Low-Cost, Green-Mode PWM Controller for Flyback Converters **SG6858**

FEATURES

- Green-mode PWM
- Supports the "Blue Angel" standard
- Low start-up current (10μA)
- Low operating current (2.5mA)
- Leading-edge blanking
- Constant output power limit
- Universal input
- Built-in synchronized slope compensation
- Current-mode operation
- Cycle-by-cycle current limiting
- Under voltage lockout (UVLO)
- Programmable PWM frequency
- V_{DD} over-voltage protection (auto restart)
- Gate output voltage clamped at 17V
- Low cost
- Few external components required
- Small SOT-26 and DIP-8 packages

APPLICATIONS

General-purpose, switching-mode power supplies and flyback power converters, such as:

- Battery chargers for cellular phones, cordless phones, PDAs, digital cameras, and power tools
- Power adapters for ink jet printers, video game consoles, and portable audio players
- Open-frame SMPS for TV/DVD standby and auxiliary supplies, home appliances, and consumer electronics
- Replacements for linear transformers and RCC SMPS
- PC 5V standby power

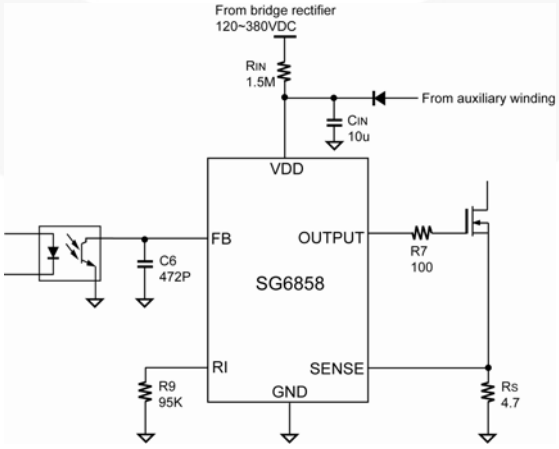
DESCRIPTION

This highly integrated PWM controller provides several special enhancements designed to meet the low standby power needs of low-power SMPS. To minimize standby power consumption, the proprietary green-mode function provides off-time modulation to linearly decrease the switching frequency under light-load conditions. This green-mode function enables the power supply to meet even the strictest power conservation requirements.

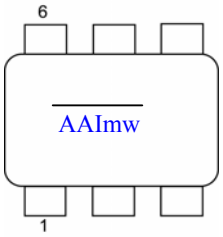
The BiCMOS fabrication process enables reducing the start-up current to 10μA and the operating current to 2.5mA. To further improve power conservation, a large start-up resistance can be used. Built-in synchronized slope compensation ensures the stability of peak current mode control. Proprietary internal compensation provides a constant output power limit over a universal AC input range ($90V_{AC}$ to $264V_{AC}$). Pulse-by-pulse current limiting ensures safe operation even during short-circuits.

To protect the external power MOSFET from being damaged by supply over-voltage events, the SG6858's output driver is clamped at 17V. SG6858 controllers can be used to improve the performance and reduce the production cost of power supplies and can replace linear and RCC-mode power adapters. It is available in 8-pin DIP and 6-pin SOT-26 packages.

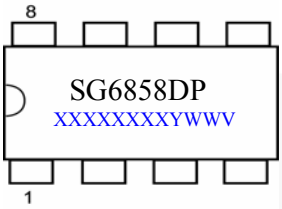
TYPICAL APPLICATION



MARKING DIAGRAMS



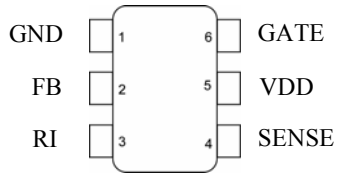
AAI: SG6858
m: Mask Version
w: Week code A~Z=W1~W26
A~Z=W27~W52
———: Lead Free Package



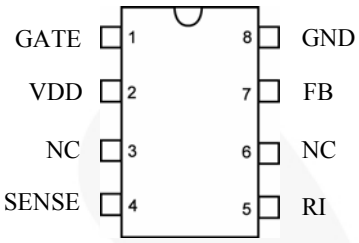
D: D=DIP
P: Z=Lead Free
Null=Regular Package
XXXXXXXX: Wafer Lot
Y: Year; WW: Week
V: Assembly Location

PIN CONFIGURATION

SOT-26



DIP-8



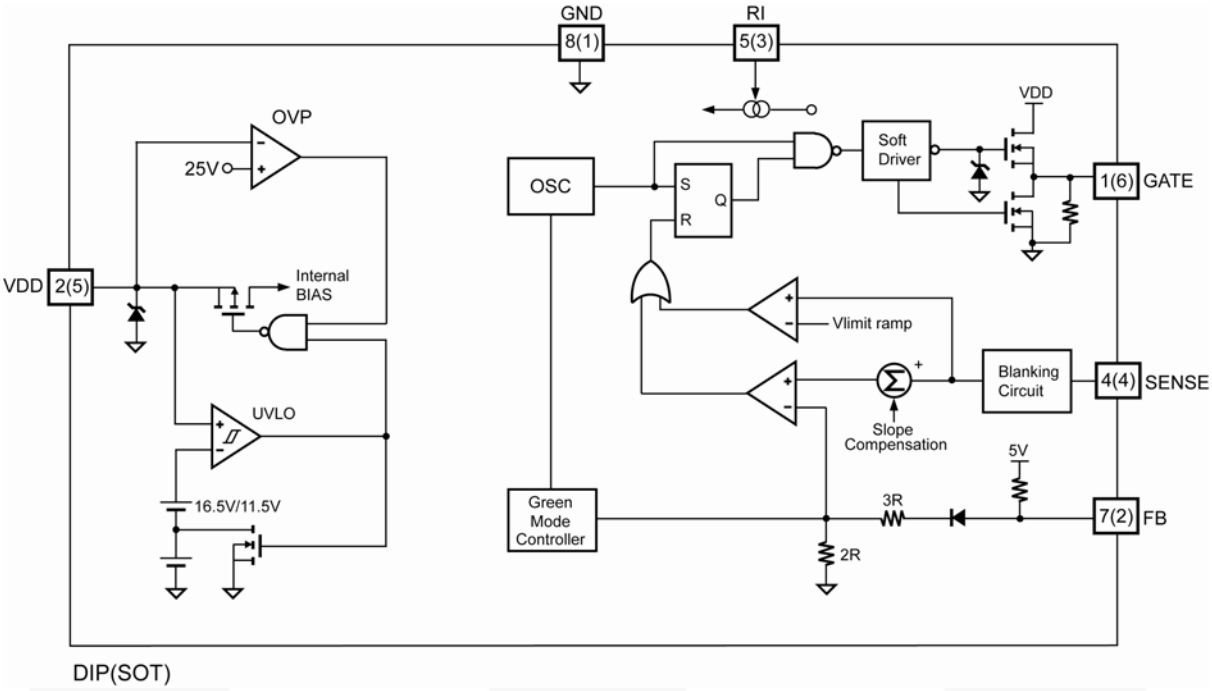
ORDERING INFORMATION

Part Number	Pb-Free	Package
SG6858TZ		6-pin SOT-26
SG6858DZ		8-pin DIP-8

PIN DESCRIPTIONS

Name	Pin No.		Type	Function
	DIP-8	SOT-26		
GATE	1	6	Driver Output	The totem-pole output driver for driving the power MOSFET.
VDD	2	5	Supply	Power supply.
NC	3		No Connection	NC pin.
SENSE	4	4	Analog Input	Current sense. This pin senses the voltage across a resistor. When the voltage reaches the internal threshold, PWM output is disabled. This activates over-current protection. This pin also provides current amplitude information for current-mode control.
RI	5	3	Analog Input/Output	A resistor connected from the RI pin to ground generates a constant current source used to charge an internal capacitor and determines the switching frequency. Increasing the resistance reduces the amplitude of the current source and reduce the switching frequency. A 95kΩ resistor, R_I, results in a 50μA constant current I_I and a 70kHz switching frequency.
NC	6		No Connection	NC pin.
FB	7	2	Analog Input	Feedback. The FB pin provides the output voltage regulation signal. It provides feedback to the internal PWM comparator, so that the PWM comparator can control the duty cycle.
GND	8	1	Supply	Ground.

BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value		Unit
V_{VDD}	DC Supply Voltage*	30		V
V_{FB}	Input Voltage to FB Pin	-0.3 to 7.0		V
V_{SENSE}	Input Voltage to Sense Pin	-0.3 to 7.0		V
T_J	Operating Junction Temperature	-40 to +125		°C
$R_{\theta JA}$	Thermal Resistance (Junction-to-Air)	SOT	208.4	°C/W
		DIP	82.5	°C/W
T_{STG}	Storage Temperature Range	-55 to +150		°C
T_L	Lead Temperature (Wave Soldering or Infrared, 10 Seconds)	260		°C
$V_{ESD-HBM}$	Electrostatic Discharge Capability, Human Body Model	3.0		kV
V_{ESD-MM}	Electrostatic Discharge Capability, Machine Model	200		V

* All voltage values, except differential voltages, are given with respect to GND pin.

* Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device.

RECOMMENDED OPERATING CONDITIONS

Symbol	Parameter	Value	Unit
V_{DD}	DC Supply Voltage	≦ 22	V
T_A	Operating Ambient Temperature	-20 to +85	°C

* For proper operation.

ELECTRICAL CHARACTERISTICS

V_{DD}=15V, T_A = 25°C, unless otherwise noted.

V_{DD} Section

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
V_{DD-OP}	Continuously Operation Voltage				22	V
V_{DD-ON}	Turn-on Threshold Voltage		15.5	16.5	17.5	V
V_{DD-OFF}	Turn-off Threshold Voltage		10.5	11.5	12.5	V
I_{DD-ST}	Start-up Current	$V_{DD}=V_{DD-ON}$ – 0.1V		10	15	μA
I_{DD-OP}	Operating Supply Current	V_{DD}=15V, GATE with 1nF to GND		2.5	3.5	mA
V_{DD-OVP}	V_{DD} Over-Voltage Protection Level		24	25	26	V
$t_{D-VDDOVP}$	V_{DD} Over-Voltage Protection Debounce		50	125	200	μs
$V_{DD-G\ OFF}$	V_{DD} Low Threshold Voltage to Exit Green-off Mode		V_{DD-OFF} + 0.95	V_{DD-OFF} + 1.10	V_{DD-OFF} + 1.25	V

Feedback Input Section

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
A_V	FB Input to Current Comparator Attenuation			2/5		V/V
Z_{FB}	Input Impedance			5		KΩ
$V_{FB-OPEN}$	FB Output High Voltage		4.5	5.0	5.5	V
V_{FB-N}	Green-Mode Entry FB Voltage			2.85		V
V_{FB-G}	Green-Mode Ending FB Voltage			2.20		V
S_G	Green-Mode Modulation Slope	R_I=95kΩ		75		Hz/mV

Current-Sense Section

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
Z_{SENSE}	Input Impedance		10			kΩ
t_{PD}	Delay to Output			60	100	ns
V_{STHFL}	Flat Threshold Voltage for Current Limit			0.96		V
V_{STHVA}	Valley Threshold Voltage for Current Limit		0.75	0.80	0.85	V
t_{LEB}	Leading-edge Blanking Time		250	300	350	ns
DCY_{SAW}	Duty Cycle of SAW Limit	Max. Duty Cycle		45		%

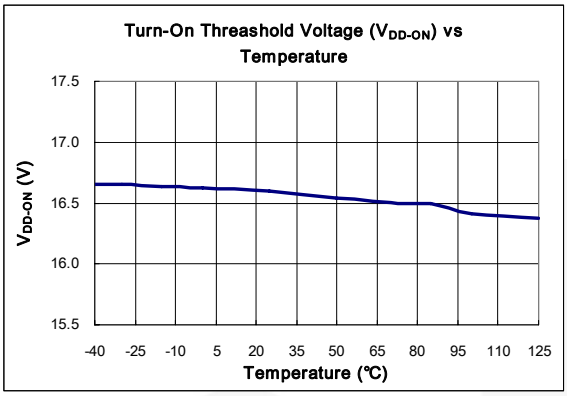
Oscillator Section

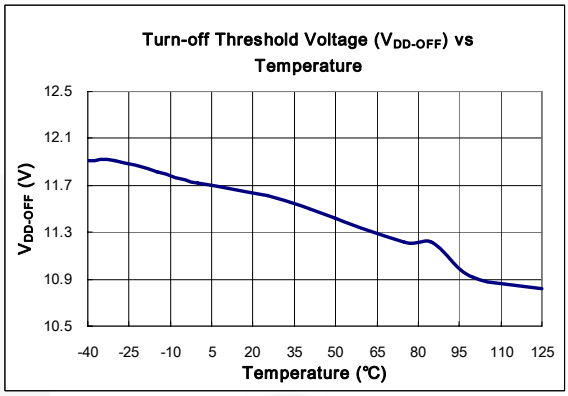
Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
F_{OSC}	Frequency	R_I=95kΩ	65	70	75	kHz
F_{OSC-G}	Green-Mode Frequency	R_I=95kΩ		22		kHz
F_{DV}	Frequency Variation vs. V_{DD} Deviation	V_{DD}=13.5V to 22V	0	0.02	2.00	%
F_{DT}	Frequency Variation vs. Temperature Deviation	T_A= -20 to 85°C			2	%

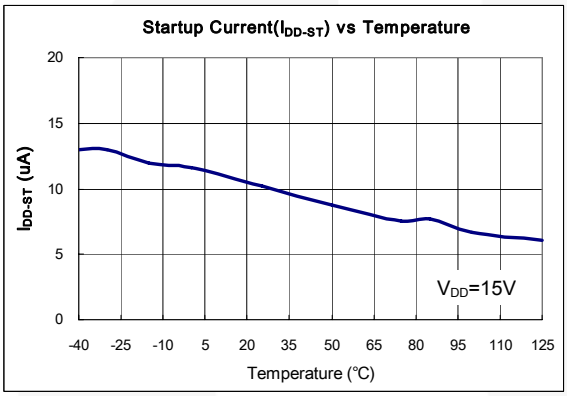
Output Section

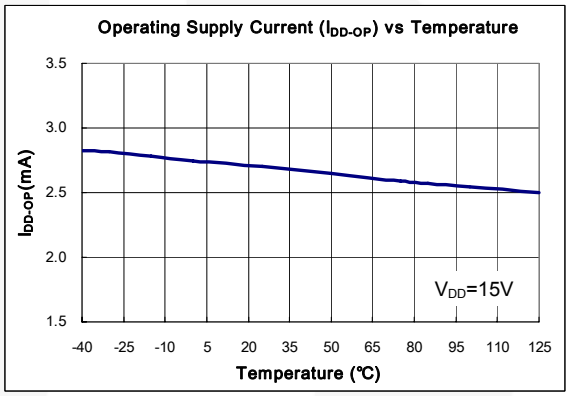
Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
DCY_{MAX}	Maximum Duty Cycle		70	75	80	%
V_{GATE-L}	Output Voltage Low	V_{DD}=15V, I_o=20mA			1.5	V
V_{GATE-H}	Output Voltage High	V_{DD}=13.5V, I_o=-20mA	8			V
t_R	Rising Time	V_{DD}=15V, C_L=1nF	150	200	250	ns
t_F	Falling Time	V_{DD}=15V, C_L=1nF	35	55	75	ns
$V_{GATE-CLAMP}$	Output Clamp Voltage	V_{DD}=22V	16	17	18	V

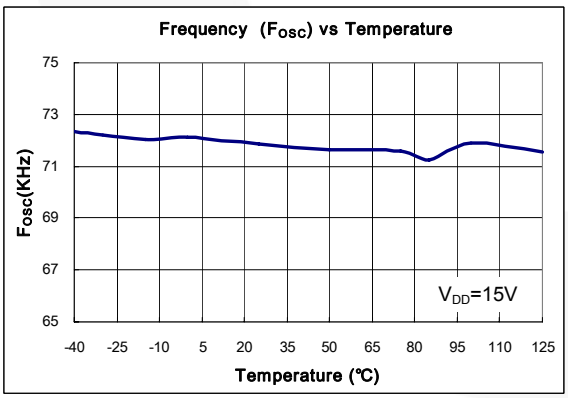
TYPICAL CHARACTERISTICS

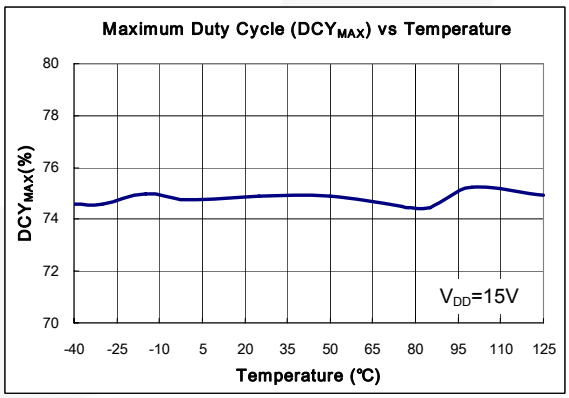


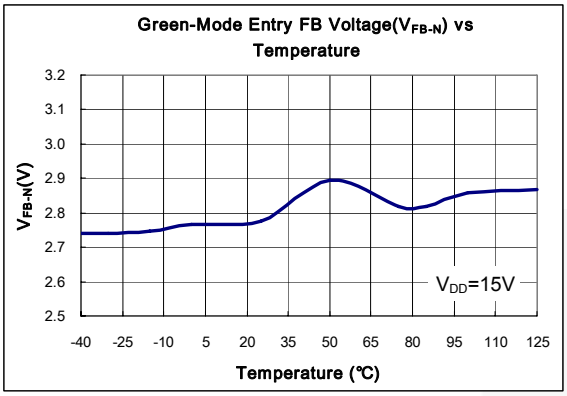


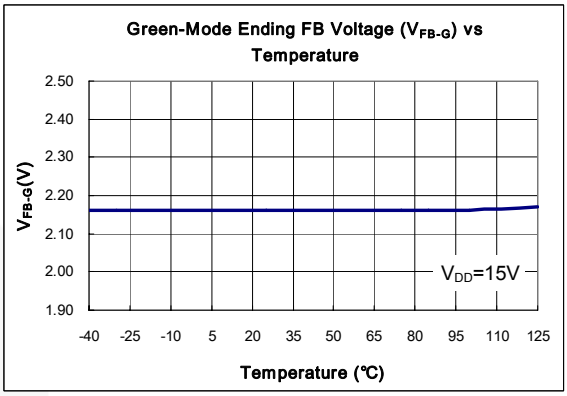


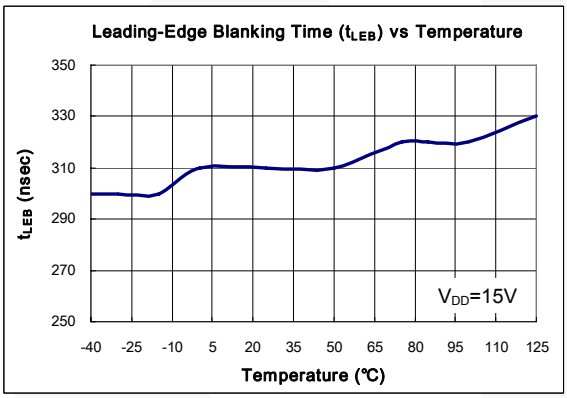


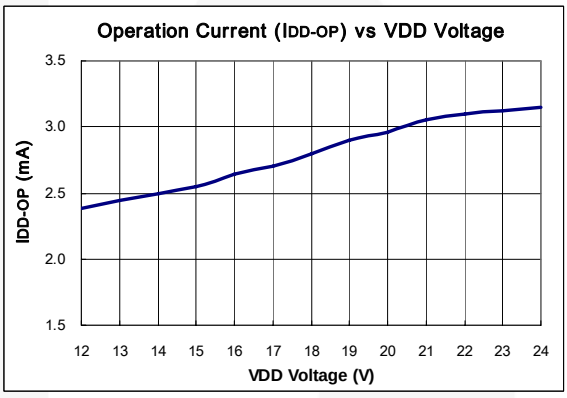





Green-Mode Entry FB Voltage(V_{FB-N}) vs Temperature
V_{FB-N}(V)
3.2
3.1
3.0
2.9
2.8
2.7
2.6
2.5
V_{DD}=15V
-40 -25 -10 5 20 35 50 65 80 95 110 125
Temperature (℃)


Green-Mode Ending FB Voltage (V_{FB-G}) vs Temperature
V_{FB-G}(V)
2.50
2.40
2.30
2.20
2.10
2.00
1.90
V_{DD}=15V
-40 -25 -10 5 20 35 50 65 80 95 110 125
Temperature (℃)


Leading-Edge Blanking Time (t_{LEB}) vs Temperature
t_{LEB} (nsec)
350
330
310
290
270
250
V_{DD}=15V
-40 -25 -10 5 20 35 50 65 80 95 110 125
Temperature (℃)


Operation Current (I_{DD-OP}) vs VDD Voltage
IDD-OP (mA)
3.5
3.0
2.5
2.0
1.5
12 13 14 15 16 17 18 19 20 21 22 23 24
VDD Voltage (V)

OPERATION DESCRIPTION

SG6858 devices integrate many useful designs into one controller for low-power switch-mode power supplies. The following descriptions highlight some of the features of the SG6858 series.

Start-up Current

The start-up current is only 10μA, which allows a start-up resistor with a high resistance and a low-wattage to supply the start-up power for the controller. A 1.5MΩ, 0.25W, start-up resistor and a 10μF/25V V_{DD} hold-up capacitor are sufficient for an AC-to-DC power adapter with a wide input range ($100V_{AC}$ to $240V_{AC}$).

Operating Current

The operating current has been reduced to 2.5mA. The low operating current results in higher efficiency and reduces the V_{DD} hold-up capacitance requirement.

Green-Mode Operation

The proprietary green-mode function provides off-time modulation to linearly decrease the switching frequency under light-load conditions. On-time is limited to provide stronger protection against brownouts and other abnormal conditions. The feedback current, which is sampled from the voltage feedback loop, is taken as the reference. Once the feedback current exceeds the threshold current, the switching frequency starts to decrease. This green-mode function dramatically reduces power consumption under light-load and zero-load conditions. Power supplies using the SG6858 can meet even the strictest regulations regarding standby power consumption.

Oscillator Operation

A resistor connected from the RI pin to ground generates a constant current source used to charge an internal capacitor. The charge-time determines the internal clock speed and the switching frequency. Increasing the resistance reduces the amplitude of the input current and the switching frequency. A 95kΩ resistor, R_I, results in a 50μA constant current, I_I, and a 70kHz switching frequency. The relationship between R_I and the switching frequency is:

$$f_{PWM} = \frac{6650}{R_I\,(k\Omega)}\,(kHz) \qquad (1)$$

Leading-Edge Blanking

Each time the power MOSFET is switched on, a turn-on spike occurs at the sense-resistor. To avoid premature termination of the switching pulse, a 300ns leading-edge blanking time is built in. Conventional RC filtering can therefore be omitted. During this blanking period, the current-limit comparator is disabled and cannot switch off the gate driver.

Constant Output Power Limit

When the SENSE voltage across the sense resistor, R_S, reaches the threshold voltage (around 0.96V), the output GATE drive is turned off following a short propagation delay t_{PD}.

This propagation delay introduces additional current proportional to $t_{PD} \bullet V_{in}/L_p$. The propagation delay is nearly constant regardless of the input line voltage V_{IN}. Higher input line voltages result in larger additional currents. At high input line voltages, the output power limit is higher than at low input line voltages.

To compensate for this output power limit variation across a wide AC input range, the threshold voltage is adjusted by adding a positive ramp (V_{LIMIT_RAMP}).

This ramp signal rises from 0.80V to 0.96V, then flattens out at 0.96V. A smaller threshold voltage forces the output GATE drive to terminate earlier. This reduces the total PWM turn-on time and makes the output power equal to that of low line input. This proprietary internal compensation ensures a constant output power limit for a wide AC input voltage range ($90V_{AC}$ to $264V_{AC}$).

Under-Voltage Lockout (UVLO)

The turn-on and turn-off thresholds of the SG6858 are fixed internally at 16.5V/11.5V. During start-up, the hold-up capacitor must be charged to 16.5V through the start-up resistor to enable SG6858. The hold-up capacitor continues to supply V_{DD} until power can be delivered from the auxiliary winding of the main transformer. V_{DD} must not drop below 11.5V during this start-up process. This UVLO hysteresis window ensures that hold-up capacitor is adequate to supply V_{DD} during start-up.

V_{DD} Over-Voltage Protection

V_{DD} over-voltage protection has been built in to prevent damage due to over-voltage conditions. When the voltage V_{DD} exceeds the internal threshold due to abnormal conditions, PWM output is turned off until the V_{DD} voltage drops below the UVLO, then starts up again. Over-voltage conditions are usually caused by open-feedback loops.

Gate Output

The BiCMOS output stage is a fast totem pole gate driver. Cross conduction has been avoided to minimize heat dissipation, increase efficiency, and enhance reliability. The output driver is clamped by an internal 17V Zener diode to protect power MOSFET transistors against undesired over-voltage gate signals.

Built-in Slope Compensation

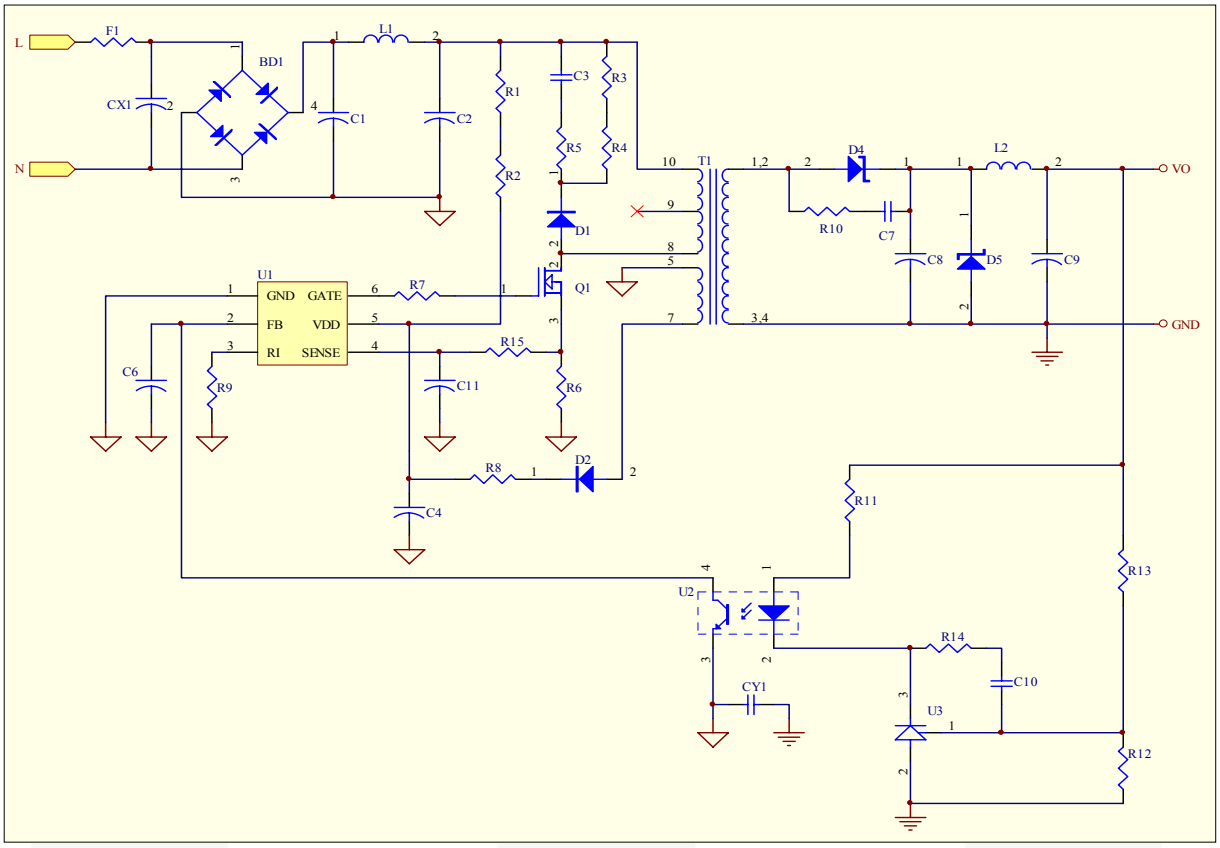
The sensed voltage across the current sense resistor is used for current-mode control and pulse-by-pulse current limiting. Built-in slope compensation improves stability and prevents sub-harmonic oscillations due to peak-current mode control. The SG6858 has a synchronized, positively-sloped ramp built-in at each switching cycle. The slope of the ramp is:

$$\frac{0.36 \times \text{Duty}}{\text{Duty(max.)}} \qquad (2)$$

Noise Immunity

Noise from the current sense or the control signal can cause significant pulse width jitter, particularly in continuous-conduction mode. While slope compensation helps alleviate these problems, further precautions should still be taken. Good placement and layout practices should be followed. Avoiding long PCB traces and component leads, locating compensation and filter components near the SG6858, and increasing the power MOS gate resistance improves performance.

REFERENCE CIRCUIT

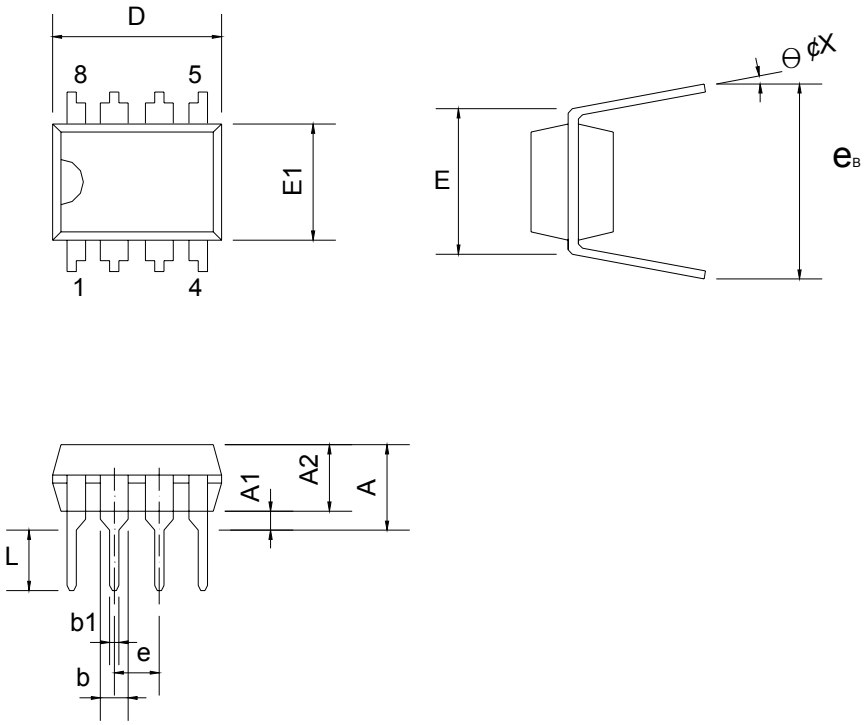


BOM

Reference	Component	Reference	Component
BD1	BD 1A/500V	L2	Inductor 10μH 6mm
CX1 (Optional)	XC 0.1μF	Q1	MOSFET 1A/600V
CY1 (Optional)	YC 1000pF/400V (Y1)	R1,R2	R 750KΩ 1206
C1	CC 10nF/500V	R4,R3	R 47KΩ 1206
C2	EC 10μF/400V 105℃	R5	R 47Ω 1206
C3	CC 1000pF/500V	R6	R 4.7Ω 1206
C4	EC 10μF/50V	R7	R 100Ω 0805
C6	CC 1000pF 0805	R8	R 10Ω 1206
C7 (Optional)	CC 1000pF/100V 1206	R9	R 100KΩ 0805
C8	EC 470μF/10V 105℃	R10 (Optional)	R 10Ω 1206
C9	EC 220μF/10V 105℃	R11	R 100Ω 1/8W
C10	CC 2200pF 0805	R12	R 33KΩ 0805
C11	N.C.	R13	R 33KΩ 1/8W
D1	Diode FRI07	R14	R 4.7KΩ 0805
D2	Diode FR102	R15	R 0Ω 0805
D4	Diode SB360	T1	Transformer EE-16
D5 (Optional)	ZD 6.8V 0.5W	U1	IC SG6858
F1	R 1Ω/0.5W	U2	IC PC817
L1	Inductor 20mH 6x8mm	U3	IC TL431

PACKAGE INFORMATION

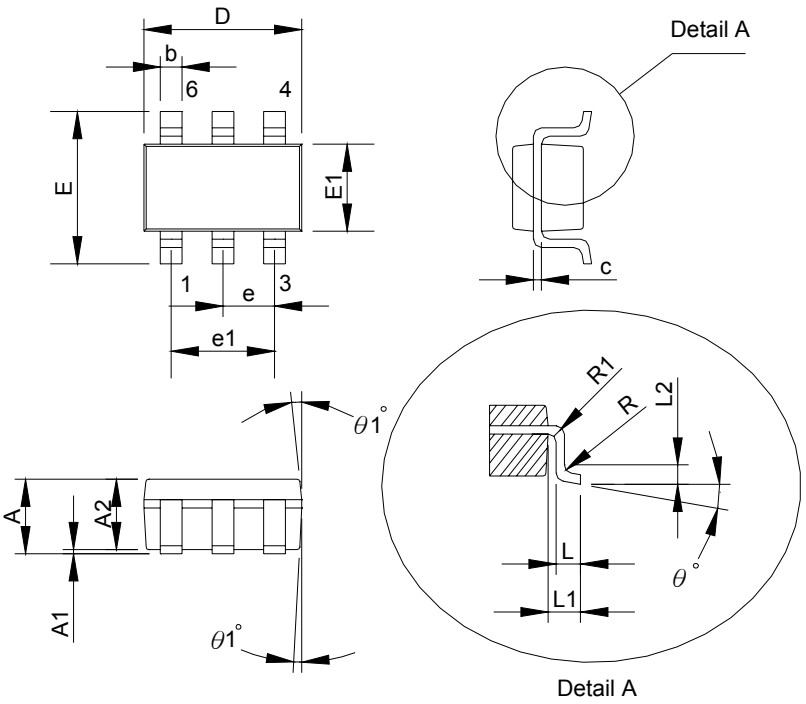
8 PINS - DIP (D)



Dimensions

Symbol	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			5.334			0.210
A1	0.381			0.015		
A2	3.175	3.302	3.429	0.125	0.130	0.135
b		1.524			0.060	
b1		0.457			0.018	
D	9.017	9.271	10.160	0.355	0.365	0.400
E		7.620			0.300	
E1	6.223	6.350	6.477	0.245	0.250	0.255
e		2.540			0.100	
L	2.921	3.302	3.810	0.115	0.130	0.150
e_B	8.509	9.017	9.525	0.335	0.355	0.375
θ°	0°	7°	15°	0°	7°	15°

6 PINS - SOT (T)



Dimensions

Symbol	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.45			0.057
A1			0.15			0.006
A2	0.90	1.15	1.30	0.036	0.045	0.051
b	0.30		0.50	0.011		0.020
c	0.08		0.22	0.003		0.009
D		2.90			0.114	
E		2.80			0.110	
E1		1.60			0.063	
e		0.95			0.037	
e1		1.90			0.075	
L	0.30	0.45	0.60	0.020	0.018	0.024
L1		0.60			0.024	
L2		0.25			0.010	
R	0.10			0.004		
R1	0.10		0.25	0.004		0.010
θ°	0°	4°	8°	0°	4°	8°
θ1°	5°	10°	15°	5°	10°	15°

FAIRCHILD SEMICONDUCTOR®

TRADEMARKS

The following are registered and unregistered trademarks and service marks Fairchild Semiconductor owns or is authorized to use and is not intended to be an exhaustive list of all such trademarks.

ACEx®
Build it Now™
CorePLUS™
CROSSVOLT™
CTL™
Current Transfer Logic™
EcoSPARK®
ƒ®
Fairchild®
Fairchild Semiconductor®
FACT Quiet Series™
FACT®
FAST®
FastvCore™
FPS™
FRFET®
Global Power Resource℠
Green FPS™
Green FPS™ e-Series™
GTO™
i-Lo™
IntelliMAX™
ISOPLANAR™
MegaBuck™
MICROCOUPLER™
MicroFET™
MicroPak™
MillerDrive™
Motion-SPM™
OPTOLOGIC®
OPTOPLANAR®
®
PDP-SPM™
Power220®
Power247®
POWEREDGE®
Power-SPM™
PowerTrench®
Programmable Active Droop™
QFET®
QS™
QT Optoelectronics™
Quiet Series™
RapidConfigure™
SMART START™
SPM®
STEALTH™
SuperFET™
SuperSOT™-3
SuperSOT™-6
SuperSOT™-8
SyncFET™
The Power Franchise®
the power franchise
TinyBoost™
TinyBuck™
TinyLogic®
TINYOPTO™
TinyPower™
TinyPWM™
TinyWire™
µSerDes™
UHC®
UniFET™
VCX™

DISCLAIMER

FAIRCHILD SEMICONDUCTOR RESERVES THE RIGHT TO MAKE CHANGES WITHOUT FURTHER NOTICE TO ANY PRODUCTS HEREIN TO IMPROVE RELIABILITY, FUNCTION, OR DESIGN. FAIRCHILD DOES NOT ASSUME ANY LIABILITY ARISING OUT OF THE APPLICATION OR USE OF ANY PRODUCT OR CIRCUIT DESCRIBED HEREIN; NEITHER DOES IT CONVEY ANY LICENSE UNDER ITS PATENT RIGHTS, NOR THE RIGHTS OF OTHERS. THESE SPECIFICATIONS DO NOT EXPAND THE TERMS OF FAIRCHILD'S WORLDWIDE TERMS AND CONDITIONS, SPECIFICALLY THE WARRANTY THEREIN, WHICH COVERS THESE PRODUCTS.

LIFE SUPPORT POLICY

FAIRCHILD'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF FAIRCHILD SEMICONDUCTOR CORPORATION.

As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body or (b) support or sustain life, and (c) whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury of the user.
2. A critical component in any component of a life support, device, or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

PRODUCT STATUS DEFINITIONS

Definition of Terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	This datasheet contains preliminary data; supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve design.
No Identification Needed	Full Production	This datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve design.
Obsolete	Not In Production	This datasheet contains specifications on a product that has been discontinued by Fairchild Semiconductor. The datasheet is printed for reference information only.

Rev. I31