

**STK730C**

5 V Single Output MOS Chopper Regulator

Overview

The STK730C is a chopper type step-down dedicated 5 V single output regulator that uses a power MOSFET as its switching element and a Schottky barrier diode (SBD) as its flywheel diode.

The STK730C covers the 2 A and higher current regions, regions that are difficult to handle with three terminal step-down regulators. As compared with earlier chopper regulator products that used bipolar transistors, the efficiency of the STK730C has been further improved by the adoption of MOSFET and SBD technologies, and use of the STK730C enables further miniaturization and increased performance in the end product since it corresponds to the adoption of a dedicated switching controller IC. Furthermore, due to the development of a unique MOS drive circuit, the STK730C can be used with a single power supply input.

The STK730C can prove useful when standardizing and rationalizing power supply circuit design, since it can handle a wide range of power supply circuits in a number of applications, either as the secondary side regulator in a switching power supply or as the output regulator following AC transformer rectification.

Applications

- Power supplies in printers and other office equipment
- Power supplies in robots and other factory automation related equipment
- Power supplies in VCRs and other consumer products
- Secondary side regulators in switching power supplies

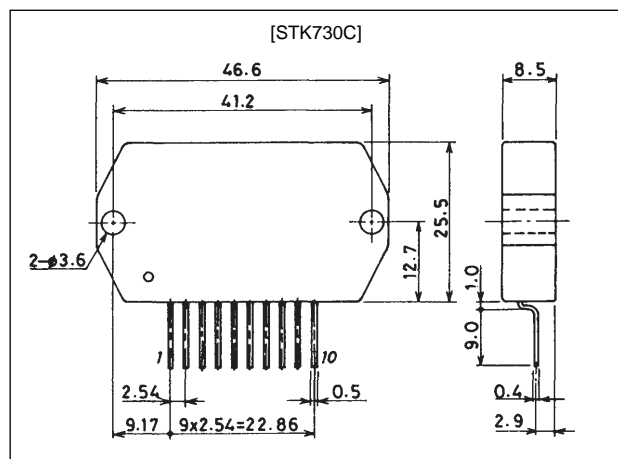
Features

- IMST substrate (insulated metal substrate technology)
- Efficiency improved (by 10%) by the adoption of MOSFET and SBD technology.
- An auxiliary drive power supply is no longer required due to the development of a unique NMOS FET drive circuit. This means that the STK730C can be used with a single power supply, thus allowing simplification of the input system.
- Built-in reverse going linear overload characteristic curve overcurrent protection circuit
- Ground line handling is eased even in multi-output power supply structures due to placement of the overcurrent detection resistor on the plus line.
- The STK730C's separate excitation oscillator structure provides high stability in the switching frequency.
- The STK730C's switching operating frequency is set at 125 kHz, which minimizes beating when used in a multiple output structure with STK731 and STK733 type products.

Package Dimensions

unit: mm

4141



Specifications

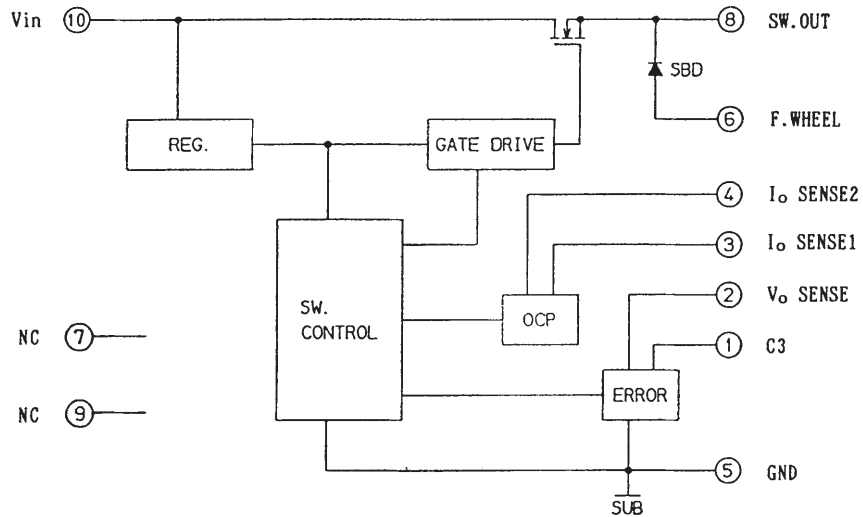
Maximum Ratings at $T_a = 25^\circ\text{C}$

| Parameter | Symbol | Rating | Unit |
|----------------------------|-------------------|---------------|---------------------------|
| Maximum DC input voltage | V_{in} (DC) max | 40 | V |
| Maximum output current | I_O max | 5 | A |
| Thermal resistance | θ_{j-c} | 3.5 (SBD 7.2) | $^\circ\text{C}/\text{W}$ |
| Junction temperature | T_J max | 150 (SBD 125) | $^\circ\text{C}$ |
| Operating case temperature | T_c max | 105 | $^\circ\text{C}$ |
| Storage temperature | T_{stg} | -30 to +105 | $^\circ\text{C}$ |

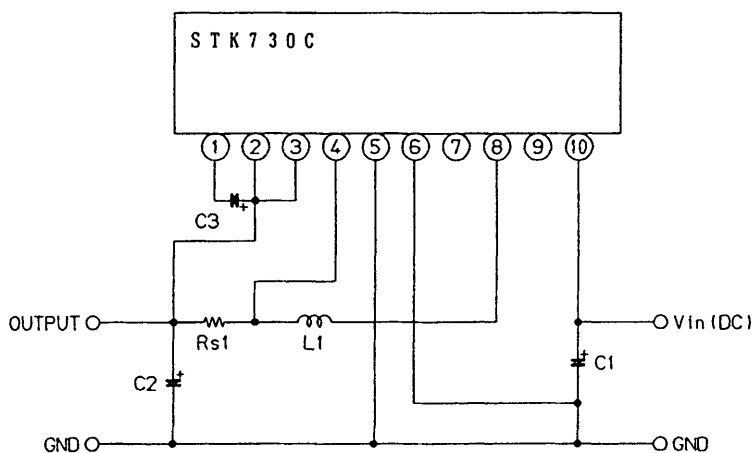
Electrical Characteristics at $T_a = 25^\circ\text{C}$, for the specified test circuit

| Parameter | Symbol | Condition | Rating | | | Unit |
|--|-----------|--|--------|------|------|-------|
| | | | min | typ | max | |
| Output voltage setting | V_O | V_{in} (DC) = 24 V, $I_O = 1$ A | 4.95 | 5.05 | 5.15 | V |
| Ripple voltage | V_{rp} | | | | 10 | mVrms |
| Input regulation | Reg-IN | V_{in} (DC) = 10 to 40 V, $I_O = 1$ A | | | 10 | mV/V |
| Load regulation | Reg-L | V_{in} (DC) = 24 V, $I_O = 0.5$ to 5 A | | | 30 | mV/A |
| Overcurrent protection start current | I_{ocp} | V_{in} (DC) = 24 V | 5 | | | A |
| Efficiency | η | V_{in} (DC) = 24 V, $I_O = 2.5$ A | | 80 | | % |
| Operating frequency | f | V_{in} (DC) = 24 V, $I_O = 1$ A | | 125 | | kHz |
| Output voltage temperature coefficient | T_{cvo} | | | | 0.02 | |

Block Diagram



Test Circuit

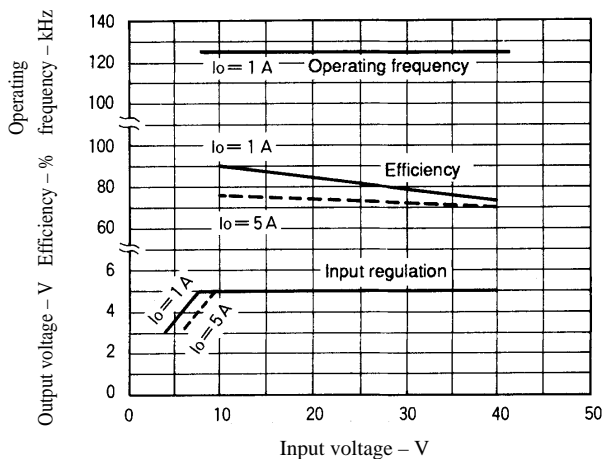


- C1: 220 μ F/50 V
- C2: 1000 μ F/10 V
- C3: 1 μ F/10 V
- L1: 200 μ H (HP-054/TOKIN)
- Rs1: 0.05 Ω

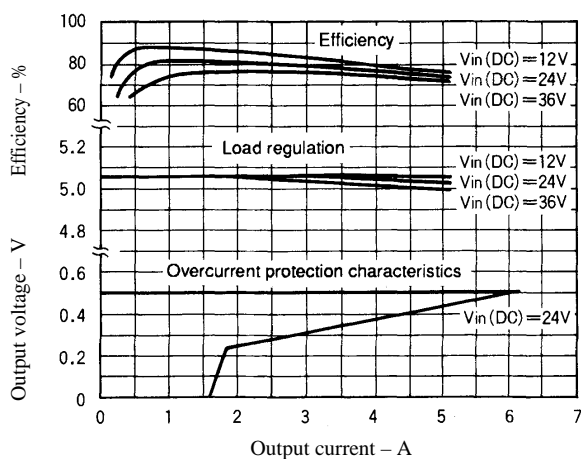
Notes: • Do not use pin 7 or pin 9 as an intermediary for any other line or pin.
 • Since pin 5 is grounded to the substrate, the noise level and other characteristics can be adversely affected if the heat sink is connected to the FG or GND lines. If this is a problem either make the heat sink floating or use an insulating sheet.

STK730C Characteristics

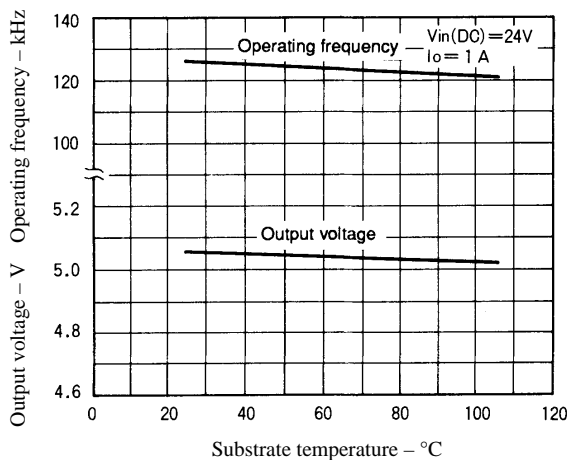
Input variation characteristics



Load variation characteristics



Temperature characteristics



Thermal Design

The power dissipating sections of a power supply block consist of the power transistor (PTR), the flywheel diode (FWD), the choke coil, and the current detection resistor. Of these, the components that are incorporated in the hybrid IC itself are the PTR and the FWD.

Taking PT to be the power dissipated in the PTR and PF to be the power dissipated in the FWD, the power dissipation Pd for the whole hybrid IC and the heat sink thermal resistance θ_{c-a} can be expressed as follows.

$$Pd = (PT + PF) \quad (W)$$

$$\theta_{c-a} = \frac{T_c - T_a}{Pd} \quad (^\circ C/W)$$

- Tc: Substrate temperature (105°C, maximum)
- Ta: IC ambient temperature

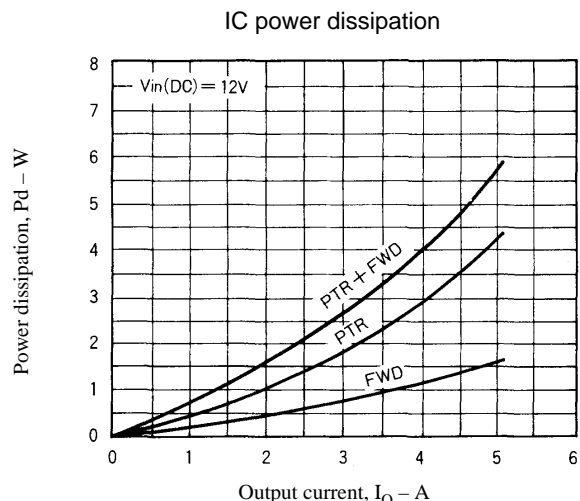
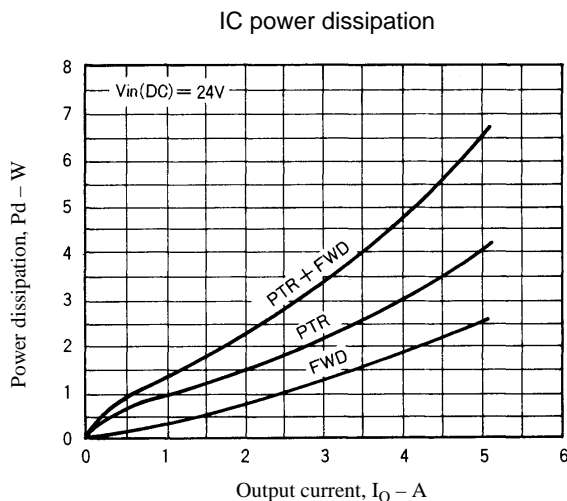
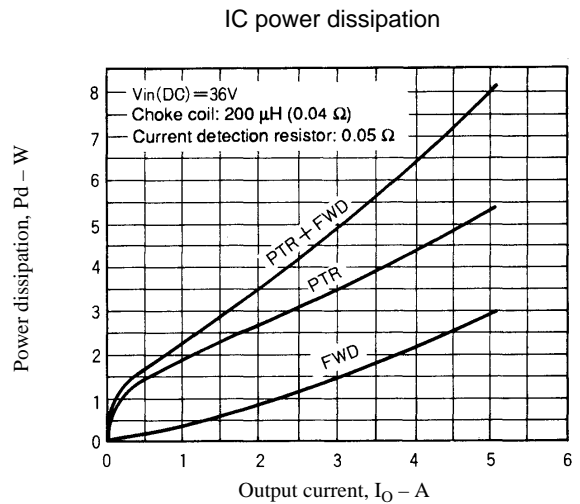
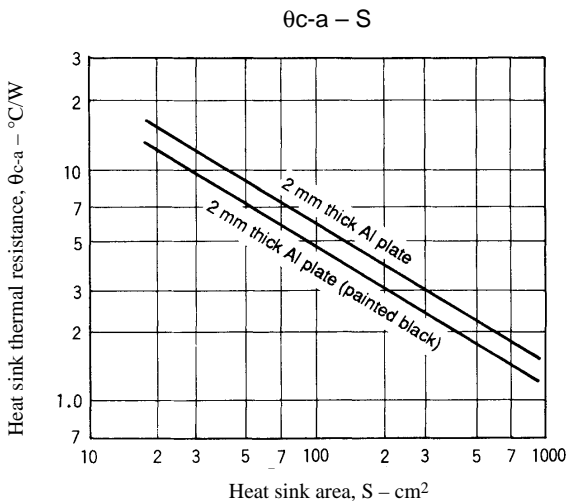
The junction temperature, Tj, of each element can be expressed as follows.

$$T_j = PD \times \theta_{j-c} + T_c \quad (^\circ C)$$

- PD: Power loss for each element (PT, PF)
- θ_{j-c} : The junction/case thermal resistance of each element

Thermal design consists of deriving the heat sink thermal resistance θ_{c-a} that satisfies the two thermal conditions, i.e., the maximum IC substrate temperature Tc max (105°C) and the maximum junction temperature Tj max for each semiconductor device, and then implementing that thermal resistance. Since thermal dissipation is greatly influenced by the ambient temperature, the structure of the equipment itself, and other factors, ample margins must be included in the thermal design to take them into account.

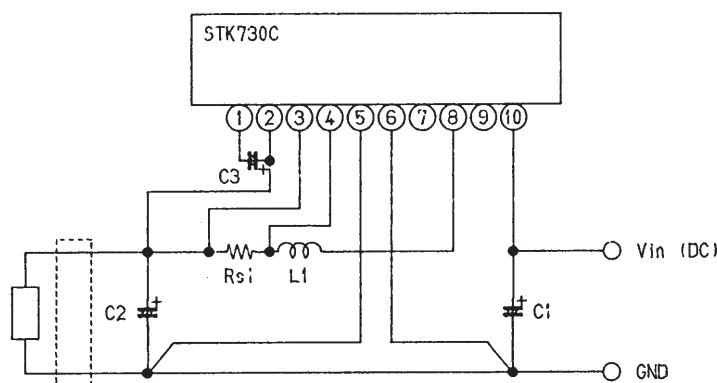
The figure below left shows the relationship between area and thermal resistance when an aluminum plate is used in the thermal design. The radiation characteristics of an aluminum plate can be improved by painting the surface black. This can reduce the thermal resistance by 20% for a given surface area.



STK730C θ_{j-c} , T_j max

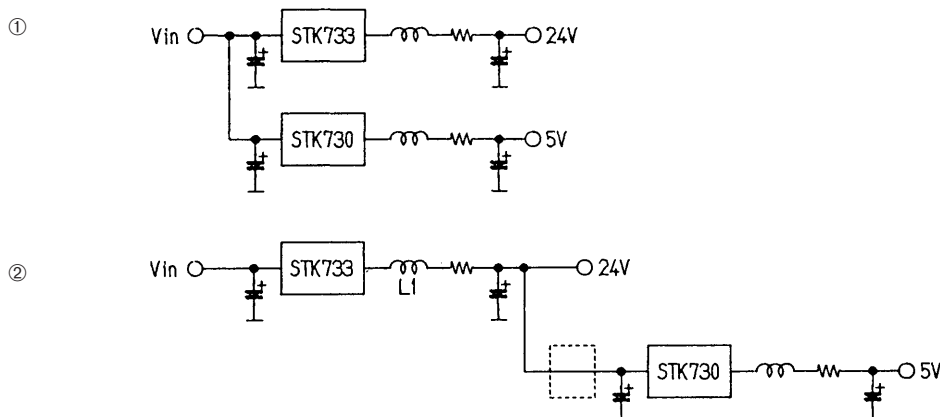
| | θ_{j-c} | T_j max |
|-----------|----------------|-----------|
| PTR (FET) | 3.5°C/W | 150°C |
| FWD (SBD) | 7.2°C/W | 125°C |

Notes on PC Board Production



- Capacitor C1 should be placed as close as possible to the pin 10 input in the layout. (This is to prevent voltage drops in the input lines and pattern. Also, a separate smoothing capacitor is required if the input is a direct current input using rectified and smoothed AC.)
- Capacitor C2 should be placed as close as possible to the load in the layout. (This is to compensate for voltage drops due to load fluctuations.)
- Pins 2 and 5 are voltage sensing lines, and should be connected close to the load, i.e., close to C2. (This is to compensate for voltage drops in the pattern.)
- Pins 3 and 4 should be directly connected to the two terminals of the current detection resistor Rs1. (This is to prevent detection based on pattern resistances.)
- Pin 6 should be connected to the capacitor C1 ground using a thick, short line to reduce the related loop area. (This is to reduce switching spikes.)
- Power lines, i.e., lines that carry current, should be made as wide as possible in the pattern.
- When a ripple suppression LC filter is added, connect it at the location indicated by dotted lines in the figure. The sensing line from pin 2 should be connected to the same position (the C2 location) as it is when no filter is used.
- The NC pins (pins 7 and 9) should not be connected to any other lines, even on the PC board.

Two Output Power Supply Structural Example (connecting to an STK733)



Note: It is possible for STK730 input ripple currents to cause L1 to vibrate audibly and adversely influence the 24 V system. If such problems occur, an inductor can be inserted at the point marked with dotted lines in the figure to form an LC filter.

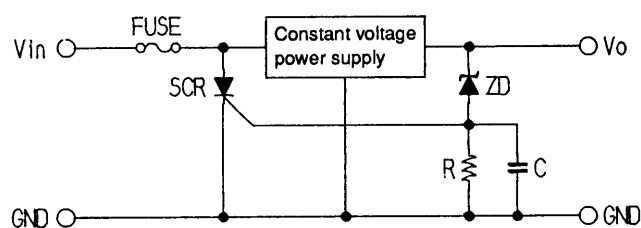
Overvoltage Protection Circuit Recommendations

When constant voltage power supply circuits fail, or a problem such as poor soldering on the PC board appears, the failure mode can involve an overvoltage state in which the output voltage becomes higher than the specified voltage. When an overvoltage failure occurs, the load driven by the power supply is often damaged, and severe damage can occur. Also, if the overvoltage exceeds the output capacitor's voltage limitation, the capacitor's internal electrolytic fluid can be vaporized and released by the operation of the capacitor's explosion prevention valve. This gas can appear to be white smoke.

When designing a power supply circuit, the need for an overvoltage protection circuit is the same regardless of whether discreet components or integrated circuits are used. We strongly recommend the use of an overvoltage protection circuit to hold to a minimum any damage that may result from an overvoltage state.

Overvoltage Protection Circuit Example

The crowbar circuit is a well known overvoltage protection circuit.



A Zener diode with a voltage 1 V to 2 V higher than the output voltage of the power supply is used as the diode ZD. When the output voltage exceeds this value due to a malfunction or other cause, the Zener diode operates and the SCR goes to the turn on short state since the SCR gate potential is pulled up. At this point the fuse at the input to the constant voltage blows, completing the operation of the overvoltage protection circuit.

If the ambient temperature varies widely the crowbar circuit operating point can change due to the temperature characteristics of both the Zener diode and the SCR's cathode/gate voltage. As a result, the protection function may operate even when the output voltage is normal. This circuit may also operate due to external noise.

Since, in general, the output voltage will be highest for the largest input and the smallest load, the operation and effectiveness of the protection circuit must be confirmed in the actual mounted configuration of the end product.

Note: Step down chopper power supplies can generate an overvoltage on the output side equivalent to the input voltage if there is an assembly error on the PC board or if the IC fails. Therefore we strongly recommend the use of a crowbar or other overvoltage protection circuit in power supply designs.

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