PQ1CF2

TO-220 Type Chopper Regulator

Features

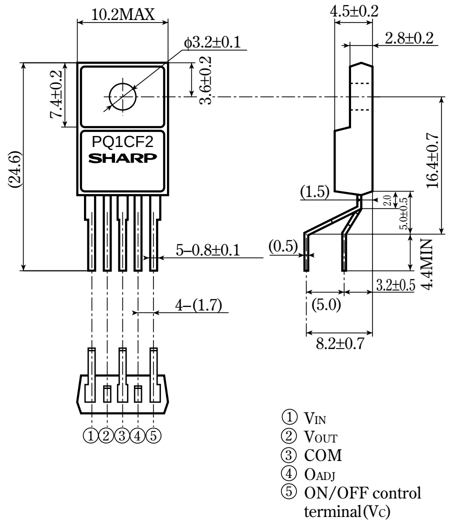
- Maximum switching current:1.5A
- Built-in ON/OFF control function
- Built-in soft start function
- Built-in oscillation circuit
  (oscillation frequency: TYP.100kHz)
- Built-in overheat protection, overcurrent protection function
- TO-220 package
- Variable output voltage
  (V_{ref} to 35V/-V_{ref} to-30V)
  [Possible to choose step down output/inversing output according to external connection circuit]

Applications

- Switching power supplies
- Facsimiles
- Printers
- Personal computers

Outline Dimensions

(Unit : mm)



Absolute Maximum Ratings

(T_a=25˚C)

Parameter	Symbol	Rating	Unit
※1 Input voltage	V_{IN}	40	V
Error input voltage	V_{ADJ}	7	V
Input-output voltage	V_{i-o}	41	V
※2 Output-COM voltage	V_{OUT}	-1	V
※3 ON/OFF control valtage	V_C	-0.3 to 40	V
Switching current	I_{SW}	1.5	A
Power dissipation (No heat sink)	P_{D1}	1.5	W
Power dissipation (With infinite heat sink)	P_{D2}	15	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_{IN} terminal and COM terminal.
※2 Voltage between V_{OUT} terminal and COM terminal.
※3 Voltage between V_C terminal and COM terminal.
※4 Overheat protection may operate at 125<=T_j<=150˚C

• Please refer to the chapter " Handling Precautions ".

Electrical Characteristics

(Unless otherwise specified, conditions shall be V_{IN}=12V, I_O=0.2A, V_O=5V⑤terminal is open. T_a=25˚C)

Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	Unit
Output saturation voltage	V_{sat}	I_O=1A,No L,D,C_O	—	0.9	1.5	V
Reference voltage	V_{ref}	—	1.235	1.26	1.285	V
Reference voltage temperature fluctuation	ΔV_{ref}	T_j=0 to 125˚C	—	±0.5	—	%
Load regulation	$\|R_{eg}L\|$	I_O=0.2 to 1A	—	0.1	1.5	%
Line regulation	$\|R_{eg}I\|$	V_{IN}=8 to 35V	—	0.5	2.5	%
Efficiency	η	I_O=1A	—	82	—	%
Oscillation frequency	fo	—	80	100	120	kHz
Oscillation frequency temperature fluctuation	Δfo	T_j=0 to 125˚C	—	±6	—	%
Maximum duty	D_{MAX}	④ terminal is open	90	—	—	%
Overcurrent detecting level	I_L	No L,D,C_O	1.55	2.0	2.6	A
Charge current	I_{CHG}	②④ terminal is open	-15	-10	-5	µA
Input threshold voltage	V_{THL}	Duty=0%, ④terminal=0V, ⑤terminal	1.95	2.25	2.55	V
	V_{THH}	Duty=D_{MAX}, ④terminal is open. ⑤terminal	3.25	3.55	3.85	V
On threshold voltage	V_{THON}	④terminal=0V,⑤terminal	1.05	1.4	1.75	V
Stand-by current	I_{SD}	V_{IN}=40V, ④terminal=0V	—	150	400	µA
Output OFF-state dissipation current	I_{qs}	V_{IN}=40V, ⑤terminal=3V	—	8	12	mA

Block Diagram

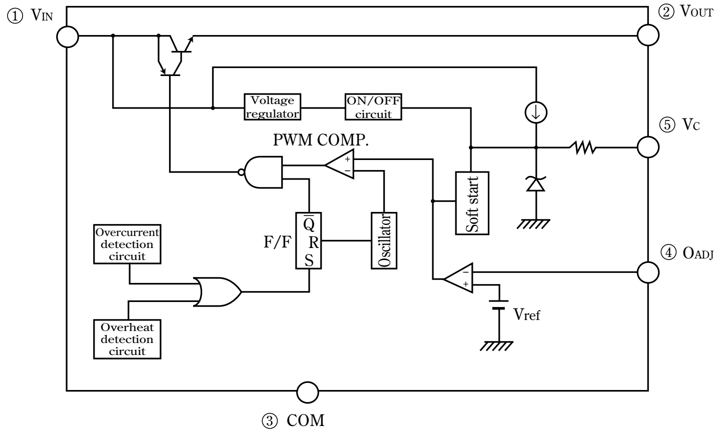
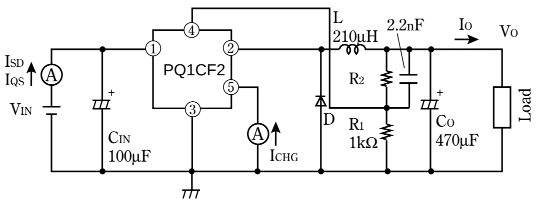
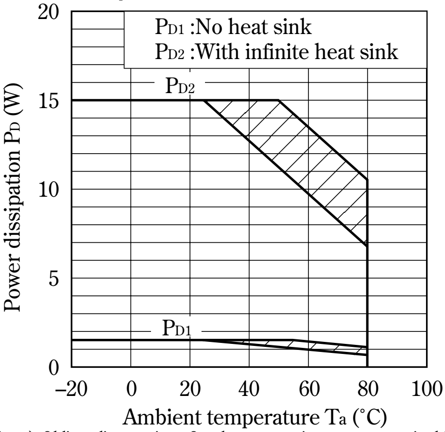


Fig. 1 Test Circuit



L : HK-14D100-2110(made by Toho Co.)
D : ERC80-004(made by Fuji electronics Co.)

Fig. 2 Power Dissipation vs. Ambient Temperature



Note) Oblique line portion : Overheat protection may operate in this area.

Fig. 3 Overcurrent Protection Characteristics (Typical Value)

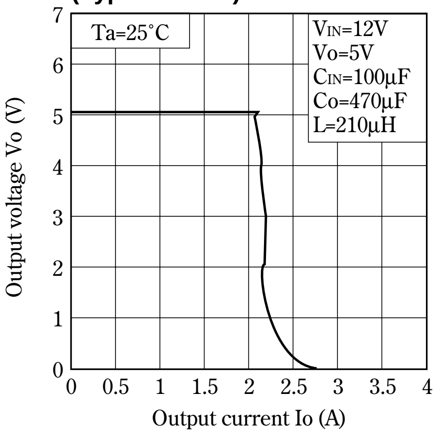


Fig. 4 Efficiency vs. Input Voltage

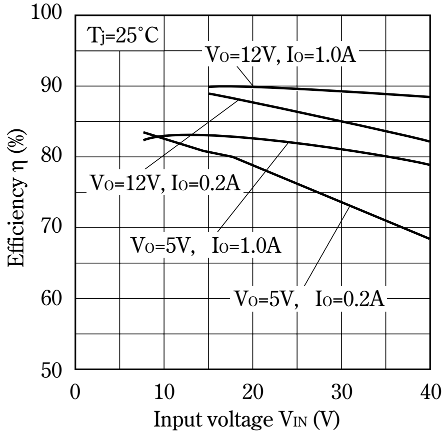


Fig. 5 Switching Current vs. Output Saturation Voltage

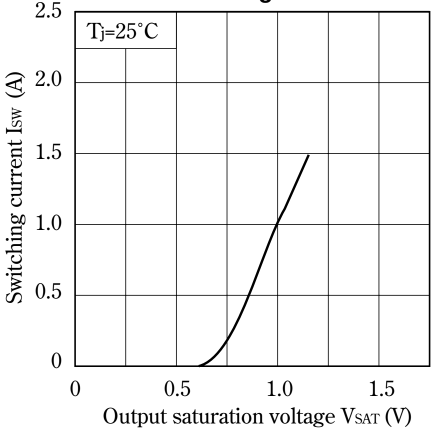


Fig. 6 Stand-by Current vs. Input Voltage

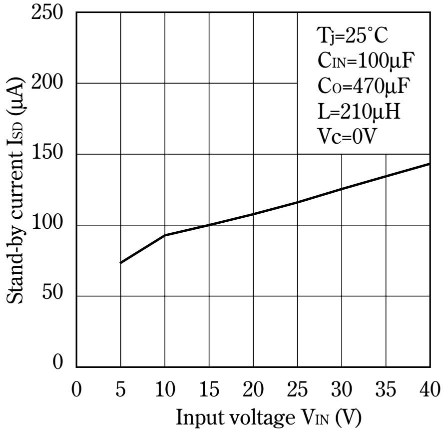


Fig. 7 Load Regulation vs. Output Current

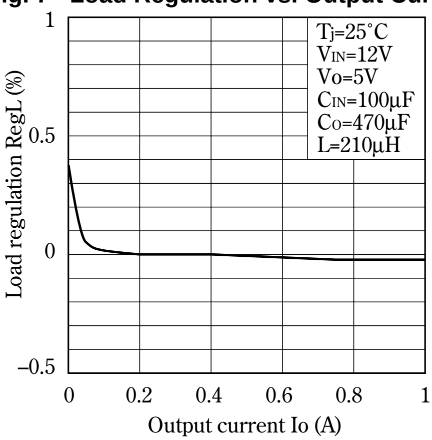


Fig. 8 Line Regulation vs. Input Voltage

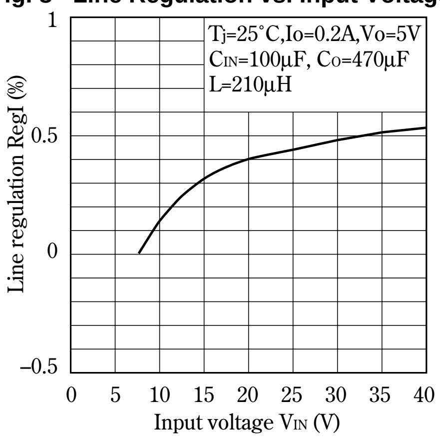


Fig. 9 Oscillation Frequency Fluctuation vs. Junction Temperature

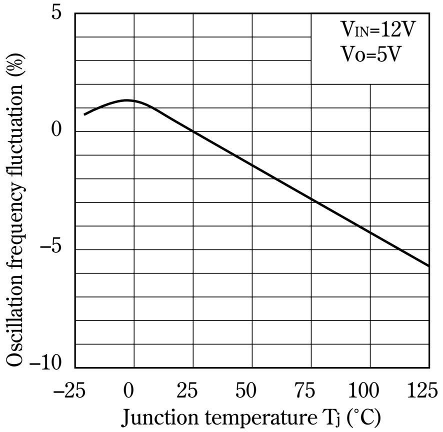


Fig.10 Overcurrent Detecting Level Fluctuation vs. Junction Temperature

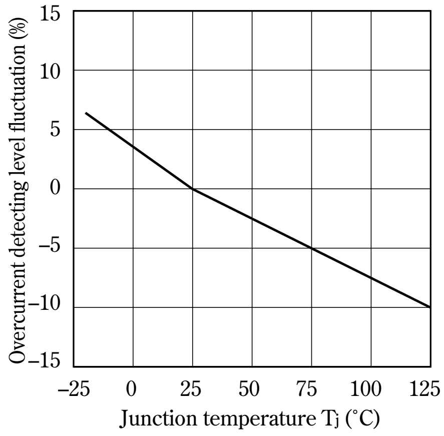


Fig.11 Threshold Voltage vs. Junction Temperature

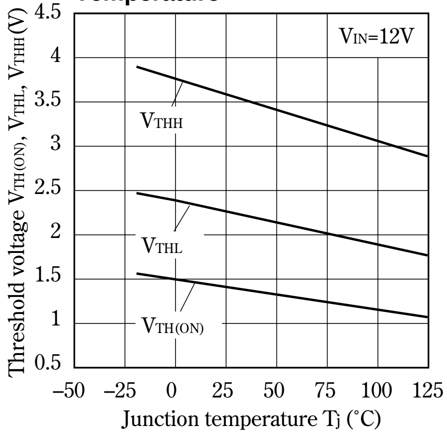
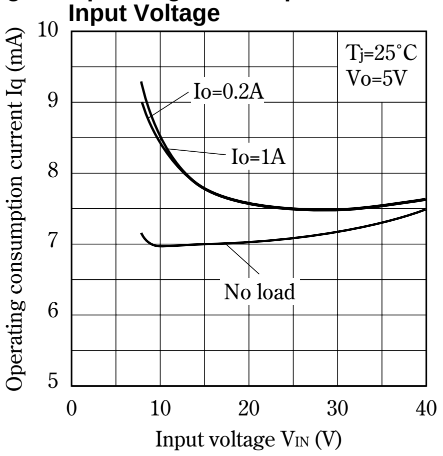
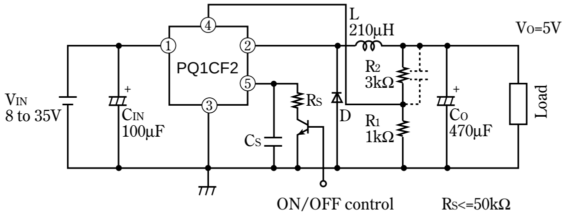


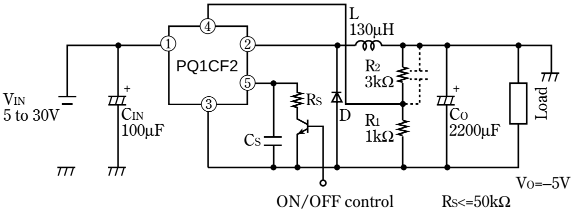
Fig.12 Operating Consumption Current vs. Input Voltage



■ Step-down Type Circuit Diagram (5V Output)



Polarity Inversion Type Circuit Diagram (-5V output)



Precaution for use

(1) ON/OFF control terminal

ON/OFF control terminal ⑤ has ON/OFF function and soft start function. It operates by level of ON/OFF control terminal voltage. (as shown in fig.1)

<ON/OFF control>

In the following circuit, when ON/OFF control terminal ⑤ becomes low by switching transistor Tr on, output voltage may be turned OFF and the device becomes stand-by mode. Dissipation current at stand-by mode becomes TYP.150µA.

<Soft start>

When capacitor Cs is added on terminal ⑤, voltage of ⑤ is gradually getting upper because of internal constant current. When voltage of ⑤ is higher than V_{THL} output, output pulse starts. And the higher voltage becomes, the wider output pulse width is. When main power supply turns on, output pulse gradually expands and output voltage will start softly.
Too large capacitance Cs causes long discharging time. In case of input voltage turning time from OFF to ON is short, soft start function may not operate.
In this case, additional capacitor discharging circuit as shown in Fig.3 can make discharging time short. In order to set voltage point A is higher than V_{THH}(3.85V) in ordinary state, please design value of resistor R_4, R_5 from several kΩ to several dozens kΩ.

<ON/OFF control with soft start up>

For ON/OFF control with capacitor Cs, be careful not to destroy a transistor Tr by discharge current from Cs, adding a resistor restricting discharge current of Cs.

Fig. 1

Step–down voltage circuit

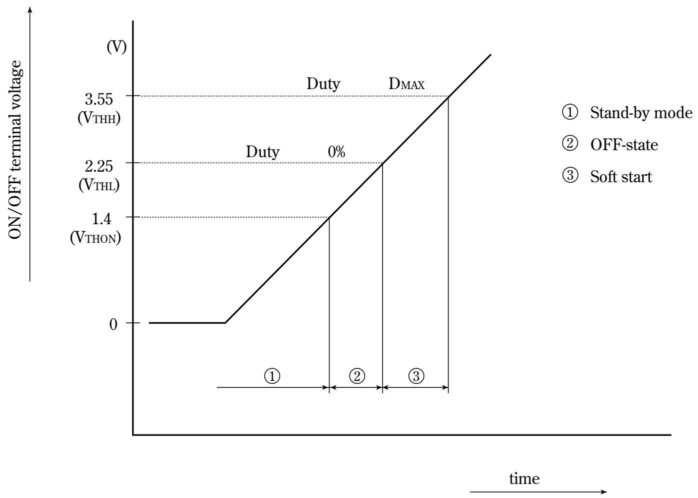


Fig. 2 ON/OFF Control and Soft Start

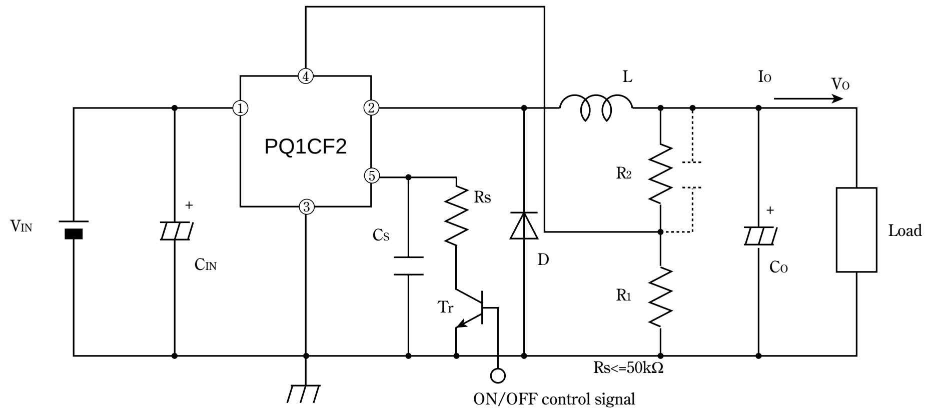
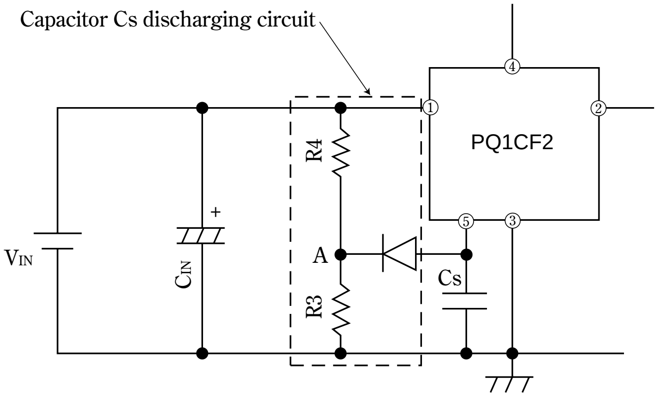


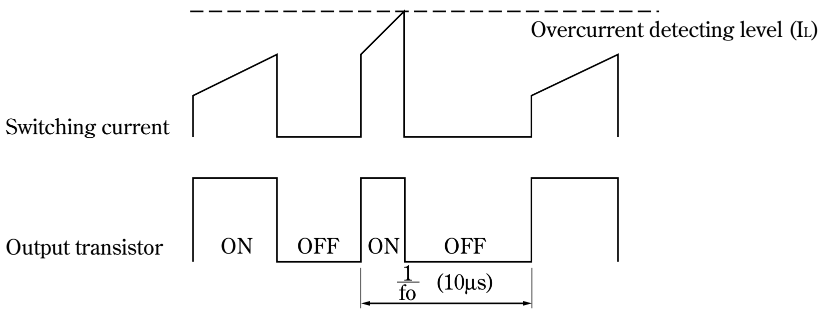
Fig. 3 Capacitor Cs Discharging Circuit



(2) Overcurrent protection

When switching current exceeds overcurrent detecting level (IL), overcurrent protection function turns off the output Tr in no time, and it maintains off-state of output Tr to next ON pulse. It means folding characteristics by pluse-by-pulse method.

Fig. 4



Precautions in Designing

①Adjustment of output voltage

Output voltage can be adjustable by attaching external resistor R_1 and R_2 to ③, ④, or output terminal. Adjustable range is as follows.

a) Step-down voltage type

$V_O=V_{ref}$ to 35V

Maximum value is limited to 0.9 x ($V_{IN}-V_{SAT}$) by input voltage.

b) Polarity inversion type

$V_O=-V_{ref}$ to −30V

V_O is limited to $40-V_{IN}-V_F$ by input voltage.

Output voltage $|V_O| = V_{ref} \times (1+R_2/R_1)$ (V)

②Coil

<<Step-down voltage type>>

In first time, the ratio of output transistor on time (T_{ON}) and catch-diode on time (T_{OFF}) is obtained by the following equations.

$$D\,(\text{Duty}) = \frac{T_{ON}}{T\,(\text{cycle})} = \frac{V_O+V_F}{V_{IN}-V_{SAT}+V_F}$$

$$L\,(\text{Coil inductance}) = \frac{V_{IN}-V_{SAT}-V_O}{\Delta I_L} \times D \times \frac{1}{f_O} \quad \text{(H)}$$

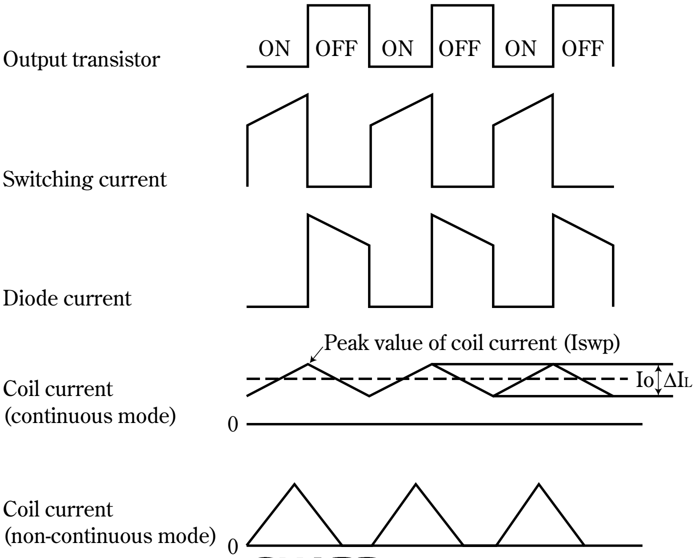
$$I_{swp}\,(\text{Peak value of coil current}) = I_O + \frac{\Delta I_L}{2} = I_O + \frac{V_{IN}-V_{SAT}-V_O}{2 \times L} \times D \times \frac{1}{f_O}$$

V_{IN} : Input voltage
V_O : Output voltage
V_F : Forward voltage of catch-diode
V_{SAT} : V_{IN}-V_{OUT} voltage at transistor ON
f_O : Oscillation frequency

Please design ripple current (ΔI_L) set up about 20 to 30% of output current (I_o), and set up continuous mode. So, it is said to be the good balance of inductor and output capacitor.

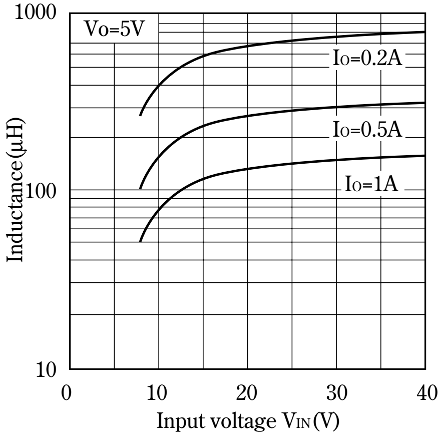
Please select the inductor which the current rating is at least 1.2 times greater than maximum peak current.

Fig. 5



Approximate inductance of coil (at output voltage is 5V)is shown in fig.6

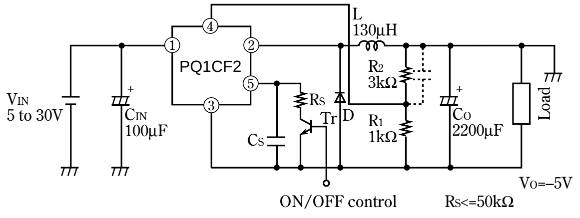
Fig. 6 Approximate Inductance of coil



<<Polarity-inversion type>>

In case of polarity-inversion type, it operates different from step down voltage type. In order to have stable output voltage, please select the inductor of from 47µH to 200 µH.

Fig. 7 Circuit Example for Polarity Inversion Type



③ Output capacitor (Co)

The output ripple voltage is highly influenced by ESR (Equivalent Series Resistor) of output capacitor, and can be minimized by selecting low ESR capacitor.

Generally, smaller capacitance, lower breakdown voltage of capacitor make ESR of capacitor high. By use of high grade "low impedance" electrolytic capacitor, output ripple voltage will decrease.
In continuous mode, output ripple voltage and ripple allowance current of capacitor are obtained by the following equations.

<Step down type>

Output ripple voltage $(V_{RIP\,P-P}) = \Delta I_L \times ESR$ (V)

$$\Delta I_L = \frac{V_{IN} - V_{SAT} - V_O}{L} \times D \times \frac{1}{f_O}$$

Ripple allowance current (effective value) $= \Delta I_L$ (A)

④ Catch diode

High switching speed and low forward voltage type schottky barrier diode should be recommended for the catch-diode D because it affects the efficiency. Please select the diode which the current rating is at least 1.2 times greater than maximum switching current.

⑤ Input capacitor (C_{IN})

Please select the input capacitor with low ESR and sufficient ripple current rating, wiring as near as possible the regulator.
In low temperature operating, ESR of capacitor increases, capacitance will greater than usual.
In continuous mode, ripple allowance current of capacitor is obtained by the following equation.

$$\text{Ripple allowance current (effective value)} = I_O \times \frac{\sqrt{V_O \times (V_{IN} - V_O)}}{V_{IN}} \quad \text{(A)}$$

(3) Thermal protection design

Internal power dissipation (P) of device is generally obtained by the following equation.

$P = I_{SW}$(Average) x V_{SAT} x D + V_{IN} (voltage between V_{IN} to COM terminal) x I_Q' (consumption current) · · · ①

Step down type

$$D\,(\text{Duty}) = \frac{T_{ON}}{T\,(\text{period})} = \frac{V_O + V_F}{V_{IN} - V_{SAT} + V_F}$$

I_{SW} (Average) = I_O (Output current)

Polarity inversion type

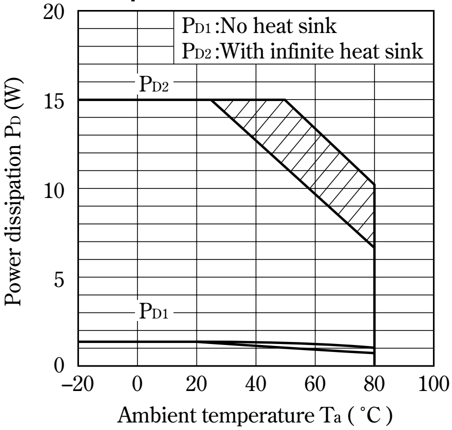
$$D\,(\text{Duty}) = \frac{T_{ON}}{T\,(\text{period})} = \frac{|V_O| + V_F}{V_{IN} + |V_O| - V_{SAT} + V_F}$$

$$I_{SW}(\text{Average}) = \frac{1}{1-D} \times I_O$$

I_Q' : Consumption current in operating mode
V_F : Forward voltage of the diode

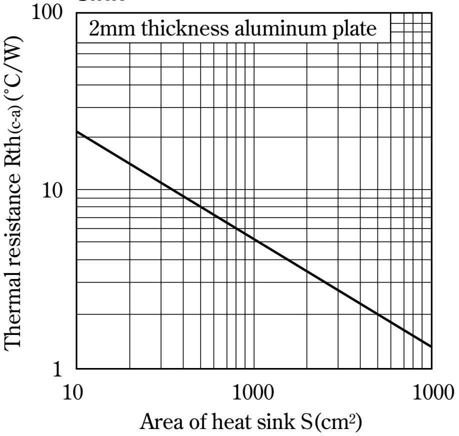
When ambient temperature T_a and maximum power dissipation P_D (MAX.) during operation are determined, use a Cu plate which allows the element to operate within the safety operation area specified by the derating curve. Insufficient radiation gives an unfavorable influence to the normal operation and reliability of the device.
In the external area of the safety operation area shown by the derating curve, the overheat protection circuit may operate to shut-down output. However, please avoid keeping such condition for a long time.

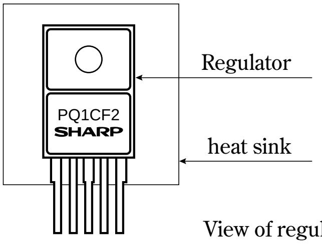
Fig. 8 Power Dissipation vs. Ambient Temperature



Oblique line portion : Overheat protection may operate in this area.

Fig. 9 Thermal Resistance vs. Area of Heat sink





View of regulator attached on the center of square heat sink.

Precations in designing heat sink

Area of heat sink is obtained as follows,

(A) Increasing junction temperature difference from ambient temperature (ΔT_j) is obtained as follows.

$\Delta T_j = T_j - Ta$

It is recommended that T_j=70 to 80% of T_jMAX.

(B) Thermal resistance $R_{th(j\text{-}a)}$ is obtained from ΔT_j and internal dissipation loss (P) obtained from equation ①

Thermal resistance $R_{th(j\text{-}a)} = \Delta T_j / P$ ˚C/W

(C) Thermal resistance of heat sink $R_{th(c\text{-}a)}$ is obtained from $R_{th(j\text{-}a)}$

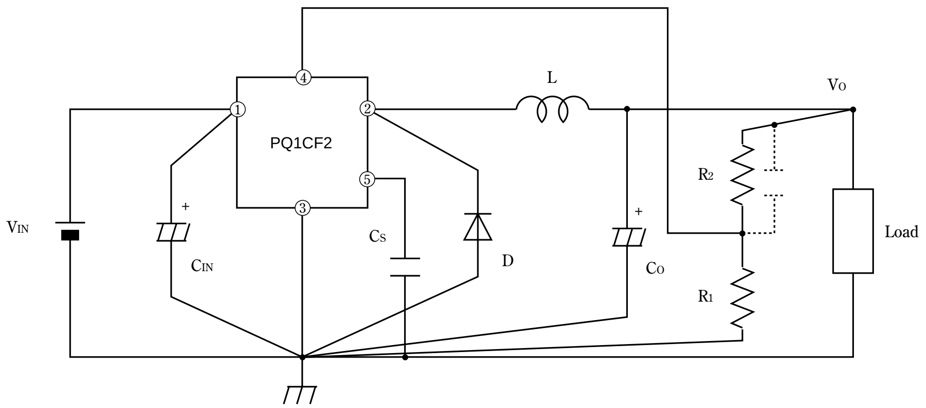
Thermal resistance $R_{th(c\text{-}a)} <= R_{th(j\text{-}a)} - R_{th(j\text{-}c)}$ ˚C/W

On condition that $R_{th(j\text{-}c)}$ of PQ1CF2=6.67˚C/W

(D) Area of heat sink is obtained from thermal resistance $R_{th(c\text{-}a)}$ with thermal resistance-heat sink area characteristics.

(4) External connection

Fig.10



① Wiring condition is very important. Noise associated with wiring inductance may cause some problems. For minimizing inductance, it is recommended to design the thick and short pattern (between large current diodes, input/output capacitors, and terminal 1, 2. Single-point grounding (as indicated) should be used for best results.

② When output voltage is not stable, it can be improved by attaching capacitor (from several nF to several dozens nF) to external resistor R_2.

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  --- Telecommunication equipment [terminal]
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  --- Industrial control
  --- Audio visual equipment
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