

# 1-2-4-Bit Bidirectional Voltage-Level Translator For Open-Drain Applications

## Features

- No Direction-Control Signal Needed
- Max Data Rates
  - 2 Mbps (Open Drain)
  - 24Mbps (Push-Pull)
- 1.65V to 3.6V on A port and 2.3V to 5.5V on B port ( $V_{CCA} \leq V_{CCB}$ )
- $V_{CC}$  Isolation Feature-If Either  $V_{CC}$  Input is at GND, Both Ports Are in the High-Impedance State
- No Power-Supply Sequencing Required-Either  $V_{CCA}$  or  $V_{CCB}$  Can Be Ramped First
- $I_{off}$  Supports Partial-Power-Down Mode Operation
- Latch-Up Performance Exceeds 100mA Per JESD 78, Class II
- ESD Protection Exceeds JESD 22
  - A Port
    - 2500V Human-Body Model (A114-B)
    - 250V Machine Model (A115-A)
    - 1500V Charged-Device Model (C101)
  - B Port
    - 8kV Human-Body Model (A114-B)
    - 250V Machine Model (A115-A)
    - 1500V Charged-Device Model (C101)
- ADFN1.0X1.4-8, ADFN3X2-8, AQFN1.7X2.0-12, SC-70-6 (SOT-363) and TSSOP-14 Package

## General Description

This two-bit non-inverting translator is a bidirectional voltage-level translator and can be used to establish digital switching compatibility between mixed-voltage systems. It uses two separate configurable power-supply rails, with the A ports supporting operating voltages from 1.65V to 3.6V while it tracks the  $V_{CCA}$  supply, and the B ports supporting operating voltages from 2.3V to 5.5V while it tracks the  $V_{CCB}$  supply. This allows the support of both lower and higher logic signal levels while providing bidirectional translation capabilities between any of the 1.8V, 2.5V, 3.3V, and 5V voltage nodes.

When the enable-output (EO) input is low, all I/Os are placed in the high-impedance state, which significantly reduces the power-supply quiescent current consumption.

To ensure the high-impedance state during power up or power down, EO 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.

## Applications

- I<sup>2</sup>C/SMBus
- UART
- GPIO

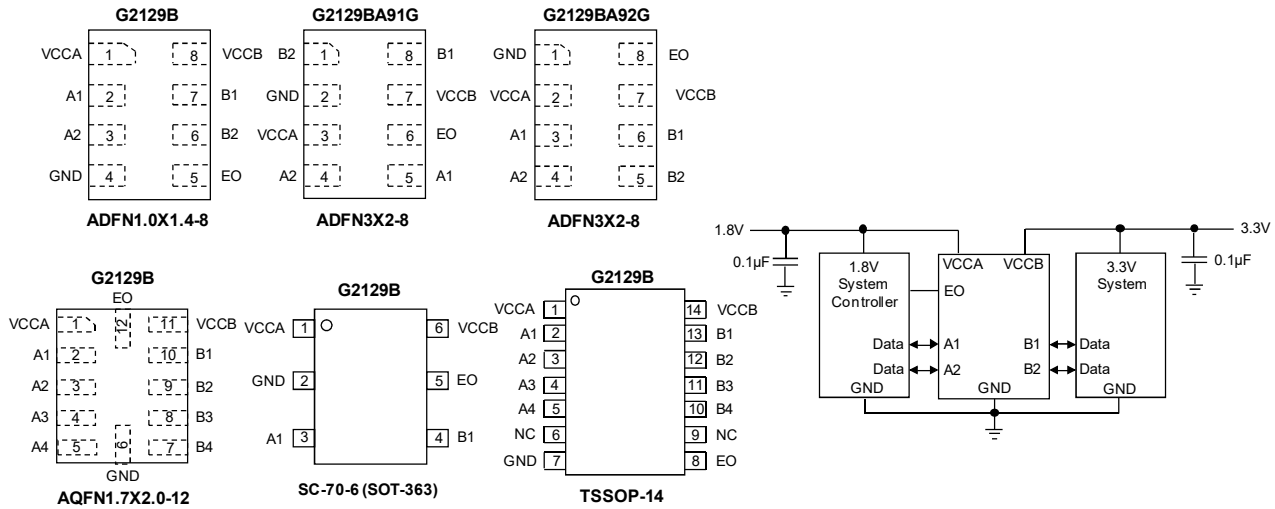
## Ordering Information

| ORDER NUMBER | MARKING | TEMP. RANGE    | PACKAGE (Green)   | REMARK   |
|--------------|---------|----------------|-------------------|----------|
| G2129BTL1U   | 29Bx    | -40°C to +85°C | SC-70-6 (SOT-363) | OBSOLETE |
| G2129BAJ1U   | 2Bx     | -40°C to +85°C | ADFN1.0X1.4-8     |          |
| G2129BA91G   | 2129B   | -40°C to +85°C | ADFN3X2-8         |          |
| G2129BA92G   | 219B2   | -40°C to +85°C | ADFN3X2-8         |          |
| G2129BAE1U   | 2129B   | -40°C to +85°C | AQFN1.7X2.0-12    |          |
| G2129BD21U   | G2129B  | -40°C to +85°C | TSSOP-14          |          |

Note: TL: SC-70-6 (SOT-363) AJ: ADFN1.0X1.4-8 AE: AQFN1.7X2.0-12 A9: ADFN3X2-8 D2:TSSOP-14  
 1&2: Bonding Code  
 U&G: Tape & Reel  
 Green : Lead Free / Halogen Free

## Pin Configuration

## Typical Application Circuit



## Absolute Maximum Ratings<sup>1</sup>

|                                                                                                     |                          |                                                            |                 |
|-----------------------------------------------------------------------------------------------------|--------------------------|------------------------------------------------------------|-----------------|
| Supply voltage range ( $V_{CCA}$ )                                                                  | -.0.5V to 4.6V           | Thermal Resistance Junction to Ambient, ( $\theta_{JA}$ )  |                 |
| Supply voltage range ( $V_{CCB}$ )                                                                  | -.0.5V to 6.5V           | SC-70-6 (SOT-363)                                          | .330°C/W        |
| Input voltage range ( $V_I$ ) <sup>2</sup>                                                          |                          | ADFN1.0X1.4-8.                                             | 380°C/W         |
| A port                                                                                              | -.0.5V to 4.6V           | ADFN3X2-8.                                                 | 165°C/W         |
| B port                                                                                              | -.0.5V to 6.5V           | AQFN1.7X2.0-12.                                            | 230°C/W         |
| Voltage range applied to any output in the high-impedance or power-off state ( $V_O$ ) <sup>2</sup> |                          | Continuous Power Dissipation ( $T_A = +25^\circ\text{C}$ ) |                 |
| A port.                                                                                             | -.0.5V to 4.6V           | SC-70-6 (SOT-363)                                          | 0.375W          |
| B port                                                                                              | -.0.5V to 6.5V           | ADFN1.0X1.4-8.                                             | 0.33W           |
| Voltage range applied to any output in the high or low state ( $V_O$ ) <sup>2,3</sup>               |                          | ADFN3X2-8.                                                 | 0.75W           |
| A port.                                                                                             | -.0.5V to $V_{CCA}+0.5V$ | AQFN1.7X2.0-12.                                            | 0.54W           |
| B port                                                                                              | -.0.5V to $V_{CCB}+0.5V$ | Thermal Resistance Junction to Case, ( $\theta_{JC}$ )     |                 |
| Input clamp current ( $I_{IK}$ ) ( $V_I < 0$ )                                                      | -50mA                    | SC-70-6 (SOT-363)                                          | 120°C/W         |
| Output clamp current ( $I_{OK}$ ) ( $V_O < 0$ )                                                     | -50mA                    | ADFN1.0X1.4-8.                                             | 140°C/W         |
| Continuous output current ( $I_O$ )                                                                 | $\pm 50\text{mA}$        | ADFN3X2-8.                                                 | 45°C/W          |
| Continuous current through $V_{CCA}$ , $V_{CCB}$ or GND                                             | $\pm 100\text{mA}$       | AQFN1.7X2.0-12.                                            | 70°C/W          |
|                                                                                                     |                          | Storage Temperature Range ( $T_{stg}$ )                    | -65°C to +150°C |

1. 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 specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.
2. The input and output negative-voltage ratings may be exceeded if the input and output current ratings are observed
3. The value of  $V_{CCA}$  and  $V_{CCB}$  are provided in the recommended operating conditions table.

## Thermal Information

| THERMAL METRIC <sup>(1)</sup> |                                              | G2129B    | UNIT |
|-------------------------------|----------------------------------------------|-----------|------|
|                               |                                              | TSSOP-14L |      |
| $R_{\theta JA}$               | Junction to ambient thermal resistance       | 182.7     | °C/W |
| $R_{\theta JC \text{ top}}$   | Junction to case top thermal resistance      | 92.0      | °C/W |
| $R_{\theta JB}$               | Junction to board thermal resistance         | 144.7     | °C/W |
| $\Psi_{JT}$                   | Junction to top characterization parameter   | 27.0      | °C/W |
| $\Psi_{JB}$                   | Junction to board characterization parameter | 144.3     | °C/W |
| $R_{\theta JC \text{ bot}}$   | Junction to case bottom thermal resistance   | N/A       | °C/W |

1. Package thermal metric is obtained using the method described in JEDEC specification JESD51-7, using a four-layer board.
2. The maximum power dissipation is  $P_{D(MAX)} = \frac{(T_{JMAX} - T_A)}{R_{\theta JA}}$ , Exceeding the maximum allowable power dissipation results in excessive die temperature, and the device will enter thermal shutdown.

## Recommended Operating Conditions (Level Translator)<sup>1,2</sup>

| PARAMETER                          | SYMBOL                        | CONDITIONS    | V <sub>CCA</sub> | V <sub>CCB</sub> | MIN                   | MAX                    | UNIT |
|------------------------------------|-------------------------------|---------------|------------------|------------------|-----------------------|------------------------|------|
| Supply voltage                     | V <sub>CCA</sub> <sup>3</sup> |               | ---              | ---              | 1.65                  | 3.6                    | V    |
|                                    | V <sub>CCB</sub>              |               | ---              | ---              | 2.3                   | 5.5                    |      |
| High-level input voltage           | V <sub>IH</sub>               | A-port I/Os   | 1.65V to 1.95V   | 2.3V to 5.5V     | V <sub>CCI</sub> -0.2 | V <sub>CCI</sub>       | V    |
|                                    |                               |               | 2.3V to 3.6V     |                  | V <sub>CCI</sub> -0.4 | V <sub>CCI</sub>       |      |
|                                    |                               | B-port I/Os   | 1.65V to 3.6V    | 2.3V to 5.5V     | V <sub>CCI</sub> -0.4 | V <sub>CCI</sub>       | V    |
|                                    |                               |               |                  |                  | EO input              | V <sub>CCA</sub> x0.65 |      |
| Low-level input voltage            | V <sub>IL</sub> <sup>4</sup>  | A-port I/Os   | 1.65V to 3.6V    | 2.3V to 5.5V     | 0                     | 0.15                   | V    |
|                                    |                               | B-port I/Os   |                  |                  | 0                     | 0.15                   |      |
|                                    |                               | EO input      |                  |                  | 0                     | V <sub>CCA</sub> x0.35 |      |
|                                    |                               |               |                  |                  |                       |                        |      |
| Input transition rise or fall rate | Δt/Δv                         | A-Port inputs | 1.65V to 3.6V    | 2.3V to 5.5V     | ---                   | 10                     | ns/V |
|                                    |                               | B-Port inputs |                  |                  | ---                   | 10                     |      |
|                                    |                               | Control input |                  |                  | ---                   | 10                     |      |
| Operating free-air temperature     | T <sub>A</sub>                |               | ---              | ---              | -40                   | 85                     | °C   |

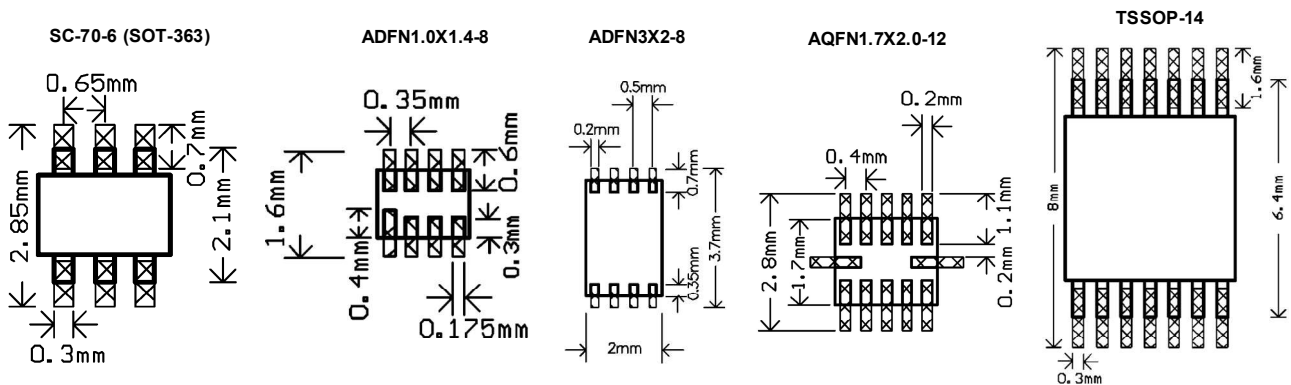
1. V<sub>CCI</sub> is the supply voltage associated with the input port.
2. V<sub>CCO</sub> is the supply voltage associated with the input port.
3. V<sub>CCA</sub> must be less than or equal to V<sub>CCB</sub> and V<sub>CCA</sub> must not exceed 3.6V.
4. The maximum V<sub>IL</sub> value is provided to ensure that a valid V<sub>OL</sub> is maintained. The V<sub>OL</sub> value is V<sub>IL</sub> plus the voltage drop across the pass-gate transistor.

**Electrical Characteristics**<sup>1,2,3</sup>

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

| PARAMETER                          | CONDITIONS                                                        | V <sub>CCA</sub>          | V <sub>CCB</sub> | MIN                    | TYP | MAX  | UNIT |
|------------------------------------|-------------------------------------------------------------------|---------------------------|------------------|------------------------|-----|------|------|
| V <sub>OHA</sub>                   | I <sub>OH</sub> = -20μA, V <sub>IB</sub> ≥ V <sub>CCB</sub> -0.4V | 1.65V to 3.6V             | 2.3V to 5.5V     | V <sub>CCA</sub> ×0.67 | --- | ---  | V    |
| V <sub>OLA</sub>                   | I <sub>OL</sub> = 1mA, V <sub>IB</sub> ≤ 0.15V                    | 1.65V to 3.6V             | 2.3V to 5.5V     | ---                    | --- | 0.4  | V    |
| V <sub>OHB</sub>                   | I <sub>OH</sub> = -20μA, V <sub>IA</sub> ≥ V <sub>CCA</sub> -0.2V | 1.65V to 3.6V             | 2.3V to 5.5V     | V <sub>CCA</sub> ×0.67 | --- | ---  | V    |
| V <sub>OLB</sub>                   | I <sub>OL</sub> = 1mA, V <sub>IA</sub> ≤ 0.15V                    | 1.65V to 3.6V             | 2.3V to 5.5V     | ---                    | --- | 0.4  | V    |
| I <sub>I</sub>                     | EO                                                                | 1.65V to 3.6V             | 2.3V to 5.5V     | ---                    | ±1  | ±2   | μA   |
| I <sub>off</sub>                   | A port                                                            | 0V                        | 0V to 5.5V       | ---                    | ±1  | ±2   | μA   |
|                                    | B port                                                            | 0 to 3.6V                 | 0V               | ---                    | ±1  | ±2   | μA   |
| I <sub>OZ</sub>                    | A or B port                                                       | EO = GND                  | 1.65V to 3.6V    | ---                    | ±1  | ±2   | μA   |
| I <sub>CCA</sub>                   | V <sub>I</sub> =V <sub>O</sub> =open, I <sub>O</sub> =0           | 1.65V to V <sub>CCB</sub> | 2.3V to 5.5V     | ---                    | --- | 2.4  | μA   |
|                                    |                                                                   | 3.6V                      | 0V               | ---                    | --- | 2.2  | μA   |
|                                    |                                                                   | 0V                        | 5.5V             | ---                    | --- | -1   | μA   |
| I <sub>CCB</sub>                   | V <sub>I</sub> =V <sub>O</sub> =open, I <sub>O</sub> =0           | 1.65V to V <sub>CCB</sub> | 2.3V to 5.5V     | ---                    | --- | 12   | μA   |
|                                    |                                                                   | 3.6V                      | 0V               | ---                    | --- | -1   | μA   |
|                                    |                                                                   | 0V                        | 5.5V             | ---                    | --- | 1    | μA   |
| I <sub>CCA</sub> +I <sub>CCB</sub> | V <sub>I</sub> =V <sub>CCI</sub> or GND, I <sub>O</sub> =0        | 1.65V to V <sub>CCB</sub> | 2.3V to 5.5V     | ---                    | --- | 14.4 | μA   |
| C <sub>i</sub>                     | EO                                                                | 3.3V                      | 3.3V             | ---                    | 2.5 | 3.5  | pF   |
| C <sub>io</sub>                    | A or B port                                                       | 3.3V                      | 3.3V             | ---                    | 10  | ---  | pF   |
|                                    | A port                                                            |                           |                  | ---                    | 5   | 6    |      |
|                                    | B port                                                            |                           |                  | ---                    | 6   | 7.5  |      |

1. V<sub>CCI</sub> is the V<sub>CC</sub> associated with the input port.
2. V<sub>CCO</sub> is the V<sub>CC</sub> associated with the output port.
3. V<sub>CCA</sub> must be less than or equal to V<sub>CCB</sub>, and V<sub>CCA</sub> must not exceed 3.6V

**Minimum Footprint PCB Layout Section**


## Pin Description

| PIN  |      |      |      |      |      | NAME | FUNCTION                                                                                   |
|------|------|------|------|------|------|------|--------------------------------------------------------------------------------------------|
| TL1U | AJ1U | A91G | A92G | AE1U | D21U |      |                                                                                            |
| 1    | 1    | 3    | 2    | 1    | 1    | VCCA | A-port supply voltage. $1.65V \leq V_{CCA} \leq 3.6V$ and $V_{CCA} \leq V_{CCB}$           |
| 2    | 4    | 2    | 1    | 6    | 7    | GND  | Ground                                                                                     |
| 3    | 2    | 5    | 3    | 2    | 2    | A1   | Input/output A1. Referenced to $V_{CCA}$ .                                                 |
| ---  | 3    | 4    | 4    | 3    | 3    | A2   | Input/output A2. Referenced to $V_{CCA}$ .                                                 |
| ---  | ---  | ---  | ---  | 4    | 4    | A3   | Input/output A3. Referenced to $V_{CCA}$ .                                                 |
| ---  | ---  | ---  | ---  | 5    | 5    | A4   | Input/output A4. Referenced to $V_{CCA}$ .                                                 |
| ---  | ---  | ---  | ---  | 7    | 10   | B4   | Input/output B4. Referenced to $V_{CCB}$ .                                                 |
| ---  | ---  | ---  | ---  | ---  | 6,9  | NC   | No Connection                                                                              |
| 5    | 5    | 6    | 8    | 12   | 8    | EO   | Output enable. Pull EO low to place all outputs in 3-state mode. Referenced to $V_{CCA}$ . |
| ---  | ---  | ---  | ---  | 8    | 11   | B3   | Input/output B3. Referenced to $V_{CCB}$ .                                                 |
| ---  | 6    | 1    | 5    | 9    | 12   | B2   | Input/output B2. Referenced to $V_{CCB}$ .                                                 |
| 4    | 7    | 8    | 6    | 10   | 13   | B1   | Input/output B1. Referenced to $V_{CCB}$ .                                                 |
| 6    | 8    | 7    | 7    | 11   | 14   | VCCB | B-port supply voltage. $1.65V \leq V_{CCB} \leq 5.5V$                                      |

## Timing Requirements

over recommended operating free-air temperature range,  $V_{CCA}=1.8V \pm 0.15V$  (unless otherwise noted)

|                |                    |       |             | $V_{CCB}=2.5V$<br>$\pm 0.2V$ |     | $V_{CCB}=3.3V$<br>$\pm 0.3V$ |     | $V_{CCB}=5.5V$<br>$\pm 0.5V$ |     | UNIT |
|----------------|--------------------|-------|-------------|------------------------------|-----|------------------------------|-----|------------------------------|-----|------|
|                |                    |       |             | MIN                          | MAX | MIN                          | MAX | MIN                          | MAX |      |
| Data rate      | Open-drain driving |       |             | ---                          | 2   | ---                          | 2   | ---                          | 2   | Mbps |
|                | Push-pull driving  |       |             | ---                          | 21  | ---                          | 22  | ---                          | 24  |      |
| Pulse duration | Open-drain driving | $t_w$ | Data inputs | 500                          | --- | 500                          | --- | 500                          | --- | ns   |
|                | Push-pull driving  |       |             | 47                           | --- | 45                           | --- | 41                           | --- |      |

over recommended operating free-air temperature range,  $V_{CCA}=2.5V \pm 0.2V$  (unless otherwise noted)

|                |                    |       |             | $V_{CCB}=2.5V$<br>$\pm 0.2V$ |     | $V_{CCB}=3.3V$<br>$\pm 0.3V$ |     | $V_{CCB}=5.5V$<br>$\pm 0.5V$ |     | UNIT |
|----------------|--------------------|-------|-------------|------------------------------|-----|------------------------------|-----|------------------------------|-----|------|
|                |                    |       |             | MIN                          | MAX | MIN                          | MAX | MIN                          | MAX |      |
| Data rate      | Open-drain driving |       |             | ---                          | 2   | ---                          | 2   | ---                          | 2   | Mbps |
|                | Push-pull driving  |       |             | ---                          | 20  | ---                          | 22  | ---                          | 24  |      |
| Pulse duration | Open-drain driving | $t_w$ | Data inputs | 500                          | --- | 500                          | --- | 500                          | --- | ns   |
|                | Push-pull driving  |       |             | 50                           | --- | 45                           | --- | 41                           | --- |      |

over recommended operating free-air temperature range,  $V_{CCA}=3.3V \pm 0.3V$  (unless otherwise noted)

|                |                    |       |             | $V_{CCB}=3.3V$<br>$\pm 0.3V$ |     | $V_{CCB}=5.5V$<br>$\pm 0.5V$ |     | UNIT |
|----------------|--------------------|-------|-------------|------------------------------|-----|------------------------------|-----|------|
|                |                    |       |             | MIN                          | MAX | MIN                          | MAX |      |
| Data rate      | Open-drain driving |       |             | ---                          | 2   | ---                          | 2   | Mbps |
|                | Push-pull driving  |       |             | ---                          | 23  | ---                          | 24  |      |
| Pulse duration | Open-drain driving | $t_w$ | Data inputs | 500                          | --- | 500                          | --- | ns   |
|                | Push-pull driving  |       |             | 43                           | --- | 41                           | --- |      |

## Switching Characteristics

over recommended operating free-air temperature range,  $V_{CCA}=1.8V \pm 0.15V$  (unless otherwise noted)

| PARAMETER     | FROM (INPUT)            | TO (OUTPUT) | Test Conditions    | $V_{CCB}=2.5V \pm 0.2V$ |      | $V_{CCB}=3.3V \pm 0.3V$ |      | $V_{CCB}=5.0V \pm 0.5V$ |      | UNIT |
|---------------|-------------------------|-------------|--------------------|-------------------------|------|-------------------------|------|-------------------------|------|------|
|               |                         |             |                    | MIN                     | MAX  | MIN                     | MAX  | MIN                     | MAX  |      |
| $t_{PHL}$     | A                       | B           | Open-drain driving | 2.3                     | 8.8  | 2.4                     | 9.6  | 2.6                     | 10   | ns   |
|               |                         |             | Push-pull driving  | ---                     | 5.3  | ---                     | 5.4  | ---                     | 6.8  |      |
| $t_{PLH}$     |                         |             | Open-drain driving | 45                      | 260  | 36                      | 208  | 27                      | 198  |      |
|               |                         |             | Push-pull driving  | ---                     | 6.8  | ---                     | 7.1  | ---                     | 7.5  |      |
| $t_{PHL}$     | B                       | A           | Open-drain driving | 1.9                     | 5.3  | 1.1                     | 4.4  | 1.2                     | 4    | ns   |
|               |                         |             | Push-pull driving  | ---                     | 4.4  | ---                     | 4.5  | ---                     | 4.7  |      |
| $t_{PLH}$     |                         |             | Open-drain driving | 45                      | 175  | 36                      | 140  | 27                      | 102  |      |
|               |                         |             | Push-pull driving  | ---                     | 5.3  | ---                     | 4.5  | ---                     | 0.5  |      |
| $t_{en}$      | EO                      | A or B      |                    | ---                     | 200  | ---                     | 200  | ---                     | 200  | ns   |
| $t_{dis}$     | EO                      | A or B      |                    | ---                     | 50   | ---                     | 40   | ---                     | 35   | ns   |
| $t_{rA}$      | A-port rise time        |             | Open-drain driving | 38                      | 165  | 30                      | 132  | 22                      | 95   | ns   |
|               |                         |             | Push-pull driving  | 3.2                     | 9.5  | 2.3                     | 9.3  | 2                       | 7.6  |      |
| $t_{rB}$      | B-port rise time        |             | Open-drain driving | 34                      | 145  | 23                      | 106  | 10                      | 58   | ns   |
|               |                         |             | Push-pull driving  | 4                       | 10.8 | 2.7                     | 9.1  | 2.7                     | 7.6  |      |
| $t_{fA}$      | A-port fall time        |             | Open-drain driving | 4.4                     | 6.9  | 4.3                     | 6.4  | 4.2                     | 6.1  | ns   |
|               |                         |             | Push-pull driving  | 2                       | 5.9  | 1.9                     | 6    | 1.7                     | 13.3 |      |
| $t_{fB}$      | B-port fall time        |             | Open-drain driving | 6.9                     | 13.8 | 7.5                     | 16.2 | 7                       | 16.2 | ns   |
|               |                         |             | Push-pull driving  | 2.9                     | 13.8 | 2.8                     | 16.2 | 2.8                     | 16.2 |      |
| $t_{SK(O)}$   | Channel-to-channel skew |             |                    | ---                     | 0.7  | ---                     | 0.7  | ---                     | 0.7  | ns   |
| Max data rate |                         |             | Open-drain driving | 2                       | ---  | 2                       | ---  | 2                       | ---  | Mbps |
|               |                         |             | Push-pull driving  | 21                      | ---  | 22                      | ---  | 24                      | ---  |      |

over recommended operating free-air temperature range,  $V_{CCA}=2.5V \pm 0.2V$  (unless otherwise noted)

| PARAMETER     | FROM (INPUT)            | TO (OUTPUT) | Test Conditions    | $V_{CCB}=2.5V \pm 0.2V$ |     | $V_{CCB}=3.3V \pm 0.3V$ |     | $V_{CCB}=5.0V \pm 0.5V$ |      | UNIT |
|---------------|-------------------------|-------------|--------------------|-------------------------|-----|-------------------------|-----|-------------------------|------|------|
|               |                         |             |                    | MIN                     | MAX | MIN                     | MAX | MIN                     | MAX  |      |
| $t_{PHL}$     | A                       | B           | Open-drain driving | 1.7                     | 6.3 | 2                       | 6   | 2.1                     | 5.8  | ns   |
|               |                         |             | Push-pull driving  | ---                     | 3.2 | ---                     | 3.7 | ---                     | 3.8  |      |
| $t_{PLH}$     |                         |             | Open-drain driving | 43                      | 250 | 36                      | 206 | 27                      | 190  |      |
|               |                         |             | Push-pull driving  | ---                     | 3.5 | ---                     | 4.1 | ---                     | 4.4  |      |
| $t_{PHL}$     | B                       | A           | Open-drain driving | 1.8                     | 4.7 | 2.6                     | 4.2 | 1.2                     | 4    | ns   |
|               |                         |             | Push-pull driving  | ---                     | 3   | ---                     | 3.6 | ---                     | 4.3  |      |
| $t_{PLH}$     |                         |             | Open-drain driving | 44                      | 170 | 37                      | 140 | 27                      | 103  |      |
|               |                         |             | Push-pull driving  | ---                     | 2.5 | ---                     | 1.6 | ---                     | 1    |      |
| $t_{en}$      | EO                      | A or B      |                    | ---                     | 200 | ---                     | 200 | ---                     | 200  | ns   |
| $t_{dis}$     | EO                      | A or B      |                    | ---                     | 50  | ---                     | 40  | ---                     | 35   | ns   |
| $t_{rA}$      | A-port rise time        |             | Open-drain driving | 34                      | 149 | 28                      | 121 | 24                      | 89   | ns   |
|               |                         |             | Push-pull driving  | 2.8                     | 7.4 | 2.6                     | 6.6 | 1.8                     | 5.6  |      |
| $t_{rB}$      | B-port rise time        |             | Open-drain driving | 35                      | 151 | 24                      | 112 | 12                      | 64   | ns   |
|               |                         |             | Push-pull driving  | 3.2                     | 8.3 | 2.9                     | 7.2 | 2.4                     | 6.1  |      |
| $t_{fA}$      | A-port fall time        |             | Open-drain driving | 4.4                     | 6.9 | 4.3                     | 6.2 | 4.2                     | 5.8  | ns   |
|               |                         |             | Push-pull driving  | 1.9                     | 5.7 | 1.9                     | 5.5 | 1.8                     | 5.3  |      |
| $t_{fB}$      | B-port fall time        |             | Open-drain driving | 5.1                     | 8.8 | 5.4                     | 9.4 | 5.4                     | 10.4 | ns   |
|               |                         |             | Push-pull driving  | 2.2                     | 7.8 | 2.4                     | 6.7 | 2.6                     | 6.6  |      |
| $t_{SK(O)}$   | Channel-to-channel skew |             |                    | ---                     | 0.7 | ---                     | 0.7 | ---                     | 0.7  | ns   |
| Max data rate |                         |             | Open-drain driving | 2                       | --- | 2                       | --- | 2                       | ---  | Mbps |
|               |                         |             | Push-pull driving  | 20                      | --- | 22                      | --- | 24                      | ---  |      |

over recommended operating free-air temperature range,  $V_{CCA}=3.3V \pm 0.3V$  (unless otherwise noted)

| PARAMETER          | FROM (INPUT)            | TO (OUTPUT) | Test Conditions    | V <sub>CCB</sub> =3.3V<br>±0.3V |     | V <sub>CCB</sub> =5.V<br>±0.5V |     | UNIT |
|--------------------|-------------------------|-------------|--------------------|---------------------------------|-----|--------------------------------|-----|------|
|                    |                         |             |                    | MIN                             | MAX | MIN                            | MAX |      |
| t <sub>PHL</sub>   | A                       | B           | Open-drain driving | 1.3                             | 4.2 | 1.4                            | 4.6 | ns   |
| t <sub>PLH</sub>   |                         |             | Push-pull driving  | ---                             | 2.4 | ---                            | 3.1 |      |
|                    |                         |             | Open-drain driving | 36                              | 204 | 28                             | 165 |      |
|                    |                         |             | Push-pull driving  | ---                             | 4.2 | ---                            | 4.4 |      |
| t <sub>PHL</sub>   | B                       | A           | Open-drain driving | 1                               | 124 | 1                              | 97  | ns   |
| t <sub>PLH</sub>   |                         |             | Push-pull driving  | ---                             | 2.5 | ---                            | 3.3 |      |
|                    |                         |             | Open-drain driving | 3                               | 139 | 3                              | 105 |      |
|                    |                         |             | Push-pull driving  | ---                             | 2.5 | ---                            | 2.6 |      |
| t <sub>en</sub>    | EO                      | A or B      |                    | ---                             | 200 | ---                            | 200 | ns   |
| t <sub>dis</sub>   | EO                      | A or B      |                    | ---                             | 40  | ---                            | 35  | ns   |
| t <sub>rA</sub>    | A-port rise time        |             | Open-drain driving | 25                              | 116 | 19                             | 85  | ns   |
|                    |                         |             | Push-pull driving  | 2.3                             | 5.6 | 1.9                            | 4.8 |      |
| t <sub>rB</sub>    | B-port rise time        |             | Open-drain driving | 26                              | 116 | 14                             | 72  | ns   |
|                    |                         |             | Push-pull driving  | 2.5                             | 6.4 | 2.1                            | 7.4 |      |
| t <sub>fA</sub>    | A-port fall time        |             | Open-drain driving | 4.3                             | 6.1 | 4.2                            | 5.7 | ns   |
|                    |                         |             | Push-pull driving  | 2                               | 5.4 | 1.9                            | 5   |      |
| t <sub>fB</sub>    | B-port fall time        |             | Open-drain driving | 5                               | 7.6 | 4.8                            | 8.3 | ns   |
|                    |                         |             | Push-pull driving  | 2.3                             | 7.4 | 2.4                            | 7.6 |      |
| t <sub>SK(O)</sub> | Channel-to-channel skew |             |                    | ---                             | 0.7 | ---                            | 0.7 | ns   |
| Max data rate      |                         |             | Open-drain driving | 2                               | --- | 2                              | --- | Mbps |
|                    |                         |             | Push-pull driving  | 23                              | --- | 24                             | --- |      |

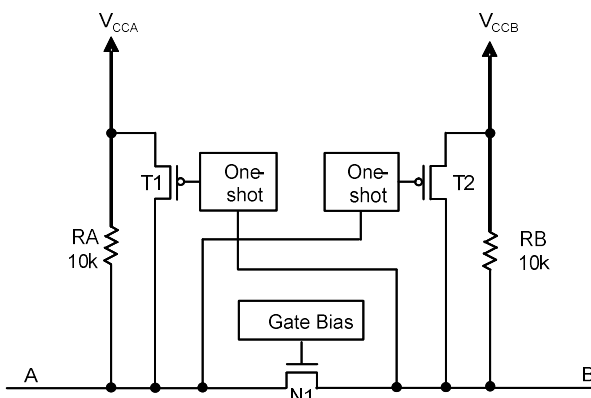
## Principles of Operation

### Applications

The G2129B can be used to bridge the digital-switching compatibility gap between two voltage nodes to successfully interface logic threshold levels found in electronic systems. It should be used in a point-to-point topology for interfacing devices or systems operating at different interface voltages with one another. Its primary target application use is for interfacing with open-drain drivers on the data I/Os such as I<sup>2</sup>C or 1-wire, where the data is bidirectional and no control signal is available. The G2129B can also be used in applications where a push-pull driver is connected to the data I/Os, **but we strong recommend that the G2129 is a better option for such push-pull applications.**

### Architecture

The G2129B architecture (see Figure 1) is an auto-direction-sensing based translator that does not require a direction-control signal to control the direction of data flow from A to B or from B to A.



**Figure 1 Architecture of a G2129B Cell**

These two bidirectional channels independently determine the direction of data flow without a direction-control signal. Each I/O pin can be automatically reconfigured as either an input or an output, which is how this auto-direction feature is realized.

The G2129B is part of GMT's "Switch" type voltage translator family and employs two key circuits to enable this voltage translation:

- 1) An N-channel pass-gate transistor (N1) topology that ties the A-port to the B-port.  
and
- 2) Output one-shot (O.S.) edge-rate accelerator circuitry to detect and accelerate rising edges on the A or B ports

For bidirectional voltage translation, pull-up resistors are included on the device for dc current sourcing capability. The  $V_{GATE}$  gate bias of the N-channel pass transistor is set at approximately one threshold voltage

( $V_T$ ) above the  $V_{CC}$  level of the low-voltage side. Data can flow in either direction without guidance from a control signal.

The O.S. rising-edge rate accelerator circuitry speeds up the output slew rate by monitoring the input edge for transitions, helping maintain the data rate through the device. During a low-to-high signal rising edge, the O.S. circuits turn on the PMOS transistors (T1, T2) to increase the current drive capability of the driver for approximately 30 ns or 95% of the input edge, whichever occurs first. This edge-rate acceleration provides high ac drive by bypassing the internal 10k $\Omega$  pull-up resistors during the low-to-high transition to speed up the signal. The output resistance of the driver is decreased to approximately 50 $\Omega$  to 70 $\Omega$  during this acceleration phase. To minimize dynamic ICC and the possibility of signal contention, the user should wait for the O.S. circuit to turn-off before applying a signal in the opposite direction. The worst-case duration is equal to the minimum pulse-width number provided in the Timing Requirements section of this data sheet.

### 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 G2129B I/O pins. Since 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-Amps, as determined by the internal 10k $\Omega$  pullup resistors.

The fall time ( $t_{fA}$ ,  $t_{fB}$ ) of a signal depends on the edge-rate and output impedance of the external device driving G2129B data I/Os, as well as the capacitive loading on the data lines.

Similarly, the  $t_{PHL}$  and max 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

GMT recommends careful PCB layout practices with short PCB trace lengths to avoid excessive capacitive loading and to ensure that proper O.S. 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 O.S. circuits have been designed to stay on for approximately 30ns. 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 O.S. duration has been set to best optimize trade-offs between dynamic  $I_{CC}$ , load driving capability, and maximum bit-rate considerations. Both PCB trace length and connectors add to the capacitance that the G2129B output sees, so it is recommended that this lumped-load capacitance be considered to avoid O.S. retriggering, bus contention, output signal oscillations, or other adverse system-level affects.

#### Power Up

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.

#### Enable and Disable

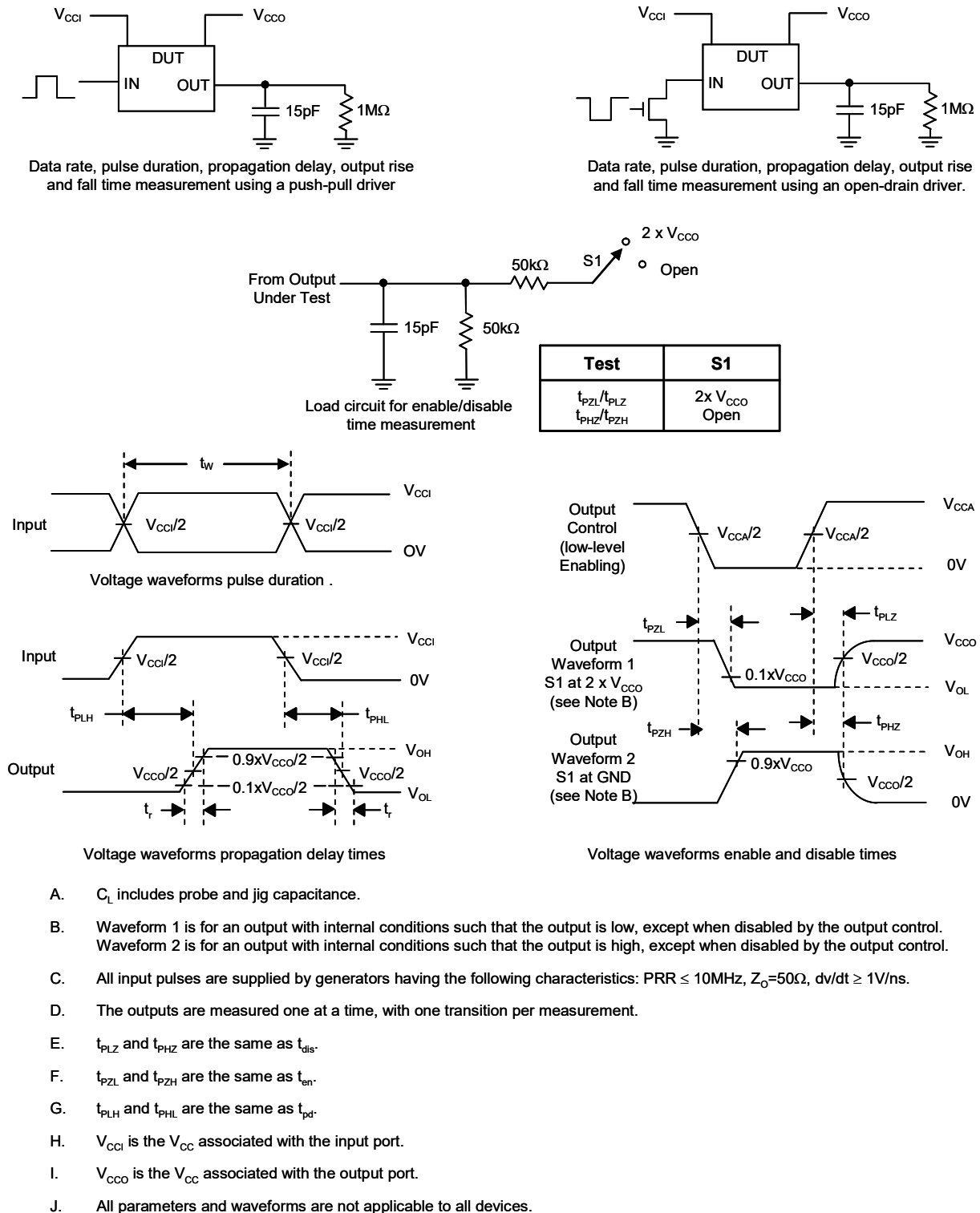
The G2129B has an EO input that is used to disable the device by setting EO low, which places all I/Os in the Hi-Z stage. The disable time ( $t_{dis}$ ) indicates the

delay between the time when EO goes low and when the outputs are disabled (Hi-Z). The enable time ( $t_{en}$ ) indicates the amount of time the user must allow for the one-shot circuitry to become operational after EO is taken high.

#### Pullup or Pulldown Resistors on I/O Lines

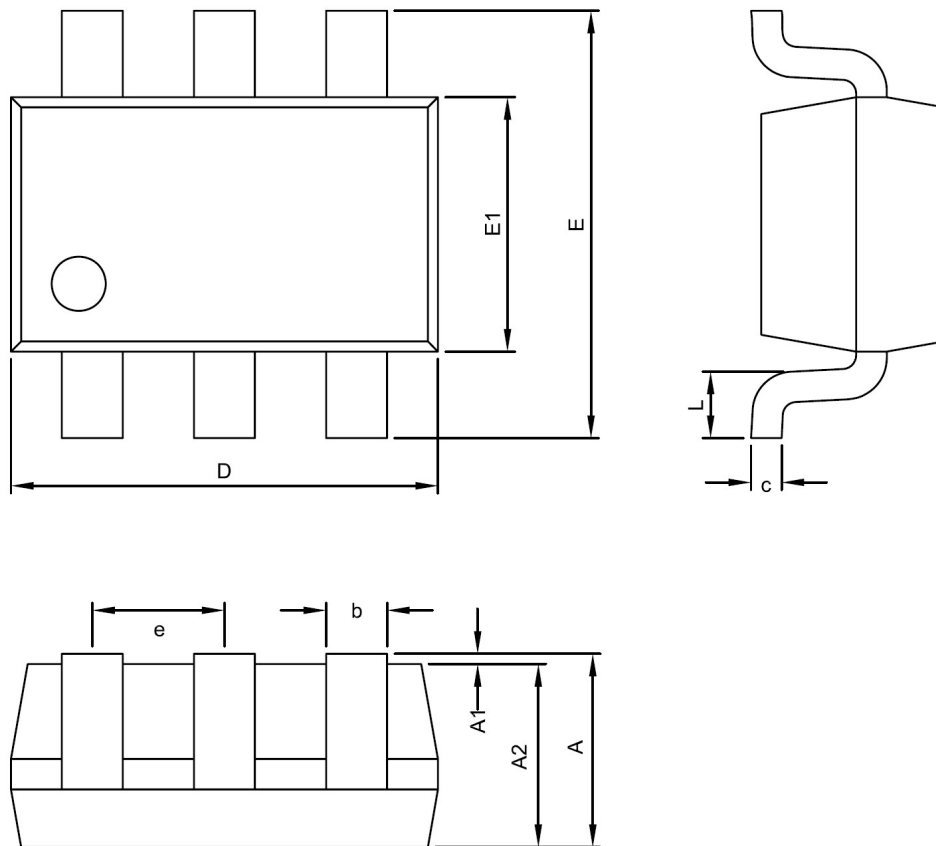
Each A-port I/O has an internal  $10k\Omega$  pullup resistor to  $V_{CCA}$ , and each B-port I/O has an internal  $10k\Omega$  pullup resistor to  $V_{CCB}$ . If a smaller value of pullup resistor is required, an external resistor must be added from the I/O to  $V_{CCA}$  or  $V_{CCB}$  (in parallel with the internal  $10k\Omega$  resistors). Adding lower value pull-up resistors will effect  $V_{OL}$  levels, however. The internal pull-ups of the G2129B are disabled when the EO pin is low. Besides, either A-port or B-port is prohibiting connecting to the device with Source Ability.

## Parameter Measurement Information



**Figure 2. Load Circuit and Voltage Waveforms**

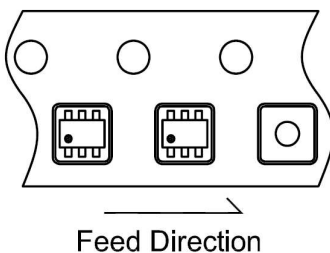
## Package Information



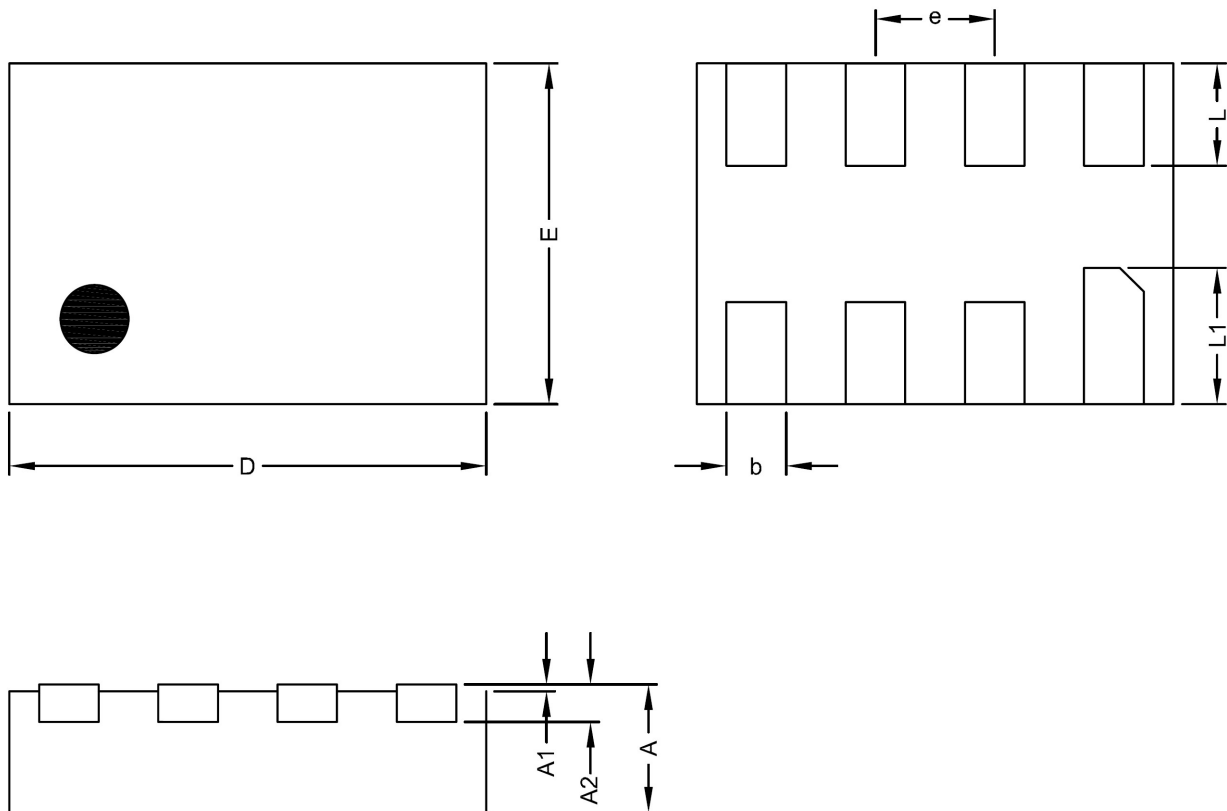
SC-70-6 (SOT-363) Package

| Symbol | DIMENSION IN MM |      |      | DIMENSION IN INCH |       |       |
|--------|-----------------|------|------|-------------------|-------|-------|
|        | MIN.            | NOM. | MAX. | MIN.              | NOM.  | MAX.  |
| A      | 0.80            | 0.95 | 1.10 | 0.031             | 0.037 | 0.043 |
| A1     | 0.00            | ---  | 0.10 | 0.000             | ---   | 0.004 |
| A2     | 0.70            | 0.90 | 1.00 | 0.028             | 0.035 | 0.039 |
| D      | 1.80            | 2.00 | 2.20 | 0.071             | 0.079 | 0.087 |
| E      | 1.80            | 2.10 | 2.40 | 0.071             | 0.083 | 0.094 |
| E1     | 1.15            | 1.25 | 1.35 | 0.045             | 0.049 | 0.053 |
| c      | 0.08            | 0.15 | 0.25 | 0.003             | 0.006 | 0.010 |
| b      | 0.15            | 0.25 | 0.30 | 0.006             | 0.010 | 0.012 |
| e      | 0.65 BSC        |      |      | 0.026 BSC         |       |       |
| L      | 0.26            | 0.36 | 0.46 | 0.010             | 0.014 | 0.018 |

## Taping Specification



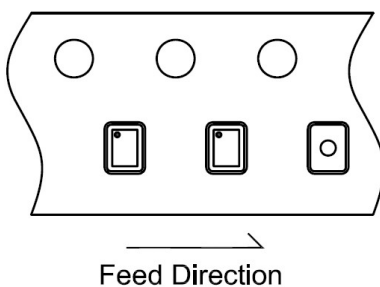
| PACKAGE           | Q'TY/REEL |
|-------------------|-----------|
| SC-70-6 (SOT-363) | 3,000 ea  |



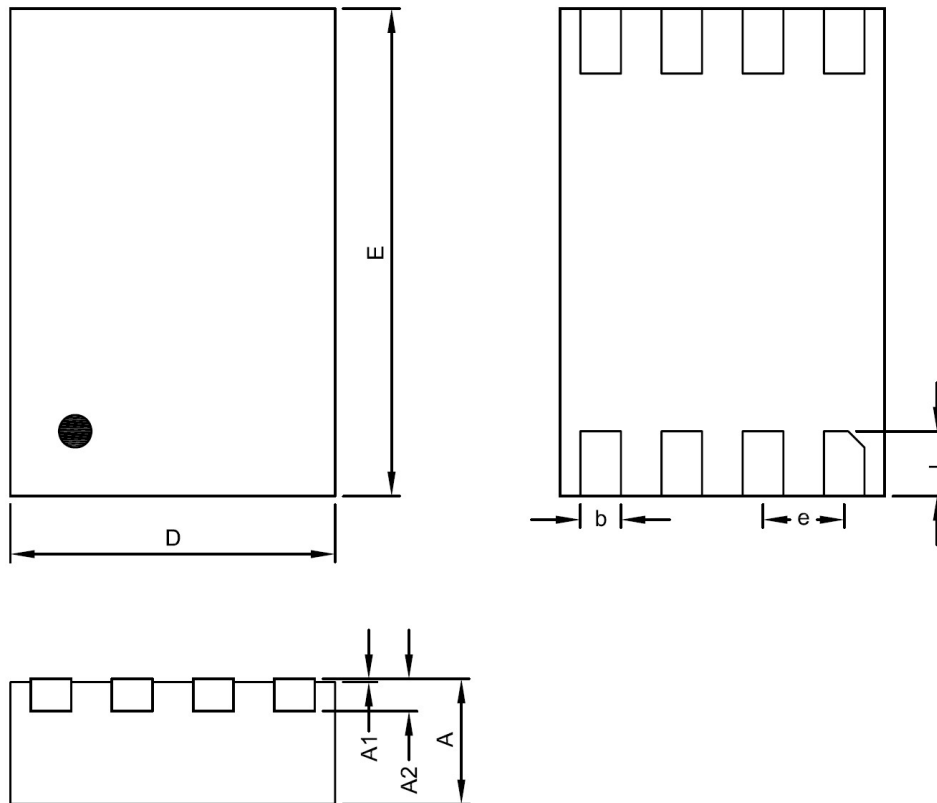
ADFN1.0X1.4-8 Package

| Symbol | DIMENSION IN MM |       |       | DIMENSION IN INCH |        |        |
|--------|-----------------|-------|-------|-------------------|--------|--------|
|        | MIN.            | NOM.  | MAX.  | MIN.              | NOM.   | MAX.   |
| A      | 0.325           | 0.375 | 0.425 | 0.0128            | 0.0148 | 0.0167 |
| A1     | 0.00            | ---   | 0.05  | 0.0000            | ---    | 0.0020 |
| A2     | 0.12 BSC        |       |       | 0.0047 BSC        |        |        |
| D      | 1.35            | 1.40  | 1.45  | 0.0531            | 0.0551 | 0.0570 |
| E      | 0.95            | 1.00  | 1.05  | 0.0374            | 0.0394 | 0.0413 |
| b      | 0.125           | 0.175 | 0.225 | 0.0049            | 0.0069 | 0.0089 |
| e      | 0.35 BSC        |       |       | 0.0138 BSC        |        |        |
| L      | 0.25            | 0.30  | 0.35  | 0.0098            | 0.0118 | 0.0138 |
| L1     | 0.35            | 0.40  | 0.45  | 0.0138            | 0.0157 | 0.0177 |

## Taping Specification



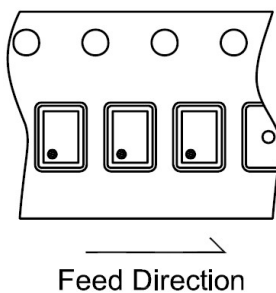
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|---------------|-----------|
| ADFN1.0X1.4-8 | 3,000 ea  |



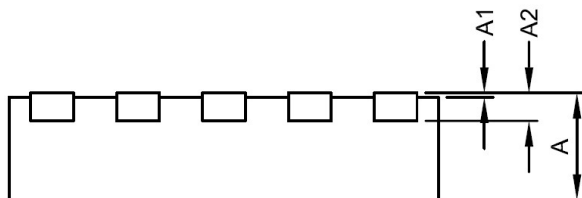
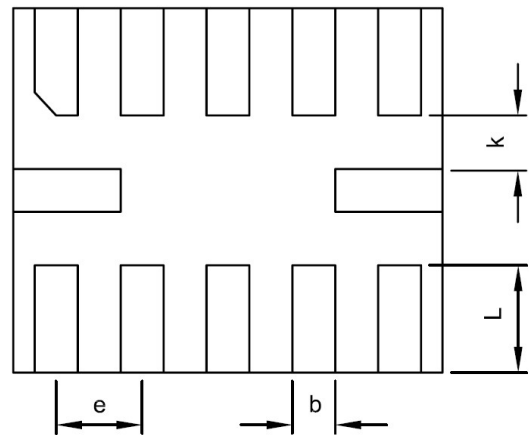
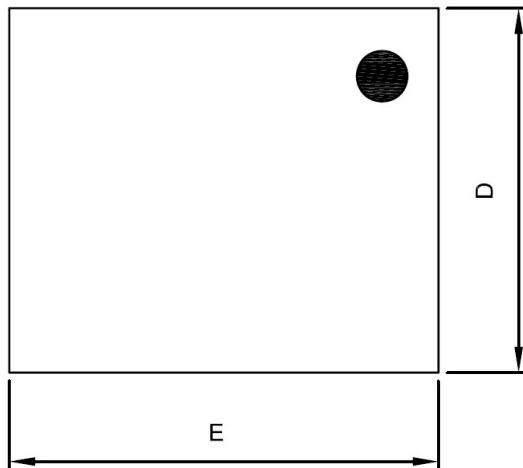
**ADFN3X2-8 Package**

| Symbol | DIMENSION IN MM |      |      | DIMENSION IN INCH |        |        |
|--------|-----------------|------|------|-------------------|--------|--------|
|        | MIN.            | NOM. | MAX. | MIN.              | NOM.   | MAX.   |
| A      | 0.70            | 0.75 | 0.80 | 0.0276            | 0.0295 | 0.0315 |
| A1     | 0.00            | ---  | 0.05 | 0.0000            | ---    | 0.0020 |
| A2     | 0.20 REF        |      |      | 0.0079 REF        |        |        |
| D      | 1.95            | 2.00 | 2.05 | 0.0768            | 0.0787 | 0.0807 |
| E      | 2.95            | 3.00 | 3.05 | 0.1161            | 0.1181 | 0.1201 |
| b      | 0.20            | 0.25 | 0.30 | 0.0079            | 0.0098 | 0.0118 |
| e      | 0.50 BSC        |      |      | 0.0197 BSC        |        |        |
| L      | 0.35            | 0.40 | 0.45 | 0.0138            | 0.0157 | 0.0177 |

## Taping Specification



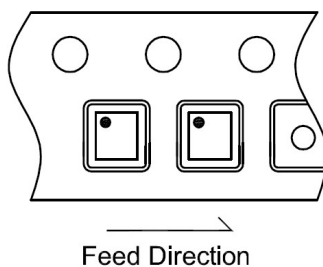
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|-----------|-----------|
| ADFN3X2-8 | 3,000 ea  |



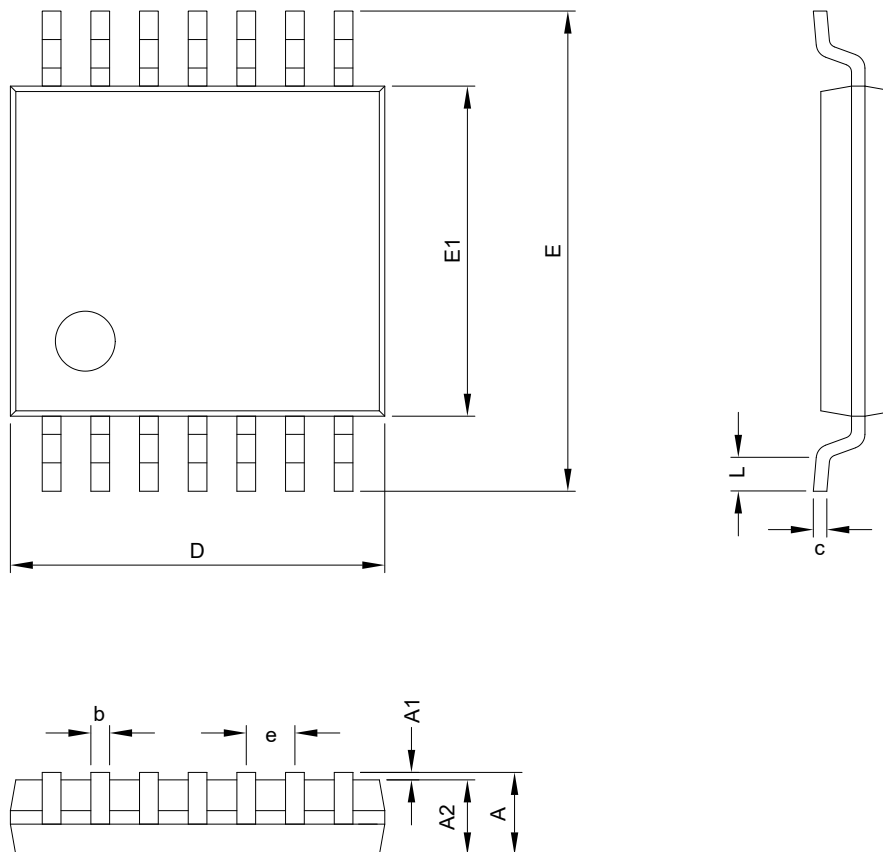
**AQFN1.7X2.0-12 Package**

| Symbol | DIMENSION IN MM |      |      | DIMENSION IN INCH |        |        |
|--------|-----------------|------|------|-------------------|--------|--------|
|        | MIN.            | NOM. | MAX. | MIN.              | NOM.   | MAX.   |
| A      | 0.50            | 0.55 | 0.60 | 0.0197            | 0.0217 | 0.0236 |
| A1     | 0.00            | ---  | 0.05 | 0.0000            | ---    | 0.0020 |
| A2     | 0.11 REF        |      |      | 0.0043 REF        |        |        |
| D      | 1.60            | 1.70 | 1.80 | 0.0629            | 0.0669 | 0.0708 |
| E      | 1.90            | 2.00 | 2.10 | 0.0748            | 0.0787 | 0.0826 |
| b      | 0.15            | 0.20 | 0.25 | 0.0059            | 0.0079 | 0.0098 |
| e      | 0.40 BSC        |      |      | 0.0157 BSC        |        |        |
| L      | 0.45            | 0.50 | 0.55 | 0.0177            | 0.0196 | 0.0216 |
| k      | 0.20 REF        |      |      | 0.0078 REF        |        |        |

## Taping Specification



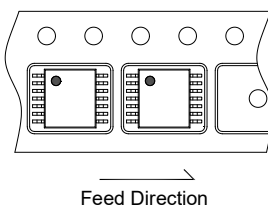
| PACKAGE        | Q'TY/REEL |
|----------------|-----------|
| AQFN1.7X2.0-12 | 3,000 ea  |



**TSSOP-14 Package**

| Symbol | DIMENSION IN MM |      |      | DIMENSION IN INCH |       |       |
|--------|-----------------|------|------|-------------------|-------|-------|
|        | MIN.            | NOM. | MAX. | MIN.              | NOM.  | MAX.  |
| A      | ---             | ---  | 1.20 | ---               | ---   | 0.048 |
| A1     | 0.00            | ---  | 0.15 | 0.000             | ---   | 0.006 |
| A2     | 0.80            | 1.00 | 1.05 | 0.031             | 0.039 | 0.041 |
| D      | 4.90            | 5.00 | 5.10 | 0.193             | 0.197 | 0.201 |
| E      | 6.20            | 6.40 | 6.60 | 0.244             | 0.252 | 0.260 |
| E1     | 4.30            | 4.40 | 4.50 | 0.169             | 0.173 | 0.177 |
| c      | 0.09            | ---  | 0.20 | 0.004             | ---   | 0.008 |
| b      | 0.19            | 0.22 | 0.30 | 0.008             | 0.009 | 0.012 |
| e      | 0.65 BSC        |      |      | 0.026 BSC         |       |       |
| L      | 0.45            | 0.60 | 0.75 | 0.018             | 0.024 | 0.030 |

## Taping Specification



| PACKAGE  | Q'TY/REEL |
|----------|-----------|
| TSSOP-14 | 3,000ea   |

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