FS6898

Adaptive Multi-Mode PWM Controller

GENERAL DESCRIPTION

The FS6898 is a high performance flyback adaptive multi-mode(CCM/QR) PWM controller, optimized to achieve high efficiency and low standby power with effective system cost.

At heavy load, the IC operates in fixed frequency (250kHz) CCM mode in the low line input voltage. At medium load, it operates in QR mode. At light load, it operates in green mode with valley skip, and no load the IC operates in extended 'burst mode' to minimize switching loss. Lower standby power and higher conversion efficiency is thus achieved.

VCC low startup current and low operating current contribute to a reliable power on startup and low standby design with FS6898 .

FS6898 coverage with auto-recovery including Cycle-by-Cycle current limiting (OCP), over load protection (OLP), and VCC under voltage lockout (UVLO). It also provides the protections with latched shut down including over temperature protection (OTP), and over voltage protection (OVP). Excellent EMI performance is achieved with our proprietary frequency shuffling technique.

The tone energy at below TBD KHz is minimized in the design and audio noise is eliminated during operation.

FS6898 is offered in SOT23-6 package.

APPLICATIONS

- Offline AC/DC flyback converter for
  - Power Adapter
  - Set-Top Box Power Supplier
  - Open-frame SMPS

FEATURES

- Power on soft start reducing MOSFET Vds stress
- Multi-Mode Operation
- CCM @ Heavy Load and Low Line
  - Quasi-Resonant operation @ Medium Load
  - Green mode with valley skip @ Light Load
  - Burst Mode @ No Load
- Frequency shuffling for EMI
- Extended burst mode control for improved efficiency and low standby power design
- Audio noise free operation
- Comprehensive protection coverage
  - VCC Under Voltage Lockout with hysteresis (UVLO)
  - VCC Over Voltage Protection (VCC OVP)
  - Cycle-by-cycle over current threshold setting for constant output power limiting over universal input voltage range
  - Over Load Protection (OLP) with auto-recovery
  - Output Over Voltage Protection (Output OVP) with latched shut down, and the OVP triggered voltage can be adjusted by the resistor connected between auxiliary winding and RT pin
  - Output diode short protection with auto-recovery

TYPICAL APPLICATION CIRCUIT

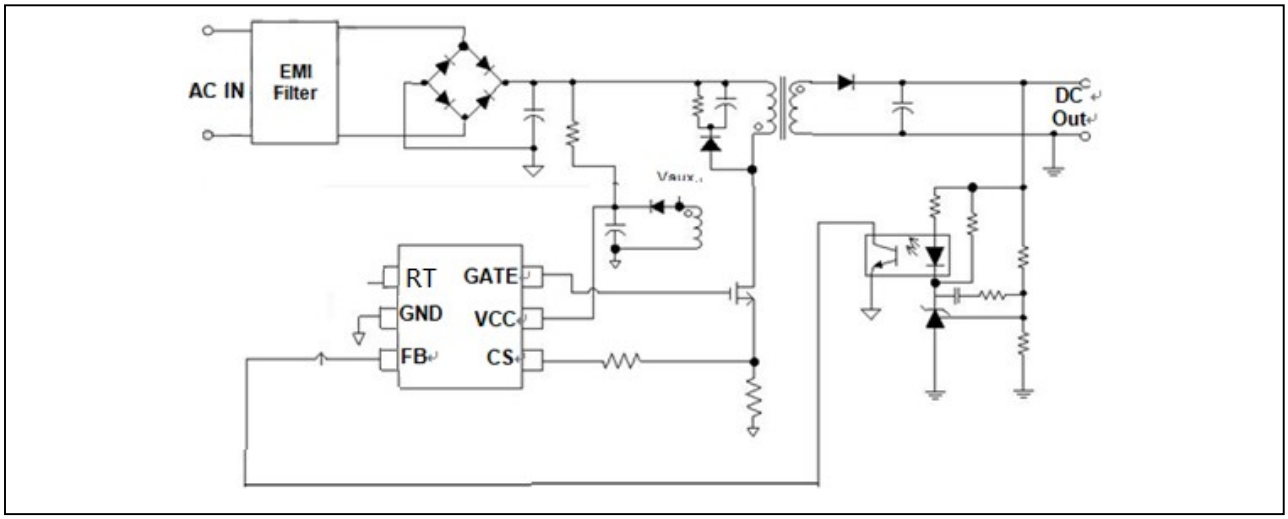
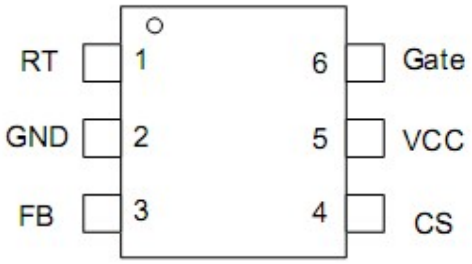


Figure 1 Typical Application Circuit

PIN CONFIGURATION

Package	Pin Configuration (Top View)
SOT23-6	

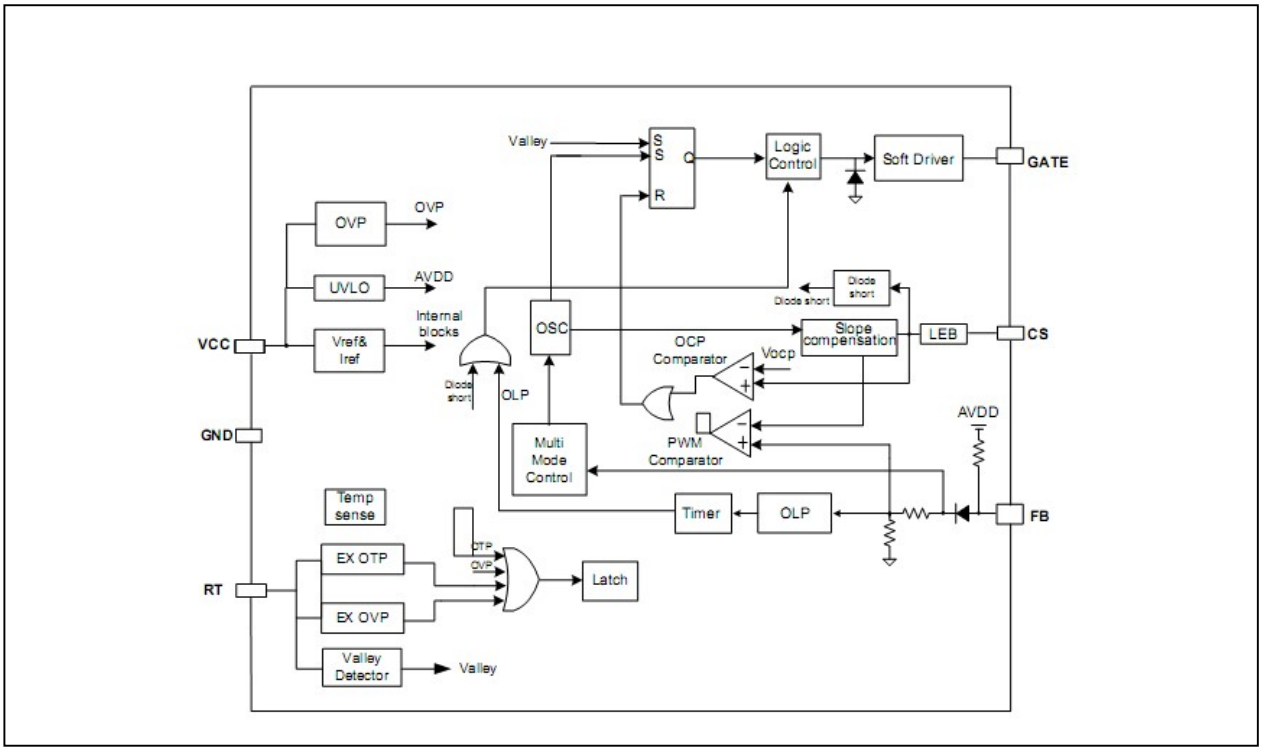
PIN DESCRIPTION

No.	Pin	Description
1	RT	Detect transformer core demagnetization. Keep floating.
2	GND	Ground.
3	FB	Feedback input pin. The PWM duty cycle is determined by voltage level into this pin and the current-sense signal at Pin CS.
4	CS	Current sense input.
5	VCC	Power supply.
6	Gate	Totem-pole gate driver output for power MOSFET.

ORDERING INFORMATION
Industrial Range: -40°C to +125°C

Order Part No.	Package	QTY
FS6898 BCA-G-7TR	SOT23-6, Pb-Free	3000/Reel

FUNCTIONAL BLOCK DIAGRAM (TBD)



ABSOLUTE MAXIMUM RATINGS

V_{CC} Voltage		-0.3V ~ V_{OVP}-1V
FB Input Voltage		-0.3V ~ 7V
CS Input Voltage		-0.3V ~ 7V
Gate Voltage		-0.3V ~ 7V
RT Input Voltage		-0.3V ~ 7V
Operating temperature range, T_A		-40°C~+125°C
Storage temperature range, T_{STG}		-65°~+150°C
Package Thermal Resistance	Junction to Ambient, R_{th-JA}	150 °C/w (SOT23-6)
	Junction to Case, R_{th-JC}	30 °C/w (SOT23-6)
ESD (HBM)		2000 V
ESD (CDM)		200 V

Note:
Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other condition beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS (TBD)

Test condition is T_A = −40°C ~ +125°C. Typical values are at T_A = 25°C, V_{CC} = 18V, unless otherwise specified.

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
Supply Voltage (V_{CC}) Section						
V_{CC}	Input voltage operation range		12.0		26	V
$I_{SART-UP}$	Start-up current	V_{CC} = $UVLO_{OFF}$-1V		2		uA
I_{STATIC}	Static current	V_{CC}=18V,CS=4V, FB=3.5V		2.5		mA
I_{BURST}	Burst current	CS=0V,FB=0.5V		0.6		mA
$UVLO_{OFF}$	Under voltage lockout exit		19	21	23	V
$UVLO_{ON}$	Under voltage lockout enter		6	7	8	V
V_{CC_OVP}	V_{CC} over voltage protection		26	27	28	V
$V_{PULL-UP}$	Pull-up PMOS active			10		V
$V_{LATCH\_RELEASE}$	Latch release voltage			5		V
Current Sense Input Section (CS Pin)						
SS t_{CS}	Soft start time for CS peak			4		ms
t_{BLK}	Leading edge blanking time			300		ns
V_{th_OCP}	Internal current limiting threshold voltage with zero duty cycle		430	450	470	mV
$V_{th\_OCP\_CLAMP}$	OCP CS voltage clamper			720		mV
t_{D_OCP}	OCP propagation delay			90		ns
FB Input Section (FB Pin)						
V_{FB} Open	V_{FB} open loop voltage			5.1		V
A_{VCS}	PWM input gain ΔVFB/ΔVCS			3.5		V/V
Maximum Duty Cycle	Max duty cycle @ V_{CC}=18V, V_{FB}=3V, V_{CS}=0V		75	78	81	%
I_{FB_SHORT}	FB pin short circuit current			0.3		mA
V_{th_OLP}	Open loop protection, FB threshold voltage			4.4		V
T_{d_OLP}	Open loop protection, debounce time			60		ms
Z_{FB_IN}	Input Impedance			16		KΩ
Oscillator						
F_{OSC}	Normal oscillation frequency	V_{CC}=18V, CS=0V, FB=3V		TBD		KHz
$\Delta f_{\_OSC}$	Frequency jittering			+/-6		%
$F_{\_shuffling}$	Shuffling frequency			TBD		Hz
$\Delta f_{\_Temp}$	Frequency temperature stability			1		%
$\Delta f_{\_VCC}$	Frequency voltage stability			1		%
$F_{\_burst}$	Burst mode switching frequency			TBD		KHz
On Chip Over Temperature Section						
T_{SD}	Thermal shutdown temperature			150		°C

T_{SD_HYS}	Thermal shutdown hysteresis			30		°C
Gate Driver						
V_{OL}	Output low level	V_{CC}=18V, I_O=5mA			1	V
V_{OH}	Output high level	V_{CC}=18V, I_O=20mA	6			V
$V_{\_clamping}$	Output clamp voltage			12		V
t_R	Output rising time	1.2V to 10.8V, @CL=1000pF		100		ns
t_F	Output falling time	10.8V to 1.2V, @CL=1000pF		100		ns

CHARACTERIZATION PLOTS

TBD

OPERATION DISCRIPTION

FS6898 is a highly integrated current mode PWM control IC optimized for high performance, low standby power and cost effective offline flyback converter applications. The 'extended burst mode' control greatly reduces the standby power consumption and helps the design easier to meet the international power conservation requirements.

Start-up current and start-up control

Start-up current of FS6898 is designed to be very low so that VDD can be charged up quickly. A large value startup resistor can therefore be used to minimize the power loss in application.

Operating Current

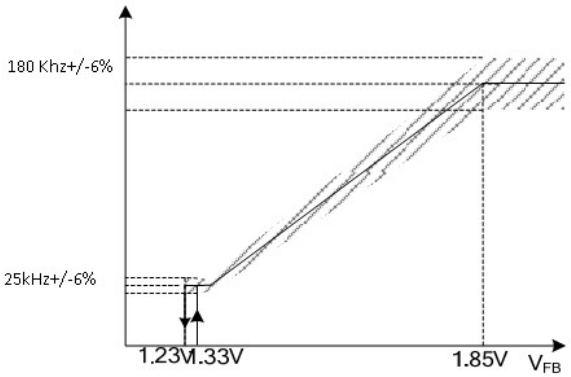
The operating current of FS6898 is as low as 2.5mA (typical). Good efficiency and low standby power is achieved with the 'extended burst mode' control features.

Soft Start

FS6898 features an internal 2ms (typical) soft start to soften the electrical stress occurring in the power supply during startup. It is activated during the power on sequence. As soon as VCC reaches UVLO(OFF), the CS peak voltage is gradually increased from 0.05V to the maximum level. Every restart up is followed by a soft start.

Frequency Shuffling for EMI Improvement

The frequency shuffling (switching frequency modulation) is implemented in FS6898 . The oscillation frequency is modulated so that the tone energy is spread out. The spread spectrum minimizes the conduction band EMI and therefore eases the system design.



Multi Mode Operation for High Efficiency

FS6898 is a multi-mode QR/CCM controller. The controller changes the mode of operation according to the FB pin voltage. At the normal operating condition, the IC operates in traditional PWM mode.
As the output load current is decreased, the IC enter into green mode smoothly from the PWM mode. In this mode , the switching frequency will start to linearly decrease from 65KHz to 25KHz, meanwhile the valley turn on can be realized by monitoring the voltage activity on auxiliary windings through the RT pin. So the switching loss is minimized and the high conversion efficiency can be achieved.
At light load or no load condition, most of the power dissipation in a switching mode power supply is from switching loss of the MOSFET, the core loss of the transformer and the loss of the snubber circuit. The magnitude of power loss is in proportion to the switching frequency. Lower switching frequency leads to the reduction on the power loss and thus conserves the energy.
The switching frequency is internally adjusted at no load or light load condition. The switch frequency reduces at light/no load condition to improve the conversion efficiency. At light load or no load condition, the FB input drops below Vref_burst_L (the threshold enter burst mode) and device enters Burst Mode control. The Gate drive output switches when FB input rises back to Vref_burst_H (the threshold exit burst mode). Otherwise the gate drive remains at off state to minimize the switching loss and reduces the standby power consumption to the greatest extend.

Current Sensing and Leading-Edge Blanking

Cycle-by-Cycle current limiting is offered in FS6898 current mode PWM control. The switch current is detected by a sense resistor into the CS pin. An internal leading edge blanking circuit chops off the sensed voltage spike at initial internal power MOSFET on state due to snubber diode reverse recovery and surge gate current of power MOSFET. The current limiting comparator is disabled and cannot turn off the internal power MOSFET during the blanking period. The PWM duty cycle is determined by the current sense input voltage and the FB input voltage.

Internal Synchronized Slope Compensation

Built-in slope compensation circuit adds voltage ramp into the current sense input voltage for PWM generation. This greatly improves the close loop stability at CCM and prevents the sub-harmonic oscillation and thus reduces the output ripple voltage.

Driver

The power MOSFET is driven by a dedicated gate driver for power switch control. Too weak the gate driver strength results in higher conduction and switch loss of MOSFET while too strong gate driver strength results the compromise of EMI.
A good tradeoff is achieved through the built-in totem pole gate design with right output strength and dead time control. The low idle loss and good EMI system design is easier to achieve with this dedicated control scheme.

Protection Controls

Good power supply system reliability is achieved with auto-recovery protection features including Cycle-by-Cycle current limiting (OCP), and Under Voltage Lockout on VDD (UVLO), and latched shutdown features including Over Temperature Protection (OTP), V_{CC} and output Over Voltage Protection (OVP).
With our proprietary technology, the OCP is line voltage compensated to achieve constant output power limit over the universal input voltage range.
At overload condition when FB input voltage exceeds power limit threshold value for more than Td_OLP, control

circuit reacts to shut down the converter. It restarts when VDD voltage drops below UVLO limit. For protection with latched shut down mode, control circuit shuts down (latch) the power MOSFET when an over temperature condition or over voltage condition is detected until V_{CC} drops below 5V (typical) (Latch release voltage), and the device enters power on restart-up sequence thereafter.

CLASSIFICATION REFLOW PROFILES

Profile Feature	Pb-Free Assembly
Preheat & Soak Temperature min (Tsmin) Temperature max (Tsmax) Time (Tsmin to Tsmax) (ts)	150°C 200°C 60-120 seconds
Average ramp-up rate (Tsmax to Tp)	3°C/second max.
Liquidous temperature (TL) Time at liquidous (tL)	217°C 60-150 seconds
Peak package body temperature (Tp)*	Max 260°C
Time (tp)** within 5°C of the specified classification temperature (Tc)	Max 30 seconds
Average ramp-down rate (Tp to Tsmax)	6°C/second max.
Time 25°C to peak temperature	8 minutes max.

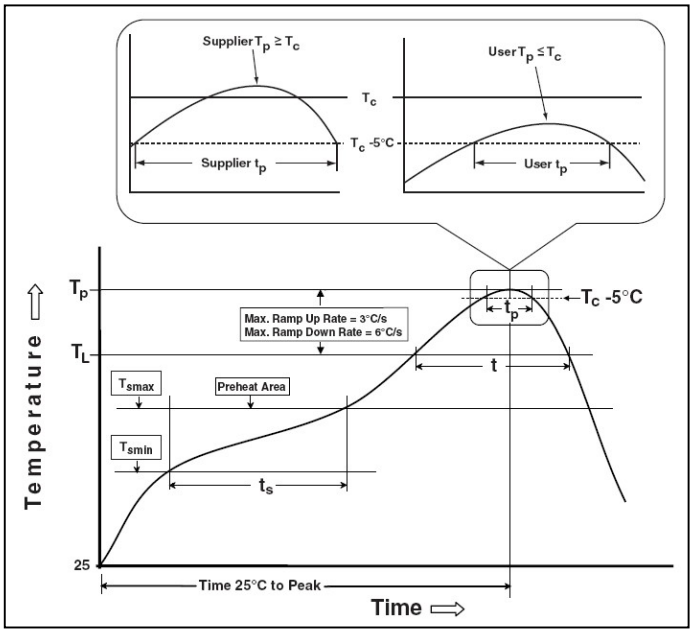


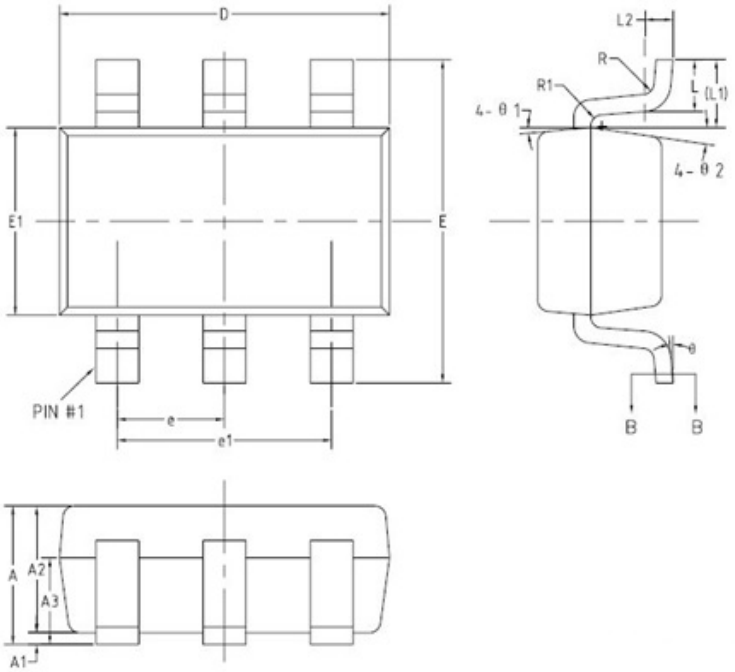
Figure 2 Classification Profile

PACKAGE INFORMATION

SOT23-6

COMMON DIMENSIONS
(UNITS OF MEASURE=MILLIMETER)

SYMBOL	MIN	NOM	MAX
A	–	–	1.30
A1	0	–	0.15
A2	0.90	1.10	1.30
A3	0.60	0.65	0.70
b	0.39	–	0.49
b1	0.38	0.40	0.45
c	0.12	–	0.19
c1	0.11	0.13	0.15
D	2.85	2.95	3.05
E	2.60	2.80	3.00
E1	1.55	1.65	1.75
e	0.85	0.95	1.05
e1	1.80	1.90	2.00
L	0.35	0.45	0.60
L1	0.59REF		
L2	0.25BSC		
R	0.05	–	–
R1	0.05	–	0.20
θ	0°	–	8°
θ 1	8°	10°	12°
θ 2	8°	10°	12°



Note: All dimensions in millimeters unless otherwise stated.