

# High Efficiency Single Inductor Auto Buck-Boost Converter

## Features

- 1.8V ~ 5.5V Input Voltage Operation
- Adjustable Output Voltage from 2.8V to 5.5V
- 95% Efficiency DC/DC Converter
- 1.5A Output Current at 3.3V for VIN > 3.6V
- Auto-Transition Between Buck and Boost Mode
- Pulse-Skipping Mode at light load for Efficiency
- DC/DC Converter can be set to lower quiescent current at light load
- Fixed 2.4MHz Frequency and Synchronization Possible
- Internal Soft-Start
- Built-In Cycle-by Cycle Current Limit and Over Voltage Protection
- Built-In Thermal Shutdown Function
- WLCSP2X4-8 Package (0.4mm pitch)

## General Description

The G2228 is a high efficiency single inductor Buck-Boost converter which can supply the load current up to 1.5A. It provides auto-transition between Buck and Boost Mode. The G2228 operates at 2.4MHz switching frequency in CCM. DC/DC converter operates at Pulse-Skipping Mode at light load. The output voltage is programmable using an external resistor divider, or is fixed to 3.3V internally. The load is disconnected from the VIN during shutdown.

The G2228 is available in WLCSP2X4-8 package.

## Applications

- Mobile Handsets
- Smart Phone

## Ordering Information

| ORDER NUMBER | MARKING      | TEMP. RANGE | PACKAGE (Green) |
|--------------|--------------|-------------|-----------------|
| G2228CD1U    | YWWS<br>2228 | -40°C~+85°C | WLCSP2X4-8      |

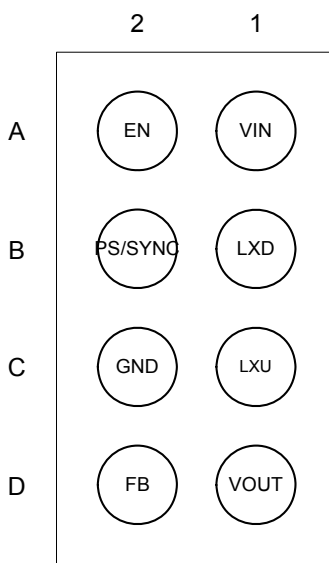
Note: CD: WLCSP2X4-8

1: Bonding code

U: Tape & Reel

Green : Lead Free / Halogen Free.

## Pin Configuration



Bottom View  
WLCSP 2X4-8

## Absolute Maximum Ratings

VIN, VOUT . . . . . -0.3V to +6.5V  
 LXD, LXU . . . . . -0.3V to +6.5V  
 EN, PS/SYNC, FB . . . . . -0.3V to +6.5V  
 Thermal Resistance Junction to Ambient, ( $\theta_{JA}$ )  
 WLCSP2X4-8 . . . . . 65°C/W  
 Continuous Power Dissipation ( $T_A=25^\circ\text{C}$ )  
 WLCSP2X4-8 . . . . . 2W

Operating Ambient Temperature . . . . .  $-35^\circ\text{C}$  to  $85^\circ\text{C}$   
 Storage Temperature Range. . . . .  $-55^\circ\text{C}$  to  $+150^\circ\text{C}$   
 Reflow Temperature (soldering, 10 sec) . . . . .  $260^\circ\text{C}$   
 EDS Susceptibility (Human Body Mode) . . . . . 2kV  
 EDS Susceptibility (Machine Mode) . . . . . 200V

- 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 are not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.
- Device is ESD sensitive. Handling precaution recommended. The Human Body model is a 100pF capacitor discharged through a 1.5K $\Omega$  resistor into each pin.

## Electrical characteristics

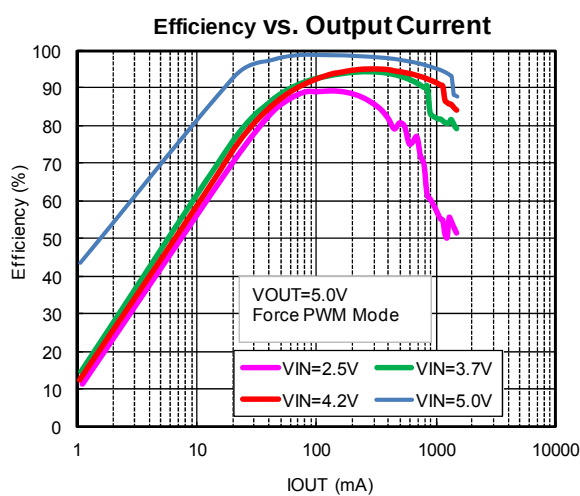
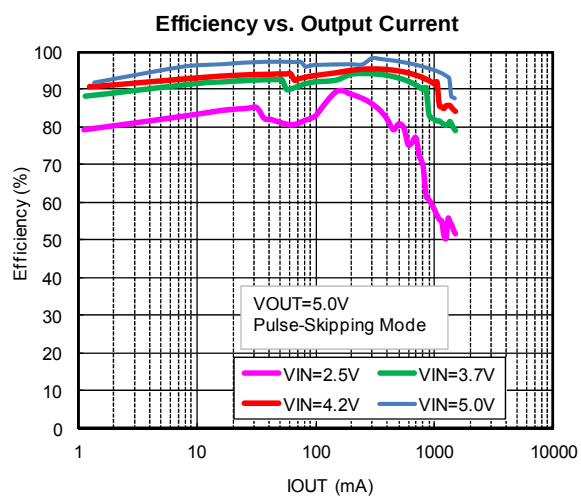
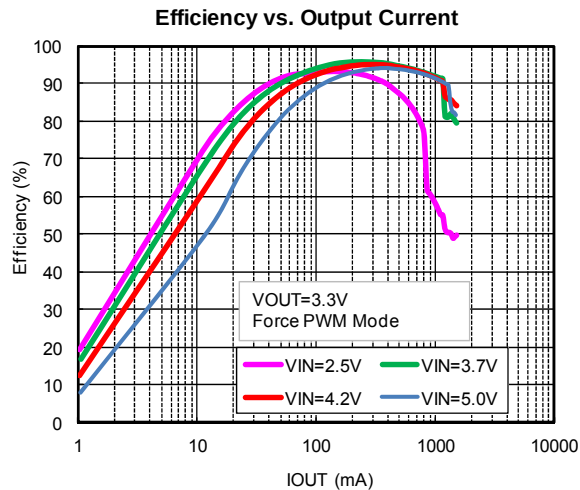
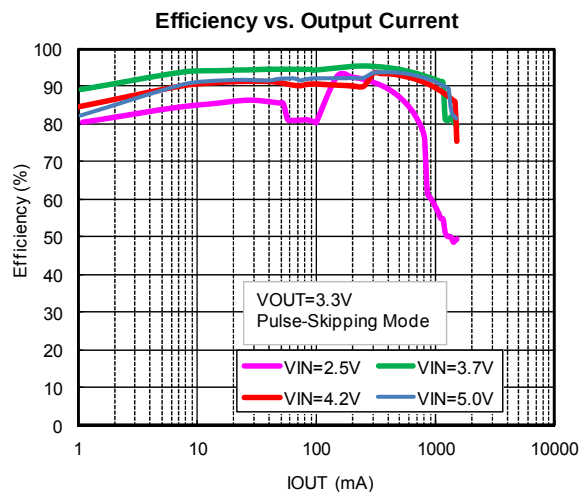
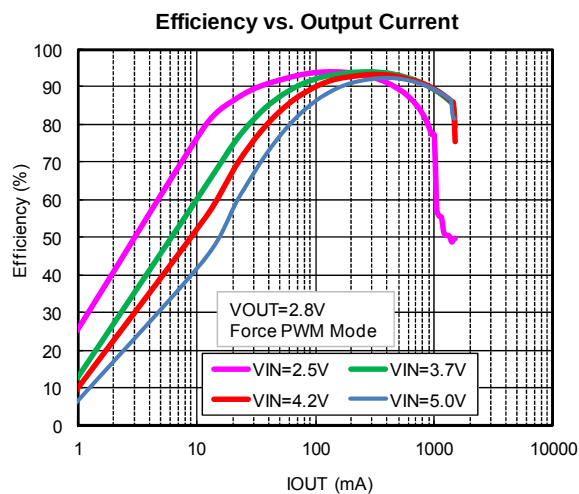
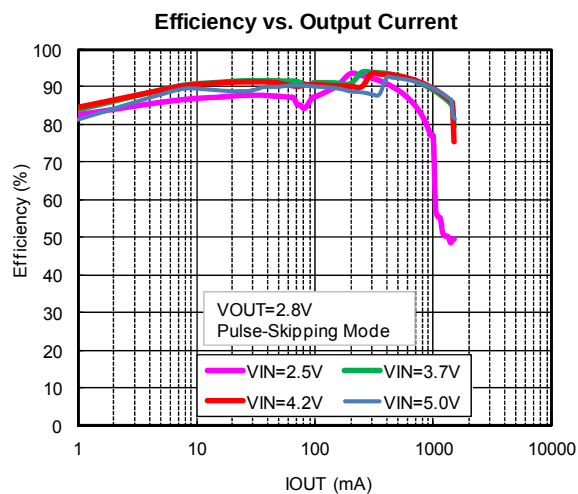
(VIN=VINA=3.6V,  $T_A=25^\circ\text{C}$ , unless otherwise specified)

The device is not guaranteed to function outside its operating conditions. Parameters with MIN and/or MAX limits are 100% tested at  $+25^\circ\text{C}$ , unless otherwise specified.

| PARAMETER                           | SYMBOL                                    | CONDITIONS                                                                                       | MIN   | TYP | MAX   | UNIT             |
|-------------------------------------|-------------------------------------------|--------------------------------------------------------------------------------------------------|-------|-----|-------|------------------|
| <b>GENERAL</b>                      |                                           |                                                                                                  |       |     |       |                  |
| VIN minimum Startup Voltage         | V <sub>IN,ST</sub>                        |                                                                                                  | ---   | --- | 1.7   | V                |
| VIN Operating Voltage               | V <sub>IN</sub>                           |                                                                                                  | 1.8   | --- | 5.5   | V                |
| Output Voltage Range                | V <sub>OUT</sub>                          |                                                                                                  | 2.8   | --- | 5.5   | V                |
| Under Voltage Lockout Threshold     | V <sub>UVLO,R</sub>                       | V <sub>INA</sub> voltage rising                                                                  | ---   | 1.7 | ---   | V                |
|                                     | V <sub>UVLO,F</sub>                       | V <sub>INA</sub> voltage falling                                                                 | ---   | 1.6 | ---   | V                |
| Quiescent Current                   | I <sub>Q</sub>                            | V <sub>EN</sub> =V <sub>IN</sub> =V <sub>INA</sub> =3.6V, I <sub>OUT</sub> =0A<br>(No Switching) | ---   | 40  | 65    | $\mu\text{A}$    |
| Shutdown Current                    | I <sub>SD</sub>                           | V <sub>EN</sub> =0V, V <sub>IN</sub> =V <sub>INA</sub> =3.6V                                     | ---   | 0.1 | 1     | $\mu\text{A}$    |
| <b>OSCILLATOR</b>                   |                                           |                                                                                                  |       |     |       |                  |
| Oscillator Frequency                | F <sub>OSC</sub>                          |                                                                                                  | 2.2   | 2.4 | 2.6   | MHz              |
| Frequency range for Synchronization | F <sub>SYN</sub>                          |                                                                                                  | 4.4   | 4.8 | 5.2   | MHz              |
| <b>DCDC Converter</b>               |                                           |                                                                                                  |       |     |       |                  |
| Soft-Start Internal                 | SS                                        | V <sub>IN</sub> =V <sub>INA</sub> =3.6V                                                          | ---   | 0.5 | ---   | ms               |
| Feedback voltage                    | V <sub>FB</sub>                           | Adjustable Output                                                                                | 495   | 500 | 505   | mV               |
| Output voltage                      |                                           | Fixed 3.3V Output                                                                                | 3.267 | 3.3 | 3.333 | V                |
| Line Regulation                     | $\Delta V_{OUT,LINE}$                     | PWM                                                                                              | ---   | 0.5 | ---   | %                |
| Load Regulation                     | $\Delta V_{OUT,LOAD}$                     | PWM                                                                                              | ---   | 0.5 | ---   | %                |
| Maximum Duty Cycle                  | D <sub>MAX,D</sub>                        | LXD                                                                                              | ---   | 100 | ---   | %                |
|                                     | D <sub>MAX,U</sub>                        | LXU                                                                                              | 90    | 93  | 96    | %                |
| FB Leakage Current                  | I <sub>FB,LK</sub>                        | Adjustable Mode                                                                                  | ---   | --- | 1     | $\mu\text{A}$    |
| VOUT Leakage Current                | I <sub>VO,LK</sub>                        | V <sub>LXU</sub> =0V, V <sub>OUT</sub> =5V                                                       | ---   | 1   | 5     | $\mu\text{A}$    |
| LXD, LXU Leakage Current            | I <sub>LXD,LK</sub> , I <sub>LXU,LK</sub> | V <sub>LXD</sub> =V <sub>LXU</sub> =5V                                                           | ---   | 1   | 5     | $\mu\text{A}$    |
| Switch ON Resistance                | R <sub>ON,P</sub>                         | V <sub>IN</sub> =V <sub>INA</sub> =3.6V                                                          | ---   | 150 | ---   | m $\Omega$       |
|                                     | R <sub>ON,N</sub>                         | V <sub>IN</sub> =V <sub>INA</sub> =3.6V                                                          | ---   | 130 | ---   |                  |
| Peak Current Limit                  | I <sub>LIM</sub>                          | V <sub>IN</sub> =V <sub>INA</sub> =3.6V                                                          | ---   | 2   | ---   | A                |
| Maximum Output Load Capability      | I <sub>OD,MAX</sub>                       | V <sub>IN</sub> $\geq$ 3.3V, V <sub>O</sub> =3.3V                                                | 1.5   |     |       | A                |
|                                     | I <sub>OU,MAX</sub>                       | V <sub>IN</sub> =1.8V, V <sub>O</sub> =3.3V                                                      | 250   |     |       | mA               |
| <b>Protection</b>                   |                                           |                                                                                                  |       |     |       |                  |
| Over Voltage Protection Threshold   | %V <sub>OVP</sub>                         | Ratio=V <sub>OVP</sub> /V <sub>OUT</sub> , V <sub>OUT</sub> voltage rising                       | ---   | 120 | ---   | %                |
| Short Circuit Protection threshold  | %V <sub>SCP</sub>                         | Ratio=V <sub>SCP</sub> /V <sub>OUT</sub> , V <sub>OUT</sub> voltage falling                      | ---   | 20  | ---   | %                |
| Thermal Shutdown Protection         | T <sub>SD</sub>                           |                                                                                                  | ---   | 150 | ---   | $^\circ\text{C}$ |
| Thermal Shutdown Hysteresis         | $\Delta T_{SD}$                           |                                                                                                  | ---   | 20  | ---   | $^\circ\text{C}$ |
| <b>Control Signal</b>               |                                           |                                                                                                  |       |     |       |                  |
| EN, PS/SYNC Input Voltage           | V <sub>TH</sub>                           | High Threshold                                                                                   | 1.2   | --- | ---   | V                |
|                                     | V <sub>TL</sub>                           | Low Threshold                                                                                    | ---   | --- | 0.4   | V                |
| EN, PS/SYNC Leakage Current         | I <sub>EN,LK</sub>                        | EN=V <sub>INA</sub> or 0V                                                                        |       |     | 1     | $\mu\text{A}$    |

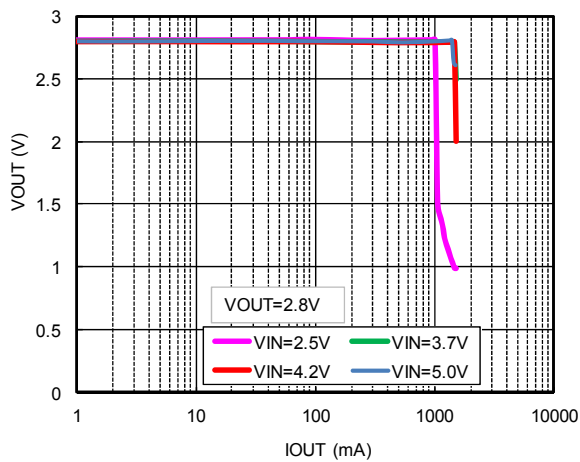
**Typical Performance Characteristics**

$T_A=25^{\circ}\text{C}$ , unless otherwise noted.

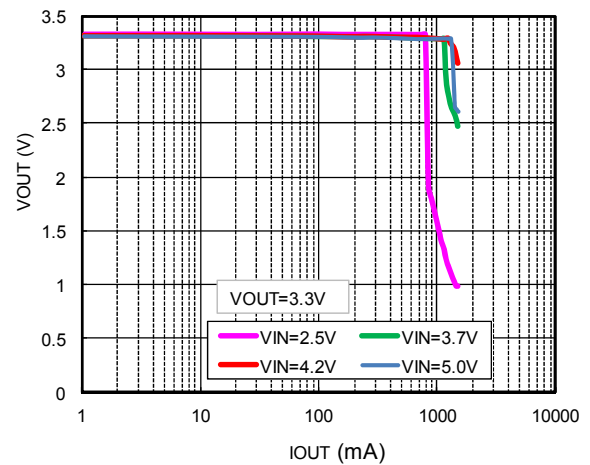


Typical Performance Characteristics (Continued)

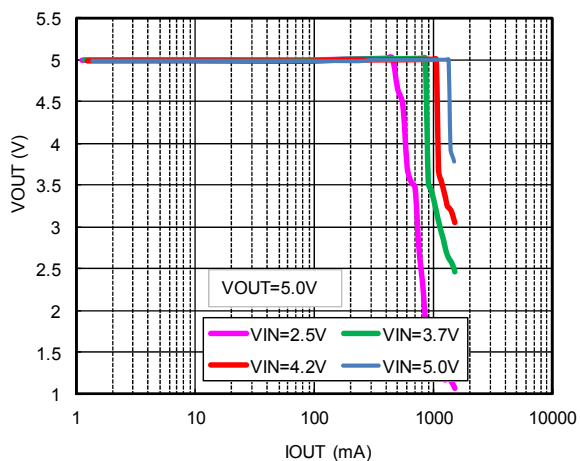
Output Voltage vs. Output Current



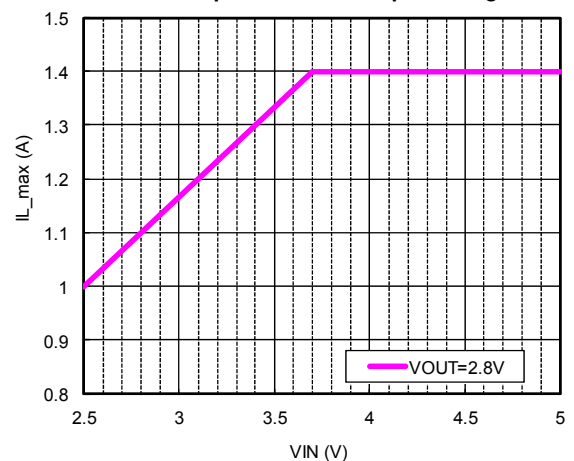
Output Voltage vs. Output Current



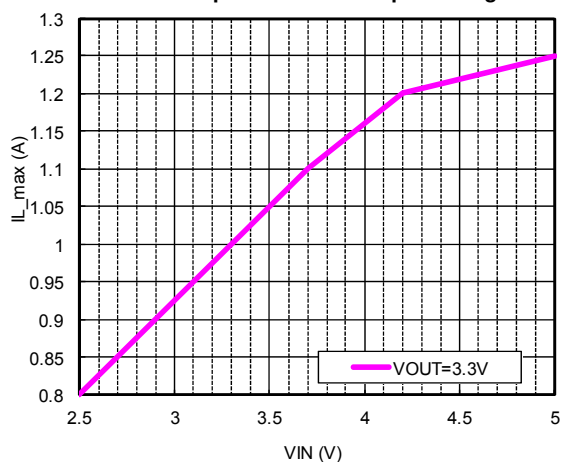
Output Voltage vs. Output Current



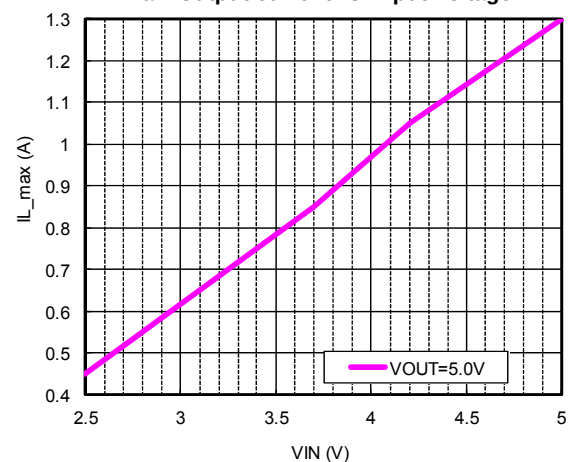
Max. Output current vs. Input Voltage



Max. Output current vs. Input Voltage

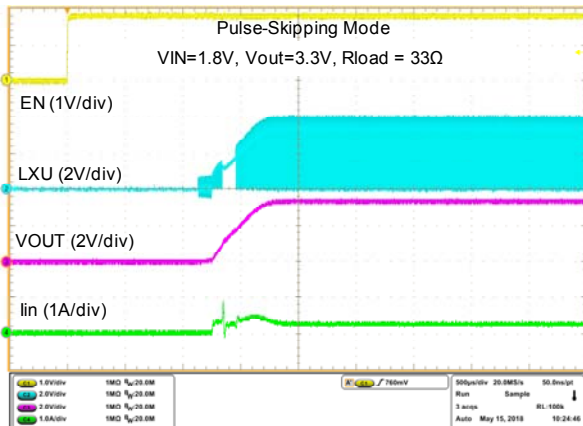


Max. Output current vs. Input Voltage

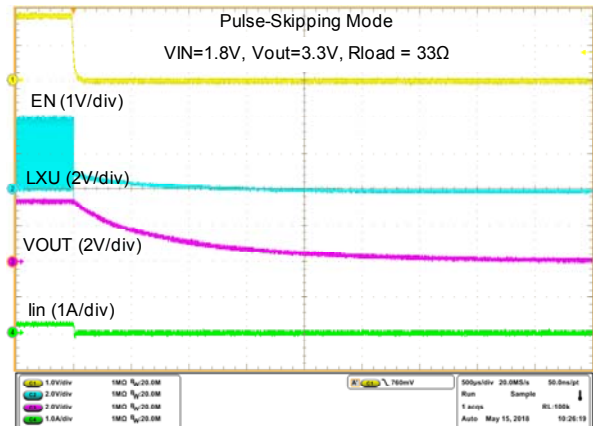


Typical Performance Characteristics (Continued)

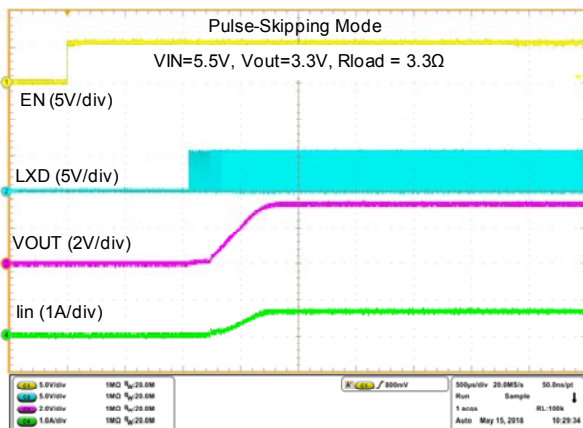
EN control IC Turn on



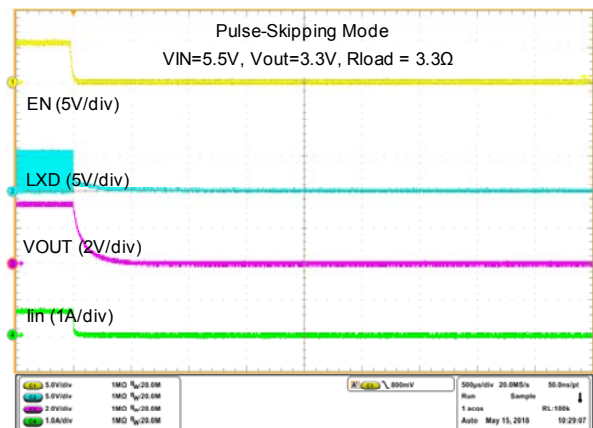
EN control IC Turn off



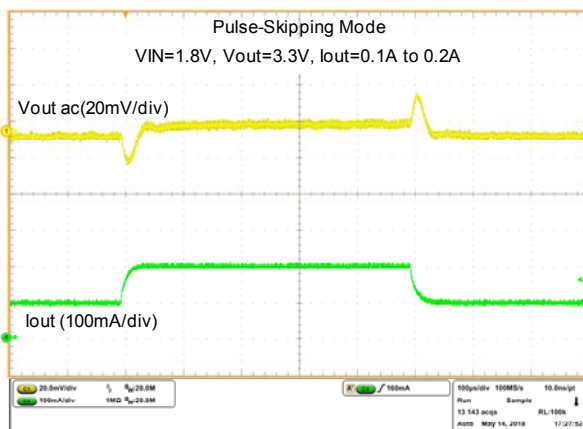
EN control IC Turn on



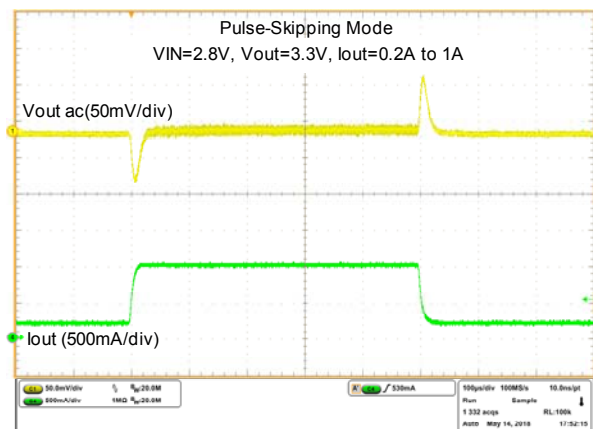
EN control IC Turn off



Load Transient

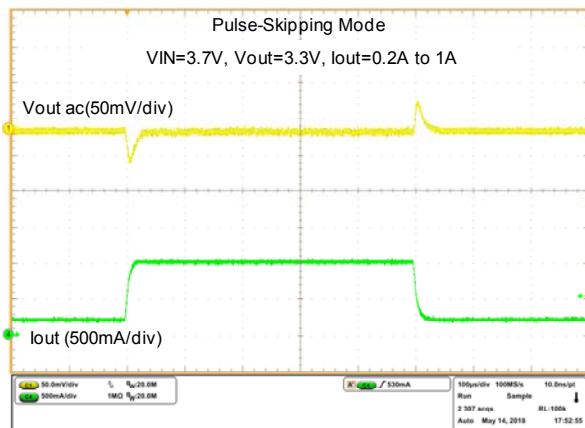


Load Transient

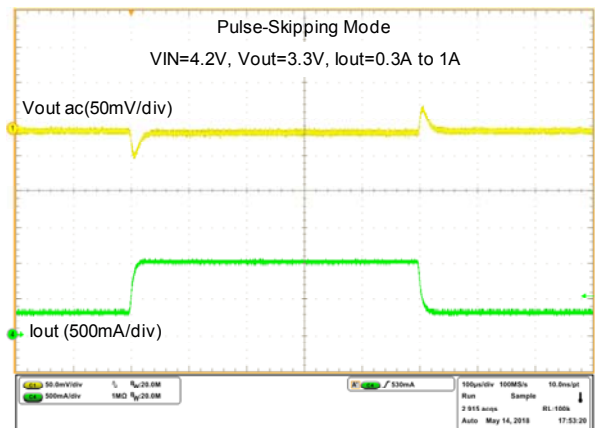


Typical Performance Characteristics (Continued)

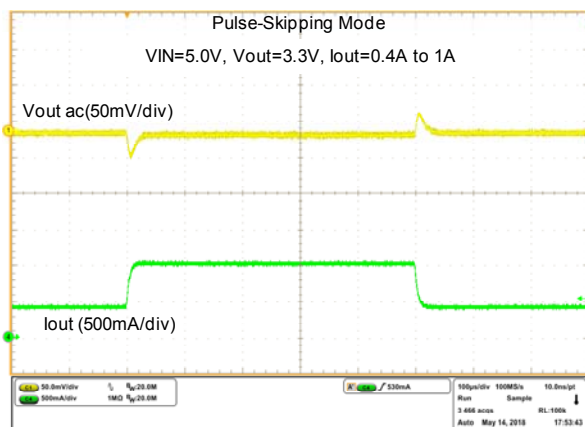
Load Transient



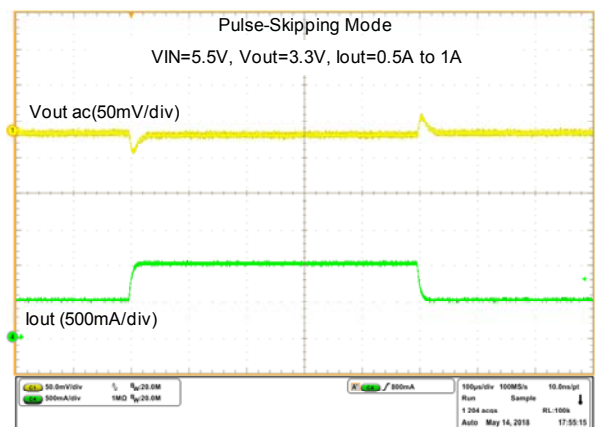
Load Transient



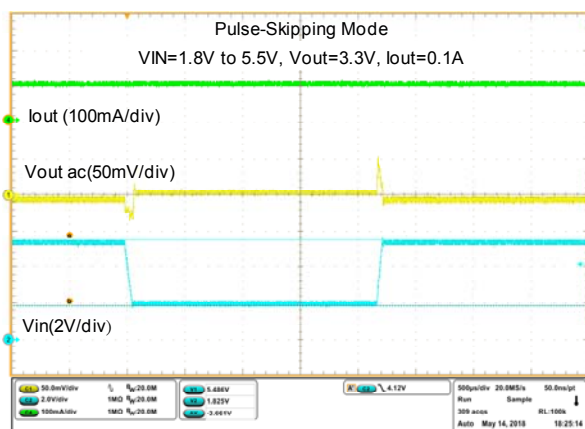
Load Transient



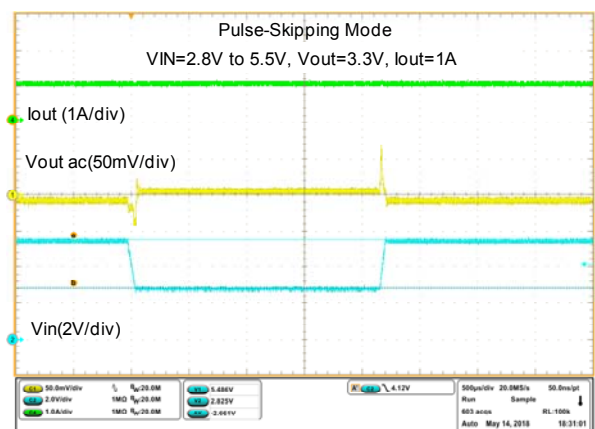
Load Transient



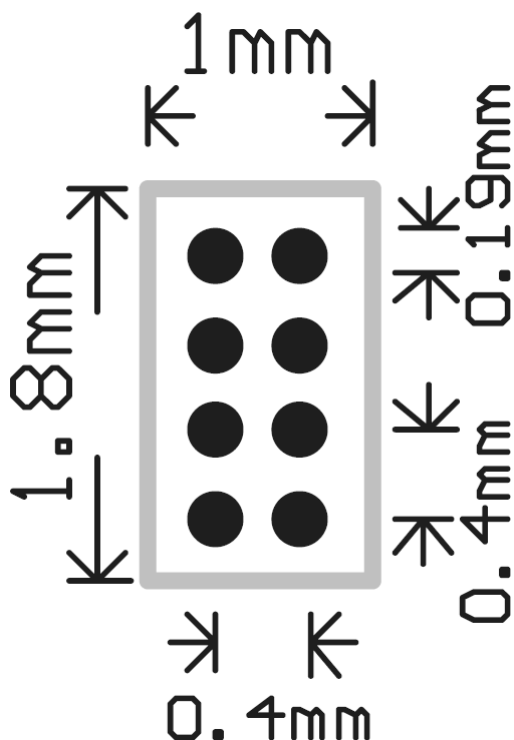
LineTransient



LineTransient



**Minimum Footprint PCB Layout Section**

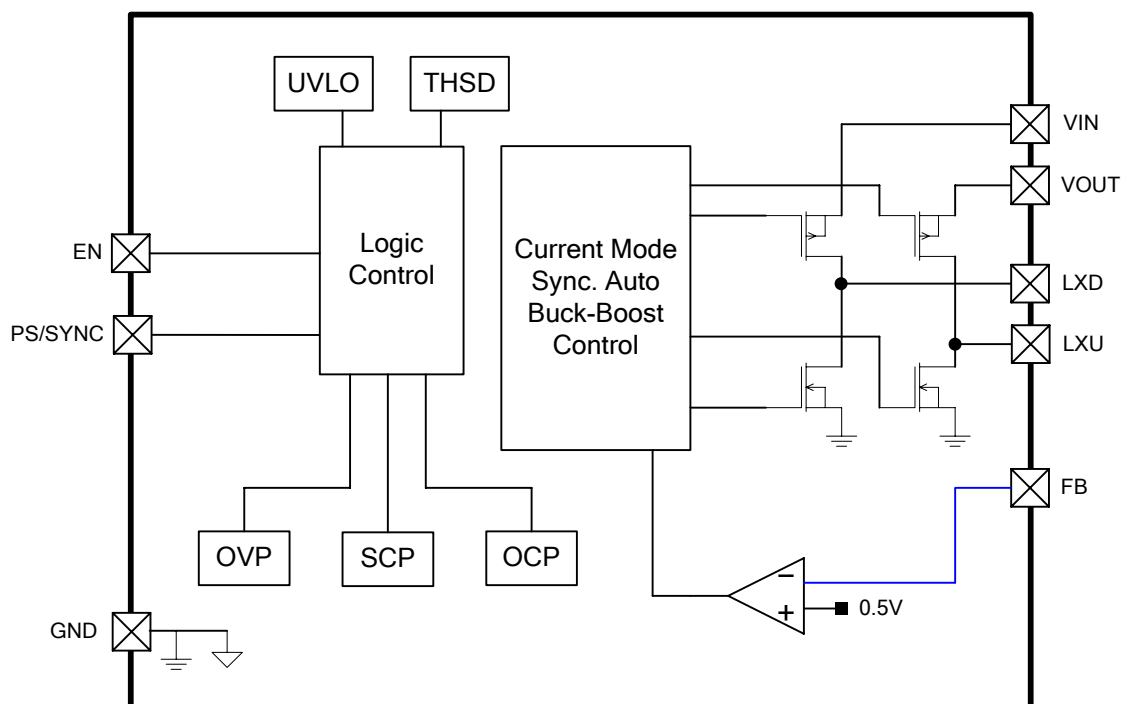


**Pin Description**

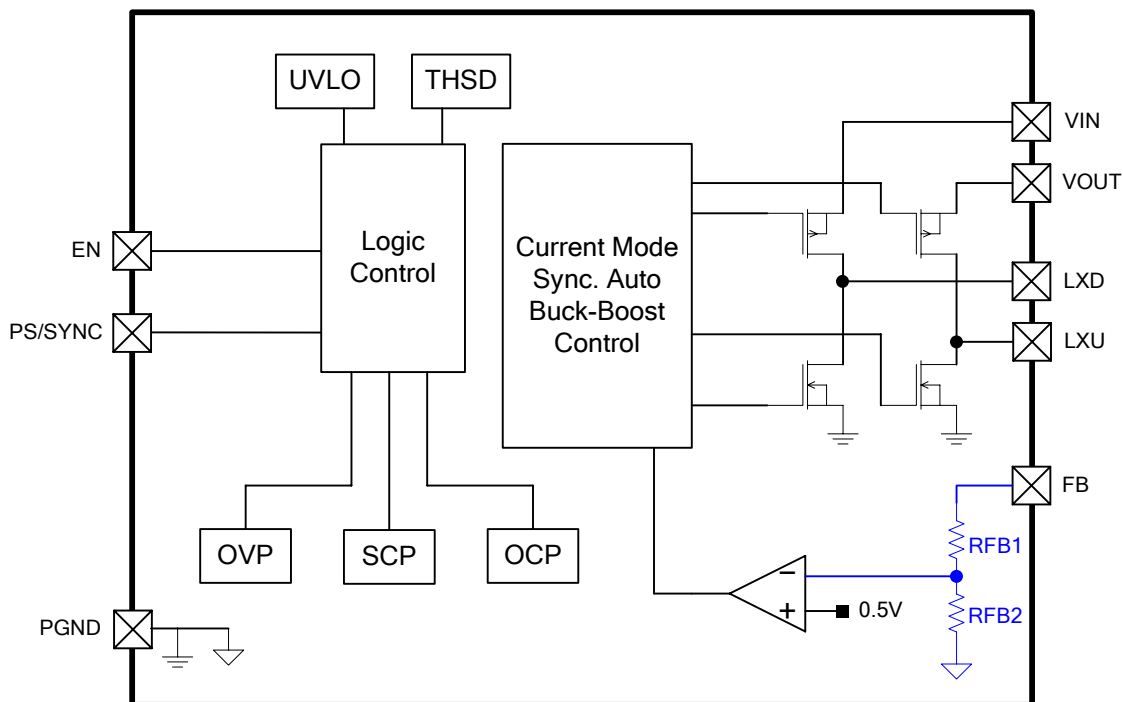
| PIN | NAME    | Function                                                                                                         |
|-----|---------|------------------------------------------------------------------------------------------------------------------|
| A1  | VIN     | Power Input of Buck-Boost Converter                                                                              |
| A2  | EN      | Enable PIN (1 Enabled, 0 Disabled), must not be left open.                                                       |
| B1  | LXD     | Inductor Switch Node                                                                                             |
| B2  | PS/SYNC | Enable/Disable Power Save Mode (1 Disabled, 0 Enabled, clock signal for synchronization), must not be left open. |
| C1  | LXU     | Inductor Switch Node                                                                                             |
| C2  | GND     | Chip Analog Ground and Power Ground of Buck-Boost Converter                                                      |
| D1  | VOUT    | Power Output of Buck-Boost Converter                                                                             |
| D2  | FB      | Voltage Feedback of adjustable version, and connected to VOUT on fixed output voltage version.                   |

## Block Diagram

### Adjustable Output Voltage

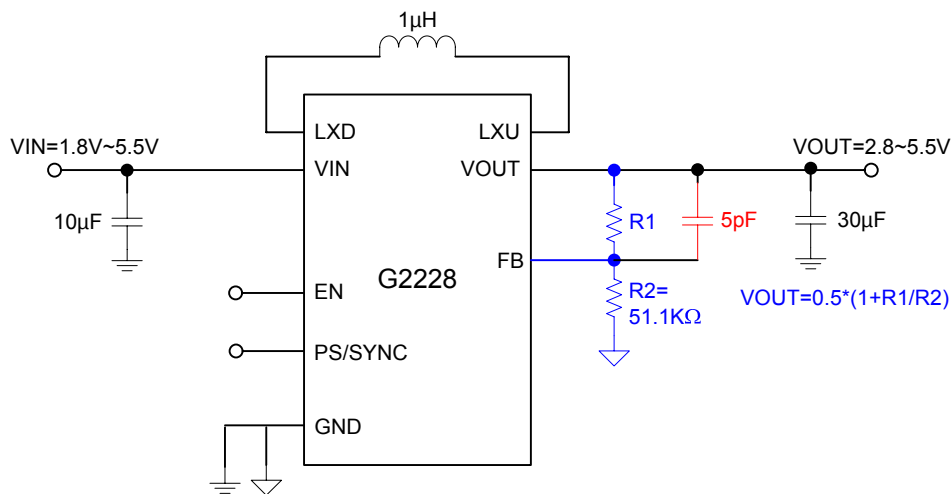


### Fixed 3.3V Output Voltage



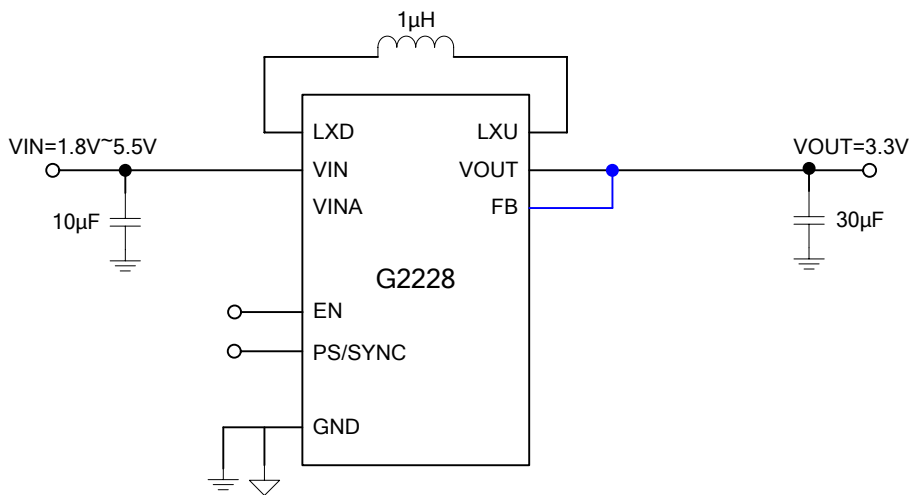
## Application circuit

### Adjustable Output Voltage



The recommended value for R2 should be in the range of 50kΩ .

### Fixed 3.3V Output Voltage



## Function Description

The G2228 includes a DC/DC Converters.

|      | Topology                               | Default<br>$V_{OUT}$ | $V_{OUT}$ range                                   | Current<br>rating |
|------|----------------------------------------|----------------------|---------------------------------------------------|-------------------|
| DCDC | 2.4MHz Sync. Auto Buck-Boost Converter | 3.3V                 | Adjustable Mode: 2.8V to 5.5V<br>Fixed Mode: 3.3V | 1.5A              |

## Fault Protection

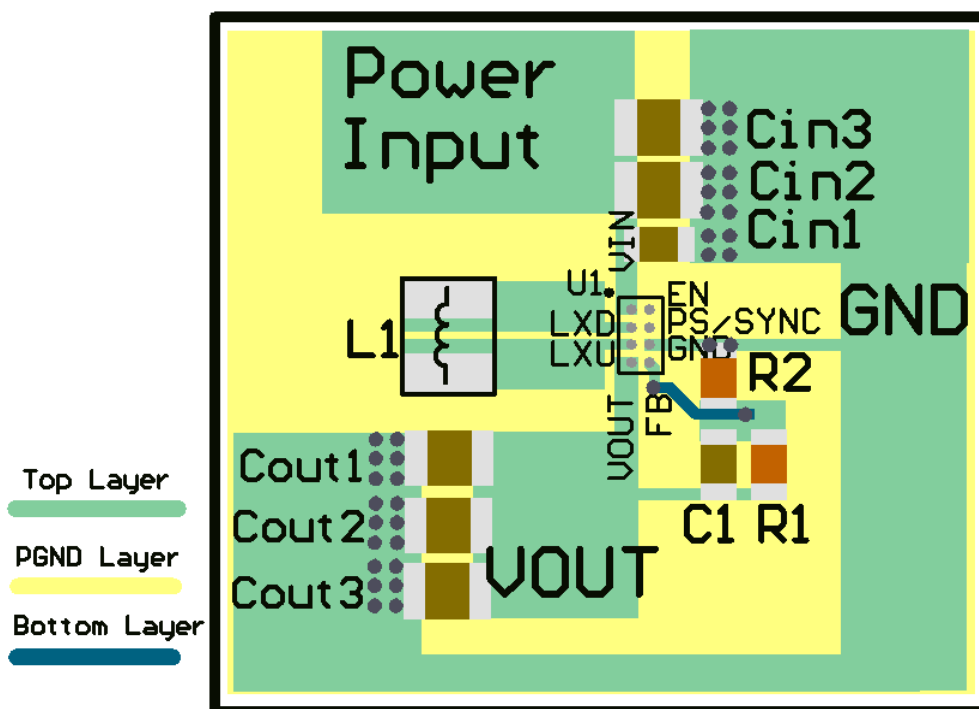
G2228 provides VIN under-voltage lockout protection, over-current protection, VOUT over-voltage protection, VOUT short-circuit protection, and thermal shutdown protection to achieve complete protection.

|                    | Protection<br>Type | Threshold                     | Protection methods                                                  | Reset Method                  |
|--------------------|--------------------|-------------------------------|---------------------------------------------------------------------|-------------------------------|
| VIN                | UVLO               | VIN<1.6V                      | DCDC shutdown                                                       | VIN>1.7V                      |
| DCDC<br>Buck-Boost | Current Limit      | Peak Inductor current>2A      | Buck Mode:<br>PMOS Off, NMOS on<br>Boost Mode:<br>NMOS Off, PMOS on | Automatic Reset at next cycle |
|                    | OVP                | VOUT>120%*VOUT <sub>SET</sub> | DCDC1 stop switching                                                | VOUT<110%*VOUT <sub>SET</sub> |
|                    | SCP                | VOUT<20%*VOUT <sub>SET</sub>  | Current Limit = 1A<br>OSC Frequency=1.2MHz                          | VOUT>30%*VOUT <sub>SET</sub>  |
| Thermal            | TSD                | Junction Temp. >150°C         | DCDC shutdown                                                       | Junction Temp. <130°C         |

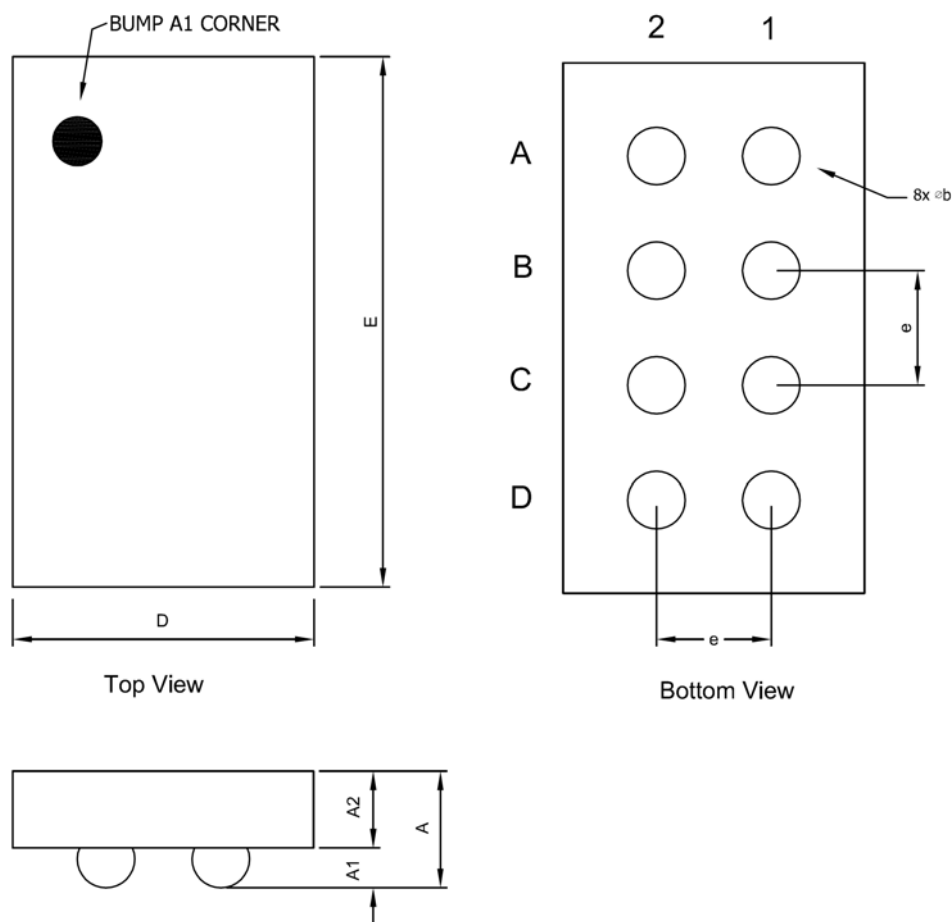
## PCB Layout Guidelines

Power loops of the switching converter were considered to minimize the area. If possible, it is suggested to arrange the power loops at the top side copper plane. And the bottom side copper plane was considered to be the analog ground.

1. Connect the bypass capacitor on VIN or VOUT as close to the device as possible.
2. Switch node experiences high frequency voltage swings and should be kept in a small area. Keep analog components away from the switch node to prevent stray capacitive noise pick-up.
3. In case, the power loop crosses different layers, put vias as many as possible.



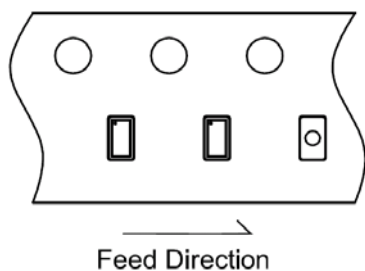
#### 4. Package Information



**WLCSP2X4-8 Package**

| Symble | DIMENSION IN MM |       |       | DIMENSION IN INCH |        |        |
|--------|-----------------|-------|-------|-------------------|--------|--------|
|        | MIN.            | NOM.  | MAX.  | MIN.              | NOM.   | MAX.   |
| A      | 0.450           | 0.500 | 0.550 | 0.0173            | 0.0197 | 0.0217 |
| A1     | 0.120           | 0.150 | 0.180 | 0.0047            | 0.0059 | 0.0071 |
| A2     | 0.330           | 0.350 | 0.370 | 0.0130            | 0.0138 | 0.0146 |
| D      | 1.000           | 1.050 | 1.100 | 0.0394            | 0.0413 | 0.0433 |
| E      | 1.800           | 1.850 | 1.900 | 0.0709            | 0.0728 | 0.0748 |
| b      | 0.190           | 0.220 | 0.250 | 0.0075            | 0.0087 | 0.0098 |
| e      | 0.40 BSC        |       |       | 0.0157 BSC        |        |        |

#### Taping Specification



| PACKAGE    | Q'TY/REEL |
|------------|-----------|
| WLCSP2X4-8 | 3,000 ea  |

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