NC-Cap/PSR-II™ (Primary Side Regulation) CV/CC Power Switch

FEATURES

- **Built-in 700V Power BJT**
- **Proprietary NC-Cap/PSR-II™ Control:**
  - **±4% CC and CV Precision**
  - **Proprietary "Audio Noise Cancellation" Control**
  - **Built-in "Fast Dynamic Response" Control to Meet USB Charge Requirements**
  - **Proprietary "Zero-Output Startup" Control**
  - **Proprietary "Smart Output Short Protection"**
  - **without External Compensation/Filtering Capacitor Needed**
  - **Max. 50V Output for AC/DC LED Lighting**
- **Direct Drive of Low Cost BJT**
- **Proprietary Cable Drop Compensation**
- **Multi Mode Control**
- **Wide VDD Operating Range**
- **11.7V UVLO Hysteresis Window**
- **Cycle-by-Cycle Current Limiting**
- **Leading Edge Blanking (LEB)**
- **Built-in Soft Start, Pin Floating Protection**
- **VDD UVLO, OVP & Clamp**

APPLICATIONS

- **Battery chargers**
- **Replaces linear transformer and RCC SMPS**
- **Small power adapter**
- **AC/DC LED lighting**

GENERAL DESCRIPTION

SF6022 is a high precision, highly integrated DCM (Discontinuous Conduction Mode) Primary Side Regulation (PSR) power switch for offline small power converter applications. It has built-in power BJT, which can further lower system cost.

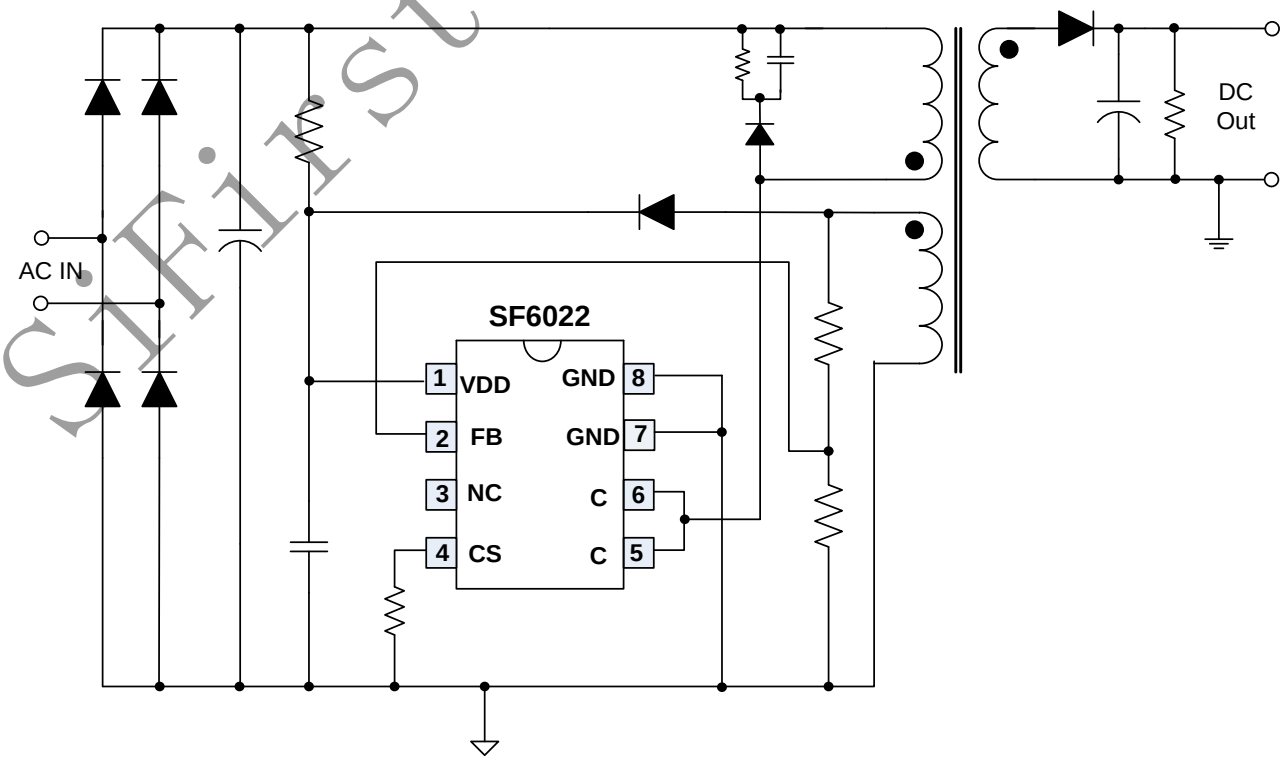
SF6022 has built-in proprietary **NC-Cap/PSR-II™** control for CV control, which eliminates external compensation or filtering capacitor. It has built-in cable drop compensation function, which can provide excellent CV performance. The IC uses Multi Mode Control to improve efficiency and reliability and to decrease audio noise energy @ light loadings.

SF6022 integrates proprietary "**Audio Noise Cancellation**" control for audio noise free operation. The IC has built-in "**Fast Dynamic Response**" control to meet USB Charge requirements. SF6022 also integrates proprietary "**Zero-Output Startup**" control to achieve startup when output is near zero voltage. The IC has proprietary "**Smart Output Short Protection**", which can protect the system with large leakage inductance when output is short circuit.

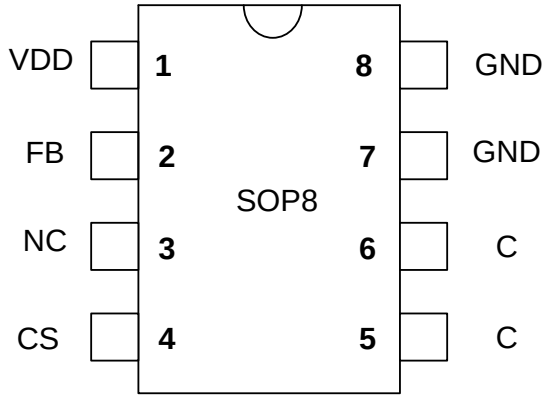
SF6022 integrates functions and protections of FB Short Protection, Under Voltage Lockout (UVLO), VDD Over Voltage Protection (VDD OVP), Soft Start, Cycle-by-cycle Current Limiting (OCP), Pin Floating Protection, VDD Clamping.

SF6022 is available SOP8 packages.

TYPICAL APPLICATION



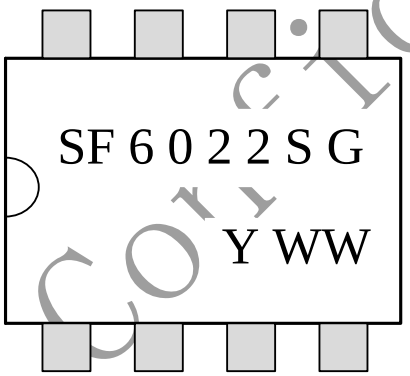
Pin Configuration



Ordering Information

Part Number	Top Mark	Package		Tape & Reel
SF6022SG	SF6022SG	SOP8	Green	
SF6022SGT	SF6022SG	SOP8	Green	Yes

Marking Information

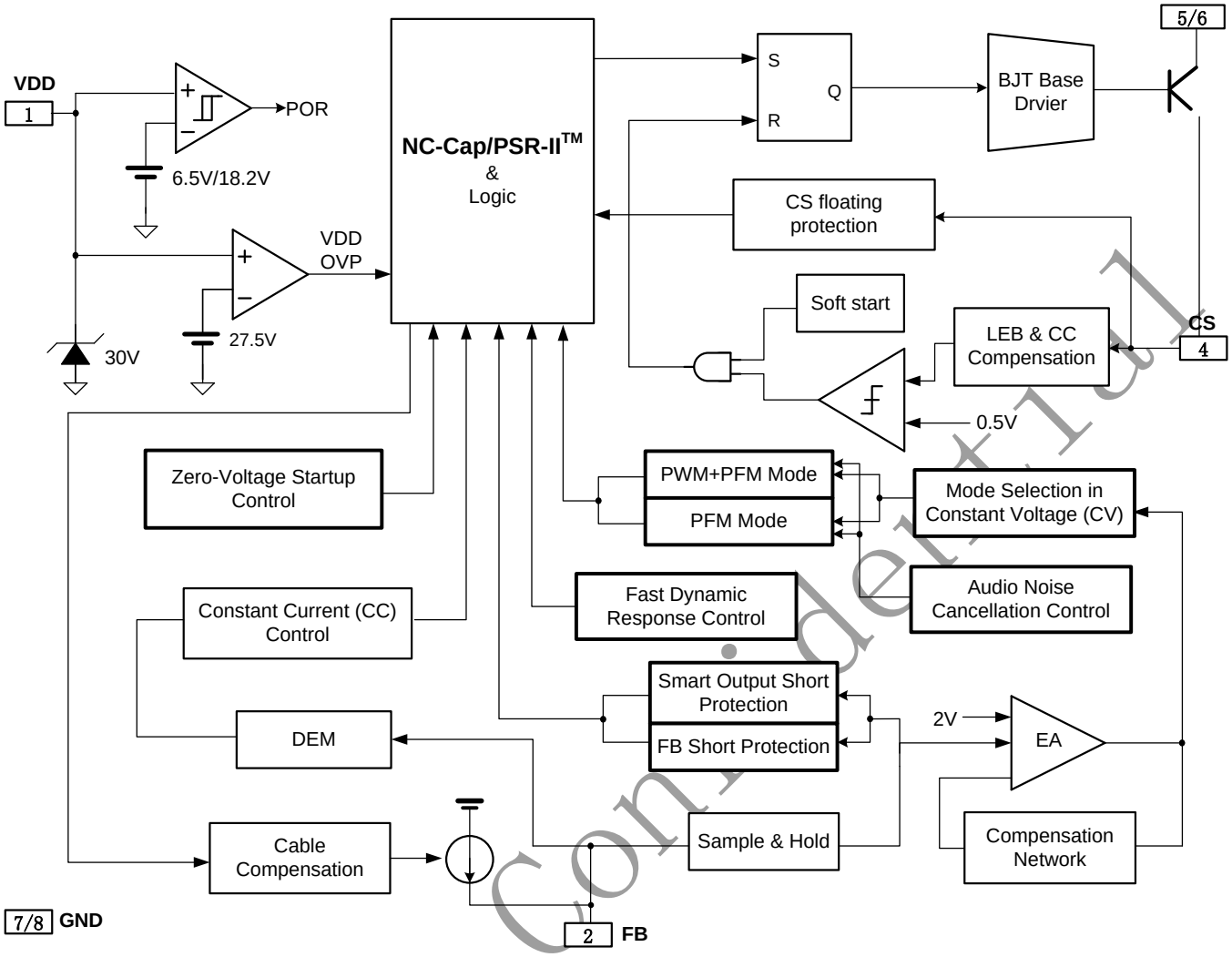


YWW: Year&Week code

Pin Description

Pin Num	Pin Name	I/O	Description
1	VDD	P	IC power supply pin.
2	FB	I	System feedback pin. This control input regulates both the output voltage in CV mode and output current in CC mode based on the flyback voltage of the auxiliary winding.
3	NC	-	No connect.
4	CS	I	Current sense pin.
5-6	C	P	High voltage power BJT collector pin.
7-8	GND	P	Ground

Block Diagram



Recommended Operation Conditions (Note 1)

Parameter	Value	Unit
Supply Voltage, VDD	7 to 24	V
Operating Ambient Temperature	-40 to 85	°C
Maximum Switching Frequency	70K	Hz

Absolute Maximum Ratings (Note 2)

Parameter	Value	Unit
VDD DC Supply Voltage	30	V
VDD DC Clamp Current	10	mA
CS voltage range	-0.3 to 7	V
FB voltage range	-0.7 to 7	V
Collector to Emitter Voltage	700	V
Package Thermal Resistance (SOP-8)	150	°C/W
Maximum Junction Temperature	150	°C
Operating Temperature Range	-40 to 85	°C
Storage Temperature Range	-65 to 150	°C
Lead Temperature (Soldering, 10sec.)	260	°C
ESD Capability, HBM (Human Body Model)	3	kV
ESD Capability, MM (Machine Model)	250	V

ELECTRICAL CHARACTERISTICS

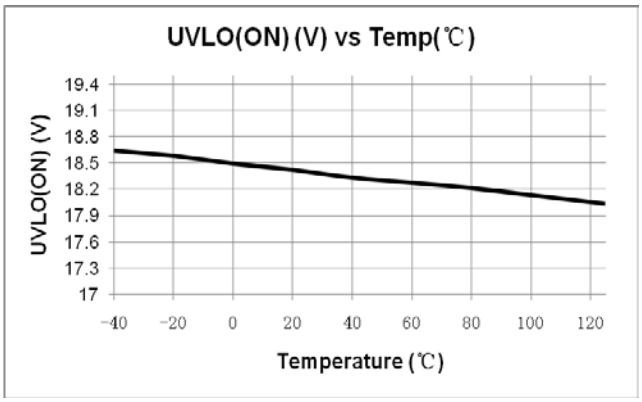
(T_A = 25°C, VDD=18V, if not otherwise noted)

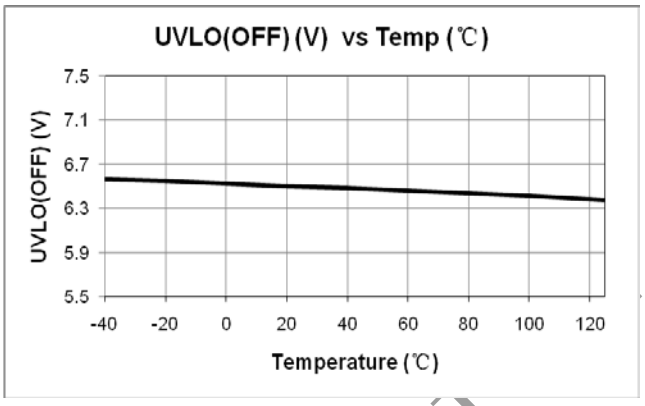
Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
Supply Voltage (VDD) Section						
I_Startup	VDD Start up Current	VDD =UVLO(ON)-1V, Measure current into VDD		3	20	uA
I_VDD_Op	Operation Current	VDD=20V		0.8	1.5	mA
UVLO(ON)	VDD Under Voltage Lockout Exit (Startup)		17	18.2	19.5	V
UVLO(OFF)	VDD Under Voltage Lockout Enter		5.9	6.5	7	V
VDD_OVP	VDD Over Voltage Protection trigger		25	27.5	30	V
V_{DD}_Clamp	VDD Zener Clamp Voltage	$I(V_{DD})$ = 10 mA	28	30	32	V
T_Softstart	Soft Start Time			2		mSec
Feedback Input Section(FB Pin)						
V_{FB}_EA_Ref	Internal Error Amplifier(EA) reference input		1.98	2.0	2.02	V
V_{FB}_DEM	Demagnetization comparator threshold			25		mV
T_{min}_OFF	Minimum OFF time			2		uSec
T_{max}_OFF	Maximum OFF time			1.2		mSec
V_{FB}_Short	Output Short Circuit Threshold			1.2		V
T_{FB}_Short	Output Short Circuit Debounce Time			13		mSec
T_{CC}/T_{DEM}	Ratio between switching period in CC mode and demagnetization time			2		
I_{Cable}_max	Max Cable compensation current			60		uA
Current Sense Input Section (CS Pin)						
T_blanking	CS Input Leading Edge Blanking Time			500		nSec
Vth_OC_max	Max. Current limiting threshold		490	500	510	mV
T_D_OC	Over Current Detection and Control Delay			100		nSec
Power BJT Section						
V_{CEO}	Collector-emitter breakdown voltage	Ic=10mA, Ib=0	450			V
V_{CBO}	Collector- base breakdown voltage	Ic=10mA	700			V
Hfe	DC current gain	Vce=5V, Ic=0.5A	10		40	
V_{CE}_sat	Collector-emitter saturation voltage	Ic=0.5A, Ib=0.1A			0.5	V

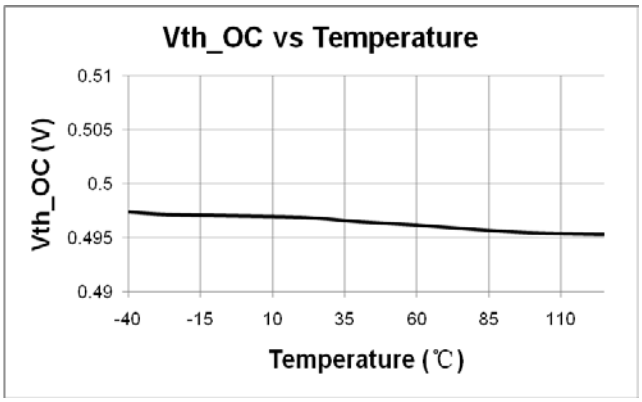
Note 1. Stresses beyond those listed under **"**Absolute Maximum Ratings**"** may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

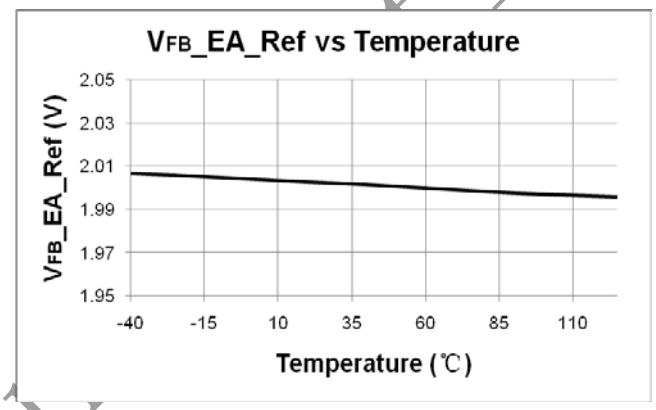
Note 2. The device is not guaranteed to function outside its operating conditions.

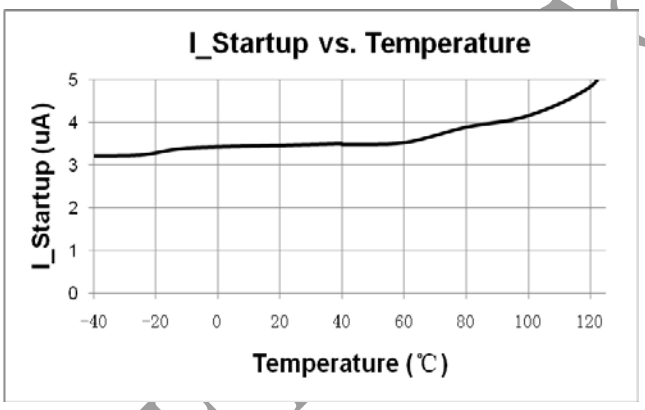
CHARACTERIZATION PLOTS











OPERATION DESCRIPTION

SF6022 is a high performance, highly integrated DCM (Discontinuous Conduction Mode) Primary Side Regulation (PSR) power switch. The built-in high precision CV/CC control makes it very suitable for offline small power converter applications.

◆ PSR Technology Introduction

Assuming the system works in DCM mode, the power transfer function is given by

$$P = \frac{\eta}{2} \times L_m \times I_{pk}^2 \times f_S = V_o \times I_o \quad \text{(Eq.1)}$$

In the equation above, P is output power, Vo and Io are system output voltage and current respectively, η is system power transfer efficiency, Lm is transformer primary inductance, fs is system switching frequency, Ipk is primary peak current in a switching cycle. The following figure illustrates the waveform in a switching cycle.

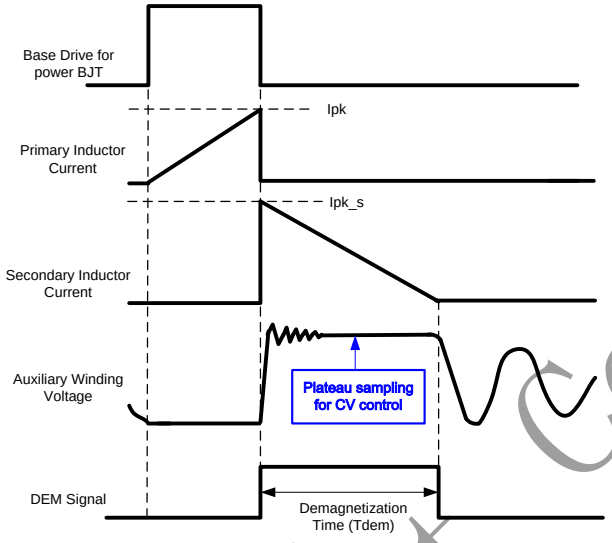


Fig.1

In the figure shown above, the IC generates a demagnetization signal (DEM) in each switching cycle through auxiliary winding. Tdem is demagnetization time for CV/CC control. In DCM mode, Tdem can be expressed as;

$$\frac{V_o}{L_m} \times T_{dem} = \frac{N_S}{N_P} \times I_{pk} \quad \text{(Eq.2)}$$

In Eq.2, Np and Ns are primary and secondary winding turns respectively.

Combined with Eq.1 and Eq. 2, the average output current can be expressed as:

$$I_o = \frac{\eta}{2} \times I_{pk} \times \frac{N_P}{N_S} \times f_S \times T_{dem} \quad \text{(Eq.3)}$$

CC (Constant Current) Control Scheme

From Eq.3, it can be easily seen that there are two ways to implement CC control: one is PFM (Pulse Frequency Modulation), the control scheme is to keep Ipk to be constant, let the product of Ts and Tdem (fs*Tdem) to be a constant. In this way, Io will be a value independent to the variation of Vo, Lm, and line input voltage. Another realization method is PWM duty control, the control scheme is to keep fs to be constant, let the product of Tdem and Ipk (Tdem*Ipk) to be a constant, in another words, by modulating system duty cycle to realize a constant Io independent to the variation of Vo, Lm and line voltages.

SF6022 adopts PFM for CC control, the product of Ts and Tdem is given by

$$f_S \times T_{dem} = 0.5 \quad \text{(Eq.4)}$$

CV (Constant Voltage) Control Scheme

CV control should sample the plateau of auxiliary winding voltage in flyback phase, as shown in Fig.1 The CV control has many implementations, for example, PWM, or PFM, or a combination of both one. In SF6022, the CV control adopts proprietary multi mode control, as mention below.

◆ Startup Current / Startup Control / Operating Current

Startup current of SF6022 is designed to be very low (typically 3uA) so that VDD could be charged up above UVLO(ON) threshold level and device starts up quickly. The operating current in SF6022 is as small as 0.8mA (typical). The small operating current results in higher efficiency and reduces the VDD hold-up capacitance requirement.

◆ NC-Cap/PSR-II™ Introduction

● ±4% Precision CV/CC Performance

SF6022 can achieve less than ± 4% variation of CC/CV precision due to the built-in CV accuracy improvement and CC line and load compensation, as shown in Fig.2.

● Proprietary "Audio Noise Cancellation" Control

SF6022 has a proprietary "Audio Noise Cancellation" control, which can achieve audio noise free operation in the whole loading range.

● Built-in Fast Dynamic Response Control to Meet USB Charge Requirements

In SF6022, a fast dynamic response control is integrated to improve system dynamic response performance, thus the charger system can meet the USB charge requirements.

● Smart Output Short Protection

The output short circuit protection of conventional PSR system is based on the coupling between auxiliary winding and secondary winding. When output is short, the auxiliary winding cannot provide enough energy to the IC any more. In this way, the system will enter into auto-recovery mode protection. However, the IC may be wrongly supplied if the leakage inductance of the primary

winding is large enough.
In SF6022, if output short circuit occurs, the IC will detect the situation and enter into auto-recovery mode protection.

• Proprietary Zero-Output Startup Control

Conventional PSR system may suffer startup failure when output voltage is near zero voltage, which means that there is a gap between OCP (CC point in PSR CV/CC system) and full loading. Larger OCP gap causes larger system cost.
In SF6022, a proprietary "Zero-Output Startup Control" is adopted to achieve successful startup @ Vout≈0V, as shown in Fig.2.

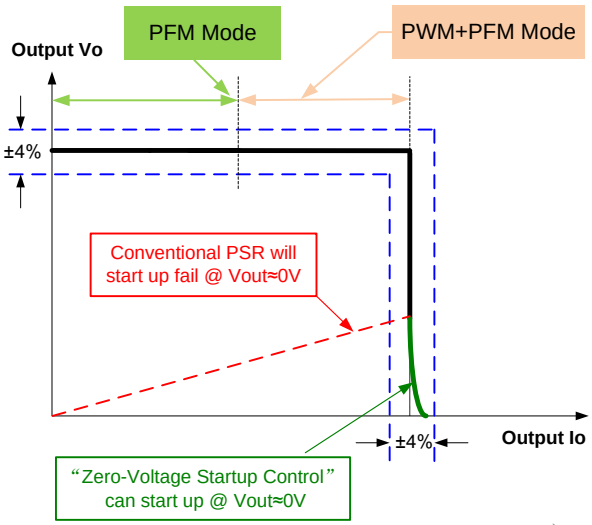


Fig.2

• No External Compensation/Filtering Capacitor Needed

SF6022 uses a proprietary control to eliminate external compensation capacitor, which can simplify system design and lower system cost.

• Maximum 50V Output for LED Lighting

SF6022 can support maximum 50V output, which can be used in AC/DC LED lighting.

◆ Proprietary Cable Drop Compensation

SF6022 has a proprietary built-in cable voltage drop compensation block which can provide a constant output voltage at the end of the cable over the entire load range in CV mode.

◆ Multi Mode PSR Control for High Reliability , High Efficiency

Conventional pure PFM controlled PSR system may suffer transformer saturation issue when heavy loading. In SF6022, a proprietary multi mode control is adopted to suppress this issue, as shown in Fig.2. Around the full load, the system operates in PWM+PFM mode, which improve the system reliability. Under normal to light load conditions, the IC operates in PFM mode to achieve excellent regulation and high efficiency.

◆ Soft Start

SF6022 features an internal 2ms (typical) soft start that slowly increases the threshold of cycle-by-cycle current limiting comparator during startup sequence. Every startup process is followed by a soft start activation.

◆ Leading Edge Blanking (LEB)

Each time the power BJT is switched on, a turn-on spike occurs across the sensing resistor. To avoid premature termination of the switching pulse, an internal leading edge blanking circuit is built in. During this blanking period (500ns, typical), the cycle-by-cycle current limiting comparator is disabled and cannot switch off the base driver.

◆ Minimum and Maximum OFF Time

In SF6022, a minimum OFF time (typically 2us) is implemented to suppress ringing when BASE drive is pull off. The maximum OFF time in SF6022 is typically 1.2ms, which provides a large range for frequency reduction. In this way, low standby power can be achieved.

◆ Pin Floating Protection

In SF6022, if pin floating situation occurs, the IC is designed to have no damage to system.

◆ Built-in Load and AC Line CC Compensation

In conventional PSR system, the output CC (Constant Current) point can vary with output and AC line voltage. In SF6022 the IC has built-in blocks to compensate the variation, as shown in Fig3. The IC can adjust CC point based on sensed output voltage and PFM duty. In this way, CC accuracy can be improved.

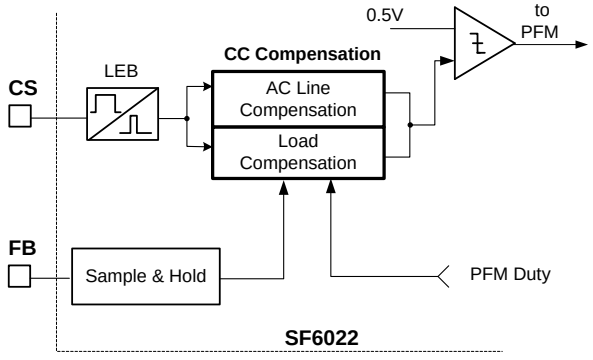


Fig.3

◆ Auto Recovery Mode Protection

As shown in Fig.4, once a fault condition is detected, switching will stop. This will cause VDD to fall because no power is delivered form the auxiliary winding. When VDD falls to UVLO(off) (typical 6.5V), the protection is reset and the

operating current reduces to the startup current, which causes VDD to rise, as shown in Fig.4. However, if the fault still exists, the system will experience the above mentioned process. If the fault has gone, the system resumes normal operation. In this manner, the auto restart can alternatively enable and disable the switching until the fault condition is disappeared.

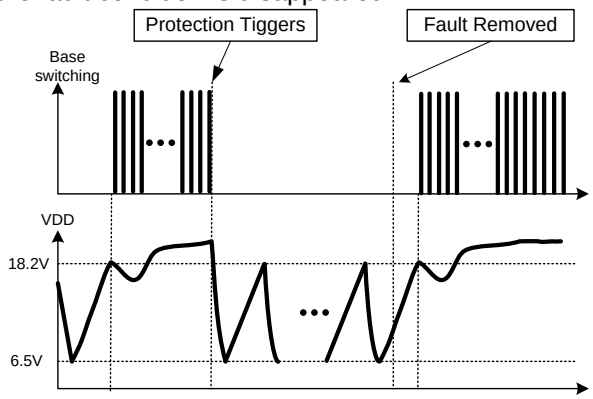


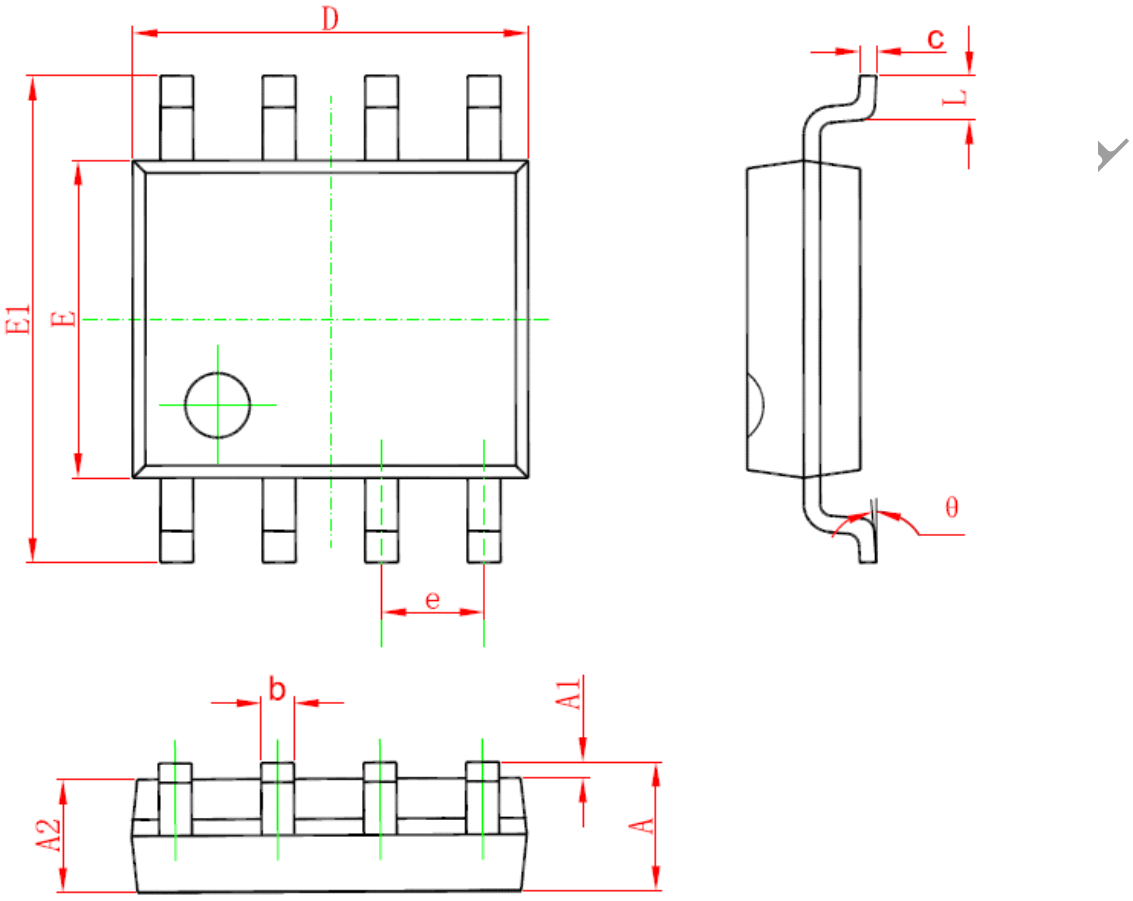
Fig.4

◆ **VDD OVP(Over Voltage Protection)**

VDD OVP is implemented in SF6022 and it is a protection of auto-recovery mode.

PACKAGE MECHANICAL DATA

SOP8 PACKAGE OUTLINE DIMENSIONS



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.050	0.250	0.002	0.010
A2	1.250	1.650	0.049	0.065
b	0.310	0.510	0.012	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.150	0.185	0.203
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.270 (BSC)		0.05 (BSC)	
L	0.400	1.270	0.016	0.050
θ	0º	8º	0º	8º

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