



SANYO Semiconductors

DATA SHEET

LA5735M — Monolithic Linear IC Separately-Excited Step-Down Switching Regulator (Variable Type)

Overview

The LA5735M is a separately-excited step-down switching regulator (variable type).

Functions

- Time-base generator (300kHz) incorporated.
- Current limiter incorporated.
- Thermal shutdown circuit incorporated.

Specifications

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

| Parameter | Symbol | Conditions | Ratings | Unit |
|------------------------------------|-------------------|------------------------------|-------------|------------------|
| Input voltage | V_{IN} | | 34 | V |
| Maximum output current | $I_O \text{ max}$ | | 0.6 | A |
| SW pin application reverse voltage | V_{SW} | | -1 | V |
| VOS pin application voltage | V_{VOS} | | -0.2 to 7 | V |
| Allowable power dissipation | $P_d \text{ max}$ | Mounted on a circuit board.* | 0.8 | W |
| Operating temperature | T_{opr} | | -30 to +125 | $^\circ\text{C}$ |
| Storage temperature | T_{stg} | | -40 to +150 | $^\circ\text{C}$ |

* Specified circuit board : 114.3×76.1×1.6mm³, glass epoxy board.

Recommended Operating Conditions at $T_a = 25^\circ\text{C}$

| Parameter | Symbol | Conditions | Ratings | Unit |
|---------------------|----------|------------|-----------|------|
| Input voltage range | V_{IN} | | 4.5 to 32 | V |

■ Any and all SANYO Semiconductor products described or contained herein do not have specifications that can handle applications that require extremely high levels of reliability, such as life-support systems, aircraft's control systems, or other applications whose failure can be reasonably expected to result in serious physical and/or material damage. Consult with your SANYO Semiconductor representative nearest you before using any SANYO Semiconductor products described or contained herein in such applications.

■ SANYO Semiconductor assumes no responsibility for equipment failures that result from using products at values that exceed, even momentarily, rated values (such as maximum ratings, operating condition ranges, or other parameters) listed in products specifications of any and all SANYO Semiconductor products described or contained herein.

SANYO Semiconductor Co., Ltd.

TOKYO OFFICE Tokyo Bldg., 1-10, 1 Chome, Ueno, Taito-ku, TOKYO, 110-8534 JAPAN

LA5735M

Electrical Characteristics at $T_a = 25^\circ\text{C}$, $V_{IN} = 15\text{V}$

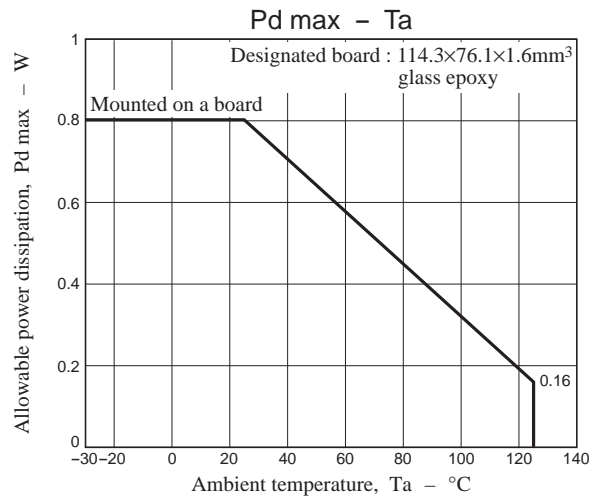
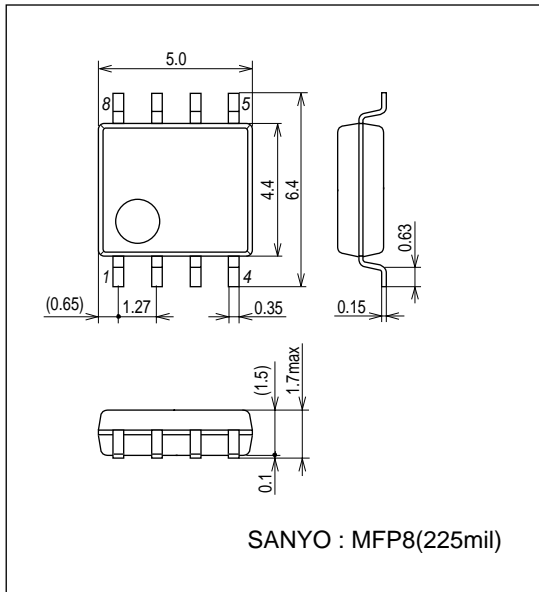
| Parameter | Symbol | Conditions | Ratings | | | Unit |
|--|--------------------|---|---------|------|------|------------------|
| | | | min | typ | max | |
| Reference voltage | V_{OS} | $I_O = 0.3\text{A}$ | 1.20 | 1.23 | 1.26 | V |
| Reference pin bias current | I_{FB} | | | 1 | 2 | μA |
| Switching frequency | fosc | | 240 | 300 | 360 | kHz |
| Short-circuit protection circuit operating switching frequency | fscp | | | 15 | | kHz |
| Saturation voltage | V_{sat} | $I_{OUT} = 0.3\text{A}$, $V_{OS} = 0\text{V}$ | | 1 | 1.15 | V |
| Maximum on duty | D max | $V_{OS} = 0\text{V}$ | | 100 | | % |
| Minimum on duty | D min | $V_{OS} = 5\text{V}$ | | 0 | | % |
| Output leakage current | I_{lk} | $V_{IN} = 30\text{V}$, $SW_{OUT} = -0.4\text{V}$ | | | 200 | μA |
| Supply current | I_{in} | $V_{OS} = 2\text{V}$ | | 5 | 10 | mA |
| Current limiter operating voltage | I_S | | 0.7 | | | A |
| Thermal shutdown operating temperature | TSD | Designed target value. * | | 165 | | $^\circ\text{C}$ |
| Thermal shutdown Hysteresis width | ΔTSD | Designed target value. * | | 15 | | $^\circ\text{C}$ |

* Design target value : Design guarantee values are replaced with electrical measurements, and are not measured by temperature.

Package Dimensions

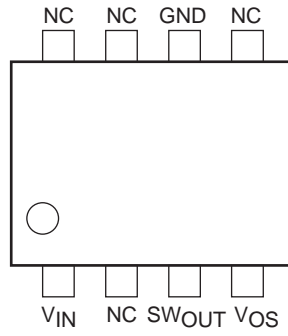
unit : mm (typ)

3032D

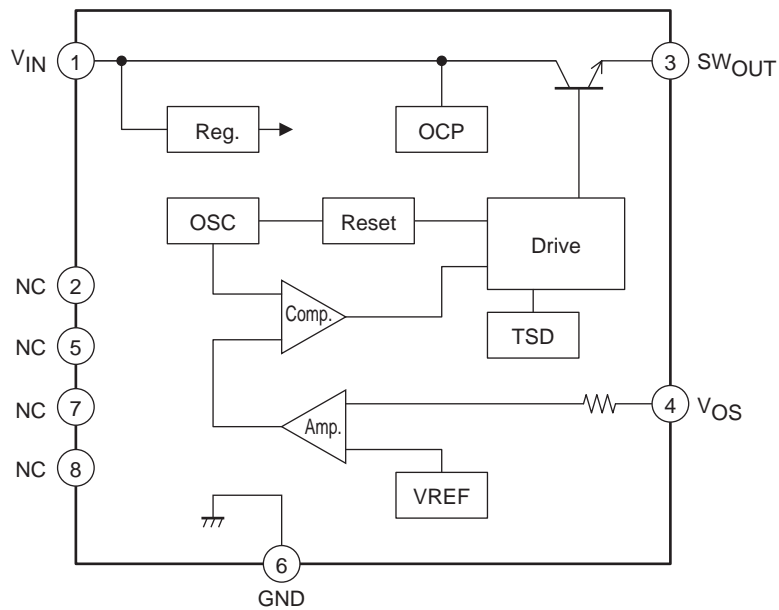


LA5735M

Pin Assignment

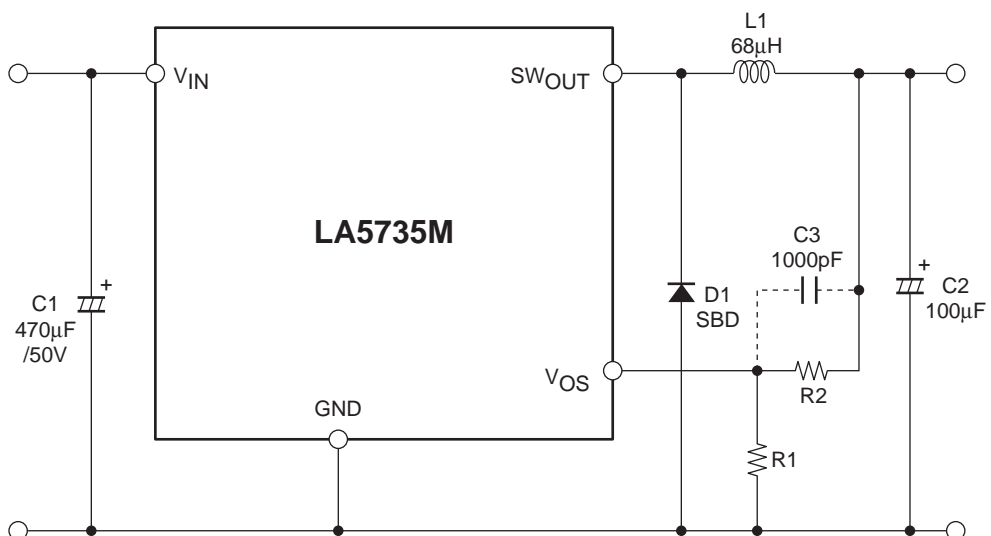


Block Diagram



Note : Since the NC pins are not connected within the IC package, they can be used as connection points.

Application Circuit Example



Choke coil L1

- Note that choke coil heating due to overload or load shorting may be a problem.

The inductance value can be determined from the following equation once the input voltage, output voltage, and current ripple conditions are known. ΔIR indicates the ripple current value.

Reference example : $V_{IN} = 12V$, $V_{OUT} = 5V$, $\Delta IR = 150mA$

$$L = \frac{V_{IN} - V_{OUT} - V_{sat}}{\Delta IR} \times T_{on}$$

$$= \frac{12 - 5.0 - 1.0}{0.15} \times 1.58 \times 10^{-6}$$

$$\approx 68\mu H$$

$$\left. \begin{aligned} T_{on} &= \frac{T}{((V_{IN} - V_{OUT} - V_{sat})/(V_{OUT} + V_F)) + 1} \\ T_{off} &= T - T_{on} \\ t : \text{Switching repetition period} &\dots\dots\dots 3.33\mu s \text{ is assumed for the calculation} \\ VF : \text{Schottky diode forward voltage} &\dots\dots 0.4V \text{ is assumed for the calculation} \end{aligned} \right\}$$

- Inductance current : peak value

The ripple current peak value must be held within the rated current values for the inductor used.

Here, IRP is the peak value of the ripple current. IRP can be determined from the following equation.

Reference example : $V_{IN} = 12V$, $V_{OUT} = 5V$, $I_{OUT} = 0.5A$, $L = 68\mu H$

$$IRP = I_{OUT} + \frac{V_{IN} - V_{OUT} - V_{sat}}{2L} \times T_{on}$$

$$= 0.5 + \frac{12 - 5.0 - 1.0}{2 \times 68 \times 10^{-6}} \times 1.58 \times 10^{-6}$$

$$\approx 0.57A$$

- Inductance current : ripple current value

Here ΔIR is the ripple current. ΔIR can be determined from the following equation.

If the load current becomes less than one half the ripple current, the inductor current will become discontinuous.

$$\Delta IR = \frac{V_{IN} - V_{OUT} - V_{sat}}{L} \times T_{on}$$

$$= \frac{12 - 5.0 - 1.0}{68 \times 10^{-6}} \times 1.58 \times 10^{-6}$$

$$\approx 0.15A$$

Diode D1

- A Schottky barrier diode must be used for this diode.

If a fast recovery diode is used, it is possible that the IC could be destroyed by the applied reverse voltage due to the recovery and the on-state voltage.

- Diode current (peak current)

Applications must be designed so that the peak value of the diode current remains within the rated current of the diode.

The peak value of the diode current will be the same current as the peak value of the inductor current.

- Repetitive peak reverse voltage

Applications must be designed so that the repetitive peak reverse voltage remains within the voltage rating of the diode.

Here, V_{RRM} is the repetitive peak reverse voltage. V_{RRM} can be determined from the following equation.

$$V_{RRM} \geq V_{CC}$$

Since noise voltage and other terms will be added in actual operation, the voltage handling capacity of the device should be about 1.5 times that given by the above calculation.

Diode D1

- Low-impedance, high-frequency components designed for use in switching power supplies must be used for C1 and C2 since large ripple currents flow in these capacitors. Note that if a ceramic capacitor, tantalum capacitor, or other capacitor with an extremely low equivalent series resistance (ESR) is used for C2, abnormal oscillations may occur in the output waveform. Do not use such a capacitor for C2.

The following equation gives the stability condition for the C2 capacitor and ESR values.

$$\frac{1}{2 \times \pi \times C2 \times ESR} \leq 20\text{kHz} \dots\dots\dots \text{Equation 5}$$

- Repetitive peak reverse voltage

The AC ripple currents flowing in the input capacitor will be larger currents than those flowing in the output capacitors.

The RMS current is given by the following equation. Note that capacitors must only be used with currents that are within their current ratings.

$$IC1 = \sqrt{\frac{V_{OUT}}{V_{IN}} \left(I_{OUT}^2 \left(1 - \frac{V_{OUT}}{V_{IN}} \right) + \frac{1}{12} \times \Delta I R^2 \right)} \quad [\text{Arms}]$$

- Output capacitor RMS current

Since the ripple current, an AC current, flowing in the output capacitors has a sawtooth waveform, the RMS value is given by the following equation. Select output capacitors whose allowable ripple current rating is not exceeded by this value.

$$IC2 = \frac{1}{2\sqrt{3}} \times \frac{V_{OUT} (V_{IN} - V_{OUT})}{L \times f_{sw} \times V_{IN}} \quad [\text{Arms}]$$

fsw = Switching frequency 300kHz

Resistors R1 and R2

- The resistors R1 and R2 set the output voltage. The error in the VOS pin voltage increases as the values used for these resistors increase. Note also that the output voltage may rise due to leakage current in the switching transistors during light load operation. For these reasons, R1 and R2 should be selected so that the current flowing in them is on the order of 500µA.

$$R1 = \frac{1.23V}{500\mu A} \approx 2.4k\Omega \qquad \text{We recommend values in the range 2.0 to 2.4k}\Omega$$

$$R2 = \left(\frac{V_{OUT}}{1.23V} - 1 \right) \times R1$$

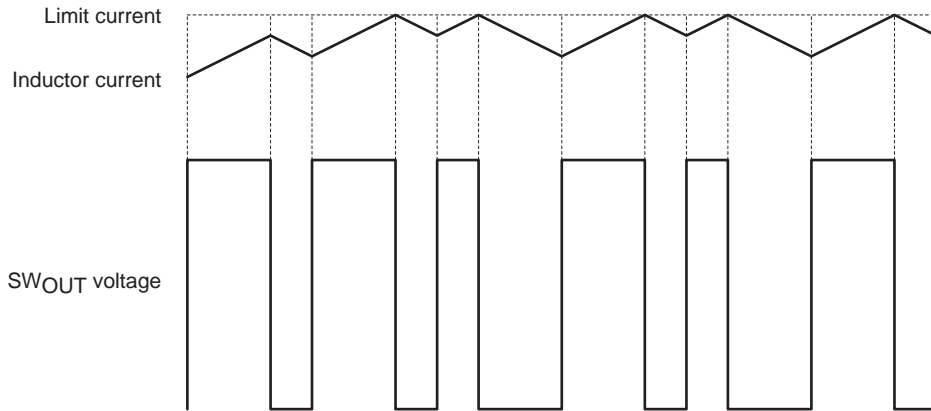
The following equation gives the output voltage set by R1 and R2.

$$V_O = \left(1 + \frac{R2}{R1} \right) \times 1.23V (typ)$$

Protection Circuit Functional Descriptions

1. Overcurrent protection function

The overcurrent protection function detects, on a cycle-by-cycle basis, the output transistor current and turns off that output transistor current if it exceeds 0.7A in a cycle-by-cycle manner.

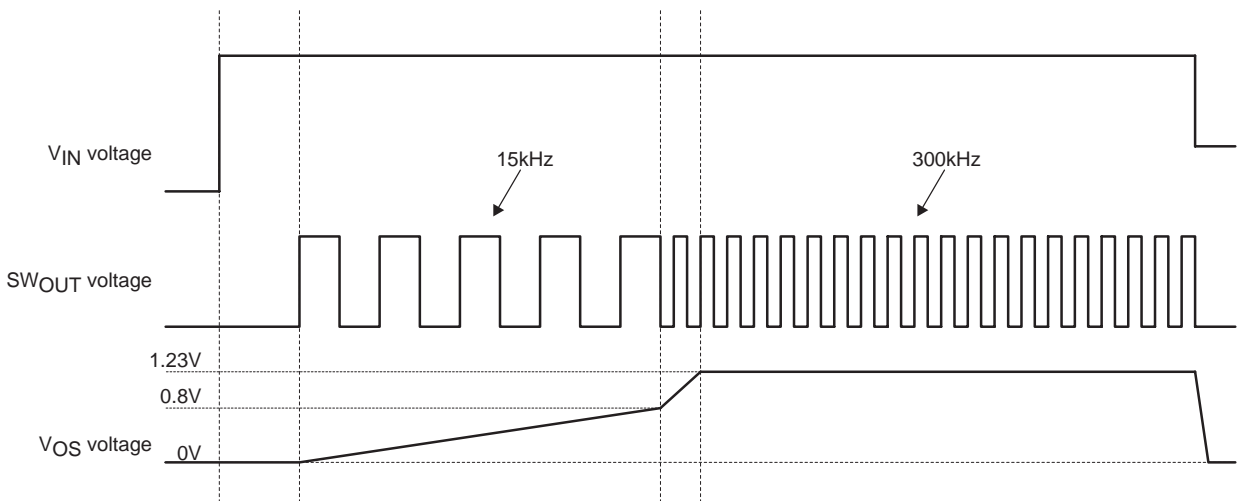


2. Short circuit protection function

This IC prevents the current from increasing when the outputs are shorted by setting the switching frequency to 15kHz if the V_{OS} pin voltage falls below 0.8V.

Note : At startup, since the switching frequency will be 15kHz while the V_{OS} pin voltage is 0.8V or lower, the current capacity is reduced. If the load is applied at startup and the applications has trouble starting, increase the value of the inductor to resolve this problem.

Timing Chart



- Specifications of any and all SANYO Semiconductor products described or contained herein stipulate the performance, characteristics, and functions of the described products in the independent state, and are not guarantees of the performance, characteristics, and functions of the described products as mounted in the customer's products or equipment. To verify symptoms and states that cannot be evaluated in an independent device, the customer should always evaluate and test devices mounted in the customer's products or equipment.
- SANYO Semiconductor Co., Ltd. strives to supply high-quality high-reliability products. However, any and all semiconductor products fail with some probability. It is possible that these probabilistic failures could give rise to accidents or events that could endanger human lives, that could give rise to smoke or fire, or that could cause damage to other property. When designing equipment, adopt safety measures so that these kinds of accidents or events cannot occur. Such measures include but are not limited to protective circuits and error prevention circuits for safe design, redundant design, and structural design.
- In the event that any or all SANYO Semiconductor products (including technical data, services) described or contained herein are controlled under any of applicable local export control laws and regulations, such products must not be exported without obtaining the export license from the authorities concerned in accordance with the above law.
- No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying and recording, or any information storage or retrieval system, or otherwise, without the prior written permission of SANYO Semiconductor Co., Ltd.
- Any and all information described or contained herein are subject to change without notice due to product/technology improvement, etc. When designing equipment, refer to the "Delivery Specification" for the SANYO Semiconductor product that you intend to use.
- Information (including circuit diagrams and circuit parameters) herein is for example only; it is not guaranteed for volume production. SANYO Semiconductor believes information herein is accurate and reliable, but no guarantees are made or implied regarding its use or any infringements of intellectual property rights or other rights of third parties.

This catalog provides information as of January, 2007. Specifications and information herein are subject to change without notice.