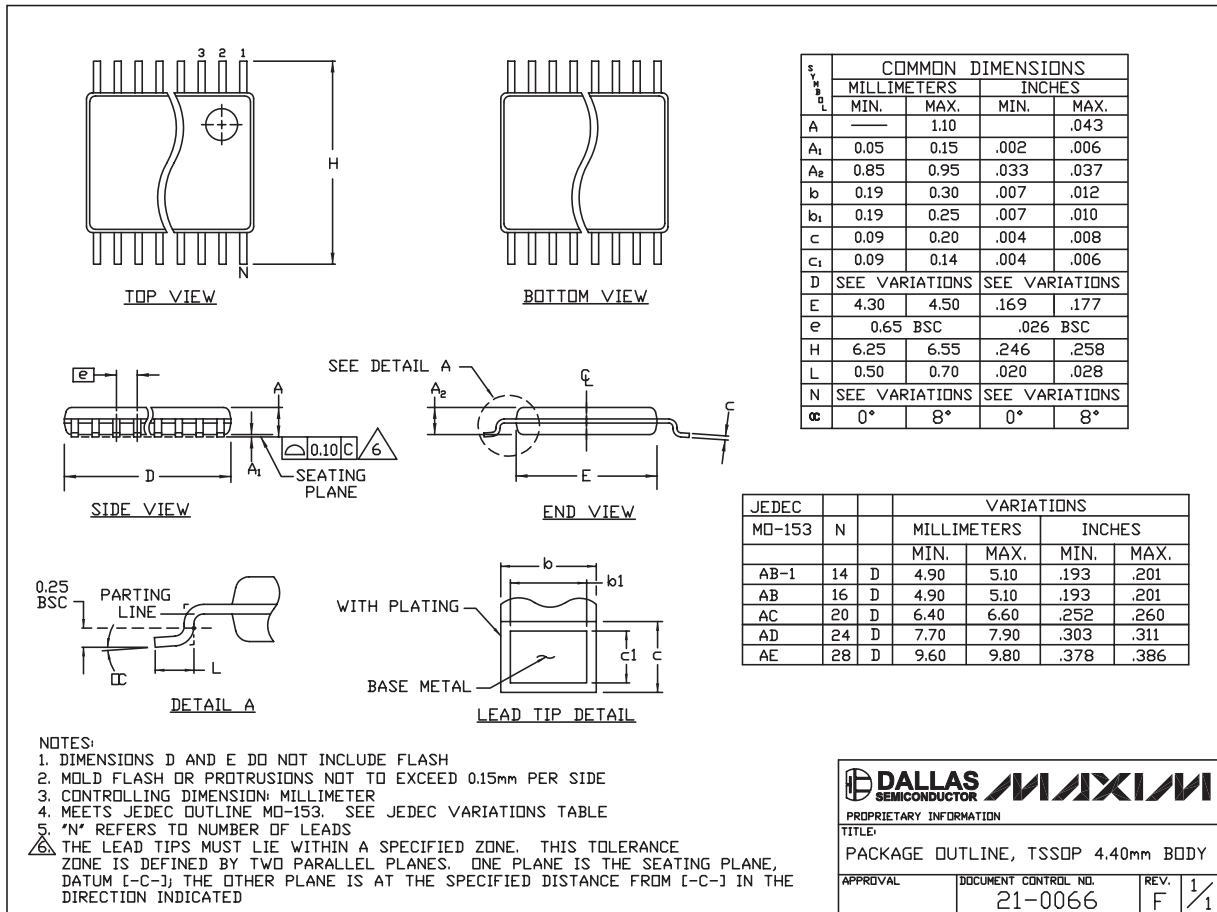
**5mm x 5mm QFN**

QFN-EP\*\* (5mm x 5mm)  
\*\*CONNECT EXPOSED PADDLE TO GND.

# +1.2V to +3.6V, 0.1 $\mu$ A, 100Mbps, 8-Channel Level Translators

## Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)



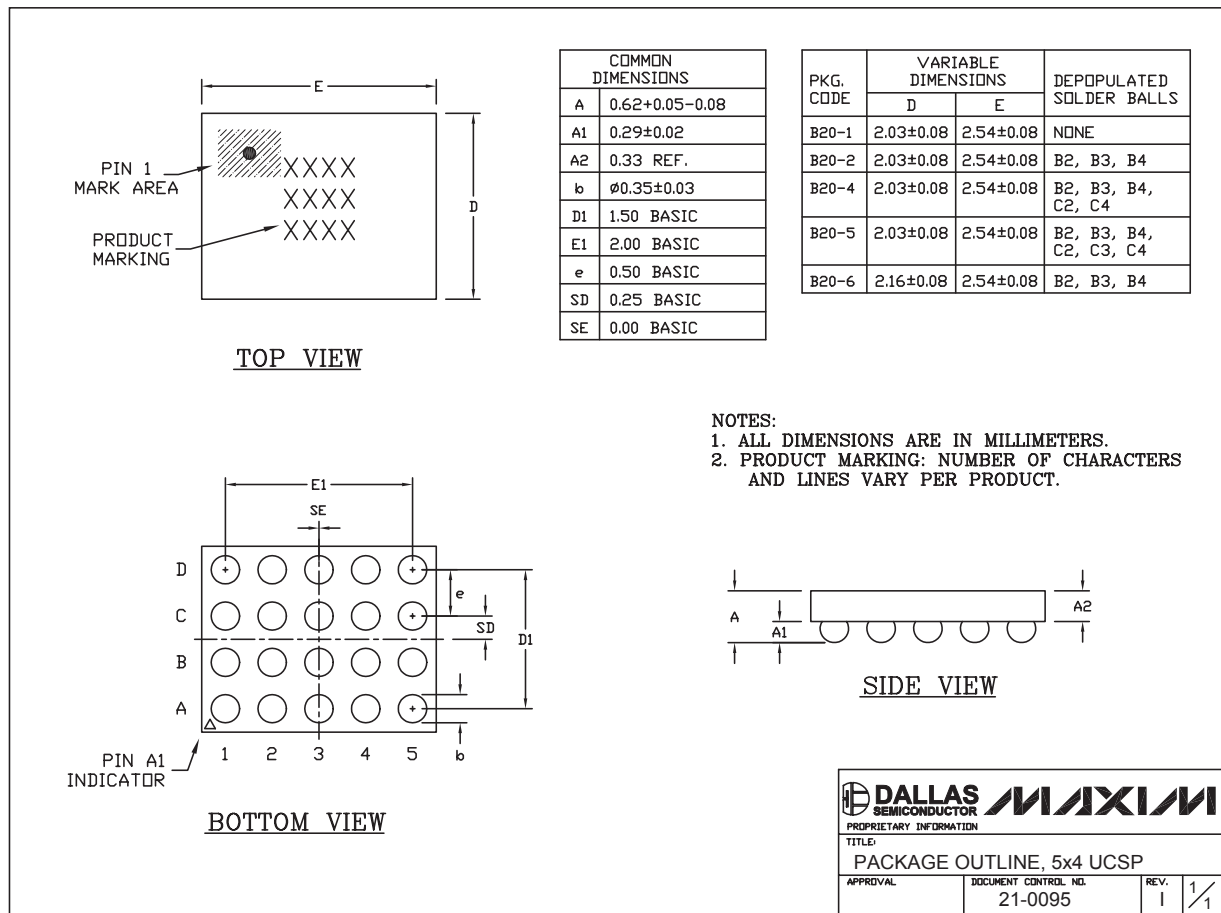
TSSOP 4.40mm EPS

MAX3013-MAX3022

# +1.2V to +3.6V, 0.1 $\mu$ A, 100Mbps, 8-Channel Level Translators

## Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)

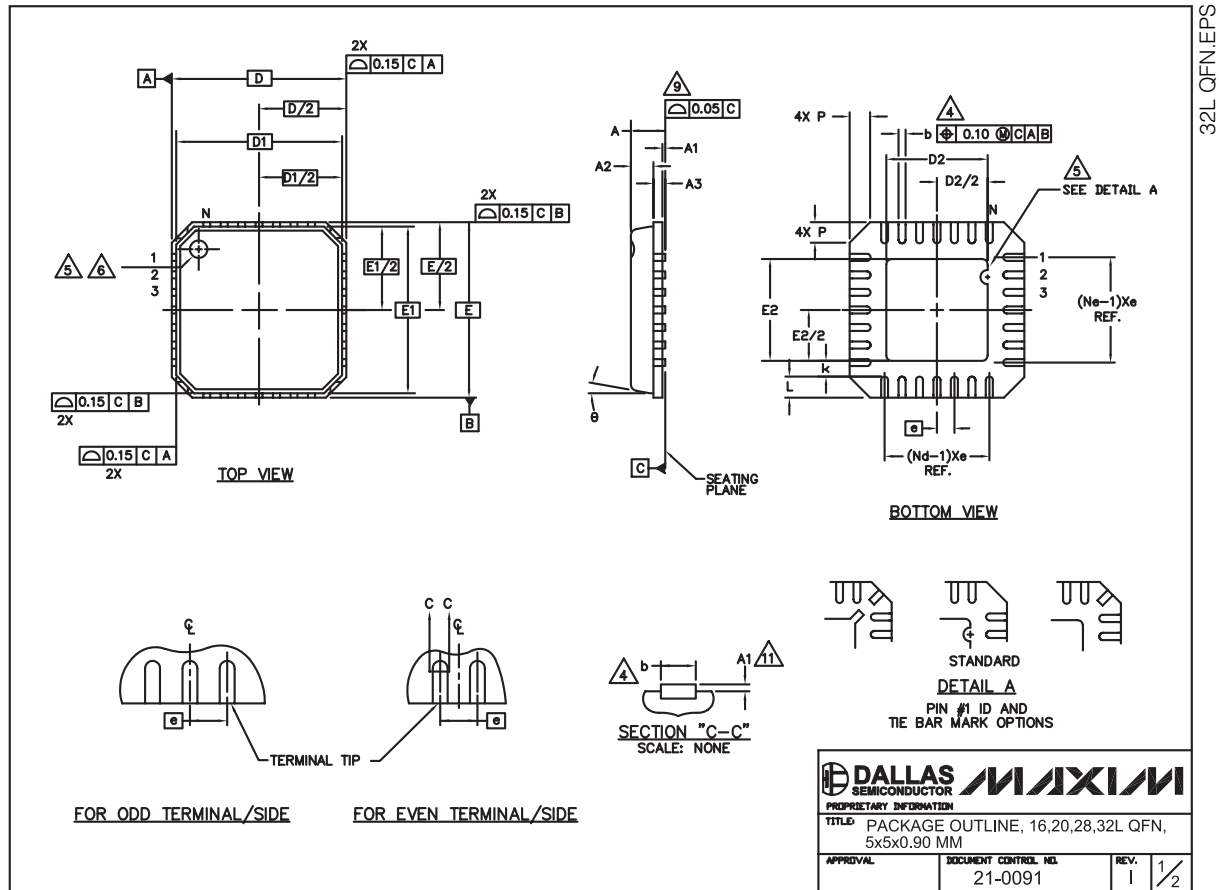


5x4 UCSP:EPS

# +1.2V to +3.6V, 0.1μA, 100Mbps, 8-Channel Level Translators

## Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)



**MAX3013-MAX3022**

# +1.2V to +3.6V, 0.1 $\mu$ A, 100Mbps, 8-Channel Level Translators

## Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)

| COMMON DIMENSIONS |          |      |      |          |      |      |          |      |      |          |      |      |
|-------------------|----------|------|------|----------|------|------|----------|------|------|----------|------|------|
| PKG               | 16L 5x5  |      |      | 20L 5x5  |      |      | 28L 5x5  |      |      | 32L 5x5  |      |      |
| SYMBOL            | MIN.     | NOM. | MAX. | MIN.     | NOM. | MAX. | MIN.     | NOM. | MAX. | MIN.     | NOM. | MAX. |
| A                 | 0.80     | 0.90 | 1.00 | 0.80     | 0.90 | 1.00 | 0.80     | 0.90 | 1.00 | 0.80     | 0.90 | 1.00 |
| A1                | 0.00     | 0.01 | 0.05 | 0.00     | 0.01 | 0.05 | 0.00     | 0.01 | 0.05 | 0.00     | 0.01 | 0.05 |
| A2                | 0.00     | 0.65 | 1.00 | 0.00     | 0.65 | 1.00 | 0.00     | 0.65 | 1.00 | 0.00     | 0.65 | 1.00 |
| A3                | 0.20 REF |      |      | 0.20 REF |      |      | 0.20 REF |      |      | 0.20 REF |      |      |
| b                 | 0.28     | 0.33 | 0.40 | 0.23     | 0.28 | 0.35 | 0.18     | 0.23 | 0.30 | 0.18     | 0.23 | 0.30 |
| D                 | 4.90     | 5.00 | 5.10 | 4.90     | 5.00 | 5.10 | 4.90     | 5.00 | 5.10 | 4.90     | 5.00 | 5.10 |
| D1                | 4.75 BSC |      |      | 4.75 BSC |      |      | 4.75 BSC |      |      | 4.75 BSC |      |      |
| E                 | 4.90     | 5.00 | 5.10 | 4.90     | 5.00 | 5.10 | 4.90     | 5.00 | 5.10 | 4.90     | 5.00 | 5.10 |
| E1                | 4.75 BSC |      |      | 4.75 BSC |      |      | 4.75 BSC |      |      | 4.75 BSC |      |      |
| e                 | 0.80 BSC |      |      | 0.65 BSC |      |      | 0.50 BSC |      |      | 0.50 BSC |      |      |
| k                 | 0.25     | —    | —    | 0.25     | —    | —    | 0.25     | —    | —    | 0.25     | —    | —    |
| L                 | 0.35     | 0.55 | 0.75 | 0.35     | 0.55 | 0.75 | 0.35     | 0.55 | 0.75 | 0.30     | 0.40 | 0.50 |
| N                 | 16       |      |      | 20       |      |      | 28       |      |      | 32       |      |      |
| ND                | 4        |      |      | 5        |      |      | 7        |      |      | 8        |      |      |
| NE                | 4        |      |      | 5        |      |      | 7        |      |      | 8        |      |      |
| P                 | 0.00     | 0.42 | 0.60 | 0.00     | 0.42 | 0.60 | 0.00     | 0.42 | 0.60 | 0.00     | 0.42 | 0.60 |
| ø                 | 0"       |      | 12"  | 0"       |      | 12"  | 0"       |      | 12"  | 0"       |      | 12"  |

| EXPOSED PAD VARIATIONS |      |      |      |      |      |      |
|------------------------|------|------|------|------|------|------|
| PKG. CODES             | D2   |      |      | E2   |      |      |
|                        | MIN. | NOM. | MAX. | MIN. | NOM. | MAX. |
| G1655-3                | 2.95 | 3.10 | 3.25 | 2.95 | 3.10 | 3.25 |
| G2055-1                | 2.55 | 2.70 | 2.85 | 2.55 | 2.70 | 2.85 |
| G2055-2                | 2.95 | 3.10 | 3.25 | 2.95 | 3.10 | 3.25 |
| G2855-1                | 2.55 | 2.70 | 2.85 | 2.55 | 2.70 | 2.85 |
| G2855-2                | 2.95 | 3.10 | 3.25 | 2.95 | 3.10 | 3.25 |
| G3255-1                | 2.95 | 3.10 | 3.25 | 2.95 | 3.10 | 3.25 |

### NOTES:

1. DIE THICKNESS ALLOWABLE IS 0.305mm MAXIMUM (.012 INCHES MAXIMUM)
2. DIMENSIONING & TOLERANCES CONFORM TO ASME Y14.5M. — 1994.
3. N IS THE NUMBER OF TERMINALS.  
Nd IS THE NUMBER OF TERMINALS IN X-DIRECTION & Ne IS THE NUMBER OF TERMINALS IN Y-DIRECTION.
4. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.20 AND 0.25mm FROM TERMINAL TIP.
5. THE PIN #1 IDENTIFIER MUST BE EXISTED ON THE TOP SURFACE OF THE PACKAGE BY USING INDENTATION MARK OR INK/LASER MARKED. DETAILS OF PIN #1 IDENTIFIER IS OPTIONAL, BUT MUST BE LOCATED WITHIN ZONE INDICATED.
6. EXACT SHAPE AND SIZE OF THIS FEATURE IS OPTIONAL.
7. ALL DIMENSIONS ARE IN MILLIMETERS.
8. PACKAGE WARPAGE MAX 0.05mm.
9. APPLIED FOR EXPOSED PAD AND TERMINALS. EXCLUDE EMBEDDED PART OF EXPOSED PAD FROM MEASURING.
10. MEETS JEDEC MO220; EXCEPT DIMENSION "b".
11. APPLIED FOR EXPOSED PAD AND TERMINALS. EXCLUDE EMBEDDING PART OF EXPOSED PAD FROM MEASURING.
12. THIS PACKAGE OUTLINE APPLIES TO ANVIL SINGULATION (STEPPED SIDES).

|                                                                                                                      |                                 |                                                                                       |     |
|----------------------------------------------------------------------------------------------------------------------|---------------------------------|---------------------------------------------------------------------------------------|-----|
|  <b>DALLAS</b><br>SEMICONDUCTOR |                                 |  |     |
| PROPRIETARY INFORMATION                                                                                              |                                 |                                                                                       |     |
| TITLE: PACKAGE OUTLINE, 16,20,28,32L QFN,<br>5x5x0.90 MM                                                             |                                 |                                                                                       |     |
| APPROVAL                                                                                                             | DOCUMENT CONTROL NO.<br>21-0091 | REV.<br>1                                                                             | 2/2 |

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