

FSBH0F70A, FSBH0170/A, FSBH0270/A, FSBH0370 Green Mode Fairchild Power Switch (FPS™)

Features

- Brownout Protection with Hysteresis
- Built-In 5ms Soft-Start Function
- Internal Avalanche Rugged 700V SenseFET
- No Acoustic Noise During Light-Load Operation
- High-Voltage Startup
- Linearly Decreasing PWM Frequency to 18KHz
- Peak-Current-Mode Control
- Cycle-By-Cycle Current Limiting
- Leading-Edge Blanking (LEB)
- Synchronized Slope Compensation
- Internal Open-Loop Protection
- V_{DD} Under-Voltage Lockout (UVLO)
- V_{DD} Over-Voltage Protection (OVP)
- Internal Auto Restart Circuit (OVP, OTP)
- Constant Power Limit (Full AC Input Range)
- Internal OTP Sensor with Hysteresis
- VIN Pin for Pull-High Latch function and Pull-Low Auto Recovery Protection

Applications

General-purpose switch-mode power supplies and flyback power converters, including:

- Auxiliary Power Supply for PC and Server
- SMPS for VCR, SVR, STB, DVD & DVCD Player, Printer, Facsimile, & Scanner
- Adapter for Camcorder

Description

The highly integrated FSBH series consists of an integrated current-mode Pulse Width Modulator (PWM) and an avalanche-rugged 700V SenseFET. It is specifically designed for high-performance off-line Switch Mode Power Supplies (SMPS) with minimal external components.

The integrated PWM controller features include a proprietary green-mode function that provides off-time modulation to linearly decrease the switching frequency at light-load conditions to minimize standby power consumption. To avoid acoustic-noise problems, the minimum PWM frequency is set above 18kHz. This green-mode function enables the power supply to meet international power conservation requirements. The PWM controller is manufactured using the BiCMOS process to further reduce power consumption. The FSBH series turns off some internal circuit to improve power saving when V_{FB} is lower than 1.6V, which allows an operating current of only 2.5mA.

The FSBH series has built-in synchronized slope compensation to achieve stable peak-current-mode control. The proprietary external line compensation ensures constant output power limit over a wide AC input voltage range, from 90V_{AC} to 264V_{AC}.

The FSBH series provides many protection functions. In addition to cycle-by-cycle current limiting, the internal open-loop protection circuit ensures safety when an open-loop or output short occurs. PWM output is disabled until V_{DD} drops below the V_{TH-OLP}, then the controller starts again. As long as V_{DD} exceeds 28V, the internal OVP circuit is triggered.

Compared with a discrete MOSFET and controller or RCC switching converter solution, the FSBH series reduces total component count, design size, and weight; while increasing efficiency, productivity, and system reliability. These devices provide a basic platform well suited for design of cost-effective flyback converters, such as in PC auxiliary power supplies.

Ordering Information

Part Number	Sense FET	Operating Temperature Range	VIN Pin	 Eco Status	Package	Packing Method
FSBH0F70ANY	0.5A 700V	-40°C to +105°C	Disable	 Green	8-Pin Dual In-Line Package (DIP)	Tube
FSBH0170ANY	1.0A 700V	-40°C to +105°C				
FSBH0270ANY	2.0A 700V	-40°C to +105°C				
FSBH0170NY	1.0A 700V	-40°C to +105°C	Enable			
FSBH0270NY	2.0A 700V	-40°C to +105°C				
FSBH0370NY	3.0A 700V	-40°C to +105°C				

For Fairchild's definition of Eco Status, please visit: http://www.fairchildsemi.com/company/green/rohs_green.html

Application Diagram

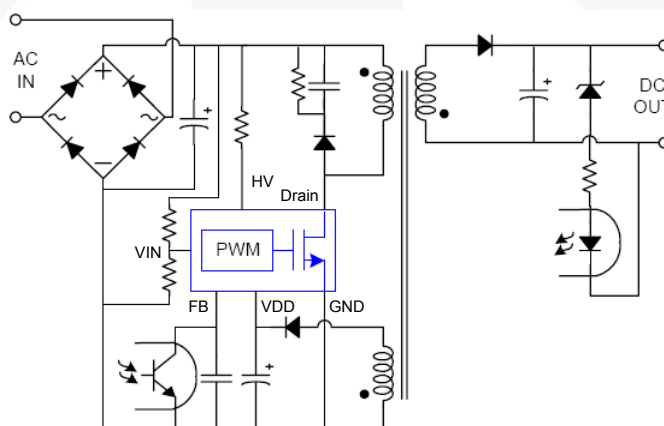


Figure 1. Typical Flyback Application

Output Power Table⁽¹⁾

Product	230V _{AC} ± 15% ⁽²⁾		85-265V _{AC}	
	Adapter ⁽³⁾	Open Frame ⁽⁴⁾	Adapter ⁽³⁾	Open Frame ⁽⁴⁾
FSBH0F70A	7W	10W	6W	8W
FSBH0170/A	10W	15W	9W	13W
FSBH0270/A	14W	20W	11W	16W
FSBH0370	17.5W	25W	13W	19W

Notes:

- The maximum output power can be limited by junction temperature.
- 230V_{AC} or 100/115V_{AC} with doublers.
- Typical continuous power in a non-ventilated enclosed adapter with sufficient drain pattern as a heat sink, at 50°C ambient.
- Maximum practical continuous power in an open-frame design with sufficient drain pattern as a heat sink, at 50°C ambient.

Internal Block Diagram

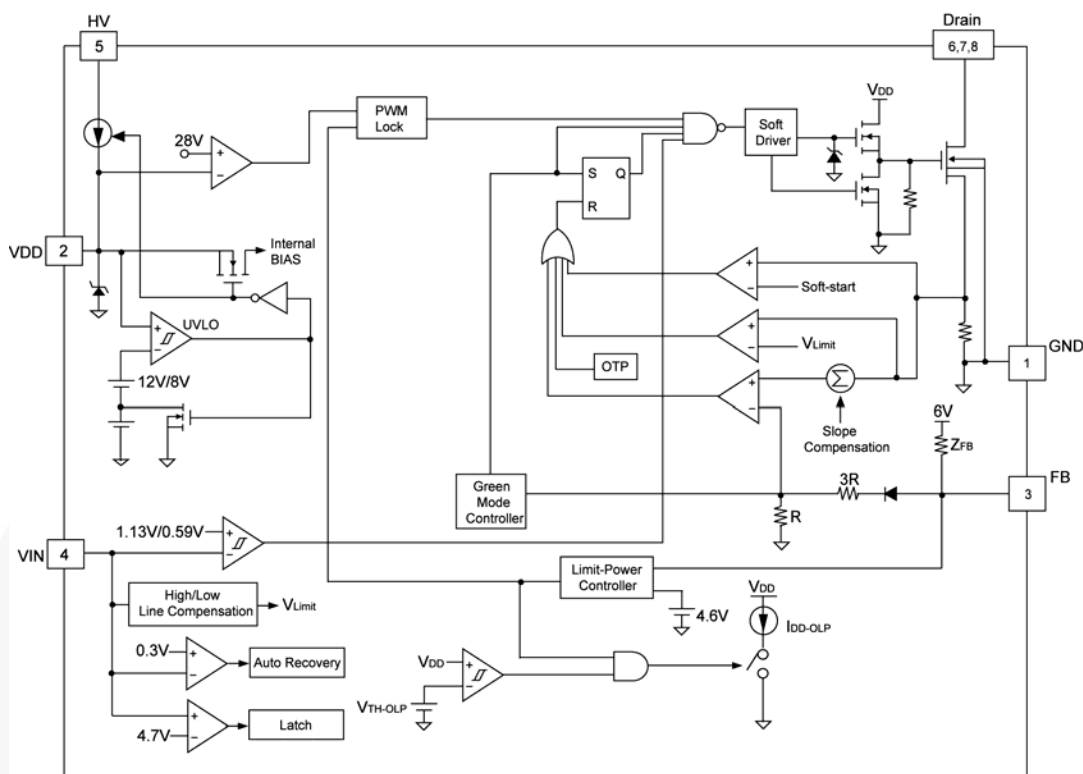


Figure 2. FSBH0170, FSBH0270, FSBH0370 Internal Block Diagram

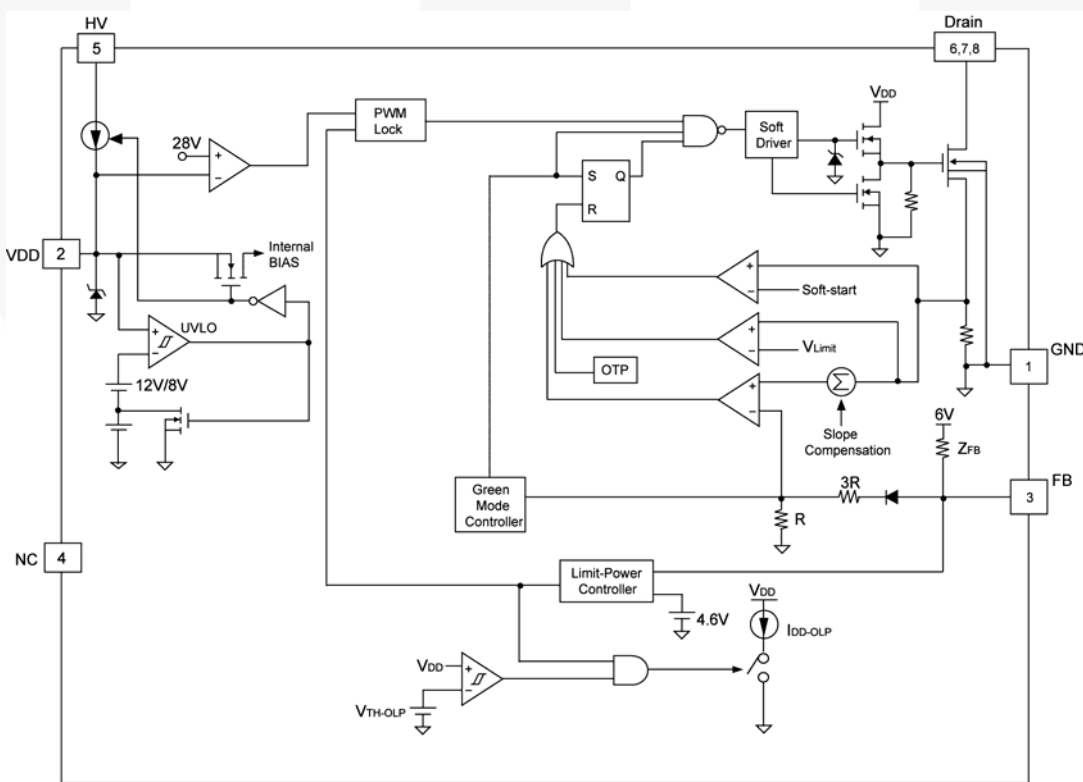


Figure 3. FSBH0F70A, FSBH0170A, FSBH0270A Internal Block Diagram

Pin Configuration

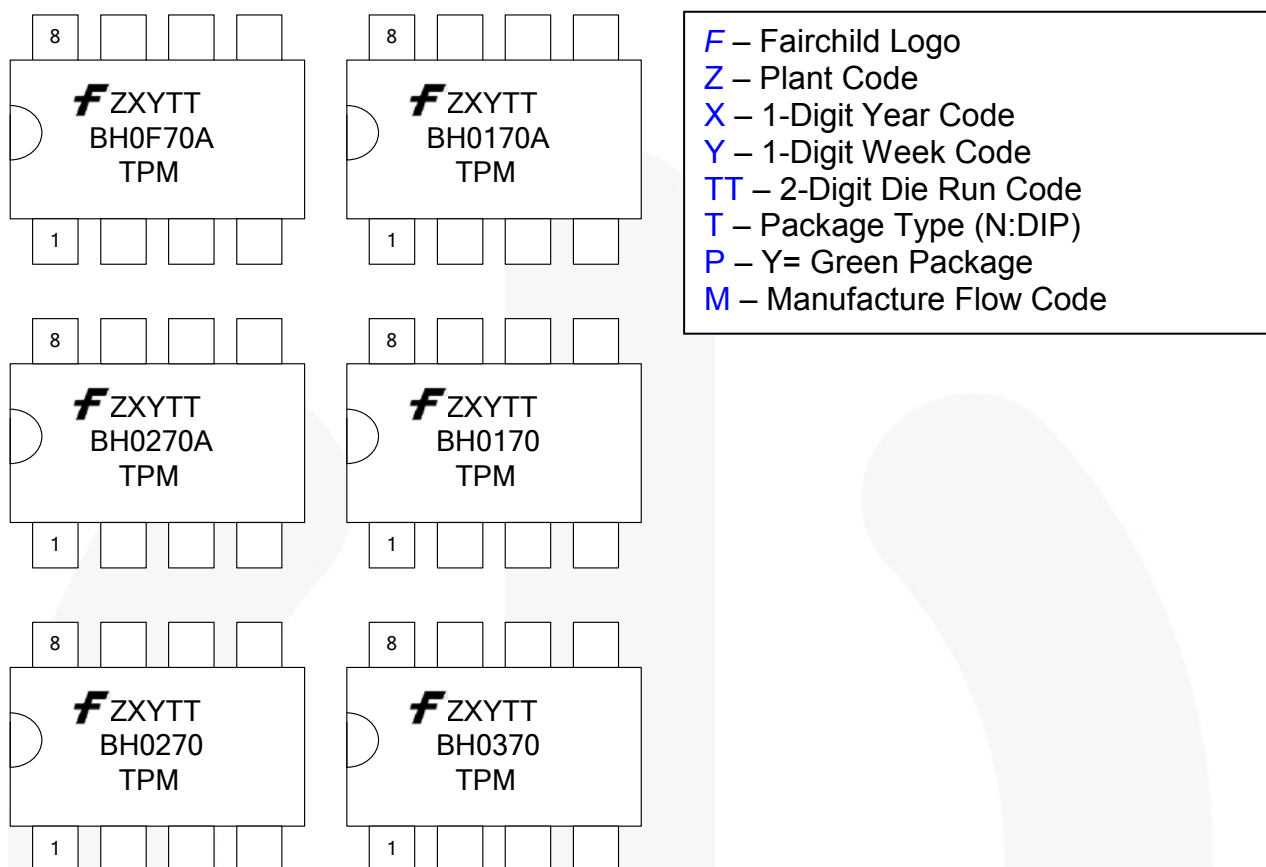


Figure 4. Pin Configuration

Pin Definitions

Pin #	Name	Description
1	GND	Ground. SenseFET source terminal on primary side and internal controller ground.
2	VDD	Power Supply. The internal protection circuit disables PWM output as long as V_{DD} exceeds the OVP trigger point.
3	FB	Feedback. The signal from the external compensation circuit is fed into this pin. The PWM duty cycle is determined in response to the signal on this pin and the internal current-sense signal.
4	VIN	Line-Voltage Detection. The line-voltage detection is used for brownout protection with hysteresis and constant output power limit over a universal AC input range. This pin has additional protections that pull HIGH for latch and pull LOW for auto recovery, which depends on the application.
	NC	NC Pin for FSBH0F70A, FSBH0170A, and FSBH0270A.
5	HV	Startup. For startup, this pin is pulled HIGH to the line input or bulk capacitor via resistors.
6, 7, 8	Drain	SenseFET Drain. High-voltage power SenseFET drain connection.

Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

Symbol	Parameter		Min.	Max.	Unit
V _{DRAIN}	Drain Pin Voltage ^(5, 6)	FSBH0x70/A		700	V
I _{DM}	Drain Current Pulsed ⁽⁷⁾	FSBH0F70A		1.5	A
		FSBH0170/A		4	
		FSBH0270/A		8	
		FSBH0370		12	
E _{AS}	Single Pulsed Avalanche Energy ⁽⁸⁾	FSBH0F70A		10	mJ
		FSBH0170/A		50	
		FSBH0270/A		140	
		FSBH0370		230	
V _{DD}	DC Supply Voltage			30	V
V _{FB}	FB Pin Input Voltage		-0.3	7.0	V
V _{IN}	VIN Pin Input Voltage		-0.3	7.0	V
V _{HV}	HV Pin Input Voltage			700	V
P _D	Power Dissipation (T _A < 50°C)			1.5	W
θ _{JA}	Thermal Resistance; Junction-to-Air			80	°C/W
θ _{JC}	Thermal Resistance; Junction-to-Case			20	°C/W
T _J	Operating Junction Temperature		Internally limited		°C
T _{STG}	Storage Temperature Range		-55	+150	°C
T _L	Lead Temperature (Wave Soldering or IR, 10 Seconds)			+260	°C
ESD	Electrostatic Discharge Capability	Human Body Model, JEDEC:JESD22-A114	3.0		kV
		Charged Device Model, JEDEC:JESD22-C101	1.0		

Notes:

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: Pulsewidth is limited by maximum junction temperature.
8. L=51mH, starting T_J=25°C.

Recommended Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. Fairchild does not recommend exceeding them or designing to Absolute Maximum Ratings.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
T _A	Operating Ambient Temperature		-40		+105	°C

Electrical Characteristics

$V_{DD}=15V$ and $T_A=25^{\circ}C$ unless otherwise specified.

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
SenseFET Section⁽⁹⁾						
BV_{DSS}	Drain- Source Breakdown Voltage	FSBH0x70/A $V_{DS}=700V, V_{GS}=0V$	700			V
I_{DSS}	Zero-Gate-Voltage Drain Current	FSBH0x70/A $V_{DS}=700V, V_{GS}=0V$			50	μA
					200	
$R_{DS(ON)}$	Drain-Source On-State Resistance ⁽¹⁰⁾	FSBH0F70A	$V_{GS}=10V, I_D=0.5A$	14.00	19.00	Ω
		FSBH0170/A		8.80	11.00	
		FSBH0270/A		6.00	7.20	
		FSBH0370		4.00	4.75	
C_{ISS}	Input Capacitance	FSBH0F70A	$V_{GS}=0V, V_{DS}=25V,$ $f=1MHz$	162	211	pF
		FSBH0170/A		250	325	
		FSBH0270/A		550	715	
		FSBH0370		315	410	
C_{OSS}	Output Capacitance	FSBH0F70A	$V_{GS}=0V, V_{DS}=25V,$ $f=1MHz$	18	24	pF
		FSBH0170/A		25	33	
		FSBH0270/A		38	50	
		FSBH0370		47	61	
C_{RSS}	Reverse Transfer Capacitance	FSBH0F70A	$V_{GS}=0V, V_{DS}=25V,$ $f=1MHz$	3.8	5.7	pF
		FSBH0170/A		10.0	15.0	
		FSBH0270/A		17.0	26.0	
		FSBH0370		9.0	24.0	
$t_{d(on)}$	Turn-On Delay Time	FSBH0F70A	$V_{DS}=350V, I_D=1.0A$	9.5	29.0	ns
		FSBH0170/A		12.0	34.0	
		FSBH0270/A		20.0	50.0	
		FSBH0370		11.2	33.0	
t_r	Rise Time	FSBH0F70A	$V_{DS}=350V, I_D=1.0A$	19	48	ns
		FSBH0170/A		4	18	
		FSBH0270/A		15	40	
		FSBH0370		34	78	
$t_{d(off)}$	Turn-Off Delay Time	FSBH0F70A	$V_{DS}=350V, I_D=1.0A$	33.0	76.0	ns
		FSBH0170/A		30.0	70.0	
		FSBH0270/A		55.0	120.0	
		FSBH0370		28.2	67.0	
t_f	Fall Time	FSBH0F70A	$V_{DS}=350V, I_D=1.0A$	42	94	ns
		FSBH0170/A		10	30	
		FSBH0270/A		25	60	
		FSBH0370		32	74	

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Electrical Characteristic (Continued)V_{DD}=15V and T_A=25°C unless otherwise specified.

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
Control Section						
V_{DD} Section						
V _{DD-ON}	Start Threshold Voltage		11	12	13	V
V _{DD-OFF}	Minimum Operating Voltage		7	8	9	V
I _{DD-ST}	Startup Current	V _{DD-ON} – 0.16V			30	μA
I _{DD-OP}	Operating Supply Current	V _{DD} =15V, V _{FB} =3V	3.0	3.5	4.0	mA
I _{DD-ZDC}	Operating Current for V _{FB} <V _{FB-ZDC}	V _{DD} =12V, V _{FB} =1.6V	1.5	2.5	3.5	mA
I _{DD-OLP}	Internal Sink Current	V _{TH-OLP} +0.1V	30	70	90	μA
V _{TH-OLP}	I _{DD-OLP} Off Voltage		5	6	7	V
V _{DD-OVP}	V _{DD} Over-Voltage Protection		27	28	29	V
t _{D-VDDOVP}	V _{DD} Over-Voltage Protection Debounce Time		75	130	200	μs
HV Section						
I _{HV}	Maximum Current Drawn from HV Pin	HV 120V _{DC} , V _{DD} =0V with 10μF	1.5	3.5	5.0	mA
I _{HV-LC}	Leakage Current after Startup	HV=700V, V _{DD} =V _{DD-OFF} +1V		1	20	μA
Oscillator Section						
f _{OSC}	Frequency in Nominal Mode	Center Frequency	94	100	106	kHz
f _{OSC-G}	Green-Mode Frequency		14	18	22	kHz
D _{MAX}	Maximum Duty Cycle			85		%
f _{DV}	Frequency Variation vs. V _{DD} Deviation	V _{DD} =11V to 22V			5	%
f _{DT}	Frequency Variation vs. Temperature Deviation ⁽⁹⁾	T _A =-25 to 85°C			5	%
V_{IN} Section (FSBH0170, FSBH0270, FSBH0370)						
V _{IN-ON}	PWM Turn-On Threshold Voltage		1.08	1.13	1.18	V
V _{IN-OFF}	PWM Turn-Off Threshold Voltage		V _{IN-ON} - 0.48	V _{IN-ON} - 0.54	V _{IN-ON} - 0.60	V
t _{IN-OFF}	PWM Turn-Off Debounce Time			500		ms
V _{IN-H}	Pull HIGH Latch Trigger Level		4.4	4.7	5.0	V
t _{IN-H}	Pull HIGH Latch Debounce Time			100		μs
V _{IN-L}	Pull LOW Auto-Recovery Trigger Level		0.2	0.3	0.4	V
Feedback Input Section						
A _V	FB Voltage to Current-Sense Attenuation		1/4.5	1/4.0	1/3.5	V/V
Z _{FB}	Input Impedance		4		7	kΩ
V _{FB-OPEN}	Output High Voltage	FB Pin Open	5.5			V
V _{FB-N}	Green-Mode Entry FB Voltage		2.3	2.5	2.7	V
V _{FB-G}	Green-Mode Ending FB Voltage		1.9	2.0	2.1	V
V _{FB-ZDC}	Zero Duty Cycle FB Voltage			1.6		V

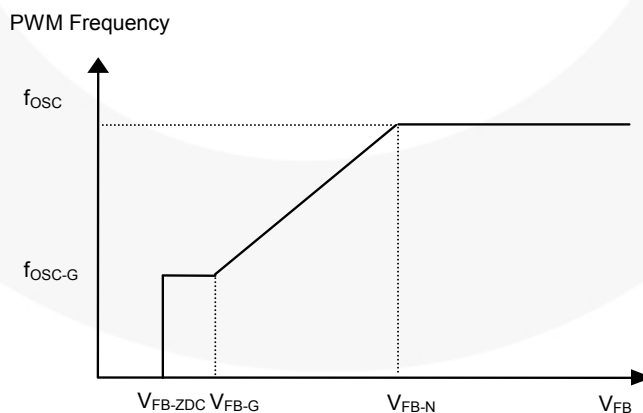
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Electrical Characteristics (Continued)V_{DD}=15V and T_A=25°C unless otherwise specified.

Symbol	Parameter		Condition	Min.	Typ.	Max.	Unit
V _{FB-OLP}	FB Open-loop Trigger Level	FSBH0F70A		5.3	5.4	5.5	V
		FSBH0x70/A		4.4	4.6	4.8	V
t _{D-OLP}	FB Open-Loop Protection Delay			50	56	59	ms
Current-Sense Section ⁽¹³⁾							
I _{LIM}	Peak Current Limit	FSBH0F70	V _{IN} =1.2V	0.5	0.6	0.7	A
		FSBH0170	V _{IN} =1.2V	0.7	0.8	0.9	
		FSBH0270	V _{IN} =1.2V	0.9	1.0	1.1	
		FSBH0370	V _{IN} =1.2V	1.1	1.2	1.3	
t _{SS}	Period During Soft-Start Time ⁽⁹⁾			4.5	5.0	5.5	ms
Constant Power Limit (FSBH0170, FSBH0270, FSBH0370)							
V _{Limit1}	Threshold Voltage 1 for Current Limit		V _{IN} =1.2V	0.73	0.80	0.87	V
V _{Limit2}	Threshold Voltage 2 for Current Limit		V _{IN} =3.6V	0.56	0.63	0.70	V
Current Limit (FSBH0F70A, FSBH0170A, FSBH0270A)							
V _{Limit}	Threshold Voltage for Current Limit		FSBH0F70A	0.97	1.00	1.03	V
			FSBH0170A/0270A	0.77	0.80	0.83	
Over-Temperature Protection Section (OTP)							
T _{OTP}	Protection Junction Temperature ^(9, 11)			135	142	150	°C
T _{Restart}	Restart Junction Temperature ^(9, 12)				T _{OTP} -25		°C

Notes:

9. These parameters, although guaranteed, are not 100% tested in production.
10. Pulse test: Pulse width ≤ 300μs, duty ≤ 2%.
11. When activated, the output is disabled and the latch is turned off.
12. The threshold temperature for enabling the output and resetting the latch after over-temperature protection has been activated.
13. These parameters, although guaranteed, are tested in wafer process.

**Figure 5. V_{FB} vs. PWM Frequency**

Typical Characteristics

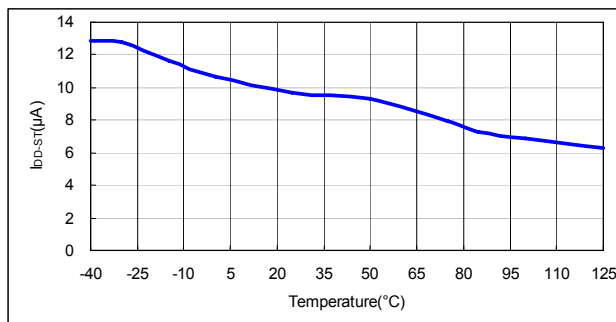


Figure 6. I_{DD-ST} vs. Temperature

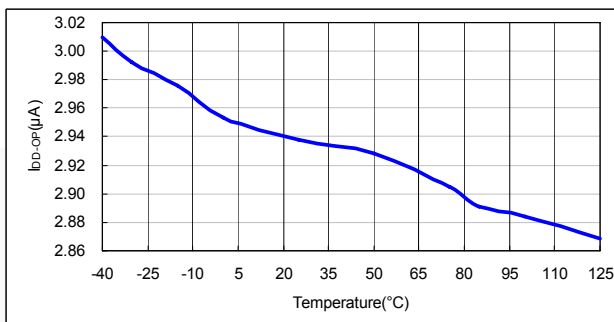


Figure 7. I_{DD-OP} vs. Temperature

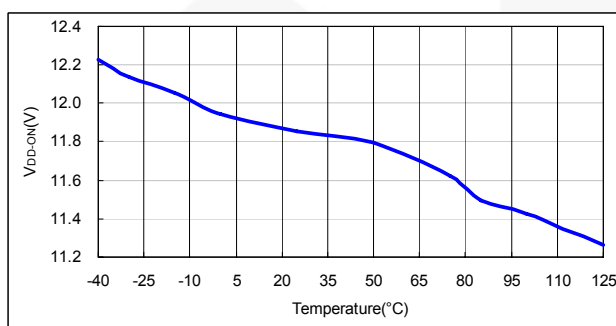


Figure 8. V_{DD-ON} vs. Temperature

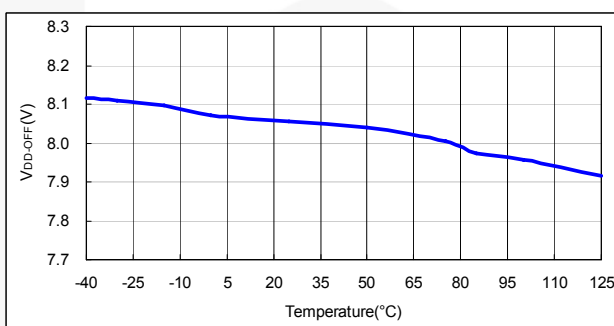


Figure 9. V_{DD-OFF} vs. Temperature

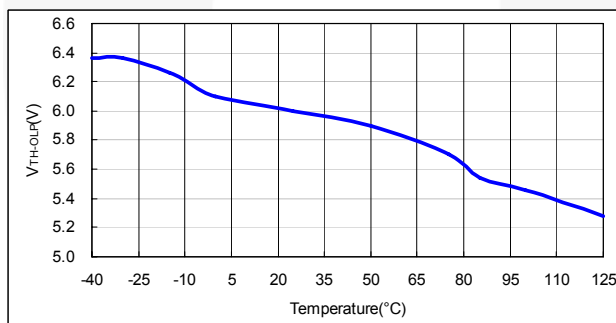


Figure 10. V_{TH-OLP} vs. Temperature

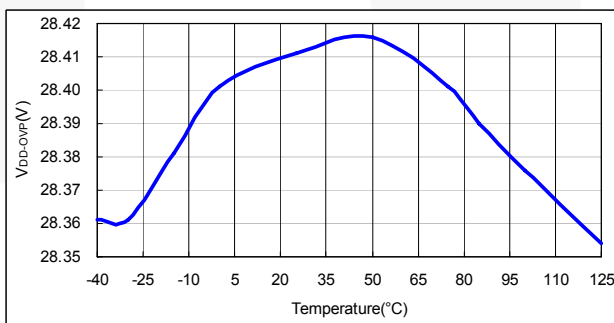


Figure 11. V_{DD-OVP} vs. Temperature

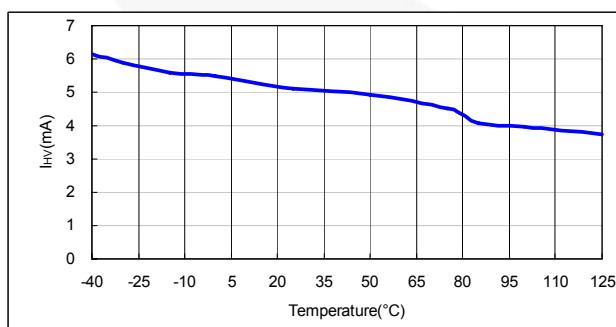


Figure 12. I_{HV} vs. Temperature

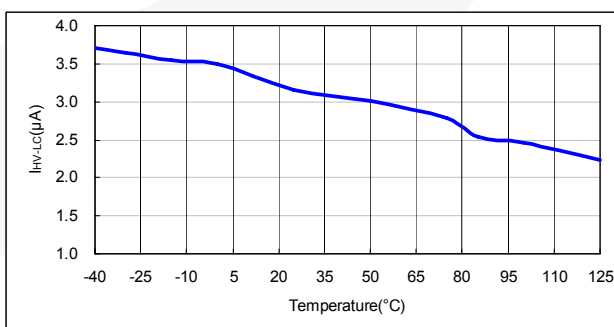


Figure 13. I_{HV-LC} vs. Temperature

Typical Characteristics

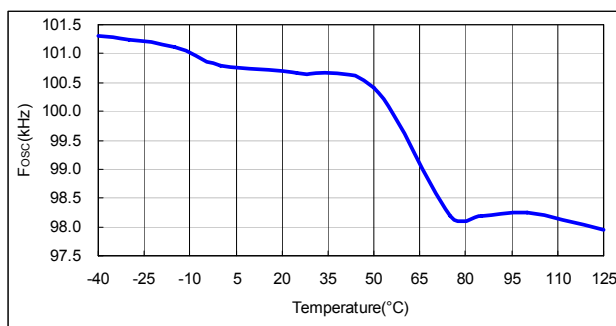


Figure 14. f_{OSC} vs. Temperature

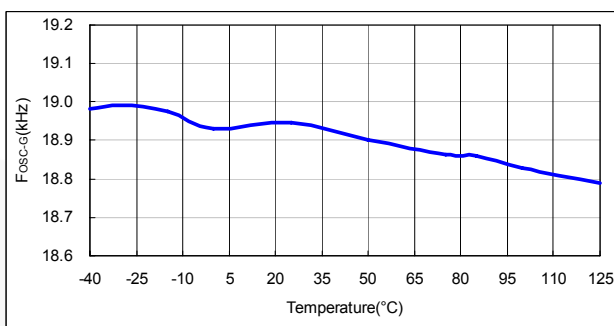


Figure 15. f_{OSC-G} vs. Temperature

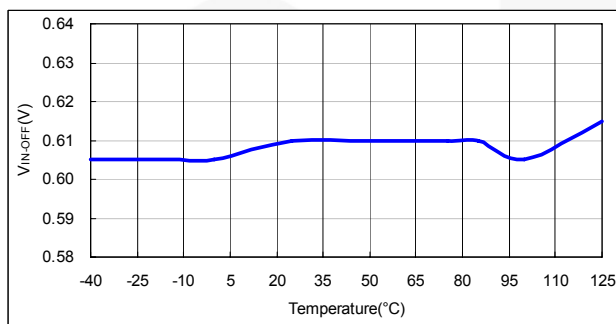


Figure 16. V_{IN-OFF} vs. Temperature

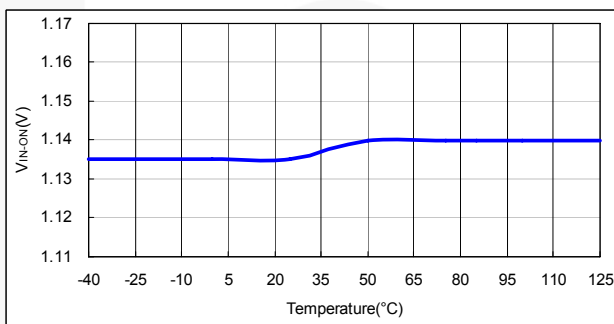


Figure 17. V_{IN-ON} vs. Temperature

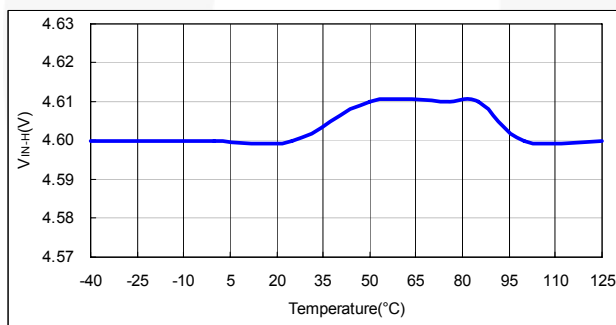


Figure 18. V_{IN-H} vs. Temperature

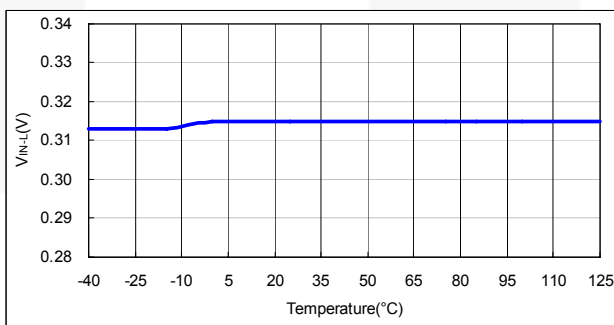


Figure 19. V_{IN-L} vs. Temperature

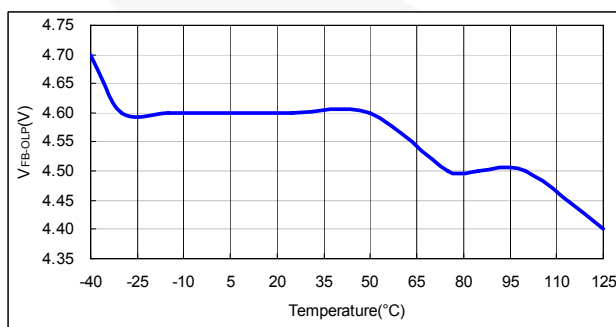


Figure 20. V_{FB-OLP} vs. Temperature

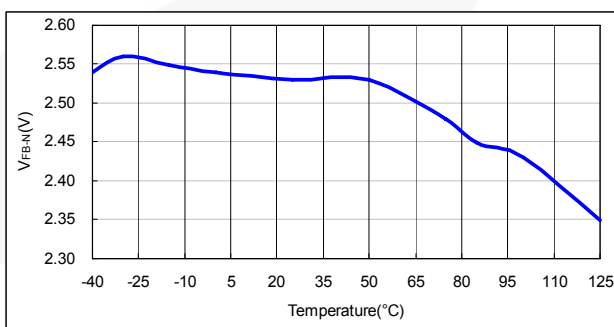


Figure 21. V_{FB-N} vs. Temperature

Typical Characteristics

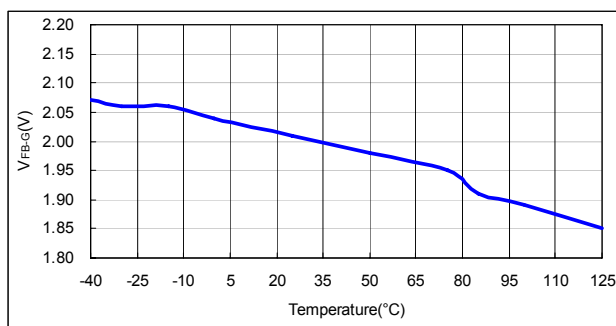


Figure 22. V_{FB-G} vs. Temperature

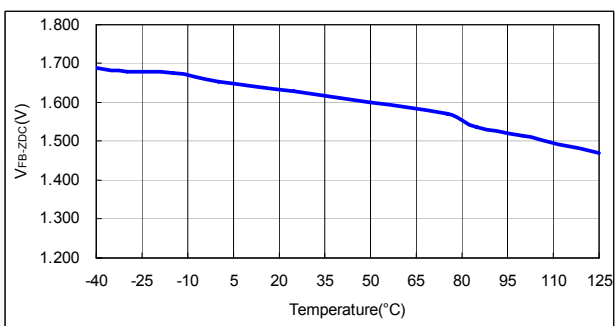


Figure 23. V_{FB-ZDC} vs. Temperature

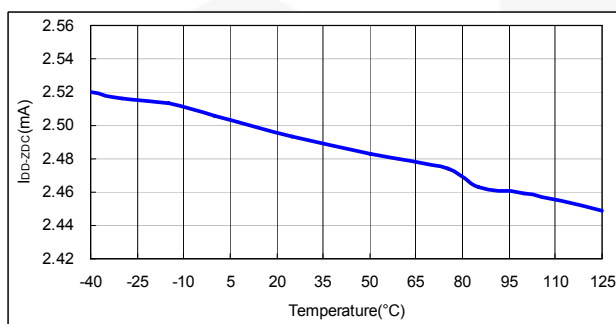


Figure 24. I_{DD-ZDC} vs. Temperature

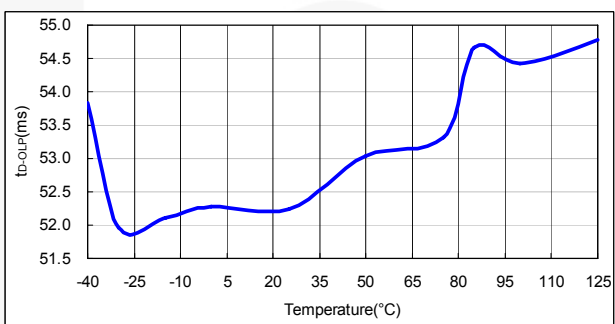


Figure 25. t_{D-OLP} vs. Temperature

Functional Description

Startup Current

For startup, the HV pin is connected to the line input or bulk capacitor through the external resistor R_{HV} . Typical startup current drawn from HV pin is 3.5mA and it charges the V_{DD} capacitor through the resistor R_{HV} . The startup current turns off when the V_{DD} capacitor voltage reaches to V_{DD-ON} . The V_{DD} capacitor then maintains the V_{DD} before the auxiliary winding of the transformer provides the operating current.

Slope Compensation

The FSBH series is designed for flyback power converters. The peak-current-mode control is used to optimize system performance. Slope compensation is added to stabilize the current loop. The FSBH series inserts a synchronized, positively sloped ramp at each switching cycle.

Soft-Start

The FSBH series has internal soft-start circuit that slowly increases the sense-FET current after startup. The typical soft-start time is 5ms during which the V_{Limit} level is increased six steps to smoothly establish the required output voltage, as shown in Figure 28. This also helps prevent transformer saturation and reduces the stress on the secondary diode during startup.

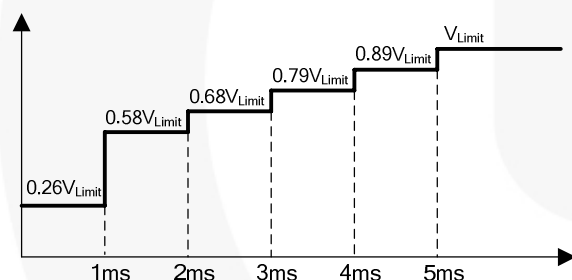


Figure 26. Soft-Start Function

Brown In/Out Function

Figure 27 shows a resistive divider with low-pass filtering for line-voltage detection on the VIN pin. The V_{IN} voltage is used for the brownout protection, when the V_{IN} voltage drops below 0.6V and debounce is 500ms. With a hysteresis voltage, the FSBH0170/0270/0370 turns on when V_{IN} reaches 1.1V.

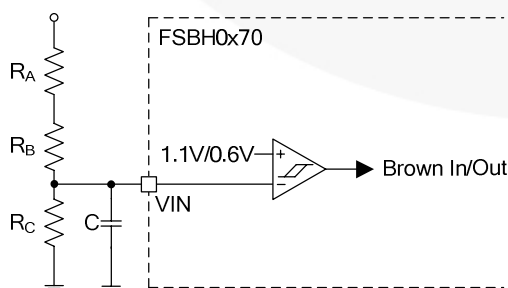


Figure 27. Brown In/Out Function on VIN Pin

Constant Power Control

To limit the output power of the converter constantly, high/low line compensation is included. Sensing the converter input voltage through the VIN pin, the high/low line compensation function generates a relative peak-current-limit threshold voltage for constant power control, as shown in Figure 28.

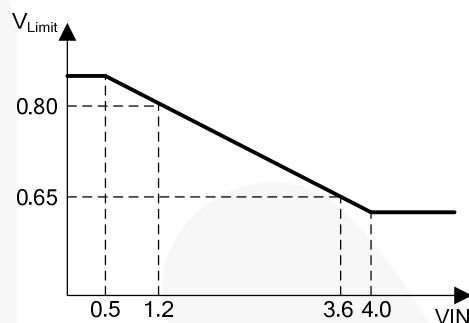


Figure 28. Constant Power Control

Latch/Auto Recovery Function

Besides the brownout protection and high/low line compensation, the FSBH0170/0270/0370 has additional protections, such as pull HIGH latch and pull LOW auto-recovery that depends on the application. As shown in Figure 29, when the V_{IN} level is higher than 4.7V, FSBH series is latched until the V_{DD} is discharged. FSBH series is auto-recovery when the V_{IN} level is lower than 0.3V.

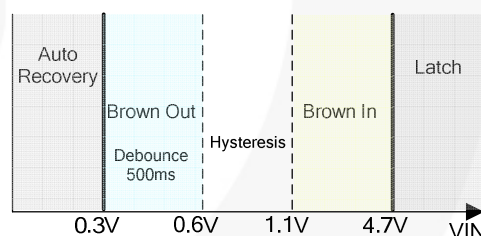


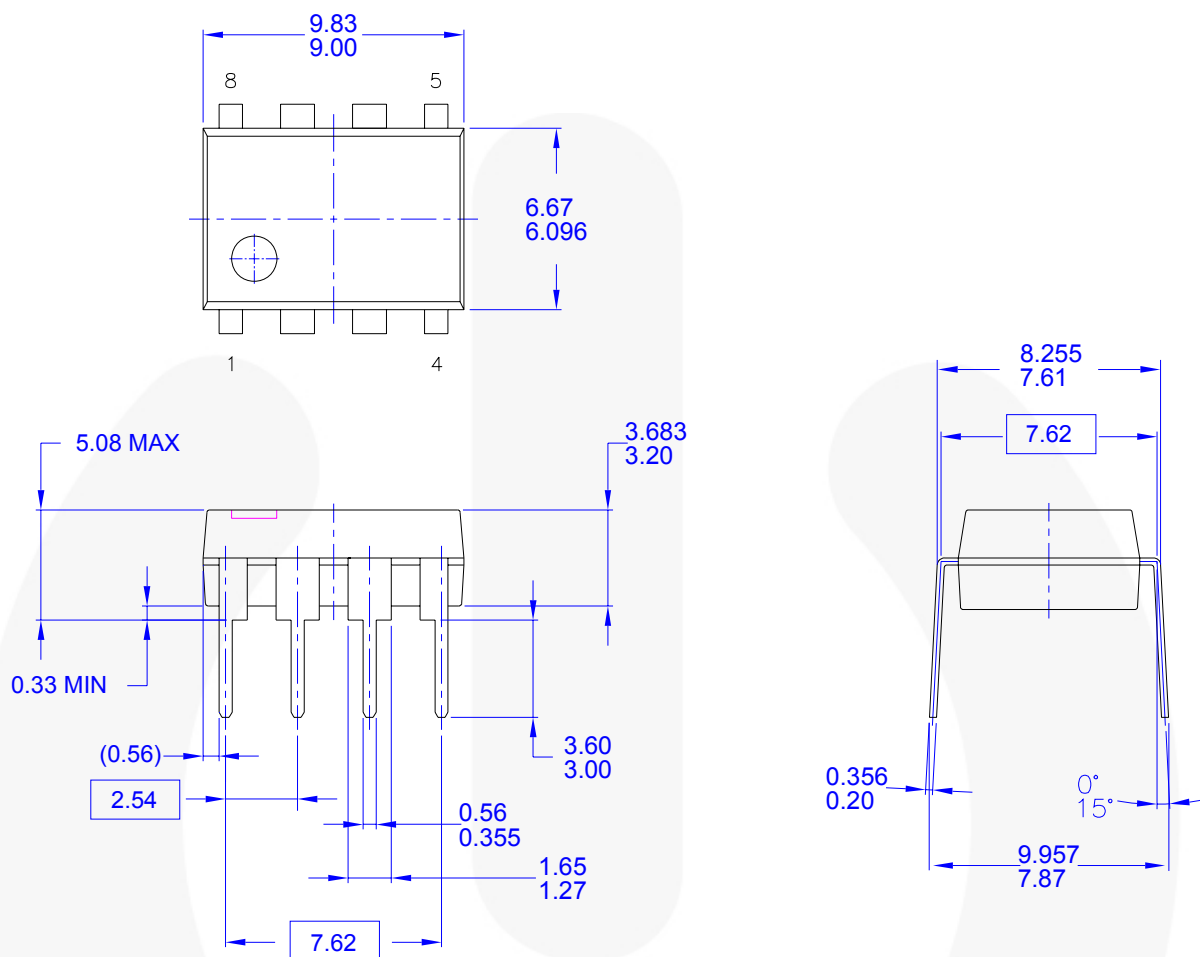
Figure 29. VIN Pin Function

Protections

The FSBH-series provides full protection functions to prevent the power supply and the load from being damaged. The protection features include:

- **V_{DD} Over-Voltage Protection.** The FSB Hseries is disabled whenever V_{DD} exceeds the over-voltage threshold of 28V.
- **Open-Loop Protection.** The FSBH series detects the feedback signal on FB pin. When over current or short circuit occurs, FB is pulled HIGH. After a 56ms debounce time, FSBH series is turned off.
- **Over-Temperature Protection.** The sense-FET and the control IC are integrated, making it easier to detect the temperature of the sense-FET. When the temperature exceeds approximately 142°C, thermal shutdown is activated.

Physical Dimensions



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Figure 30. 8-pin Dual In-Line Package (DIP)

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