SFA0001

Application Note (Ver 0.3)

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Sanken Electric Co.,Ltd.
AMD Division
Automotive device engineering 1G

1. General Descriptions

SFA0001 is an IC for flyback type switching power control equipped with high precision error lamps. It has a smaller number of external parts necessary for control, and making it easier to design circuits, and suitable for downsizing and standardization of power.

2. Features

- ●Mountable on small surface, full molding 8PIN package (SOP8)
- ●High-precision error lamps incorporated in ICs and switching power supply can be simply configured.
- ●IC power pin voltage 36V resistance
- ●Controlled by fixed frequency PWM method and oscillation frequency can be set by external capacitor.
- ●Current mode control
- ●Vehicle mountable product
- ●Soft start function which can set time by external capacitor is included.
- ●Various protection functions
  - ･Overcurrent protection function (OCP)→Turns OFF the MOSFET in pulse-by-pulse.
  - ･Overload protection function (OLP) → Auto-restart
  - ･Overheat thermal protection→Restart by sensed temperature hysteresis

Absolute maximum ratings (Ta=25℃)

Parameter	Symbol	Ratings	Unit
OCP terminal voltage	VOCP	-0.3 - +6	V
SS/ELP terminal voltage	VSS	-0.3 - +9	V
FB terminal voltage	VFB	-0.3 - +6	V
Input voltage for control part	VCC	0 - 36	V
Phase compensation terminal voltage	VCOMP	-0.3 - +6	V
Frequency setting terminal voltage	FREQ	-0.3- +6	V
Power dissipation for control part (MIC)	PD	1.2 (*1)	W
Junction temperature	Tj	-40 - 150	℃
Storage temperature	Tstg	-40 - 150	℃

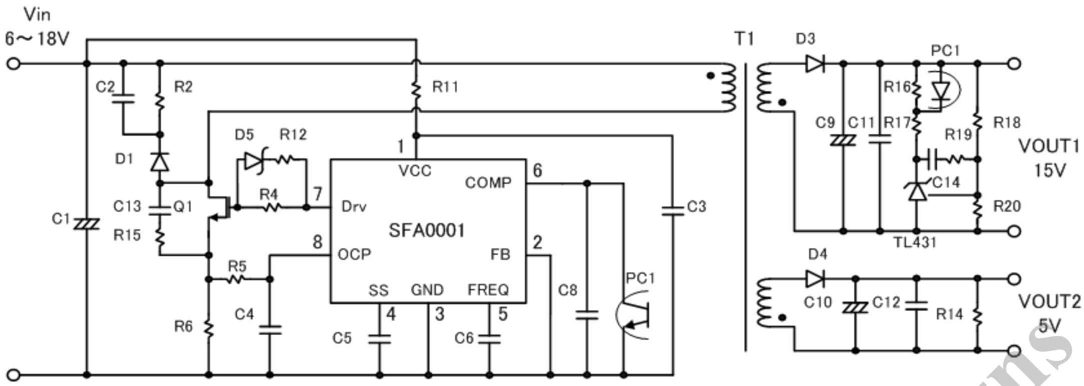
(*1) mounted on glass epoxy board (board size: 42mm×32mm×1mmt)

Recommended operation conditions

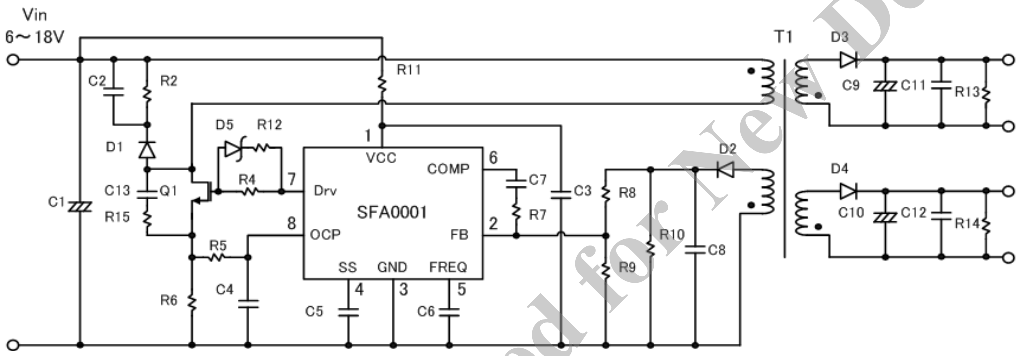
Parameter	Symbol	Ratings	Unit
Operating voltage for control part	VOP	6 - 24	V
Switching frequency	FOSC	20 - 200	kHz

3. Typical Application Circuit

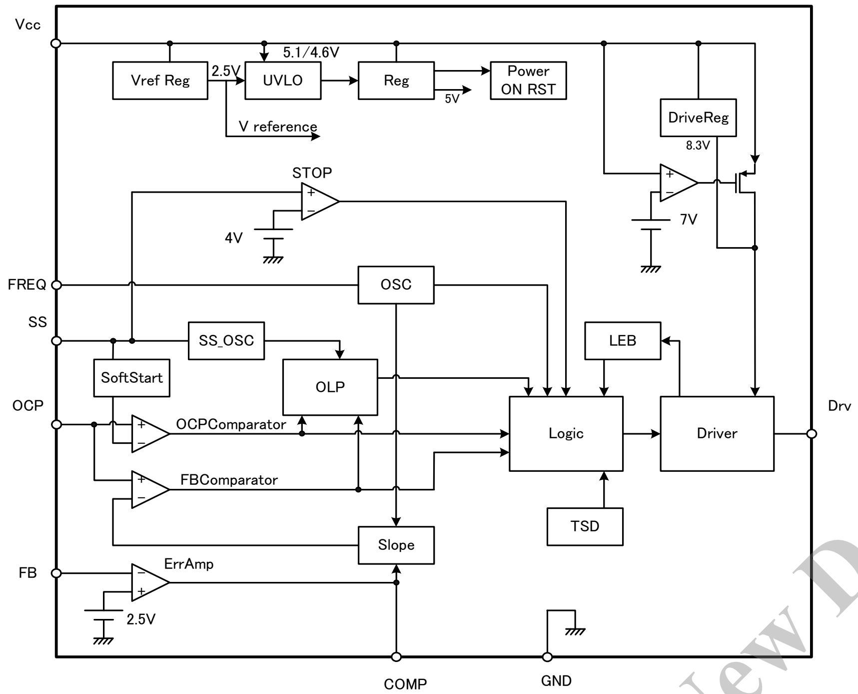
3.1 Flyback buck-boost converter



3.2 Flyback buck-boost converter (photocoupler is not used)



4. Block Diagram



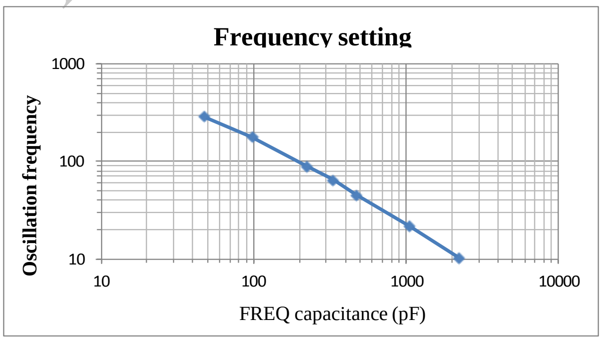
Description of each function

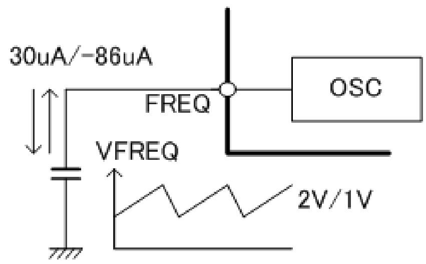
VCC pin

VCC pin is a power input pin for IC. When power is turned on, regular power is started at the beginning. The regular power is high-precision power of 2.5V±2% which produces a comparative voltage of the comparator.
When a voltage not lower than the operation start voltage VCC(ON) is entered into the VCC terminal, the power in the IC is turned ON and the IC starts operation. When VCC decreases and becomes a voltage not higher than the operation stop voltage VCC (OFF), the power in the IC is turned OFF and the IC stops operation.
If the impedance in the power line is high, the VCC pin voltage significantly fluctuates and a malfunction may result. In such a case, use a resistor and a capacitor to moderate the fluctuation of the VCC pin voltage.

FREQ pin

FREQ pin sets oscillation frequency of Drv pin output by connecting the capacitor. The FREQ pin charges at Isrc(FREQ)=30uA, and discharges at Isnk(FREQ)=-86uA between VHF=2V and VLF=1V, and further oscillates in a triangular wave. This oscillation allows the Drv pin oscillation frequency to be set. In addition, a maximum ONDuty is controlled by a ratio of charge and discharge.
Set the oscillation frequency with reference to the following graph.





FB pin

For control of output voltage of switching power, current mode control excellent in response speed and stability is adopted. An error amplifier is incorporated between the FB pin and COMP pin and is controlled so as to set the FB pin voltage to a feedback voltage VFB=2.5V. When controlling the secondary voltage without using a photocoupler, application circuit example control it by using an auxiliary winding as shown in the producing a voltage coupled with the secondary output by transformer on the primary side. When an auxiliary winding system is configured as shown in the following diagram, a relationship between smooth voltage V3 of the auxiliary winding system and the secondary output voltage VOUT is determined by a winding ratio of N2 and N3, and expressed as

$VOUT=N2/N3 \times V3$.

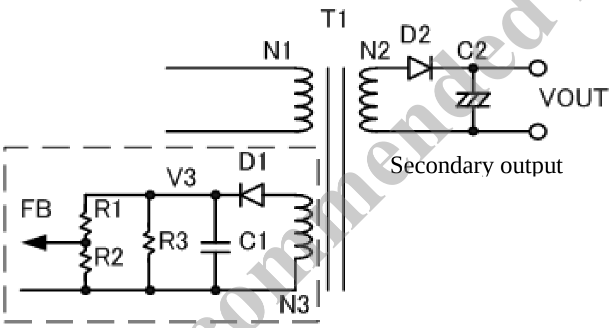
V3 is divided by a resistance and entered to the FB pin, and the IC controls the FB pin so as to reach VFB=2.5V, therefore, V3 is expressed as

$V3=(R1+R2)/R2 \times 2.5$.

Accordingly, the secondary output is controlled so that it is expressed as

$VOUT=N2/N3 \times (R1+R2)/R2 \times 2.5$.

In fact, the output voltage may be deviated from the above equation due to improper coupling between the secondary side and transformer of the auxiliary winding system and difference in VF between the secondary rectifying diode D2 and auxiliary winding system diode D1, then check the output voltage on the actual machine operation to adjust. If transformer winding number N2=N3 and VOUT=V3 are set and the secondary rectifying diode D2 and the auxiliary winding system diode D1 are used for the same type, accuracy of the secondary output voltage is further improved. If there is any large difference in consuming power between the auxiliary winding system and the secondary side, load regulation is worsened by improper transformer coupling, therefore, insert a dummy resistance R3 into the auxiliary winding system. Determine a value of R3 from the actual machine operation and specification.



Auxiliary winding system

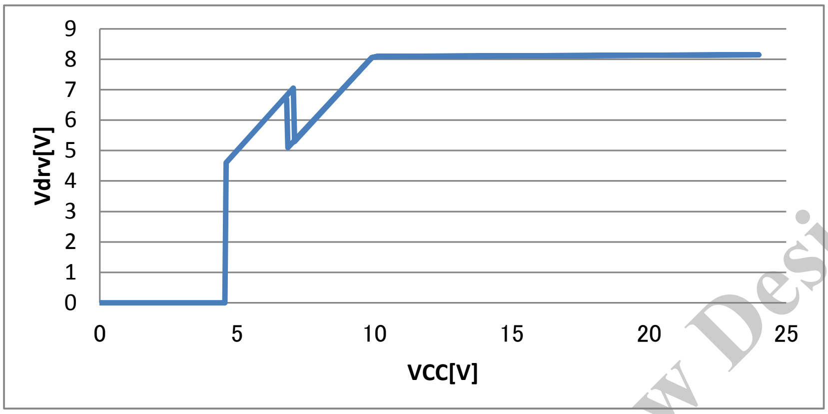
Regarding the operation of constant voltage control, if the secondary load decreases, voltage in the auxiliary winding system also increases as the output voltage increases, and voltage entered into the FB pin also increases. This voltage is negatively amplified by the error amplifier in the IC, so add a slope compensation signal to generate a target value of the FB Comparator.
On the other hand, a peak value of voltage generated from the drain current waveform of the power MOSFET, in other words, a peak value of the drain current is input from the OCP pin and feedback is performed so as to approach the target value of the decreased FB Comparator. As a result, the peak value of the drain current in the power MOSFET is reduced and operation is made so that the output voltage does not increase.
When the load is heavier, reverse operation is performed, to increase the target voltage of the FB Comparator, furthermore, the peak value of the drain current also increases with it and operation is performed so that the output voltage does not decrease.

COMP pin

This is an output pin for an error amplifier. Compensate the phase in time with actual machine operation.
In addition, when controlling the secondary output voltage using a photocoupler, connect a photocoupler to the COMP pin as shown in the application circuit example.

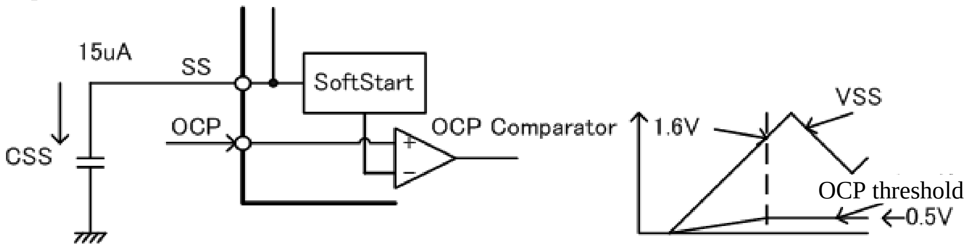
Drv pin

Drv pin connects the gate of MOSFET.
Since the drive pin outputs from the VCC pin through the internal regulator, High level of the drive pin is clamped at Vdrv=8.1V as the VCC is increased. The drive voltage switches the internal regulator near VCC=7V and prevents MOSFET from not being turned ON when the drive voltage decreases at the time of VCC decrease.
For the MOSFET used, also consider that the source of the MOSFET raised by approximately 0.5V due to drain current detection resistance and use MOSFET of which the MOSFET threshold value is sufficiently lower than the drive voltage near the switching voltage.



SS pin

SS pin has three functions to set soft start time, to set delay time of the overload protection function (OLP) and of drive stop function. For the overload protection function and drive stop function, refer to those items.
In order to reduce the voltage and current stress of the power MOSFET and rectifying diode when power is on, a soft start function is incorporated. The soft start time is set by a capacitor connected to the SS pin. Since the SS pin also sets a delay time of the overload protection function, the SS pin always oscillates in a triangular wave at VHSS/VLSS＝2V/1V during operation of the IC.
When power is on and VCC≧VCC(ON) is established, the IC starts operation. The capacitor connected to the SS pin is charged at a constant current Isrc (SS) = 15uA. The OCP threshold value is a voltage proportional to the SS pin voltage until the SS pin voltage becomes VHSS=2V from power start, and is latched when the SS pin voltage once becomes VSS≧VHSS, and then the OCP threshold value is fixed at VOCP=0.5V. The drain current also gradually increases and the soft start works by such a gradual increase of the OCP threshold value in synchronization with the SS pin when power is on.
Because the OCP threshold value becomes approximately 0.5V and is clamped when the VSS pin voltage becomes approximately 1.6V at operation of soft start, the soft start time Tss is generally expressed as
Tss[s]=1.6[V]×CSS[uF]/15[uA].
The capacitor capacity of the SS pin also sets delay time of the overload protection function, and if capacitor capacity of the SS pin is small, the overload protection works when power is on before stationary operation is established, and then the start may malfunction. Determine the capacity to be approximately 0.01uF to 0.47uF as a guide while checking the actual machine operation.



OCP pin

OCP pin detects drain current of the power MOSFET. Connect a current detection resistance between the source of the MOSFET and GND to input voltage to the OCP pin. Because SFA0001 is an IC by current mode control, use drain current value input to the OCP pin to control the output voltage. For this reason, the OCP pin is required for control. In addition, the OCP pin detects peak value of the drain current of the MOSFET every one pulse, and when the OCP pin voltage exceeds VOCP=0.5V, the over-current protection function works to turn OFF the power MOSFET with pulse-by-pulse.
Because high-frequency switching current flows through the current detecting resistance, use of internal large inductance may result in defects such as malfunction. Use a detecting resistance of which internal inductance is small and of which surge withstand is large. In addition, if any malfunction occurs due to switching surge etc., install an RC filter or the like.

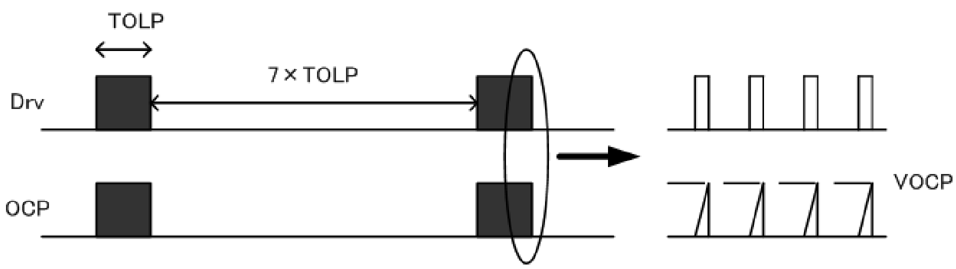
*Example of OCP detecting resistance design

If the operation is supposed to be discontinuous, and input voltage is assumed to be VIN, output voltage WOUT, efficiency η, and OnDuty of MOS is assumed to be Duty, then peak value of the drain current is expressed as
Ipeak=2×WOUT/(η×VIN×Duty).
If the over-current point is assumed to be 130% of the rated power, the current value is proportional to the square root of the power, therefore, design approximately 114% of Ipeak for minimum input voltage and maximum load as OCP point.
If Duty=50% and efficiency of 70% are assumed for design at the time of minimum input voltage and maximum load, the OCP threshold voltage is VOCP=0.5V, then
ROCP=(0.5×η×VIN(MIN)×Duty)/(1.14×2×WOUT(MAX)) is established.

In addition, because current flowing through the OCP detecting resistance is of a triangular wave, the effective value is expressed as
Irms=(Duty/3)^(1/2)×Ipeak,
this allows consuming power of the OCP detecting resistance to be expressed as
WOCP=ROCP×Irms^2
These calculated values are values at the time of discontinuous operation, and are deviated from the above equation at the time of continuous operation. Set values from actual machine operation with reference to this calculated value.

Overload protection (OLP)

The SFA0001 includes an overload protection (OLP) circuit, and if an overload state (state that peak value of drain current is limited by OCP operation, or the Drv pin is kept ON until maximum ONDuty) continues for a certain time (TOLP=42ms when the SS pin connecting capacity is 10nF), the Drv pin stops oscillation operation to reduce stress on components of the power MOSEFT and rectifying diode. The SS pin charges at Isrc(SS)=15uA and discharges at Isnk(SS)=-17uA through VHSS/VLSS=2V/1V to oscillate in a triangular wave. This allows this delay time to be set by the capacitor capacity connected to the SS pin, and when the connection capacity of the SS pin is
CSS[nF], TOLP(CSS)[ms]=42[ms]×CSS[nF]/10[nF] is established.
When the overload protection function works, the Drv pin stops 7×TOLP (CSS) oscillation, and then automatically restarts oscillation. Unless overload protection state is released, the Drv pin repeats oscillation and stop in a period of 8×TOLP.



Drive stop function

Drive output is compulsorily fixed at LOW level and oscillation of the Drv pin can be stopped by applying voltage exceeding drive threshold voltage VST=4[V] to the SS pin from the outside. When there is no voltage applied to the SS pin from the outside and VSS<VST is established, the Drv pin restarts oscillation again.

Thermal shutdown (TSD)

This function stops oscillation of the Drv pin when junction temperature in the control circuit of the IC reaches TjH=165° C. When it decreases down to a temperature TjL=150° C, the protection function is released and oscillation of the Drv pin is restarted.