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LA5735MC

ON Semiconductor®

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Monolithic Linear IC

Separately-Excited Step-Down Switching Regulator (Variable Type)

Overview

The LA5735MC 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 Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Input voltage	V_{IN}		34	V
SW pin application reverse voltage	V_{SW}		-1	V
VOS pin application voltage	V_{VOS}		-0.2 to 7	V
Allowable power dissipation	Pd max	Mounted on a circuit board.*	0.75	W
Operating temperature	Topr		-30 to +125	°C
Storage temperature	Tstg		-40 to +150	°C
Junction temperature	Tjmax		150	°C

* Specified circuit board : 114.3×76.1×1.6mm^3, glass epoxy board.

Caution 1) Absolute maximum ratings represent the value which cannot be exceeded for any length of time.

Caution 2) Even when the device is used within the range of absolute maximum ratings, as a result of continuous usage under high temperature, high current, high voltage, or drastic temperature change, the reliability of the IC may be degraded. Please contact us for the further details.

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

Recommended Operating Conditions at Ta = 25°C

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

Electrical Characteristics at Ta = 25°C, V_{IN} = 15V

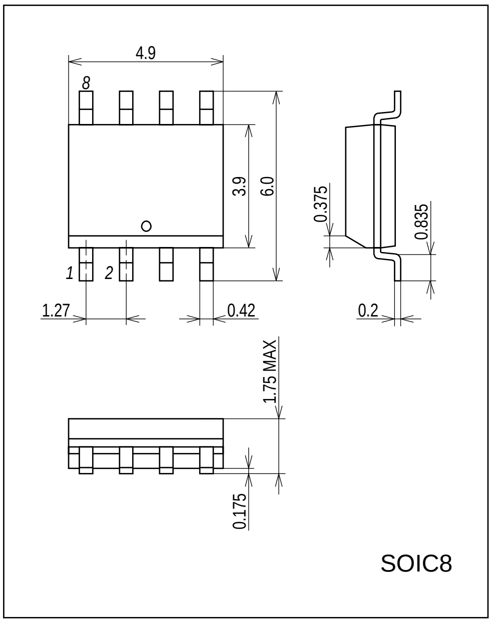
Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Reference voltage	V_{OS}	I_O = 0.3A	1.20	1.23	1.26	V
Reference pin bias current	I_{FB}			1	2	μA
Switching frequency	fosc		240	300	360	kHz
Short-circuit protection circuit operating switching frequency	fscp			15		kHz
Saturation voltage	Vsat	I_{OUT}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

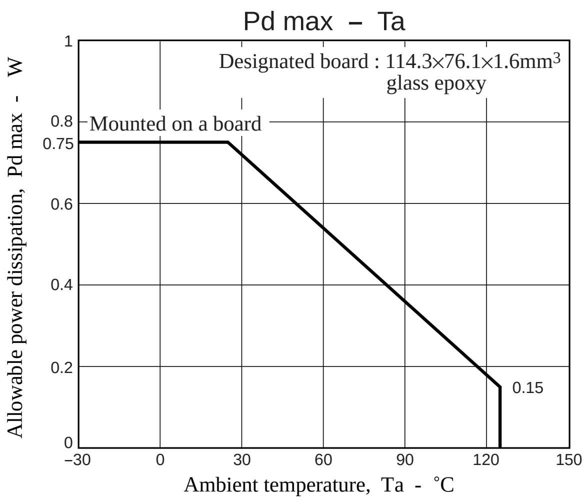
* Design target value : Design guarantee values are replaced with electrical measurements, and are not measured by temperature.

Package Dimensions

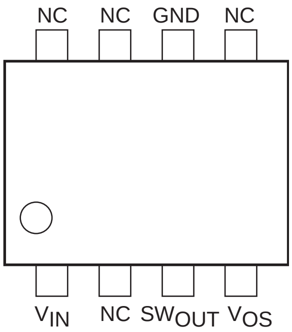
unit : mm (typ)

3424

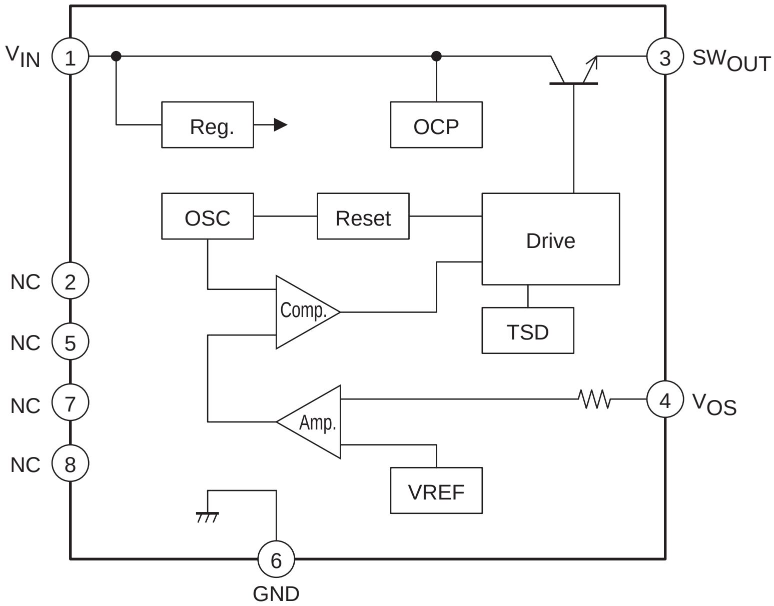




Pin Assignment

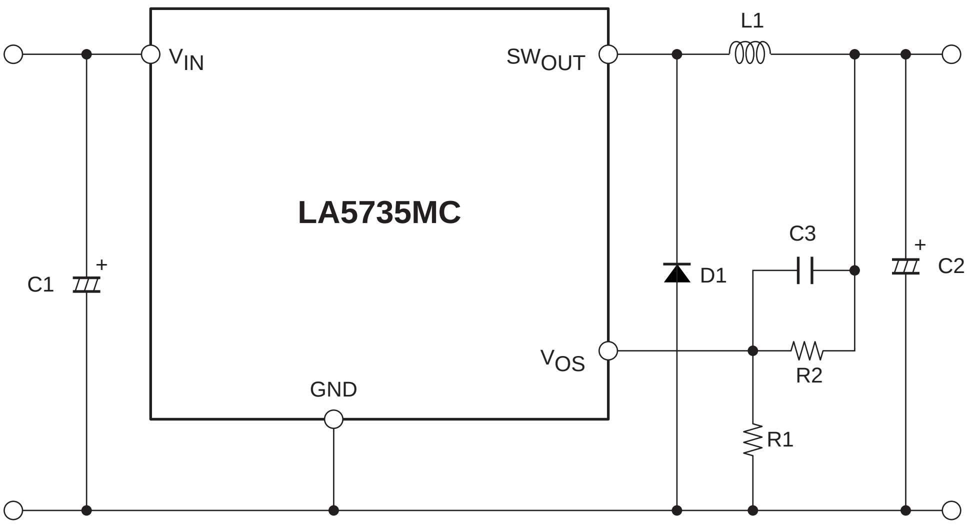


Block Diagram



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

Application Circuit Example

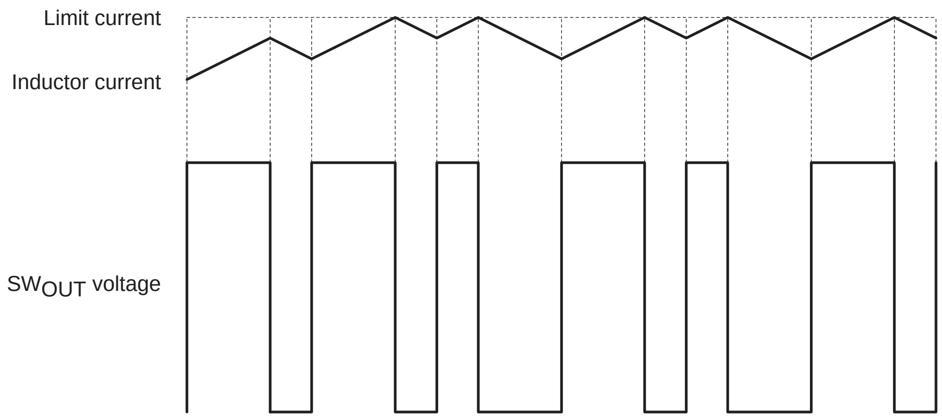


Note: Insome cases, the output may not turn on if power is applied when a load is connected. If this is a problem, increase the value of the inductor.

Protection Circuit Functional Descriptions

1. Overcurrent protection function

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

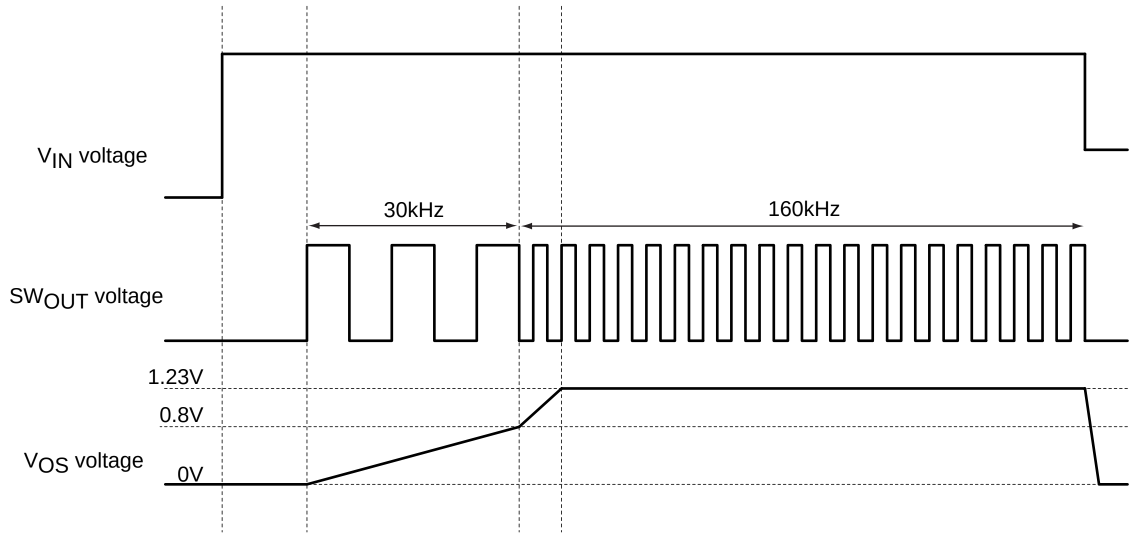


2. Short circuit protection function

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



Part selection and set

1. Resistors R1 and R2
   R1 and R2 are resistors to set the output voltage. When the large resistance value is set, the error of set voltage increases due to the V_{OS} pin current. The output voltage may also increases due to the leak current of switching transistor at light load. In consequence, it is essential to see R1 and R2 currnet to around 500µA.

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

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

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

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

2. Capacitor C1, C2 and C3
   The large ripple current flows through C1 and C2, so that the high-frequency low-impedance product for switching power supply must be used. Do not use, for C2, a capacitor eith extremely small equivalent series resistance (ESR), such as ceramic capacitor, tantalum capacitor. Otherwise, the output waveform may develop abnormal oscillation. The C2 capacitance and ESR value stabilization conditions are as follows:

$$\frac{1}{2\times\pi\times C2\times ESR}\leq 20kHz$$

   C3 is a capacitor for phase compensation of the feedback loop. Abnormal oscillation may occur when the C2 capacitance value is small or the equivalent series resistance is small. In this case, addition od the capacitance of C3 enables phase compensation, contributing to stabilization of power supply.

3. Input capacitor: Effective-value current
   The AC ripple currents flowing in the input capacitor is large than that in the output capacitor. The equation expressing the effective-value current is as follows. Use the capacitor within the rated current range.

$$IC1=\sqrt{\frac{Vout}{Vin}\left(Iout^2\left(1-\frac{Vout}{Vin}\right)+\frac{1}{12}\times\Delta IR^2\right)}\quad [Arms]$$

4. Output capacitor: Effective-value current
   The AC ripple current flowing in the output capacitor is the triabgular wave. Therefore, its effective value is obtained from the following equation. Select the output capacitor so that it does not exceed the allowable ripple current value.

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

   fsw = Switching frequency 300kHz

5. 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, ΔIR = 150mA

$$L=\frac{V_{IN}-V_{OUT}-Vsat}{\Delta IR}\times Ton$$

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

$$\approx 68\mu H$$

$$Ton=\frac{T}{((V_{IN}-V_{OUT}-Vsat)/(V_{OUT}+VF))+1}$$

$Toff = T - Ton$
t : Switching repetition period ··· 3.33µs is assumed for the calculation
VF : Schottky diode forward voltage0.4V is assumed for the calculation

6. 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 ripple current. IRP can be determined from the following equation.

Reference example : V_{IN} = 12V, V_{OUT} = 5V, I_{OUT} = 0.5A, L = 68μH

$$IRP = I_{OUT} + \frac{V_{IN} - V_{OUT} - Vsat}{2L} \times Ton$$

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

$$\approx 0.57A$$

7. 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.

$$\Delta IR = \frac{V_{IN} - V_{OUT} - Vsat}{L} \times Ton$$

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

$$\approx 0.15A$$

8. 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.

9. 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.

10. 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.