



SANYO Semiconductors

DATA SHEET

An ON Semiconductor Company

LA5724MC

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

Overview

The LA5724MC is a separately-excited step-down switching regulator (variable type).

Functions

- Time-base generator (160kHz) 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}		30	V
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 max	Mounted on a circuit board.*	0.8	W
Operating temperature	T _{opr}		-30 to +125	°C
Storage temperature	T _{stg}		-40 to +150	°C
Junction temperature	T _j max		150	°C

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

Recommended Operating Conditions at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Input voltage range	V _{IN}		4.5 to 28	V

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<http://semicon.sanyo.com/en/network>

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

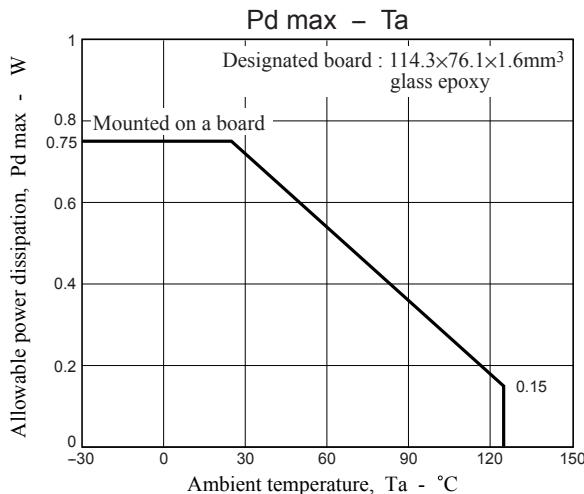
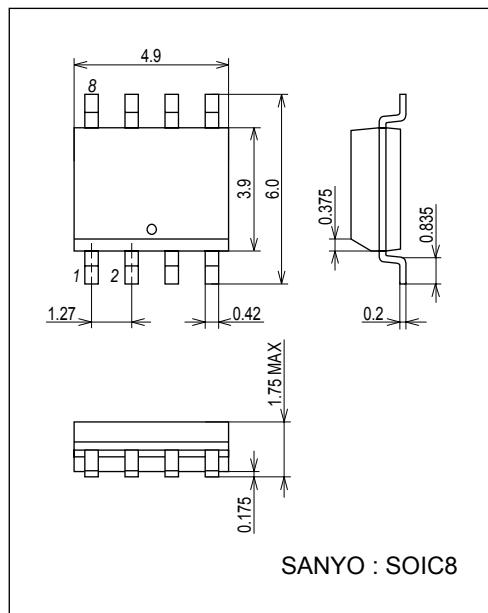
Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Reference voltage	V_{OS}	$I_O = 0.3\text{A}$	1.20	1.23	1.26	V
Reference pin bias current	I_{FB}			1	2	μA
Switching frequency	f_{osc}		128	160	192	kHz
Efficiency	η	$V_{OUT} = 5\text{V}$, $I_O = 0.3\text{A}$		82		%
Short-circuit protection circuit operating switching frequency	f_{scp}			30		kHz
Saturation voltage	V_{sat}	$I_{OUT} = 0.3\text{A}$, $V_{OS} = 0\text{V}$		1.2		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}	$V_{OUT} = -1\text{V}$			200	μA
Supply current	I_{in}	$V_{OS} = 2\text{V}$		5	10	mA
Current limiter operating current	I_S		0.7			A
Thermal shutdown operating temperature	T_{SD}	Designed target value. *		165		$^\circ\text{C}$
Thermal shutdown Hysteresis width	ΔT_{SD}	Designed target value. *		15		$^\circ\text{C}$

* Design target value : No measurement made.

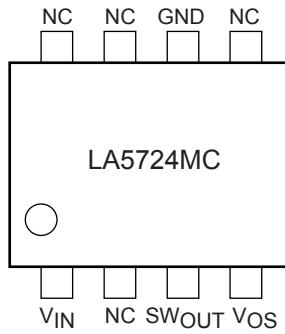
Package Dimensions

unit : mm (typ)

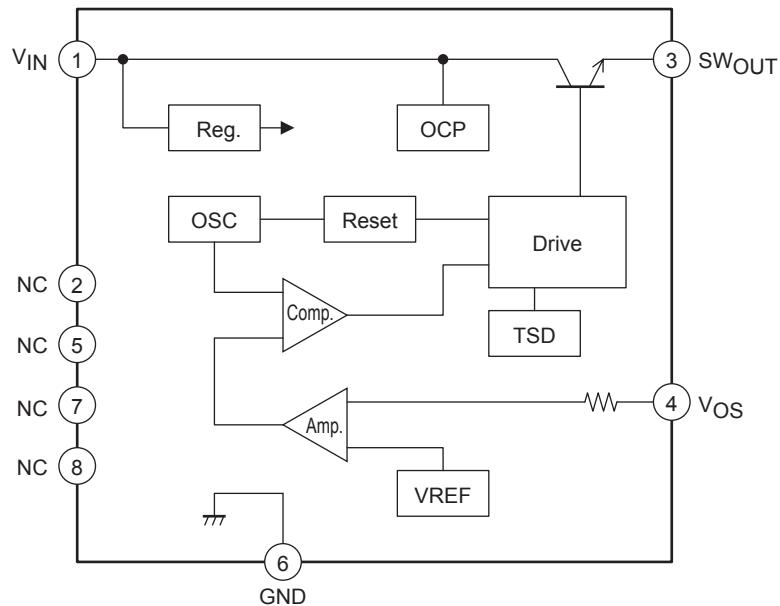
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Pin Assignment

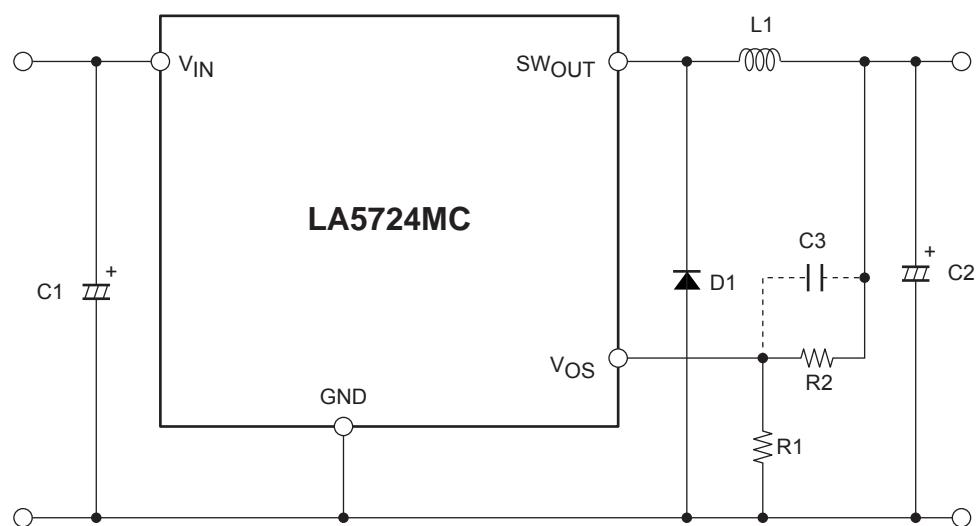


Block Diagram



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

Application Circuit Example

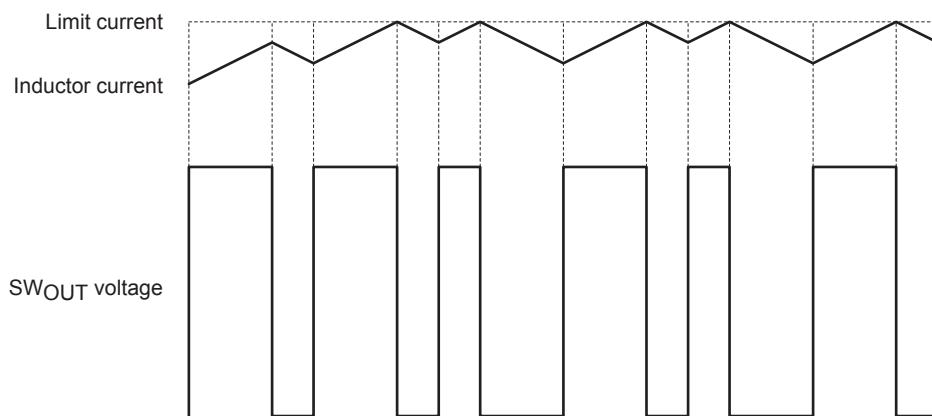


Note : In some cases, the output may not turn on if power is applied when a load is connected. If this is a problem, increase the value of the inductor.

Protection Circuit Functional Descriptions

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.

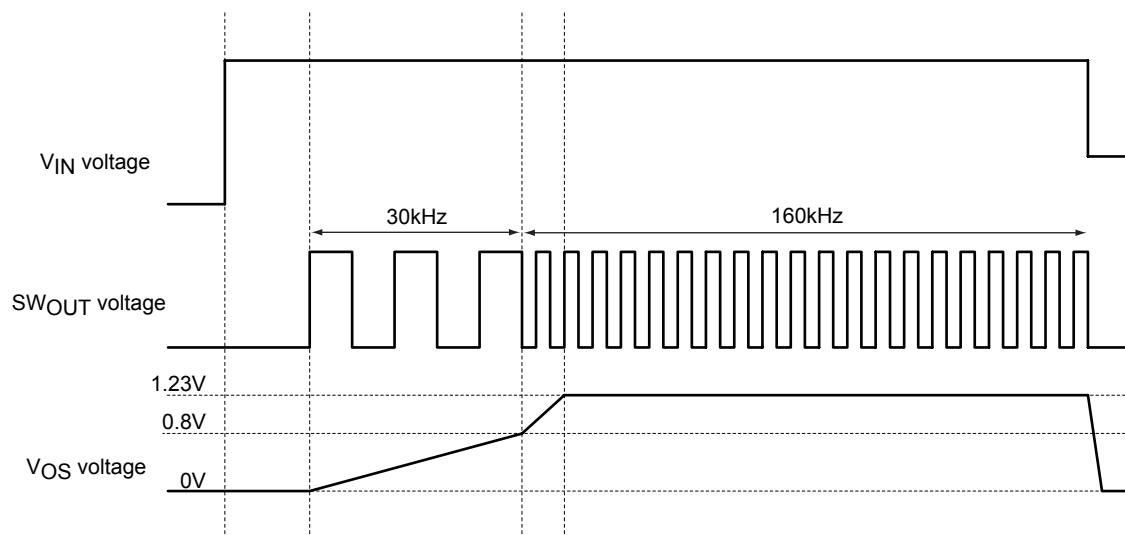


Short circuit protection function

This IC prevents the current from increasing when the outputs are shorted by setting the switching frequency to 30kHz if the VOS pin voltage falls below 0.8V.

Note : At startup, since the switching frequency will be 30kHz while the VOS 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 VOS 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 currents to around 500μA.

$$R1 = \frac{1.23V}{500\mu A} \approx 2.4k\Omega \quad 2.0k\Omega \text{ to } 2.4k\Omega \text{ recommended}$$

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

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

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

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 with 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:

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

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 of the capacitance of C3 enable phase compensation, contributing to stabilization of power supply.

3. Input capacitor: Effective-value current

The AC ripple current flowing in the input capacitor is larger than that in the output capacitor. The equation expressing the effective-value current is as follows. Use the capacitor within the rated current range.

$$IC1 = \sqrt{\frac{V_{out}}{V_{in}} \left(I_{out}^2 \left(1 - \frac{V_{out}}{V_{in}} \right) + \frac{1}{12} \times \Delta IR^2 \right)} \quad [\text{Arms}]$$

4. Output capacitor: Effective-value current

The AC ripple current flowing in the capacitor is the triangular 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.

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

f_{SW} = switching frequency ⋯ 160kHz

5. Choke coil

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

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

$$= \frac{12 - 5.0 - 0.4}{0.15} \times 2.8 \times 10^{-6}$$

$$\approx 120\mu H$$

$$\left. \begin{aligned} T_{on} &= \frac{T}{(V_{IN} - V_{OUT} - V_{sat}) / (V_{OUT} + V_{F}) + 1} \\ T_{off} &= T - T_{on} \\ T: \text{Switching repetition period} & \cdots 6.25\mu s \text{ is assumed for the calculation} \\ V_{F}: \text{Schottky diode forward voltage} & \cdots 0.4V \text{ is assumed for the calculation} \end{aligned} \right\}$$

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.

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

$$= 0.5 + \frac{12 - 5.0 - 0.4}{2 \times 120 \times 10^{-6}} \times 2.8 \times 10^{-6}$$

$$\approx 0.57A$$

7. Inductance current: ripple current value

Here ΔI_{R} is the ripple current. ΔI_{R} 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.

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

$$= \frac{12 - 5.0 - 0.4}{120 \times 10^{-6}} \times 2.8 \times 10^{-6}$$

$$\approx 0.15A$$

8. Diode D1

A Schottky barrier diode must be used for the 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 headroom capacity of the device should be about 1.5 times that given by the above calculation.

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