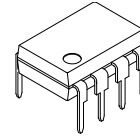


# Green-Mode Power Switch

## GF001H



PDIP8 9.59x6.6, 2.54P  
CASE 646CN

### Description

The GF001H is a next-generation, Green-Mode Power Switch. It integrates an advanced current-mode Pulse Width Modulator (PWM) and an avalanche-rugged 700 V SENSEFET® in a single package, allowing auxiliary power designs with higher standby energy efficiency, reduced size, improved reliability, and lower system cost than previous solutions.

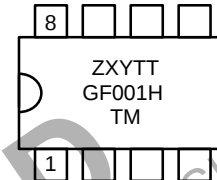
A new frequency modulation reduces EMI emission and built-in synchronized slope compensation allows stable peak-current-mode control over a wide range of input voltage.

Requiring a minimum number of external components, the GF001H provides a solid platform for cost-effective flyback converter design with low standby power consumption.

### Features

- Advanced Burst Mode Operation at No-Load Condition
- 700 V High-Voltage JFET Startup Circuit
- Internal Avalanche-Rugged 700 V SENSEFET
- Built-in 5 ms Soft-Start
- Peak-Current-Mode Control
- Cycle-by-Cycle Current Limiting
- Leading-Edge Blanking (LEB)
- Synchronized Slope Compensation
- Frequency Modulation to Attenuating EMI
- Internal Overload / Open-Loop Protection (OLP)
- V<sub>DD</sub> Under-Voltage Lockout (UVLO)
- V<sub>DD</sub> Over-Voltage Protection (OVP)
- Internal Auto-Restart Circuit (OLP, VDD OVP)
- Adjustable Peak Current Limit
- This Device is Pb-Free, Halide Free and are RoHS Compliant

### MARKING DIAGRAM



Z = Plant Code  
X = 1-Digit Year Code  
Y = 1-Digit Week Code  
TT = 2-Digit Die Run Code  
T = Package Type (N: DIP)  
M = Manufacture Flow Code  
GF001H = Device Code

### ORDERING INFORMATION

See detailed ordering and shipping information on page 11 of this data sheet.

## APPLICATION DIAGRAM

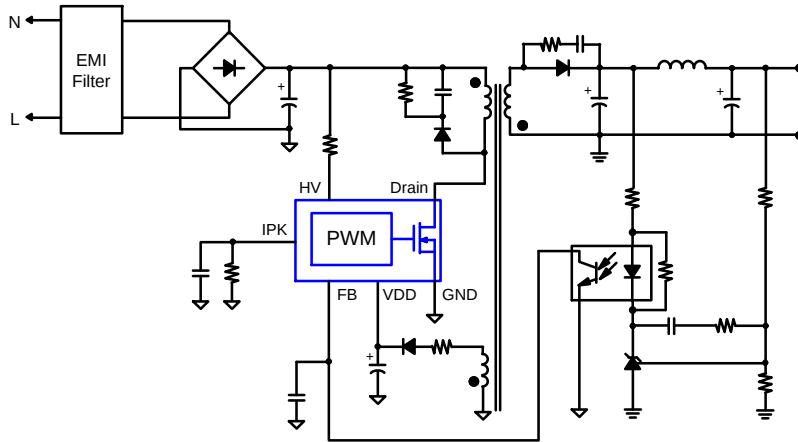


Figure 1. Typical Flyback Application

## OUTPUT POWER TABLE (Note 1)

| Product | 230 V <sub>AC</sub> ±15% (Note 2) |                     | 85 – 265 V <sub>AC</sub> |                     |
|---------|-----------------------------------|---------------------|--------------------------|---------------------|
|         | Adapter (Note 3)                  | Open-Frame (Note 4) | Adapter (Note 3)         | Open-Frame (Note 4) |
| GF001HN | 14 W                              | 20 W                | 11 W                     | 16 W                |

1. The maximum output power can be limited by junction temperature.
2. 230 V<sub>AC</sub> or 100/115 V<sub>AC</sub> with voltage doublers.
3. Typical continuous power in a non-ventilated enclosed adapter, with sufficient drain pattern of printed circuit board (PCB) as a heat sink, at 50°C ambient.
4. Maximum practical continuous power in an open-frame, design with sufficient drain pattern of printed circuit board (PCB) as a heat sink, at 50°C ambient.

## BLOCK DIAGRAM

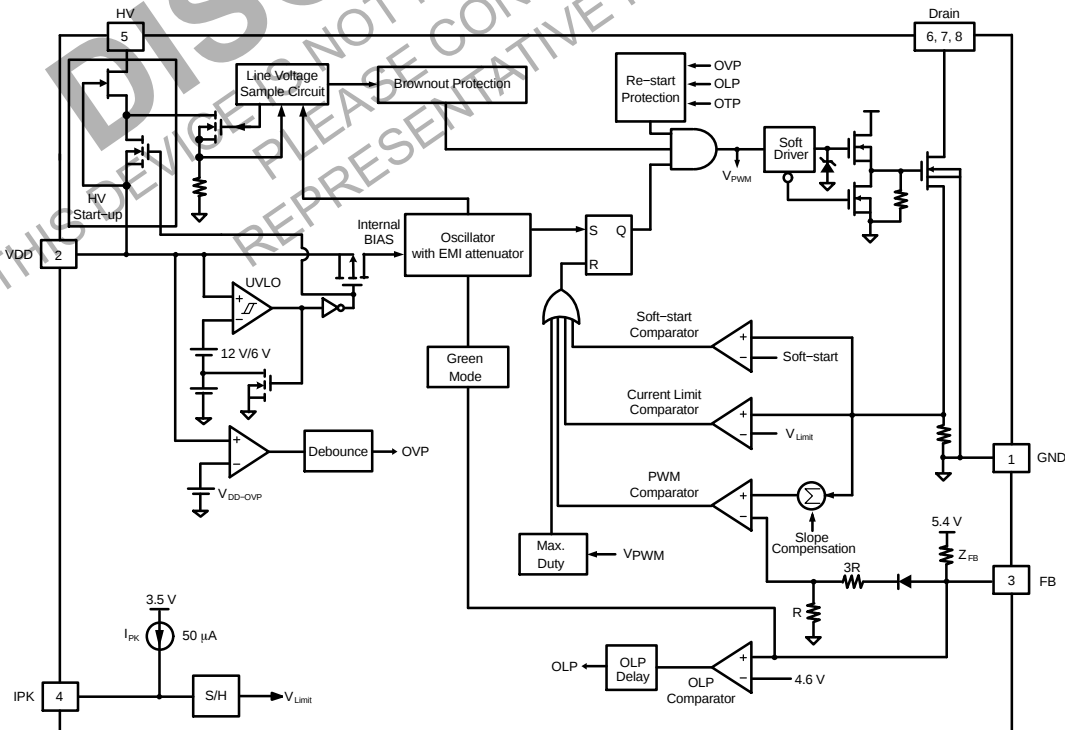


Figure 2. Internal Block Diagram

## PIN CONFIGURATION

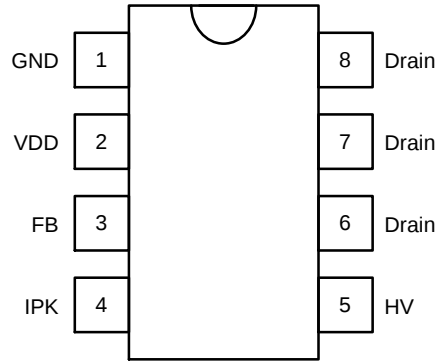


Figure 3. Pin Assignment

## PIN DEFINITIONS

| Pin # | Name  | Description                                                                                                                                                                                                                                                                                |
|-------|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1     | GND   | <i>Ground.</i> This pin internally connects to the SENSEFET source and signal ground of the PWM controller.                                                                                                                                                                                |
| 2     | VDD   | <i>Supply Voltage of the IC.</i> Typically the hold-up capacitor connects from this pin to ground. A rectifier diode in series with the transformer auxiliary winding connects to this pin to supply bias during normal operation.                                                         |
| 3     | FB    | <i>Feedback.</i> The signal from the external compensation circuit connects to this pin. The PWM duty cycle is determined by comparing the signal on this pin and the internal current-sense signal.                                                                                       |
| 4     | IPK   | <i>Adjust Peak Current.</i> Typically a resistor connects from this pin to the GND pin to program the current-limit level. The internal current source (50 $\mu$ A) introduces voltage drop across the resistor, which determines the current-limit level of pulse-by-pulse current limit. |
| 5     | HV    | <i>Startup.</i> Typically, resistors in series from DC line connect to this pin to supply internal bias and to charge the external capacitor connected between the VDD pin and the GND pin during startup. This pin is also used to sense the line voltage for brownout protection.        |
| 6     | Drain | <i>SENSEFET Drain.</i> This pin is designed to directly drive the transformer.                                                                                                                                                                                                             |
| 7     |       |                                                                                                                                                                                                                                                                                            |
| 8     |       |                                                                                                                                                                                                                                                                                            |

## ABSOLUTE MAXIMUM RATINGS

| Symbol      | Parameter                                                     | Min  | Max                         | Unit             |
|-------------|---------------------------------------------------------------|------|-----------------------------|------------------|
| $V_{DRAIN}$ | Drain Pin Voltage (Note 5, 6)                                 | –    | 700                         | V                |
| $I_{DM}$    | Drain Current Pulsed (Note 7)                                 | –    | 8.0                         | A                |
| $E_{AS}$    | Single Pulsed Avalanche Energy (Note 8)                       | –    | 140                         | mJ               |
| $V_{DD}$    | DC Supply Voltage                                             | –    | 25                          | V                |
| $V_{FB}$    | FB Pin Input Voltage                                          | –0.3 | 6.0                         | V                |
| $V_{IPK}$   | IPK Pin Input Voltage                                         | –0.3 | 6.0                         | V                |
| $V_{HV}$    | HV Pin Input Voltage                                          | –    | 700                         | V                |
| $P_D$       | Power Dissipation ( $T_A < 50^\circ\text{C}$ )                | –    | 1.5                         | W                |
| $T_J$       | Operating Junction Temperature                                | –40  | Internally Limited (Note 9) | $^\circ\text{C}$ |
| $T_{STG}$   | Storage Temperature Range                                     | –55  | +150                        | $^\circ\text{C}$ |
| $T_L$       | Lead Soldering Temperature (Wave Soldering or IR, 10 Seconds) | –    | +260                        | $^\circ\text{C}$ |

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

5. All voltage values, except differential voltages, are given with respect to the network ground terminal.

6. Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device.

7. Non-repetitive rating: pulse width is limited by the maximum junction temperature.

8.  $L = 51\text{ mH}$ , starting  $T_J = 25^\circ\text{C}$ .

9. Internally limited by Over-Temperature Protection (OTP). Refer to  $T_{OTP}$ .

## THERMAL RESISTANCE TABLE

| Symbol        | Parameter                                        | Value | Unit               |
|---------------|--------------------------------------------------|-------|--------------------|
| $\theta_{JA}$ | Junction-to-Air Thermal Resistance               | 86    | $^\circ\text{C/W}$ |
| $\Psi_{JT}$   | Junction-to-Package Thermal Resistance (Note 10) | 20    | $^\circ\text{C/W}$ |

10. Measured on the package top surface.

## ESD CAPABILITY

| Symbol | Parameter                                   |                           | Value | Unit |
|--------|---------------------------------------------|---------------------------|-------|------|
| ESD    | Human Body Model, JESD22-A114 (Note 11)     | All Pins Excluding HV Pin | 7     | kV   |
|        |                                             | All Pins Including HV Pin | 3     |      |
|        | Charged Device Model, JESD22-C101 (Note 11) | All Pins Excluding HV Pin | 2     |      |
|        |                                             | All Pins Including HV Pin | 2     |      |

11. Meets JEDEC standards JESD 22-A114 and JESD 22-C101.

# GF001H

## ELECTRICAL CHARACTERISTICS ( $V_{DD} = 15\text{ V}$ , and $T_A = 25^\circ\text{C}$ unless otherwise specified.)

| Symbol                            | Parameter                                  | Condition                                                                      | Min | Typ | Max | Unit          |
|-----------------------------------|--------------------------------------------|--------------------------------------------------------------------------------|-----|-----|-----|---------------|
| <b>SENSEFET SECTION</b> (Note 12) |                                            |                                                                                |     |     |     |               |
| $BV_{DSS}$                        | Drain-Source Breakdown Voltage             | $V_{DS} = 700\text{ V}$ , $V_{GS} = 0\text{ V}$                                | 700 | –   | –   | V             |
| $I_{DSS}$                         | Zero-Gate-Voltage Drain Current            | $V_{DS} = 700\text{ V}$ , $V_{GS} = 0\text{ V}$                                | –   | –   | 50  | $\mu\text{A}$ |
|                                   |                                            | $V_{DS} = 560\text{ V}$ , $V_{GS} = 0\text{ V}$ ,<br>$T_C = 125^\circ\text{C}$ | –   | –   | 200 |               |
| $R_{DS(ON)}$                      | Drain-Source On-State Resistance (Note 12) | $V_{GS} = 10\text{ V}$ , $I_D = 0.5\text{ A}$                                  | –   | 6.0 | 7.2 | $\Omega$      |
| $C_{ISS}$                         | Input Capacitance                          | $V_{GS} = 0\text{ V}$ , $V_{DS} = 25\text{ V}$ ,<br>$f = 1\text{ MHz}$         | –   | 550 | 715 | pF            |
| $C_{OSS}$                         | Output Capacitance                         | $V_{GS} = 0\text{ V}$ , $V_{DS} = 25\text{ V}$ ,<br>$f = 1\text{ MHz}$         | –   | 38  | 50  | pF            |
| $C_{RSS}$                         | Reverse Transfer Capacitance               | $V_{GS} = 0\text{ V}$ , $V_{DS} = 25\text{ V}$ ,<br>$f = 1\text{ MHz}$         | –   | 17  | 26  | pF            |
| $t_{d(on)}$                       | Turn-On Delay                              | $V_{DS} = 350\text{ V}$ , $I_D = 1.0\text{ A}$                                 | –   | 20  | 50  | ns            |
| $t_r$                             | Rise Time                                  | $V_{DS} = 350\text{ V}$ , $I_D = 1.0\text{ A}$                                 | –   | 15  | 40  | ns            |
| $t_{d(off)}$                      | Turn-Off Delay                             | $V_{DS} = 350\text{ V}$ , $I_D = 1.0\text{ A}$                                 | –   | 55  | 120 | ns            |
| $t_f$                             | Fall Time                                  | $V_{DS} = 350\text{ V}$ , $I_D = 1.0\text{ A}$                                 | –   | 25  | 60  | ns            |

## CONTROL SECTION

### VDD SECTION

|                |                                                                      |                                                |    |     |     |               |
|----------------|----------------------------------------------------------------------|------------------------------------------------|----|-----|-----|---------------|
| $V_{DD-ON}$    | UVLO Start Threshold Voltage                                         |                                                | 11 | 12  | 13  | V             |
| $V_{DD-OFF1}$  | UVLO Stop Threshold Voltage                                          |                                                | 5  | 6   | 7   | V             |
| $V_{DD-OFF2}$  | $I_{DD-OLP}$ Enable Threshold Voltage                                |                                                | 8  | 9   | 10  | V             |
| $V_{DD-OLP}$   | $V_{DD}$ Voltage Threshold for HV Startup Turn-On at Protection Mode |                                                | 5  | 6   | 7   | V             |
| $I_{DD-ST}$    | Startup Supply Current                                               | $V_{DD-ON} - 0.16\text{ V}$                    | –  | –   | 30  | $\mu\text{A}$ |
| $I_{DD-OP1}$   | Operating Supply Current with Normal Switching Operation             | $V_{DD} = 15\text{ V}$ , $V_{FB} = 3\text{ V}$ | –  | –   | 3.8 | mA            |
| $I_{DD-OP2}$   | Operating Supply Current without Switching Operation                 | $V_{DD} = 15\text{ V}$ , $V_{FB} = 1\text{ V}$ | –  | –   | 1.8 | mA            |
| $I_{DD-OLP}$   | Internal Sinking Current                                             | $V_{DD-OLP} + 0.1\text{ V}$                    | 40 | 60  | 100 | $\mu\text{A}$ |
| $V_{DD-OVP}$   | $V_{DD}$ Over-Voltage Protection                                     |                                                | 23 | 24  | 25  | V             |
| $t_{D-VDDOVP}$ | $V_{DD}$ Over-Voltage Protection Debounce Time                       |                                                | 40 | 105 | 170 | $\mu\text{s}$ |

### HV SECTION

|              |                                                              |                                                                            |     |     |     |               |
|--------------|--------------------------------------------------------------|----------------------------------------------------------------------------|-----|-----|-----|---------------|
| $I_{HV}$     | Supply Current Drawn from HV Pin                             | HV = 120 V <sub>DC</sub> ,<br>$V_{DD} = 0\text{ V}$ with 10 $\mu\text{F}$  | 1.2 | –   | 4.7 | mA            |
| $V_{HV}$     | Minimum HV Voltage for $V_{DD}$ being charged to $V_{DD-ON}$ | $R_{HV} = 0\ \Omega$ ,<br>$T_A = -40^\circ\text{C}$ to $105^\circ\text{C}$ | 30  | –   | –   | V             |
| $I_{HV-LC}$  | Leakage Current after Startup                                | HV = 700 V,<br>$V_{DD} = V_{DD-OFF1} + 1\text{ V}$                         | –   | –   | 10  | $\mu\text{A}$ |
| $V_{DC-ON}$  | Brown-in Threshold Level ( $V_{DC}$ )                        | DC Voltage Applied to<br>HV Pin Through 200 k $\Omega$<br>Resistor         | 104 | 114 | 124 | V             |
| $V_{DC-OFF}$ | Brownout Threshold Level ( $V_{DC}$ )                        |                                                                            | 89  | 99  | 109 | V             |
| $t_{UVP}$    | Brownout Protection Time                                     |                                                                            | 0.8 | 1.2 | 1.6 | s             |

### OSCILLATOR SECTION

|             |                                                         |                                                  |    |         |     |     |
|-------------|---------------------------------------------------------|--------------------------------------------------|----|---------|-----|-----|
| $f_{OSC}$   | Frequency in Nominal Mode                               | Center Frequency                                 | 94 | 100     | 106 | kHz |
| $f_M$       | Frequency Modulation                                    |                                                  | –  | $\pm 6$ | –   | kHz |
| $f_{OSC-G}$ | Green-Mode Frequency                                    |                                                  | 20 | 23      | 26  | kHz |
| $f_{DV}$    | Frequency Variation vs. $V_{DD}$ Deviation              | $V_{DD} = 11\text{ V}$ to $22\text{ V}$          | –  | –       | 5   | %   |
| $f_{DT}$    | Frequency Variation vs. Temperature Deviation (Note 12) | $T_A = -40^\circ\text{C}$ to $105^\circ\text{C}$ | –  | –       | 5   | %   |

# GF001H

## ELECTRICAL CHARACTERISTICS ( $V_{DD} = 15\text{ V}$ , and $T_A = 25^\circ\text{C}$ unless otherwise specified.) (continued)

| Symbol | Parameter | Condition | Min | Typ | Max | Unit |
|--------|-----------|-----------|-----|-----|-----|------|
|--------|-----------|-----------|-----|-----|-----|------|

### FEEDBACK INPUT SECTION

|               |                                                      |                     |       |                    |       |            |
|---------------|------------------------------------------------------|---------------------|-------|--------------------|-------|------------|
| $A_V$         | Internal Voltage Dividing Factor of FB Pin (Note 12) |                     | 1/4.5 | 1/4.0              | 1/3.5 | V/V        |
| $Z_{FB}$      | Pull-Up Impedance of FB Pin                          |                     | 15    | 21                 | 27    | k $\Omega$ |
| $V_{FB-OPEN}$ | FB Pin Pull-Up Voltage                               | FB Pin Open         | 5.2   | 5.4                | 5.6   | V          |
| $V_{FB-OLP}$  | FB Voltage Threshold to Trigger Open-Loop Protection |                     | 4.3   | 4.6                | 4.9   | V          |
| $t_{D-OLP}$   | Delay of FB Pin Open-Loop Protection                 |                     | 46    | 56                 | 66    | ms         |
| $V_{FB-N}$    | FB Voltage Threshold to Exit Green Mode              | $V_{FB}$ is Rising  | 2.4   | 2.6                | 2.8   | V          |
| $V_{FB-G}$    | FB Voltage Threshold to Enter Green Mode             | $V_{FB}$ is Falling | –     | $V_{FB-N} - 0.2$   | –     | V          |
| $V_{FB-ZDC}$  | FB Voltage Threshold to Enter Zero-Duty State        | $V_{FB}$ is Falling | 1.1   | 1.2                | 1.3   | V          |
| $V_{FB-ZDCR}$ | FB Voltage Threshold to Exit Zero-Duty State         | $V_{FB}$ is Rising  | –     | $V_{FB-ZDC} + 0.1$ | –     | V          |

### IPK PIN SECTION

|                |                                                                 |                                                                                 |      |      |      |               |
|----------------|-----------------------------------------------------------------|---------------------------------------------------------------------------------|------|------|------|---------------|
| $V_{IPK-OPEN}$ | IPK Pin Open Voltage                                            |                                                                                 | 3.0  | 3.5  | 4.0  | V             |
| $V_{IPK-H}$    | Internal Upper Clamping Voltage of IPK Pin (Note 12)            |                                                                                 | –    | –    | 3    | V             |
| $V_{IPK-L}$    | Internal Lower Clamping Voltage of IPK Pin (Note 12)            |                                                                                 | 1.5  | –    |      | V             |
| $I_{PK}$       | Internal Current Source of IPK Pin                              | $T_A = -40^\circ\text{C}$ to $105^\circ\text{C}$ ,<br>$V_{IPK} = 2.25\text{ V}$ | 45   | 50   | 55   | $\mu\text{A}$ |
| $I_{LMT-H}$    | Flat Threshold Level of Current Limit for the Highest IPK Level | $V_{IPK} = 3\text{ V}$                                                          | 0.90 | 1.00 | 1.10 | A             |
| $I_{LMT-L}$    | Flat Threshold Level of Current Limit for the Lowest IPK Level  | $V_{IPK} = 1.5\text{ V}$                                                        | 0.45 | 0.50 | 0.55 | A             |

### CURRENT-SENSE SECTION (Note 13)

|           |                                        |  |     |     |     |    |
|-----------|----------------------------------------|--|-----|-----|-----|----|
| $t_{PD}$  | Current Limit Turn-Off Delay (Note 14) |  | –   | 100 | 200 | ns |
| $t_{LEB}$ | Leading-Edge Blanking Time (Note 14)   |  | 160 | 210 | 260 | ns |
| $t_{SS}$  | Soft-Start Time (Note 12)              |  | –   | 5   | –   | ms |

### GATE SECTION (Note 13)

|             |                    |  |    |   |   |   |
|-------------|--------------------|--|----|---|---|---|
| $DCY_{MAX}$ | Maximum Duty Cycle |  | 70 | – | – | % |
|-------------|--------------------|--|----|---|---|---|

### OVER TEMPERATURE PROTECTION SECTION (OTP)

|           |                                               |  |     |   |   |                  |
|-----------|-----------------------------------------------|--|-----|---|---|------------------|
| $T_{OTP}$ | Junction Temperature to Trigger OTP (Note 12) |  | 140 | – | – | $^\circ\text{C}$ |
|-----------|-----------------------------------------------|--|-----|---|---|------------------|

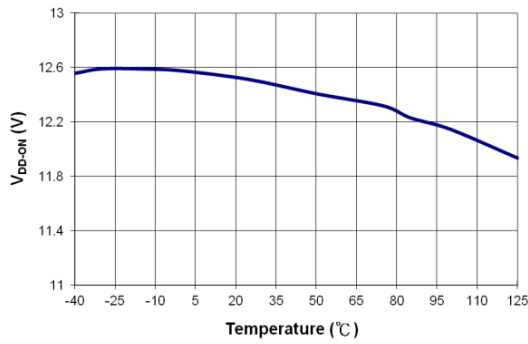
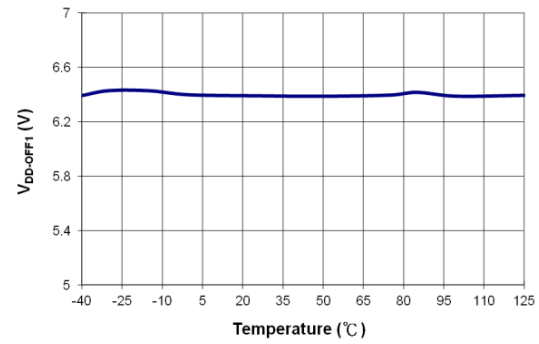
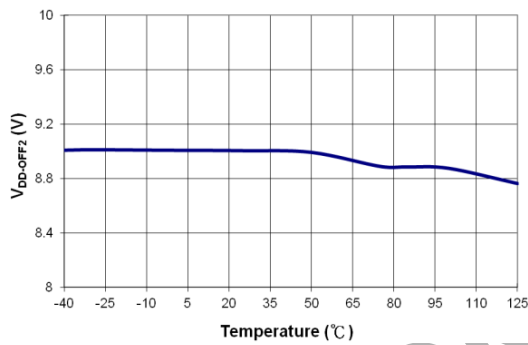
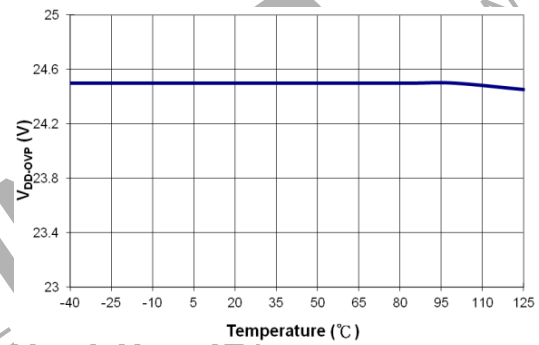
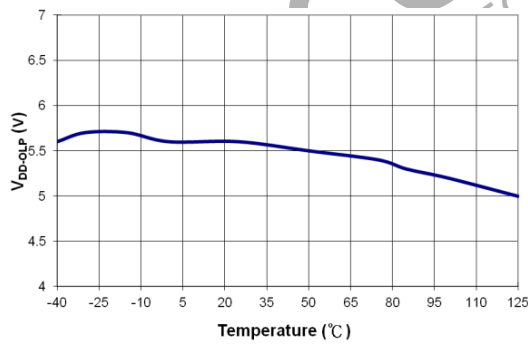
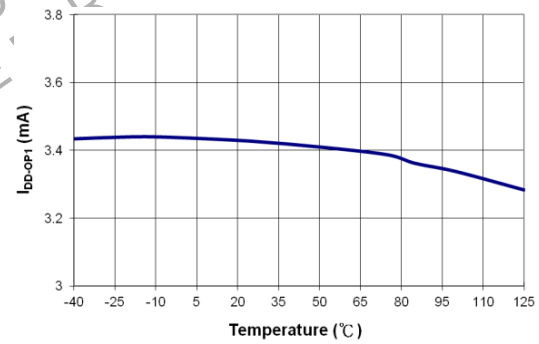
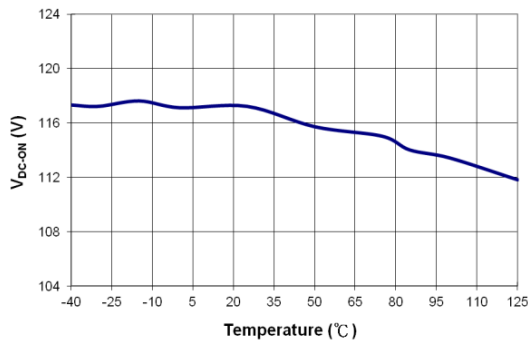
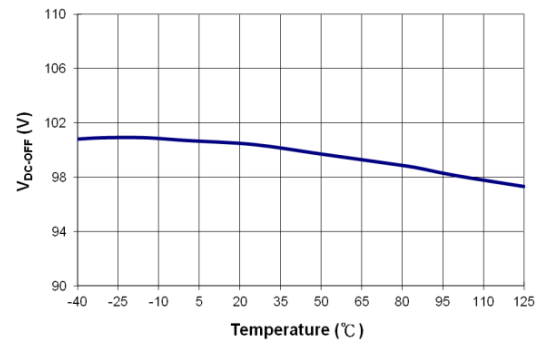
Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

12. Guaranteed by design; not 100% tested in production.

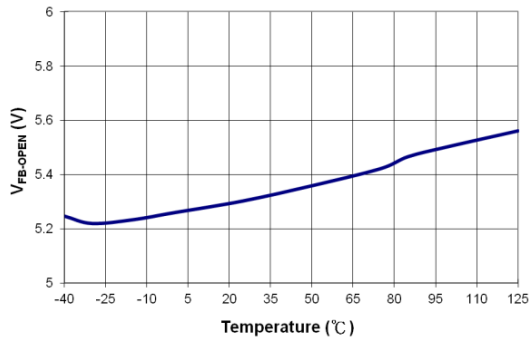
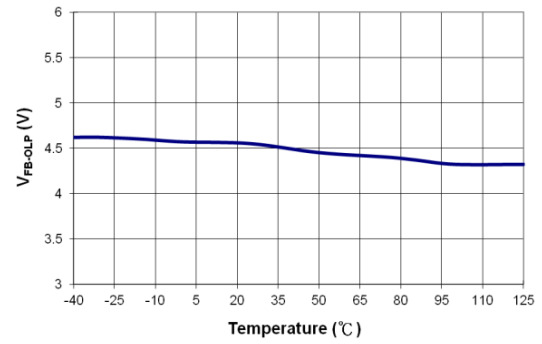
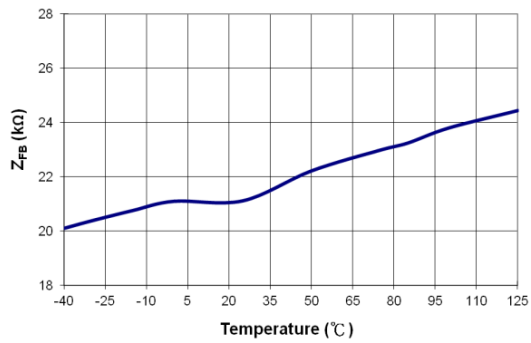
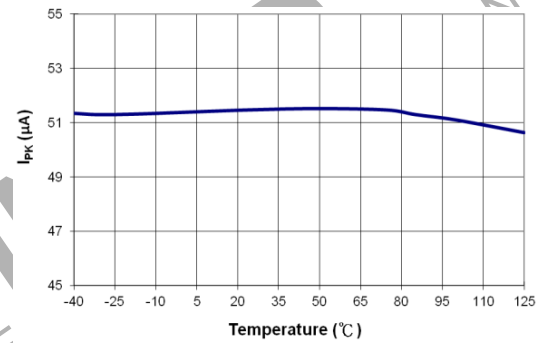
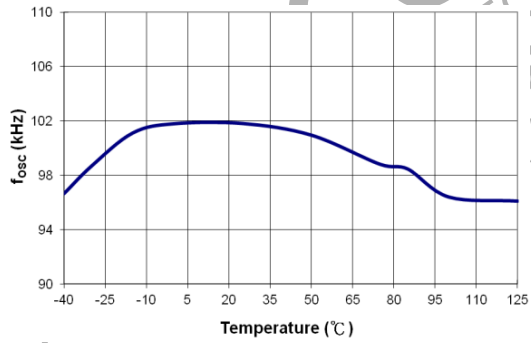
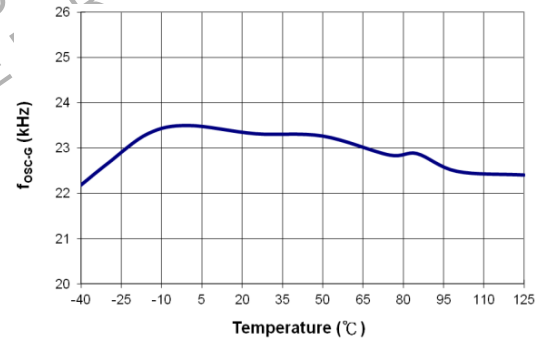
13. Pulse test: pulse width  $\leq 300\text{ }\mu\text{s}$ , duty  $\leq 2\%$ .

14. These parameters, although guaranteed, are tested in wafer-sort process.

## TYPICAL CHARACTERISTICS

Figure 4.  $V_{DD-ON}$  vs. TemperatureFigure 5.  $V_{DD-OFF1}$  vs. TemperatureFigure 6.  $V_{DD-OFF2}$  vs. TemperatureFigure 7.  $V_{DD-OVP}$  vs. TemperatureFigure 8.  $V_{DD-OLP}$  vs. TemperatureFigure 9.  $I_{DD-OP1}$  vs. TemperatureFigure 10.  $V_{DC-ON}$  vs. TemperatureFigure 11.  $V_{DC-OFF}$  vs. Temperature

## TYPICAL CHARACTERISTICS (Continued)

Figure 12.  $V_{FB-OPEN}$  vs. TemperatureFigure 13.  $V_{FB-OLP}$  vs. TemperatureFigure 14.  $Z_{FB}$  vs. TemperatureFigure 15.  $I_{PK}$  vs. TemperatureFigure 16.  $f_{osc}$  vs. TemperatureFigure 17.  $f_{osc-G}$  vs. Temperature

## FUNCTIONAL DESCRIPTION

## Startup Operation

The HV pin is typically connected to the DC link input through one resistor ( $R_{HV}$ ), as shown in Figure 18. When the DC input voltage is applied, the  $V_{DD}$  hold-up capacitor is charged by the line voltage through the resistor. After  $V_{DD}$  voltage reaches the turn-on threshold voltage ( $V_{DD-ON}$ ), the startup circuit charging the  $V_{DD}$  capacitor is switched off and  $V_{DD}$  is supplied by the auxiliary winding of the transformer. Once the GF001H starts, it continues operation until  $V_{DD}$  drops below 6 V ( $V_{DD-OFF1}$ ). The IC startup time with a given DC input voltage is:

$$t_{STARTUP} = R_{HV} \cdot C_{DD} \cdot \ln \frac{V_{DC}}{V_{DC} - V_{DD-ON}} \quad (\text{eq. 1})$$

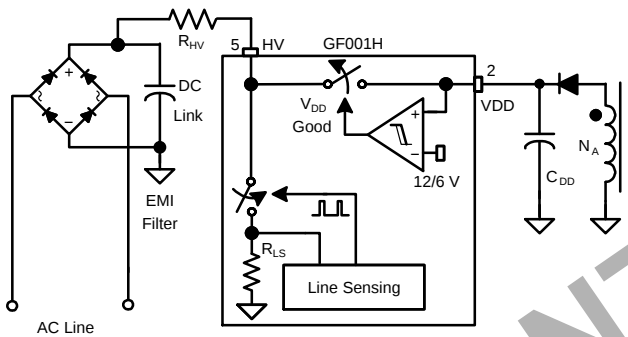


Figure 18. Functional Description

## Brown-in/out Function

The HV pin can detect the DC link voltage using a switched voltage divider that consists of external resistor ( $R_{HV}$ ) and internal resistor ( $R_{LS}$ ), as shown in Figure 18. The internal DC input voltage sensing circuit detects the input voltage using a sampling circuit and peak-detection circuit. Since the voltage divider causes power consumption when it is switched on, the switching is driven by a signal with a very narrow pulse width to minimize power loss. The sampling frequency is adaptively changed according to the load condition to minimize power consumption in light-load condition.

Based on the detected DC input voltage, brown-in and brownout thresholds are determined. Since the internal resistor ( $R_{LS}$ ) of the voltage divider is much smaller than  $R_{HV}$ , the thresholds are given:

$$V_{BROWN-IN} = \frac{R_{HV}}{200k} \cdot V_{DC-ON} \quad (\text{eq. 2})$$

$$V_{BROWNOUT} = \frac{R_{HV}}{200k} \cdot V_{DC-OFF} \quad (\text{eq. 3})$$

## PWM Control

The GF001H employs current-mode control, as shown in Figure 19. An opto-coupler (such as the H11A817A) and shunt regulator (such as the KA431) are typically used to implement the feedback network. Comparing the feedback voltage with the voltage across the  $R_{sense}$  resistor makes it possible to control the switching duty cycle. A synchronized positive slope is added to the SENSEFET current information to guarantee stable current-mode control over a wide range of input voltage. The built-in slope compensation stabilizes the current loop and prevents sub-harmonic oscillation.

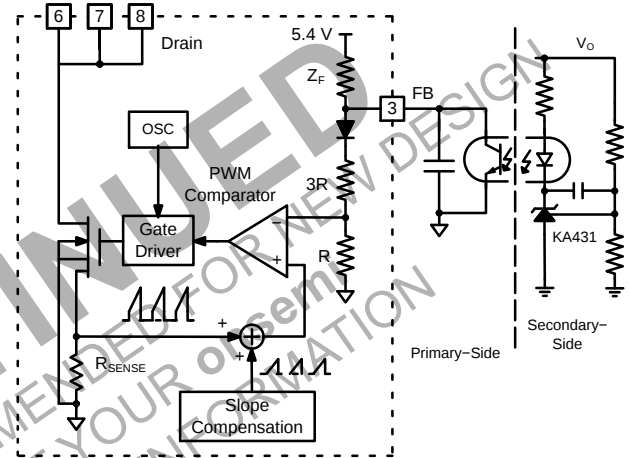


Figure 19. Current Mode Control

## Soft-Start

The GF001H has an internal soft-start circuit that progressively increases the pulse-by-pulse current limit level of MOSFET during startup to establish the correct working conditions for transformers and capacitors, as shown in Figure 20. The current limit levels have nine steps, as shown in Figure 21. This prevents transformer saturation and reduces stress on the secondary diode during startup.

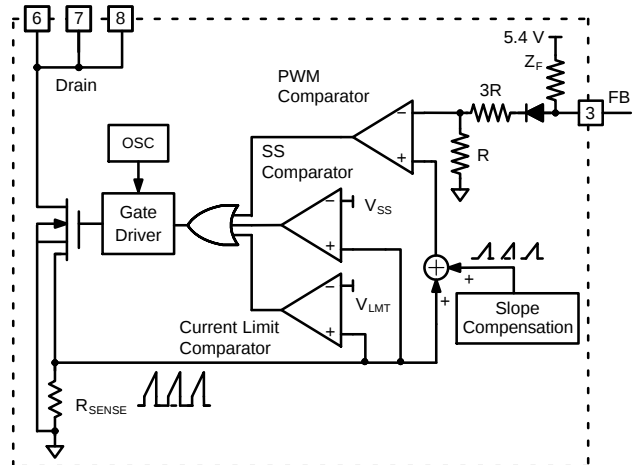


Figure 20. Soft-Start and Current-Limit Circuit

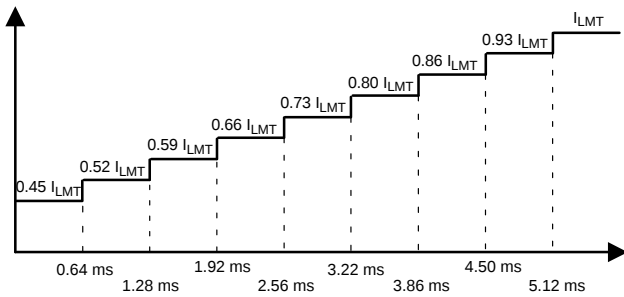


Figure 21. Current Limit Variation During Soft-Start

#### Adjustable Peak Current Limit

The peak current limit is programmable using a resistor on the IPK pin. The internal current 50  $\mu$ A source for the IPK pin generates voltage drop across the resistor. The voltage of the IPK pin determines the current-limit level. Since the upper and lower clamping voltage of the IPK pin are 3 V and 1.5 V, respectively; the suggested resistor value is from 30 k $\Omega$  to 60 k $\Omega$ .

#### Green Mode

As output load condition is reduced, the switching loss becomes the largest power loss factor. GF001H uses the FB pin voltage to monitor output load condition. As output load decreases,  $V_{FB}$  decreases and switching frequency declines, show in Figure 22. Once  $V_{FB}$  falls to 2.4 V, the switching frequency varies between 21.5 kHz and 24.5 kHz before Burst Mode operation. At Burst Mode operation, random frequency fluctuation still functions.

As  $V_{FB}$  falls below  $V_{FB-ZDC}$ , the GF001H enters Burst Mode, where PWM switching is disabled. The output voltage starts to drop, causing the feedback voltage to rise. Once  $V_{FB}$  rises above  $V_{FB-ZDCR}$ , switching resumes. Burst Mode alternately enables and disables switching, thereby reducing switching loss to reduce power consumption, shown in Figure 23.

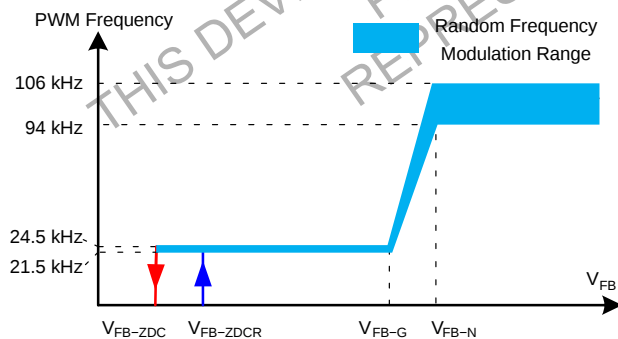


Figure 22. PWM Frequency

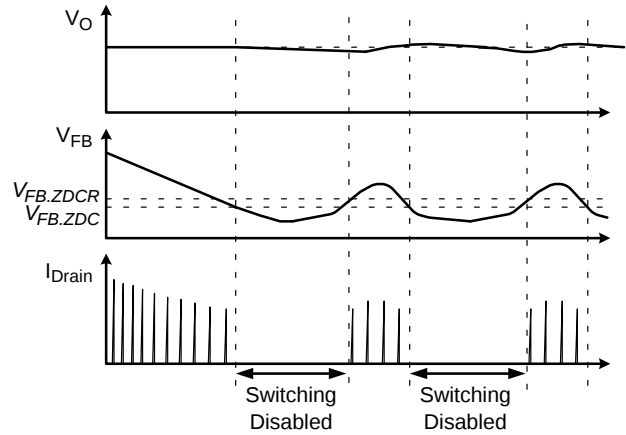


Figure 23. Burst-Mode Operation

#### Protections

The GF001H provides protection functions that include Overload / Open-Loop Protection (OLP) and Over-Voltage Protection (OVP). All the protections are implemented as Auto-Restart Mode. Once the fault condition is detected, switching is terminated and the SENSEFET remains off, this causes  $V_{DD}$  to fall. When  $V_{DD}$  falls to 6 V, the protection is reset and HV startup circuit charges  $V_{DD}$  up to 12 V voltage, allowing restart.

##### Open-Loop / Overload Protection (OLP)

Because of the pulse-by-pulse current-limit capability, the maximum peak current through the SENSEFET is limited and maximum input power is limited. If the output consumes more than the limited maximum power, the output voltage ( $V_O$ ) drops below the set voltage. The current through the opto-coupler LED and the transistor become virtually zero and FB voltage is pulled HIGH, shown in Figure 24. If feedback voltage is above 4.6 V for longer than 56 ms, OLP is triggered. This protection is also triggered when the feedback loop is open due to a soldering defect.

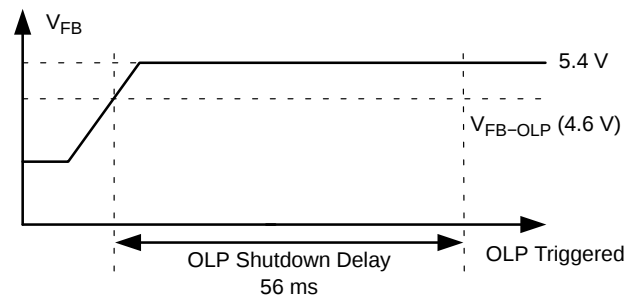


Figure 24. OLP Operation

### *V<sub>DD</sub> Over-Voltage Protection (OVP)*

If the secondary-side feedback circuit malfunctions or a solder defect causes an opening in the feedback path, the current through the opto-coupler transistor becomes virtually zero. Feedback voltage climbs in a similar manner to the overload situation, forcing the preset maximum current to be supplied to the SMPS until the overload protection triggers. Since more energy than required is provided to the output, the output voltage may exceed the rated voltage before the overload protection triggers, resulting in the breakdown of the devices in the secondary side. To prevent this situation, an OVP circuit is employed. Since  $V_{DD}$  voltage is proportional to the output voltage by the transformer coupling, the over-voltage of output is indirectly detected using  $V_{DD}$  voltage. The OVP is triggered when  $V_{DD}$  voltage reaches 24 V. Debounce time (typically 105  $\mu$ s) is applied to prevent false triggering by switching noise.

### *Two-Level UVLO*

Since all the protections of the GF001H are auto-restart, the power supply repeats shutdown and restart until the fault condition is removed. GF001H has two-level UVLO, which is enabled when protection is triggered, to delay the re-startup by slowing down the discharge of  $V_{DD}$ . This effectively reduces the input power of the power supply during the fault condition, minimizing the voltage/current stress of the switching devices. Figure 25 shows the normal UVLO operation and two-step UVLO operation. When  $V_{DD}$  drops to 6 V without triggering the protection, PWM stops switching and  $V_{DD}$  is charged up by the HV startup circuit. Meanwhile, when the protection is triggered, GF001H has a different  $V_{DD}$  discharge profile. Once the protection is triggered, the IC stops switching and  $V_{DD}$

drops. When  $V_{DD}$  drops to 9 V, the operating current becomes very small and  $V_{DD}$  is slowly discharged. When  $V_{DD}$  is naturally discharged down to 6 V, the protection is reset and  $V_{DD}$  is charged up by the HV startup circuit. Once  $V_{DD}$  reaches 12 V, the IC resumes switching operation.

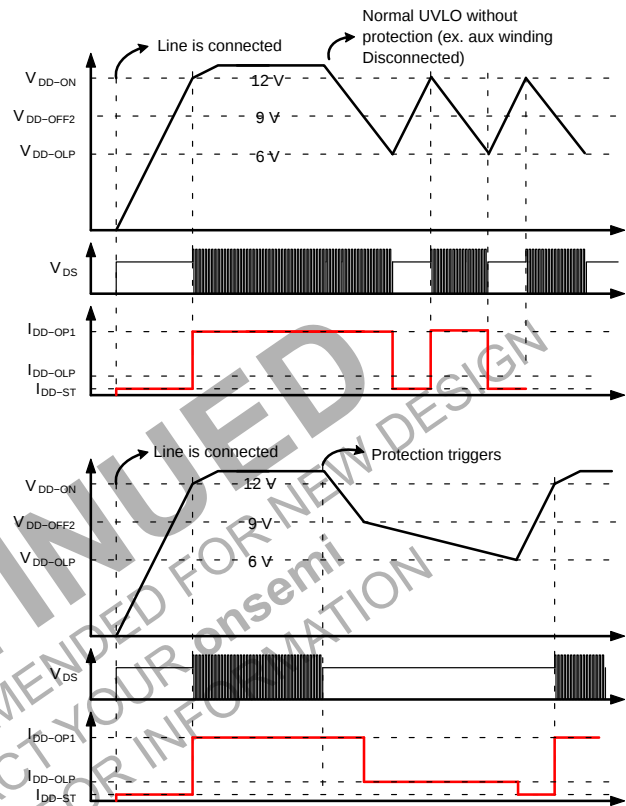


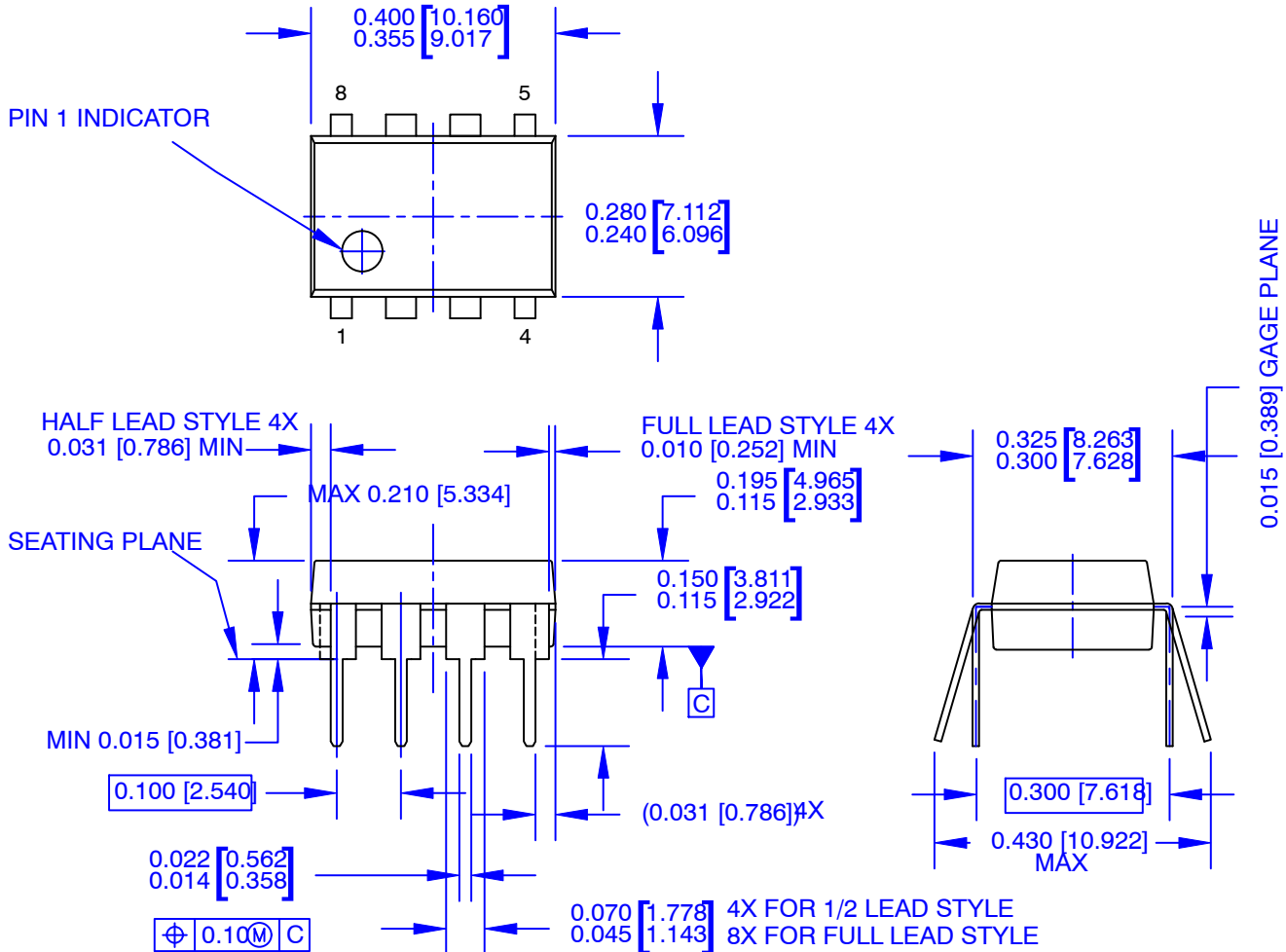
Figure 25. Two-Level UVLO

### ORDERING INFORMATION

| Part Number | SENSEFET  | Operating Temperature Range | Package                                                    | Shipping          |
|-------------|-----------|-----------------------------|------------------------------------------------------------|-------------------|
| GF001HN     | 2 A 700 V | -40°C to +105°C             | 8-Pin, Dual Inline Package (DIP)<br>(Pb-Free, Halide Free) | 3000 Units / Tube |

PDIP8 9.59x6.60, 2.54P  
CASE 646CN  
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