# General Information

## ■ General Description

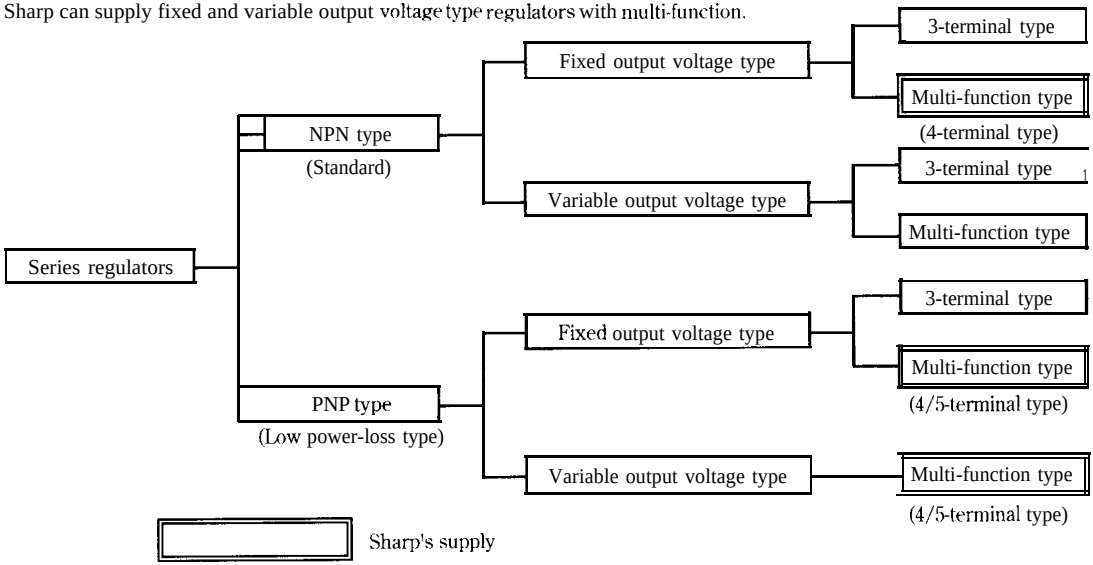
A voltage regulator enables to get specific stable DC voltage without being affected by fluctuation of input voltage, load current, and ambient temperature. It is widely used for every power supply for drives, controllers, and operating devices in equipment.

The regulators are classified into linear regulators and switching regulators. Linear regulators are classified into series regulators and shunt regulators. Generally, linear regulators are used in the audio equipment, VCRs, and electronic musical instruments because of their low ripple and low noise characteristics. On the other hand, the switching regulators are classified into chopper type and converter type. They are mainly used for medium and high power supplies (more than 20W) owing to their high efficiency. Sharp's regulators are series regulators, chopper regulators, and primary regulators which are used in primary side of switching power supplies.

## ■ Classification of Series Regulators

The series regulators are divided into two types; NPN type and low power-loss PNP type. They are also classified by output into two groups ; fixed output voltage type and variable output voltage type. Another available modification is the multi-function type with added functions such as ON/OFF control function and reset signal generation function in addition to the output voltage supplying function.

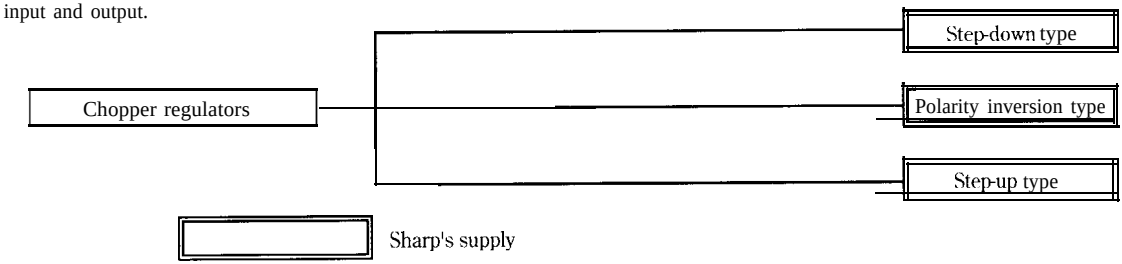
Sharp can supply fixed and variable output voltage type regulators with multi-function.




## ■ Classification of Chopper Regulators

The chopper regulators are classified into step-down type, polarity inversion type, and step-up type. They change the input voltage into constant voltage (DC) by repetition of circuit ON/OFF.

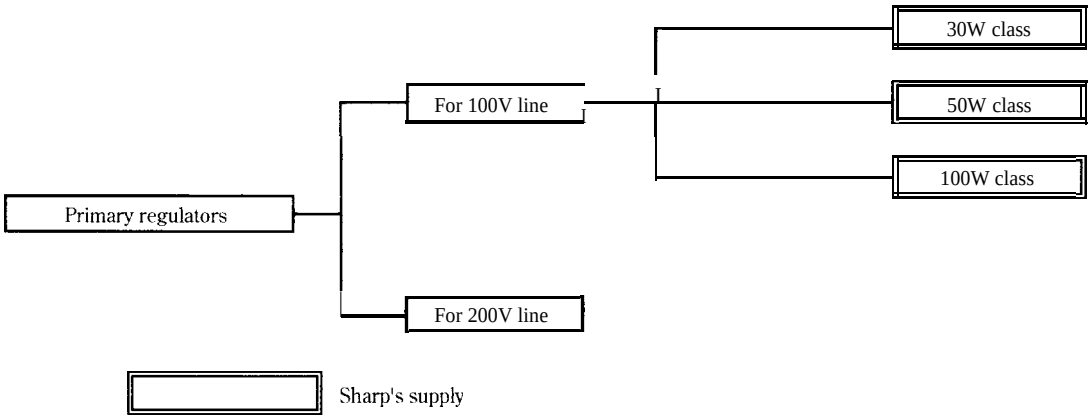
Thermal power-loss of chupper regulators is extensively low. So, they are suitable for large voltage difference applications between input and output.



## ■ Classification of Primary Regulators

Primary regulators which are used for primacy side of switching power supplies realized an integration of power MOS-FET and control IC into a single package

Primary regulators can reduce the number of components and reduce the power-loss compared with discrete construction. They are suitable for switching power supplies, personal computers, TVs, VCRs and word processors




※Primary regulator is a trademark of the SHARP Corporation

## ■ Features of Sharp's Low Power-Loss Voltage Regulators

① Low power-loss: Low dropout voltage

② Multi-functions : Built-in ON/OFF control function, output minute adjustable type, variable output voltage type, low dissipation current type at OFF-state, built-in reset signal generation function and overheat shut-down function

③ Built-in protection functions: Overcurrent protection function, overheat protection function, input-output reverse voltage protection function

④ Various package

. Equivalent to TO-220 full-mold 4-terminal (Lead forming type is also available.)

. Equivalent to TO-3P 5-terminal

. Equivalent to SC-63 3-terminal (Tape-packaged products are also available,)

Equivalent to SC-63 5-terminal (Tape-packaged products are also available.)

⑤ Industry's first RCJ certification (based on 1S0-9001)"

1 › Owing to low power-loss

| Conventional type | Dropout voltage MAX. 2.5V |
|---|---|

This input-output difference voltage, however, causes power-loss, and heat generation. Therefore, it is better to reduce the dropout voltage.

| Sharp's low power-loss voltage regulator | Dropout voltage MAX. 0.5V |
|---|---|

Owing to reduction of power-loss, the size of heat sink can be reduced.
The input voltage can be reduced in designing. Therefore the transformer winding can be reduced,
In case of battery drive, the service life of battery is long, even when the battery voltage drops.
The power-loss is reduced and the power efficiency is improved. As a result, the output current has been increased from MAX. 1.OA or so to MAX. 4.6A. (Equivalent to TO-220 package), MAX, 10A (TO-3P package),
. High energy efficiency enables power saving of equipment.

2. Multi-functions

• ON/OFF control function : The ON/OFF control function enables power saving of equipment. (It is possible to provide the equipment with a function tu operate only the stand-by power supply in stand-by mode and to turn on the main power supply in ordinary use.)

output minute adjustable type, variable output voltage type
: It is possible to get minute adjustment of the output voltage and variable output voltage by using two externally attached resistors.

Low dissipation current at OFF-state
: It is suitable for battery-drive equipment because of low dissipation current at OFF-state (stand-by mode).

. Reset signal generation function : When power supply is turned on, resetting is worked for the specified time to initialize the system. In case of instantaneous interruption or lowering of output voltage, the system reset signal is generated so as to prevent errors of microcomputer.

( )verheat shut-down function : ( )wing to TEMIC (Temperature IC : SHARP's trade mark. It is an integration of (temperature sensor and IC), output is shut-down to prevent excessive heat when detecting overheat (Junction temperature ≧ 11 0°C.) Once output is shut-down, output do nuf return until restart or Vc (ON/OFF control terminal) changes from "Low" to "High".

3. Protection functions

Overcurrent protection function : This function is worked **when** current exceeding the rating flows to output. A particular case is short-circuiting. In this case the output current lowers instantaneously and is stabilized.

overheat protection functior This function is worked when the chip temperature exceeds the specified limit due to insufficient heat radiation which may be caused as a result of the current exceeding the designed current or power consumption exceeding the designed limit in short-circuited state. It operates at about Tj ≧ 125 C.
The output is kept turned off until the temperature drops below the specified limit. The normal operation is automatically restored when the temperature lowers

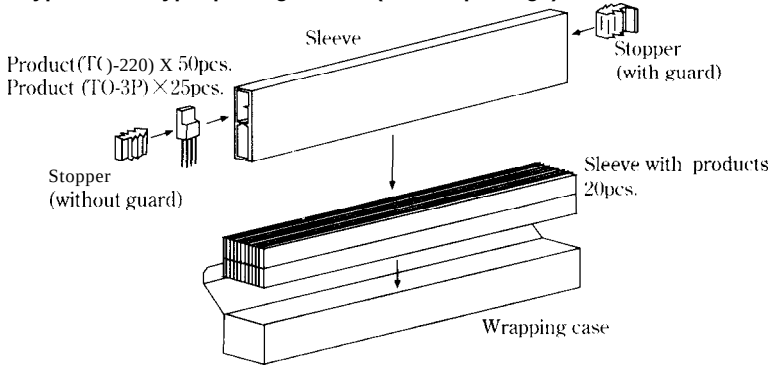
input-output reverse voltage protection function
: This function is to protect the element when the electric potential of output terminal exceeds the one of input terminal (for example input instantaneous short-circuit, etc.).

(Note) Although the protection functions are designated to protect the element upon occurrence of trouble, the detection point is not warranted value. Please design within an absolute maximum ratings.

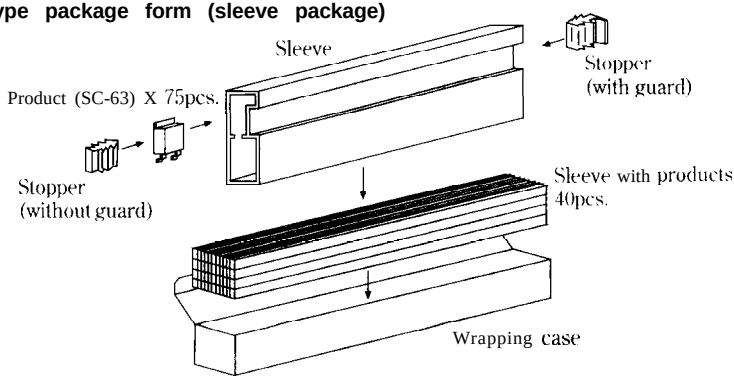
4 Various package

Since the insulation sheet is not required when the heat sink is mounted, production cost can be reduced.
Full-mold enables complete insulation with adjacent devices, which improves safety.
Surface mount package enables automatic high density mounting.
Surface mount type regulators employ taping package. (Refer to the following figure.)

**TO-220 type/TO-3P type package form (sleeve package)**




**SC-63 type package form (sleeve package)**

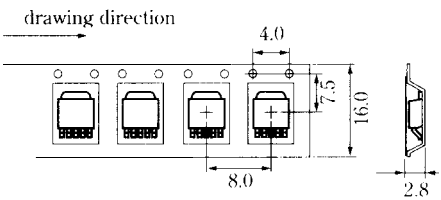


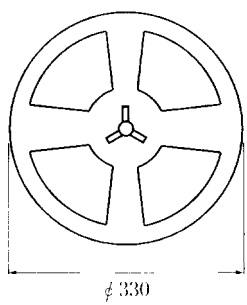

● **SC-63 type package form (taping package)**

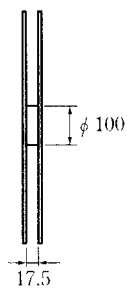
EIAJ (RC-1009B)
. EIAJ RC-1009B-TE1608L
Taping material: Polystyrene

· EIAJ (RC-1009B)
· EIAJ RC-1009B-R33
· 1 reel (3000pcs.)

Size: TYP value
Unit: mm



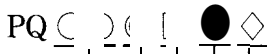




5 Acquisition of RCJ certification based on ISO 9000 series
High quality and high reliability are supported by reliable quality control system.

< RCJ quality certification mark >

## ■ Numbering System (Low Power-Loss Voltage Regulator)



None, 2,5 : Standard output voltage precision (reference voltage precision) type (±5%/±4%)
0,1,3,4,5,6 : High precision output voltage (reference voltage precision) type (±2.5%/±2%)
A, B, C, D, F, G, H : Lead forming type
T, U : Tape-packaged type
V : Output voltage minute adjustment type (Adjustment range: *10%)

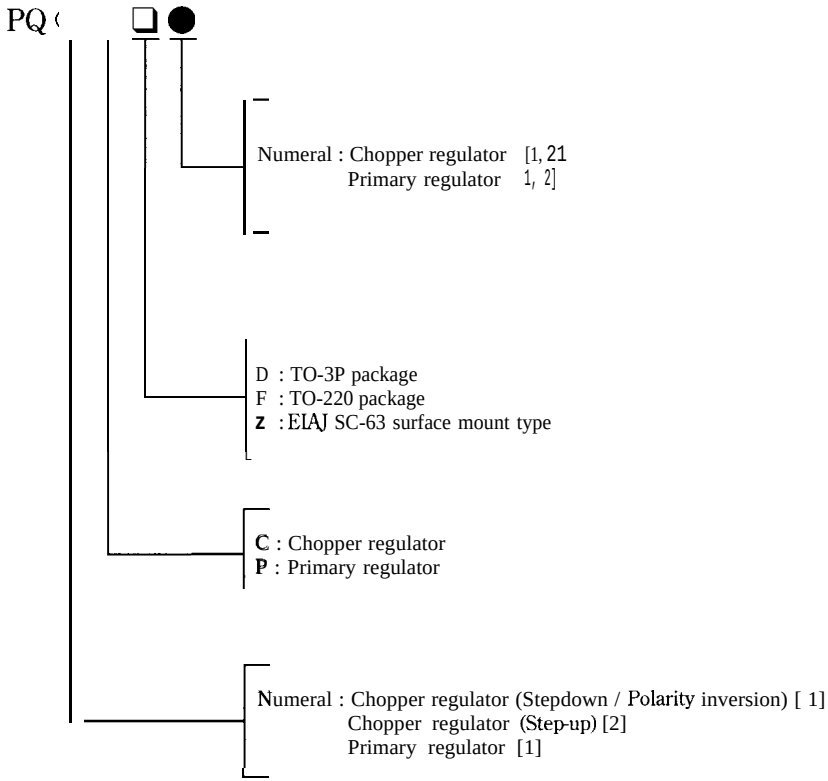
— Numeral : Represents the output current
[1 ": 1A (1.5A), 2: 2A, 3: 3A (3.5A), 4: 4.6A, 5 : 0.5A (5A), 10: lOA]

A : OFF-state low dissipation current type, full-mold package
B : overheat shut-down function, full-mold package
D, F : Full-mold package (except TO-3P)
G : Reverse voltage protection type, full-mold package
H : 1.5A output current, full-mold package
R, S : Full-mold package with reset signal generation function
V : Variable output voltage type
Z : Surface mount type

N : NPN transistor output type
R : TO-220 full-mold package
S : EIAJ SC-633-tefiinal package
T : EIAJ SC-63 5-terminal package
D : TO-3P package
V : Variable output voltage type

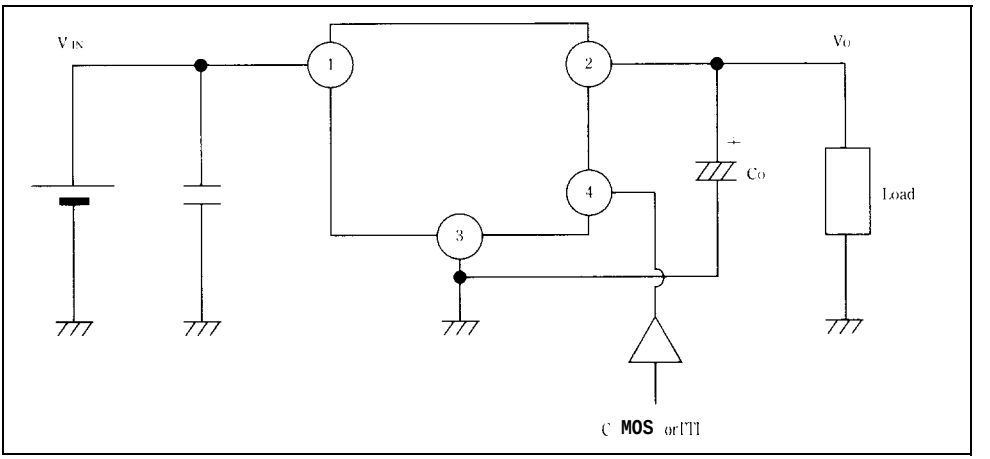
Numeral : Represents the output voltage [2: 2.5V, 3: 3.0V (or 3.3V), 05 or 5: 5V (or 5.1V or 5.3V), 09: 9V (or 9.3V), 12 : 12V (or 12.3V), 15 : 15v (or 15.7V), 7 (or 20 or30) : Variable]

## ■ Numbering System (Chopper Regulator/ Primary Regulator)



## ■ Precaution for Use of Low Power-Loss Voltage Regulators (TO-220/ TO-3P series)

### (1) External connection (TO-220 series)

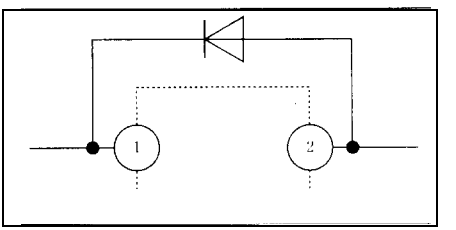



① The connecting wiring of Co and each terminal must be as short as possible. Owing to type, value and wiring condition of capacitor, it may oscillate. Confirm the output waveform under the actual condition before using.

② ON/OFF control terminal 4 is compatible with LS-TTL. It enables to be directly drive by TTL or C-MOS standard logic (RCA4000 series). If ON/OFF" control terminal is not used, it is recommended to directly connect applicable terminals with input terminal.

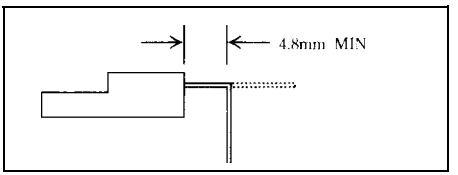
③ If voltage is applied under the conditions that the device pin is connected divergently or reversely, the deterioration of characteristics or damage may occur. Never allow improper mounting.

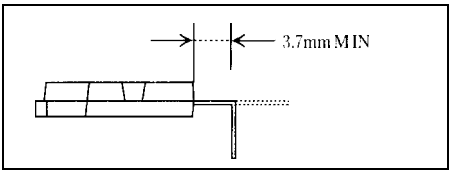
④ If voltage exceeding the voltage of DC input terminal (1) is applied to the output terminal 2, the element maybe damaged. Especially when the DC input terminal ! is short-circuited to the GND in ordinary operating state, charges accumulated in the output capacitor Co flow to the input side, causing damage to the element. In this case, connect the ordinary silicon diode as shown in the figure.



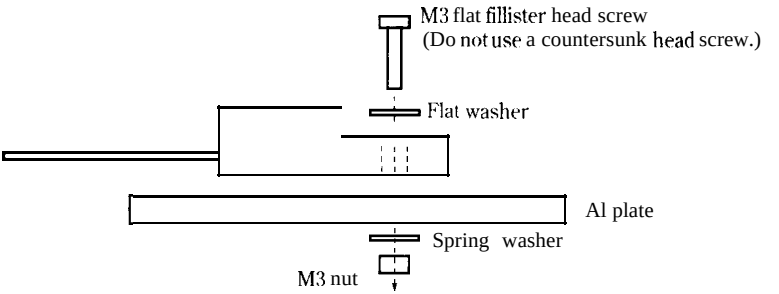
## (2) Mounting

1 In case of lead forming, please be careful to keep minimum size as follows so that mechanical stress shall not be applied to the portion between terminal and mold resin




2) Please be careful to meet the following items in mounting a device to a heat sink
Refer to the following drawing in tightening screws.




Please be careful not to apply mechanical stress to the lead terminal in mounting and after mounting.
[n case of TO-220, 0,4 to 0.5N m torque is recommended, (In case of TO-3P, 0,4 to 0.6N . m torque)

Be careful to meet the following requirements so that the heat from inside of device shall be radiated efficiently and mounting shall not cause damages for the device,

(A) Warp and unevenness shall not occur on the contact surface between the heat sink and device.

(B) Metal dust and burr shall not be attached to the contact surface between the heat sink and device.

(C) Silicone grease shall be uniformly applied on the contact suface between the heat sink and device. Please select the following grease.

(a) No secular variation in operating temperature range.

fb) Base oil does not separate and it does not permeate into the device.

(c) Even if base oil permeates into the device, operation and life time are not given bad influence.

Fur example, we recommend G-746; Shin-Etsu Chemical Cu., Ltd. and SC-102 ; Dow Corning Toray Silicone Co.. Ltd.

(D) Please use a M3 flat fillister head screw. Do not use a countersunk head screw etc.

### (3) Thermal protection design

Maximum power dissipation of devices is obtained by the following equation.

$$P_D = I_O \times (V_{IN} - V_U)$$

When ambient temperature $T_a$ and power dissipation $P_D$ (MAX.) during operation are determined, use a heat sink 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.

### (4) ESD (Electro Static Discharge)

Be careful not to apply electro static discharge to the device since this device employs a bipolar IC and maybe damaged by electro static discharge. Followings are some methods against excessive voltage caused by electro static discharge.

① Human body must be grounded to discharge the electro charge which is charged in the body or cloth.

② Anything that is in contact with the device such as workbench, inserter, or measuring instrument must be grounded.

③ Use a soldering dip basin with a minimum leak current (isolation resistance 10M Ω or more) from the AC power supply line Also the soldering dip basin must be grounded.

### (5) For cleaning

Be careful to meet the following requirements in cleaning.

① Solvent cleaning : Solvent temperature : 45℃ or less, Immersion :3 min. or less

② Ultrasonic cleaning : The influence to device by ultrasonic cleaning is different by the size of cleaning bath, ultrasonic power output, cleaning time, PWB size or device mounting condition etc. Please test it in actual using condition and confirm that no detects arise beforehand.

③ Applicable solvent : Ethyl alcohol, Methyl alcohol, Isopropyl alcohol.

Before using alternative solvents, confirm that they do not dissolve the package resin or promote corrosion within the chip.

A use of fluorocarbons type solvents is internationally prohibited. Do not use solvents containing these substances.

(6) Precautions in designing heat sink of regulators (TO-220, TO-3P Series)

1 In case that thermal resistance of heat sink is indistinct :

Take the case temperature ($T_C$) with $\phi 0.1$ (mm) thermocouple between device case and heat sink. (Ambient temperature is MAX temperature of ordinary operating condition,)

$T_j = P \times R_{th(j-c)} + T_c$

$= (V_{i-O} \times I_O) \times R_{th(j-c)} + T_c$

Confirm $T_j \leqq T_j MAX$ (125-C), (It is recommended that $T_j$ is 70 to 80% of TIMAX.)

2 In case that thermal resistance of radiation plate is distinct :

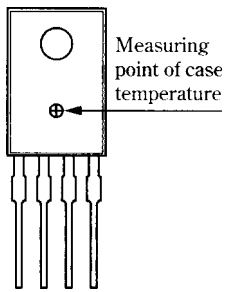
$T_j = P \times R'_{th(j-a)} + T_a$

$= (V_{i-O} \times I_n) \times R'_{th(j-a)} + T_a$ On condition that $R'_{th(j-a)} = R_{th(j-c)} + R_{th(c-a)}$

Confirm $T_j \leqq T_j MAX$ (125℃). (It is recommended that $T_j$ = 70 to 80% of $T_j MAX$.)

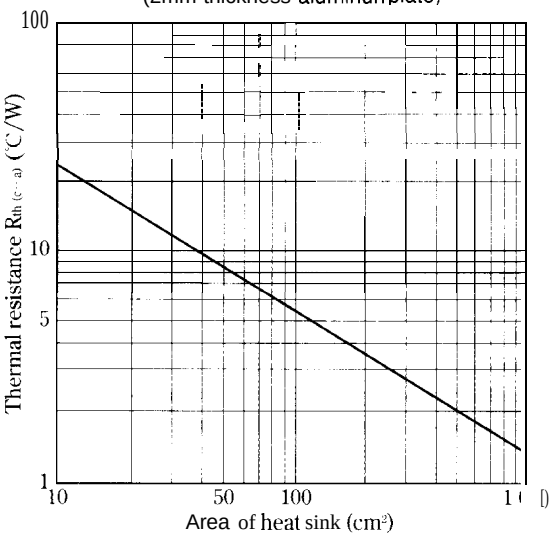
However, it is desirable to confirm on the mounted condition, so it is recommended to take 1) method,

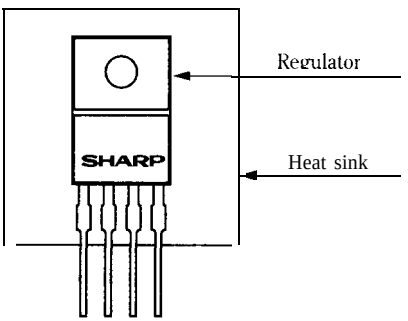
P : Power dissipation of device
$T_a$ : Ambient temperature (MAX)
$T_c$ : Case temperature (MAX)
$R_{th}$ (~<) : Thermal resistance between junction and case
1A regulator: 6.67℃/W
1.5A, 2A regulator: 5.56℃/W
3A regulator: 5.00℃/W
4A regulator :5.56℃/W
5A, 10A regulator :1.67℃/W
$R'_{th(j-a)}$: Thermal resistance between junction and ambience with heat sink



Reverse side of device

Thermal Resistance-Area of Heat Sink
(2mm thickness aluminun plate)

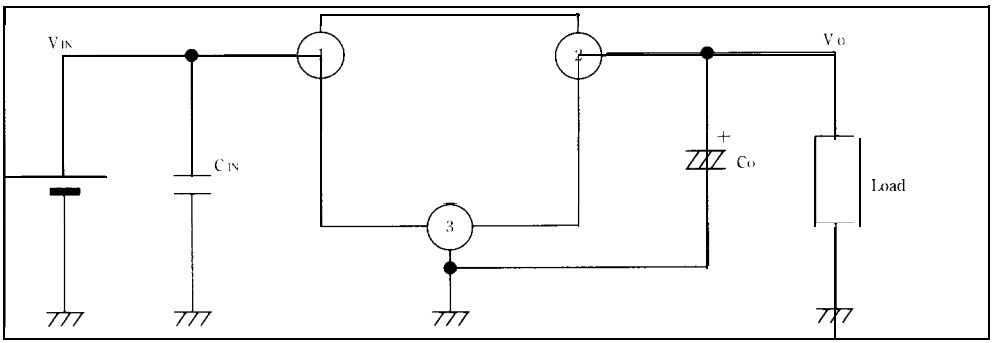


View of regulator attached on the center of square heat sink

## ■ Precautions for Use of Low Power-Loss Voltage Regulators (SC-63 Series)

### (1) External connection




1. The connecting wiring of $C_O$, $C_{IN}$ and each terminal, fin portion must be as short as possible. It may oscillate by type, value and wiring condition of capacitor. Confirm tbe output wareform in actual using condition beforehand.
2. If voltage is applied under the conditions that device pin is connected divergently or reversely, the deterioration of characteristics or damage may occur. Never allow improper mounting.

### (2) Thermal protection design

Maximum power dissipation of devices is obtained by the following equation.

$$P_D = I_O \times (V_{IN} - V())$$

When ambient temperature $T_a$ and power dissipation $P_D$ (MAX.) during operation are determined, use a heat sink 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.

### (3) ESD (Electro Static Discharge)

Be careful not to apply electro static discharge to the device since this device employs a bipolar IC and maybe damaged by electro static discharge. Followings are some methods against excessive voltage caused by electro static discharge.

1. Human body must be grounded to discharge the electro charge which is charged in the body or cloth.
2. Anything that is in contact with the device such as workbench, inserter, or measuring instrument must be grounded.
3. Use a soldering dip basin with a minimum leak current (isolation resistance 10M Ω or more) from the AC power supply line. Also the soldering dip basin must be grounded.

### (4) For cleaning

Be careful to meet the following requirements in cleaning.

1. Solvent cleaning : Solvent temperature : 45 C or less. Immersion :3 min. or less
2. Ultrasonic cleaning : The influence to device by ultrasonic cleaning is different by the size of cleaning bath, ultrasonic power output, cleaning time, PWB size or device mounting condition etc. Please test it in actual using condition and confirm that no detects arise beforehand.
3. Applicable solvent : Ethyl alcohol, Methyl alcohol, Isopropyl alcohol.

Before using alternative solvents, confirm that they do not dissolve the package resin or promote corrosion within the chip.

A use of fluorocarbons type solvents is internationally prohibited. Do not use solvents containing these substances.

**(5) Soldering**

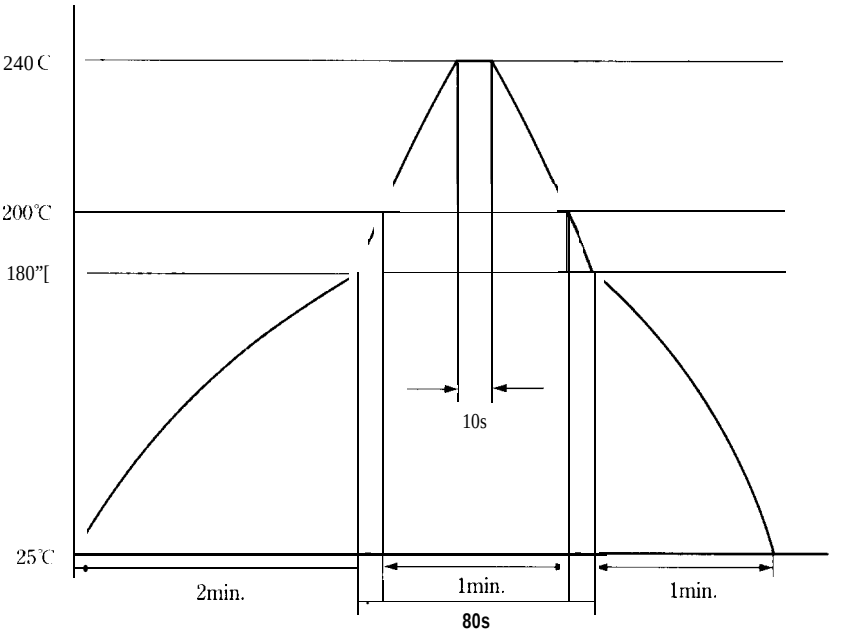
**1** Reflow soldering

Maximum 2 times soldering * is available within the temperature profile shown below. temperature shown in the figure is the temperature in a fin portion of the devices.)

(A) A use of infrared lamps to heat up for soldering may cause a localized temperature rise in the resin. The temperature of resin portion should be within the temperature profile below.

(B) The **temperature rise in soldering-reflow should** be 4 ℃/s or less.

* ‘ PQ X X S2 series/PQ2TZ X X series /PQ3TZ X X series/PQ7VZ5/PQ20VZ X X series : 2 times or less




2 Dip soldering

It is recommended that only one soldering dip should be done at 260℃, for 10s or less. Please be careful to meet the note items below concerning dip soldering,

(A) Please cool the device naturally after soldering dip.

(PI) Please be careful nut to give any mechanical stress or the impact stress to the device during naturally cooling,

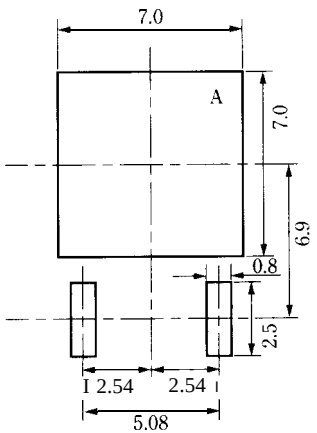
Even under the above conditions, there is a possibility that the stress given to the terminals by the deformation of PWB makes the gold wire cut in the package. Please confirm under the condition of actual use beforehand.

## (6) Mounting

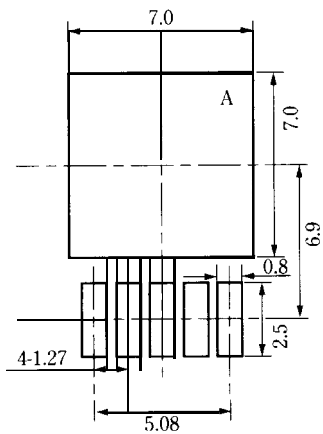
Standard mounting patterns of surface mount type regulators

Following is the standard mounting pattern of surface mount type regulators. A pattern of radiation plate is A portion shown below. In actual use, however, Cu area must be suited to power dissipation based on derating curve of each data of data book.

3-terminal package equivalent to SC-63




5-terminal package equivalent to SC-63




(Unit: mm)

## ■ Cares When Composing the Negative Output Power Supply

The positive and negative power supplies can be used in the following way. Fig. 1

Use a multiple transformer, and add the protection diodes (D1, D2*), and decoupling capacitor. For the RA, RG, RR, SZ, TZ series, the $V_F$ value of protection diode should be less than 0.8V (Silicon diode). For other regulators, the value should be less than 0.4V (schottky diode).

For the variable output type RV series, set the value of protection diode so that the terminal ④ (output voltage adjustment terminal Vadj) is set to Vadj $> -0.4$V.

(Such configuration of center trap transformer as applied for negative power supply type 3-terminal regulator of 79 series is not applicable. Fig. 2)

*If there is a load Rx given directly from $V_{O1}$ to $V_{O2}$ as shown in Fig. 1 and if one of regulators is started earlier than other owing to difference of output start-up time in Regl and Reg2, the voltage of output terminal of one regulator lowers below GND potential, resulting in malfunction or damage to the regulator. The protection diodes prevents such malfunction and damage.

Fig.1 Example Circuit of Positive/Negative Power Supply

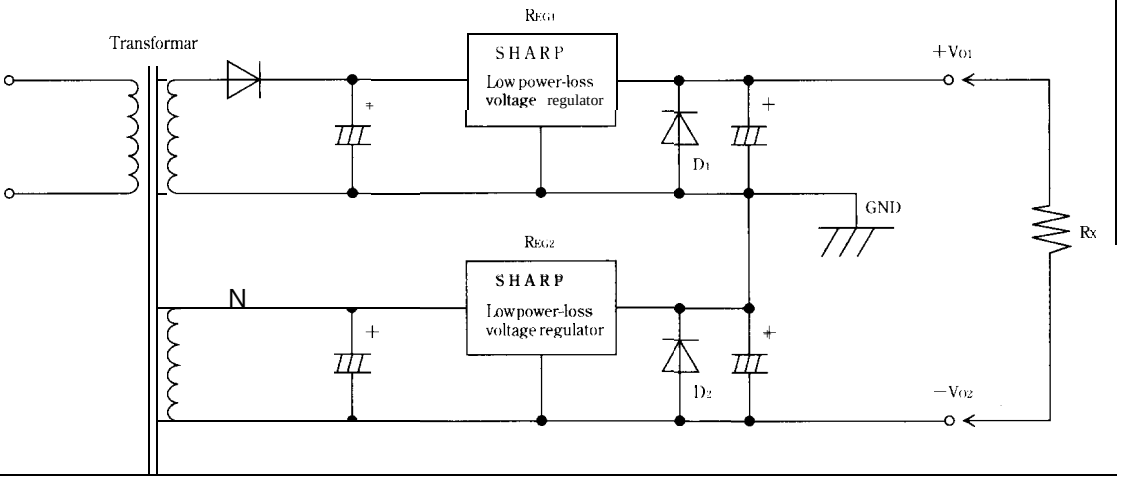
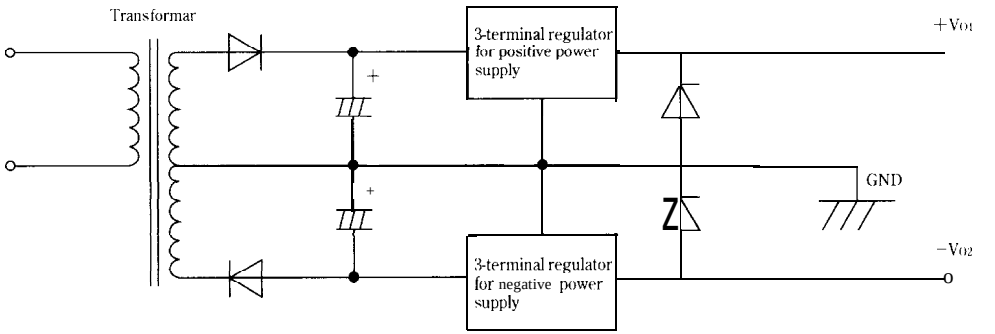
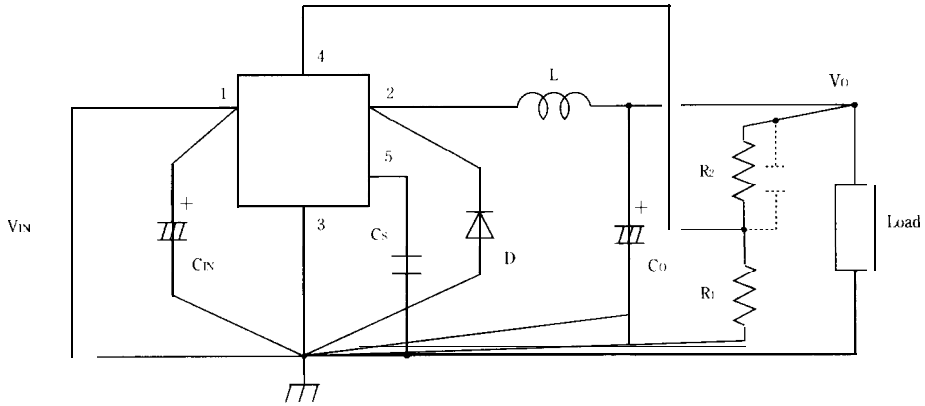



Fig.2 Example of Center Tap Transformer Circuit of Negative Power Supply Type 3-terminal Regulator



## ■ Precaution for Use of Chopper Regulators (SC-63 Series)

### (1) External connection




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 $R_2$.

③ 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.

④ The output ripple voltage is highly influenced by ESR (Equivalent Series Resistor) of output capacitor, and can be minimized by selecting Low ESR capacitor.

⑤ An inductor should not be operated beyond its maximum rated current so that it may not saturate.

### (2) Thermal protection design

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

$P = I_{SW}$ (Average) $\times V_{SAT} \times D' + V_{IN}$ (voltage between $V_{IN}$ to COM terminal) $\times I_q'$ (consumption current)

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

$$D' \text{ (Duty)} = \frac{T_{ON}}{T(\text{period})} = \frac{V_O + V_F}{V_{IN} + V_O - V_{SAT} + V_F}$$

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

$V_F$: 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 externalarea 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 fur a long time.

### (3) Adjustment of output voltage

output voltage can be adjustable by attaching external resistor $R_1$ anrf $R_2$ to}, 1or output terminal. Adjustable range is as follows.

a) Step-down voltage type

$V_O = V_{ref}$ to 35V

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

b) Polarity inversion type

$V_O = -V_{ref}$ to $-30$V

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

output voltage $V_O \fallingdotseq V_{ref}$ (1.26) X $(1 + R_2/R_1)$ (V)

### (4) ON/OFF control terminal

( ON/OFF control)

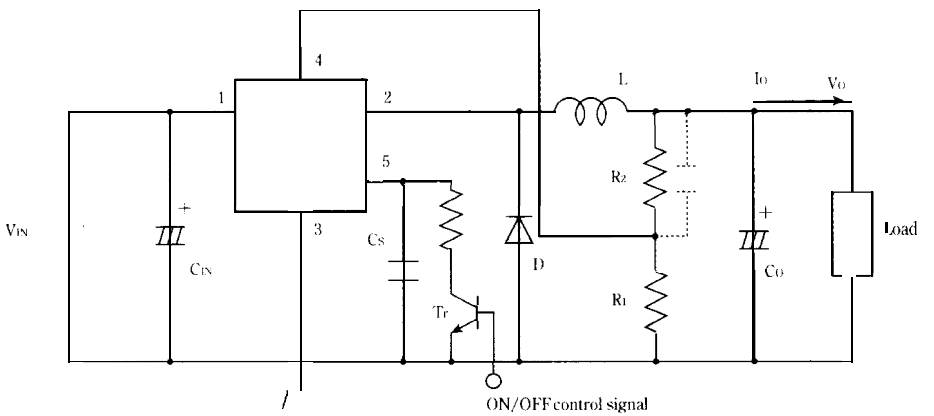
In the following circuit, when ON/OFF control terminal 5 becomes low by switching transistor Tr on, output voltage may be turned OFF and the device becomes stand-by mode. Dissipation current at stand-by mode becomes Max. 400$\mu$A.

( Soft start)

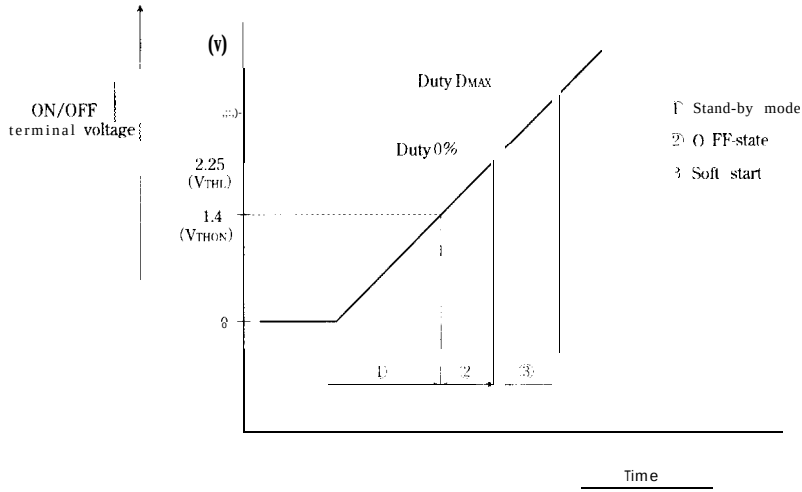
When capacitor Cs is loaded, output pulse gradually expanded and output voltage will start softly.

( f) N/OFF control with soft startup>

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.




Step-down Output Type Circuit Diagram




### (5) Soldering

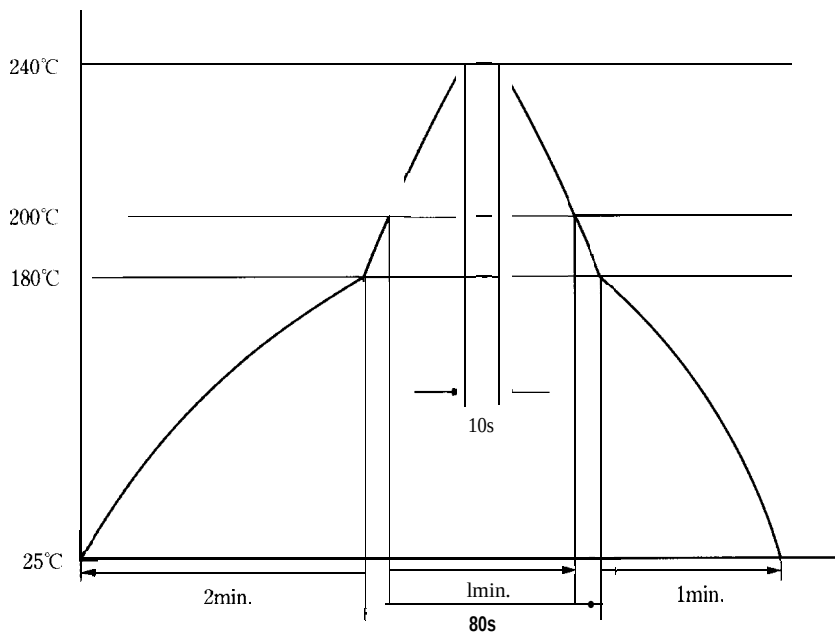
① Reflow soldering

It is recommended that only one soldering should be done within the temperature profile shown below. (Temperature shown in the figure is the temperature in a fin portion of the devices.)

(A) Please avoid mounting to ceramic PWB.

(B) A use of infrared lamps to heat up for soldering may cause a localized temperature rise in the resin. The temperature of resin portion should be within the temperature profile below.

(C) The temperature rise in soldering-reflow should be 4℃/s or less.



② Dip soldering

It is recommended that only one soldering dip should be done at 260'C, for 10s or less. Please be careful to meet the note items below concerning dip soldering.

(A) Please cool the device naturally after soldering dip.

(B) Please be careful not to give any mechanical stress or the impact stress to the device.

Even under the above conditions, there is a possibility that the stress given to the terminals by the deformation of PWB makes the gold wire cut in the package.

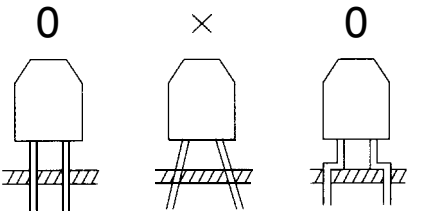
Please confirm under the condition of actual use beforehand.

③ Distance and stress

In order to avoid thermal damage to the device, solder should be applied to the lead portion only, and must be kept a specified distance away from the point where the leads meets the body.

Care must be taken to avoid unusual stresses during soldering. In particular, never overheat the resin area, and avoid mechanical stresses to resins and leads. Failure to exercise these precautions can cause problems such as package cracking, lead/resin separation, or breakage of the gold wire, resulting in a dramatic loss in reliability or a significant change in operating characteristics.

Soldering methods include dip soldering (wave soldering), reflow soldering, and application by soldering iron. Here we describe typical soldering methods and the potential problems that they can cause to optoelectronic devices.




Avoid Stressing of Leads

Common Adverse Effects of Soldering

| | |
|---|---|
| Appearance | Separation of resin from lead<br>Package cracking |
| Reliability | Lowered humidity resistance<br>Lowered insulation strength<br>Gold-wire breakage |

## (6) For cleaning

Be careful to meet the following requirements in cleaning.

① Solvent cleaning: Solvent temperature: 45℃ or less, Immersion: 3 min. or less

② [Ultrasonic cleaning: The influence to device by ultrasonic cleaning is different by the size of cleaning bath, ultrasonic power output, cleaning time, PWB size or device mounting condition etc. Please test it in actual using condition and confirm that no defects arise beforehand.

③ Applicable solvent: Ethyl alcohol, Methyl alcohol, Isopropyl alcohol.

Before using alternative solvents, confirm that they do not dissolve the package resin or promote corrosion within the chip.

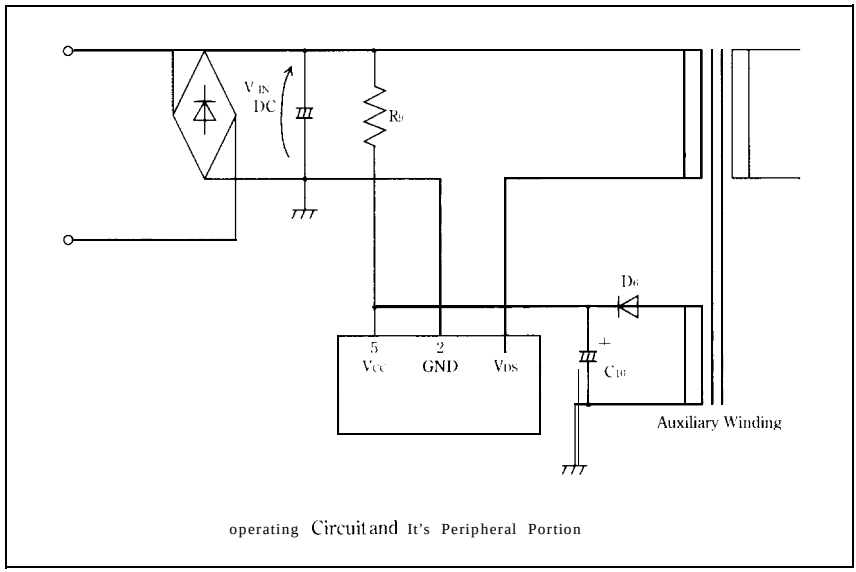
A use of fluorocarbons type solvents is internationally prohibited. Do not use solvents containing these substances.

## ■ Precautions for Use of Sharp's Primary Regulators (TO-220 Series [PQ1PF11 )

### (1) For designing

1 Starting circuit

Following is a diagram of operating circuit and it's peripheral portion.




operating Circuit and It's Peripheral Portion

2 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 tu 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. $70V_{AC} \times \sqrt{2} = 99V_{DC}$ )

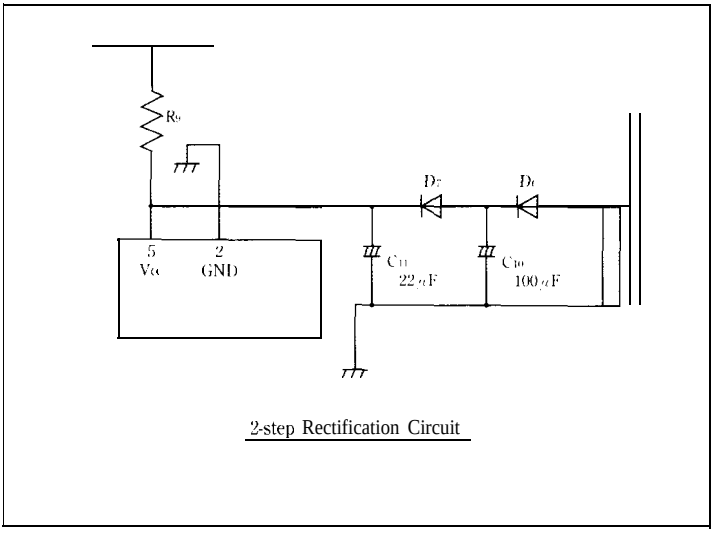
$V_{CC(ON)}$: operation starting voltage of IC (18.5V MAX.)

When IC starts to operate, current to $V_{CC}$ terminal increases. The current is supplied by an auxiliary winding of main transformer. After rectification of auxiliary winding, voltage (both sides of $C_{10}$) must be set on operation stopping voltage ($V_{CC(ON)}$=9.3V Typ.) ur 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.

3 Extending 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 diameters 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 buth starting resistor $R_9$ and $C_{10}$. "10 shorten the starting time, it is recommended to employ 2-step rectification circuit. (Refer to following figure.)



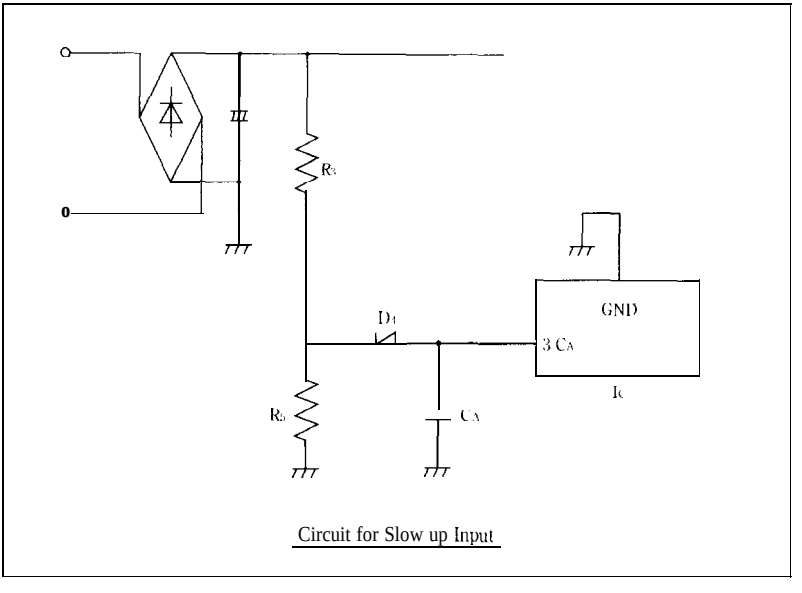

2-step Rectification Circuit

As a standard in designing, proper capacity of $C_{11}$ is 10 to 47 μF.
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 of IC

(4. Slow up input

During slow up start (input voltage is gradually rising), there are some cases when output is soon shut down after it starts to operate, This 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 in voltage control system OFF-state. In that condition, CA terminal voltage is not fixed at 3.6V, and will 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 shut down, output must be maintained at the rated level, making operation starting voltage higher, or add a discharge circuit of capacitor $C_A$ which is connected to CA terminal. (refer to the figure. )




Circuit 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 $75V_{AC}$. To do this, ues a $R_3$ 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 $V_{R5}$.

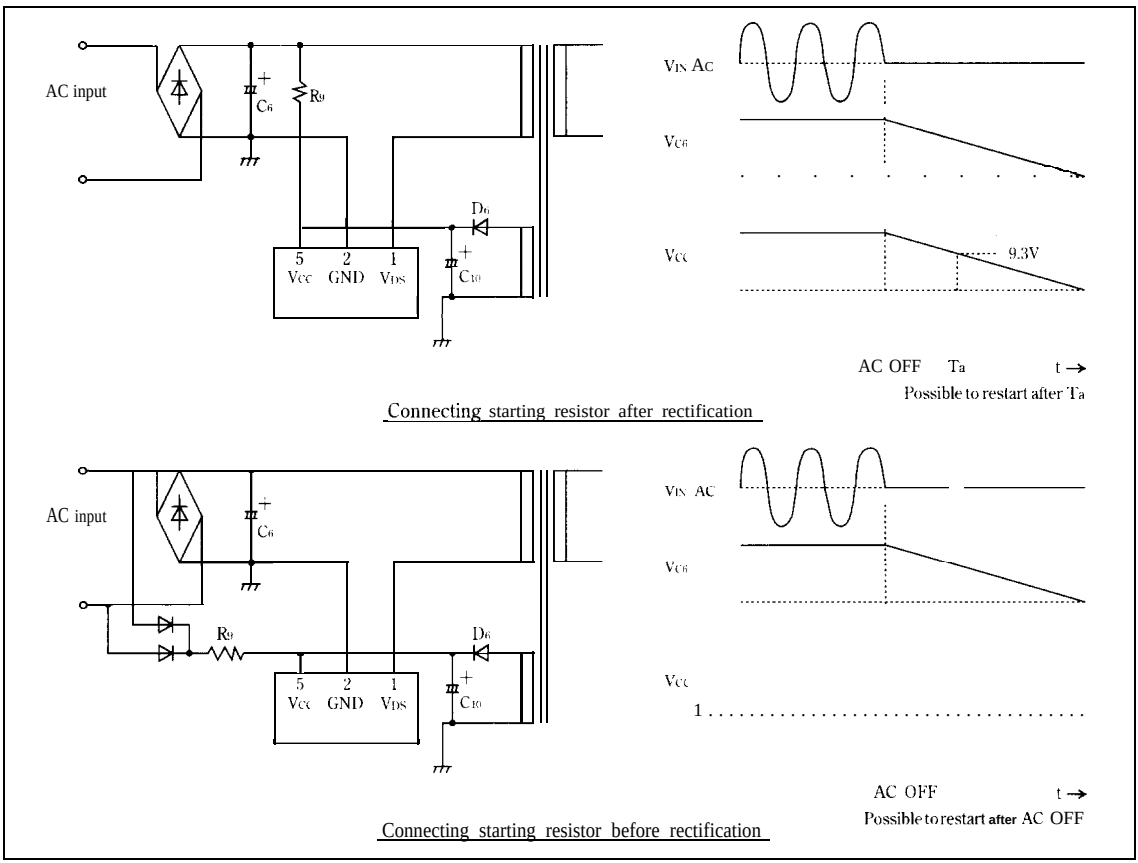
$V_{R5} < 7.7 - V_{FD4}$ $V_{FD4}$ : forward voltage of diode D4

When current flowing into $R_3$ is 0.2mA,

$R_3 = (\sqrt{2}V_{IN(AC)}\ [MIN.] - 7.7 + V_{FD4}) / (0.2 \times 10^{-3})$
$R5 = (7.7 - V_{FD4}) / (0.2 \times 10^{-3})$
$V_{IN(AC)}$ [MIN. ] :Minimum input voltage to gain the rated output

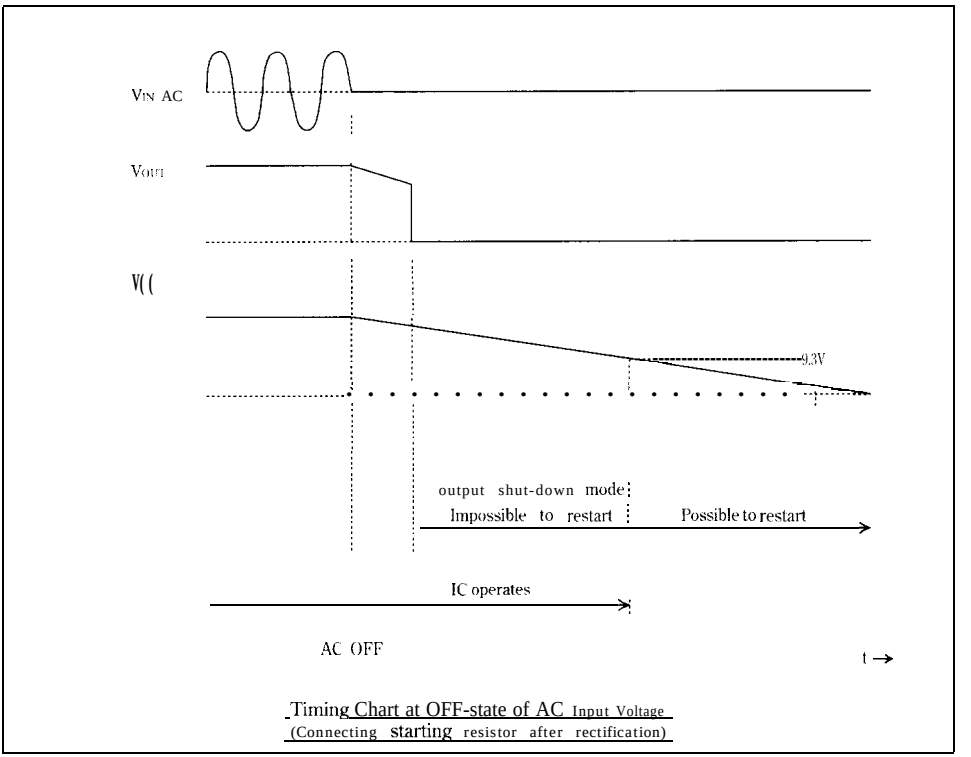
⑤ Reduction of restarting time from shut-down state

Under the shut down condition due to overcurrent and overvoltage protection function, once supply voltage of IC ($V_{CC}$) 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 fumed off. However, in cases that starting resistor $R_9$ is connected after smoothing rectification of input voltage, 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. And $V_{CC}$ has no influence of storaged charge of smoothing capacitor $C_6$ while AC input voltage is () FF. $V_{CC}$ soon drops to OV, and that can shorten the restarting time.



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 ($V_{CC}$) is more than operation stopping voltage ($V_{CC(OFF)}$) 9.3V Typ. and IC keeps operating. (refer to the following figure.)

In this case, connect the starting resistor before smoothing so that $V_{CC}$ soon drops to 0V. As a result, output will not be shut down while AC input voltage is OFF

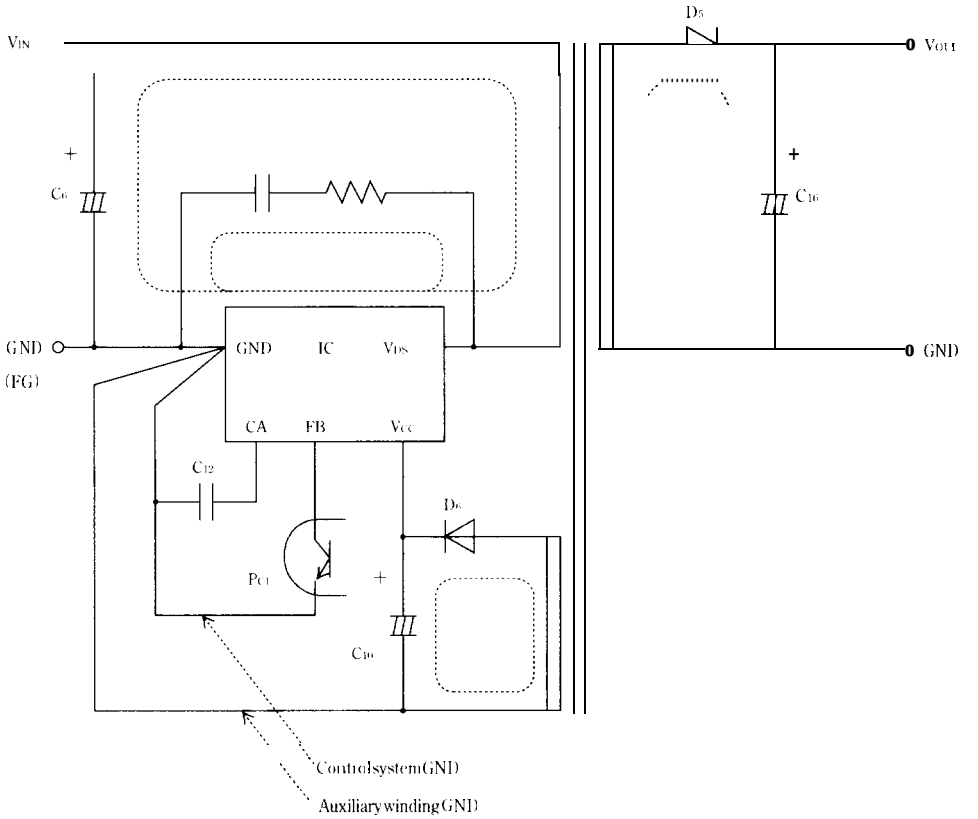



Timing Chart at OFF-state of AC Input Voltage
(Connecting starting resistor after rectification)

⑥ Patterning to printed circuit board

Patterning to a printed circuit board may cause a noise and a malfunction. Especially for dotted line portion in the figure, reduce the mop 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 terminal must be connected as close as possible to IC, and auxiliary winding GND must be directly connected to IC GND (do not connect by way of control system GND)




Patterning to PCB

### (2) Mounting

In case of mounting, please be careful not to apply mechanical stress to the portion between terminal and mold resin.
Please fix the device on the heat sink with tightening torque uf 0.4 to 0.5N m by using M3 screw. Strictly observe the following items to effectively radiate the heat from inside of the device.

(A) Warp and unevenness shall not occur on the contact surface between the beat sink and device.
(B) Metal dust and burr shall not be attached to the contact surface between the heat sink and device.
(C) Silicone grease shall be uniformly applied on the contact surface between the heat sink and device. Please select the following grease.
  (a) No secular variation in operating temperature range.
  (b) Base oil does not separate and it does not permeate into the device.
  (c) Even if base oil permeates into the device, operation and fife time are not given bad influence.
  For example, we recommend G-746 ;Shin-Etsu Chemical Co., Ltd. and SC-102 : Dow Corning Toray Silicone Co.. Ltd.
(D) Please use a M3 flat fillister head screw. 1)0 not use a countersunk head screw etc.

### (3) ESD (Electro Static Discharge)

Be careful not to apply electro static discharge to the device since this device employs MOS-FET and a bipolar IC and may be damaged by electro static discharge. Following are some examples of counter measures against excessive voltage caused by electro static discharge.

(A) Human body must be grounded to discharge the static electricity which is charged in the body or cloth
(B) Anything that is in contact with the device such as workbench, inserter, or measuring instrument must be grounded.
(C) Use a soldering dip basin with a minimum leak current (isolation resistance 10M Ω or more) from the AC power supply fine. Also the soldering dip basin must be grounded.

### (4) For cleaning

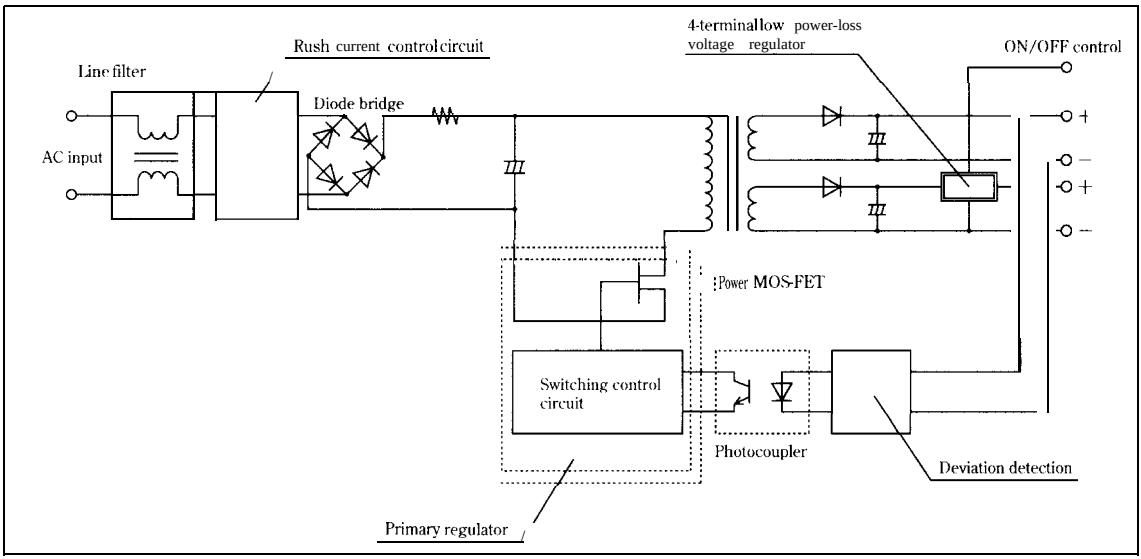
Be careful to meet the following requirements in cleaning.

(A) Solvent cleaning : Solvent temperature: 45 C or less, Immersion :3 min. or less
(B) Ultrasonic cleaning : The influence to device by ultrasonic cleaning is different by the size of cleaning bath, ultrasonic power output, cleaning time, PWB size or device mounting condition etc. Please test it in actual using condition and confirm that no detects arise beforehand.
(C) Applicable solvent : Ethyl alcohol, Methyl alcohol, Isopropyl alcohol.

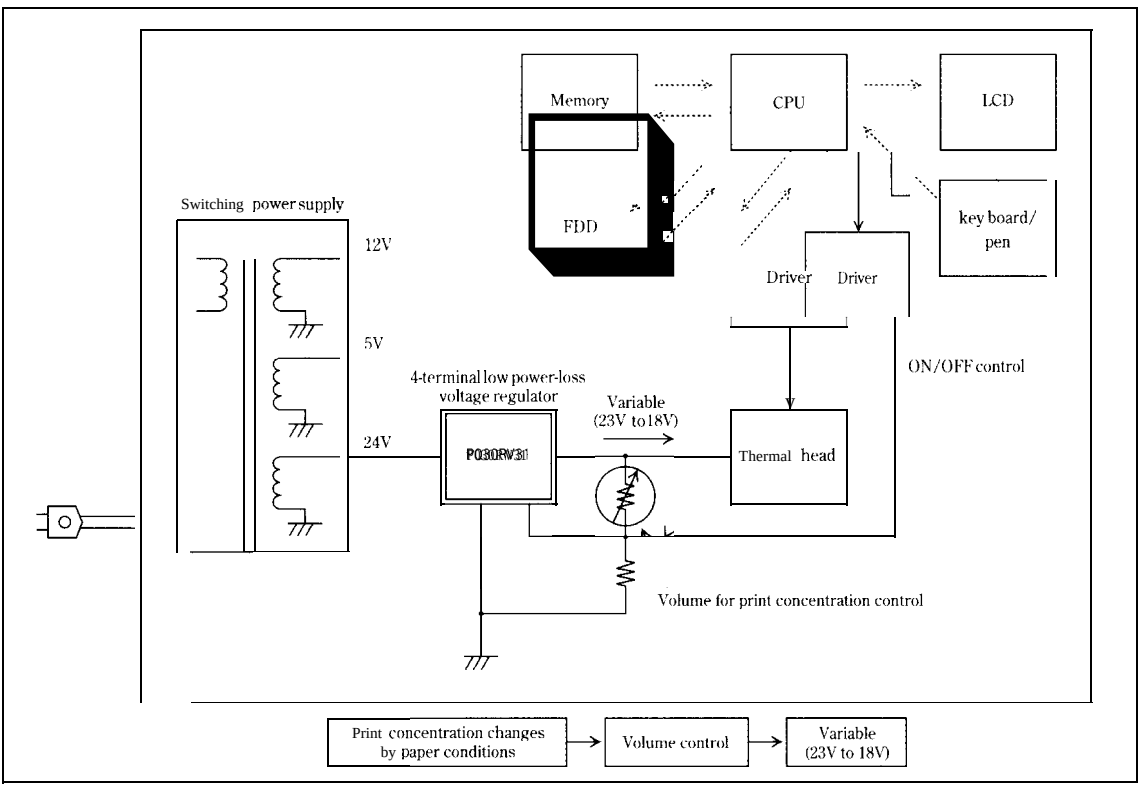
Before using alternative solvents. confirm that they do not dissolve the package resin or promote corrosion within the chip.
A use of fluorocarbons type solvents is internationally prohibited. Do not use solvents containing these substances.

## ■ Example of Application Circuit

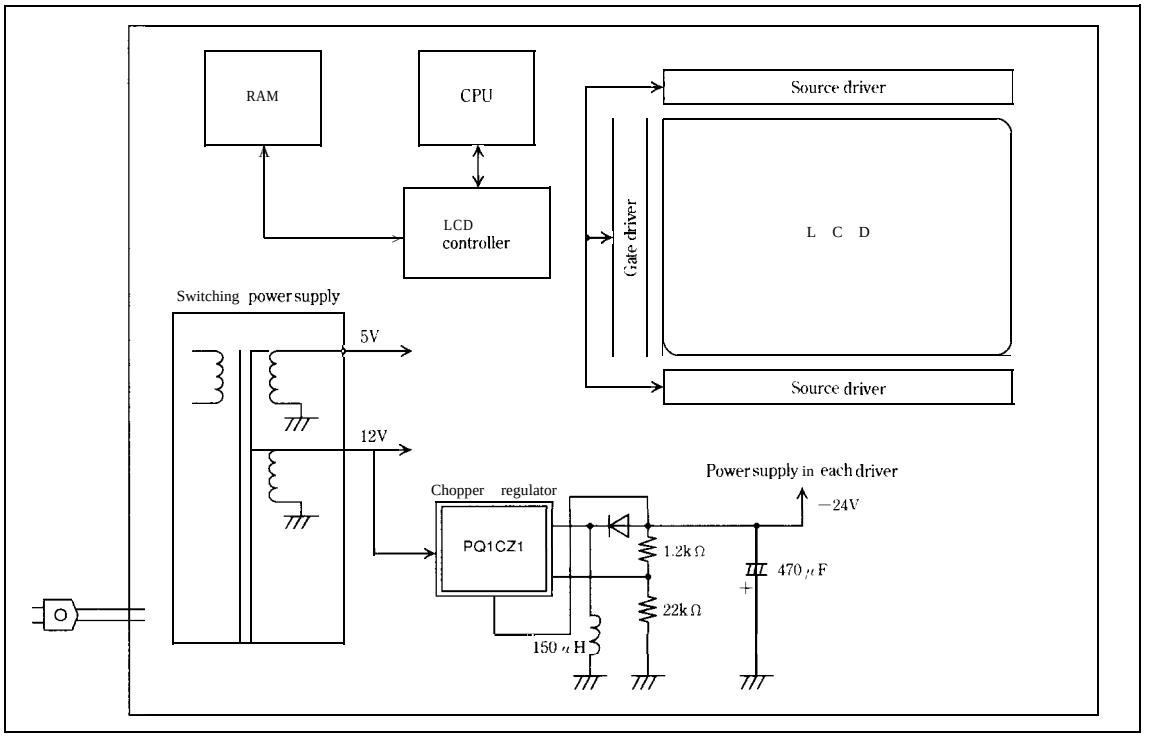
1. Multi-output switching power supply (using fixed output voltage regulator and primary regulator)




2. Print concentration control of word processor (using variable output voltage type)



3. LCD driver (using chopper regulator)




4. Power supply for personal computer (using high current output type regulator)