SC1117DG

Energy-Efficient, Low Power Off-Line Switcher IC

Product Highlights

Optimized for Lowest System Cost

- Fully integrated auto-restart for short circuit and open-loop protection
- Frequency jittering greatly reduces EMI
- Meets HV creepage requirements between DRAIN and all other pins both on the PCB and at the package
- Lowest component count switcher solution

Features Superior to Linear/RCC

- Accurate hysteretic thermal shutdown protection – automatic recovery improves field reliability
- Universal input range allows worldwide operation
- Simple ON/OFF control, no loop compensation needed
- Very low component count – higher reliability and single side printed circuit board
- Auto-restart reduces delivered power by 95% during short circuit and open-loop fault conditions
- High bandwidth provides fast turn-on with no overshoot and excellent transient load response
- Ideal for Buck/Buck-Boost configuration
- Simplified feedback in non-isolated flyback configuration

EcoSmart™ – Extremely Energy-Efficient

- Easily meets all global energy efficiency regulations with no added components
- No-load consumption <300 mW without bias winding at 265 VAC input (<30 mW with bias winding)
- ON/OFF control provides constant efficiency to very light loads – ideal for mandatory CEC regulations

Applications

- Supplies for appliances, industrial systems, and metering

Description

SC1117DG incorporates a 700 V power MOSFET, oscillator, simple ON/OFF control scheme, a high-voltage switched current source, frequency jittering, cycle-by-cycle current limit and thermal shutdown circuitry onto a monolithic IC. The startup and operating power are derived directly from the DRAIN pin, eliminating the need for a bias winding and associated circuitry.

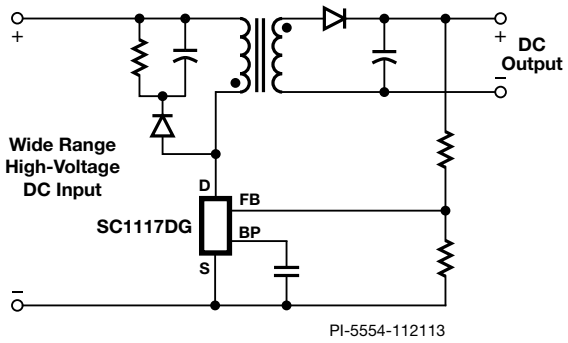


Figure 1. Typical Application Schematic. Flyback Non-Isolated.

Output Power Table

Product[3]	230 VAC ±15%		85-265 VAC	
	Adapter[1]	Open Frame[2]	Adapter[1]	Open Frame[2]
SC1117DG	9 W	12 W	6 W	7 W

Table 1. Output Power Table.

Notes:
1. Minimum continuous power in a typical non-ventilated enclosed adapter measured at +50 °C ambient.
2. Maximum practical continuous power in an open frame design with adequate heatsinking, measured at 50 °C ambient.
3. Packages: D: SO-8C.

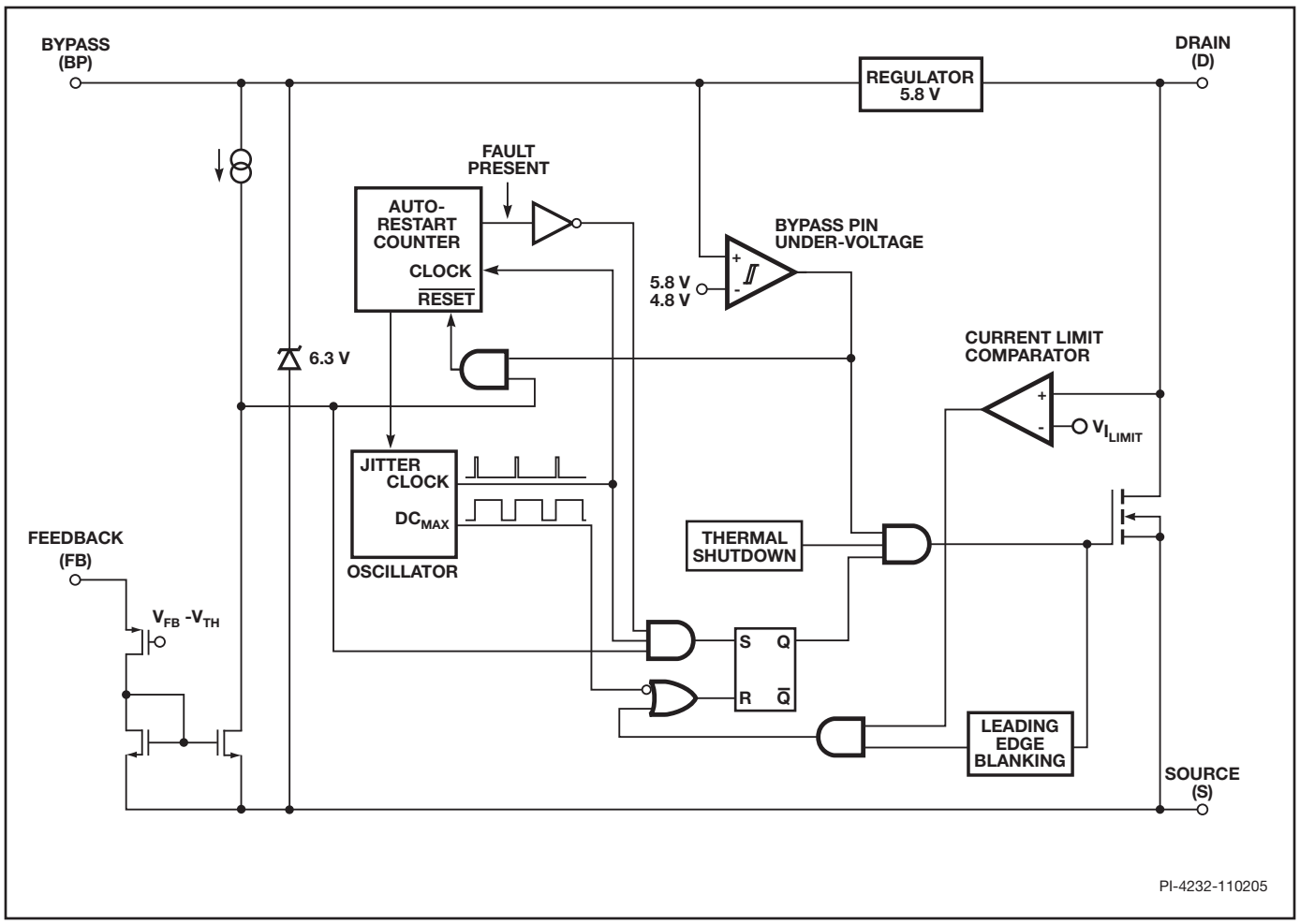


Figure 2. Functional Block Diagram.

Pin Functional Description

DRAIN (D) Pin:
Power MOSFET drain connection. Provides internal operating current for both startup and steady-state operation.

BYPASS (BP) Pin:
Connection point for a 0.1 µF external bypass capacitor for the internally generated 5.8 V supply. If an external bias winding is used, the current into the BYPPASS pin must not exceed 1 mA.

FEEDBACK (FB) Pin:
During normal operation, switching of the power MOSFET is controlled by this pin. MOSFET switching is disabled when a current greater than 49 µA is delivered into this pin.

SOURCE (S) Pin:
This pin is the power MOSFET source connection. It is also the ground reference for the BYPASS and FEEDBACK pins.

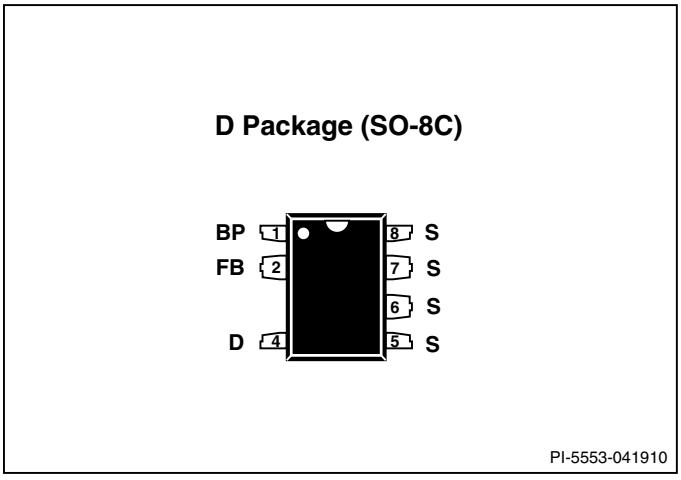


Figure 3. Pin Configuration.

SC1117DG Functional Description

SC1117DG combines a high-voltage power MOSFET switch with a power supply controller in one device. Unlike conventional PWM (pulse width modulator) controllers, a simple ON/OFF control regulates the output voltage. The controller consists of an oscillator, feedback (sense and logic) circuit, 5.8 V regulator, BYPASS pin undervoltage circuit, over-temperature protection, frequency jittering, current limit circuit, and leading edge blanking integrated with a 700 V power MOSFET. The SC1117DG incorporates additional circuitry for auto-restart.

Oscillator

The typical oscillator frequency is internally set to an average of 66 kHz. Two signals are generated from the oscillator: the maximum duty cycle signal (DC_{MAX}) and the clock signal that indicates the beginning of each cycle.

The oscillator incorporates circuitry that introduces a small amount of frequency jitter, typically 4 kHz peak-to-peak, to minimize EMI emission. The modulation rate of the frequency jitter is set to 1 kHz to optimize EMI reduction for both average and quasi-peak emissions. The frequency jitter should be measured with the oscilloscope triggered at the falling edge of the DRAIN waveform. The waveform in Figure 4 illustrates the frequency jitter.

Feedback Input Circuit

The feedback input circuit at the FEEDBACK pin consists of a low impedance source follower output set at 1.65 V. When the current delivered into this pin exceeds 49 µA, a low logic level (disable) is generated at the output of the feedback circuit. This output is sampled at the beginning of each cycle on the rising edge of the clock signal. If high, the power MOSFET is turned on for that cycle (enabled), otherwise the power MOSFET remains off (disabled). Since the sampling is done only at the beginning of each cycle, subsequent changes in the FEEDBACK pin voltage or current during the remainder of the cycle are ignored.

5.8 V Regulator and 6.3 V Shunt Voltage Clamp

The 5.8 V regulator charges the bypass capacitor connected to the BYPASS pin to 5.8 V by drawing a current from the voltage on the DRAIN, whenever the MOSFET is off. The BYPASS pin is the internal supply voltage node. When the MOSFET is on, the SC1117DG runs off of the energy stored in the bypass capacitor. Extremely low power consumption of the internal circuitry allows the device to operate continuously from the current drawn from the DRAIN pin. A bypass capacitor value of 0.1 µF is sufficient for both high frequency decoupling and energy storage.

In addition, there is a 6.3 V shunt regulator clamping the BYPASS pin at 6.3 V when current is provided to the BYPASS pin through an external resistor. This facilitates powering of the device externally through a bias winding to decrease the no-load consumption to less than 50 mW.

BYPASS Pin Undervoltage

The BYPASS pin undervoltage circuitry disables the power MOSFET when the BYPASS pin voltage drops below 4.85 V. Once the BYPASS pin voltage drops below 4.8 V, it must rise back to 5.8 V to enable (turn-on) the power MOSFET.

Over-Temperature Protection

The thermal shutdown circuitry senses the die temperature. The threshold is set at 142 °C typical with a 75 °C hysteresis. When the die temperature rises above this threshold (142 °C) the power MOSFET is disabled and remains disabled until the die temperature falls by 75 °C, at which point it is re-enabled.

Current Limit

The current limit circuit senses the current in the power MOSFET. When this current exceeds the internal threshold (I_{LIMIT}), the power MOSFET is turned off for the remainder of that cycle. The leading edge blanking circuit inhibits the current limit comparator for a short time (t_{LEB}) after the power MOSFET is turned on. This leading edge blanking time has been set so that current spikes caused by capacitance and rectifier reverse recovery time will not cause premature termination of the switching pulse.

Auto-Restart

In the event of a fault condition such as output overload, output short circuit, or an open-loop condition, SC1117DG enters into auto-restart operation. An internal counter clocked by the oscillator gets reset every time the FEEDBACK pin is pulled high. If the FEEDBACK pin is not pulled high for approximately 50 ms, the power MOSFET switching is disabled for 800 ms. The auto-restart alternately enables and disables the switching of the power MOSFET until the fault condition is removed.

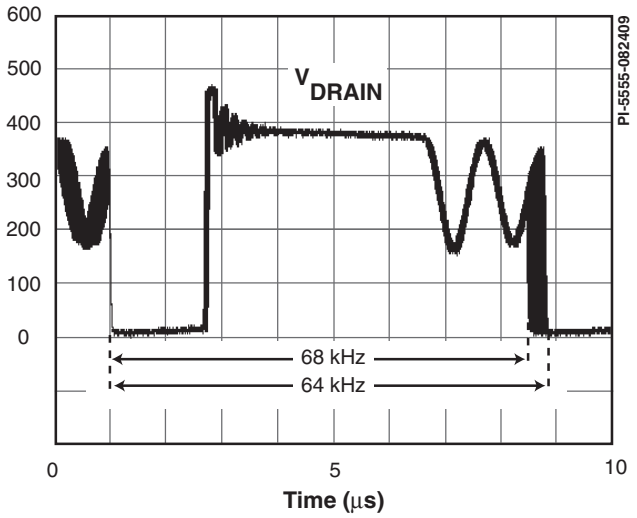


Figure 4. Frequency Jitter.

Absolute Maximum Ratings[1,5]

DRAIN Voltage .....-0.3 V to 700 V
Peak DRAIN Current (SC1117)..... 800 mA (1500 mA)[2]
FEEDBACK Voltage .....-0.3 V to 9 V
FEEDBACK Current.....100 mA BYPASS
Voltage .....-0.3 V to 9 V
Storage Temperature .....-65 °C to 150 °C
Operating Junction Temperature[3] .....-40 °C to 150 °C
Lead Temperature[4] .....260 °C

Notes:
1. All voltages referenced to SOURCE, T_A = 25 °C.
2. The higher peak DRAIN current is allowed if the DRAIN to SOURCE voltage does not exceed 400 V.
3. Normally limited by internal circuitry.
4. 1/16 in. from case for 5 seconds.
5. Maximum ratings specified may be applied, one at a time, without causing permanent damage to the product. Exposure to Absolute Maximum Rating conditions for extended periods of time may affect product reliability.

Thermal Resistance

Thermal Resistance: D Package:
(θ_{JA}) .....100 °C/W[3]; 80 °C/W[4]
(θ_{JC})[1] ..... 30 °C/W

Notes:
1. Measured on pin 8 (SOURCE) close to plastic interface.
2. Soldered to 0.36 sq. in. (232 mm^2), 2 oz. (610 g/m^2) copper clad.
3. Soldered to 1 sq. in. (645 mm^2), 2 oz. (610 g/m^2) copper clad.

Parameter	Symbol	Conditions SOURCE = 0 V; T_J = -40 to 125 °C (Unless Otherwise Specified)		Min	Typ	Max	Units
Control Functions							
Output Frequency	f_{OSC}	T_J = 25 °C	Average	62	66	70	kHz
			Peak-Peak Jitter		4		
Maximum Duty Cycle	DC_{MAX}	S2 Open		66	69	72	%
FEEDBACK Pin Turnoff Threshold Current	I_{FB}	T_J = 25 °C		30	49	68	µA
FEEDBACK Pin Voltage at Turnoff Threshold	V_{FB}	T_J = 25 °C		1.55	1.60	1.65	V
DRAIN Supply Current	I_{S1}	V_{FB} ≥2 V (MOSFET Not Switching) See Note A			160	220	µA
	I_{S2}	FEEDBACK Open (MOSFET Switching) See Notes A, B	SC1117DG		220	280	µA

Parameter	Symbol	Conditions SOURCE = 0 V; T_J = -40 to 125 °C (Unless Otherwise Specified)		Min	Typ	Max	Units
Control Functions (cont.)							
BYPASS Pin Charge Current	I_{CH1}	V_{BP} = 0 V, T_J = 25 °C	SC1117DG	-7.5	-4.6	-2.5	mA
	I_{CH2}	V_{BP} = 4 V, T_J = 25 °C	SC1117DG	-4.5	-3.3	-1.5	
BYPASS Pin Voltage	V_{BP}			5.55	5.8	6.10	V
BYPASS Pin Voltage Hysteresis	V_{BPH}			0.8	0.95	1.2	V
BYPASS Pin Supply Current	I_{BPSC}			68			µA
Circuit Protection							
Current Limit	I_{LIMIT}	di/dt = 75 mA/ms, T_J = 25 °C	SC1117DG	350	375	401	mA
		di/dt = 500 mA/ms, T_J = 25 °C	SC1117DG	396	450	504	
Minimum On Time	$t_{ON(MIN)}$	SC1117DG		360	460	610	ns
Leading Edge Blanking Time	t_{LEB}	T_J = 25 °C, See Note C		170	215		ns
Thermal Shutdown Temperature	T_{SD}			135	142	150	°C
Thermal Shutdown Hysteresis	T_{SHD}	See Note D			75		°C

Parameter	Symbol	Conditions SOURCE = 0 V; T_J = -40 to 125 °C (Unless Otherwise Specified)		Min	Typ	Max	Units
Output							
ON-State Resistance	$R_{DS(ON)}$	SC1117DG I_D = 35 mA	T_J = 25 °C		12	13.8	Ω
			T_J = 100 °C		19	22.1	
OFF-State Drain Leakage Current	I_{DSS}	V_{BP} = 6.2 V, V_{FB} ≥2 V, V_{DS} = 560 V, T_J = 25 °C	SC1117DG			70	µA
Breakdown Voltage	BV_{DSS}	V_{BP} = 6.2 V, V_{FB} ≥2 V, T_J = 25 °C		700			V
Rise Time	t_R	Measured in a Typical Buck Converter Application			50		ns
Fall Time	t_F				50		ns
DRAIN Supply Voltage				50			V
Output Enable Delay	t_{EN}					10	µs
Output Disable Setup Time	t_{DST}				0.5		µs
Auto-Restart ON-Time		T_J = 25 °C See Note E	SC1117DG		50		ms
Auto-Restart Duty Cycle			SC1117DG		6		%

NOTES:

A. Total current consumption is the sum of I_{S1} and I_{DSS} when FEEDBACK pin voltage is ≥2 V (MOSFET not switching) and the sum of I_{S2} and I_{DSS} when FEEDBACK pin is shorted to SOURCE (MOSFET switching).

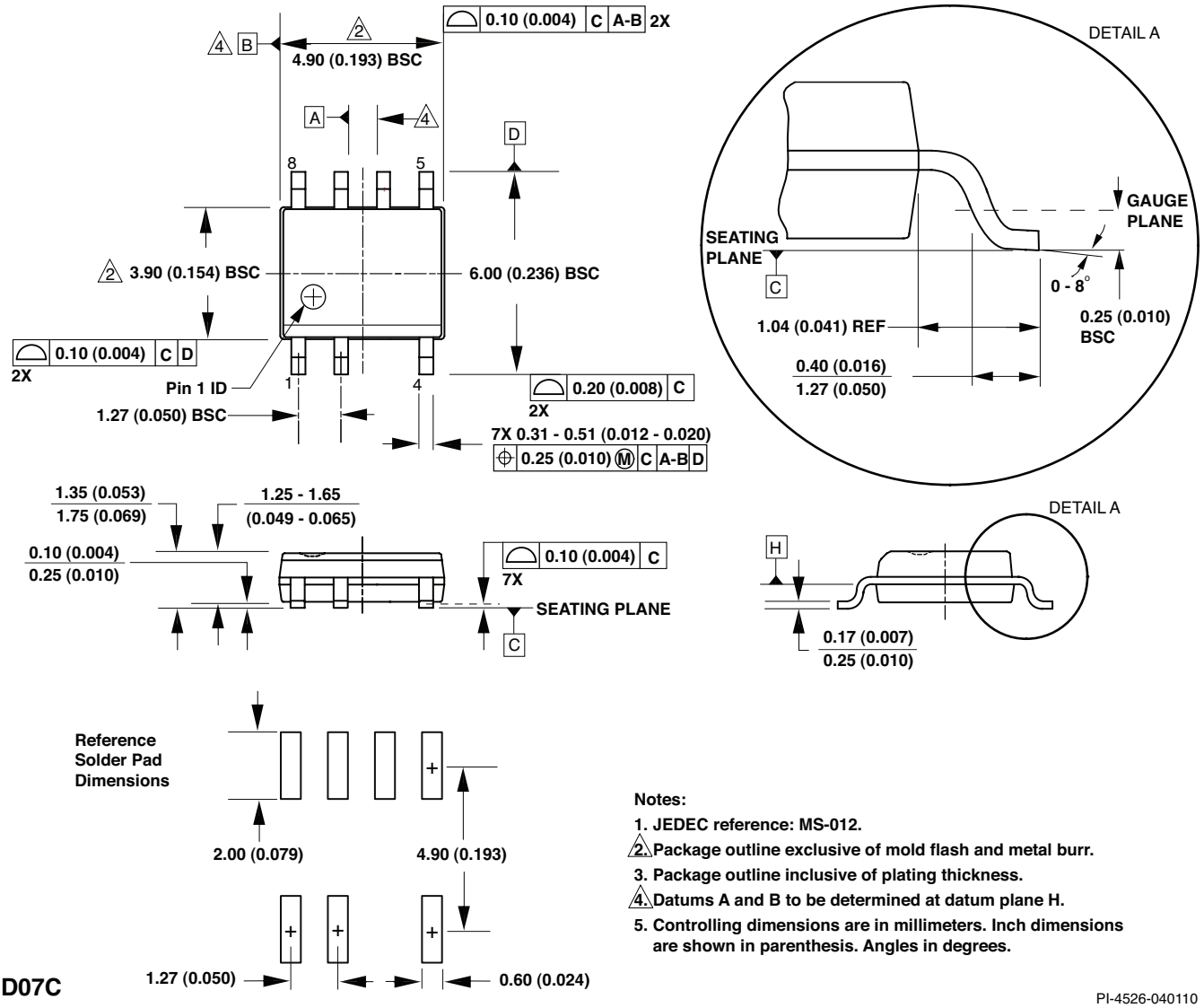
B Since the output MOSFET is switching, it is difficult to isolate the switching current from the supply current at the DRAIN. An alternative is to measure the BYPASS pin current at 6 V.

C. This parameter is guaranteed by design.

D. This parameter is derived from characterization.

E. Auto-restart on time has the same temperature characteristics as the oscillator (inversely proportional to frequency).

SO-8C (D Package)



Notes:

1. JEDEC reference: MS-012.
2. Package outline exclusive of mold flash and metal burr.
3. Package outline inclusive of plating thickness.
4. Datums A and B to be determined at datum plane H.
5. Controlling dimensions are in millimeters. Inch dimensions are shown in parenthesis. Angles in degrees.

D07C

PI-4526-040110

Revision	Notes	Date
A	Final data sheet release.	04/10
B		11/13
C	Tightened V_{FB} limits.	04/15

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