

Green-Mode Power Switch GF001H

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.

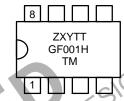
Features

- 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
- Internal Overload / Open-Loop Protection (OLP)
 V_{DD} Under-Voltage Lockout (Livit A)
- V_{DD} 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



PDIP8 9.59x6.6, 2.54P **CASE 646CN**

MARKING DIAGRAM



Plant Code

1-Digit Year Code

= 1-Digit Week Code

2-Digit Die Run Code

= Package Type (N: DIP) = Manufacture Flow Code

GF001H = Device Code

ORDERING INFORMATION

See detailed ordering and shipping information on page 11 of

APPLICATION DIAGRAM

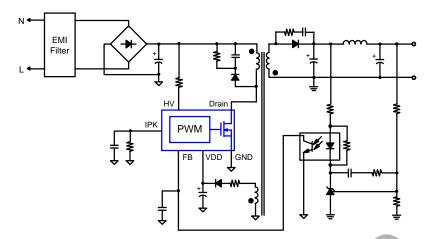


Figure 1. Typical Flyback Application

OUTPUT POWER TABLE (Note 1)

	230 V _{AC} ±1	5 % (Note 2)	85 - 2	65 V _{AC}
Product	Adapter (Note 3)	Open-Frame (Note 4)	Adapter (Note 3)	Open-Frame (Note 4)
GF001HN	14 W	20 W	1) W	16 W

- 1. The maximum output power can be limited by junction temperature.
- 2. 230 V_{AC} or $100/115 \text{ V}_{AC}$ with voltage doublers.
- 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.
- 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

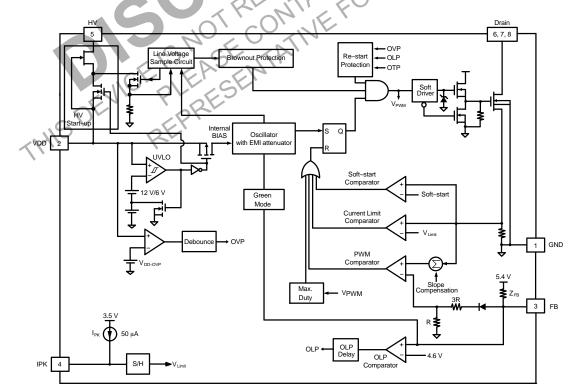


Figure 2. Internal Block Diagram

PIN CONFIGURATION

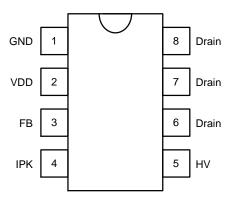


Figure 3. Pin Assignment

PIN DEFINITIONS

PIN DEFIN	NITIONS	GIGN
Pin#	Name	Description
1	GND	Ground. This pin internally connects to the SENSEFET source and signal ground of the PWM controller.
2	VDD	Supply Voltage of the IC. 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	Feedback. 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	Adjust Peak Current. Typically a resistor connects from this pin to the GND pin to program the current–limit level. The internal current source (50 μA) introduces voltage drop across the resistor, which determines the current–limit level of pulse–by–pulse current limit.
5	HV	Startup. Typically, resistors in serious 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	SENSEFET Drain. This pin is designed to directly drive the transformer.
7		SON CONVE
8		I S R GE KATT
<	HISDE	VICE PLEASENTA!

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	Α
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°C)	-	1.5	W
TJ	Operating Junction Temperature	-40	Internally Limited (Note 9)	°C
T _{STG}	Storage Temperature Range	-55	+150	°C
TL	Lead Soldering Temperature (Wave Soldering or IR, 10 Seconds)	-	+260	°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 mH, starting $T_J = 25$ °C.
- 9. Internally limited by Over-Temperature Protection (OTP). Refer to Total

THERMAL RESISTANCE TABLE

Symbol	Parameter	Value	Unit
θ_{JA}	Junction-to-Air Thermal Resistance	86	°C/W
$\Psi_{\sf JT}$	Junction-to-Package Thermal Resistance (Note 10)	20	°C/W

^{10.} Measured on the package top surface.

FSD CAPABILITY

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

^{11.} Meets JEDEC standards JESD 22-A114 and JESD 22-C101.

ELECTRICAL CHARACTERISTICS (V_{DD} = 15 V, and T_A = 25°C unless otherwise specified.)

SenseFet Section (Note 12) Stype Drain-Source Breakdown Voltage V _{DS} = 700 V, V _{OS} = 0 V 700 - - V V _{DS} = 700 V, V _{OS} = 0 V 700 - - V V _{DS} = 700 V, V _{OS} = 0 V - - 50 V _{DS} V _{DS} = 800 V, V _{OS} = 0 V - - 50 V _{DS} V _{DS} = 800 V, V _{OS} = 0 V - - 200 V _{DS} = 800 V, V _{DS} = 90 V - - 200 V _{DS} = 800 V, V _{DS} = 90 V V _{DS} = 10 V V _{DS} = 25 V - 580 715 PF V _{DS} = 10 V V _{DS} = 25 V - 177 26 PF V _{DS} = 10 V V _{DS} = 25 V - 177 26 PF V _{DS} = 10 V V _{DS} = 25 V - 177 26 PF V _{DS} = 10 V V _{DS} = 25 V - 177 26 PF V _{DS} = 10 V V _{DS} = 10 V V _{DS} = 25 V - 177 26 PF V _{DS} = 10 V V _{DS} = 10 V V _{DS} = 25 V - 177 26 PF V _{DS} = 10 V V _{DS} V	Symbol	Parameter	Condition	Min	Тур	Max	Unit
Diss Zero-Gate-Voltage Drain Current Vos = 700 V. Vos = 0 V - - 50 pA	SENSEFET	SECTION (Note 12)			ı	l.	
V _{DS} = 560 V, V _{OS} = 0 V,	BV _{DSS}	Drain-Source Breakdown Voltage	V _{DS} = 700 V, V _{GS} = 0 V	700	_	-	V
T _C = 125°C	I _{DSS}	Zero-Gate-Voltage Drain Current	V _{DS} = 700 V, V _{GS} = 0 V	_	_	50	μΑ
Ciss Input Capacitance			V _{DS} = 560 V, V _{GS} = 0 V, T _C = 125°C	-	-	200	
F = 1 MHz	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	Ω
F = 1 MHz	C _{ISS}	Input Capacitance	$V_{GS} = 0V, V_{DS} = 25 V,$ f = 1 MHz	-	550	715	pF
F = 1 MHz	C _{OSS}	Output Capacitance	$V_{GS} = 0 \text{ V}, V_{DS} = 25 \text{ V},$ f = 1 MHz	-	38	50	pF
t _t Rise Time V _{DS} = 350 V, I _D = 1.0 Å 15 40 ns t _t (or) Turn-Off Delay V _{DS} = 350 V, I _D = 1.0 Å 565 120 ns t _t Fall Time V _{DS} = 350 V, I _D = 1.0 Å 25 60 ns CONTROL SECTION VDD-ON UVLO Start Threshold Voltage 41 32 13 V VDD-OFF UVLO Stop Threshold Voltage 6 6 7 V VDD-OFF UVLO Stop Threshold Voltage 8 9 10 V VDD-OFF UVLO Stop Threshold Voltage 8 9 10 V VDD-OFF UP-OPE Protection Mode 8 9 10 V IDD-ST Startup Supply Current 40 40 - - 38 mA IDD-OP2 Operating Supply Current without Switching Operation VDD-OP Protection Mode VDD-OP Protection Mode 40 10 10 µA IDD-OP2 Operating Supply Current without Switching Operation VDD-OP Protection Mo	C _{RSS}	Reverse Transfer Capacitance		1 (17	26	pF
tgl.eff) Tum—Off Delay	t _{d(on)}	Turn-On Delay	$V_{DS} = 350 \text{ V}, I_{D} = 1.0 \text{ A}$		20	50	ns
ty Fall Time	t _r	Rise Time	$V_{DS} = 350 \text{ V}, I_{D} = 1.0 \text{ A}$		15	40	ns
VDD_ON VVD SECTION VDD_ON VVLO Start Threshold Voltage	t _{d(off)}	Turn-Off Delay	$V_{DS} = 350 \text{ V}, I_{D} = 1.0 \text{ A}$	_	55	120	ns
VoD-ON VoD-OFF VoD-	t _f	Fall Time	$V_{DS} = 350 \text{ V}, I_{D} = 1.0 \text{ A}$		25	60	ns
Vod-Op-Op-Op-Op-Op-Op-Op-Op-Op-Op-Op-Op-Op-				1 Win			
VDD-OFF1 UVLO Stop Threshold Voltage 66 6 7 V	1		50,	an)	M		
VDD-OFFZ IDD-OLP Enable Threshold Voltage 8 9 10 V VDD-OLP Protection Mode VDD-OLP Protection Mode VDD-OLP Protection Mode 5 6 7 V IDD-ST Startup Supply Current With Normal Switching Operation VDD-OLP		The state of the s		2 1	10		
VDD-OLP VDD Voltage Threshold for HV Startup Turn-On at Protection Mode 5 6 7 VDD-OLP Protection Mode IDD-ST Startup Supply Current VDD-ON-0.16 V - - 30 μA IDD-OP1 Operating Supply Current with Normal-Switching Operation VDD-15 V, VFB = 3 V - - 3.8 mA IDD-OP2 Operating Supply Current without Switching Operation VDD-15 V, VFB = 1 V - - 1.8 mA IDD-OP2 Internal Sinking Current VDD-OLP + 0.1 V 40 60 100 μA VDD-OVP VDD Over-Voltage Protection 23 24 25 V MD-VDDOVP VDD Over-Voltage Protection Debounce-Time 40 105 170 μs HV SECTION HV 120 VDC-VDDOVP VDD Over-Voltage Protection Debounce-Time HV = 120 VDC-VDDOVP 12 - 4.7 mA VHV Minimum HV Voltage for VDD being charged to VDD-ON RHV = 120 VDC-VDDOVP 30 - - V IHV-LC Leakage Current after Startup HV = 700 V, VDD-VDD			100000	0/1/1			-
Protection Mode Protectio			IEI OUT OF				
IDD-OP1 Operating Supply Current with Normal Switching Operation $V_{DD} = 15 \text{ V}$, $V_{FB} = 3 \text{ V}$ - - 3.8 mA IDD-OP2 Operating Supply Current without Switching Operation $V_{DD} = 15 \text{ V}$, $V_{FB} = 1 \text{ V}$ - - 1.8 mA IDD-OLP Internal Sinking Current $V_{DD} = 15 \text{ V}$, $V_{FB} = 1 \text{ V}$ - - - 1.8 mA $V_{DD} = 0V_{DD} = 0V_{DD}$ $V_{DD} = 15 \text{ V}$, $V_{FB} = 1 \text{ V}$ - - - 1.8 mA $V_{DD} = 0V_{DD} = 0V_{DD$	V _{DD-OLP}		7 10 11/10	5	6	7	V
IDD-OP2 Operating Supply Current without Switching Operation $V_{DD} = 15 \text{ V}$, $V_{FB} = 1 \text{ V}$ - - 1.8 mA IDD-OLP Internal Sinking Current $V_{DD-OLP} + 0.1 \text{ V}$ 40 60 100 μA V_{DD-OVP} V_{DD} Over-Voltage Protection 23 24 25 V V_{DD-OVP} V_{DD} Over-Voltage Protection Debounce Time 40 105 170 μS HV SECTION IHV Supply Current Drawn from HV Pin HV = 120 V _{DC} , V _{DD} over with 10 μF 1.2 - 4.7 mA VHV Minimum HV Voltage for V _{DD} being charged to V _{DD-ON} R _{HV} = 0 Ω, T _A = -40°C to 105°C 30 - - - V IHV-LC Leakage Current after Startup HV = 700 V, V _{DD-OFF1} + 1 V - - 10 μA VDC-ON Brown-in Threshold Level (V _{DC}) DC Voltage Applied to HV Pin Through 200 kΩ 89 99 109 V t _{UVP} Brownout Protection Time 0.8 1.2 1.6 s OSCILLATOR SECTION Frequency Mo	I _{DD-ST}		V _{DD-ON} - 0.16 V	_	_	30	μΑ
Internal Sinking Current VDD-OLP + 0.1 V 40 60 100 μA VDD-OVP VDD Over-Voltage Protection 23 24 25 V VDD-OVP VDD Over-Voltage Protection Debounce Time 40 105 170 μs HV SECTION HV Supply Current Drawn from HV Pin HV = 120 VDC, VDD = 0 V with 10 μF 1.2 - 4.7 mA VHV Minimum HV Voltage for VDD being charged to VDD-ON RHV = 0 Ω, TA = -40°C to 105°C 30 - - V HV-LC Leakage Current after Startup HV = 700 V, VDD = VDD-OFF1 + 1 V VDD = VDD-OFF1 + 1 V VDC-ON Brown-in Threshold Level (VDC) DC Voltage Applied to HV Pin Through 200 kΩ Resistor 89 99 109 V TUVP Brownout Threshold Level (VDC) Resistor 0.8 1.2 1.6 s OSCILLATOR SECTION Frequency Modulation - ±6 - kHz Fosc Green-Mode Frequency 20 23 26 kHz Foy Frequency Variation vs. VDD Deviation VDD = 11 V to 22 V - - 5 %	I _{DD-OP1}	Operating Supply Current with Normal Switching Operation	$V_{DD} = 15 \text{ V}, V_{FB} = 3 \text{ V}$	_	_	3.8	mA
VDD-OVP VDD Over-Voltage Protection 23 24 25 V tD-VDDOVP VDD Over-Voltage Protection Debounce Time 40 105 170 μs HV SECTION I _{HV} Supply Current Drawn from HV Pin HV = 120 V _{DC} . V _{DD} = 0 V with 10 μF 1.2 - 4.7 mA V _{HV} Minimum HV Voltage for V _{DD} being charged to V _{DD-ON} R _{HV} = 0 Ω, T _A = -40°C to 105°C 30 - - - V I _{HV-LC} Leakage Current after Startup HV = 700 V, V _{DD} = V _{DD-OFF1} + 1 V - - 10 μA V _{DC-ON} Brown-in Threshold Level (V _{DC}) DC Voltage Applied to HV Pin Through 200 kΩ Resistor 89 99 109 V t _{UVP} Brownout Protection Time 0.8 1.2 1.6 s OSCILLATOR SECTION Frequency in Nominal Mode Center Frequency 94 100 106 kHz f _{DSC} -G Green-Mode Frequency Center Frequency 94 100 106 kHz f _{DSC} -G Green-Mode Frequency V	I _{DD-OP2}	Operating Supply Current without Switching Operation	$V_{DD} = 15 \text{ V}, V_{FB} = 1 \text{ V}$	_	_	1.8	mA
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	I _{DD-OLP}	Internal Sinking Current	V _{DD-OLP} + 0.1 V	40	60	100	μΑ
HV SECTION I_{HV} Supply Current Drawn from HV Pin $HV = 120 \text{ V}_{DC}$, $V_{DD} = 0 \text{ V with } 10 \text{ μF}$ $1.2 - 4.7 \text{ mA}$ V_{HV} Minimum HV Voltage for V_{DD} being charged to V_{DD-ON} $R_{HV} = 0 \Omega$, $T_{A} = -40^{\circ}\text{C to } 105^{\circ}\text{C}$ $30 - - - V$ I_{HV-LC} Leakage Current after Startup $HV = 700 \text{ V}$, $V_{DD} = V_{DD-OFF1} + 1 \text{ V}$ $- - 10 \mu \text{A}$ V_{DC-ON} Brown-in Threshold Level (V_{DC}) $HV = 100 $	V_{DD-OVP}	V _{DD} Over–Voltage Protection		23	24	25	V
IHV Supply Current Drawn from HV Pin HV = 120 V _{DC} , V _{DD} = 0 V with 10 μF 1.2 - 4.7 mA VHV Minimum HV Voltage for V _{DD} being charged to V _{DD} ON $R_{HV} = 0 \Omega$, $T_A = -40^{\circ}C$ to $105^{\circ}C$ 30 - - - V I _{HV} -LC Leakage Current after Startup HV = 700 V, $V_{DD} = V_{DD} = V_{DD$	t _{D-VDDOVP}	V _{DD} Over–Voltage Protection Debounce Time		40	105	170	μS
$V_{DD} = 0 \text{ V with } 10 \ \mu\text{F}$ $V_{HV} \text{Minimum HV Voltage for V}_{DD} \text{ being charged to V}_{DD-ON} R_{HV} = 0 \ \Omega, \\ T_A = -40^{\circ}\text{C to } 105^{\circ}\text{C}$ $I_{HV-LC} \text{Leakage Current after Startup} HV = 700 \ V, \\ V_{DD} = V_{DD-OFF1} + 1 \ V - - 10 \mu\text{A}$ $V_{DC-ON} \text{Brown-in Threshold Level (V}_{DC}) DC \text{Voltage Applied to } \\ V_{DC-OFF} \text{Brownout Threshold Level (V}_{DC}) Resistor 89 99 109 V$ $I_{UVP} \text{Brownout Protection Time} 0.8 1.2 1.6 \text{s}$ $OSCILLATOR SECTION$ $I_{MM} \text{Frequency in Nominal Mode} Center Frequency 94 100 106 \text{kHz}$ $I_{MM} \text{Frequency Modulation} - \pm 6 - \text{kHz}$ $I_{DSC-G} \text{Green-Mode Frequency} 20 23 26 \text{kHz}$ $I_{DV} \text{Frequency Variation vs. V}_{DD} \text{Deviation} V_{DD} = 11 \ V \text{ to } 22 \ V - - 5 \%$	HV SECTIO	N D P					
$T_{A} = -40^{\circ}\text{C to } 105^{\circ}\text{C}$ I_{HV-LC} Leakage Current after Startup V_{DC-ON} V_{DC-ON} Brown-in Threshold Level (V _{DC}) V_{DC-OFF} Brownout Threshold Level (V _{DC}) V_{UVP} Brownout Protection Time V_{UVP} Brownout Protection Time V_{DC-OFF} Frequency in Nominal Mode V_{DC-OFF} Frequency Modulation V_{DC-OFF} Frequency Modulation V_{DC-OFF} Frequency Modulation V_{DC-OFF} Frequency Variation vs. V _{DD} Deviation $V_{DD} = 11 \text{ V to } 22 \text{ V}$ V_{DC-OFF} Frequency in Nominal Mode $V_{DD} = 11 \text{ V to } 22 \text{ V}$	I _{HV}	Supply Current Drawn from HV Pin	$HV = 120 V_{DC}$, $V_{DD} = 0 V$ with 10 μF	1.2	_	4.7	mA
$V_{DC-ON} \text{Brown-in Threshold Level (V}_{DC}) \qquad DC \text{Voltage Applied to} \\ V_{DC-OFF} \text{Brownout Threshold Level (V}_{DC}) \qquad DC \text{Voltage Applied to} \\ V_{DC-OFF} \text{Brownout Threshold Level (V}_{DC}) \qquad Resistor \qquad 89 \qquad 99 \qquad 109 \qquad V \\ I_{UVP} \text{Brownout Protection Time} \qquad 0.8 \qquad 1.2 \qquad 1.6 \qquad s \\ \hline \textbf{OSCILLATOR SECTION} \\ \hline I_{OSC} \text{Frequency in Nominal Mode} \qquad Center Frequency \qquad 94 \qquad 100 \qquad 106 \qquad kHz \\ \hline I_{M} \text{Frequency Modulation} \qquad - \qquad \pm 6 \qquad - \qquad kHz \\ \hline I_{OSC-G} \text{Green-Mode Frequency} \qquad 20 \qquad 23 \qquad 26 \qquad kHz \\ \hline I_{DV} \text{Frequency Variation vs. V}_{DD} \text{Deviation} \qquad V_{DD} = 11 V \text{ to } 22 V \qquad - \qquad - \qquad 5 \qquad \%$	V_{HV}	Minimum HV Voltage for V_{DD} being charged to V_{DD-ON}	$R_{HV} = 0 \Omega$, $T_A = -40$ °C to 105 °C	30	-	_	V
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	I _{HV-LC}	Leakage Current after Startup		-	_	10	μΑ
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	V _{DC-ON}	Brown-in Threshold Level (V _{DC})		104	114	124	V
OSCILLATOR SECTION fosc Frequency in Nominal Mode Center Frequency 94 100 106 kHz f _M Frequency Modulation - ±6 - kHz f _{OSC-G} Green-Mode Frequency 20 23 26 kHz f _{DV} Frequency Variation vs. V _{DD} Deviation V _{DD} = 11 V to 22 V - - 5 %	V _{DC-OFF}	Brownout Threshold Level (V _{DC})		89	99	109	V
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	t _{UVP}	Brownout Protection Time		0.8	1.2	1.6	S
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	OSCILLATO	DR SECTION					
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	fosc	Frequency in Nominal Mode	Center Frequency	94	100	106	kHz
f _{DV} Frequency Variation vs. V _{DD} Deviation V _{DD} = 11 V to 22 V - 5 %	f _M	Frequency Modulation		-	±6	-	kHz
	f _{OSC-G}	Green-Mode Frequency		20	23	26	kHz
f_{DT} Frequency Variation vs. Temperature Deviation (Note 12) $T_A = -40^{\circ}\text{C}$ to 105°C - 5 %	f _{DV}	Frequency Variation vs. V _{DD} Deviation	V _{DD} = 11 V to 22 V	-	-	5	%
	f _{DT}	Frequency Variation vs. Temperature Deviation (Note 12)	$T_A = -40^{\circ}C$ to $105^{\circ}C$	-	_	5	%

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

Symbol	Parameter	Condition	Min	Тур	Max	Unit
_	(INPUT SECTION	Containon		',74	max	O I III
A _V	Internal Voltage Dividing Factor of FB Pin (Note 12)		1/4.5	1/4.0	1/3.5	V/V
·	Pull–Up Impedance of FB Pin		1/4.5	21	27	kΩ
Z _{FB}		ED Dia Ones				V KS2
V _{FB-OPEN}	FB Pin Pull–Up Voltage	FB Pin Open	5.2	5.4	5.6	•
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	- 1	V
IPK PIN SE	CTION				3/0,	
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)			1 -	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	$T_A = -40^{\circ}\text{C} \text{ to } 105^{\circ}\text{C},$ $V_{IPK} = 2.25 \text{ V}$	45	50	55	μΑ
I _{LMT-H}	Flat Threshold Level of Current Limit for the Highest IPK Level	V _{IPK} = 3 V	0.90	1.00	1.10	Α
I _{LMT-L}	Flat Threshold Level of Current Limit for the Lowest IPK Level	V _{IPK} = 1.5 V	0.45	0.50	0.55	Α
CURRENT-	SENSE SECTION (Note 13)	T IM				
t _{PD}	Current Limit Turn-Off Delay (Note 14)	U OK	_	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 SEC	FION (Note 13)					
DCY _{MAX}	Maximum Duty Cycle		70	_	_	%
OVER TEM	PERATURE PROTECTION SECTION (OTP)					
T _{OTP}	Junction Temperature to Trigger OTP (Note 12)		140	_	_	°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 $\leq 300~\mu s$, duty $\leq 2\%$. 14. These parameters, although guaranteed, are tested in wafer–sort process.

TYPICAL CHARACTERISTICS

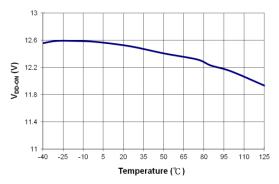


Figure 4. V_{DD-ON} vs. Temperature

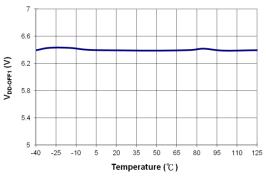


Figure 5. $V_{DD-OFF1}$ vs. Temperature

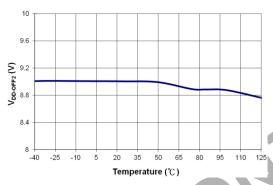


Figure 6. V_{DD-OFF2} vs. Temperature

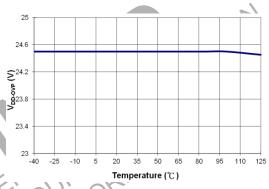


Figure 7. V_{DD-OVP} vs. Temperature

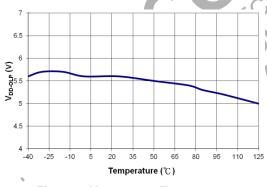


Figure 8. V_{DD-OLP} vs. Temperature

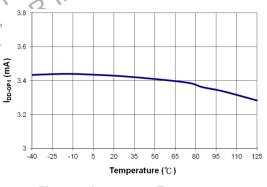


Figure 9. I_{DD-OP1} vs. Temperature

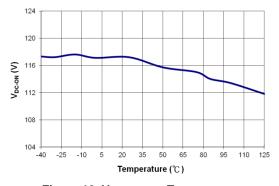


Figure 10. V_{DC-ON} vs. Temperature

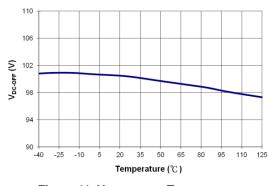


Figure 11. V_{DC-OFF} vs. Temperature

TYPICAL CHARACTERISTICS (Continued)

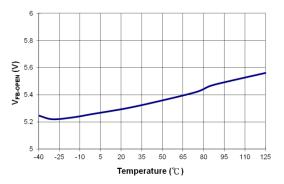


Figure 12. V_{FB-OPEN} vs. Temperature

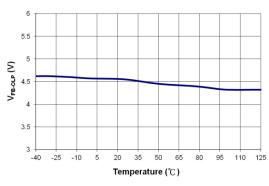


Figure 13. V_{FB-OLP} vs. Temperature

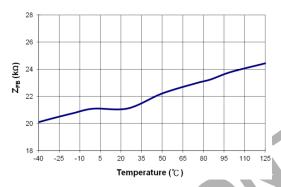


Figure 14. Z_{FB} vs. Temperature

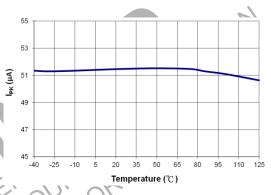


Figure 15. I_{PK} vs. Temperature

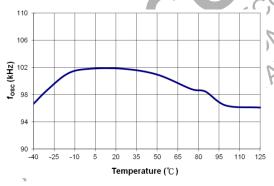


Figure 16. f_{OSC} vs. Temperature

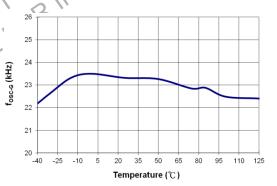


Figure 17. f_{OSC-G} vs. Temperature

FUNCTIONAL DESCRIPTION

Startup Operation

The HV pin is typically connected to the DC link input through one resistor (RHV), 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:

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

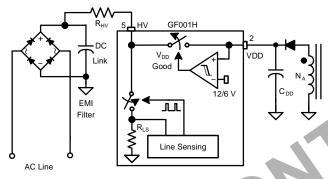


Figure 18. Functional Description

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:

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

$$V_{BROWNOUT} = \frac{R_{HV}}{200 \text{ k}} \cdot V_{DC_OFF}$$
 (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.

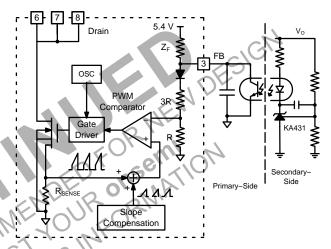


Figure 19. Current Mode Control

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.

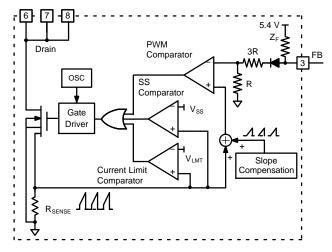


Figure 20. Soft-Start and Current-Limit Circuit

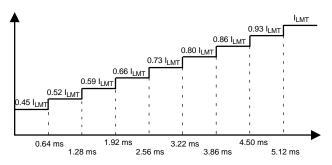


Figure 21. Current Limit Variation During Soft-Start

Adjustable Peak Current Limit

The peak current limit is programmable using a resistor on the IPK pin. The internal current 50 μA 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.

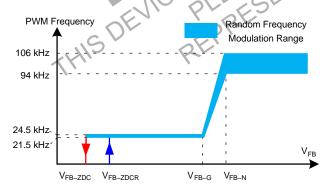


Figure 22. PWM Frequency

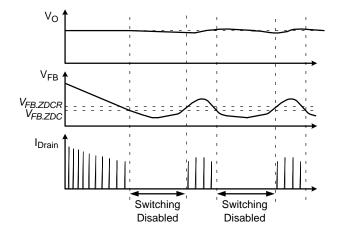


Figure 23. Burst-Mode Operation

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.

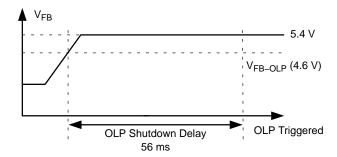


Figure 24. OLP Operation

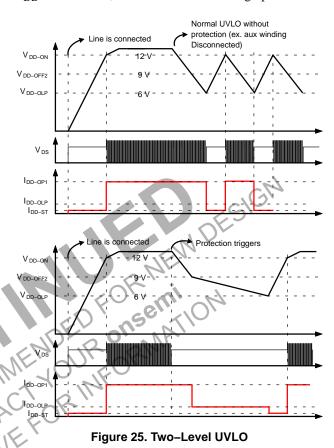
V_{DD} Over-Voltage Protection (OVP)

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 µs) 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.



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) (Pb-Free, Halide Free)	3000 Units / Tube

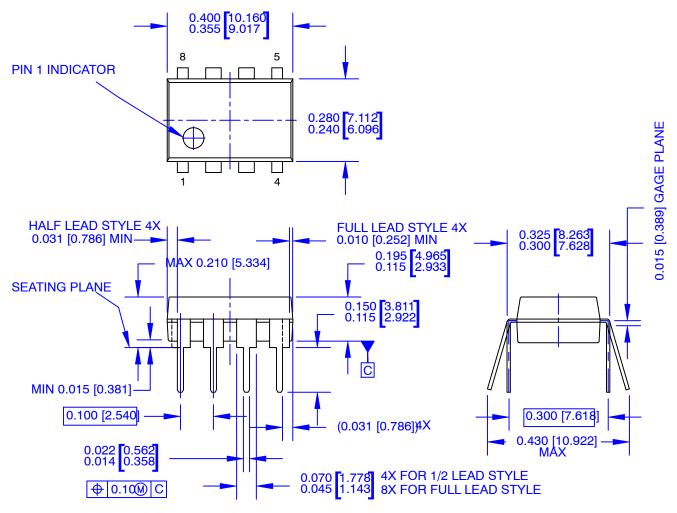
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