Ordering number : ENA1240

SANYO Semiconductors

DATA SHEET

An ON Semiconductor Company

ExPD (Excellent-Performance Power & RF Device)

# TN5D61A — Separately-Excited Step-Down Switching Regulator (24V Output type)

## Features

- High efficiency (ON resistance 100mΩ, Vertical-type P-ch Power MOSFET).
- Over current protection function (Self recovery type).
- Under voltage protection function.
- Over temperature protection function (Self recovery type).
- Soft start function (Variable subject to externally-connected capacitor).
- Stand-by mode function (Compatible with soft start terminal).

## Specifications

### Absolute Maximum Ratings at Ta=25°C

| Parameter | Symbol | Conditions | Ratings | Unit |
|---|---|---|---|---|
| Maximum Input Voltage | $V_{IN}$ max | | 57 | V |
| Maximum Output Current | $I_O$ max | | 5 | A |
| Drain-to-Source Voltage of built-in MOSFET | $V_{DSS}$ | | −60 | V |
| Drain Current of built-in MOSFET (DC) | $I_D$ | | −9 | A |
| Drain Current of built-in MOSFET (Pulse) | $I_{DP}$ | PW≤10μs, duty cycle≤1% | −36 | A |
| FB Pin Maximum Input Voltage | $V_{fb}$ | | 30 | V |
| SS Pin Maximum Input Voltage | $V_{SS}$ | | 7 | V |
| Allowable Power Dissipation | $P_D$ | | 2.0 | W |
| | | Tc=25°C | 15 | W |
| Operating Temperature | Topr | | −25 to +125 | °C |
| Junction Temperature | Tj | | 150 | °C |
| Storage Temperature | Tstg | | −55 to +150 | °C |

## Recommend Operating Conditions

| Parameter | Symbol | Conditions | Ratings | Unit |
|---|---|---|---|---|
| Input Voltage | $V_{IN}$ | Ta=25°C | 30 to 48 | V |
| Output Current | $I_{OUT}$ | Ta=25°C | 0 to 5 | A |
| Operating Temperature Range | Topr rec | | −10 to +85 | °C |

## Electrical Characteristics at Ta=25°C, See Specified Test Circuit

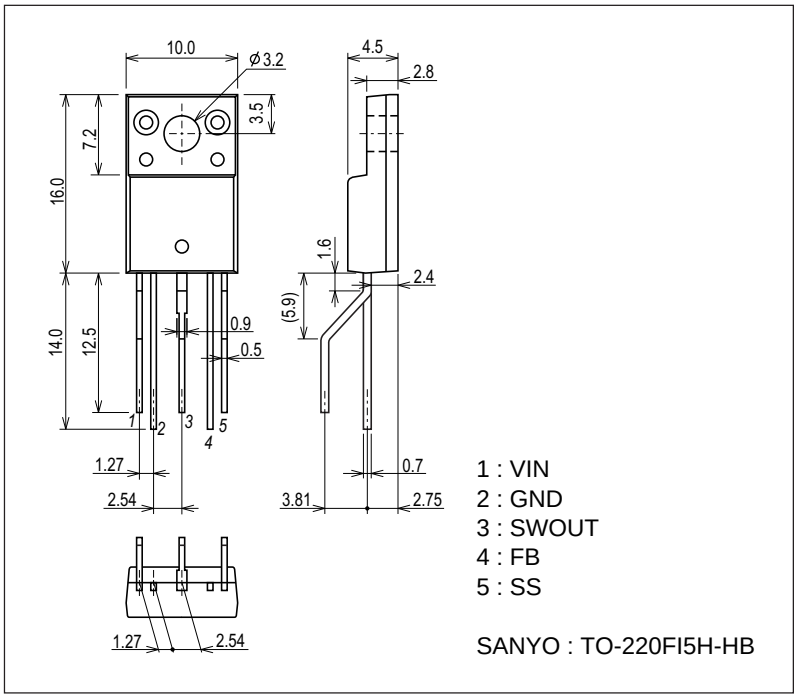
| Parameter | Symbol | Conditions | Ratings | | | Unit |
|---|---|---|---|---|---|---|
| | | | min | typ | max | |
| Output Voltage | $V_{OUT}$ | $V_{IN}$=40V, $I_{OUT}$=3A | 23.3 | 24.0 | 24.7 | V |
| Efficiency | η | $V_{IN}$=40V, $I_{OUT}$=3A | | 94 | | % |
| Drain-to-Source Breakdown Voltage of built-in MOSFET | $V_{(BR)DSS}$ | $I_D$=−1mA, $V_{IN}$, GND, $V_{fb}$, $V_{SS}$=0V | −60 | | | V |
| Drain-to-Source On Resistance of built-in MOSFET | $R_{DS}$(on) | $I_{SW}$=5A | | 100 | | mΩ |
| Switching Frequency | Freq | $V_{IN}$=40V, $I_{OUT}$=3A | 120 | 150 | 180 | kHz |
| Maximum Duty | Duty max | $V_{IN}$=40V, $V_{fb}$=0V | 88 | 92 | 96 | % |
| Line Regulation | ΔVline | $V_{IN}$=30 to 48V, $I_{OUT}$=3A | | 260 | 400 | mV |
| Load Regulation | ΔVload | $V_{IN}$=40V, $I_{OUT}$=0.5 to 5A | | 140 | 200 | mV |
| Output Voltage Temperature Coefficient *1 | $\Delta V_O$ / ΔTa | $V_{IN}$=40V, $I_{OUT}$=3A, Ta= −25 to +125°C | | ±2.4 | | mV / °C |
| Over-Current-Protection-Operation -Threshold Current | $I_{ocp}$ | $V_{IN}$=40V | 5.1 | 7.5 | 10 | A |
| Under-Voltage-Protection-Operation -Threshold Voltage | Vuvlo on | | 7.2 | 8.0 | 8.8 | V |
| Under-Voltage-Protection-Operation -Release Voltage | Vuvlo off | | 8.1 | 9.0 | 9.9 | V |
| Under-Voltage-Protection Hysteresis Voltage | Vuvlo hys | | | 1.0 | | V |
| Over-Temperature-Protection-Operation -Threshold-Current *1 | Ttsd on | | | 165 | | °C |
| Over-Temperature-Protection-Operation -Release Temperature *1 | Ttsd off | | | 140 | | °C |
| Over-Temperature-Protection -Hysteresis Temperature *1 | Ttsd hys | | | 25 | | °C |
| SS Terminal Current | $I_{SS}$ | $V_{IN}$=40V | | 10 | | μA |
| Standby Operating Voltage | Vstb on | $V_{IN}$=40V | | 0.3 | | V |
| Standby Current | Istb | $V_{IN}$=40V, $V_{SS}$=0V | | | 500 | μA |

Note: the values with "*1" are our targeted values, but not guaranteed.

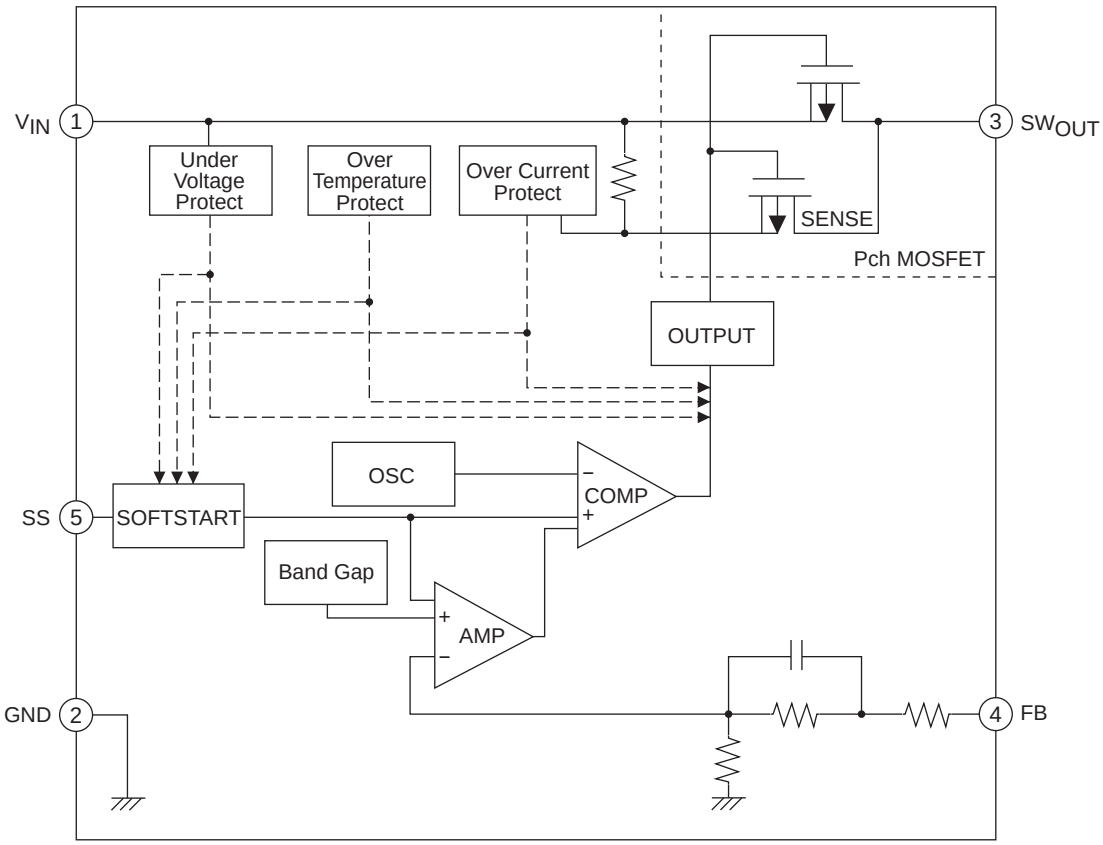
## Package Dimensions

unit : mm (typ)

7527-001



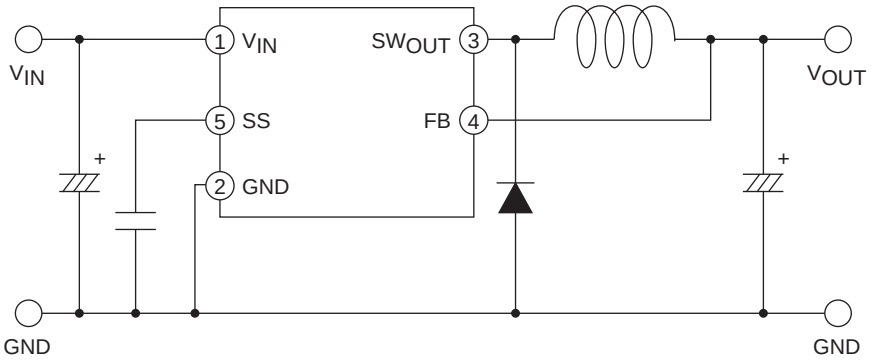
## Block Diagram

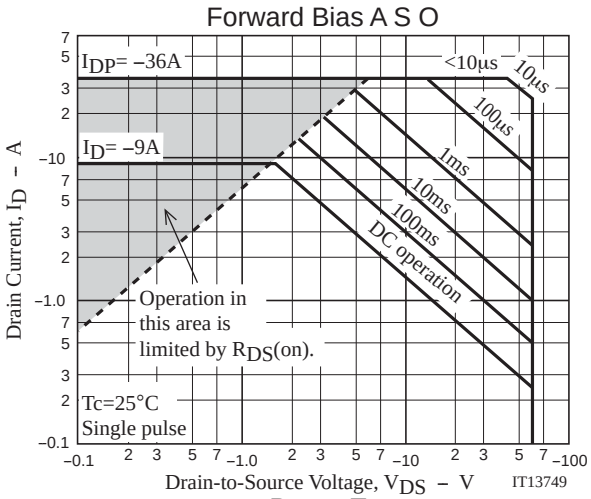


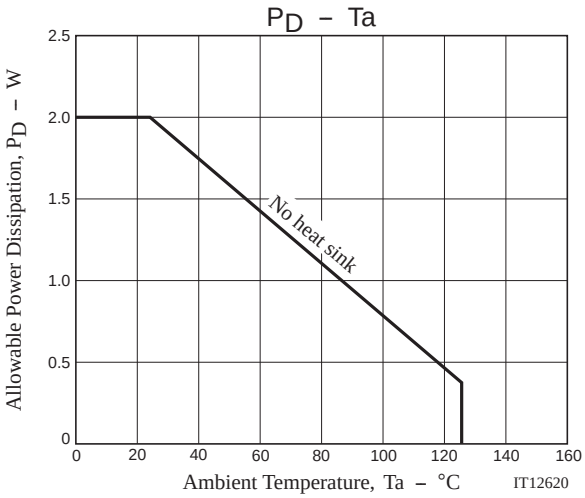

## Pin Functions

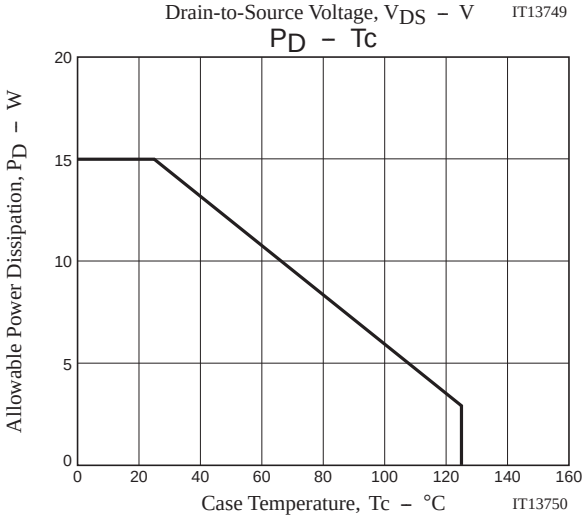
| Pin No. | Symbol | Function |
|---|---|---|
| 1 | $V_{IN}$ | Power Supply Input (Maximum 57V) |
| 2 | GND | GND |
| 3 | $SW_{OUT}$ | Pulse Voltage Output |
| 4 | FB | Feedback from Output Voltage |
| 5 | SS | For Soft Start Capacitor Connection and Standby Mode Switching |

## Application Circuit Example



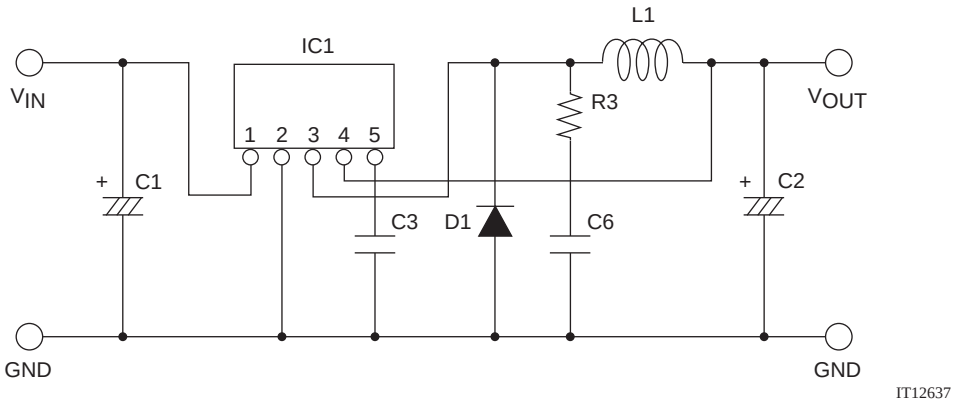



## Specified Circuit for Electrical Characteristics

[Circuit]



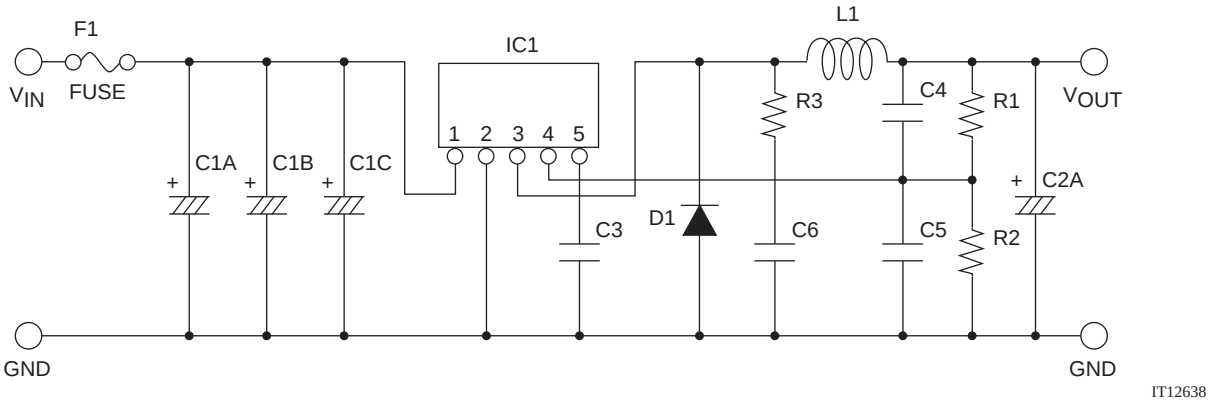

[Components]

| Symbol | Component | Specification |
|---|---|---|
| C1 | Electrolytic Capacitor | 3000 to 3600μF |
| C2 | Electrolytic Capacitor | 2000 to 2200μF |
| C3 | Capacitor | 0.1μF |
| C6 | Ceramic Capacitor | 1000pF |
| R3 | Metal Oxide Film Resistor | 47Ω / 2W |
| L1 | Choke Coil | 100μH |
| D1 | Schottky Barrier Diode | SBT250-06J |

* When measuring ripple noise voltage, put 47μF (electrolytic capacitor) and 0.1μF (ceramic or film capacitor) into measuring point.

## Evaluation Board

[Circuit]

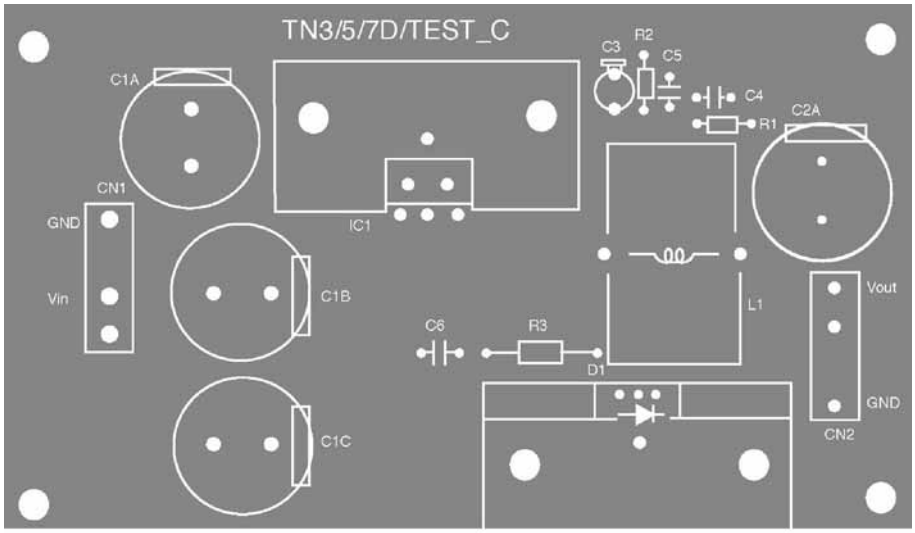



[Components]

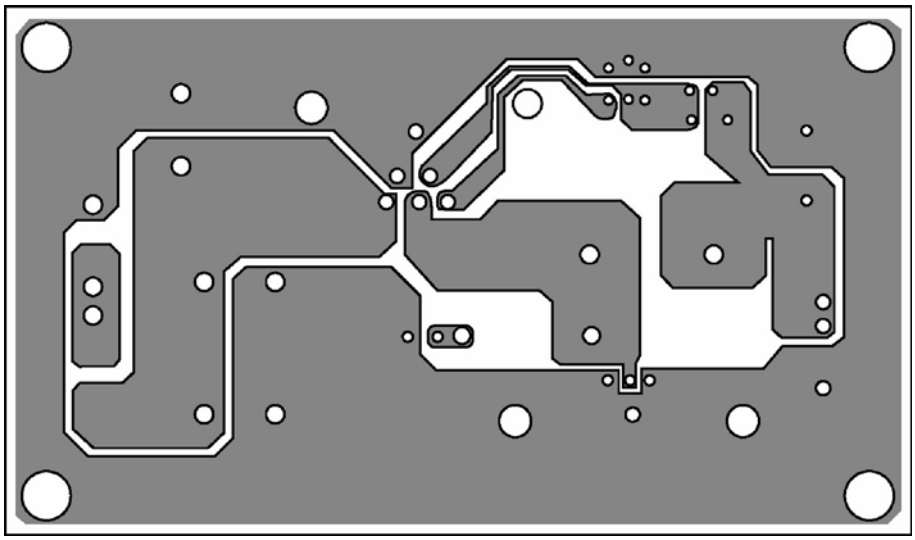
| Symbol | Component | Specification | Maker | Remark |
|---|---|---|---|---|
| F1 | Fuse | 4A | Littelfuse | 452 004 |
| C1A | Electrolytic Capacitor | 1200μF / 80V | Nippon Chemi-Con Corp. | KZE |
| C1B | Electrolytic Capacitor | 1200μF / 80V | Nippon Chemi-Con Corp. | KZE |
| C1C | Electrolytic Capacitor | 1200μF / 80V | Nippon Chemi-Con Corp. | KZE |
| C2A | Electrolytic Capacitor | 2200μF / 35V | SANYO Electronic Co., Ltd. | MV |
| C3 | Film Capacitor | 0.1μF / 100V | Matsushita Electronic Components Corp. | ECQ-B |
| C4 | N.C. | | | |
| C5 | N.C. | | | |
| C6 | Ceramic Capacitor | 1000pF | Murata Manufacturing Co., Ltd. | |
| R1 | Jumper Line | | | |
| R2 | N.C. | | | |
| R3 | Metal Oxide Film Resistor | 47Ω / 2W | Matsushita Electronic Components Corp. | |
| L1 | Choke Coil | HK-10S100-1010 | TOHO ZINC CO.,LTD. | 100μH |
| D1 | Schottky Barrier Diode | SBT250-06J | SANYO Semiconductor Co., Ltd. | |

## Recommended PCB Pattern

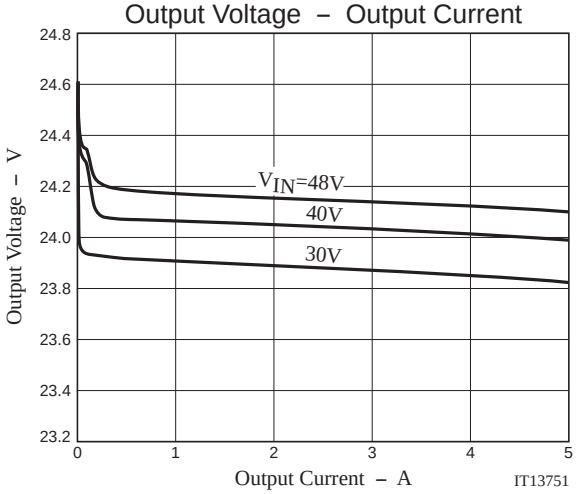
TO-220FI5H-HB Specification Silk Printing (Top View)



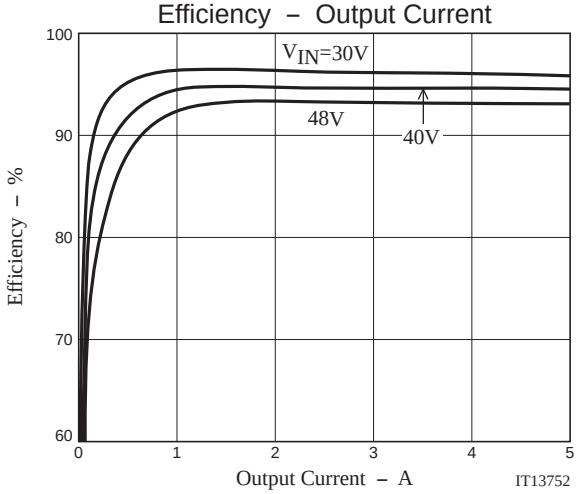

TO-220FI5H-HB Specification Pattern (Perspective View)



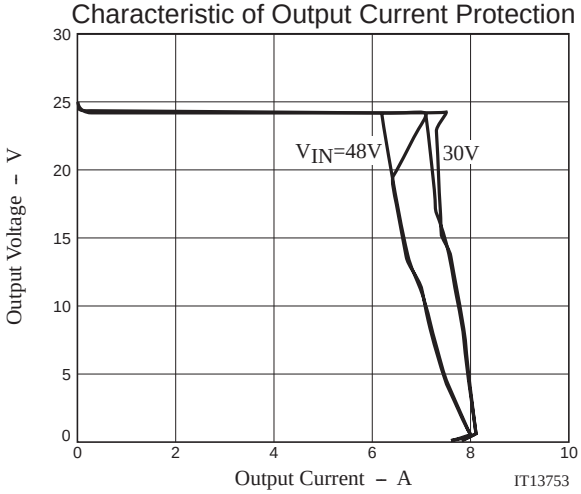
Output Voltage – Output Current



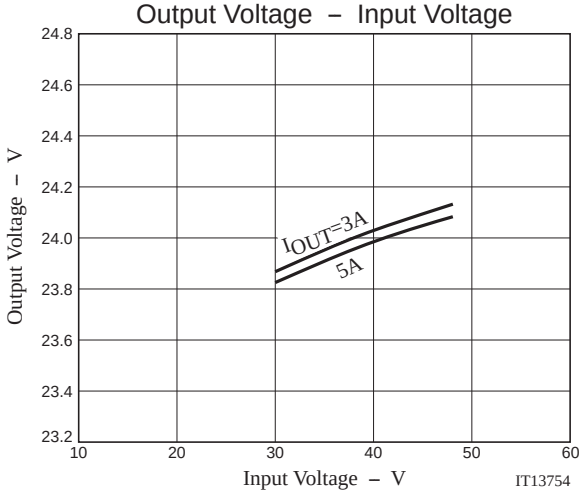

Efficiency – Output Current



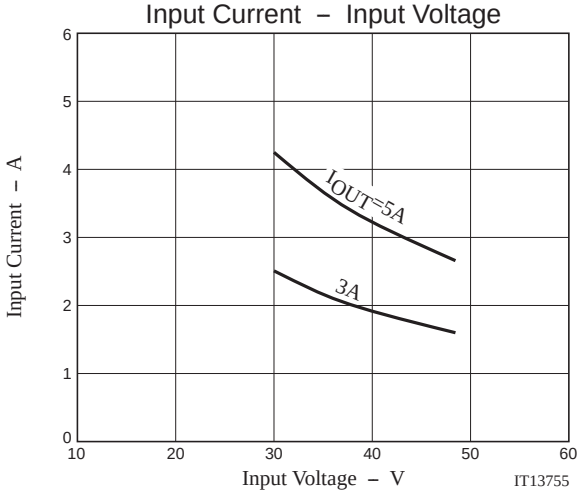

Characteristic of Output Current Protection



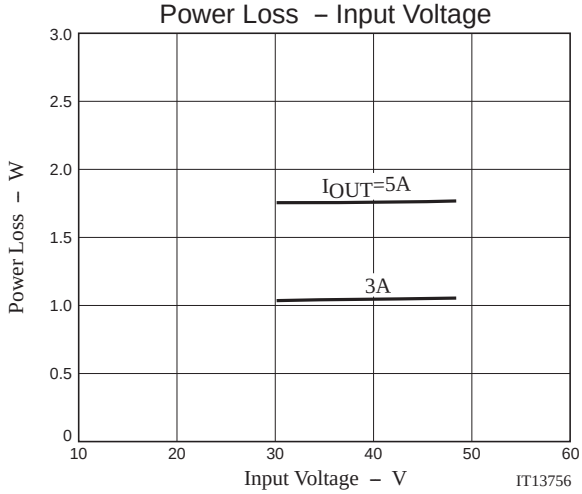

Output Voltage – Input Voltage



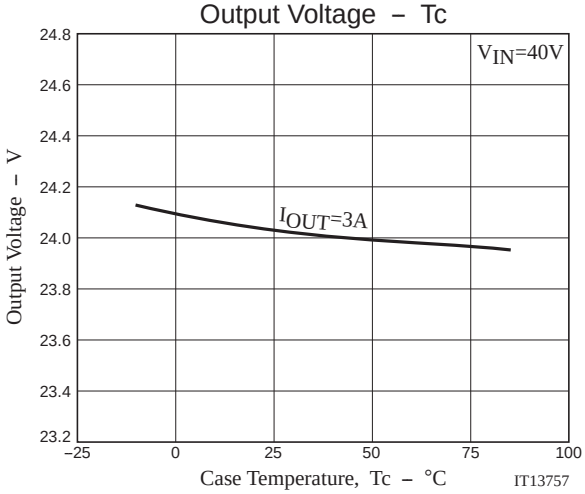

Input Current – Input Voltage



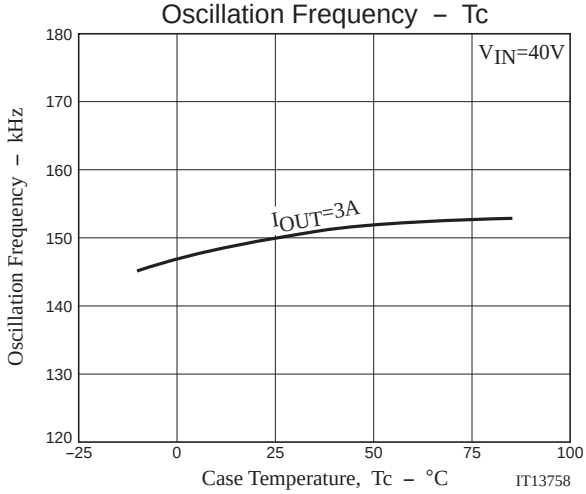

Power Loss – Input Voltage



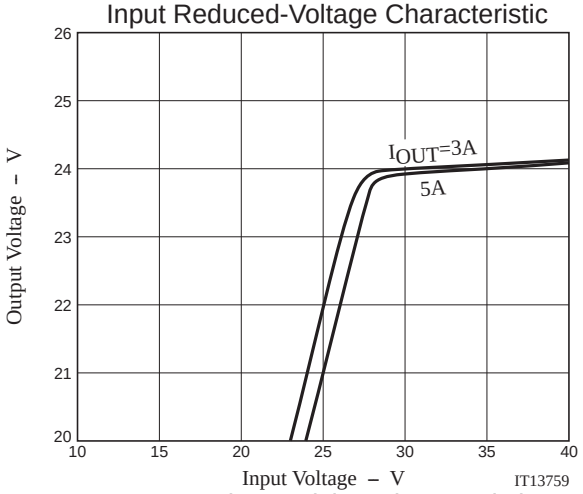

Output Voltage – Tc



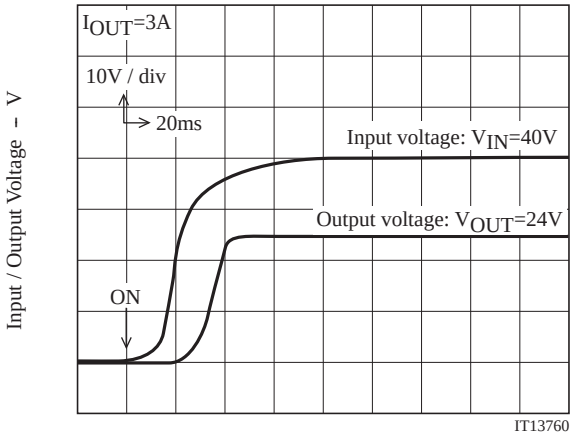

Oscillation Frequency – Tc



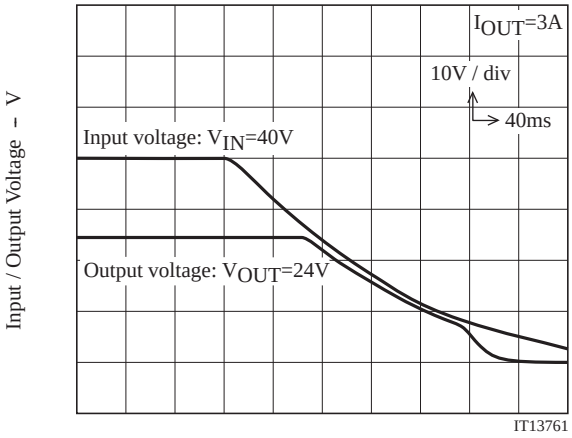
Input Reduced-Voltage Characteristic



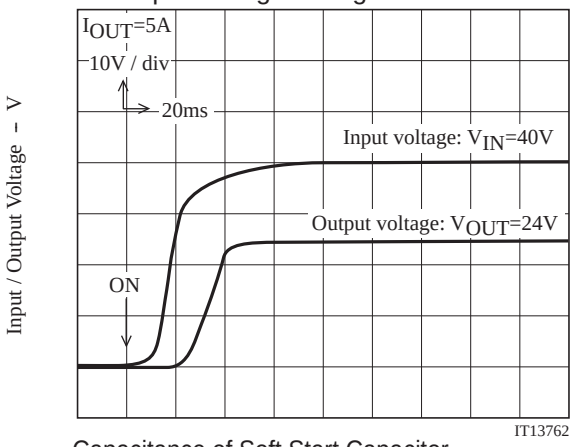

Output Voltage Rising Characteristic



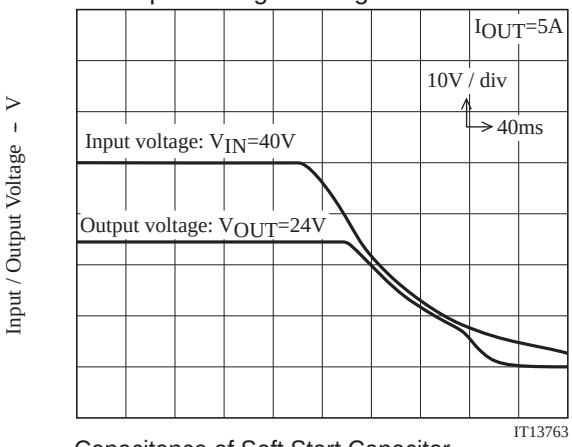

Output Voltage Falling Characteristic



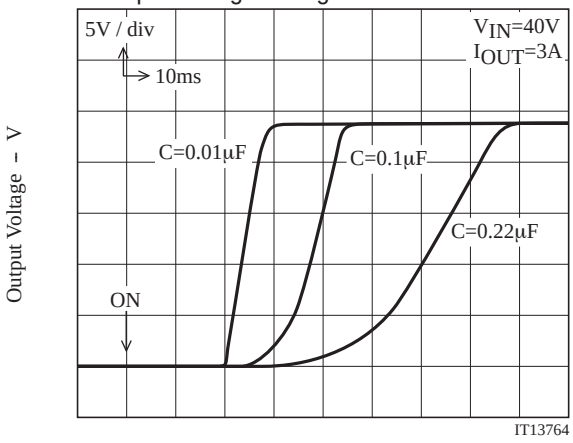

Output Voltage Rising Characteristic



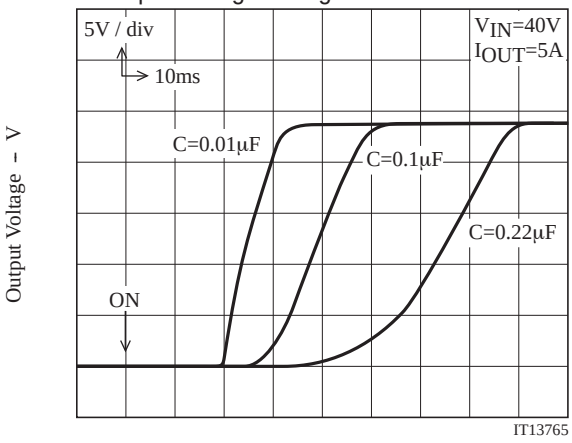

Output Voltage Falling Characteristic




Capacitance of Soft Start Capacitor – Output Voltage Rising Characteristic




Capacitance of Soft Start Capacitor – Output Voltage Rising Characteristic

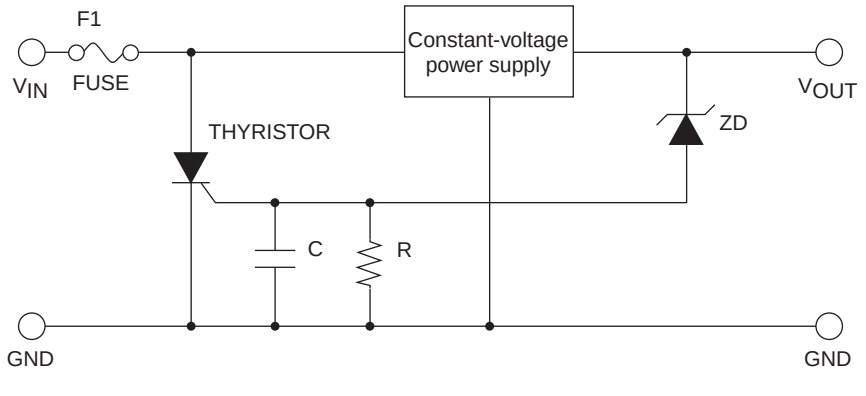


## Example of Over-voltage Protection Circuit.

Generally, in constant-voltage power supply circuit, output voltage will become higher than the specified value (over-voltage state) in case of any failures or PC board solderability defects. To minimize the damage caused by this over voltage, we recommend setting an over-voltage protection circuit.

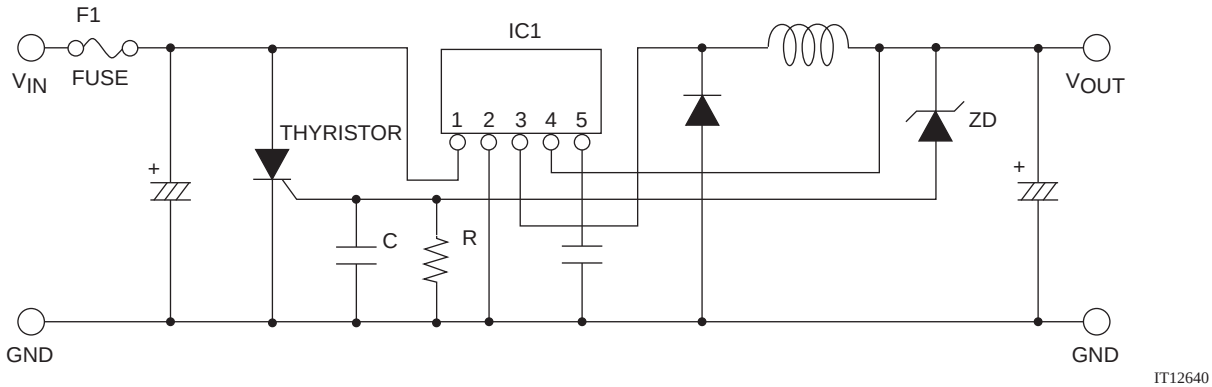
In designing, the following confirmations are necessary in actual circuit.
1) How the over-voltage protection circuit operates and its effects.
2) Is there any malfunction due to ambient temperature change of each device or exogenous noises?

Over-voltage Protection Circuit Example




## Example of Over-voltage Protection Circuit

The thyristor will operate when it accept an over-voltage ($V_{OUT}$) signal, then the fuse is melted and the input power is cut off, then the operation of IC1 is stopped.

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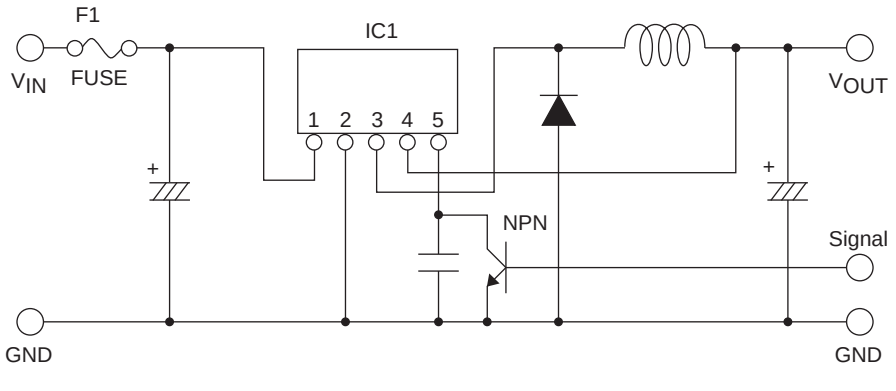
SS terminal (5 pin) also acts as standby mode switch. By setting SS terminal (5 pin) voltage to be equal or less than 0.3Vtyp, the output ON/OFF is able to be controlled by external signals.

ON/OFF Control Circuit Example




In addition, confirmation of the following points is necessary in actual circuit.
1) How the output ON/OFF control operates and its effects.
2) Is there any malfunction due to the ambient temperature change of each device or exogenous noises?

## Points to Remember in Pattern Designing

1) Transient large current flows to $V_{IN}$ terminal (1 pin), so we recommend the input capacitor should be 3000μF and above. In addition, (+) (-) terminals of the input capacitor should be set near to $V_{IN}$ terminal (1 pin) and GND terminal (2 pin).

2) Large current flows to C1A to C, $V_{IN}$ terminal (1 pin) of IC1, SWOUT terminal (3 pin), D1, L1, and C2A. So, the wiring should be thick and short.

3) FB terminal (4 pin) of IC1 is the feedback terminal from output voltage. It should be near to the output capacitor C2A.

- For the purpose of ensuring the stability of oscillation, a capacitor should be inserted between SS terminal (5 pin) and GND terminal (2 pin).

- The absolute maximum rated voltage of SS terminal (5 pin) is 7V. The absolute maximum rated voltage of FB terminal (4 pin) is within the range of 5 to 30V according to the output voltage type. When a voltage equal or higher than the rated value is applied to SS terminal (5 pin) or FB terminal (4 pin) in some cases such as abnormal test, protection measures like inserting fuses should be taken.

- The built-in over-heat protection is a function to prevent the circuit from overheat state caused by transient temperature rise, but not a function to prevent from abnormal caused by a sudden heat generation. In addition, the reliability of over-heat protection function is guarantee.