# 10A Fully-Integrated Synchronous Boost Converter

## Features

- **2.7V ~ 12V Input Voltage Operation.**
- **4.5V ~ 12.6V Output Voltage Range**
- **91% Efficient DC/DC Converter**
- **10A Switch Current**
- **Resistor-Programmable Switch Peak Current Limit**
- **Adjustable Switching Frequency:200kHz to 2.2MHz**
- **Mode Selection Between PFM Mode and Forced PWM Mode at Light Load**
- **Programmable Soft Start**
- **Output Overvoltage Protection at 13.2V**
- **Cycle-by-Cycle Overcurrent Protection**
- **Built-In OTP Protection**
- **QFN3.5X4.5-20 Package.**

## Applications

- **Battery-powered Products**
- **Portable POS terminal**
- **E-Cigarette**
- **Power Bank**

## General Description

The G2280 is a high efficiency, synchronous, COT, boost converter .The G2280 has wide input voltage range from 2.7V to 12V to support applications with single cell or two cell Lithium batteries. The device has 10A switch current capability and is capable of providing an output voltage up to 12.6V.

The G2280 uses adaptive constant off-time peak current control topology to regulated the output voltage. In moderate to heavy load condition, the G2280 works in the PWM mode. In light load condition, the device has two operation modes selected by the MODE pin. One is the PFM mode and another one is forced PWM mode. The switching frequency in the PWM mode is adjustable ranging from 200kHz to 2.2MHz by an external resistor. A programmable soft-start function, and an adjustable switching peak current limit function are also implanted in G2280. In addition, 13.2V output overvoltage protection, cycle-by-cycle overcurrent protection, and thermal shutdown protection are also embedded.

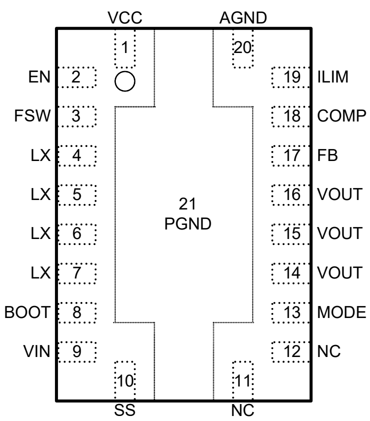
The G2280 is available in QFN3.5x4.5-20 package.

## Ordering Information

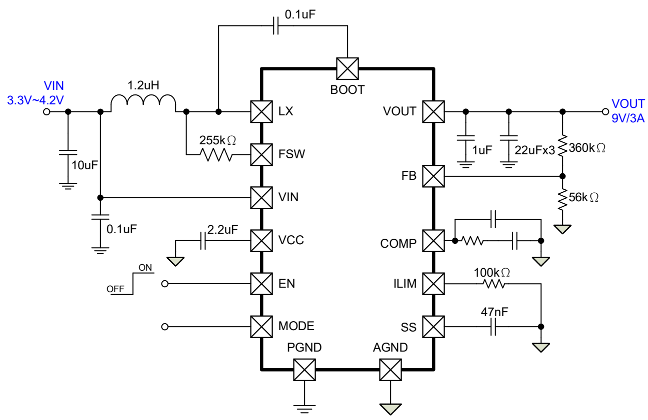
| ORDER NUMBER | MARKING | TEMP. RANGE | PACKAGE (Green) |
|---|---|---|---|
| G2280HL1U | 2280 | -40°C~+85°C | QFN3.5X4.5-20 |

Note: HL: QFN3.5X4.5-20
1: Bonding code
U: Tape & Reel
Green : Lead Free / Halogen Free

## Pin Configuration




## Typical Application Circuit



## Absolute Maximum Ratings

BOOT. . . . . . . . . . . . . . . . . . . . . . . . -0.3V to (LX+7)V
LX. . . . . . . . . . . . . . . . . .-0.3V to +14.5V (20V for < 5nS)
VIN, FSW, VOUT. . . . . . . . . . . . . . . . . . . .-0.3V to +14.5V
All other Pins. . . . . . . . . . . . . . . . . . . . . . . . . -0.3V to +7V

Operating Junction Temperature . . . . -40°C to +150°C
Storage Temperature Range. . . . . . -65°C to +150°C
Reflow Temperature (soldering, 10 sec) . . . . . 260°C
ESD Susceptibility (Human Body Mode) . . . . . . . . . 2KV
ESD Susceptibility (Machine Mode) . . . . . . . . . . 200V

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

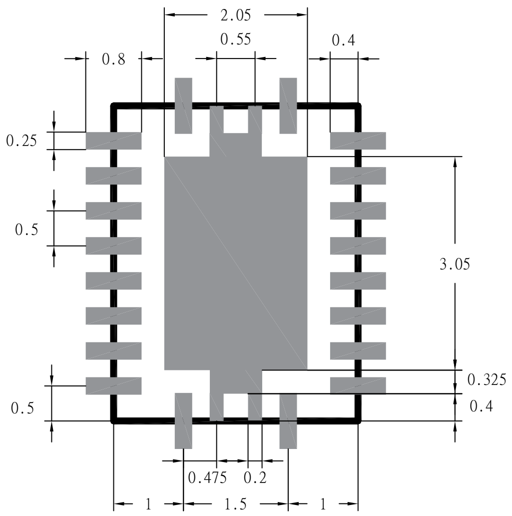
## Thermal Information

| THERMAL METRIC | | G2280 QFN3.5x4.5-20 | UNIT |
|---|---|---|---|
| $R_{\theta JA}$ | Junction to ambient thermal resistance | 38.2 | °C/W |
| $R_{\theta JC\_top}$ | Junction to case top thermal resistance | 38.6 | °C/W |
| $R_{\theta JB}$ | Junction to board thermal resistance | 13.7 | °C/W |
| $\Psi_{JT}$ | Junction to top characterization parameter | 0.6 | °C/W |
| $\Psi_{JB}$ | Junction to board characterization parameter | 13.6 | °C/W |
| $R_{\theta JC\_bot}$ | Junction to case bottom thermal resistance | 2.2 | °C/W |

Package thermal metric were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board.

## Minimum Footprint PCB Layout Section

**QFN3.5X4.5-20**



## Electrical characteristics

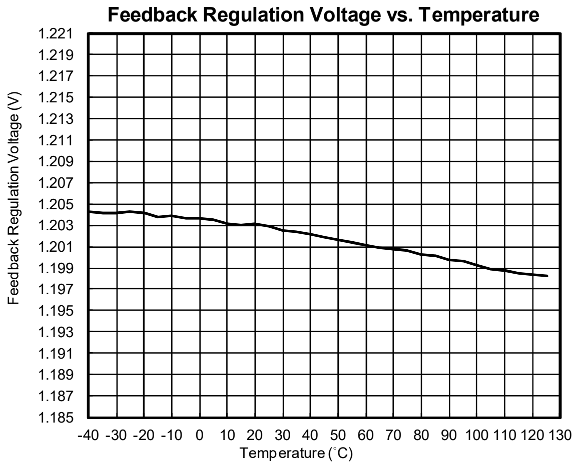
**($V_{IN}$= 3.6V, $V_{OUT}$=9V, $T_A$=25°C)**

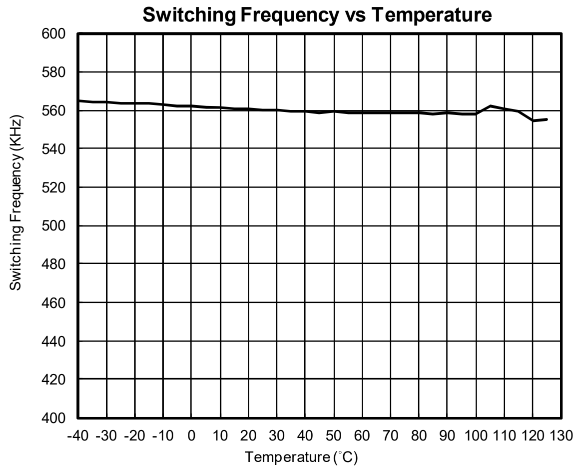
The device is not guaranteed to function outside its operating conditions. Parameters with MIN and/or MAX limits are 100% tested at +25°C, unless otherwise specified.

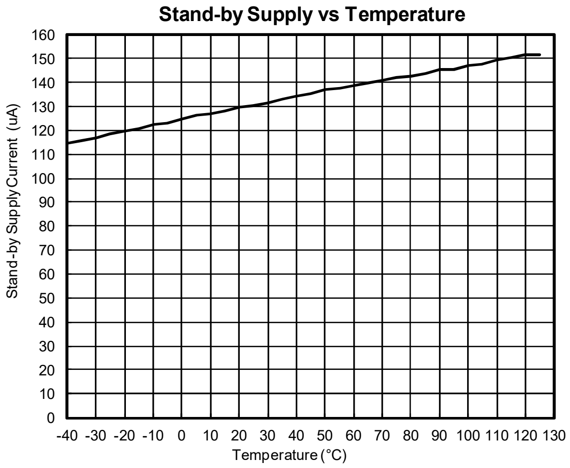
| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| **GENERAL** | | | | | | |
| VIN Operating Voltage | $V_{VIN}$ | | 2.7 | --- | 12 | V |
| VIN Under Voltage Threshold | $V_{VINR\_UVLO}$ | VIN rising | --- | 2.6 | 2.7 | V |
| | $V_{VINF\_UVLO}$ | VIN falling | --- | 2.4 | 2.5 | V |
| VCC Under Voltage Threshold | $V_{VCC\_UVLO}$ | | --- | 1.9 | --- | V |
| Stand-by Supply Current | $I_{VIN}$ | IC enabled, Zero output loading, $V_{FB}$=1.3V, | --- | 1 | 3 | μA |
| | $I_{VOUT}$ | $V_{OUT}$=12V, $R_{ILIM}$=100kΩ | --- | 130 | 250 | μA |
| Shutdown Current | $I_{SD}$ | IC disabled, $V_{EN}$=0v | --- | 1 | 3 | μA |
| **Boost Converter** | | | | | | |
| Output Voltage Range | $V_{OUT}$ | | 4.5 | --- | 12.6 | V |
| Feedback Regulation Voltage | $V_{REF}$ | | 1.185 | 1.203 | 1.221 | V |
| FB pin leakage current | $I_{LKG\_FB}$ | $V_{FB}$=1.2V | --- | --- | 100 | nA |
| Soft-start charging current | $I_{SS}$ | | --- | 5 | --- | μA |
| COMP sink current | $I_{SINK\_COMP}$ | $V_{FB}$=$V_{REF}$+200mV, $V_{COMP}$=1.5V | --- | 24 | --- | μA |
| COMP source current | $I_{SOURCE\_COMP}$ | $V_{FB}$=$V_{REF}$-200mV, $V_{COMP}$=1.5V | --- | 24 | --- | μA |
| High clamp voltage at COMP pin | $V_{CCLPH}$ | $V_{FB}$=1V, $R_{ILIM}$=100kΩ | --- | 2.15 | --- | V |
| Low clamp voltage at COMP pin | $V_{CCLPL}$ | $V_{FB}$=1.5V, $R_{ILIM}$=100kΩ, MODE floating | --- | 1.28 | --- | V |
| Error Amplifier transconductance | $G_{EA}$ | $V_{COMP}$=1.5V | --- | 190 | --- | μA/V |
| Switching Frequency | $F_{SW}$ | $R_{FSW}$=255KΩ,$V_{IN}$=3.3V,$V_{OUT}$=9V | 500 | 600 | 700 | kHz |
| Minimum on time | $t_{ON\_min}$ | $R_{FSW}$=255KΩ,$V_{IN}$=3.3V,$V_{OUT}$=9V | --- | 130 | 200 | ns |
| Switch ON Resistance | $R_{ON\_HS}$ | High side MOSFET | --- | 13 | 18 | mΩ |
| | $R_{ON\_LS}$ | Low side MOSFET | --- | 11 | 16.5 | mΩ |
| Peak Current Limit Threshold | $I_{LIM\_PFM}$ | $R_{ILIM}$=100kΩ, MODE pin floating | 10.6 | 11.9 | 13 | A |
| | $I_{LIM\_FPWM}$ | $R_{ILIM}$=100kΩ, MODE pin short to ground | 9.7 | 10.9 | 12 | |
| ILIM Reference Voltage | $V_{ILIM}$ | | 1.185 | 1.203 | 1.221 | V |
| **Protection** | | | | | | |
| Output overvoltage protection threshold | $V_{OVP}$ | $V_{OUT}$ rising | 12.7 | 13.2 | 13.6 | V |
| Thermal Shutdown Detect | $T_{SD}$ | | --- | 150 | --- | °C |
| Thermal Shutdown Hysteresis | $\Delta T_{SD}$ | | --- | 20 | --- | °C |
| **Control Signal** | | | | | | |
| EN, MODE Logic-Input Threshold | $V_{TH}$ | High threshold | 1.2 | --- | --- | V |
| | $V_{TL}$ | Low threshold | --- | --- | 0.4 | V |
| EN internal pull-down resistance | $R_{EN}$ | | --- | 800 | --- | kΩ |
| MODE internal pull-up resistance | $R_{MODE}$ | | --- | 800 | --- | kΩ |

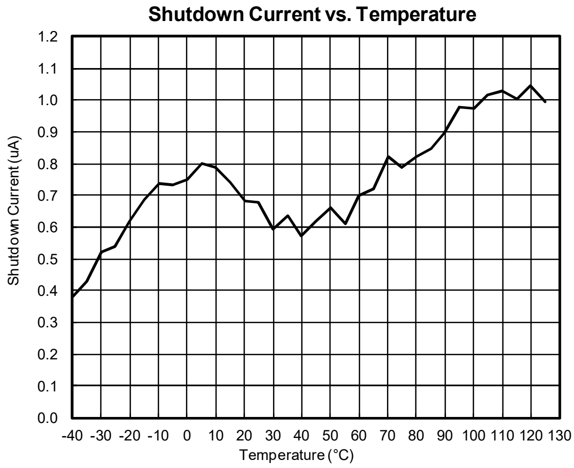
## Typical Performance Characteristics

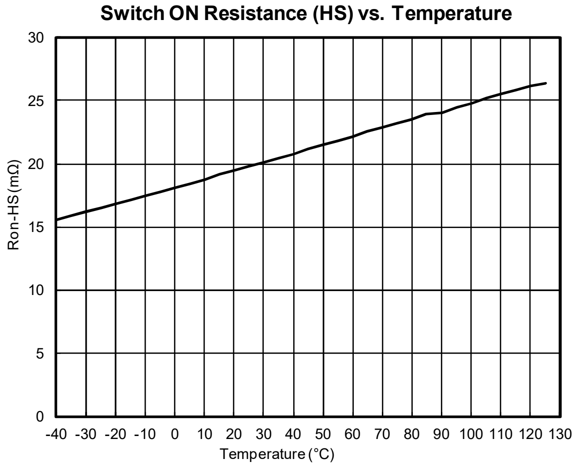
**($V_{IN}$=3.6V，$V_{OUT}$=9V，L1=1.5uH，$T_A$=25 °C，unless otherwise noted.)**

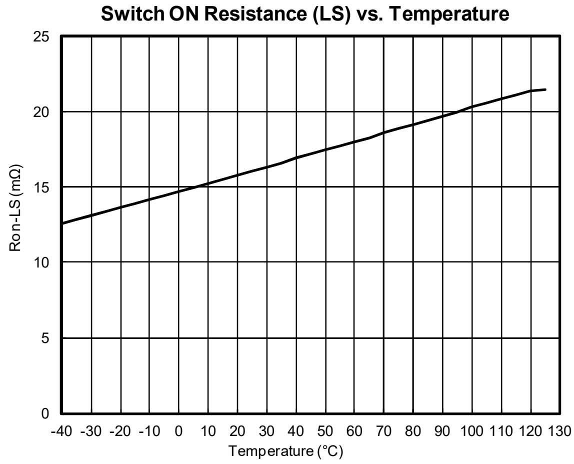


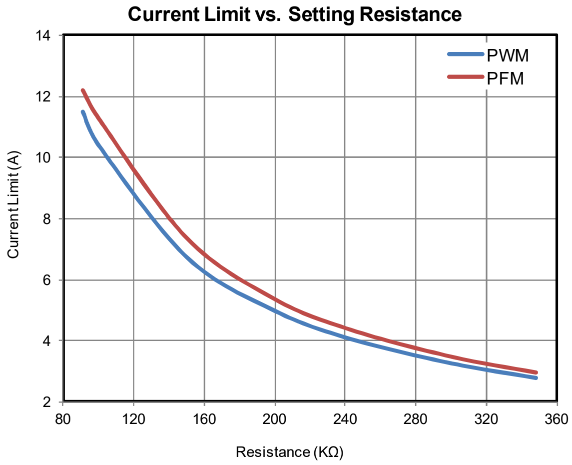



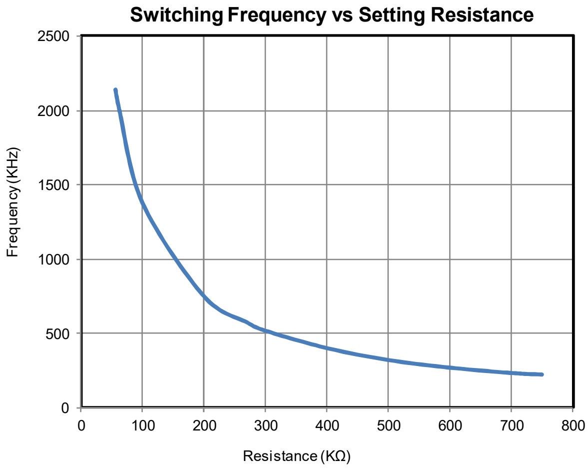



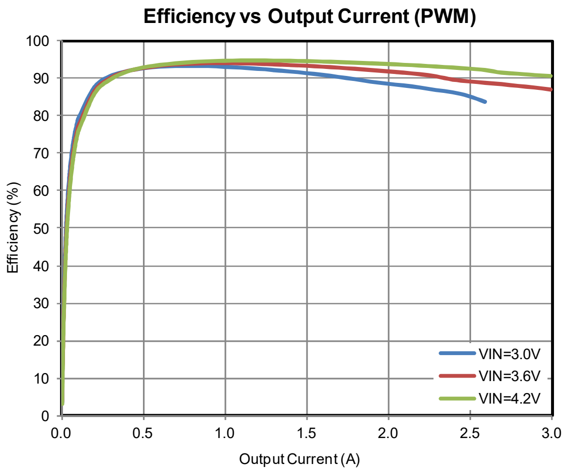



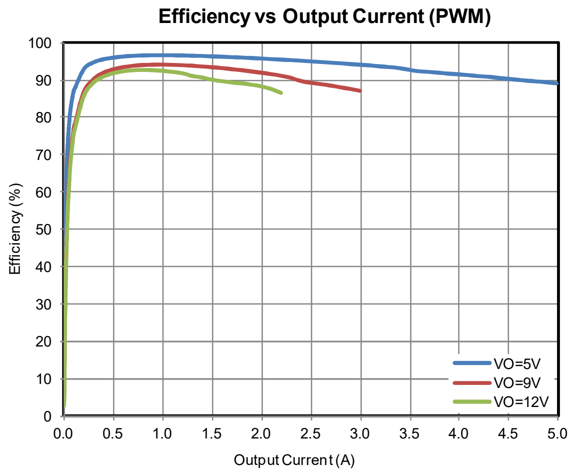



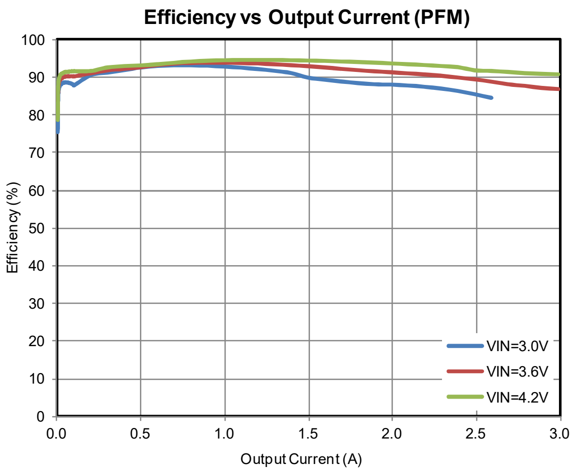
## Typical Performance Characteristics (continued)

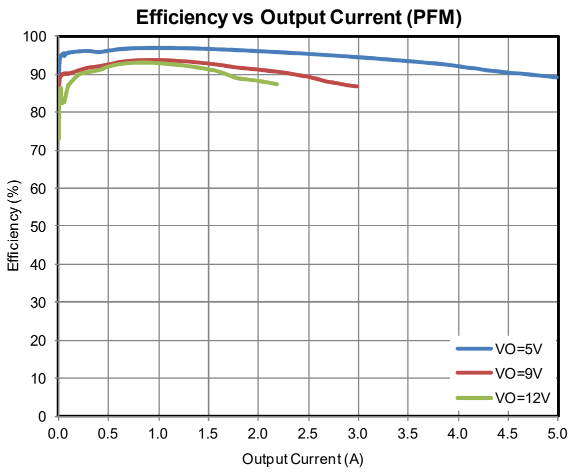


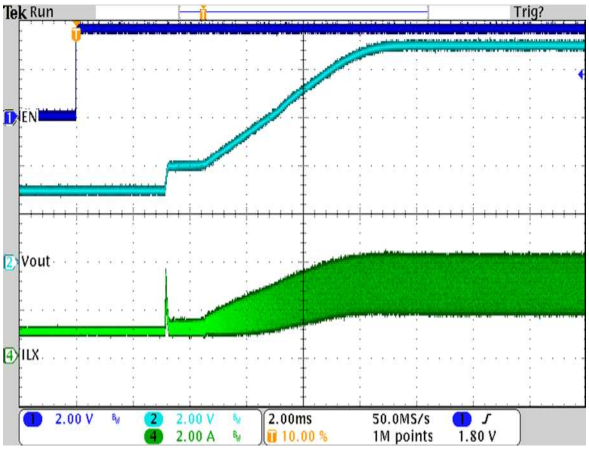



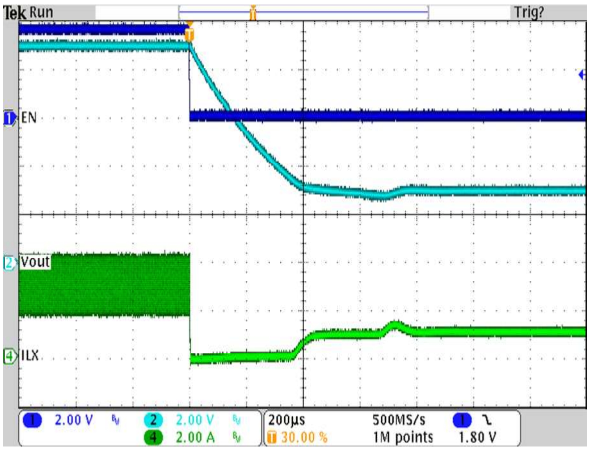



## Typical Performance Characteristics (continued)

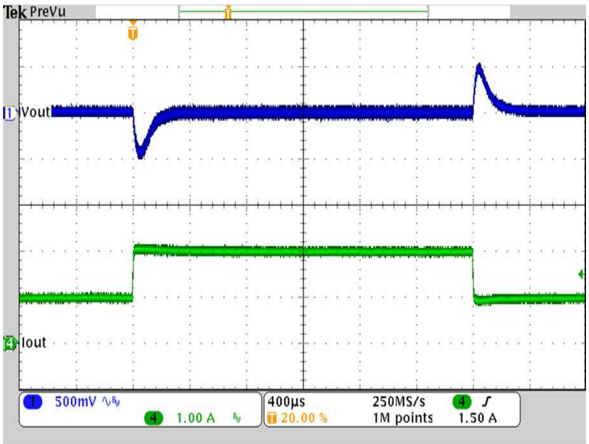
EN On Waveform



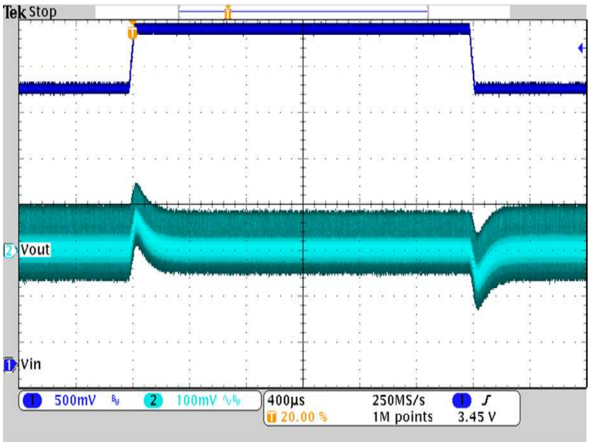

EN Off Waveform



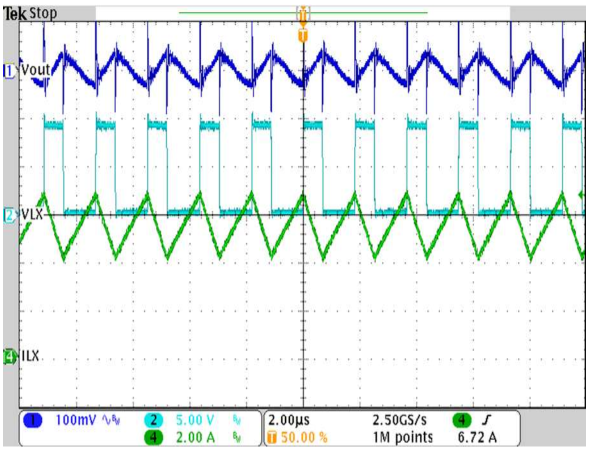

Load Transient ($I_{OUT}$=1 to 2A)



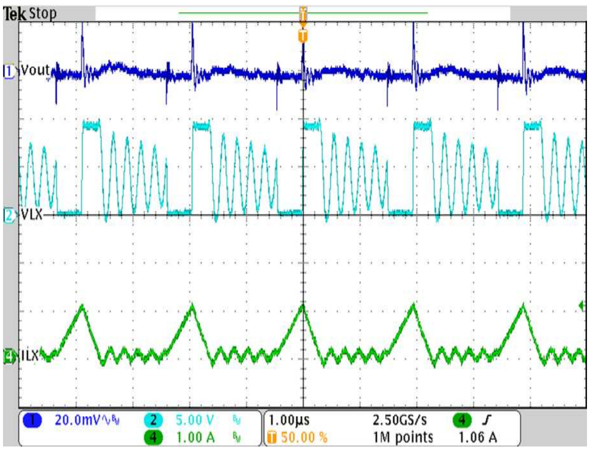

Line Transient ($V_{IN}$=3.3 to 3.6V)




Switching Waveforms in CCM

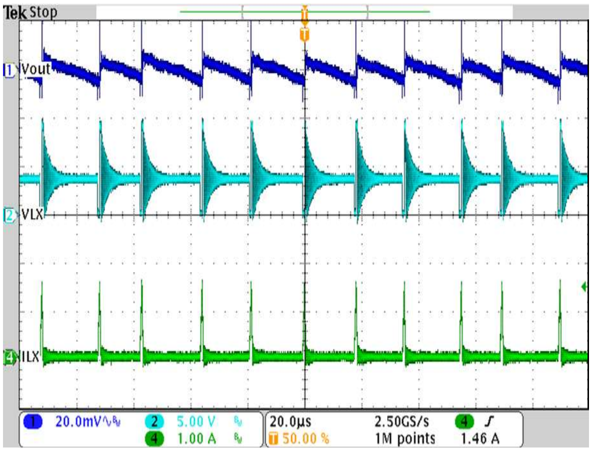



Switching Waveforms in DCM



## Typical Performance Characteristics (continued)

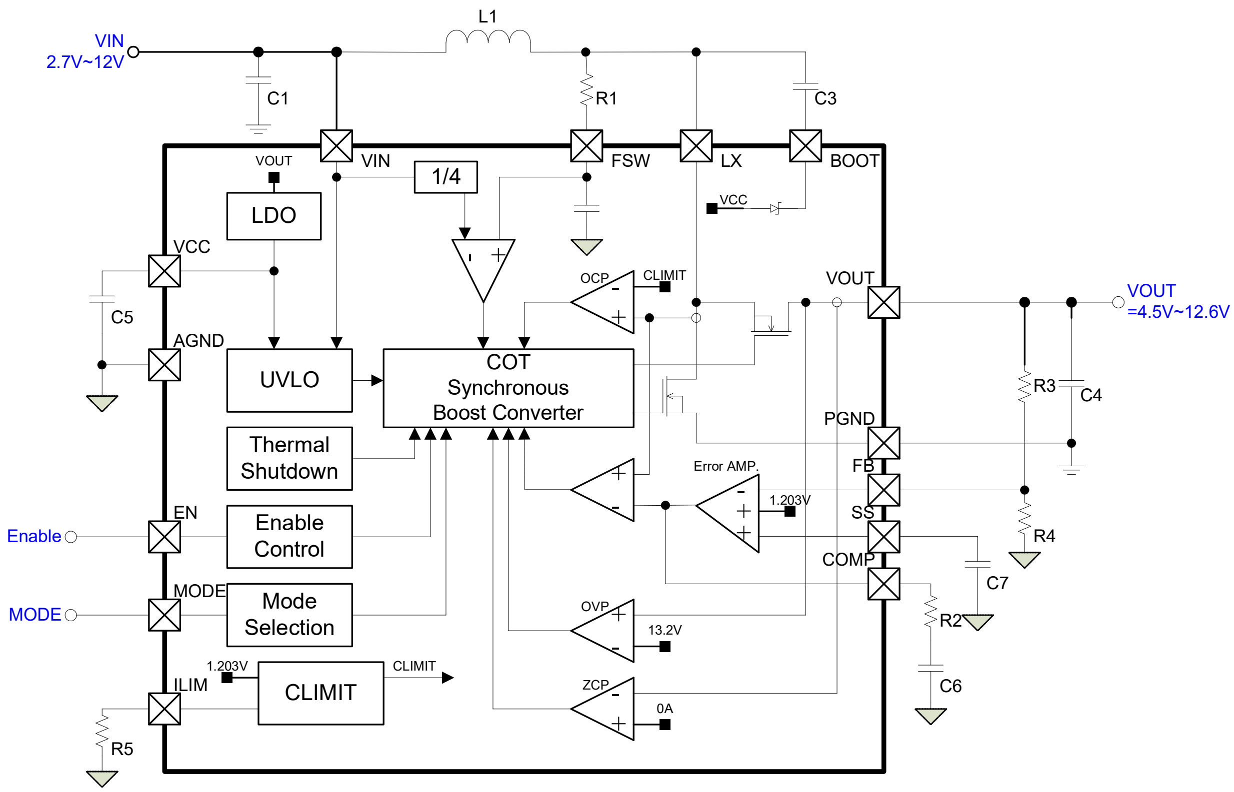
**Switching Waveforms in PFM Mode**



## Pin Description

| Pin No | NAME | FUNCTION |
|---|---|---|
| 1 | VCC | Output of the internal regulator. Bypass with a 1uF or greater ceramic capacitor to AGND |
| 2 | EN | Chip Enable Control Input. |
| 3 | FSW | The switching frequency is programmed by a resistor between this pin and the LX pin. |
| 4,5,6,7 | LX | Inductor switch node of Boost Converter. |
| 8 | BOOT | Power supply for high-side MOSFET gate driver. A ceramic capacitor of 0.1uF must be connected between this pin and the LX pin. |
| 9 | VIN | Power supply input of Boost Converter. Bypass with a 10uF or greater ceramic capacitor to PGND. |
| 10 | SS | Soft-start programming pin. |
| 11,12 | NC | No connection inside the device. Connect these two pins to ground plane on the PCB for good thermal dissipation. |
| 13 | MODE | Operation mode selection pin for the device in light load condition. When this pin is connected to ground, the device works in forced PWM mode, and when this pin is left floating, the device works in PFM mode. |
| 14,15,16 | VOUT | Output Voltage of Boost Converter. |
| 17 | FB | Voltage feedback. Connect to the center tape of a resistor divider to program the output voltage. |
| 18 | COMP | Output of the internal error amplifier, the loop compensation network should be connected between this pin and the AGND pin. |
| 19 | ILIM | Adjustable switch peak current limit. An external resister should be connected between this pin and the AGND pin. |
| 20 | AGND | Signal ground of the IC |
| 21 | PGND | Power ground of the IC. |

## Block Diagram



## Function Description

### Soft-Start

The G2280 has an adjustable soft start function to prevent high inrush current during start-up. When the EN pin is pulled high, the soft-start capacitor is charged with a constant current of 5μA(typ.). When the EN pin is pulled low, the voltage of the soft-start capacitor is discharged to ground.

$$t_{SS} = \frac{V_{REF} X C_{SS}}{I_{SS}}$$

Where

- $t_{SS}$ is the soft start time
- $V_{REF}$ is the internal reference voltage of 1.203V
- $C_{SS}$ is the capacitor between the SS pin and ground.
- $I_{SS}$ is the soft-start charging current of 5μA

### Under Voltage Lockout

The G2280 has both VIN UVLO and VCC UVLO function. When the voltage at the VIN pin drops below UVLO threshold $V_{IN\_UVLO}$ (2.4V typ.), which is typically 2.4V, or the voltage of VCC drops below $V_{CC\_UVLO}$ (1.9V typ.), the device stops switching.

### Adjustable Switching Frequency

The switching frequency is set by resistor connected between FSW pin and the LX pin of the G2280. The resistor value required for a desired frequency can be calculated using equation as below:

$$R_{FREQ} = \frac{\frac{V_{IN}}{V_{OUT}} \times \frac{1}{f_{SW}} - t_{DELAY}}{C_{FREQ} \times \ln\left(\frac{4 \times V_{OUT}}{4 \times V_{OUT} - V_{IN}}\right)}$$

Where

- $R_{FREQ}$ is the resistance connected between the FSW pin and the LX pin
- $C_{FREQ}$=23pF
- $f_{SW}$ is the desired switching frequency
- $t_{DELAY}$=50ns
- $V_{IN}$ is the input voltage
- $V_{OUT}$ is the output voltage

### Adjustable Peak Current Limit

The internal cycle-by-cycle current limit is adopted in the G2280. The low-side switch is turned off immediately as soon as the switch current touches the limit, set by a resistor at the ILIM pin to ground. The relationship between the current limit and the resistance depends on the status of the MODE pin.

When the MODE pin is floating, namely the G2280 is set to work in the PFM mode at light load, and the current limit is set using the equation as below:

$$I_{LIM} = \frac{1190000}{R_{ILIM}}$$

Where

- $R_{ILIM}$ is the resistance between the ILIM pin and ground
- $I_{LIM}$ is the switch peak current limit

When the resistor value is 100kΩ, the current limit is 11.9A.

When the MODE pin is connected to ground, namely the G2280 is set to work in the forced PWM mode at light load, and the current limit is set using the equation as below:

$$I_{LIM} = \frac{1090000}{R_{ILIM}}$$

When the resistor value is 100kΩ, the current limit is 10.9A.

### Overvoltage Protection

If the output voltage at the VOUT pin is detected above 13.2V, the G2280 turn off the low-side switch immediately, and turn on the high-side switch. The high-side switch is kept in on state until the zero-current threshold is detected. When the output voltage drops below the overvoltage threshold, the low-side switch is turn on. This function prevents overvoltage on the output and secures the circuits connected to the output from excessive overvoltage.

### Thermal Shutdown

A thermal shutdown is implemented to prevent damage due to excessive heat and power dissipation. Typically, the thermal shutdown happens at a junction temperature of 150°C. When the thermal shutdown is triggered, the device stops switching until the junction temperature fall below typically 130°C, the the device starts switching again.

### Setting Output Voltage

The output voltage is set by an external resistor divider R3, R4.
A standard 56-kΩ resistor is typically selected for low-side resistor R4.

The value of R3 is then calculated as below:

$$\mathrm{R3} = \frac{(V_{OUT} - V_{REF}) \times \mathrm{R4}}{V_{REF}}$$

### Inductor Selection

Because the selection of the inductor affects the power supply's steady state operation, transient behavior, loop stability, and boost converter efficiency, the inductor is the most important component in switching power regulator design. Three most important specifications to the performance of the inductor are the inductor value, DC resistance, and saturation current.

When selecting an inductor, make sure its rated current, especially the saturation current, is larger than its peak current during the operation.
Follow Equation $I_{DC}$ to Equation $I_{LPEAK}$ to calculate the peak current of the inductor. To calculate the current in the worst case, use the minimum input voltage, maximum output voltage, and maximum load current of the application.

In a boost regulator, calculate the inductor DC current as below:

$$I_{DC} = \frac{V_{OUT} \times I_{OUT}}{V_{IN} \times \eta}$$

Calculate the inductor current peak-to-peak ripple as below:

$$I_{PP} = \frac{1}{L \times \left( \frac{1}{V_{OUT} - V_{IN}} + \frac{1}{V_{IN}} \right) \times f_{SW}}$$

Where

- $I_{PP}$ is the inductor peak-to-peak ripple.
- L is the inductor value.
- $f_{SW}$ is the switching frequency.
- $V_{IN}$ is the input voltage.
- $V_{OUT}$ is the output voltage.

Therefore, the peak current, ILpeak, seen by the inductor is calculated as below:

$$I_{Lpeak} = I_{DC} + \frac{I_{PP}}{2}$$

Set the current limit of the G2280 higher than the peak current ILpeak. Then select the inductor with saturation current higher than the setting current limit.

### Input Capacitor Selection

Recommend low-ESR MLCC capacitors for good input voltage filtering.
10μF MLCC bypass capacitor is recommended as close as possible to the VIN pin .
The VCC pin is the output of the internal LDO.
A MLCC capacitor of more than 1 μF is required at the VCC pin to get a stable operation of the LDO.

For the power stage, because of the inductor current ripple, the input voltage changes if there is parasite inductance and resistance between the power supply and the inductor. It is recommended to have enough input capacitance to make the input voltage ripple less than 100mV. Generally, 10-μF input capacitance is sufficient for most applications.

### Output Capacitor Selection

The output filter capacitor could be used with MLCC type capacitor. It is recommended to use three 22μF MLCC output capacitors work for most applications. Higher capacitor values can be used to improve the load transient response. MLCC capacitors can lose most of their capacitance at rated voltage.
Therefore, leave margin on the voltage rating to ensure adequate effective capacitance. From the required output voltage ripple, use the following equations to calculate the minimum required effective capacitance COUT:

$$\mathrm{V_{RIPPLE\_CAP}} = \frac{(V_{OUT} - V_{IN}) \times I_{OUT}}{V_{REF} \times f_{SW} \times C_{OUT}}$$

$$\mathrm{V_{RIPPLE\_ESR}} = I_{Lpeak} \times R_{C\_ESR}$$

Where

- $V_{RIPPLE\_CAP}$ is output voltage ripple caused by charging and discharging of the output capacitor.
- $V_{RIPPLE\_ESR}$ is output voltage ripple caused by ESR of the output capacitor.
- $V_{IN}$ is the input voltage.
- $V_{OUT}$ is the output voltage.
- $I_{OUT}$ is the output current.
- $f_{SW}$ is the switching frequency.
- $I_{Lpeak}$ is the peak current of the inductor.
- $R_{C\_ESR}$ is the ESR of the output capacitors.

**Loop Stability**

The G2280 requires external compensation, which allows the loop response to be optimized for each application. The COMP pin is the output of the internal error amplifier. An external compensation network
comprised of resistor R2, ceramic capacitors C6 and CZ is connected to the COMP pin.

$$f_P = \frac{2}{2\pi \times \frac{V_{OUT}}{I_{OUT}} \times C_{OUT}}$$

$$f_{ESRZ} = \frac{1}{2\pi \times R_{ESR} \times C_{OUT}}$$

$$f_{RHPZ} = \frac{\frac{V_{OUT}}{I_{OUT}} \times (1-D)^2}{2\pi \times L}$$

loop crossover frequency, The higher in frequency that the loop gain stays above zero before crossing over, the faster the loop response is.

It is generally accepted that the loop gain cross over no higher than the lower of either 1/10 of the switching frequency or 1/5 of the RHPZ frequency.

$$R2 = \frac{2\pi \times V_{OUT} \times ZCS \times f_C \times C_{OUT}}{(1-D) \times V_{REF} \times G_{EA}}$$

Where

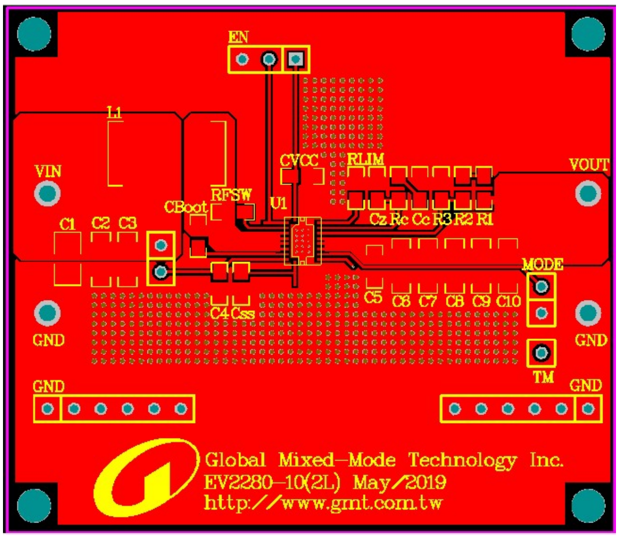
- ZCS =80mV/A.
- $f_C$ is the selected crossover frequency.

$$C6 = \frac{\frac{V_{OUT}}{I_{OUT}} \times C_{OUT}}{2R2}$$

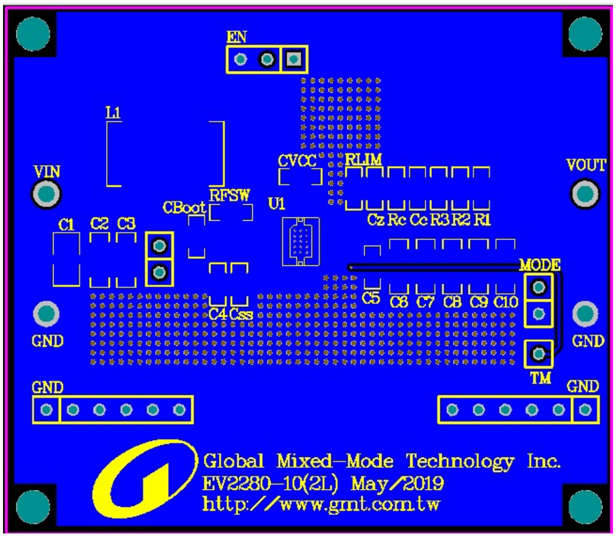
$$C_Z = \frac{R_{ESR} \times C_{OUT}}{R2}$$

## PCB Layout

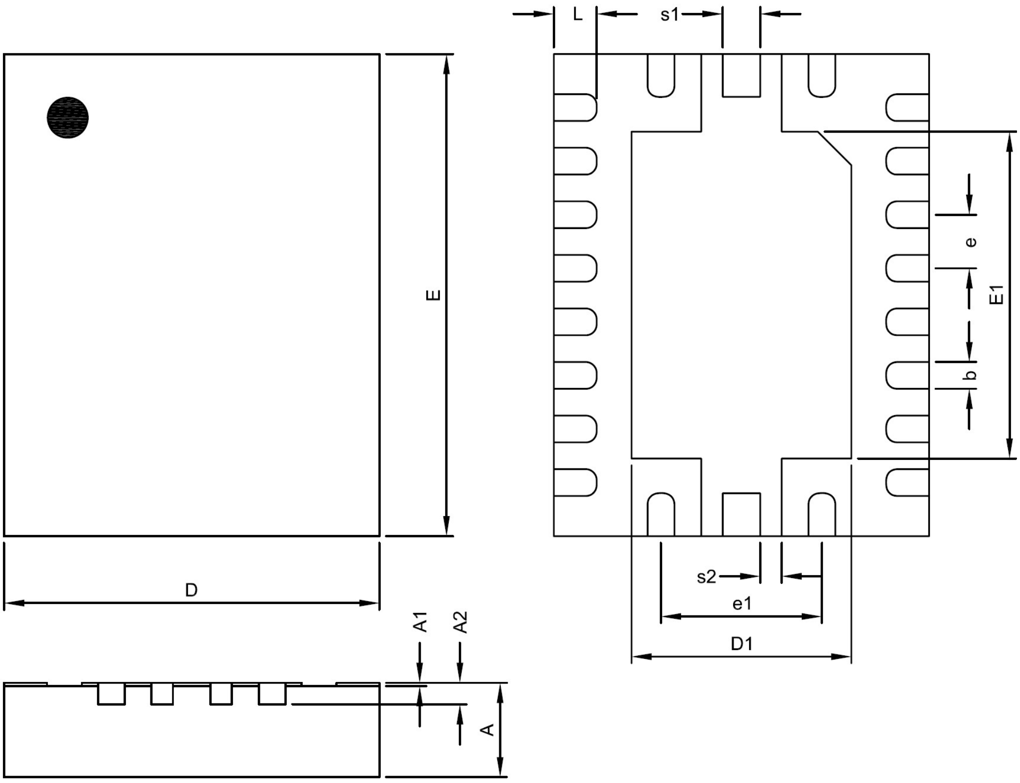
**Top Layer**




**Bottom Layer**



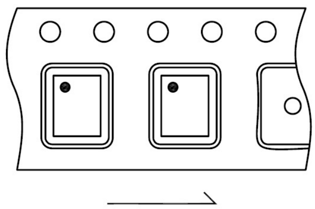
## Package Information




**QFN3.5X4.5-20 Package**

| Symbol | DIMENSION IN MM | | | DIMENSION IN INCH | | |
|---|---|---|---|---|---|---|
| | MIN. | NOM. | MAX. | MIN. | NOM. | MAX. |
| A | 0.80 | 0.85 | 0.90 | 0.0315 | 0.0335 | 0.0354 |
| A1 | 0.00 | - - - | 0.05 | 0.0000 | - - - | 0.0020 |
| A2 | 0.20 REF | | | 0.0079 REF | | |
| D | 3.45 | 3.50 | 3.55 | 0.1358 | 0.1378 | 0.1400 |
| E | 4.45 | 4.50 | 4.55 | 0.1752 | 0.1772 | 0.1791 |
| D1 | 1.95 | 2.05 | 2.15 | 0.0768 | 0.0807 | 0.0846 |
| E1 | 2.95 | 3.05 | 3.15 | 0.1161 | 0.1201 | 0.1240 |
| b | 0.20 | 0.25 | 0.30 | 0.0078 | 0.0098 | 0.0118 |
| e | 0.50 BSC | | | 0.0197 BSC | | |
| e1 | 1.50 BSC | | | 0.0591 BSC | | |
| s1 | 0.35 REF | | | 0.0138 REF | | |
| s2 | 0.20 REF | | | 0.0079 REF | | |
| L | 0.30 | 0.40 | 0.50 | 0.0118 | 0.0157 | 0.0197 |

## Taping Specification




| PACKAGE | Q'TY/REEL |
|---|---|
| QFN3.5X4.5-20 | 3,000 ea |