PQ1PF1

Primary Regulator for Switching Power Supply (50W Class)

■ Features

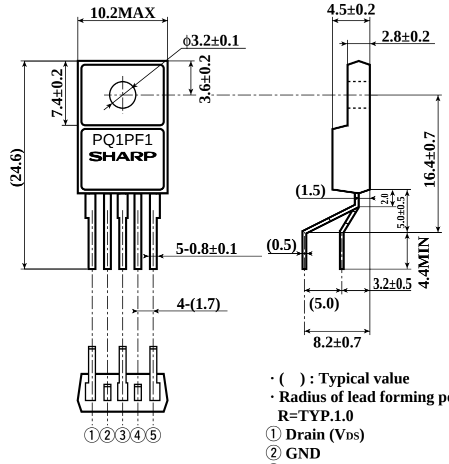
- 5-terminal lead forming package (equivalent to TO-220)
- Built-in oscillation circuit
  (oscillation frequency : TYP. 100kHz)
- Output for power supply : 50W class
- Built-in overheat protection, overcurrent protection, low voltage mulfunction prevention function

■ Applications

- Switching power supplies for VCRs
- Switching power supplies for word processors

■ Outline Dimensions

(Unit : mm)



· ( ) : Typical value
· Radius of lead forming portion R=TYP.1.0
① Drain (V_{DS})
② GND
③ Control (CA)
④ Feed back (FB)
⑤ Supply voltage (V_{CC})

■ Absolute Maximum Ratings

(T_a=25˚C)

Parameter	Symbol	Rating	Unit
Drain-GND(source)voltage	V_{DS}	500	V
Drain current	I_D	4.5	A
*1 Power supply voltage	V_{CC}	35	V
*2 FB terminal input voltage	V_{FB}	4	V
CA terminal input current	I_{CA}	2	mA
*3 Power dissipation	P_{D1}	2	W
	P_{D2}	20	W
*4 Junction temperature	T_j	150	˚C
Operating temperature	T_{opr}	-20 to +80	˚C
Storage temperature	T_{stg}	-40 to +150	˚C
Soldering temperature	T_{sol}	260 (For 10s)	˚C

*1 Voltage between V_{CC} terminal and GND terminal.
*2 Voltage between FB terminal and GND terminal.
*3 P_{D1}:No heat sink, P_{D2}:With infinite heat sink
*4 Overheat protection may operate at 125=<Tj=<150˚C

· Please refer to the chapter“ Handling Precautions ”.

■ Electrical Characteristics

(Unless otherwise specified, conditions shall be V_{DS}=10V, Vcc=18V, V_{CA}=OPEN, V_{FB}=2.2V, R_L=56Ω, T_a=25˚C)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Drain-source onstate resistance	$R_{DS(on)}$	I_D=2A	-	1.2	1.5	Ω
Drain-source leakage current	I_{DSS}	V_{DS}=500V, Vcc=7V V_{CA}=GND, V_{FB}=GND	-	-	250	µA
Oscillation frequency	fo		90	100	110	kHz
Temperature change in oscillation frequency	∆fo	T_j=0 to 125˚C	-	±5	-	%
Maximum duty	D_{MAX}		42	45	50	%
FB threshold voltage	V_{FBL}	Duty=0%	-	0.9	-	V
	V_{FBH}	Duty=D_{MAX}	-	1.8	-	V
	$V_{FB(OCP)}$	V_{CA}=6V	2.6	2.8	3.1	V
FB current	I_{FB}	V_{FB}=GND	-800	-620	-440	µA
CA threshold voltage	V_{CAL}	Duty=0%	-	0.9	-	V
	V_{CAH}	Duty=D_{MAX}	-	1.8	-	V
	$V_{CA(ON/OFF)}$		0.49	0.6	0.74	V
	$V_{CA(OVP)}$		7.2	7.7	8.2	V
CA sink current	I_{CAIN}	V_{FB}=1V, V_{CA}=6V	20	36	52	µA
Overcurrent detecting level	$I_{D(OCP)}$		-	2.5	-	A
Operation starting voltage	$V_{CC(ON)}$	V_{DS}=OPEN, V_{FB}=OPEN	15.5	17.0	18.5	V
Operation stopping voltage	$V_{CC(OFF)}$	V_{DS}=OPEN, V_{FB}=OPEN	8.5	9.3	10.1	V
Stand-by current	$I_{CC(ST)}$	V_{DS}=OPEN, Vcc=14V, V_{FB}=OPEN	-	100	150	µA
Output OFF-mode consumption current	$I_{CC(OFF)}$	V_{DS}=OPEN, V_{CA}=GND V_{FB}=OPEN	-	0.6	1.8	mA
Output-operating mode consumption current	$I_{CC(OP)}$		-	10	18	mA
Charging current	$I_{CA(CHG)}$	V_{CA}=GND, V_{FB}=OPEN	-15	-10	-5	µA

Fig. 1 Test circuit

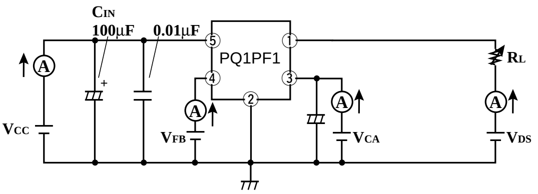


Fig. 2 Power Dissipation vs. Ambient Temperature

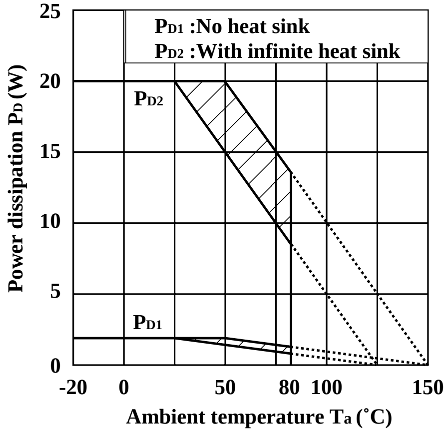


Fig. 3 Stand-by Current vs. Junction Temperature

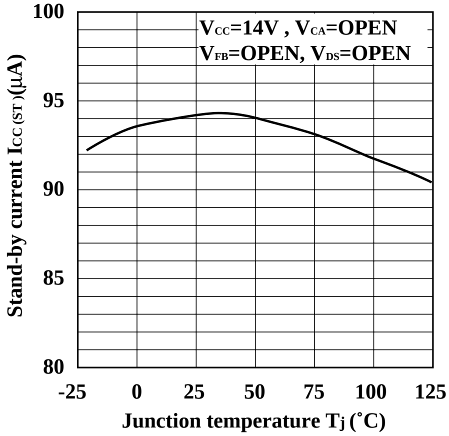


Fig. 4 Operation Starting Voltage vs. Junction Temperature

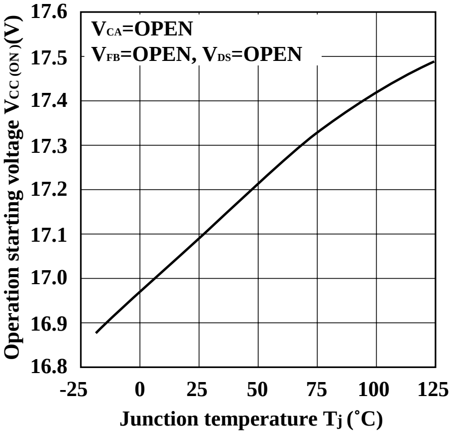


Fig. 5 Output-Operating Mode Consumption Current vs. Junction Temperature

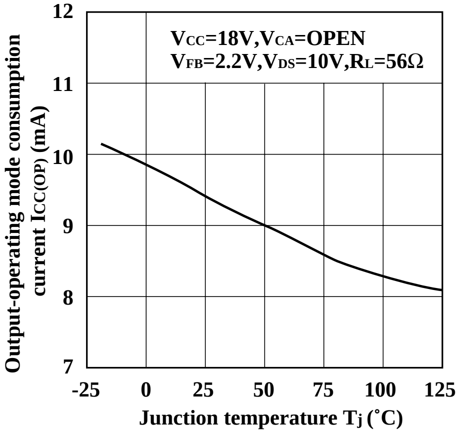


Fig. 6 Oscillation Frequency vs. Junction Temperature

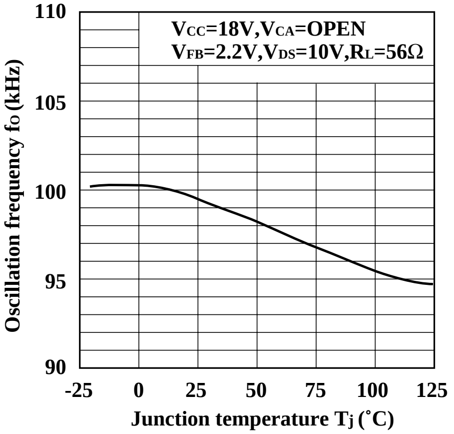


Fig. 7 Maximum Duty vs. Junction Temperature

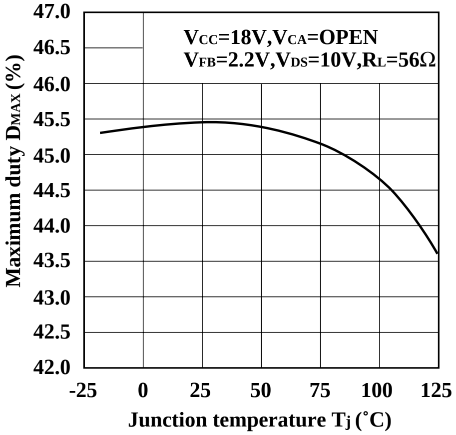


Fig.8 Drain-soure onstate resistance vs. Junction Temperature

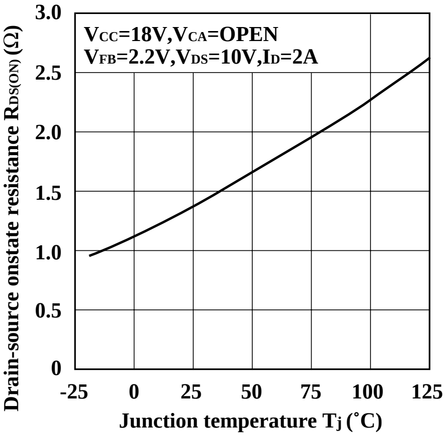


Fig.9 Overcurrent Detecting Level vs. Junction Temperature

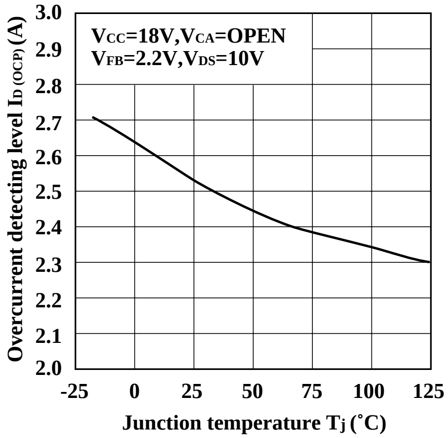


Fig.10 FB Threshold Voltage vs. Junction Temperature

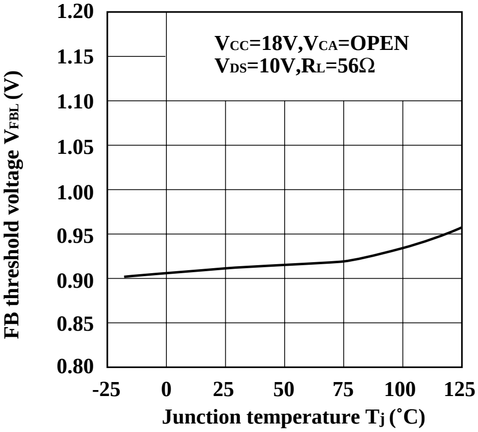


Fig.11 FB Threshold Voltage vs. Junction Temperature

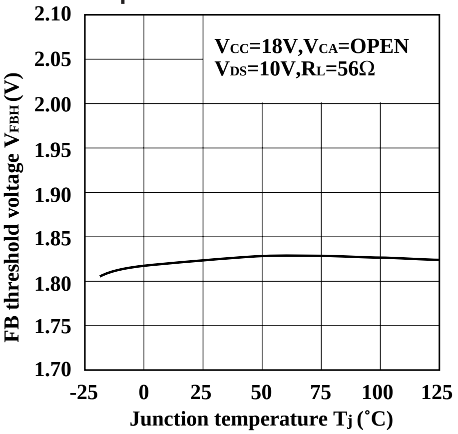


Fig.12 CA Threshold Voltage vs. Junction Temperature

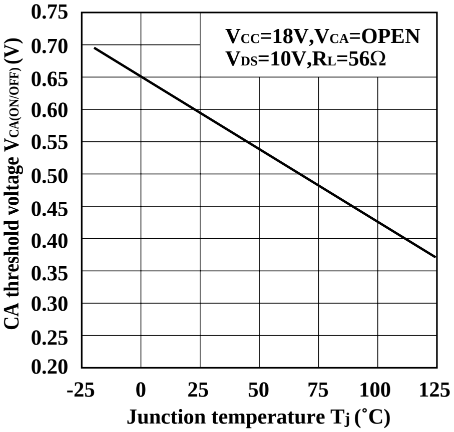


Fig.13 CA Threshold Voltage vs. Junction Temperature

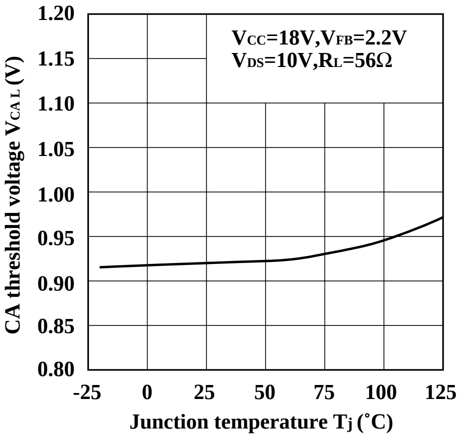


Fig.14 CA Threshold Voltage vs. Junction Temperature

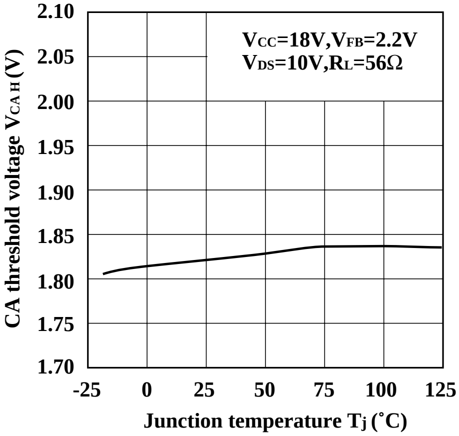


Fig.15 CA Threshold Voltage vs. Junction Temperature

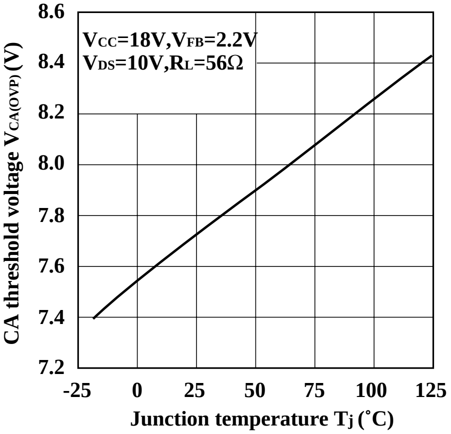


Fig.16 FB Threshold Voltage vs. Junction Temperature

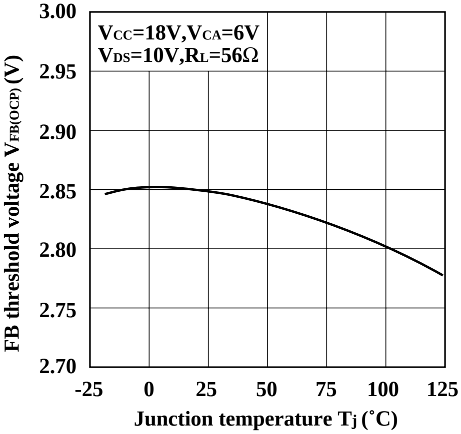


Fig.17 CA Sink Current vs. Junction Temperature

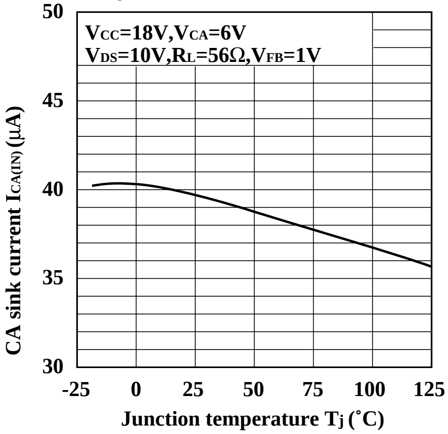


Fig.18 FB Current vs. Junction Temperature

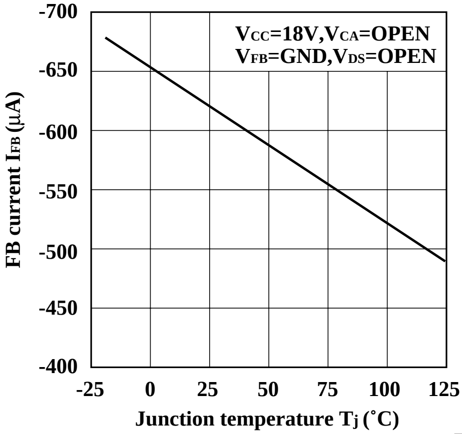


Fig.19 Charging Current vs. Junction Temperature

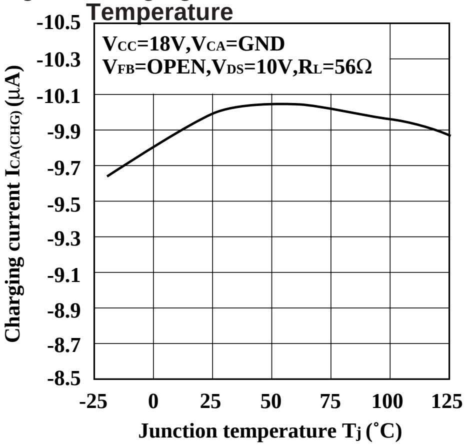


Fig.20 Output-OFF Mode Consumption Current vs. Junction Temperature

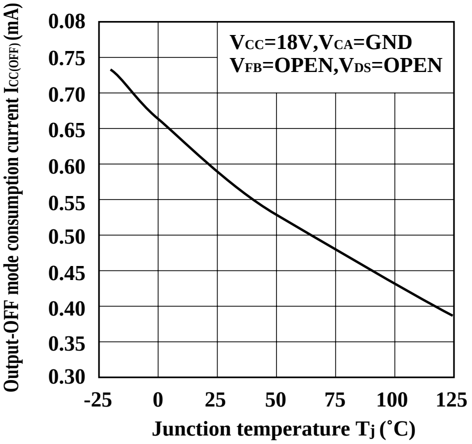
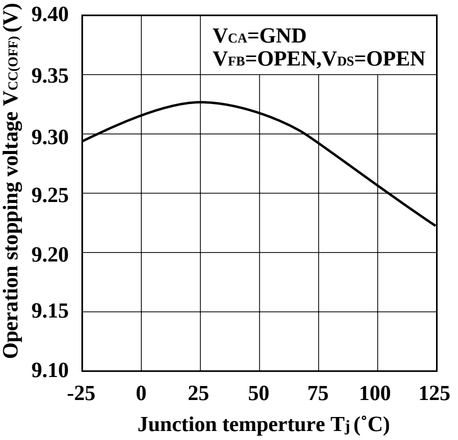
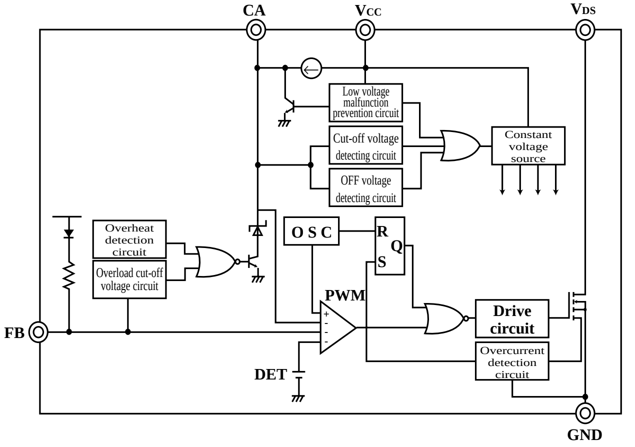


Fig.21 Operation Stopping Voltage vs. Junction Temperature



■ Block Diagram



■ Description for Each Operation

1. Low voltage mulfunction prevention circuit

This device has a built-in low voltage malfunction prevention circuit to prevent malfuncting when power supply voltage Vcc becomes as low as starting time. When power supply voltage comes up to operation starting voltage$V_{CC(ON)}$17.0V TYP., IC will start to operate. When power supply voltage falls short of operation stopping voltage$V_{CC(OFF)}$9.3V TYP., IC will stop operating, and output is shut down.

Before starting power supplies or after stopping operation, applying current to Vcc terminal is stood for stand-by current $I_{CC(ST)}$, and it is kept at 100µA TYP. (Vcc=14V)

2. Oscillator

IC has a built-in oscillator, and oscillation frequncy is fixed at 100kHz TYP.

3. CA terminal

CA terminal can be connected to capacitor C_A, and it enables to perform various functions such as soft start function, overcurrent protection function, overvoltage protection function, and ON/OFF control function.

3-1 Soft start function

Soft start circuit is shown in Fig.1. When voltage Vcc is supplied, CA terminal voltage V_{CA} starts rising, charging a capacitor C_A with charge current from CA terminal(10µA TYP.). According to rising CA teminal voltage V_{CA}, output pulse width becomes gradually wider, and it may cause soft start.

ON duty D of output pulse width is as follows.

D=0% at V_{CA}=0.9V TYP.

D=Dmax=45% at V_{CA}=1.8V TYP.

During normal operaion, V_{CA} is clamped at 3.6V by the internal circuit of IC.

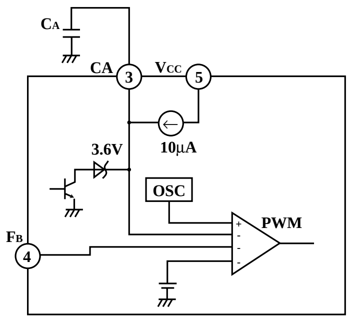


Fig.1 Soft Start Circuit

3-2 Overcurrent protection function

Overcurrent protection circuit is shown in Fig.2. Fig.3 shows timing chart of OFF control process after detecting overcurrent.

First, drain current of MOS-FET (which is built-in device) is getting high due to overcurrent. When it comes up to overcurrent detection level $I_{D(OCP)}$≒2.5A, overcurrent protection circuit will operate and minimize output pulse width to minimum duty by pulse-by-pulse. Minimizing output pulse width makes output voltage lower. As output voltage is lowered, collector-emitter voltage of PC_1 will be turned OFF and FB voltage V_{FB} will be high. When V_{FB} comes up to threshold voltage of overload shut-down $V_{FB(OCP)}$ 2.8V, CA voltage V_{CA} will be released from clamped voltage 3.6V and the capacitor C_A which is connected to CA terminal will be charged again by 10µA of charge current. When V_{CA} increases to CA threshold voltage$V_{CA (OVP)}$ 7.7V, internal constant voltage supply of IC becomes OFF-state and maintain shut-down state. To maintain output shut-down condition, 0.3mA (Vcc=11V) TYP. is required. To restart, Vcc needs to be lowered less then operation stopping voltage$V_{CC(OFF)}$ 9.3V by applying input voltage again.

Fig.2 Overcurrent Protection Circuit

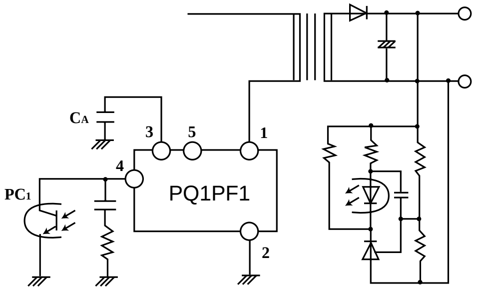
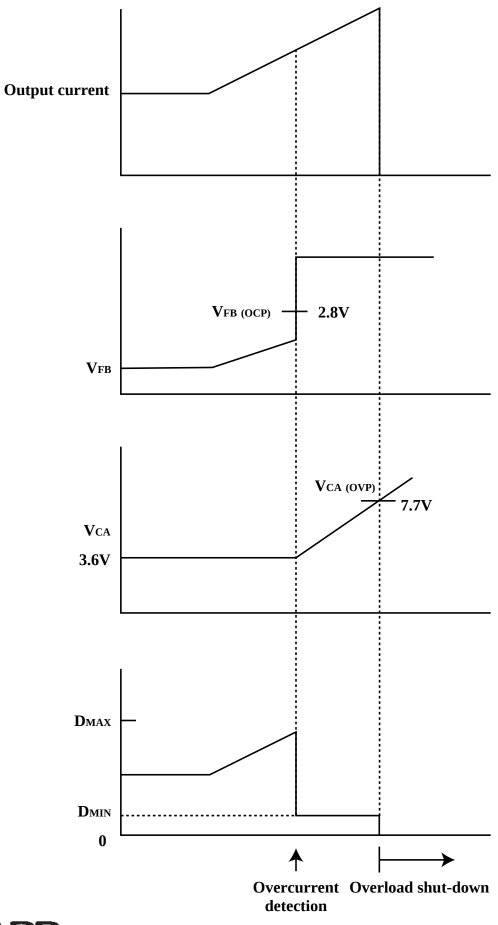


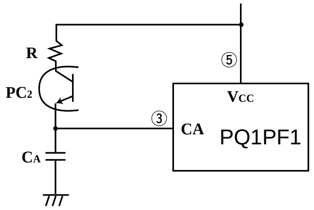
Fig.3 Timing Chart Overcurrent Protection



3-3 Overvoltage protection function

Fig.4 shows overvoltage protection circuit. Photocoupler PC_2 becomes ON-state when output voltage is in overvoltage condition. When PC_2 is ON-state, current from Vcc via resistor R charges capacitor C_A and CA voltage V_{CA} increases. When V_{CA} reaches CA threshold voltage$V_{CA(OVP)}$ 7.7V, internal constant voltage supply of IC becomes OFF-state and maintain shut-down state. To maintain output shut-down condition, 0.3mA (Vcc=11V) TYP. is reguired. To restart, Vcc needs to be lowered less than operation stopping voltage $V_{CC(OFF)}$ 9.3V by applying input voltage again.

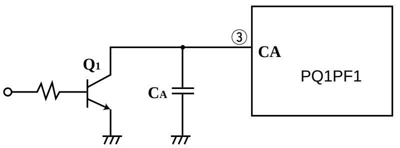
Fig.4 Overvoltage Protection Cricuit



3-4 ON/OFF control function

IC operation can be stopped and output voltage can be OFF-state by lowering CA voltage V_{CA} less than 0.6V TYP. Fig.5 shows ON/OFF control circuit. When transistor Q_1 becomes ON-state by external signal and V_{CA} is less than 0.6V, output turns off. Output is ON-state again by soft start function which is caused by Q_1 OFF.

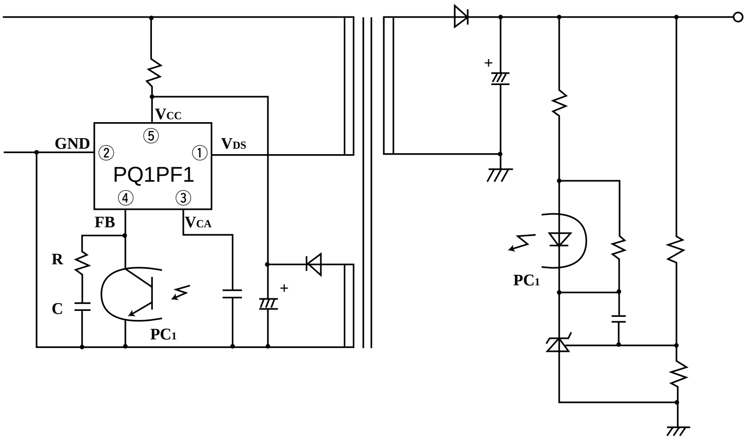
Fig. 5 ON/OFF Control Function



4. FB-terminal

Fig.6 shows circuit example of feedback signal input circuit for fixed output voltage.

Fig.6



Output voltage is controlled by connecting photocoupler PC_1 between FB-terminal and GND terminal . When output voltage or transmisslon waveform is unstable, connect C&R on both sides of PC_1 to reduce gain of control system.

5. Overcurrent detection circuit

This module detects drain current I_D of MOS-FET, and minimize output pulse width by pulse-by-pulse at I_D=2.5A TYP.

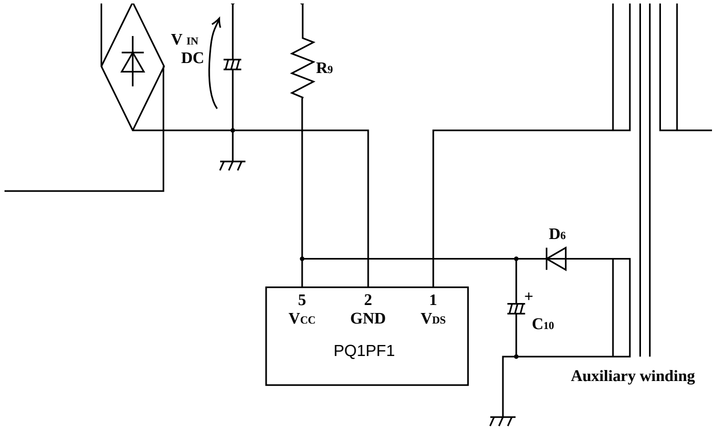
6. Overheat protection circuit

Overheat protection circuit starts to operate when internal temperature of IC is at 140˚C TYP. CA voltage V_{CA} will be released from clamped voltage 3.6V and the capacitor C_A which is connected to CA terminal will be charged again by 10µA of charge current. When V_{CA} increases to CA threshold voltage$V_{CA\ (OVP)}$ 7.7V, internal constant voltage supply of IC becomes OFF-state and maintain shut-down state. To maintain output shut-down condition, 0.3mA (Vcc=11V) TYP. is required. Output shut-down condition is maintained even if lowering internal temperature of IC. To restart, Vcc needs to be lowered less than 9.3V by applying input voltage again.

Precautions in Designing

1 Starting circuit

Fig.7 Diagram of Starting Circuit and It's Peripheral Portion



1-1 Setting starting resistance

Concerning stand-by current (0.15mA) MAX. and *starting time of power supply, the value of starting resistor R_9 is obtained by the following equation.

*For ex.) during 0.5s, C_{10} is charged to the level of operation starting voltage (18.5V) MAX.

$$R_9 = (V_{IN(DC)} - V_{CC(ON)}) / [0.15 \times 10^{-3} + (18.5 \times C_{10})/0.5]$$

$V_{IN(DC)}$: DC input voltage

(Minimum input voltage which is necessary for IC to start operation ex. $70V_{AC} \times \sqrt{2} = 99V_{DC}$)

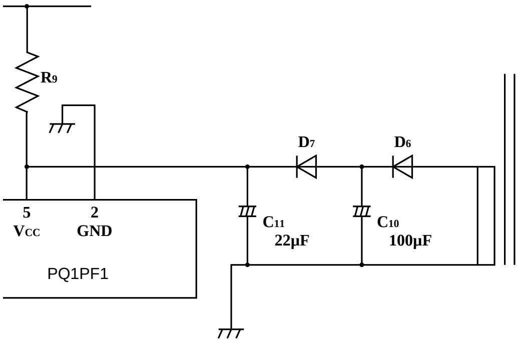
$V_{CC(ON)}$: Operation starting voltage of IC (18.5V MAX.)

When IC start to operate, current to V_{CC} terminal increases. The current is supplied by an auxiliary winding of main tramsformer. After rectification of auxiliary winding, voltage (both side of C_{10}) must be set on operation stopping voltage ($V_{CC(OFF)}$=9.3V Typ.) or more. MOS-FET driving voltage in IC is about 13V, which is applied from Vcc terminal. When Vcc is about 16.5V or more, MOS-FET driving voltage is in optimum condition due to built-in voltage regulator circuit for driving voltage.

1-2Extending the capacity of smoothing capacitor (C_{10}) for auxiliary winding voltage.

After smoothing rectification of auxiliary winding (both sides of C_{10}=Vcc), ripple voltage becomes high by turns and diameter of auxiliary winding. When voltage falls below operation stopping voltage$V_{CC(OFF)}$, it may sometimes cause operating error. In this case, it is recommended to extend C_{10}. However, starting time becomes longer due to extending C_{10} because starting time is determined by both startig resistor R_9 and C_{10}. To shorten the starting time, it is recommended to employ 2-step rectification circuit. (Fig.8)

Fig.8 2-step Rectification Circuit



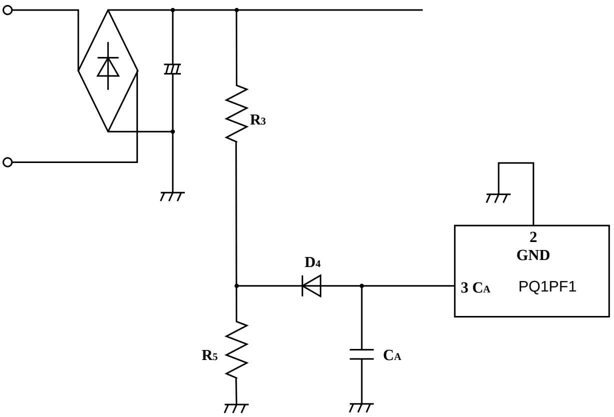
As a standard in designing, proper capacity of C_{11} is 10 to 47µF.
Extending the capacity of C_{10} in 2-step rectification circuit, current to Vcc terminal can be supplied from storaged charge in C_{10} after starting operation IC.

1-3 Slow up input

During slow up start (input voltage is gradually rising), there is some cases that output is soon shut down after it starts to operate. It is because output voltage does not exceed the rated value due to halfway of slow up starting.

A fall of output voltage during operating IC makes photocoupler PC_1 (Fig.2) in voltage control system OFF-state. In that condition, CA terminal voltage is not fixed at 3.6V, and start to rise soon after starting to operate IC. When CA terminal voltage exceeds $V_{CA\ (OVP)}$ 7.7V, output of IC is shut down. To avoid the shud down, output must be kept the rated level, making operation starting voltage higher. Or add a discharge circuit of capactor C_A which is connected to CA terminal. (Fig.9)

Fig. 9 Circuit Diagram for Slow Up Input



To avoid shut down, keep V_{CA} below 7.7V, by discharging the charge of C_A at R_5 through D_4.

To do this, use a power supply which can supply the rated power under the condition that AC input voltage is $75V_{AC}$, R_3 and R_5 are designed as follows when AC input voltage is less than $75V_{AC}$.

Electric potential of both side of R_5 stands for V_{R5}.

$V_{R5}<7.7-V_{FD4}$ V_{FD4} : forward voltage of diode D_4

When current flowing into R_3 is 0.2mA,

$$R_3 = (\sqrt{2}V_{IN\ (AC)\ [MIN]} - 7.7 + V_{FD4}) / (0.2 \times 10^{-3})$$

$$R_5 = (7.7 - V_{FD4}) / (0.2 \times 10^{-3})$$

$V_{IN\ (AC)\ [MIN]}$: Minimum input voltage to gain the rated output

1-4 Redudtion of restarting time from shut-down state

Under the shut down condition due to overcurrent and overvoltage protection function, once supply voltage of IC (Vcc) must be lowered below operation stopping voltage $V_{CC\ (OFF)}$ 9.3V TYP. in order to restart the power supply. Generally, AC input voltage is once turned off. However, in cases that starting resistor R_9 is connected after smoothing rectification of input voltage(Reter to Fig. 10), it takes sometimes unexpected time to make the electric potential of Vcc drop to less than 9.3V. This is due to storaged charge of smoothing capacitor C_6.

In this case, connect a starting resistor before rectification of AC input voltage(Reter to Fig. 11). And Vcc has no influence of storaged charge of smoothing capacitor C_6 while AC input voltage is OFF. Vcc soon drop to 0V, and that can shorten the restarting time.

Fig.10 Connecting Starting Resistor after Rectification

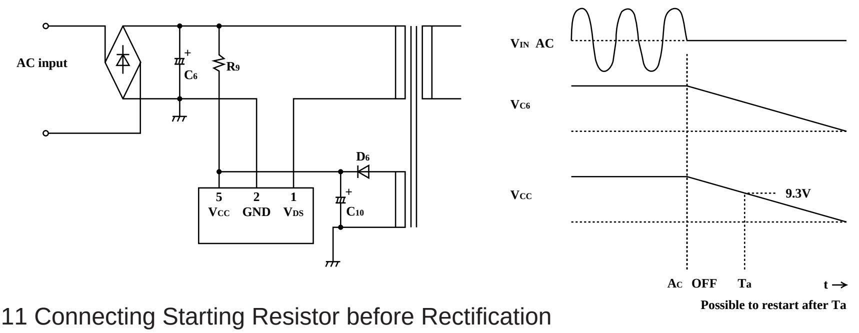
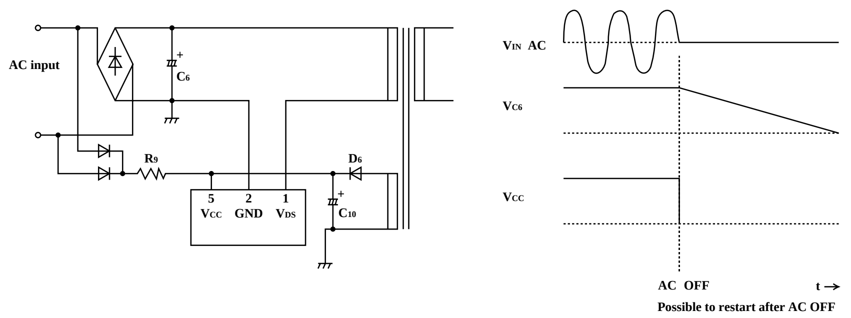


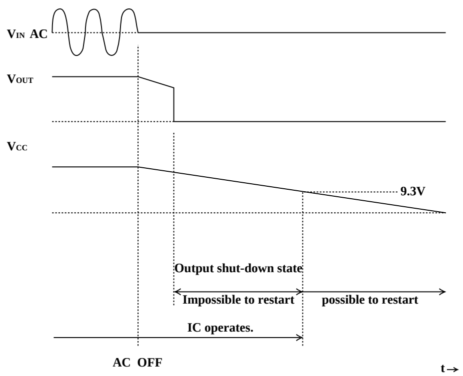
Fig.11 Connecting Starting Resistor before Rectification



While AC input voltage is OFF, output of IC is shut down and it takes some time to restart. This is because electric potential of IC input terminal (Vcc) is more than operation stopping voltage$V_{CC\ (OFF)}$ 9.3V Typ., and IC keeps operating.(Refer to Fig.12)

In this case, connect the starting resistor before smoothing so that Vcc soon drops to 0V. As a result, output will not be shut down while AC input voltage is OFF. (Refer to Fig.11)

Fig. 12 Timing Chart at OFF-state of AC Input Voltage (Connecting Starting Resistor after Rectification)



2 Patterning to Printed Circuit Board

Patterning to a printed circuit board may cause a noise and a malfuntion. Especially for dotted line portion Fig.13, reduce the roop area and make the pattern thick and short because high frequency current flows in that portion.

The capacitor C_{12} which should be connected to CA teminal must be connected as close as possible to IC, and auxitiary winding GND must be directly connected to IC GND (do not connect by way of control system GND).

Fig. 13 Patterning to PCB