Synchronous Rectifier Controller for Flyback Converter **SG6203**

FEATURES

- Low operation current (1.7mA)
- One resistor for timing setting
- Internal automatic tracking for optimum dead time
- No reverse energy flow at light load
- Best suited for primary green mode PWM IC
- Wide supply voltage range from 6V to 20V
- Built in 18V Zener diode
- Optional current sensing:
  - Current shunt
  - RC network for better efficiency

APPLICATIONS

Flyback converters, such as

Power adaptors

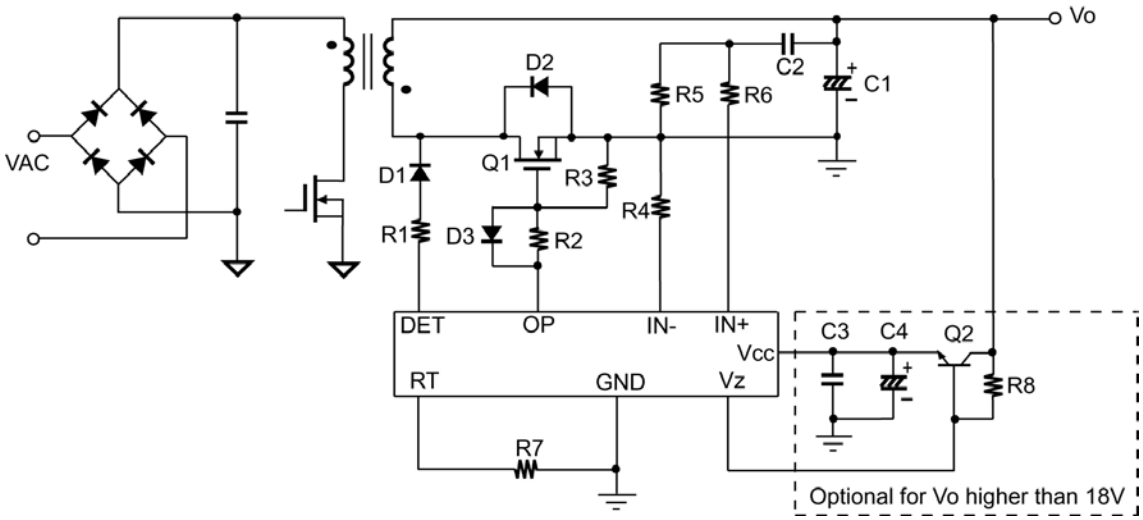
Open frame SMPS

DESCRIPTION

The SG6203 is designed to control and drive the synchronous rectifier for the flyback converter. The synchronous signal of the primary switch is obtained by a single diode connected between the transformer secondary winding and the SG6203. Using the SG6203, no additional transformer winding is required and the circuit complexity can be minimized.

No matter, the power unit is operated under discontinuous conduction mode (DCM) or continuous conduction mode (CCM), the SG6203 can operate properly. The so called “shoot through” or “cross conduction” problem in CCM and the energy reverse problem from the secondary to the primary in DCM will not happen.

TYPICAL APPLICATION



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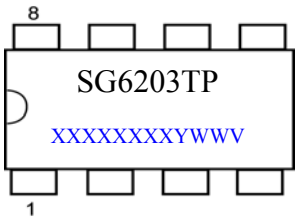
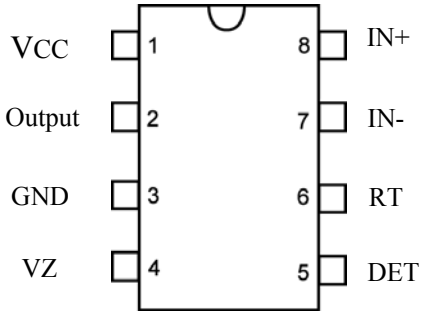
MARKING DIAGRAMS



T: D = DIP, S = SOP
P : Z =Lead Free + ROHS Compatible
XXXXXXXX: Wafer Lot
Y: Year; WW: Week
V: Assembly Location

PIN CONFIGURATION



ORDERING INFORMATION

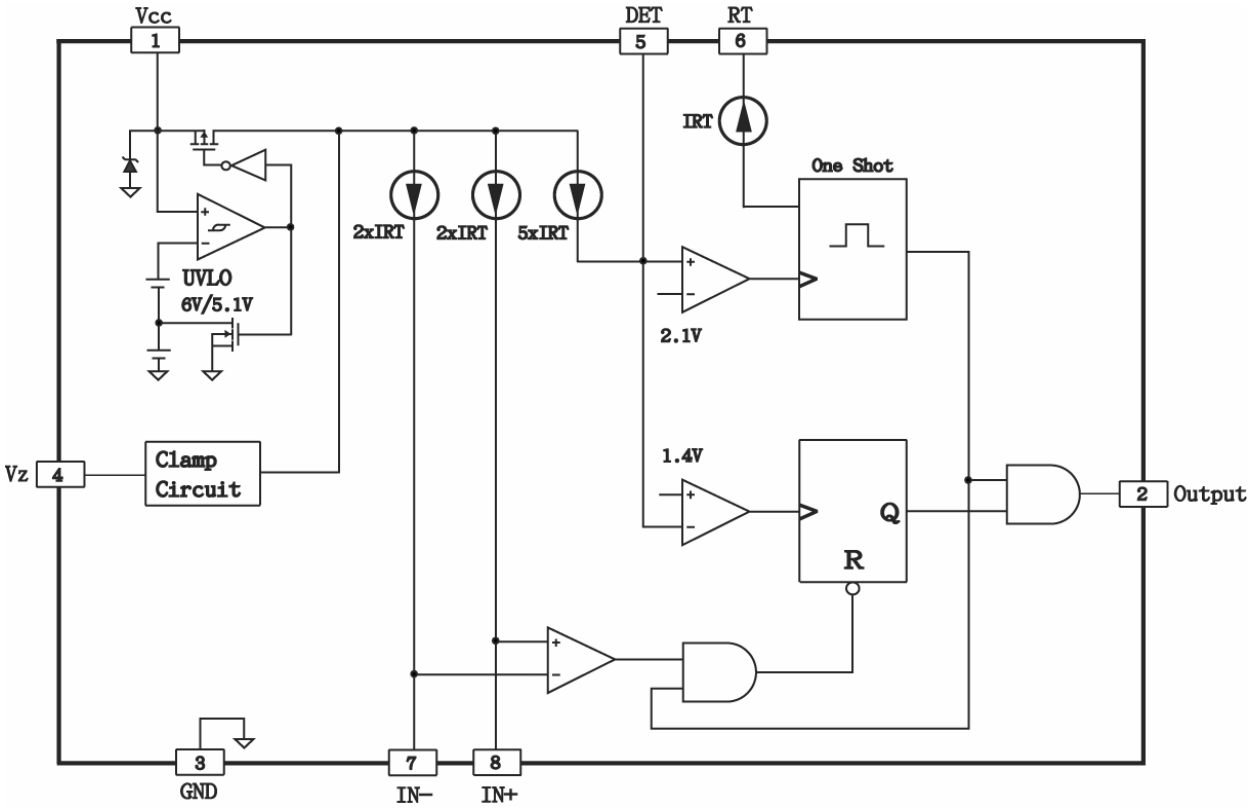
Part Number	Package
SG6203SZ	8-Pin SOP (Lead Free)
SG6203DZ	8-Pin DIP (Lead Free)

PIN DESCRIPTIONS

Pin No.	Name	Function
1	Vcc	Supply voltage of gate driver and control circuits.
2	Output	Totem-pole output to drive the synchronous power MOSFET. When the voltage on DET pin falls below 1.4V from above 2.1V, the synchronous MSOFET will be turned on. To prevent the reversed energy flow, this pin will be disabled once the voltage on IN+ pin is lower than that of IN- pin or internal one shot timer is terminated.
3	GND	The power ground and signal ground. A 0.1uF decoupling capacitor placed between Vcc and GND is recommended.
4	VZ	Built in 18V Zener diode. When the flyback output voltage is higher than 18V, this pin can be used to provide a stable 18V to Vcc pin. If the flyback output voltage is lower than 18V, this pin can be left open and connect the output voltage directly to Vcc pin.
5	DET	Connecting a diode from this pin to the transformer secondary winding, this pin can provide on/off information of the primary switch. Low DET level indicates the secondary rectifier is conducted, therefore the synchronous MOSFET should be turnd on. DET will stay high when the primary switch is conducting or secondary rectifier turns off, and the synchronous MOSFET should be turned off.
6	RT	Current reference. Connecting a resistor from this pin to ground can program the internal current reference IRT. Three internal current sources, which are IIN+, IIN- ,and Idet, are then mirrored from IRT. IRT determines the duration of internal one shot signal, and then the maximum on time of the synchronous MOSFET is obtained by subtracting the on time of the primary switch from the one shot signal duration. If the resistor is too small, the synchronous MOSFET may be turned off even when the secondary rectifier is still conducting, and hence decreases the system efficiency. However, if the resistor is too large, the Output will be shut off immediately once DET gets high. In SG6203, an internal phase locked loop will modulate the duration of the internal one shot signal to maintain a suitable dead time between the primary switch and the synchronous MOSFET.
7	IN-	The inverting input of the current sense comparator. In discontinuous conduction mode, the secondary rectifier will turn off before the next switching cycle of the primary switch. Once the secondary rectifier is off, the synchronous MOSFET must be turned off to prevent the reversed energy flow. A resistor connected between IN+ and IN- can used to develop the zero current crossing signal of the secondary rectifier. Once the voltage on IN+ is lower than IN-, the Output will be pulled low.

8	IN+	The non-inverting input of the current sense comparator. In discontinuous conduction mode, the secondary rectifier will turn off before the next switching cycle of the primary switch. Once, the secondary rectifier is off, the synchronous MOSFET must be turned off to prevent the reversed energy flow. A resistor connected between IN+ and IN- can used to develop the zero current crossing signal of the secondary rectifier. Once the voltage on IN+ is lower than IN-, the Output will be pulled low.

BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter		Value	Unit
Vcc	DC Supply Voltage*		25	V
Iout	Gate Output Current		500	mA
V_H	DET, OUT, VZ		-0.3 to 25	V
V_L	RT, IN+, IN-		-0.3 to 7	V
P_D	Power Dissipation	SOP8 DIP8	400 800	mW
$R_{\theta JA}$	Thermal Resistance (Junction to Air)	SOP8 DIP8	208.4 82.5	°C/W
T_J	Operating Junction Temperature		150	°C
T_{STG}	Storage Temperature Range		-65 to +150	°C
T_L	Lead Temperature (Soldering)	10 sec	300	°C
	ESD Capability, Human Body Model		2.0	KV
	ESD 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
Vcc	DC Supply Voltage	<20	V
T_A	Operating Ambient Temperature	-30~85	°C
RT	Pulse width of the one-shot signal	12~36	KΩ

ELECTRICAL CHARACTERISTICS V_{CC} = 12V; RT = 24KΩ ; T_A = 25°C, unless noted

Timing Control Section

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
V_{RT}	Voltage on RT pin		1.14	1.2	1.26	V
T_{RT}	Pulse width of the one-shot signal	RT=12KΩ	6.5	7.5	8.5	uS
		RT=24KΩ	13	15	17	uS
		RT=36KΩ	19.5	22.5	25.5	uS
$\triangle T_{RT}$	Adjustable range of the pulse width compared to T_{RT}	RT=12KΩ; RT=24KΩ; RT=36KΩ	+40	+60	+80	%
T_{DEAD}	Timing margin between turn off of output (Output falling) and start of the next switching cycle (DET rising)		200		1000	nS

Synchronous Detection Section

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
V_{TH}	Threshold voltage to enable an one shot signal		1.9	2.1	2.3	V
V_{TL}	Threshold voltage to enable the output	IN+ - IN- > 5mV	1.2	1.4	1.6	V
I_{DET}	Current output from DET pin	RT=24KΩ		250	300	uA
T_{D_LOW}	Debounce time from DET low to enable the output		150		300	nS

Current Detection Section

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
V_{OFFSET}	Offset voltage				10	mV
I_{IN+}	Current output from IN+	RT=24KΩ	90	100	110	uA
I_{IN-}	Current output from IN-	RT=24KΩ	90	100	110	uA
I_{IN+} - I_{IN-}	Differential current of IN+ and IN-	12KΩ < RT < 36KΩ			1.5	uA
T_P	Propagation delay (OUTPUT from Low to High)	DET< V_{TL}, IN+ - IN- > 5mV			200	nS
PSRR	Power Supply Rejection Ratio			65		dB
CMRR	Common mode Rejection Ration			65		dB
CMRR-f	Common mode Rejection Ration @ 70KHz			32		dB

Zener Section

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
V_Z	Zener voltage	I_{VZ} = 0.1 ~ 3mA	18	19	20	V

Output Section

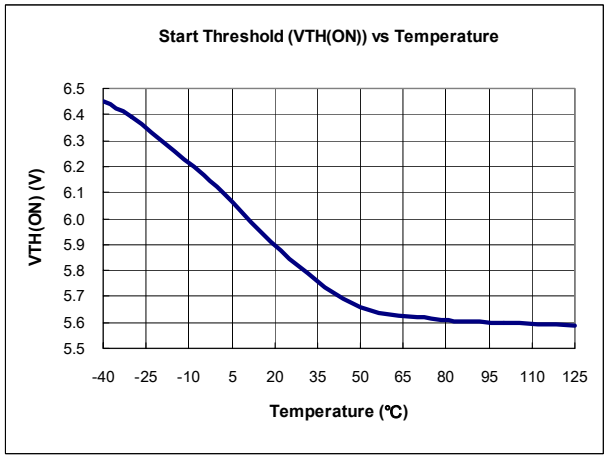
Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
V_{OH}	Output Voltage High	Vcc=12V, I_{source}=50mA	11.2			V
		Vcc=6V, I_{source}=30mA	3.5			V
V_{OL}	Output Voltage Low	Vcc=12V, I_{sink}=50mA			1	V
		Vcc=6V, I_{sink}=30mA			1.2	V
Tr	Rising Time	T_a=25°C; C_L=5nF, Vcc=12V		150	175	nS
Tf	Falling Time	T_a=25°C; C_L=5nF, Vcc=12V		150	175	nS

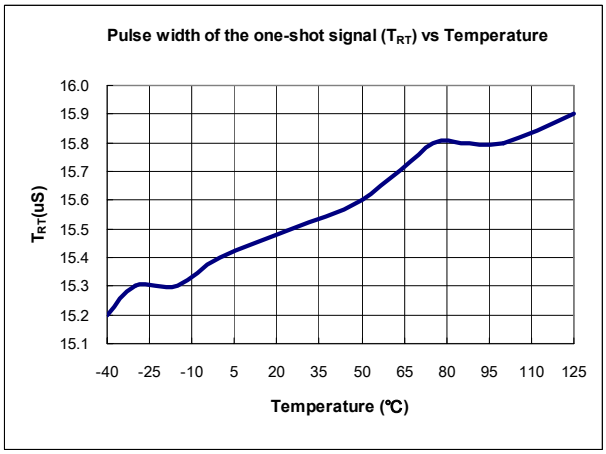
Vcc Section

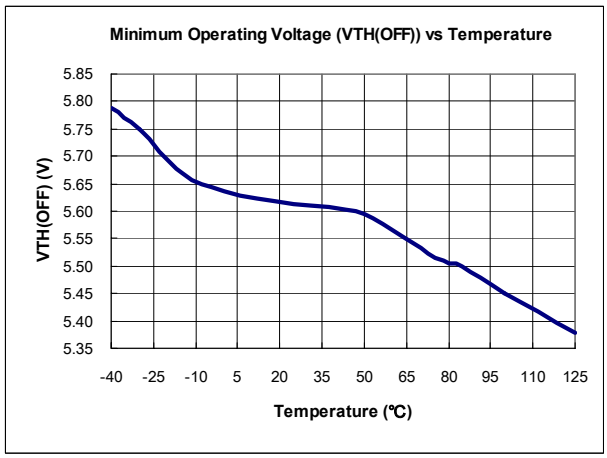
Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
V_{OP}	Continuously Operating Voltage				20	V

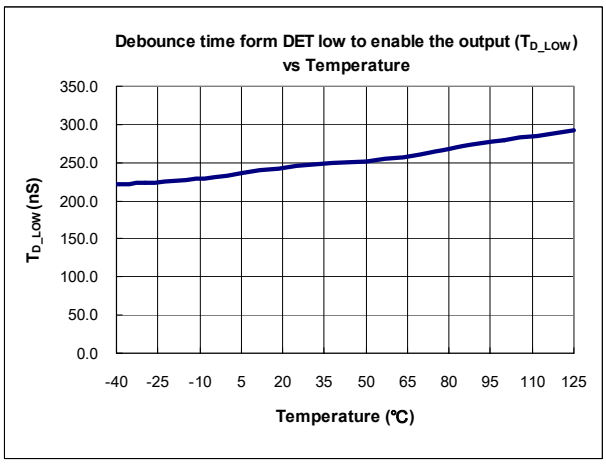
Icc_op	Operating Current	VDD=12V, Output = open, DET=50KHz, IN- = IN+ = open, RT=12KΩ		1.7	4	mA
$V_{TH(ON)}$	Start Threshold			6	6.3	V
$V_{TH(OFF)}$	Minimum Operating Voltage		4.8	5.1		V

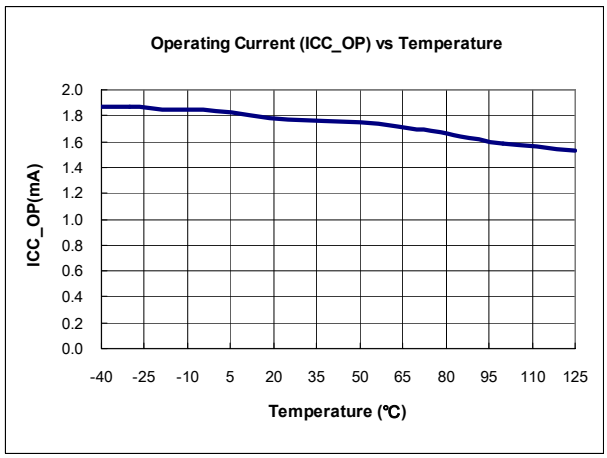
TYPICAL CHARACTERISTIC

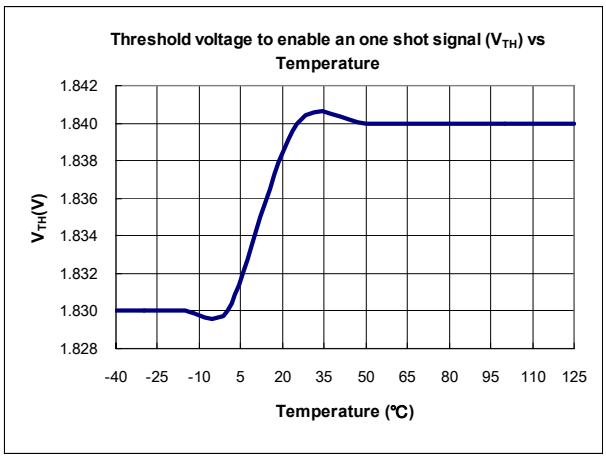


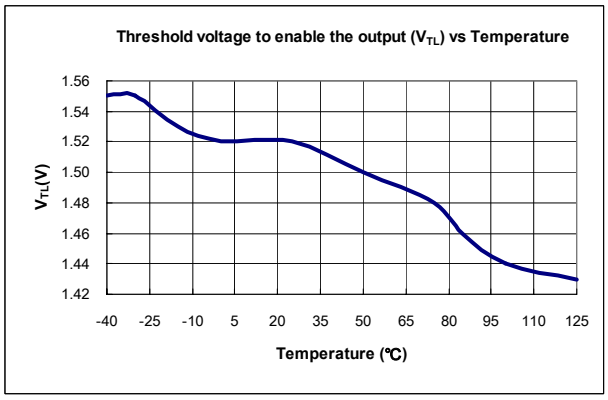











Threshold voltage to enable the output (V_{TL}) vs Temperature
1.56
1.54
1.52
1.50
1.48
1.46
1.44
1.42
V_{TL}(V)
-40
-25
-10
5
20
35
50
65
80
95
110
125
Temperature (℃)

OPERATION DESCRIPTION

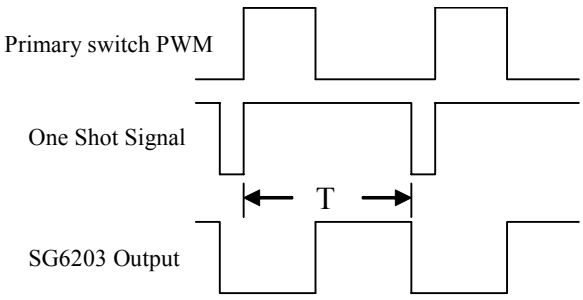
Synchronization

The DET pin provides on/off information of the primary switch. As shown in the following reference circuits, one diode connected between DET pin and the secondary winding of the transformer is used to get this information. Low DET voltage level indicates the secondary rectifier is conducted, therefore the synchronous MOSFET should be turned on. The voltage on DET pin will stay high when the primary switch is conducting, and the synchronous MOSFET should be turned off. This innovative feature of the SG6203 requires no auxiliary winding and hence circuit complexity is greatly reduced.

Anticipation and Phase lock loop

A resistor from RT pin to ground is used to determine the internal current source reference. When primary switch is turned on with DET high, an internal one shot timer will output high for a duration which is proportional to the RT resistor. The duration of this one shot signal can be expressed as

$$T_{RT} = \frac{15 \times RT(K\Omega)}{24}(u\,\mathrm{sec})$$



The on time of the synchronous MOSFET is then obtained by subtracting the on time of the primary switch from the one shot signal duration. If the resistor is too small, the synchronous MOSFET may be turned off even when the secondary rectifier is still conducting, and hence decreases the system efficiency. However, if the resistor is too large, the Output will be shut off immediately once DET gets high. In SG6203, an internal phase locked loop will modulate the duration of the internal one shot signal to maintain a suitable dead time between the primary switch and the synchronous MOSFET. The duration of the one shot signal can be extended 80% compared with the original value decided by RT resistor.

Current Sense

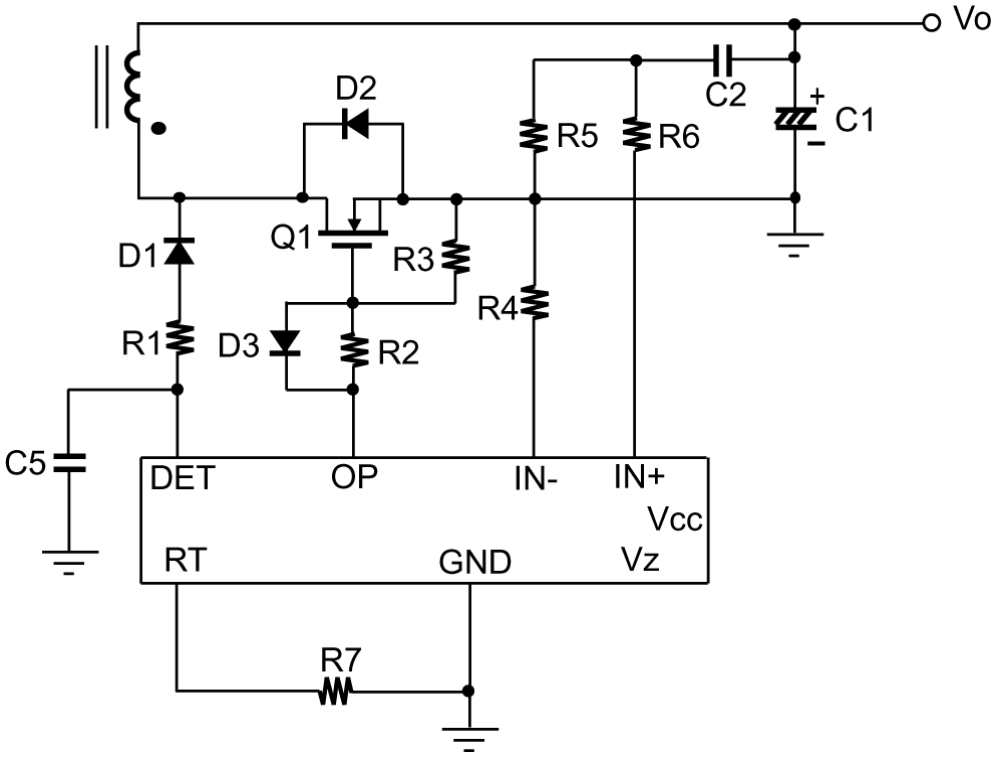
In discontinuous conduction mode, the secondary rectifier will turn off before the next switching cycle of the primary switch. Once the secondary rectifier is off, the synchronous MOSFET must be turned off to prevent the reversed energy flow. Therefore, a zero current crossing detector is needed when the converter is operated under DCM. The SG6203 provides two different configurations to achieve this: output capacitor ESR method (Reference Circuit-A) and current sensing resistor method (Reference Circuit-B). When the secondary rectifier is turned off, the voltage on the IN+ will be lower than that of IN-. Once this happens, the driving signal for the synchronous MOSFET will be turned off.

Under-Voltage Lockout (UVLO)

The SG6203 has an internal UVLO circuit with hysteresis. The IC will be turned on for Vcc higher than 6V. Once turned on, SG6203 will be turned off for Vcc lower than 5.1V. When the flyback output voltage is higher than 18V, this Vz pin can be used to provide a stable 18V to Vcc pin.

REFERENCE CIRCUIT-A

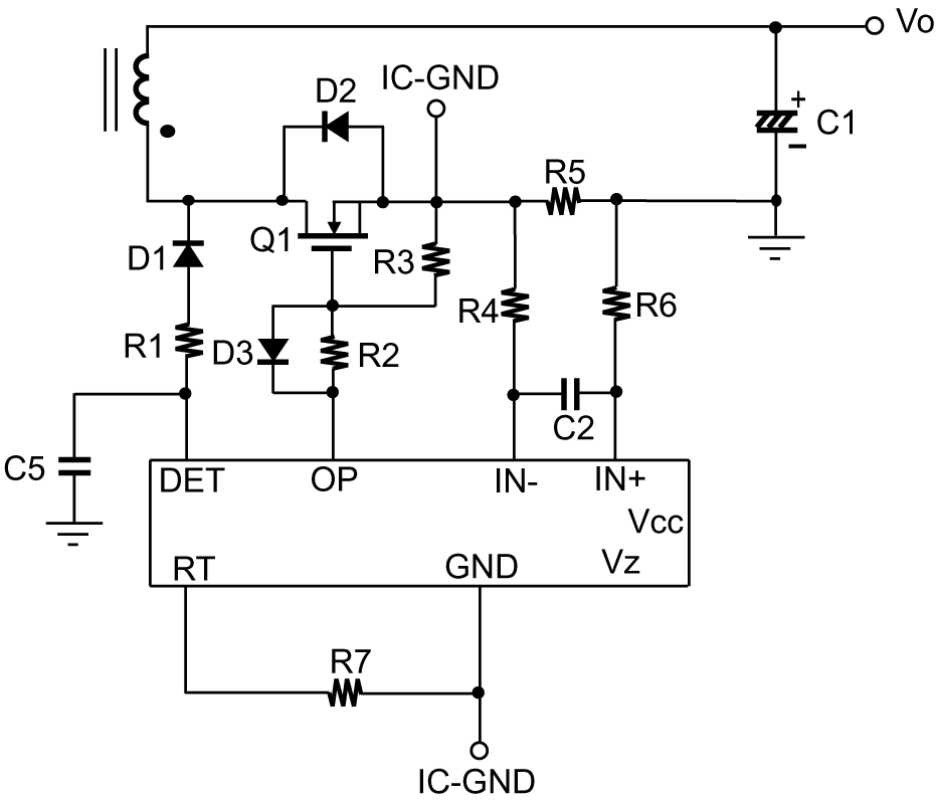
Circuit



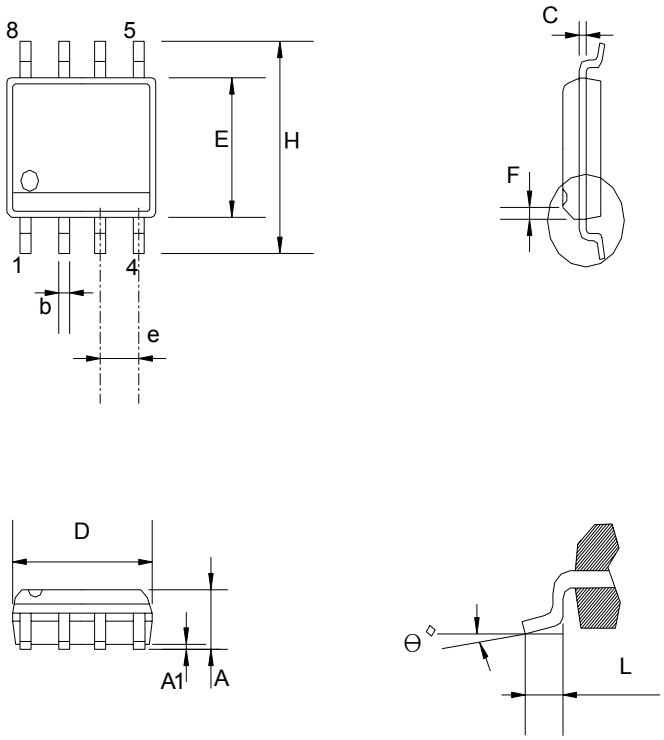
BOM

Ref Des	Part Number	Description
C2		0.1 uF
C5		22 pF
D1	FR102	100V/1A
D2	SB1100	100V/1A
D3	1N4148	100V/0.2A
Q1	PSMN015-110P	110V/75A; 15 mohm
R1		2.2 Kohm
R2		22 ohm
R3		47 Kohm
R4		1.8 Kohm
R5		2 Kohm
R6		0
R7		16.2 Kohm

REFERENCE CIRCUIT-B



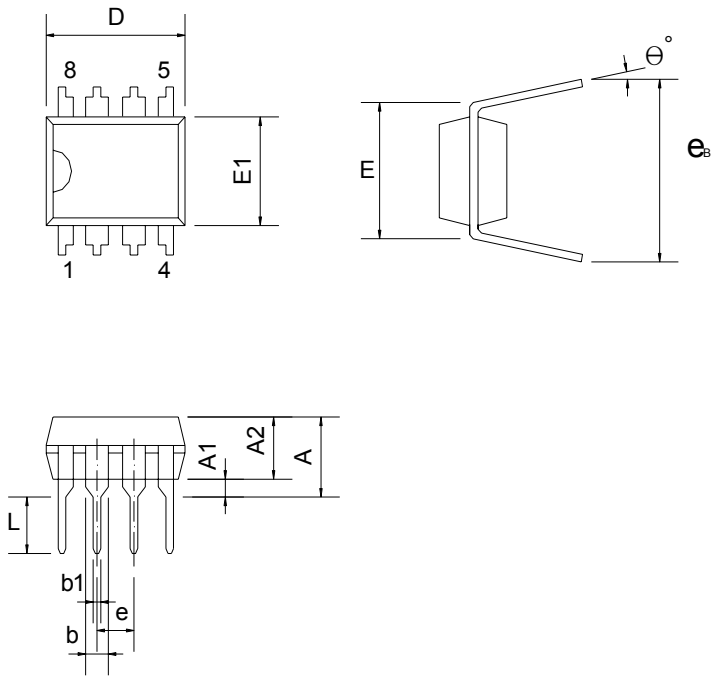
PACKAGE INFORMATION
8 PINS-SOP(S)



Dimensions

Symbol	Millimeter			Inch		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	1.346		1.752	0.053		0.069
A1	0.101		0.254	0.004		0.010
b		0.406			0.016	
c		0.203			0.008	
D	4.648		4.978	0.183		0.196
E	3.810		3.987	0.150		0.157
e	1.016	1.270	1.524	0.040	0.050	0.060
F		0.381X45°			0.015X45°	
H	5.791		6.197	0.228		0.244
L	0.406		1.270	0.016		0.050
θ°	0°		8°	0°		8°

8PINS–DIP(D)



Dimension

Symbol	Millimeter			Inch		
	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°

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