



SANYO Semiconductors

# DATA SHEET

An ON Semiconductor Company

## 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 : 114.3×76.1×1.6mm<sup>3</sup>, 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

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# LA5735M

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

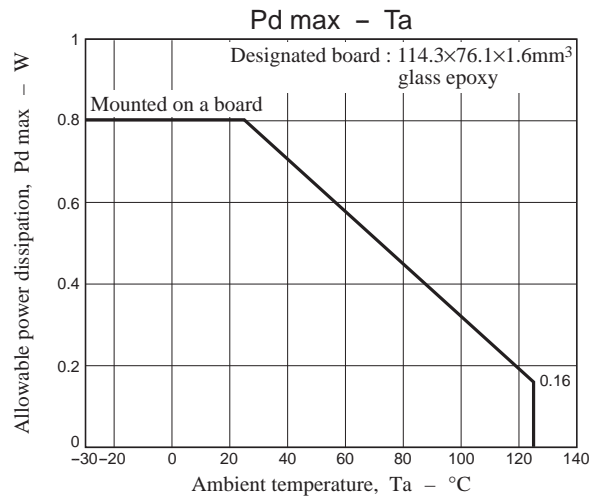
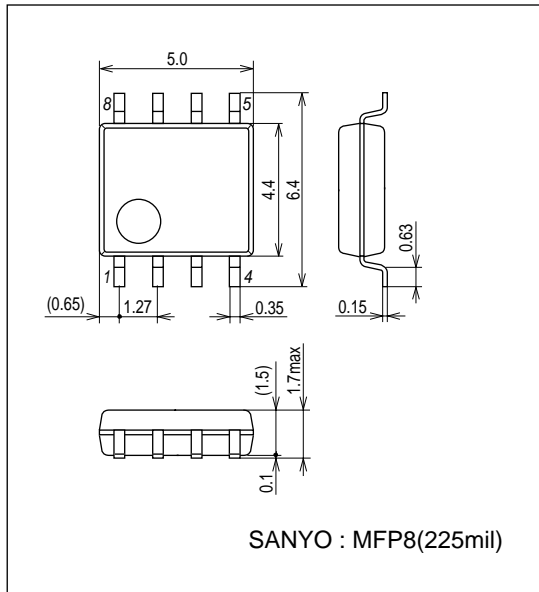
Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Reference voltage	$V_{OS}$	$I_O = 0.3\text{A}$	1.20	1.23	1.26	V
Reference pin bias current	$I_{FB}$			1	2	$\mu\text{A}$
Switching frequency	$f_{osc}$		240	300	360	kHz
Short-circuit protection circuit operating switching frequency	$f_{scp}$			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	$\mu\text{A}$
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	$\Delta\text{TSD}$	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

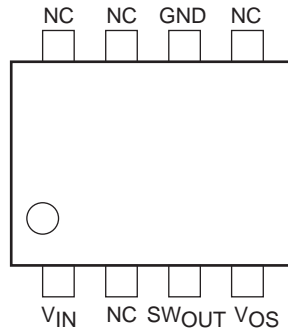
unit : mm (typ)

3032D

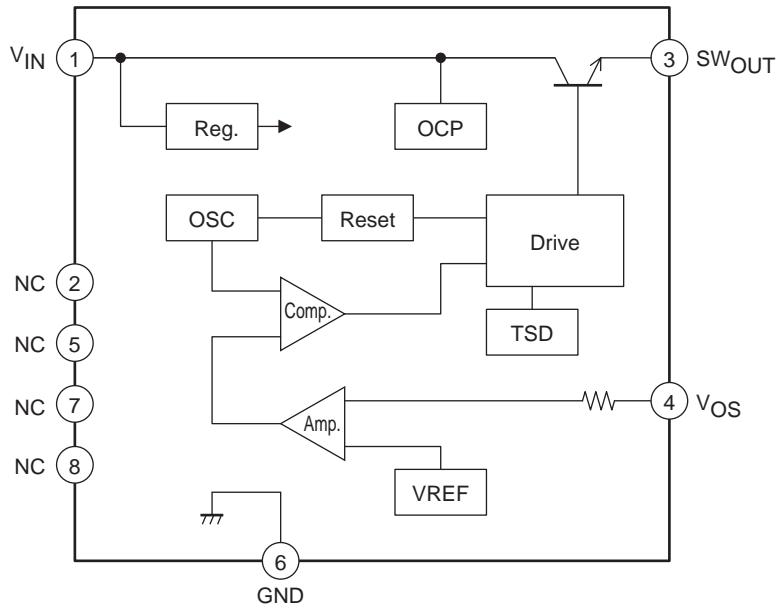


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## Pin Assignment

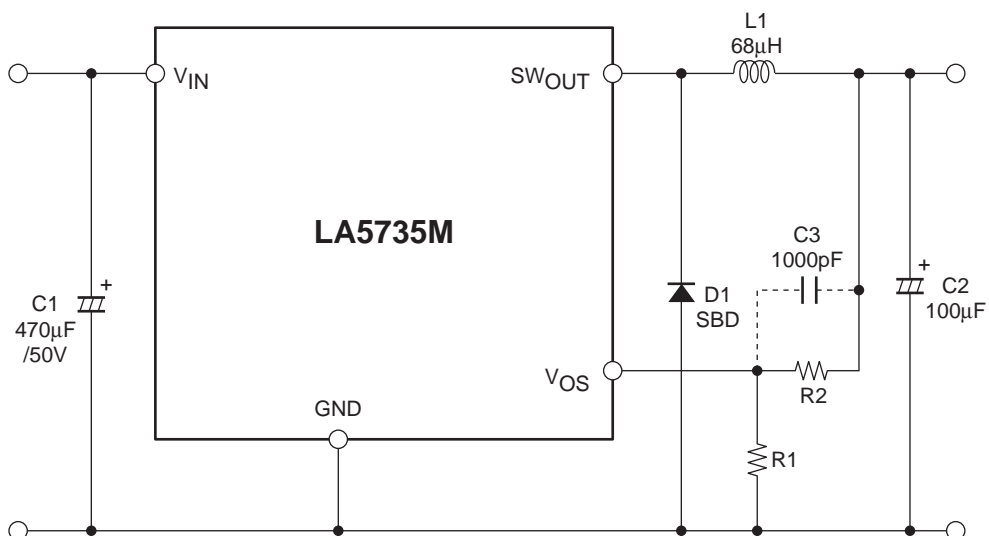


## Block Diagram



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.  $\Delta IR$  indicates the ripple current value.

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

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

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

$$\approx 68\mu H$$

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

- 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  $\Delta IR$  is the ripple current.  $\Delta IR$  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.

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

- 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.

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

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.

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

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

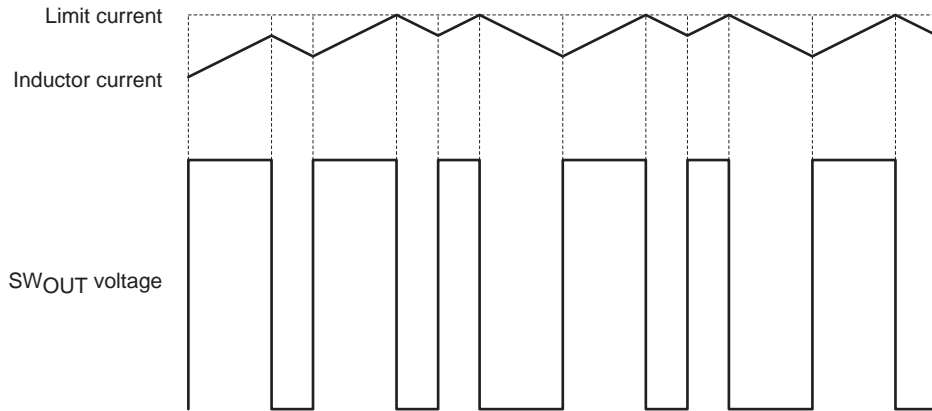
The following equation gives the output voltage set by R1 and R2.

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

## 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.

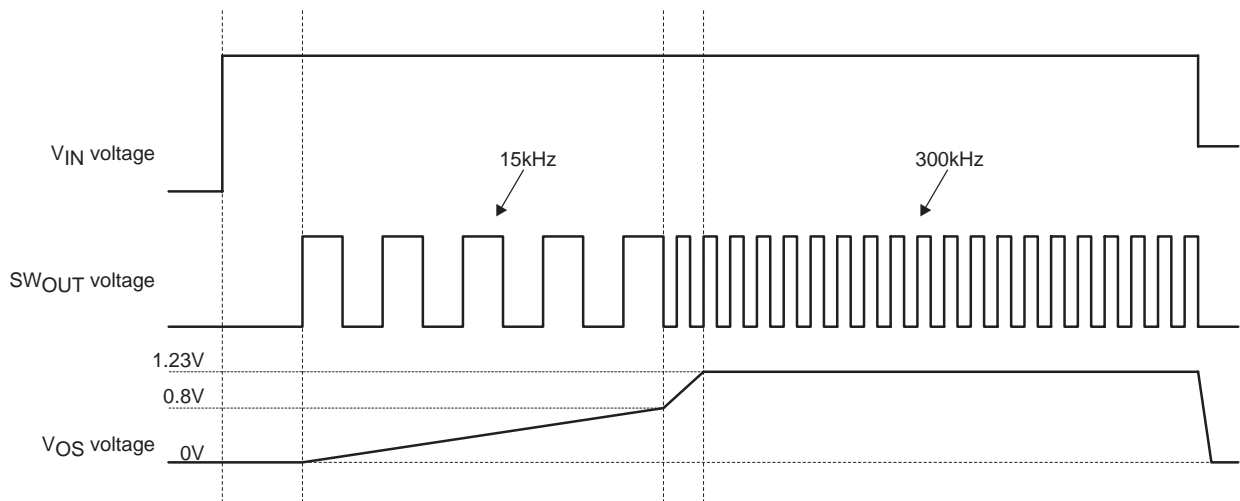


### 2. Short circuit protection function

This IC prevents the current from increasing when the outputs are shorted by setting the switching frequency to 15kHz if the V<sub>OS</sub> pin voltage falls below 0.8V.

Note : At startup, since the switching frequency will be 15kHz while the V<sub>OS</sub> 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



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