HT77xxS PFM DC/DC Step-up Converter

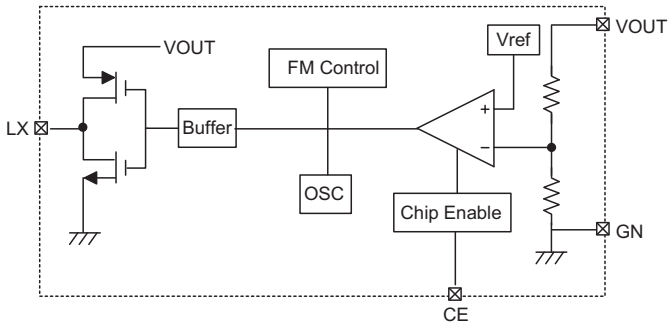
D/N：AN0298E

Introduction

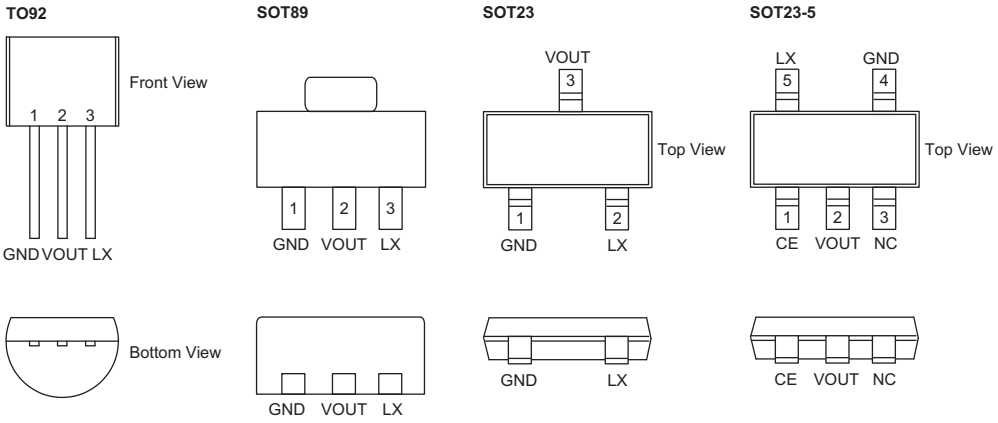
The HT77xxS is a series of high-efficiency PFM DC/DC synchronous step-up converters, which can use both multi-layer and wire-wound inductor types. This series has the advantages of low start-up voltage and high-accuracy output voltage and uses CMOS technology to ensure that the supply current is kept ultra-low. It can use smaller value capacitors and inductors due to its high operating frequency of up to 500kHz. Its high operating frequency also greatly reduces audio noise. Additionally, this series provides a range of 1.8V, 2.2V, 2.7V, 3.0V, 3.3V, 3.7V and 5.0V output voltages with only three external components.

The HT77xxS devices include an internal oscillator, a PFM control circuit, driver transistor, a reference voltage circuit and a high speed comparator. It uses pulse frequency modulation to keep the supply current to a minimum and also has light-load minimum ripple current. It is supplied in four package types, namely TO92, SOT89, SOT23 and SOT23-5. The SOT23-5 type has an enable control, which gives very low power losses in the power-down mode.

Block Diagram



Pin Assignment

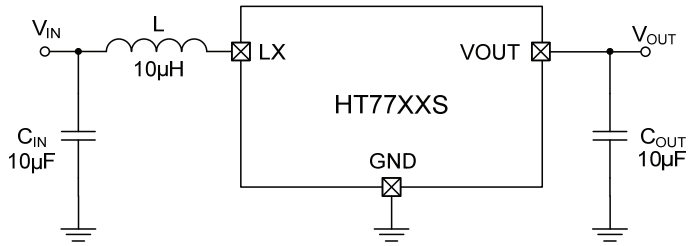


Pin Description

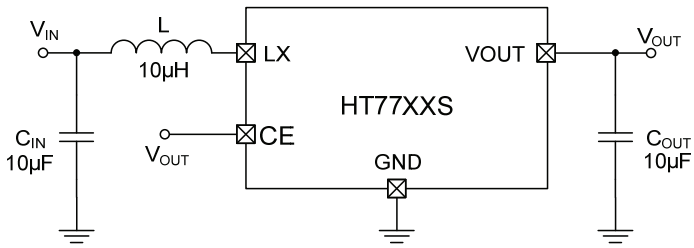
Package Type				Name	Description
TO92	SOT89	SOT23	SOT23-5		
—	—	—	1	CE	Enable pin. When the pin is set high, the device is enabled and, when low, the device is disabled.
2	2	3	2	VOUT	Output line
—	—	—	3	NC	Reserved line
1	1	1	4	GND	Ground
3	3	2	5	LX	Switching signal line

Application Circuit

Application Circuit without CE Pin



Application Circuit with CE Pin



Functional Description

The HT77xxS is a series of synchronous step-up converter using pulse frequency modulation to control the time constant. The PFM control method is essentially stable. The necessary inuput/output capacitors and inductors must be carefully selected to prevent instability.

The HT77xxS contains a fully integrated synchronous rectifier, thereby reducing the costs. This is due to smaller inductors sizes, capacitors sizes, removed schottky diode cost and smaller circuit board areas. The real load circuit ensures that the HT77xxS is fully shut-down.

Low-power Start

The HT77xxS has a very low start voltage of about 0.7V. When connected to the supply power, the initial synchronisation switch will be turned off, but the energy is transferred through the body diodes to the load.

Shut-down Mode

The EN line should be high for the normal operating mode or be connected to the VOUT line or the VIN power line. When the EN line is low the device enters the power-down mode and the internal circuits will be powered down. During the power-down mode, the PMOS power transistor is turned off and the output will be in a floating state.

Synchronous Rectification

During the shut down operation, there is a dead time between the N-channel and P-channel Mosefet switching. The usual schottky diode is replaced by the P-channel Mosefet during synchronous rectification. At the same time, the P-channel must be turned off before the N-channel conducts. After one cycle, it requires a period of 30ns dead time to ensure that the N-channel is completely turned off before the P-channel conducts. In this way it can maintain high efficiency operation for a variety of input voltages and output power ranges.

Application Information

Inductor Selection

Taking into account the output current requirements, the inductor saturation current and the acceptable voltage ripple, selecting a proper inductor is an important factor to consider. Lower inductance provides a higher output current, but result in a higher ripple voltage and reduced efficiency. Higher inductance reduces the output ripple voltage and improves efficiency, but also limits the output current. For the inductor selection, the lower core losses and lower DC impedances can provide higher efficiencies. The three important parameters, the inductance value, the DCR and the saturation current must be considered when selecting the inductors.

The inductor peak current can be calculated by the following formula:

$$I_{L(PEAK)} = \frac{V_{OUT} \times I_O}{V_{IN} \times \eta} + \frac{V_{IN} \times (V_{OUT} - V_{IN})}{2 \times V_{OUT} \times L}$$

In the above formula:

V_{IN} —— input voltage

V_{OUT} —— output voltage

I_O —— output current

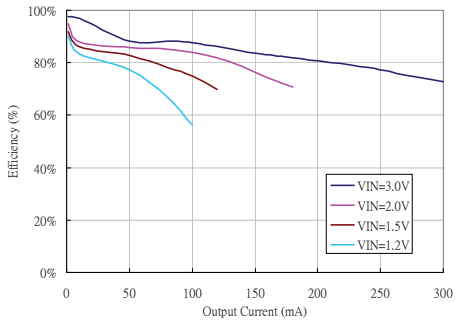
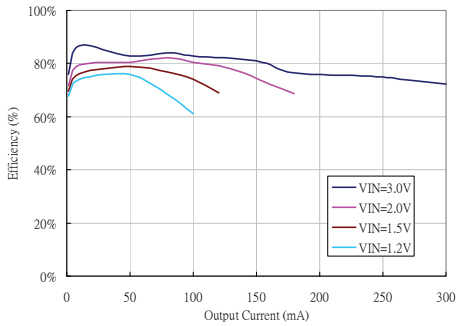
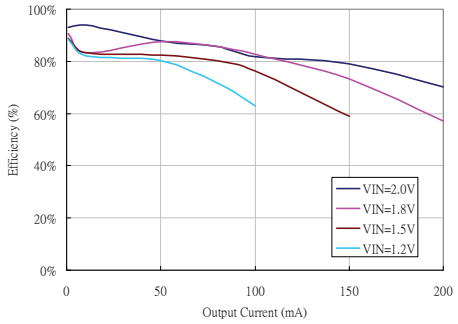
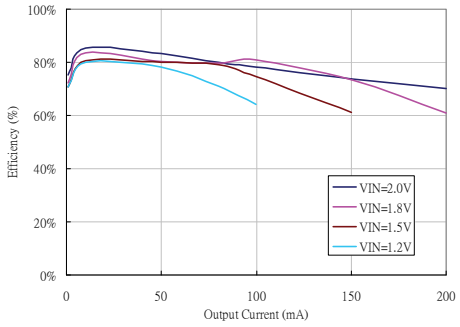
η —— efficiency

L —— the inductance

Capacitor Selection

The output capacitor selection will also affect operating efficiency and output ripple voltage, therefore it must be selected for maximum efficiency. The output ripple voltage is generated when the current is at its peak inductor current and is related to the ESR, which is the capacitor equivalent series resistance. Using a low ESR capacitor is a very important factor to achieve the desired operation. Paralleling two or more filter capacitors can get the lower ESR values.

This application example shows the HT77xxS efficiency when using wire-wound and multi-layer capacitors.

The Efficiency when Using Wire-wound Capacitor	The Efficiency when Using Multi-layer Capacitor
HT7750S	
 Fig 1. Efficiency vs. Output Current	 Fig 2. Efficiency vs. Output Current
HT7737S	
 Fig 3. Efficiency vs. Output Current	 Fig 4. Efficiency vs. Output Current

The Efficiency when Using Wire-wound Capacitor	The Efficiency when Using Multi-layer Capacitor
HT7733S	

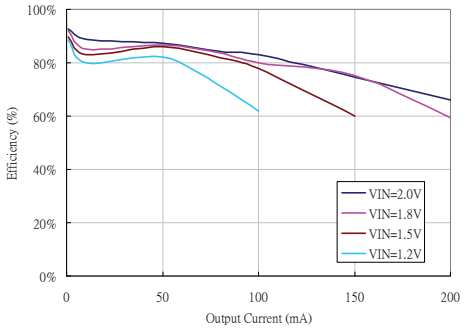
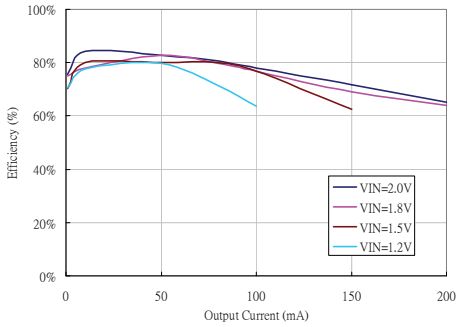

	

Fig 5. Efficiency vs. Output Current	Fig 6. Efficiency vs. Output Current
HT7730S	

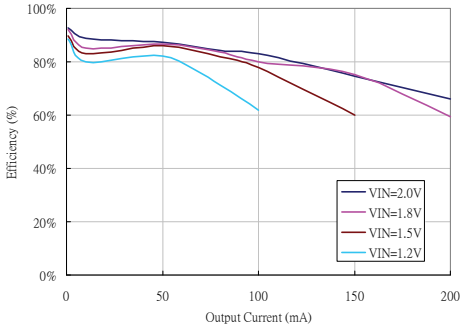
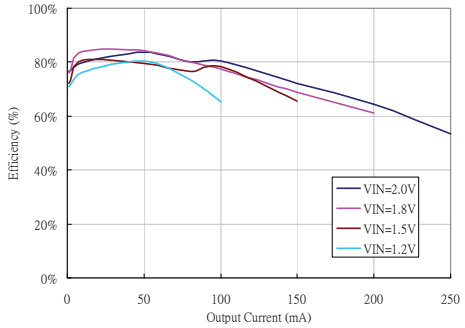

	

Fig 7. Efficiency vs. Output Current	Fig 8. Efficiency vs. Output Current
HT7727S	

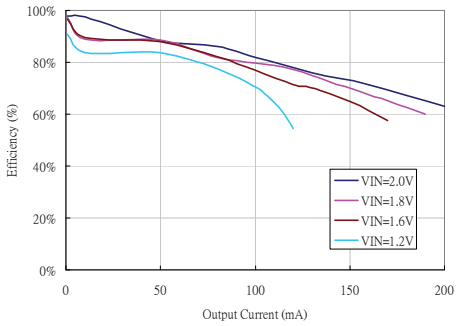
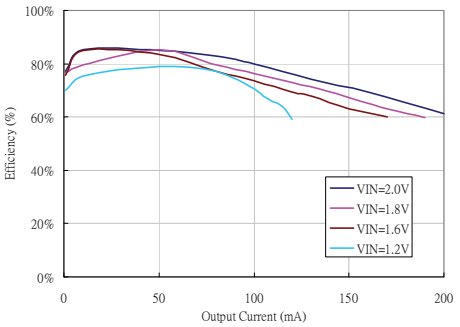

	

Fig 9. Efficiency vs. Output Current	Fig 10. Efficiency vs. Output Current
HT7722S	

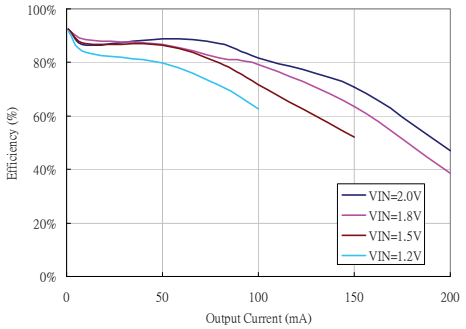
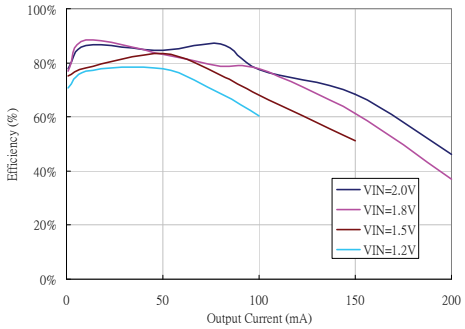

	

Fig 11. Efficiency vs. Output Current	Fig 12. Efficiency vs. Output Current

HT7718S	

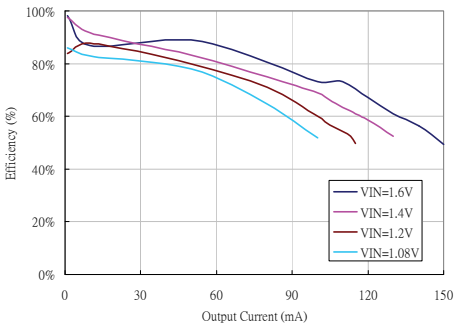
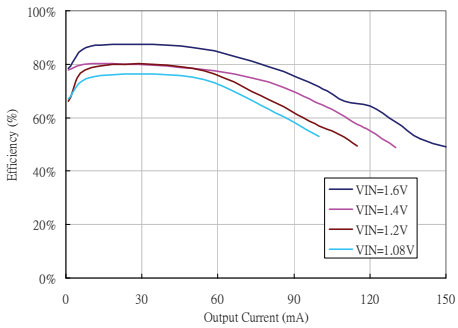

	

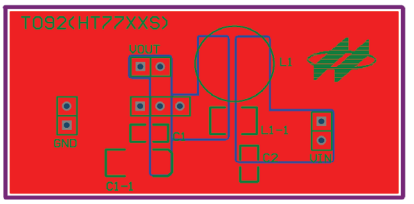
Fig 13. Efficiency vs. Output Current	Fig 14. Efficiency vs. Output Current

Layout Considerations

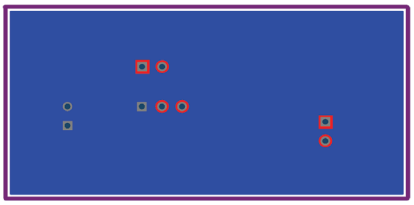
The circuit board layout is important for stable switching operation. Poor layout may lead to associated noise. In order to reduce both EMI and switching noise, the follwing recommendations are provided:

- Line width should be as wide as possible
- Input/output capacitors should be located as close as possible to the VIN, VOUT and GND pins
- Ground connections can help to prevent electromagnetic interfernce

A recommended PCB layout and component location diagram is shown below:



Top Layer



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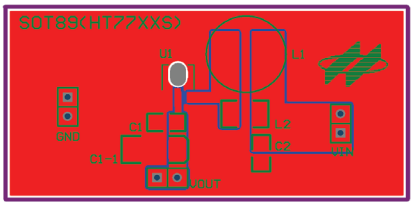

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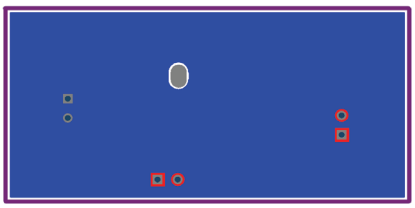

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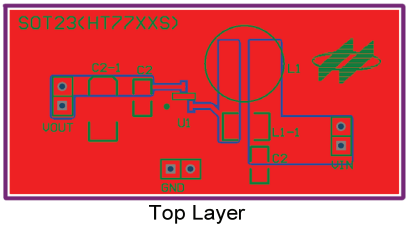

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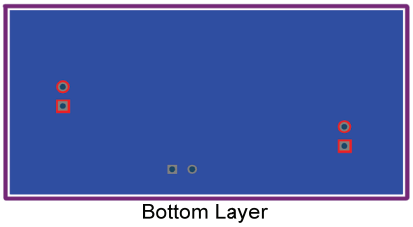

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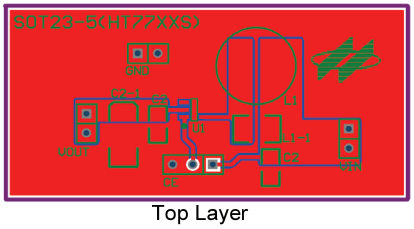

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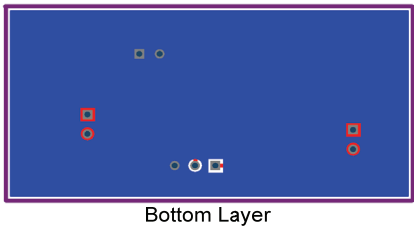

Bottom Layer

Conclusion

This article has explained in detail the HT77xxS internal function operation and functional description. It has also introduced the HT77xxS application and discussed performance efficiency when using wire-wound and multi-layer capacitors.

Appendix

Components List:

Component	Type	Manufacturer	Parameter
C_{IN}, C_{OUT}	GJ831CR61E106KE83L	Murata	10μF, 25V. X5R ceramic capacitor
L	SR0302100MLB	ABC Taiwan Electronics Corp.	10μH, R_{DC}=0.25Ω wire-wound power inductor
L	LBC3225T100MR	TAIYO YUDEN	10μH, R_{DC}=0.133Ω multi-layep power inductor