

STRUCTURE Silicon Monolithic Integrated Circuit
 TYPE Step-Down Switching Regulator with integrated Power MOSFET
 PRODUCT SERIES **BD9778HFP**
 PHYSICAL DIMENSIONS Fig. 1 (Plastic Mold)
 BLOCK DIAGRAM Fig. 2
 POWER DISSIPATION Fig. 3

- FEATURES
- Wide Input Range: from 5 to 35V
 - Current Capability: Up to 2A
 - High Precision: +/-2% (Reference Voltage)
 - Low Dropout Operating: 100% ON-Duty Cycle
 - Stand-by Current: 0μA (Typ.)
 - Adjustable Frequency: from 50 to 500kHz
 - Soft Start
 - Over Current Protection (OCP)
 - Thermal Shut Down Circuit (TSD)
 - Package: 7 Pins High Power Flat Package: HRP-7

ABSOLUTE MAXIMUM RATINGS (T_A=25°C)

Parameter	Symbol	Limits	Unit
Supply Voltage	V _{IN}	36	V
SW, EN Pin Voltage	V _{SW} , V _{EN}	V _{IN}	V
Output SW Current	I _{SW}	2 ⁽¹⁾	A
RT, FB, INV Pin Voltage	V _{EN} , V _{RT} , V _{INV}	7	V
Power Dissipation	P _d	5.5 ⁽²⁾	W
Operating Temperature Range	T _{opr}	-40~+125	°C
Storage Temperature Range	T _{stg}	-55~+150	°C
Junction Temperature	T _{jmax}	150	°C

⁽¹⁾ In operating temperature range, should not exceed T_{jmax}=150°C.

⁽²⁾ Pd derated at 44mW/°C for temperatures above T_A=25°C when mounted on a double layer PCB 70mm×70mm×1.6mm. (with Thermal vias / Copper area: 70mm×70mm)

★This specification may have to be changed for the purpose of improvement without notification in advance.

Application example

The application circuit is recommended for use. Make sure to confirm the adequacy of the characteristics.

When using the circuit with changes to the external circuit constants, make sure to leave an adequate margin for external components including static and transitional characteristics as well as dispersion of the IC.

Note that ROHM cannot provide adequate confirmation of patents.

The product described in this specification is designed to be used with ordinary electronic equipment or devices (such as audio-visual equipment, office-automation equipment, communications devices, electrical appliances, and electronic toys).

Should you intend to use this product with equipment or devices which require an extremely high level of reliability and the malfunction of which would directly endanger human life (such as medical instruments, transportation equipment, aerospace machinery, nuclear-reactor controllers, fuel controllers and other safety devices), please be sure to consult with our sales representative in advance.

ROHM assumes no responsibility for use of any circuits described herein, conveys no license under any patent or other right, and makes no representations that the circuits are free from patent infringement.

DESIGN	CHECK	APPROVAL	DATE: 12/19/03	SPECIFICATION No. : TSZ02201-BD9778HFP-1-2
			REV. A	ROHM CO., LTD.

RECOMMENDED OPERATING CONDITIONS ($T_A=25^\circ\text{C}$)

Parameter	Symbol	Min	Max	Unit
Input Voltage	V_{IN1}	5	35	V
Output Switch Current	I_{SW}	-	2	A
Oscillator Frequency	F_{OSC}	50	500	kHz
Oscillator Timing Resistance	RT	40	800	k Ω
Output Voltage	V_o	1 or $V_{IN} \times 6\%$	V_{IN}	V

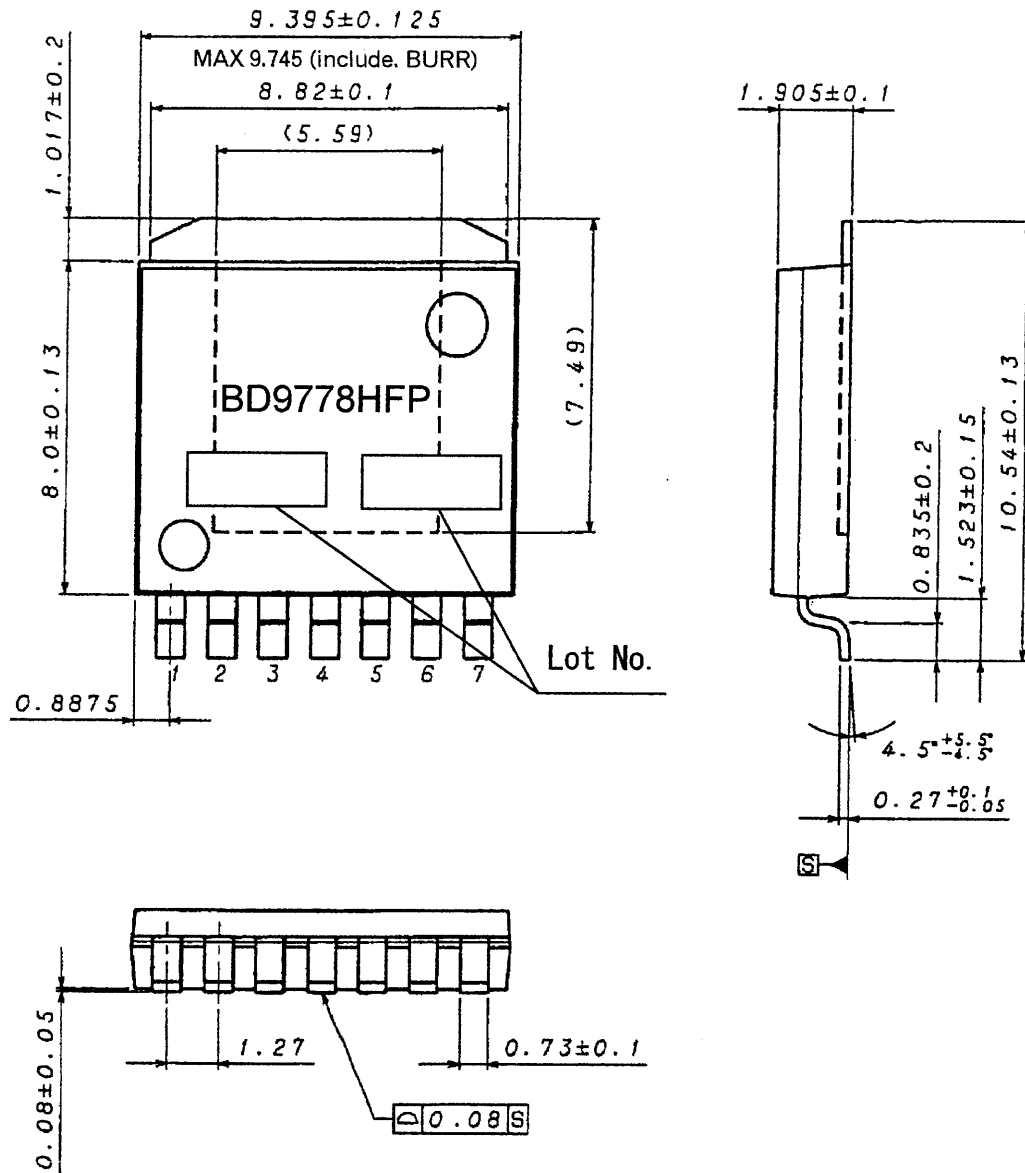
ELECTRICAL CHARACTERISTICS (Unless otherwise specified, $V_{IN}=13.2\text{V}$, $V_{EN}=5\text{V}$, $T_A=25^\circ\text{C}$)

Parameter	Symbol	Limit			Unit	Conditions	Test Circuit
		Min	Typ	Max			
[Entire Device]							
Stand-by Current	I_{STB}	-	0	10	μA	$V_{EN}=0\text{V}$	9
Quiescent Current	I_Q	-	3	4.2	mA	$I_O=0\text{A}$	9
[Switch]							
Switch On Resistance	R_{ON}	-	0.53	0.7	Ω	$I_{SW}=1\text{A}$	9
Output Current Limit	I_{OLIMIT}	2	4	-	A	Ensured by design	9
Leakage Current	I_{OLEAK}	-	0	10	μA	$V_{IN}=35\text{V}$, $V_{EN}=0\text{V}$	9
[Error Amplifier]							
Reference Voltage	V_{REF}	0.98	1.00	1.02	V	$V_{FB}=V_{INV}$, S:ON	9
Line Regulations	ΔV_{REF}	-	0.5	-	%	$V_{IN}=5$ to 35V, S:ON	9
Input Bias Current	I_B	-1	-	-	μA	$V_{INV}=1.1\text{V}$	9
Maximum FB Voltage	V_{FBH}	2.4	2.5	-	V	$V_{INV}=0.5\text{V}$	9
Minimum FB Voltage	V_{FBL}	-	0.05	0.1	V	$V_{INV}=1.5\text{V}$	9
FB sink current	I_{FBSINK}	-5.0	-3.0	-0.5	mA	$V_{FB}=1.5\text{V}$, $V_{INV}=1.5\text{V}$	9
FB source current	$I_{FBSOURCE}$	70	120	170	μA	$V_{FB}=1.5\text{V}$, $V_{INV}=0.5\text{V}$	9
Soft Start Period	T_{SS}	-	5	-	mS	Ensured by design	9
[Oscillator Section]							
Switching Frequency	F_{OC}	82	102	122	kHz	RT=390k Ω	9
Frequency Line Regulation	ΔF_{OFC}	-	2	-	%	$V_{IN}=5$ to 35V	9
[Enable]							
Enable Threshold Voltage	V_{EN}	1.0	1.7	2.4	V		9
Sense Current	I_{EN}	-	13	35	μA	$V_{EN}=5\text{V}$	9

ELECTRICAL CHARACTERISTICS (Unless otherwise specified, $V_{IN}=13.2V$, $V_{EN}=5V$, $T_A=-40\sim 125^{\circ}C$)

Parameter	Symbol	Limit			Unit	Conditions	Test Circuit
		Min	Typ	Max			
[Entire Device]							
Quiescent Current	I_Q	-	3	4.2	mA	$I_Q=0A$	9
[Switch]							
Switch On Resistance	R_{ON}	-	0.53	0.9	Ω	$I_{SW}=50mA$	9
Output Current Limit	I_{OLIMIT}	2	4	-	A	Ensured by design	9
Leakage Current	I_{OLEAK}	-	0	30	μA	$V_{IN}=35V$, $V_{EN}=0V$	9
[Error Amplifier]							
Reference Voltage	V_{REF}	0.96	1.00	1.04	V	$V_{FB}=V_{INV}$, S:ON	9
Line Regulations	ΔV_{REF}	-	0.5	-	%	$V_{IN}=5$ to 35V, S:ON	9
Input Bias Current	I_B	-1	-	-	μA	$V_{INV}=1.1V$	9
Maximum FB Voltage	V_{FBH}	2.4	2.5	-	V	$V_{INV}=0.5V$	9
Minimum FB Voltage	V_{FBL}	-	0.05	0.1	V	$V_{INV}=1.5V$	9
FB sink current	I_{FBSINK}	-5.0	-3.0	-0.5	mA	$V_{FB}=1.5V$, $V_{INV}=1.5V$	9
FB source current	$I_{FBSOURCE}$	70	120	170	μA	$V_{FB}=1.5V$, $V_{INV}=0.5V$	9
Soft Start Period	T_{SS}	-	5	-	mS	Ensured by design	9
[Oscillator Section]							
Switching Frequency	F_{OC}	82	102	122	kHz	$RT=390k\Omega$	9
Frequency Line Regulation	ΔF_{OC}	-	2	-	%	$V_{IN}=5$ to 35V	9
[Enable]							
Enable Threshold Voltage	V_{EN}	0.8	1.7	2.6	V		9
Sense Current	I_{EN}	-	13	50	μA	$V_{EN}=5V$	9

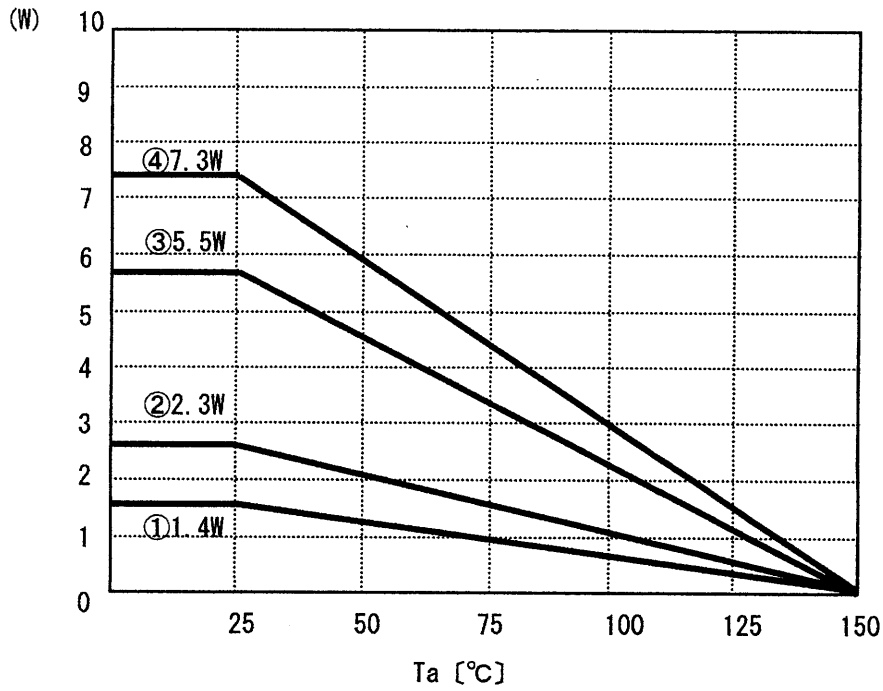
PHYSICAL DIMENSIONS



(UNIT : mm)

Fig. 1 Physical Dimensions (Plastic Mold)

POWER DISSIPATION



① IC only

PCB size : $70 \times 70 \times 1.6\text{mm}^3$ (with Thermal vias)

Copper area : $10.5 \times 10.5\text{mm}^2$

② a double layer PCB (Copper area : $15\text{mm} \times 15\text{mm}$)

③ a double layer PCB (Copper area : $70\text{mm} \times 70\text{mm}$)

④ a four layer PCB (Copper area : $70\text{mm} \times 70\text{mm}$)

fig. 3 POWER DISSIPATION CURVE

TIMING CHART

• Standard behavior

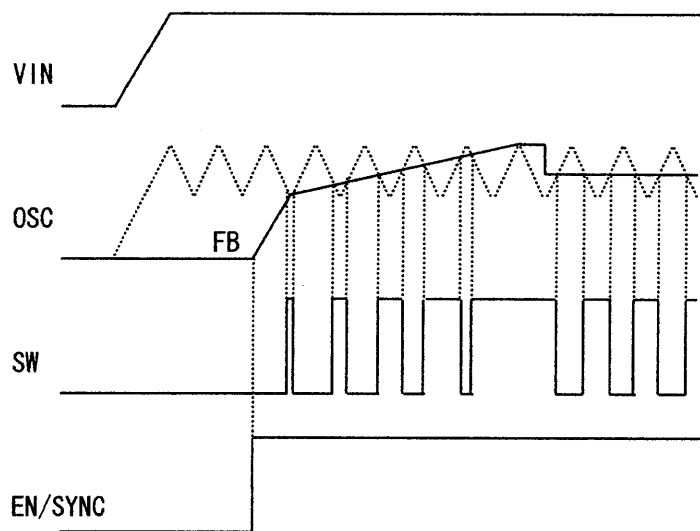


Fig. 4 Standard behavior

• Over Current Protect

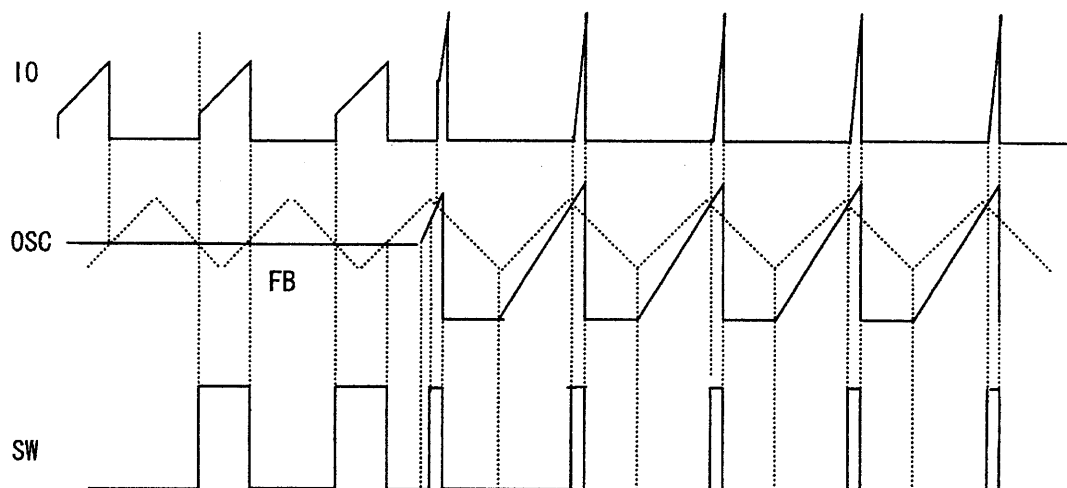


Fig. 5 Over current protect behavior

Application Circuit

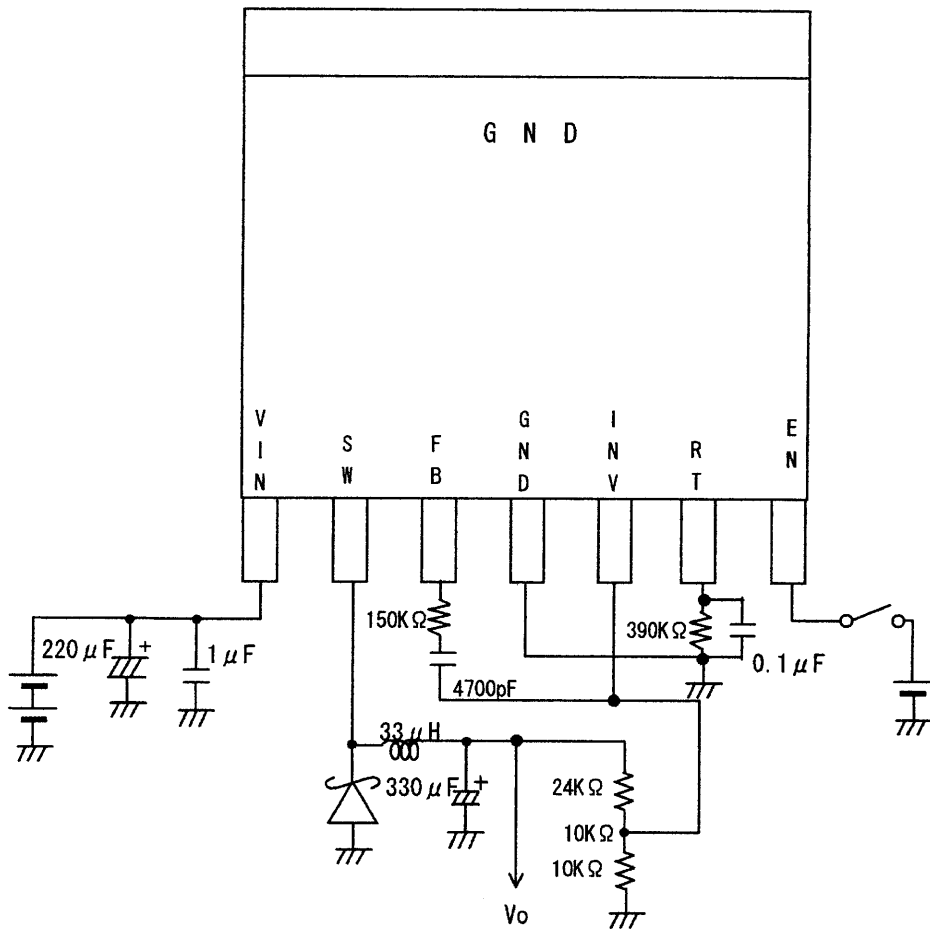


Fig. 6 Application Circuit

Switching Frequency Adjustment

Fixed frequency can be set by RT resistor.

The Fig. 7 shows the relation between RT resistor and switching frequency.

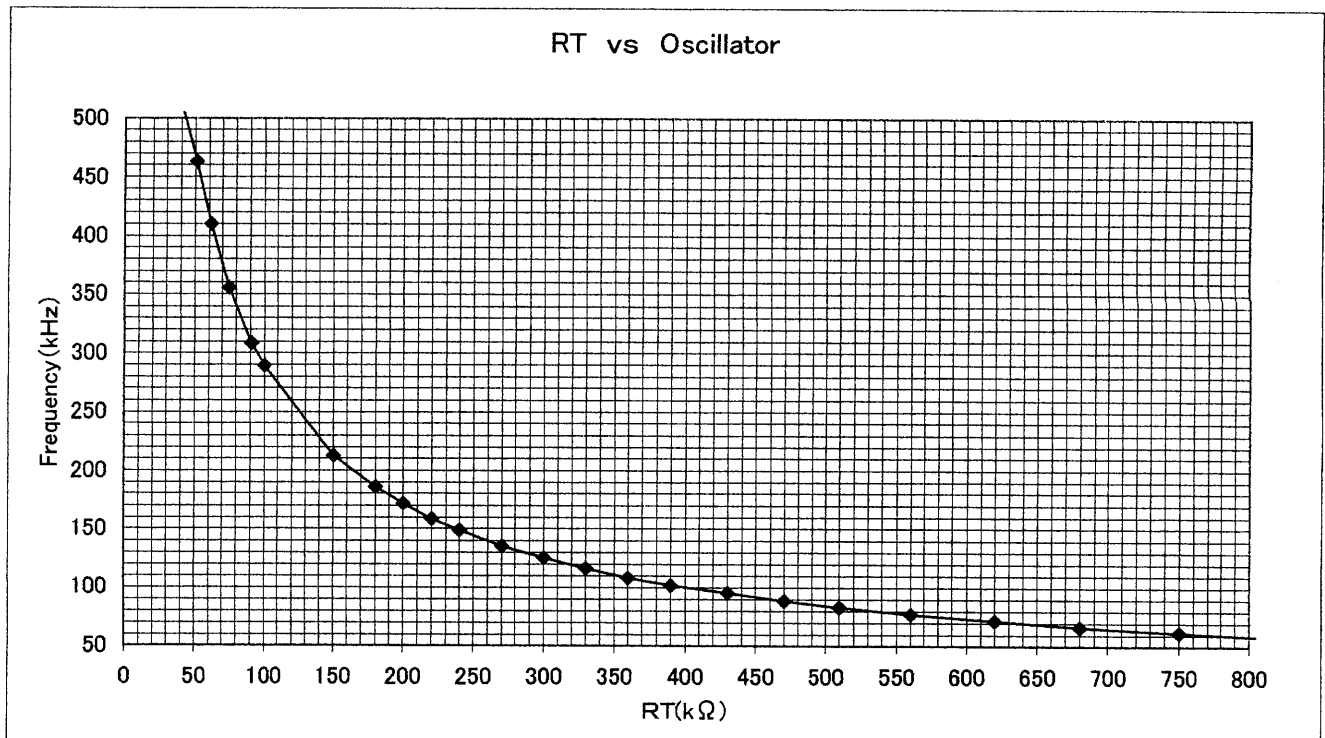
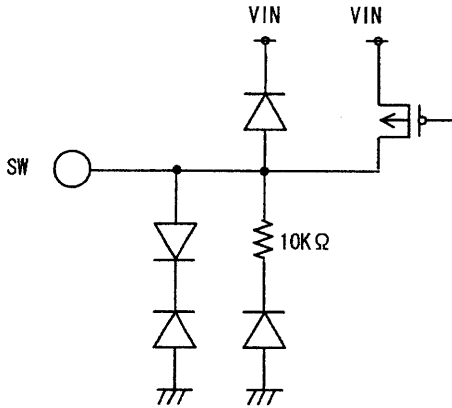


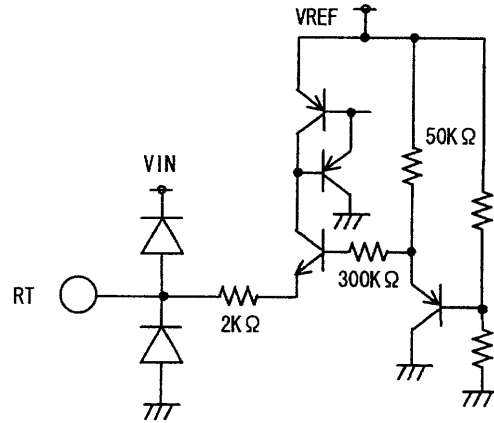
Fig. 7

INPUT AND OUTPUT CIRCUIT

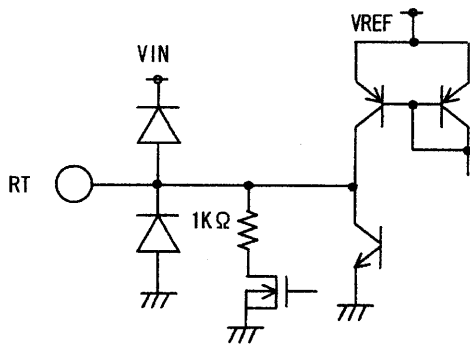
2. SW



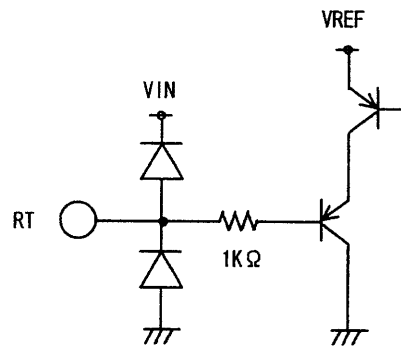
6. RT



3. FB



5. INV



7. EN

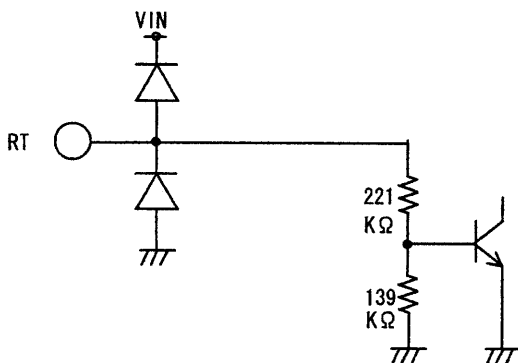


Fig. 8 I/O CIRCUIT

MEASUREMENT CIRCUIT

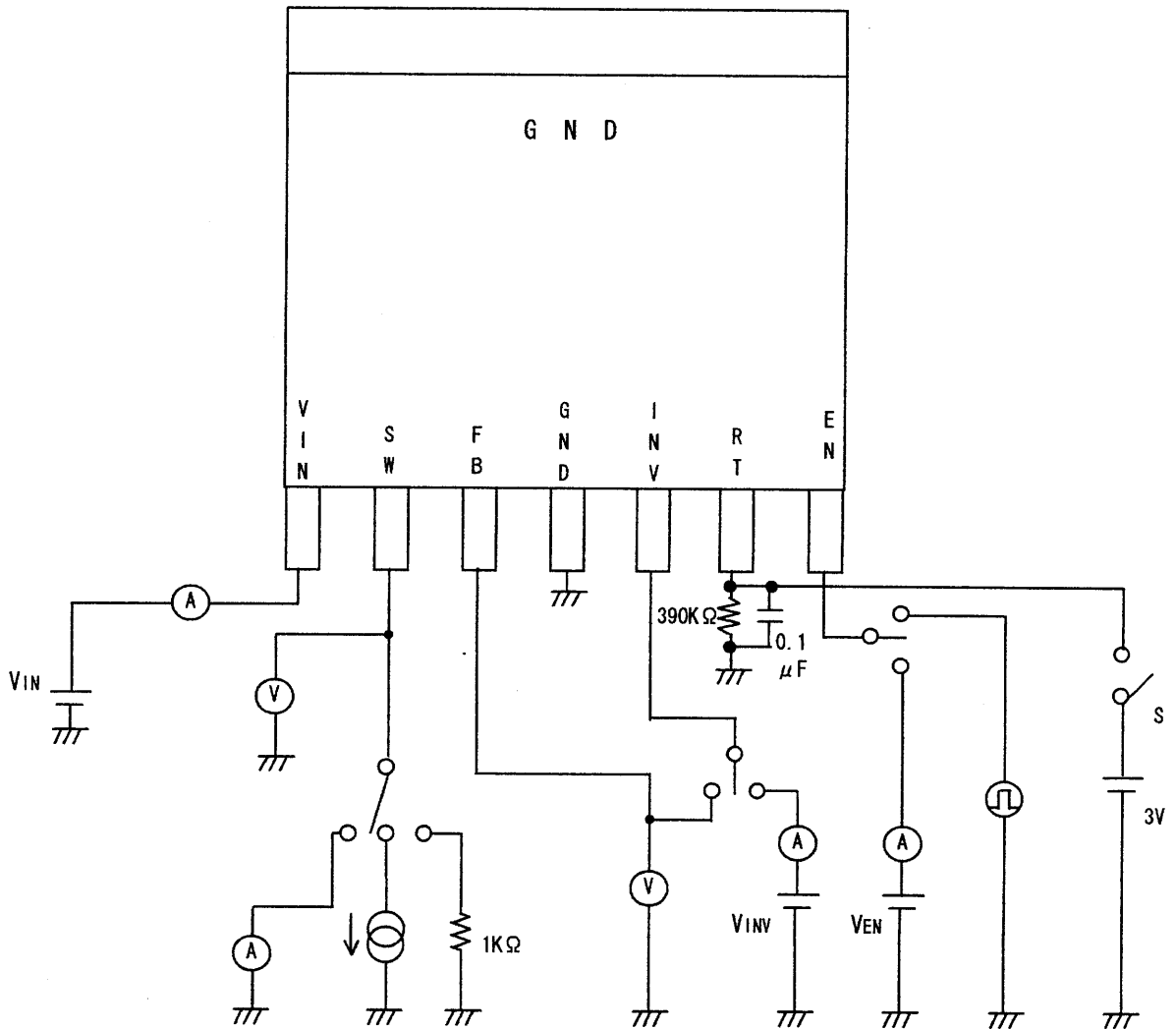


Fig. 9 MEASUREMENT CIRCUIT

NOTES FOR USE

1. Operation supply voltage range

The circuit functionality is guaranteed within operation of ambient temperature range, as long as it is within operation supply voltage range. The standard electrical characteristic values are guaranteed at the test circuit voltage of VCC=13.2V. They cannot be guaranteed at other voltages in the operating range of 5V-35V. However, the variation will be small.

2. Power dissipation

Refer to the thermal deration characteristics shown in Fig-3. Also, be sure to use this IC within a power dissipation range allowing enough margins.

3. Grounding

It is recommended that every capacitor (bypass and another capacitors) is grounded to PIN4 and FIN using single-point connections.

4. FB Terminal

The FB terminal is for phase margin of the DC/DC system. A capacitor and a resistor or an only capacitor placed between the FB terminal and the INV terminal. The values of the capacitor and the resistor shall be adjusted according to the output current and the output capacitor value. The output may be oscillating if the value of capacitor is not sufficient, also the transient response may become insufficient if the value is too large. Therefore, the value of the capacitor and the resistor shall be adequately set up based on the condition of the temperature, and so on. Since the FB terminal also detects output short condition compulsorily applying an external voltage onto the FB terminal must not be performed because it may activate the timer latch protection circuit.

5. VCC Terminal

For reduce the influence of switching noise, bypass capacitor is connected between VCC and GND.

6. Electromagnetic Fields

The IC is susceptible to strong electromagnetic fields and may cause malfunction. Therefore, caution should be used when placing it on the PCB.

7. Application Design

When designing the external circuit, included adequate margins, including not only steady state but also transient characteristics.

8. Over Output Current Protection

SW Output terminal has over current protection circuit of 4A, with prevents IC from being damage by short circuit at over current.

9. Thermal Shut Down Circuit

A temperature control is built in the IC to prevent the damage due to overheat. Therefore, the output is turned off when the thermal circuit works and are turned on when the temperature goes down to the specified level.

10. Output Voltage

The output voltage is able to calculate with below the exercise.

$$V_o = V_{ref} \times \left(1 + \frac{R_2}{R_1} \right)$$

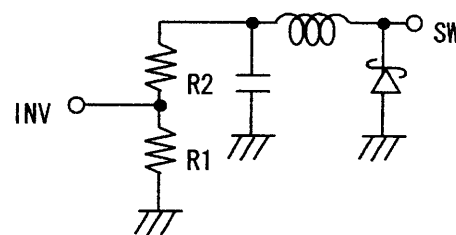


Fig. 10

NOTES FOR USE

This IC is a monolithic IC which has P⁺ isolation in the P substrate and between the various pins. A P-N junction is formed from this P layer and the N layer of each pin.

For example such as Fig. 11, when a resistor and a transistor is connected to a pin.

- When GND > Pin A in resistor or GND > Pin B in transistor the P-N junction operates as a parasitic diode.
- When GND > Pin B in transistor the P-N junction and near-by other element operates as a parasitic transistor.

Parasitic diodes can occur inevitably in the structure of the IC. The operation of parasitic diodes can result in mutual interference among circuits as well as operation faults and physical damage. Accordingly, you must not use methods by which parasitic diodes operate, such as applying a voltage that is lower than the GND (P substrate) voltage to an input pin.

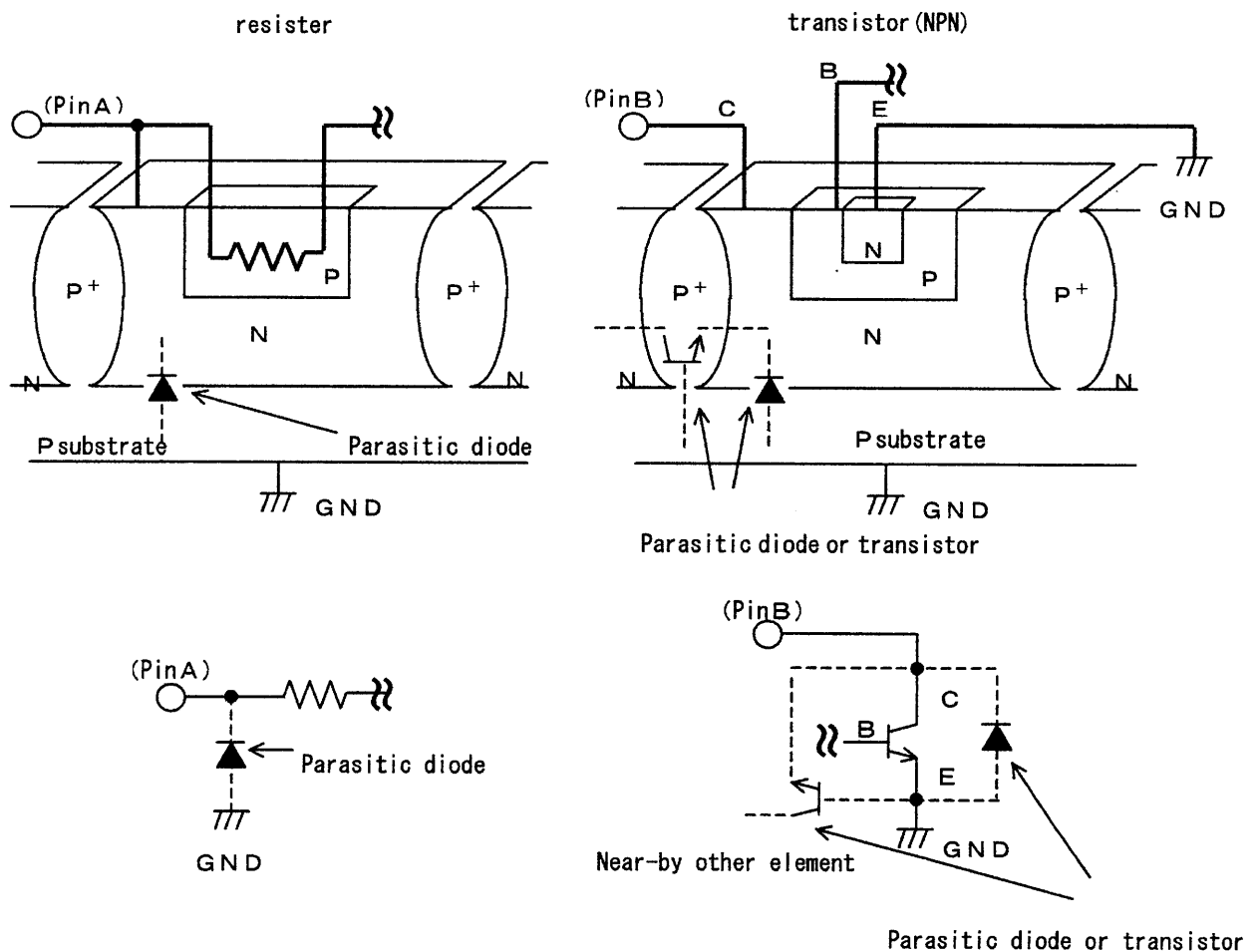


Fig. 11 SIMPLIFIED STRUCTURE OF BI-POLAR IC