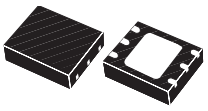
ST1S06xx

Synchronous rectification with inhibit, 1.5 A, 1.5 MHz fixed or adjustable, step-down switching regulator

Features

- Step-down current mode PWM (1.5 MHz) DC-DC converter
- 2% DC output voltage tolerance
- Synchronous rectification
- Inhibit function
- Internal soft start
- Typical efficiency: > 90 %
- 1.5 A Output current capability
- Not switching quiescent current: max 1.5 mA over temperature range
- $R_{DS(ON)}$ typ.150 mΩ
- Uses tiny capacitors and inductors
- Operative junction temp. - 30 °C to 125 °C
- Available in DFN6D 3x3 exposed pad



DFN6D (3x3 mm)

Description

The ST1S06 is a step down DC-DC converter optimized for powering low-voltage digital core in HDD applications and, generally, to replace the high current linear solution when the power dissipation may cause an high heating of the application environment. It provides up to 1.5 A over an input voltage range of 2.7 V to 6 V. An high switching frequency (1.5 MHz) allows the use of tiny surface-mount components: as well as the resistor divider to set the output voltage value, only an inductor and two capacitors are required. Besides, a low output ripple is guaranteed by the current mode PWM topology and by the use of low ESR SMD ceramic capacitors. The device is thermal protected and current limited to prevent damages due to accidental short circuit. The ST1S06 is available in DFN6D 3x3 package.

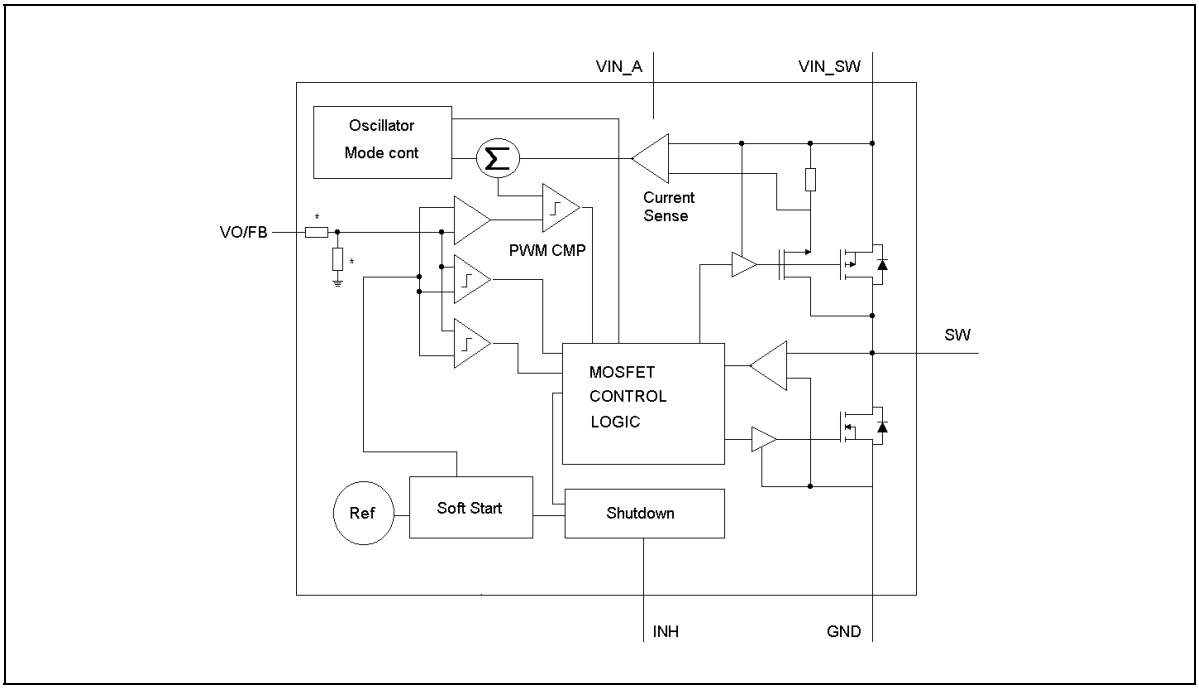
Table 1. Device summary

Part numbers	Order codes	Package
ST1S06	ST1S06PUR	DFN6D (3x3 mm)
ST1S06A	ST1S06APUR	DFN6D (3x3 mm)
ST1S06XX12	ST1S06PU12R	DFN6D (3x3 mm)
ST1S06XX33	ST1S06PU33R	DFN6D (3x3 mm)

Contents

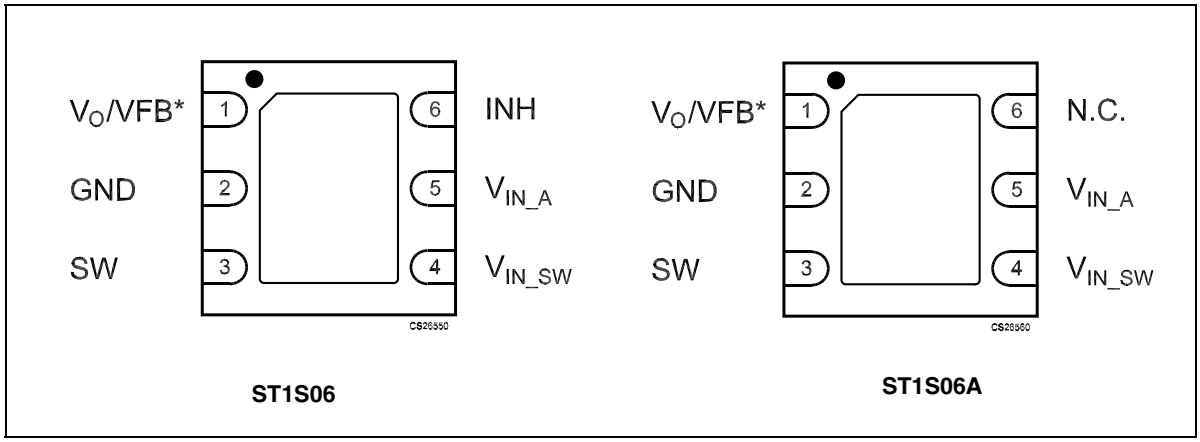
1 Diagram

Figure 1. Schematic diagram



2 Pin configuration

Figure 2. Pin configuration (top view)



*Note: * Pin 1 is V_{FB} for ADJ version and V_O for Fixed version*

Table 2. Pin description

Pin n°	Symbol	Note
1	FB/V_O	Feedback voltage / output voltage
2	GND	System ground
3	SW	Switching pin
4	V_{IN_SW}	Power supply for the mosfet switch
5	V_{IN_A}	Power supply for analogic circuit
6	V_{INH}	Inhibit pin to turn off the device
		Exposed pad to be connected to GND

3 Maximum ratings

Table 3. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{IN_SW}	Positive power supply voltage	-0.3 to 7	V
V_{IN_A}	Positive power supply voltage	-0.3 to 7	V
V_{INH}	Inhibit voltage	-0.3 to V_I + 0.3	V
SWITCH voltage	Max. voltage of output pin	-0.3 to 7	V
V_{FB}/V_O	Feedback voltage	-0.3 to 3	V
V_O	Output voltage (for V_O > 1.6 V)	-0.3 to 6	V
T_J	Max junction temperature	-40 to 150	°C
T_{STG}	Storage temperature range	-65 to 150	°C
T_{LEAD}	Lead temperature (soldering) 10 sec	260	°C

Note: Absolute maximum ratings are those values beyond which damage to the device may occur. Functional operation under these conditions is not implied.

Table 4. Thermal data

Symbol	Parameter	Value	Unit
R_{thJA}	Thermal resistance junction-ambient	55	°C/W
R_{thJC}	Thermal resistance junction-case	10	°C/W

4 Electrical characteristics

Table 5. Electrical characteristics for ST1S06
(V_{IN_SW} = V_{IN_A} = V_{INH} = 5 V, V_O = 1.2 V, C_I = 4.7 µF, C_O = 22 µF, L1 = 3.3 µH, T_J = -30 °C to 125 °C (unless otherwise specified. Typical values are referred to T_J = 25 °C)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
FB	Feedback voltage		784	800	816	mV
I_{FB}	V_{FB} pin bias current				600	nA
V_I	Minimum input voltage	I_O = 10mA to 1.5A	2.7			V
I_Q	Quiescent current	V_{INH} > 1.2V			1.5	mA
		V_{INH} < 0.4V, T_J = -30°C to 85°C			1	µA
I_O	Output current	V_I = 2.7 to 5.5V *Note 1*	1.5			A
V_{INH}	Inhibit threshold	Device ON, V_I = 2.7 to 5.5V	1.3			V
		Device ON, V_I = 2.7 to 5V	1.2			
		Device OFF			0.4	
I_{INH}	Inhibit pin current				2	µA
$\%V_O/\Delta V_I$	Reference line regulation	V_I = 2.7V to 5.5V *Note 1*		0.2	0.3	$\%V_O/\Delta V_I$
$\%V_O/\Delta I_O$	Reference load regulation	I_O = 10mA to 1.5A *Note 1*		0.2	0.3	$\%V_O/\Delta I_O$
$PWMf_S$	PWM switching frequency	V_{FB} = 0.8V	1.2	1.5	1.8	MHz
D_{MAX}	Maximum duty cycle		80	87		%
R_{DSON}-N	NMOS switch on resistance	I_{SW} = 750 mA		0.12		Ω
R_{DSON}-P	PMOS switch on resistance	I_{SW} = 750 mA		0.15		Ω
I_{SWL}	Switching current limitation	*Note 1*		2.3		A
ν	Efficiency *Note 1*	I_O = 10mA to 100mA, V_O = 3.3V	65			%
		I_O = 100mA to 1.5A, V_O = 3.3V	85	90		
T_{SHDN}	Thermal shutdown		130	150		°C
T_{HYS}	Thermal shutdown hysteresis			15		°C
$\%V_O/\Delta I_O$	Load transient response	I_O = 100mA to 750mA, T_J = 25°C $t_R = t_F \geq$ 200ns, *Note 1*	-5		+5	$\%V_O$
$\%V_O/\Delta I_O$	Short circuit removal response	I_O = 10mA to I_O = short, T_J = 25°C *Note 1*	-10		+10	$\%V_O$

Note: 1 Guaranteed by design, but not tested in production

Table 6. Electrical characteristics for ST1S06PM12
(V_{IN_SW} = V_{IN_A} = V_{INH} = 5 V, V_O = 1.2 V, C_I = 4.7 µF, C_O = 22 µF, L1 = 3.3 µH, T_J = -30 °C to 125 °C unless otherwise specified. Typical values are referred to T_J = 25 °C)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
OUT	Output feedback pin		1.176	1.2	1.224	V
I_O	I_O pin bias current	V_O = 1.5V		15	20	µA
V_I	Minimum input voltage	I_O = 10mA to 1.5A	2.7			V
I_Q	Quiescent current	V_{INH} > 1.2V			1.5	mA
		V_{INH} < 0.4V, T_J = -30°C to 85°C			1	µA
I_O	Output current	V_I = 2.7 to 5.5V *Note 1*	1.5			A
V_{INH}	Inhibit threshold	Device ON, V_I = 2.7 to 5.5V	1.3			V
		Device ON, V_I = 2.7 to 5V	1.2			
		Device OFF			0.4	
I_{INH}	Inhibit pin current				2	µA
$\%V_O/\Delta V_I$	Reference line regulation	V_I = 2.7V to 5.5V *Note 1*		0.2	0.3	$\%V_O/\Delta V_I$
$\%V_O/\Delta I_O$	Reference load regulation	I_O = 10mA to 1.5A *Note 1*		0.2	0.3	$\%V_O/\Delta I_O$
$PWMf_S$	PWM switching frequency	V_{FB} = 0.8V	1.2	1.5	1.8	MHz
D_{MAX}	Maximum duty cycle		80	87		%
R_{DSON}-N	NMOS switch on resistance	I_{SW} = 750 mA		0.12		Ω
R_{DSON}-P	PMOS switch on resistance	I_{SW} = 750 mA		0.15		Ω
I_{SWL}	Switching current limitation	*Note 1*		2.3		A
ν	Efficiency *Note 1*	I_O = 10mA to 100mA, V_O = 1.2V	60			%
		I_O = 100mA to 1.5A, V_O = 1.2V	80	85		
T_{SHDN}	Thermal shutdown		130	150		°C
T_{HYS}	Thermal shutdown hysteresis			15		°C
$\%V_O/\Delta I_O$	Load transient response	I_O = 100mA to 750mA, T_J = 25°C $t_R = t_F \geq$ 200ns, *Note 1*	-5		+5	$\%V_O$
$\%V_O/\Delta I_O$	Short circuit removal response	I_O = 10mA to I_O = short, T_J = 25°C *Note 1*	-10		+10	$\%V_O$

Note: 1 Guaranteed by design, but not tested in production

Table 7. Electrical characteristics for ST1S06PM33
(V_{IN_SW} = V_{IN_A} = V_{INH} = 5 V, V_O = 3.3 V, C_I = 4.7 µF, C_O = 22 µF, L1 = 3.3 µH, T_J = -30 °C to 125 °C unless otherwise specified. Typical values are referred to T_J = 25 °C)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
OUT	Output feedback pin		3.23	3.3	3.37	V
I_O	I_O pin bias current	V_O = 3.5V		15	20	µA
V_I	Minimum input voltage	I_O = 10mA to 1.5A	4.2			V
I_Q	Quiescent current	V_{INH} > 1.2V			1.5	mA
		V_{INH} < 0.4V, T_J = -30°C to 85°C			1	µA
I_O	Output current	V_I = 4.2 to 5.5V *Note 1*	1.5			A
V_{INH}	Inhibit threshold	Device ON, V_I = 4.2 to 5.5V	1.3			V
		Device ON, V_I = 4.2 to 5V	1.2			
		Device OFF			0.4	
I_{INH}	Inhibit pin current				2	µA
$\%V_O/\Delta V_I$	Reference line regulation	V_I = 4.2V to 5.5V *Note 1*		0.2	0.3	$\%V_O/\Delta V_I$
$\%V_O/\Delta I_O$	Reference load regulation	I_O = 10mA to 1.5A *Note 1*		0.2	0.3	$\%V_O/\Delta I_O$
$PWMf_S$	PWM switching frequency	V_{FB} = 0.8V	1.2	1.5	1.8	MHz
D_{MAX}	Maximum duty cycle		80	87		%
R_{DSON}-N	NMOS switch on resistance	I_{SW} = 750 mA		0.12		Ω
R_{DSON}-P	PMOS switch on resistance	I_{SW} = 750 mA		0.15		Ω
I_{SWL}	Switching current limitation	*Note 1*		2.3		A
ν	Efficiency *Note 1*	I_O = 10mA to 100mA, V_O = 3.3V	65			%
		I_O = 100mA to 1.5A, V_O = 3.3V	85	90		
T_{SHDN}	Thermal shutdown		130	150		°C
T_{HYS}	Thermal shutdown hysteresis			15		°C
$\%V_O/\Delta I_O$	Load transient response	I_O = 100mA to 750mA, T_J = 25°C $t_R = t_F \geq$ 200ns, *Note 1*	-5		+5	$\%V_O$
$\%V_O/\Delta I_O$	Short circuit removal response	I_O = 10mA to I_O = short, T_J = 25°C *Note 1*	-10		+10	$\%V_O$

Note: 1 Guaranteed by design, but not tested in production

5 Typical performance characteristics

(V_{IN_SW} = V_{IN_A} = V_{INH} = 5 V, C_I = 4.7 µF, C_O = 22 µF, L1 = 3.3 µH, unless otherwise specified. Typical values are referred to 25 °C)

Figure 3. Efficiency vs output current

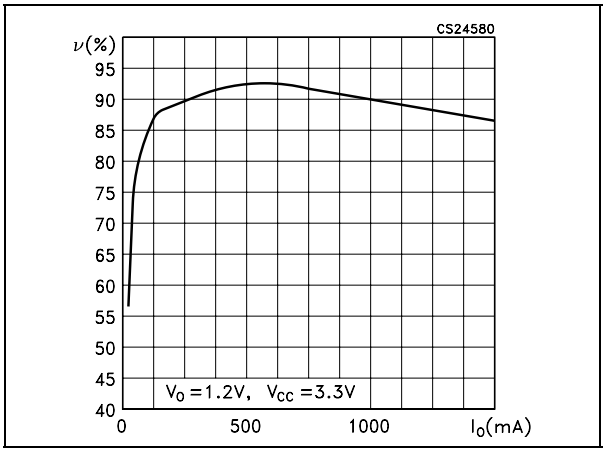


Figure 4. Efficiency vs output current

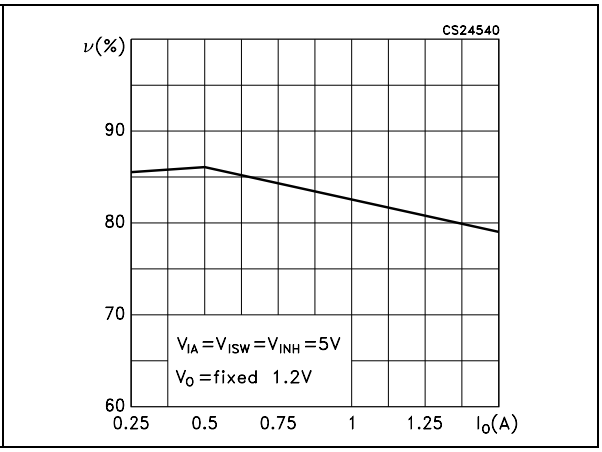


Figure 5. Efficiency vs output current

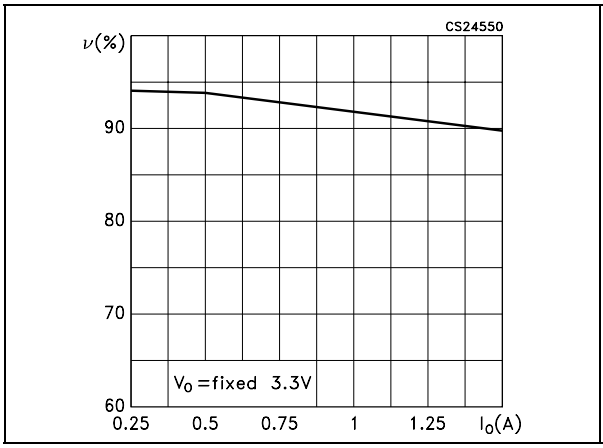


Figure 6. Efficiency vs output current

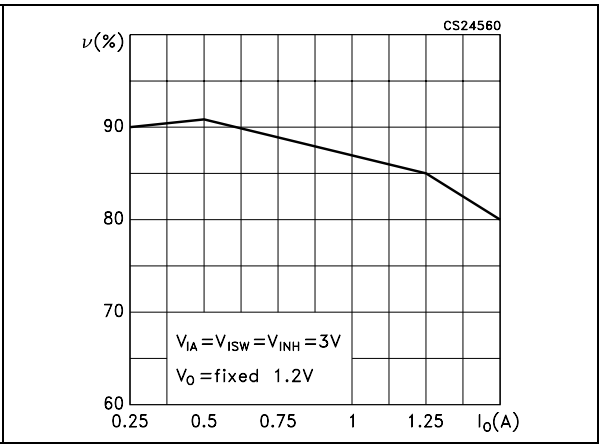


Figure 7. Efficiency vs output current

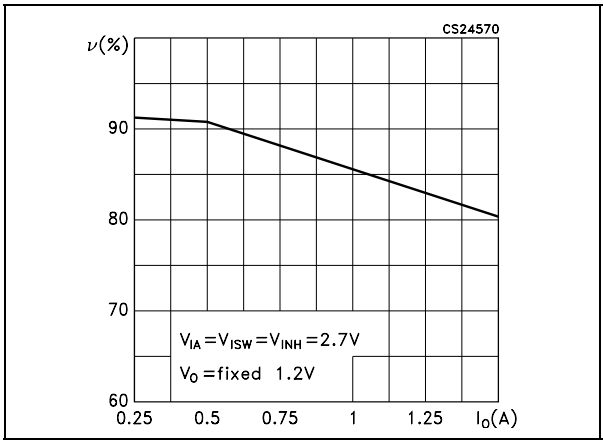


Figure 8. Efficiency vs inductor

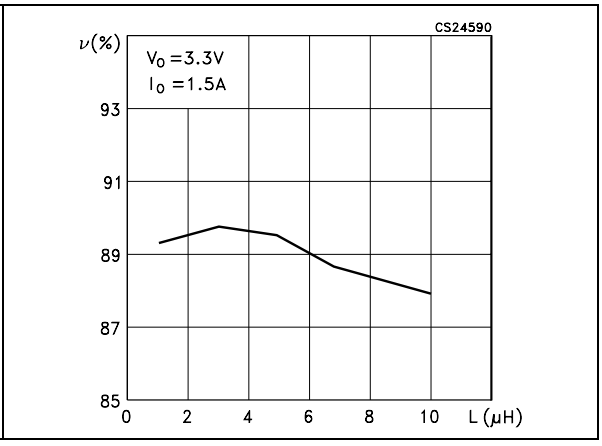


Figure 9. Voltage feedback vs temperature

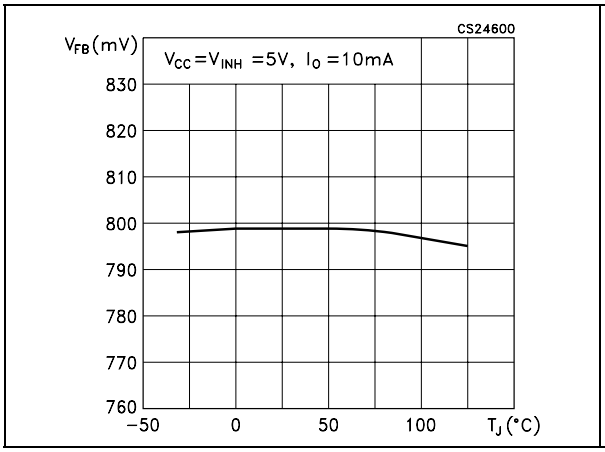


Figure 10. Input voltage vs output voltage

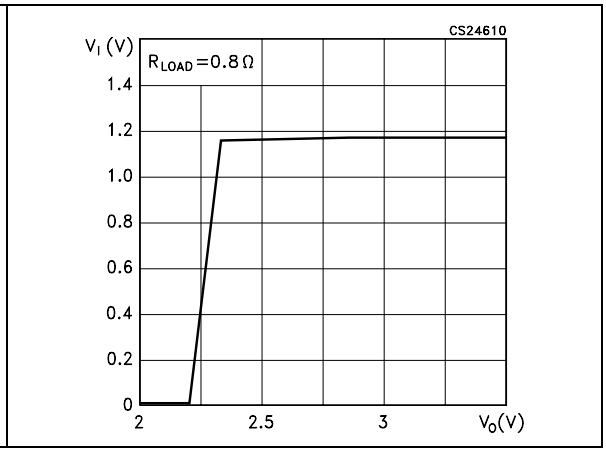


Figure 11. Feedback pin bias current vs temperature

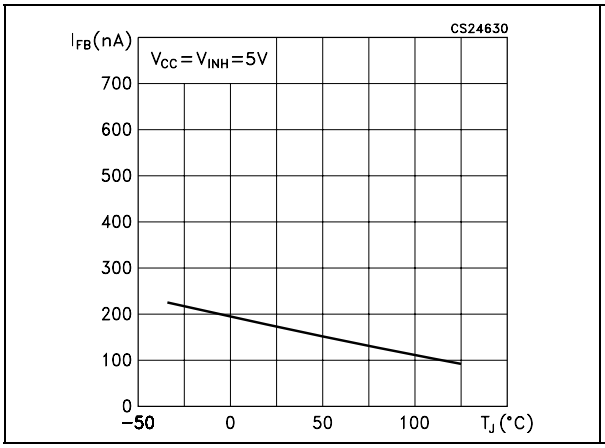


Figure 12. Quiescent current vs temperature

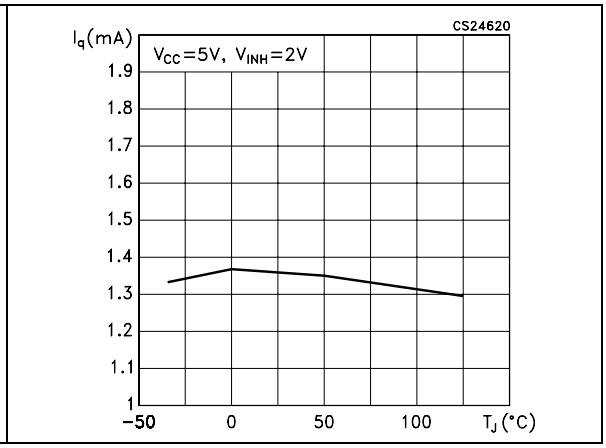


Figure 13. Quiescent current vs temperature

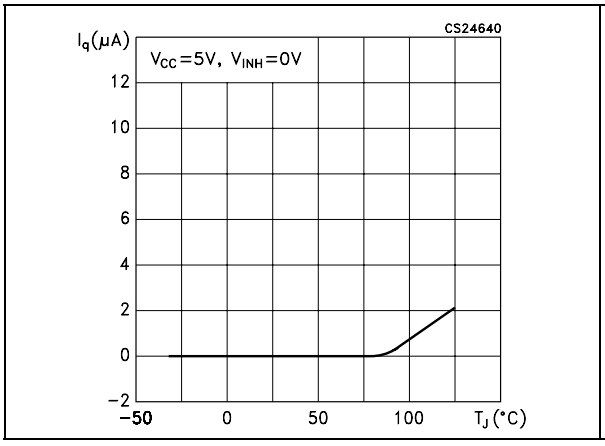


Figure 14. Inhibit voltage vs input voltage

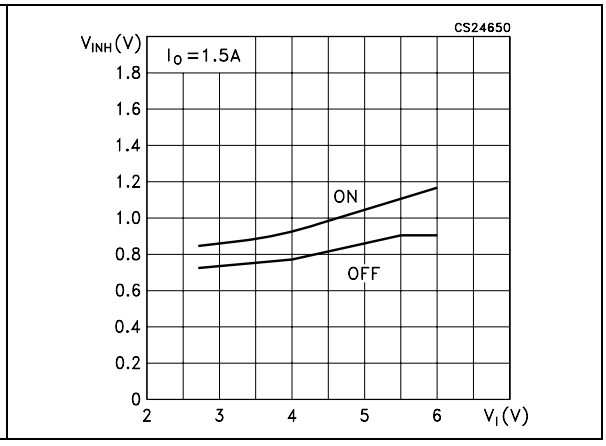


Figure 15. Inhibit voltage vs temperature

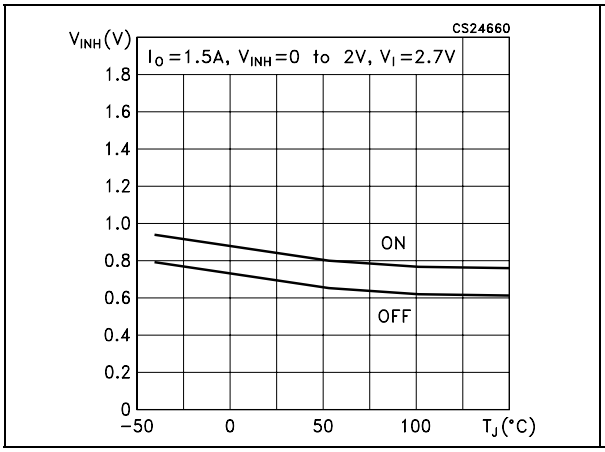


Figure 16. Inhibit voltage vs temperature

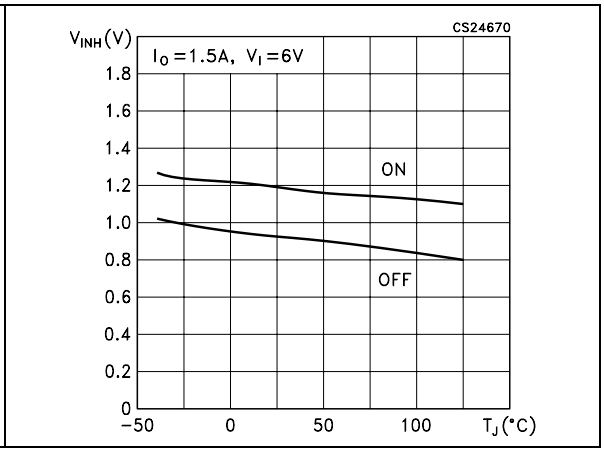


Figure 17. Line regulation vs temperature

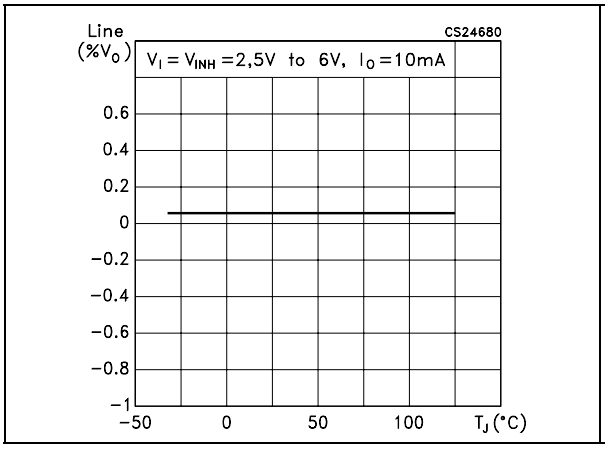


Figure 18. Load regulation vs temperature

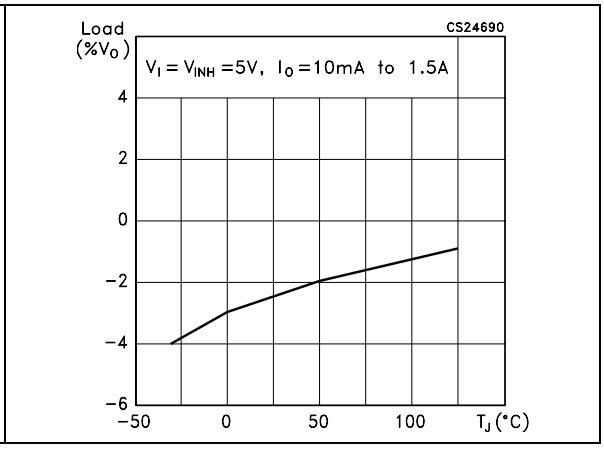


Figure 19. PWM switching frequency vs temperature

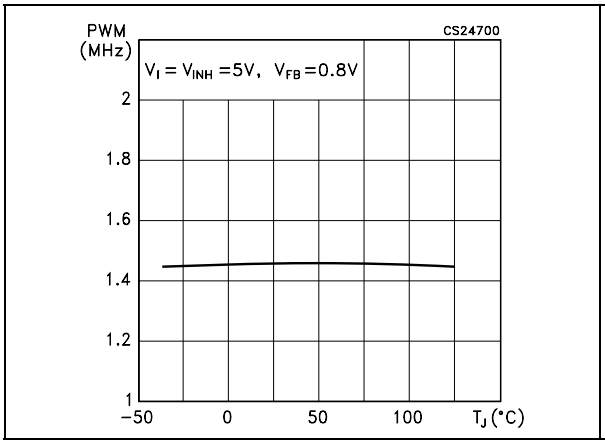


Figure 20. NMOS switch on resistance vs temperature

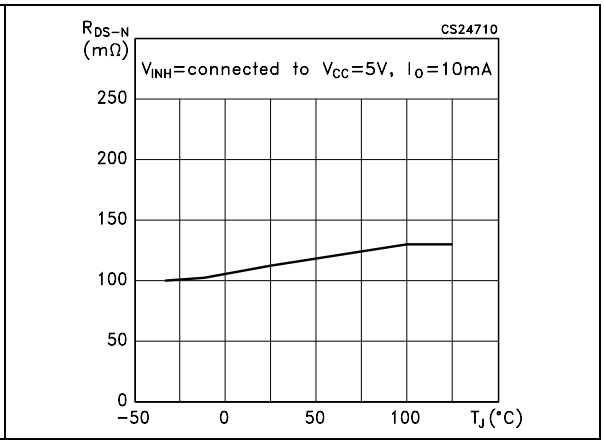


Figure 21. PMOS switch on resistance vs temperature

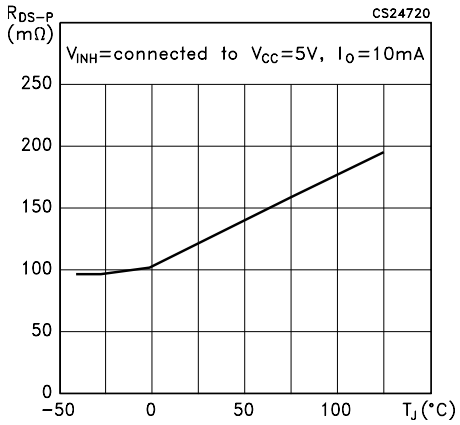
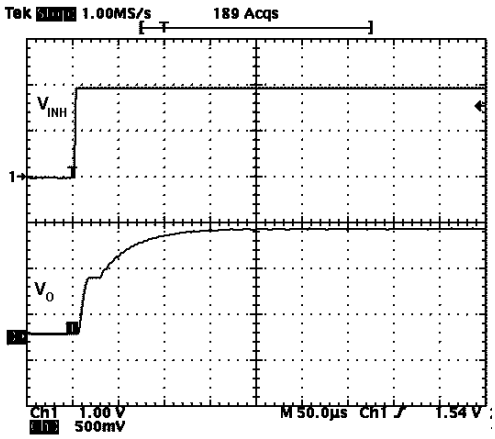
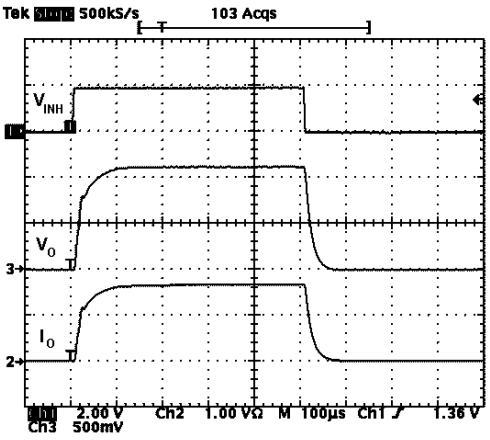


Figure 22. Inhibit transient



V_I = 5V, V_{INH} = 0 to 2V, I_O = 1.5A

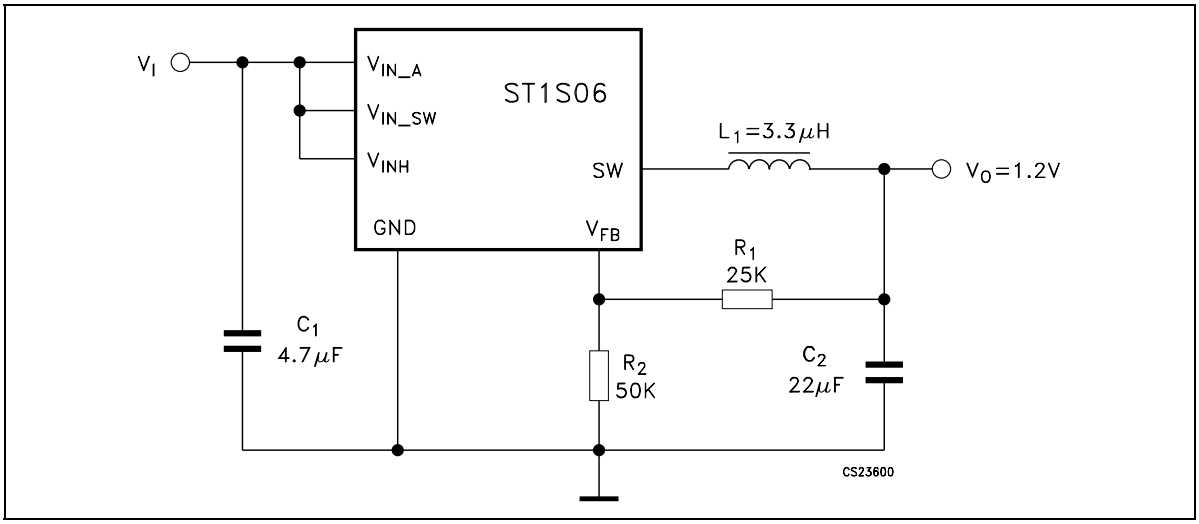
Figure 23. Inhibit transient



V_I = 5V, V_{INH} = 0 to 2V, I_O = 10mA

6 Typical application

Figure 24. Application circuit



7 Application notes

The ST1S06 is an adjustable current mode PWM step-down DC-DC converter with internal 1.5 A power switch, packaged in a 6-lead DFN 3x3.

It's a complete 1.5 A switching regulator with its internal compensation eliminating additional component.

The constant frequency, current mode, PWM architecture and stable operation with ceramic capacitors results in low, predictable output ripple. However, in order to maximize the power conversion efficiency with light load, the regulator reduces automatically the switching frequency when the output load becomes less than 250 mA typically.

To clamp the error amplifier reference voltage a soft start control block generating a voltage ramp, has been implemented. Besides an on-chip power on reset of 50 = 100 µs ensure the proper operation when switching on the power supply. Other circuits fitted to the device protection are the thermal shut down block which turn off the regulator when the junction temperature exceeds 150 °C typically and the cycle-by-cycle current limiting that provides protection against shorted outputs.

Being the ST1S06 an adjustable regulator, the output voltage is determined by an external resistor divider. The desired value is given by the following equation:

$V_O = V_{FB} [1+R1/R2]$

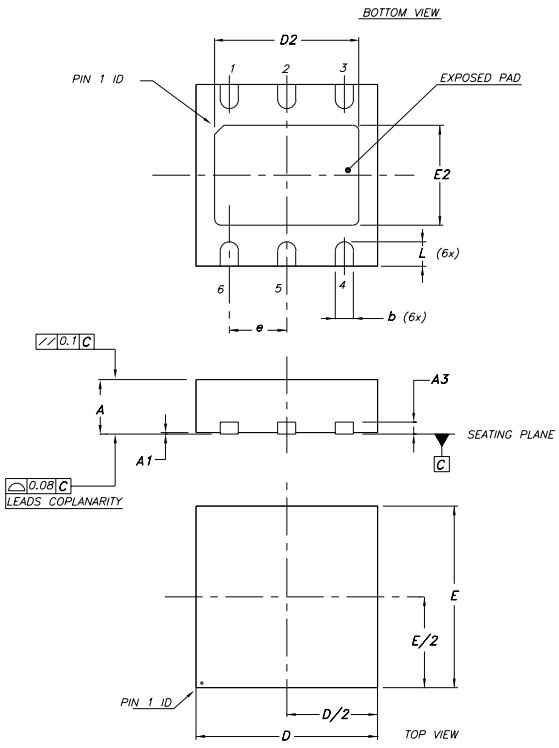
To make the device working, only few component are required: an inductor and two capacitors and the resistor divider. The chosen inductor must be able to not saturate at the peak current level. Besides, its value can be selected keeping in account that a large inductor value increases the efficiency at low output current and reduces output voltage ripple, while a smaller inductor can be chosen when it is important to reduce the package size and the total cost of the application. Finally, the ST1S06 has been designed to work properly with X5R or X7R SMD ceramic capacitors both at the input and at the output. this kind of capacitors, thanks to their very low series resistance (ESR), minimize the output voltage ripple. Other low ESR capacitors can be used according to the need of the application without invalidate the right functioning of the device.

8 Package mechanical data

In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a lead-free second level interconnect. The category of second Level Interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at: www.st.com.

DFN6D (3x3 mm) mechanical data

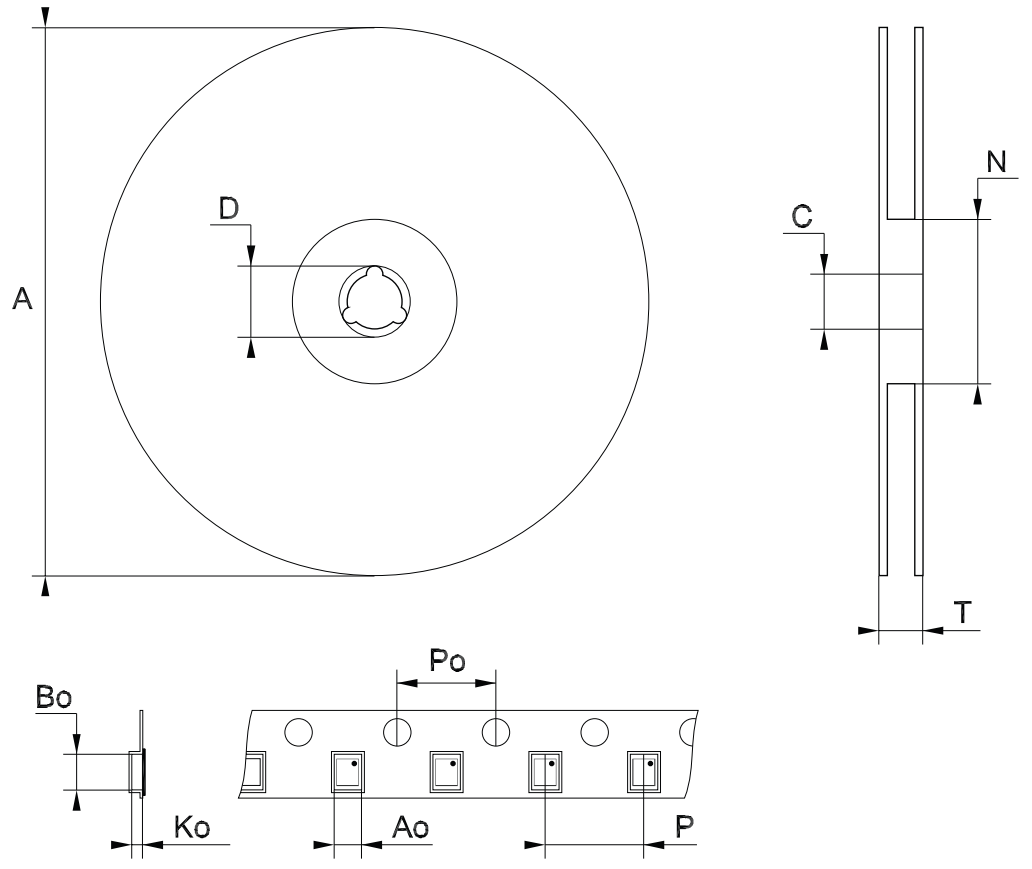
Dim.	mm.			inch.		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	0.80		1.00	0.031		0.039
A1	0	0.02	0.05	0	0.001	0.002
A3		0.20			0.008	
b	0.23		0.45	0.009		0.018
D	2.90	3.00	3.10	0.114	0.118	0.122
D2	2.23		2.50	0.088		0.098
E	2.90	3.00	3.10	0.114	0.118	0.122
E2	1.50		1.75	0.059		0.069
e		0.95			0.037	
L	0.30	0.40	0.50	0.012	0.016	0.020



7946637B

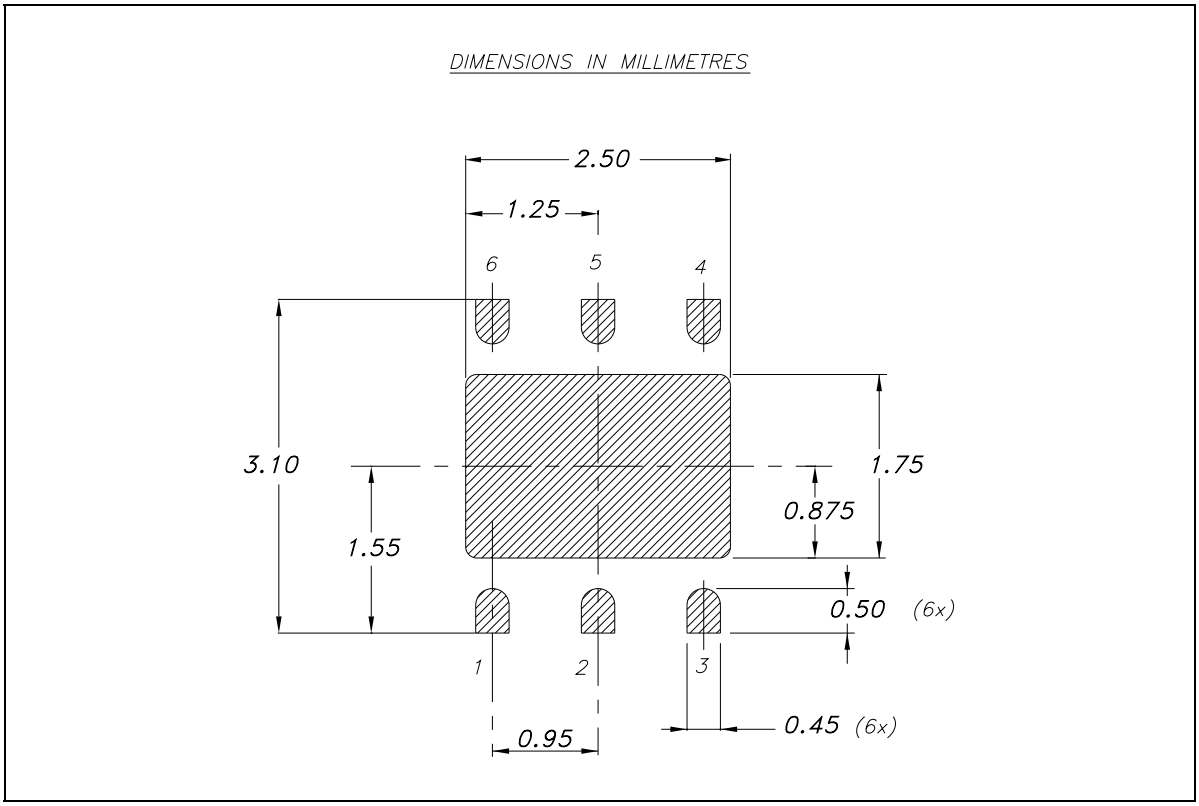
Tape & Reel QFNxx/DFNxx (3x3) Mechanical Data

Dim.	mm.			inch.		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			330			12.992
C	12.8		13.2	0.504		0.519
D	20.2			0.795		
N	60			2.362		
T			18.4			0.724
Ao		3.3			0.130	
Bo		3.3			0.130	
Ko		1.1			0.043	
Po		4			0.157	
P		8			0.315	



Note: Drawing not in scale

Figure 25. DFN6 (3x3 mm) footprint recommended data



9 Revision history

Table 8. Document revision history

Date	Revision	Changes
08-May-2006	1	Initial release.
06-Jun-2006	2	*Table 3* updated.
16-Oct-2006	3	Add new mechanical data DFN6D.
09-Nov-2006	4	Mechanical data information for DFN6 update.
03-Apr-2007	5	Tape and reel updated.
12-Mar-2008	6	Added: *Table 1 on page 1*.
15-Apr-2008	7	Modified: *Figure 6 on page 9*.

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