3-Pin Simple Step-Up DC/DC Converter

FEATURES

- A guaranteed start-up from less than 0.9 V.
- High efficiency.
- Low quiescent current.
- Fewer external components needed.
- Low ripple and low noise.
- Fixed output voltage: 2.7V, 3.0V, 3.3V, 3.7V, 4.5V and 5V.
- Space-saving packages: SOT-23, SOT-89 and TO-92.
- **Pb-free, RoHS compliant.**

APPLICATIONS

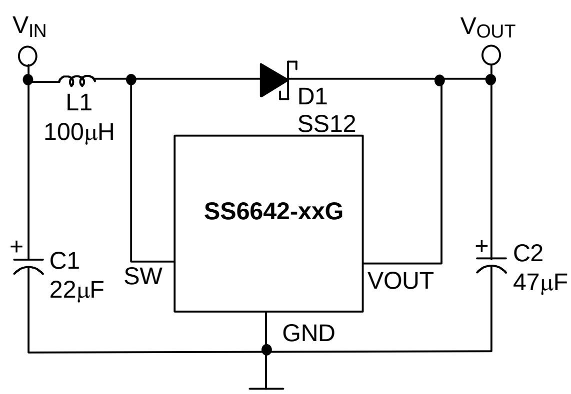
- Pagers.
- Cameras.
- Wireless Microphones.
- Pocket Organizers.
- Battery Backup Suppliers.
- Portable Instruments.

DESCRIPTION

The SS6642G is a high efficiency step-up DC/DC converter for applications using 1 to 4 NiMH battery cells. Only three external components are required to deliver a fixed output voltage of 2.7V, 3.0V, 3.3V, 3.7V, 4.5V or 5V. The SS6642G starts up from less than 0.9V input with 1mA load. A Pulse Frequency Modulation scheme optimizes performance for applications with light output loading and low input voltages. The output ripple and noise are lower when compared with circuits operating in PSM mode.

The PFM control circuit operating at a 100KHz (max.) switching rate results in smaller passive components. The space saving SOT-23, SOT-89 and TO-92 packages make the SS6642G an ideal choice for DC/DC converter for space conscious applications, such as pagers, electronic cameras, and wireless microphones.

TYPICAL APPLICATION CIRCUIT



One Cell Step-Up DC/DC Converter

ORDERING INFORMATION

SS6642-XXXXXX

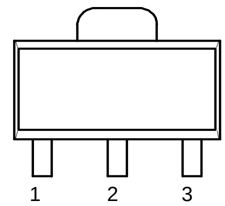
- Packing type
  - TR: Tape and reel
  - TB: Tube
- Package type
  - GU: RoHS-compliant SOT-23
  - GX: RoHS-compliant SOT-89
  - GZ: RoHS-compliant TO-92
- Output voltage
  - 27: 2.7V
  - 30: 3.0V
  - 33: 3.3V
  - 37: 3.7V
  - 45: 4.5V
  - 50: 5.0V

Example: SS6642-27GXTR

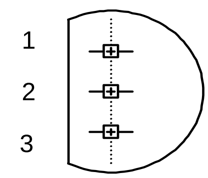
→ 2.7V output version, in RoHS-compliant SOT-89 shipped on tape and reel.

PIN CONFIGURATION

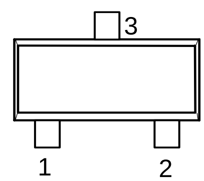
SOT-89
TOP VIEW
1: GND
2: VOUT
3: SW



TO-92
TOP VIEW
1: GND
2: VOUT
3: SW



SOT-23
TOP VIEW
1: GND
2: SW
3: VOUT



SOT-23 MARKING

Part No.	GU
SS6642-27G	GM27P
SS6642-30G	GM30P
SS6642-33G	GM33P
SS6642-37G	GM37P
SS6642-45G	GM45P
SS6642-50G	GM50P

SOT-89 MARKING

Part No.	GX
SS6642-27G	AM27P
SS6642-30G	AM30P
SS6642-33G	AM33P
SS6642-37G	AM37P
SS6642-45G	AM45P
SS6642-50G	AM50P

ABSOLUTE MAXIMUM RATINGS

Supply Voltage (VOUT pin)	6V
SW pin Voltage	6V
SW pin Switch Current	0.6A
Operating Temperature Range	-40°C to 85°C
Maximum Junction Temperature	125°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering 10 Sec.)	260°C

Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

TEST CIRCUIT

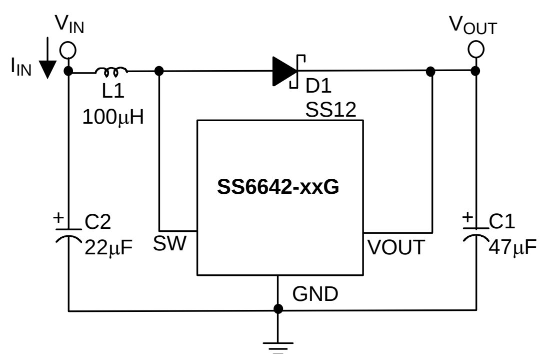


Fig. 1 Test Circuit 1

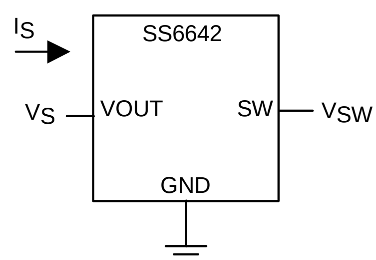


Fig. 2 Test Circuit 2

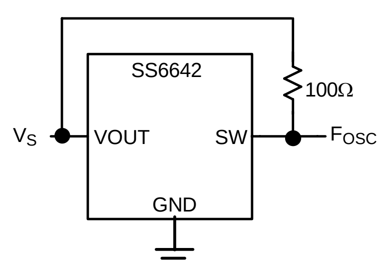


Fig. 3 Test Circuit 3

ELECTRICAL CHARACTERISTICS (Note1) (T_A=25°C, I_{OUT}=10mA, unless otherwise specified)

PARAMETER	TEST CONDITIONS	TEST CKT	SYMBOL	MIN.	TYP.	MAX.	UNIT
Output Voltage	SS6642-27G V_{IN}=1.8V	1	V_{OUT}	2.633	2.700	2.767	V
	SS6642-30G V_{IN}=1.8V			2.925	3.000	3.075	
	SS6642-33G V_{IN}=2.0V			3.218	3.300	3.382	
	SS6642-37G V_{IN}=2.0V			3.607	3.700	3.792	
	SS6642-45G V_{IN}=3.0V			4.387	4.500	4.613	
	SS6642-50G V_{IN}=3.0V			4.875	5.000	5.125	
Start-Up Voltage	I_{OUT}=1mA, V_{IN}:0→2V	1	V_{START}		0.8	0.9	V
Min. Hold-on Voltage	I_{OUT}=1mA, V_{IN}:2→0V	1	V_{HOLD}			0.7	V
No-Load Input Current	I_{OUT}=0mA	1	I_{IN}		15		μA
Supply Current	SS6642-27G	2	I_{S1}		42		μA
	SS6642-30G				50		
	SS6642-33G				60		
	SS6642-37G				65		
	SS6642-45G				70		
	SS6642-50G				90		
	V_S=V_{OUT} x 0.95						
	Measurement of the IC input current (VOUT pin)						
Supply Current	SS6642-27G	2	I_{S2}		7		μA
	SS6642-30G				7		
	SS6642-33G				7		
	SS6642-37G				7		
	SS6642-45G				7		
	SS6642-50G				7		
	V_S=V_{OUT} + 0.5V						
	Measurement of the IC input current (VOUT pin)						
SW Leakage Current	V_{SW}=6V, V_S=V_{OUT} + 0.5V	2				0.5	μA

ELECTRICAL CHARACTERISTICS (Continued)

PARAMETER	TEST CONDITIONS	TEST CKT	SYMBOL	MIN.	TYP.	MAX.	UNIT
SW Switch-On Resistance	SS6642-27G SS6642-30G SS6642-33G SS6642-37G SS6642-45G SS6642-50G V_S=V_{OUT} x 0.95, V_{SW}=0.4V	2	R_{ON}		2.2 2.1 2.0 2.0 1.9 1.9		Ω
Oscillator Duty Cycle	V_S=V_{OUT} x 0.95 Measurement of the SW pin waveform	3	DUTY	65	75	85	%
Max. Oscillator Freq.	V_S=V_{OUT} x 0.95 Measurement of the SW pin waveform	3	F_{OSC}	80	105	130	KHz
Efficiency		1	η		85		%

Note 1: Specifications are production tested at T_A=25°C. Specifications over the -40°C to 85°C operating temperature range are assured by design, characterization and correlation with Statistical Quality Controls (SQC).

TYPICAL PERFORMANCE CHARACTERISTICS

Test circuit refer to typical application circuit
Capacitor (C2) : 47 µ F (Tantalum Type)
Diode (D1) : 1N5819 Schottky Type

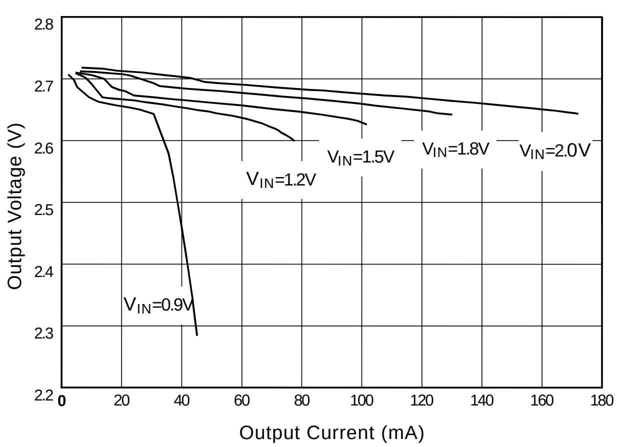


Fig. 4 SS6642-27 Load Regulation (L=100µH CD54)

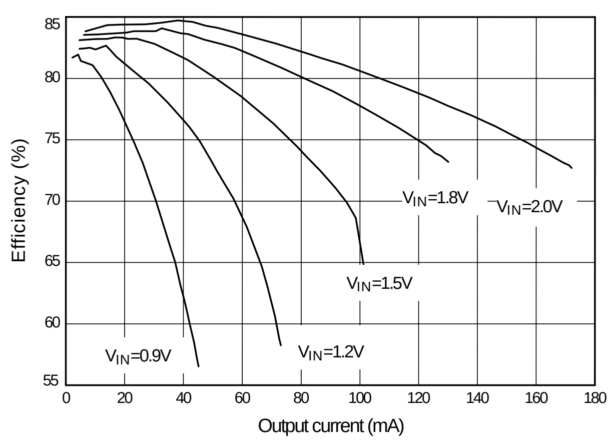


Fig. 5 SS6642-27 Efficiency (L=100µH CD54)

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

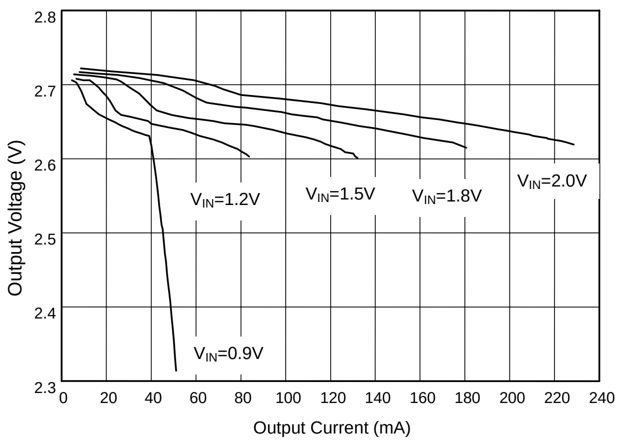


Fig. 6 SS6642-27 Load Regulation (L=47µH CD54)

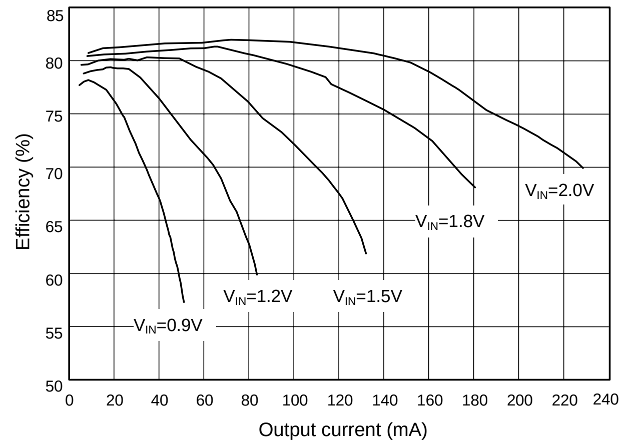


Fig. 7 SS6642-27 Efficiency (L=47µH CD54)

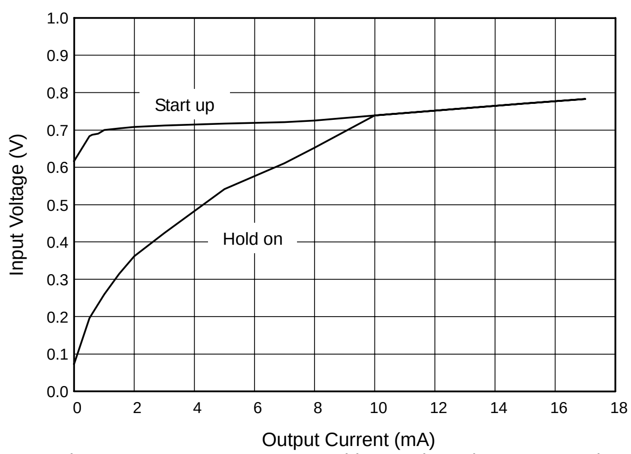


Fig. 8 SS6642-27 Start-Up & Hold-ON Voltage (L=47µH CD54)

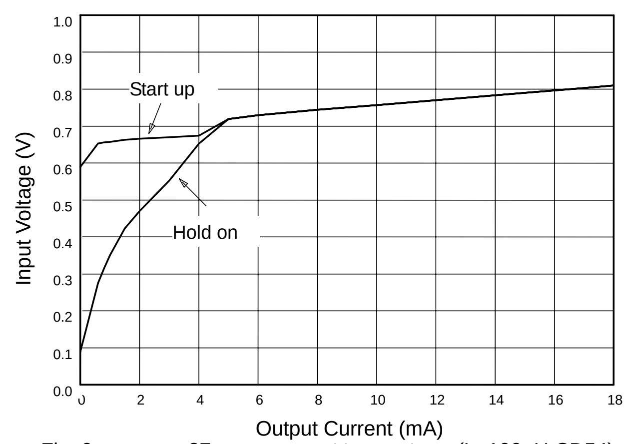


Fig. 9 SS6642-27 Start-Up & Hold-ON Voltage (L=100µH CD54)

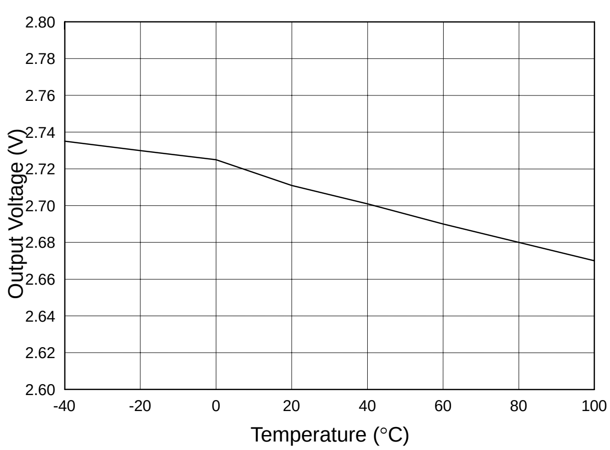


Fig. 10 SS6642-27 Output Voltage vs. Temperature

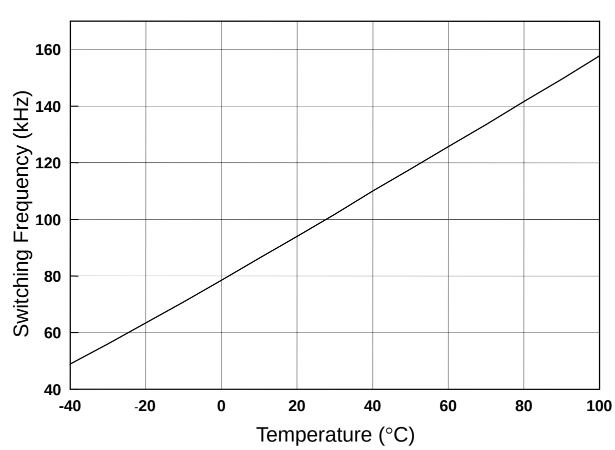


Fig. 11 SS6642-27 Switching Frequency vs. Temperature

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

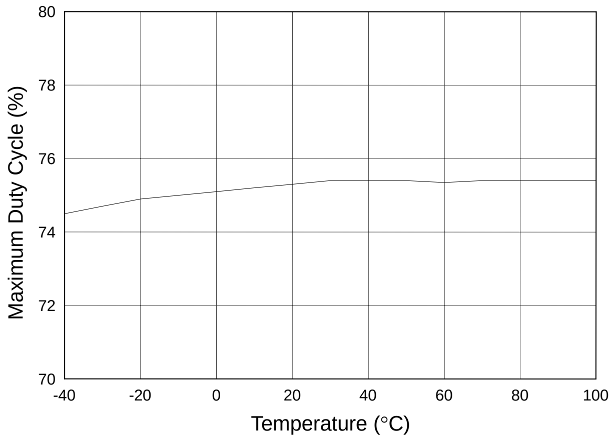


Fig. 12 SS6642-27 Maximum Duty Cycle vs. Temperature

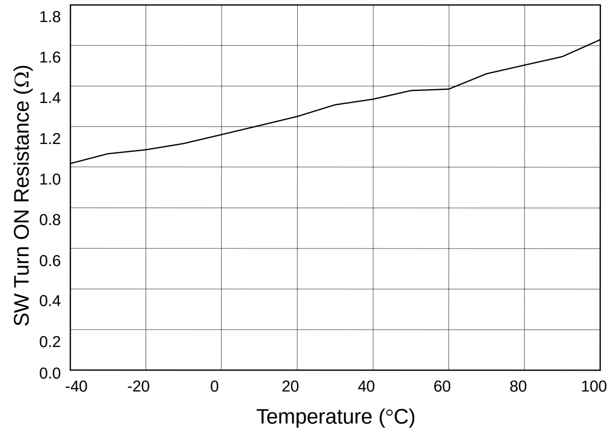


Fig. 13 SS6642-27 SW Turn ON Resistance vs. Temperature

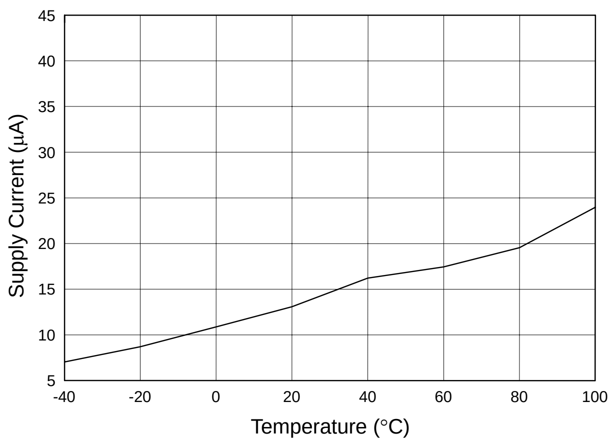


Fig. 14 SS6642-27 Supply Current vs. Temperature

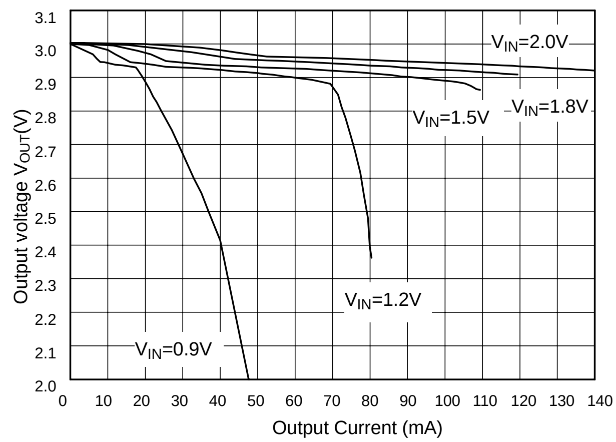


Fig. 15 SS6642-30 Load Regulation (L=100μH, CD54)

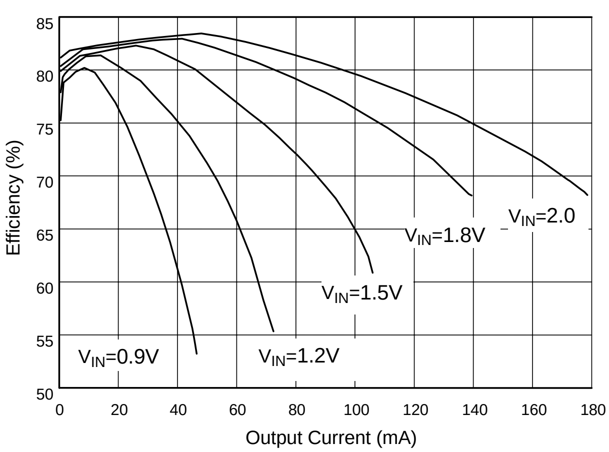


Fig. 16 SS6642-30 Efficiency (L=100μH, CD54)

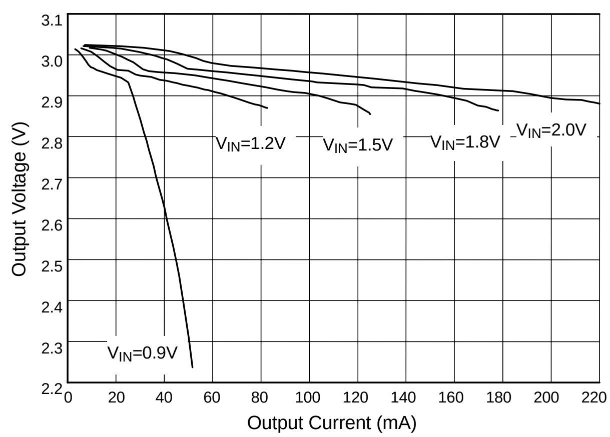


Fig. 17 SS6642-30 Load Regulation (L=47μH CD54)

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

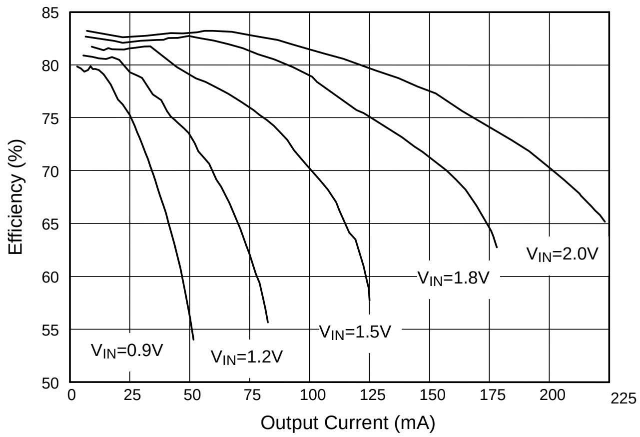


Fig. 18 SS6642-30 Efficiency (L=47μH CD54)

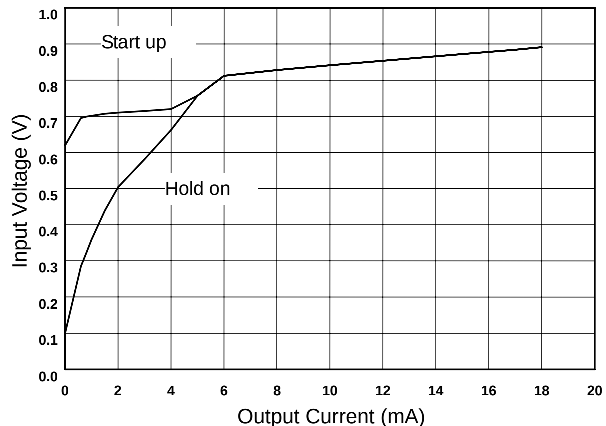


Fig. 19 SS6642-30 Start-up & Hold-on Voltage (L=100μH CD54)

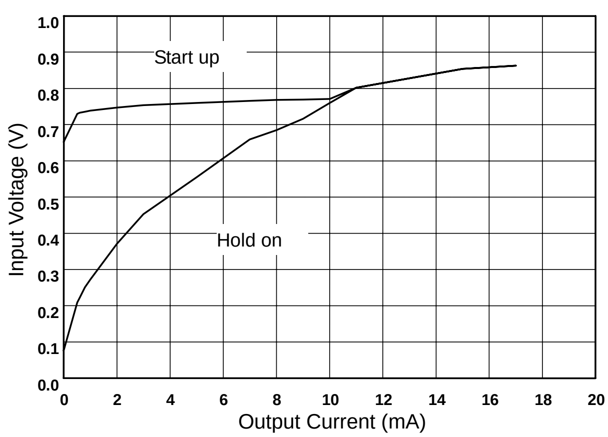


Fig. 20 SS6642-30 Start-up & Hold-on Voltage (L=47μH CD54)

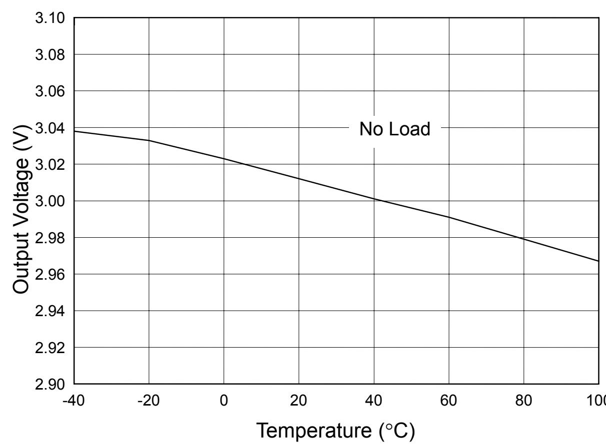


Fig. 21 SS6642-30 Output Voltage vs. Temperature

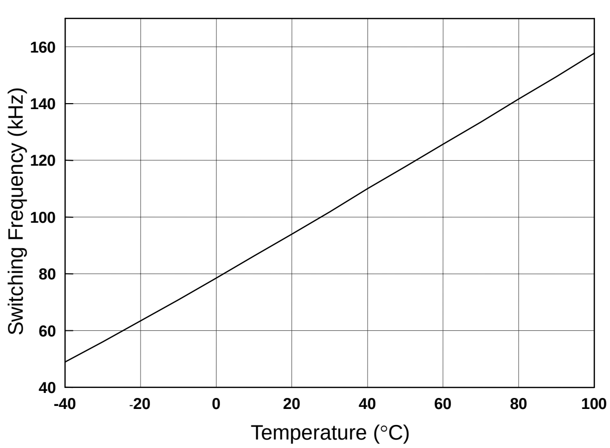


Fig. 22 SS6642-30 Switching Frequency vs. Temperature

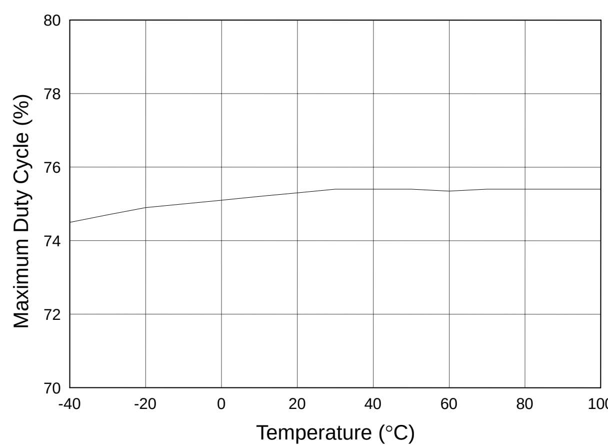


Fig. 23 SS6642-30 Maximum Duty Cycle vs. Temperature

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

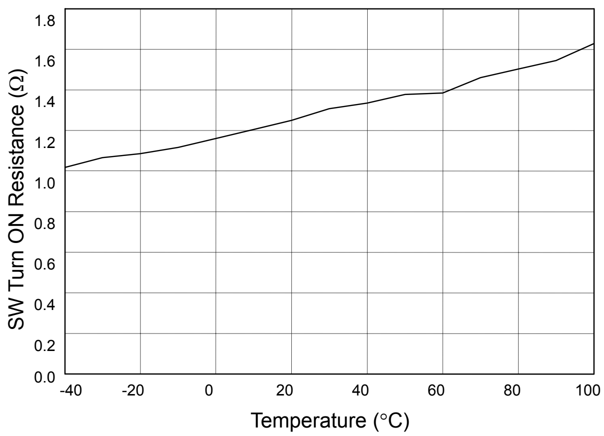


Fig. 24 SS6642-30 SW Turn ON Resistance vs. Temperature

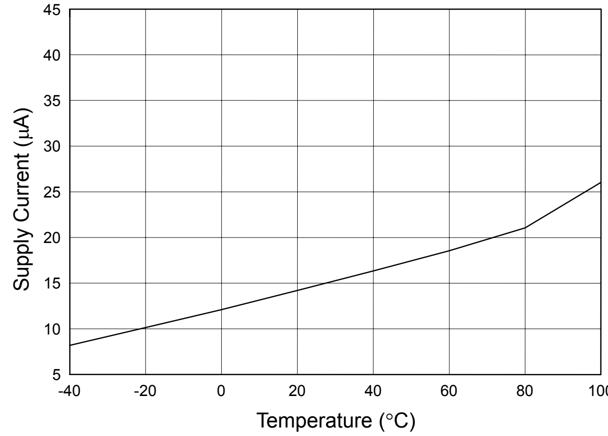


Fig. 25 SS6642-30 Supply Current vs. Temperature

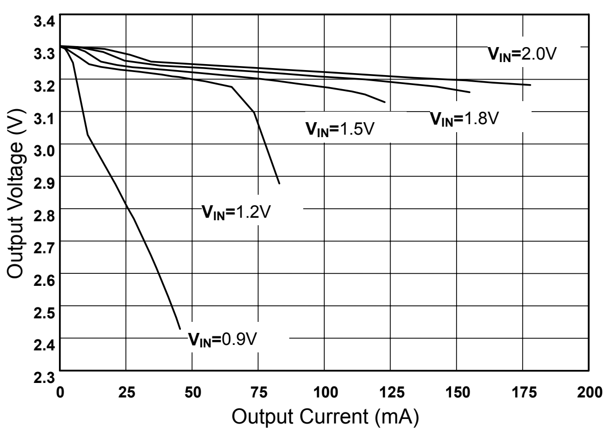


Fig. 26 SS6642-33 Load Regulation (L=100μH, CD54)

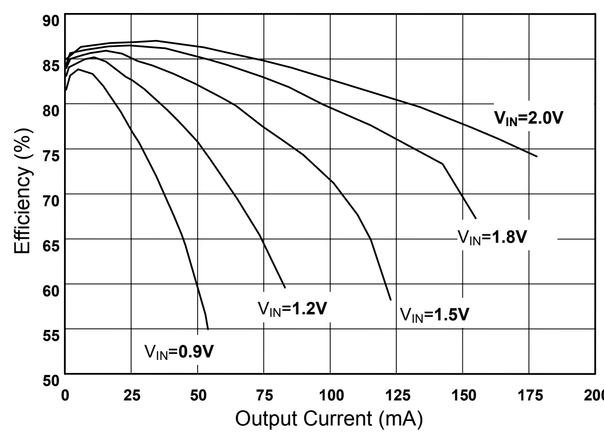


Fig. 27 SS6642-33 Efficiency (L=100μH, CD54)

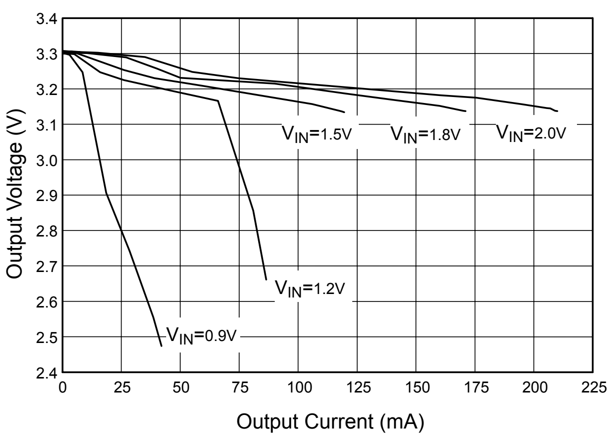


Fig. 28 SS6642-33 Load Regulation (L=47μH, CD54)

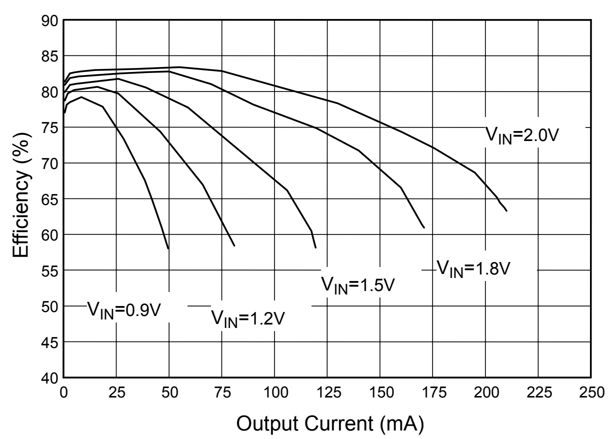


Fig. 29 SS6642-33 Efficiency (L=47μH,CD54)

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

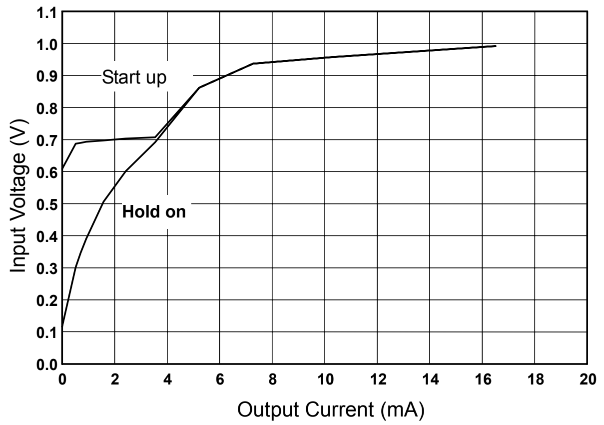


Fig. 30 SS6642-33 Start-up & Hold-on Voltage (L=100µH CD54)

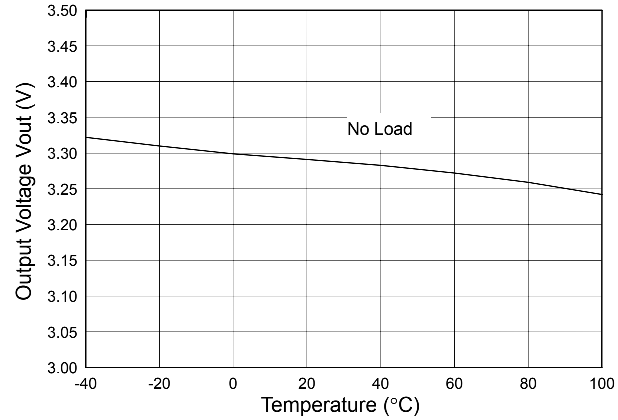


Fig. 31 SS6642-33 Output Voltage vs. Temperature

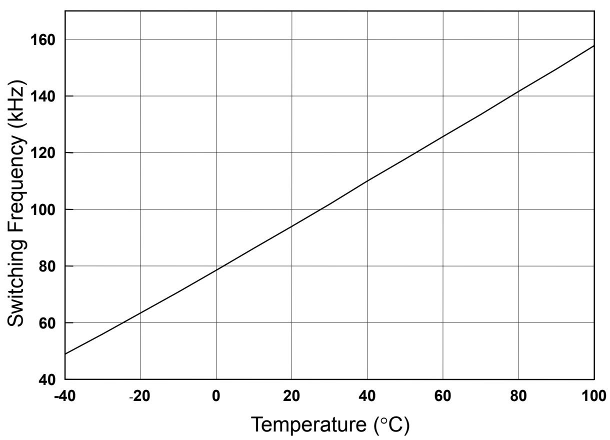


Fig. 32 SS6642-33 Switching Frequency vs. Temperature

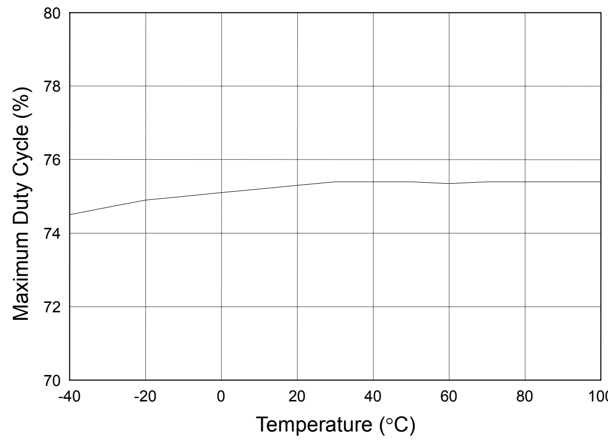


Fig. 33 SS6642-33 Maximum Duty Cycle vs. Temperature

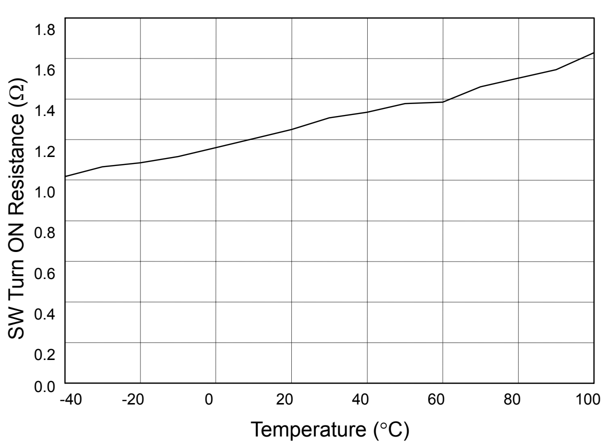


Fig. 34 SS6642-33 SW Turn ON Resistance vs. Temperature

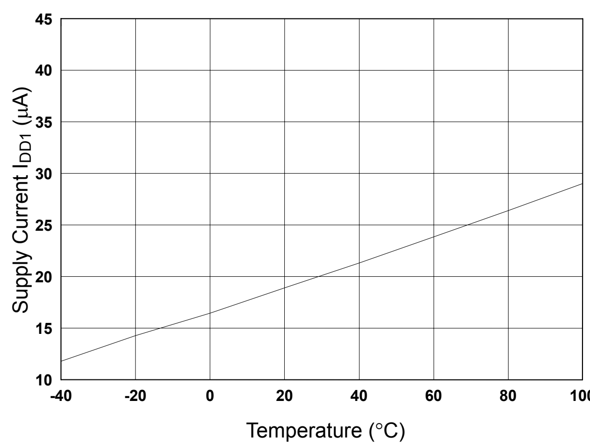


Fig. 35 SS6642-33 Supply Current vs. Temperature

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

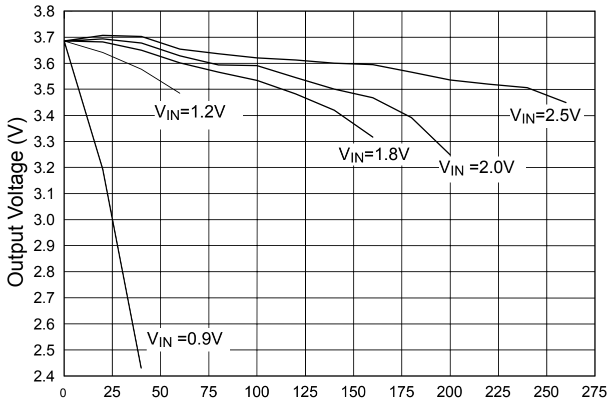


Fig. 36 SS6642-37 Load Regulation (L=100µH)

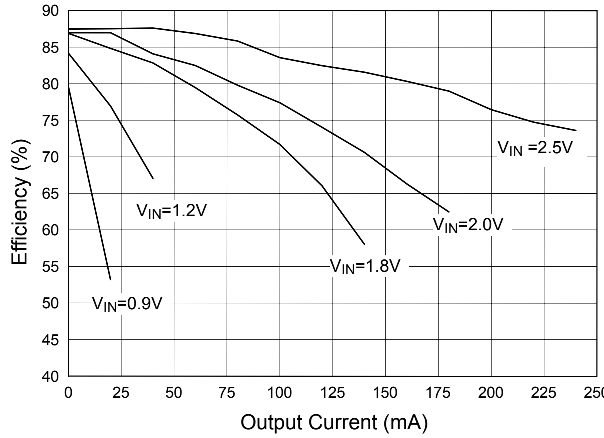


Fig. 37 SS6642-37 Efficiency (100µH)

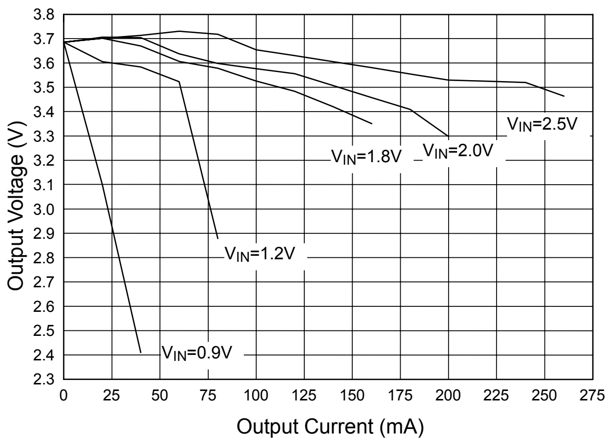


Fig. 38 SS6642-37 Load Regulation (L=47µH)

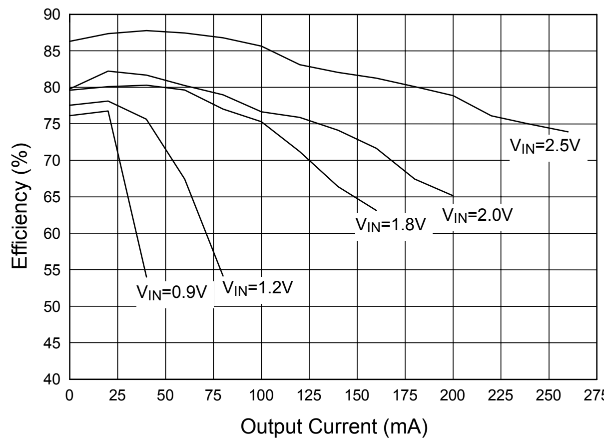


Fig. 39 SS6642-37 Efficiency (47µH)

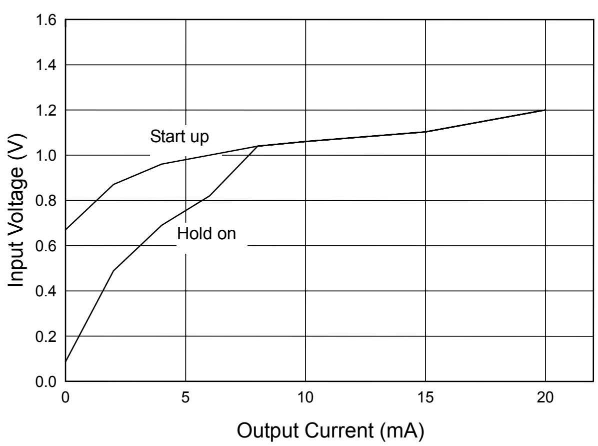


Fig. 40 SS6642-37 Start-up & Hold-on Voltage (L=100µH)

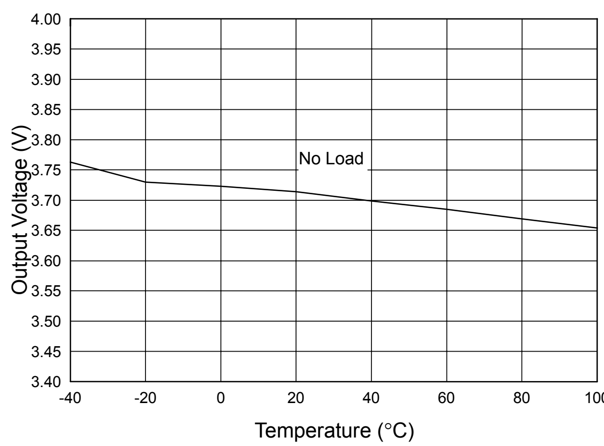


Fig. 41 SS6642-37 Output Voltage vs. Temperature

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

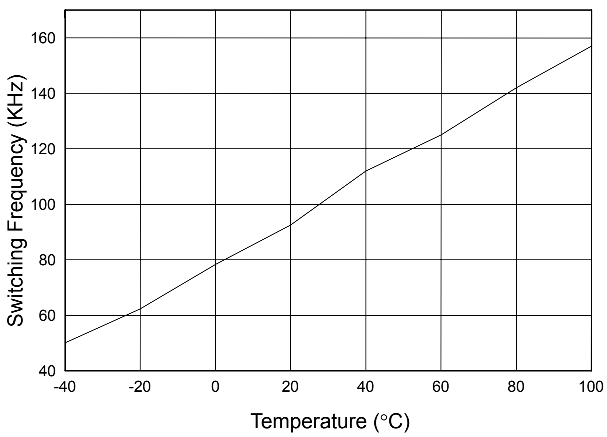


Fig. 42 SS6642-37 Switching Frequency vs. Temperature

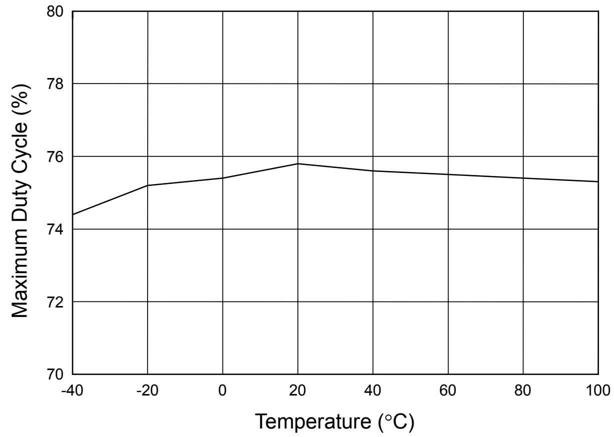


Fig. 43 SS6642-37 Maximum Duty Cycle vs Temperature

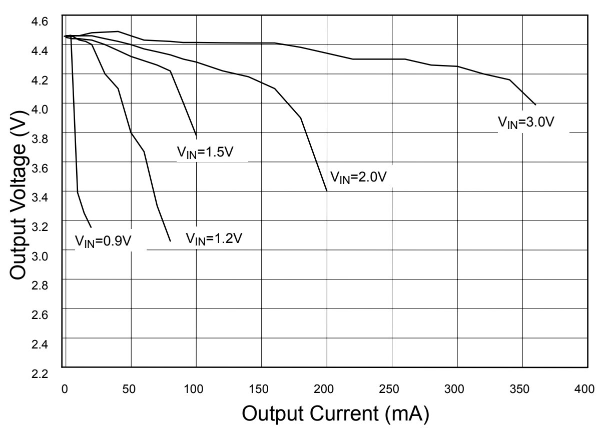


Fig. 44 SS6642-45 Load Regulation (L=100μH)

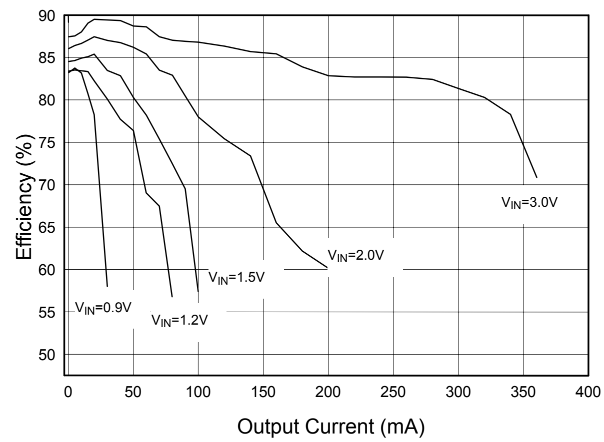


Fig. 45 SS6642-45 Efficiency (L=100μH)

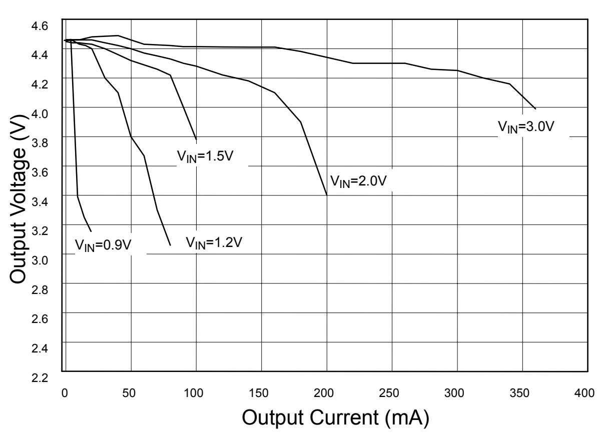


Fig. 46 SS6642-45 Load Regulation (L=100μH)

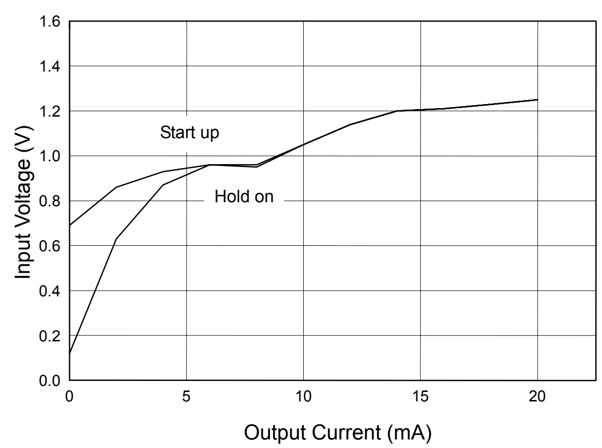


Fig. 47 SS6642-45 Start-up & Hold-On Voltage (L=100μH)

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

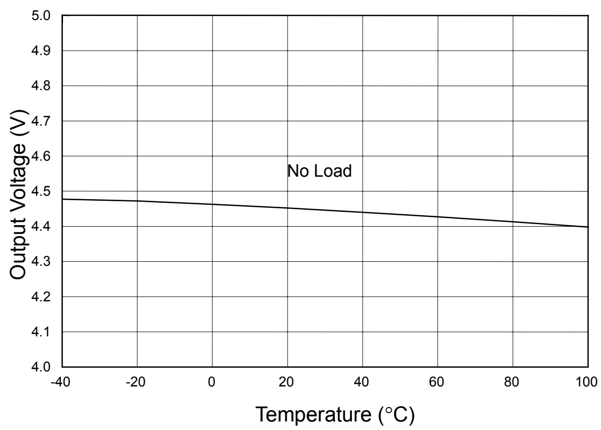


Fig. 48 SS6642-45 Output Voltage vs. Temperature

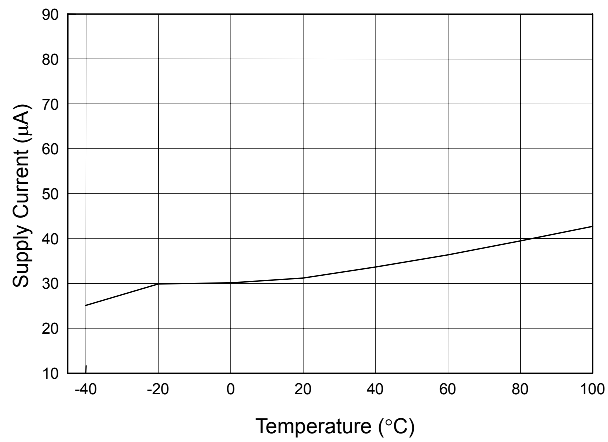


Fig. 49 SS6642-45 Supply Current vs. Temperature

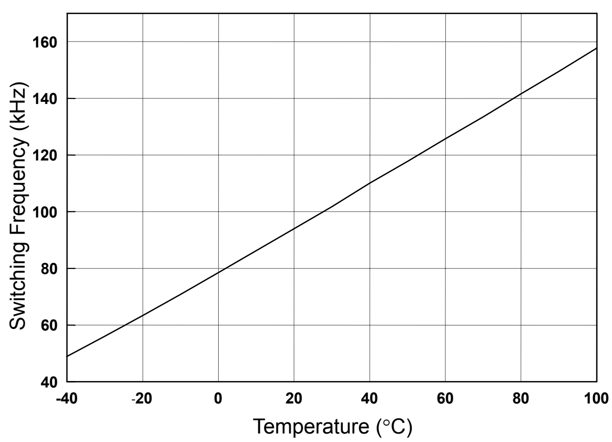


Fig. 50 SS6642-45 Switching Frequency vs. Temperature

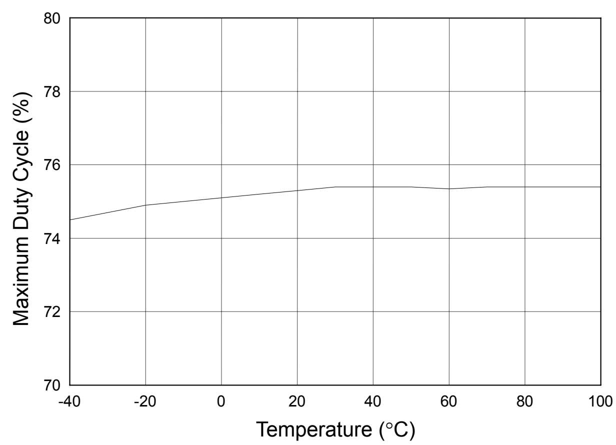


Fig. 51 SS6642-45 Maximum Duty Cycle vs. Temperature

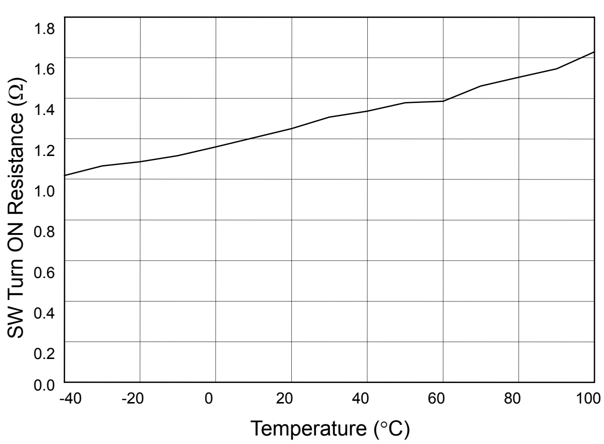


Fig. 52 SS6642-45 SW Turn ON Resistance vs. Temperature

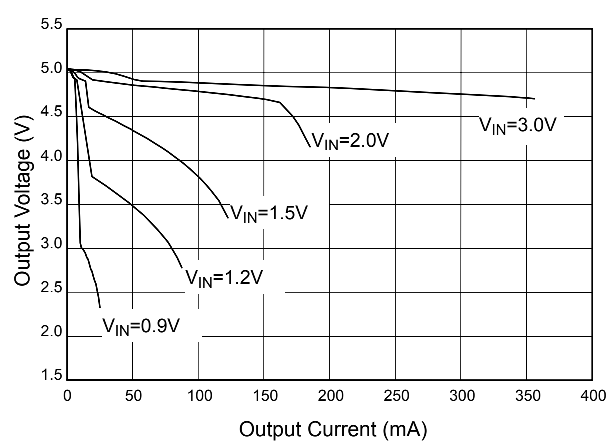


Fig. 53 SS6642-50 Load Regulation (L=100µH CD54)

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

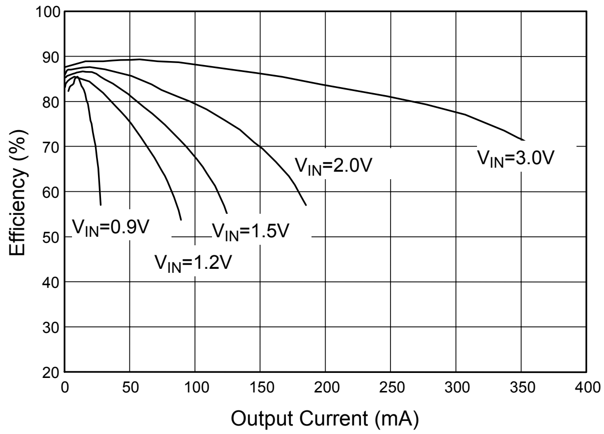


Fig. 54 SS6642-50 Efficiency (L=100µH CD54)

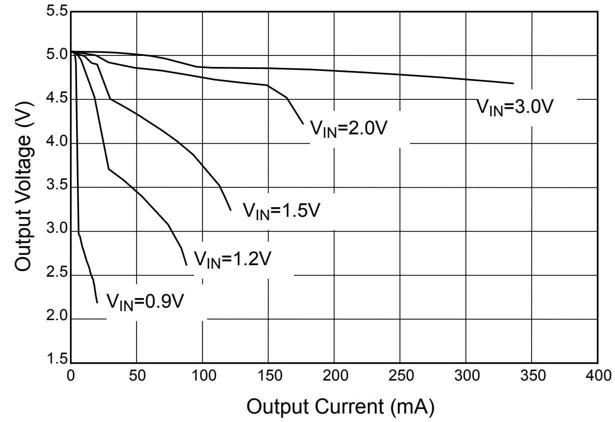


Fig. 55 SS6642-50 Load Regulation (L=47µH CD54)

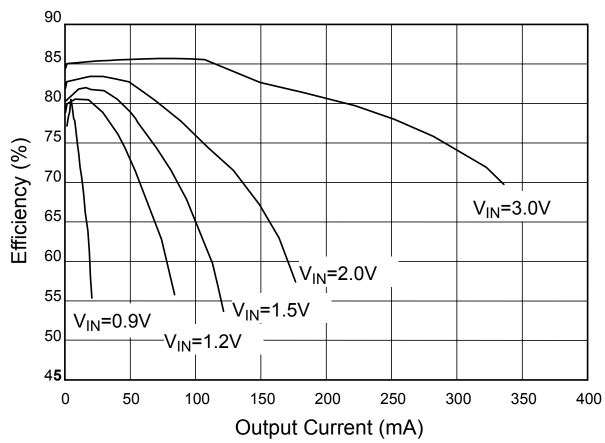


Fig. 56 SS6642-50 Efficiency (L=47µH CD54)

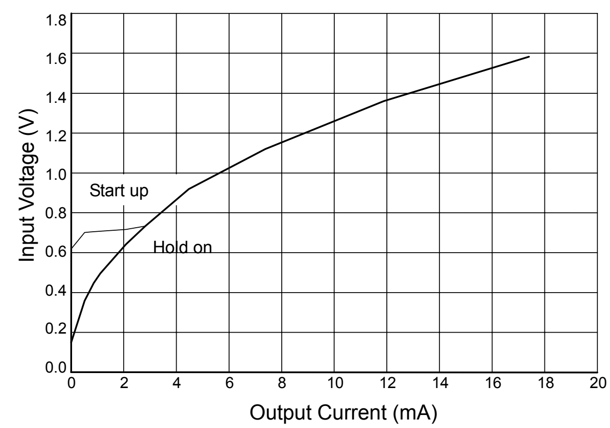


Fig. 57 SS6642-50 Start-up & Hold-on Voltage (L=100µH CD50)

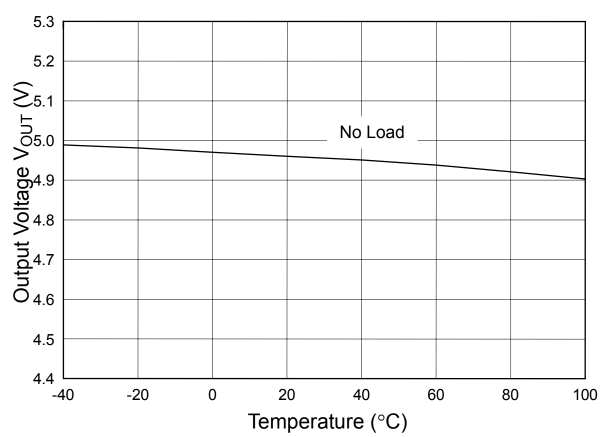


Fig. 58 SS6642-50 Output Voltage vs. Temperature

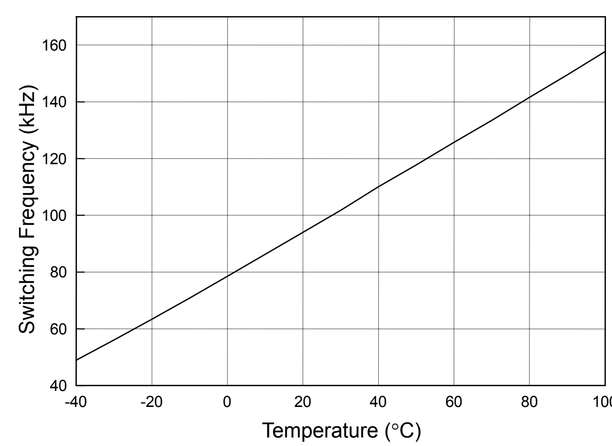


Fig. 59 SS6642-50 Switching Frequency vs. Temperature

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

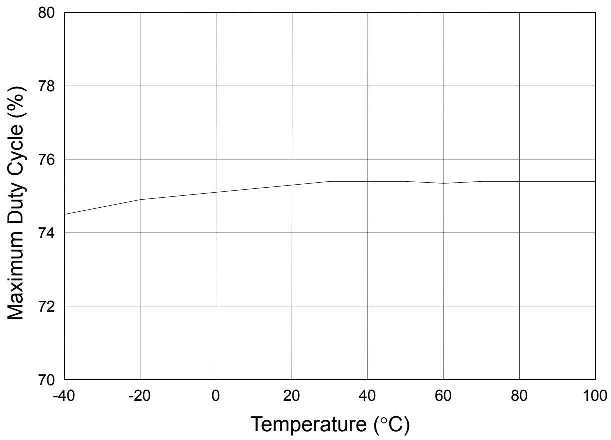


Fig. 60 SS6642-50 Maximum Duty Cycle vs. Temperature

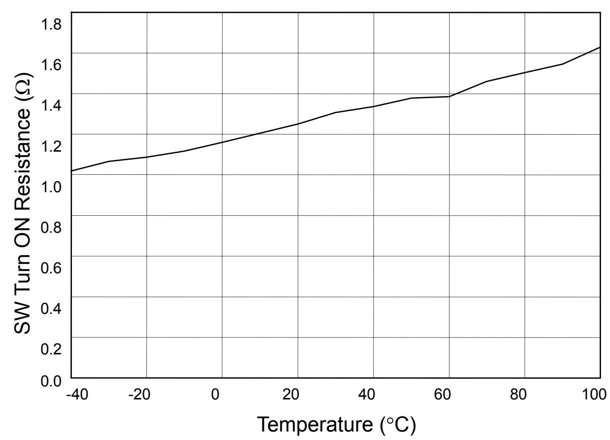


Fig. 61 SS6642-50 SW Turn ON Resistance vs. Temperature

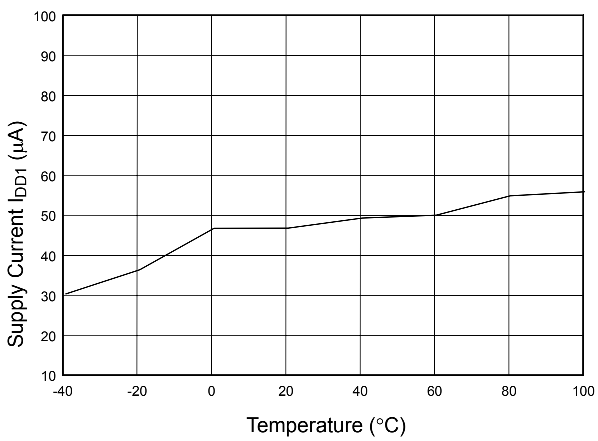


Fig. 62 SS6642-50 Supply Current vs. Temperature

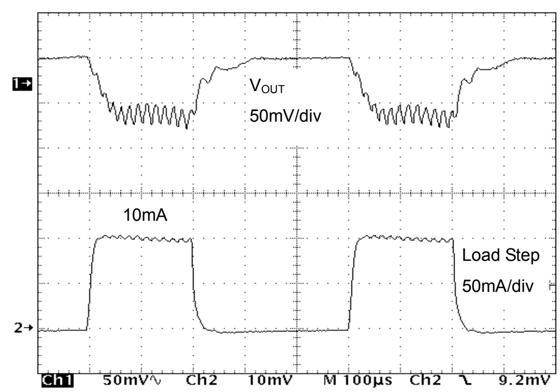


Fig. 63 Load Transient Response
($L1=100\mu H$, $C2=47\mu F$, $V_{IN}=2V$)

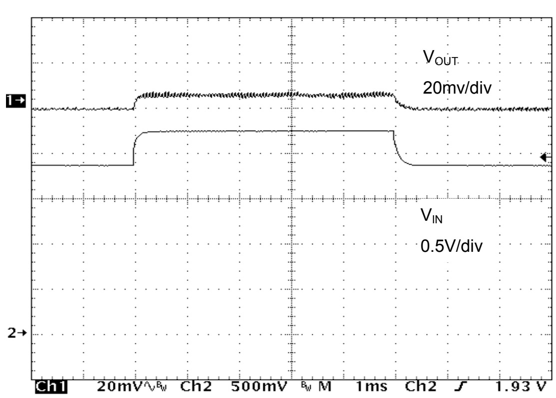
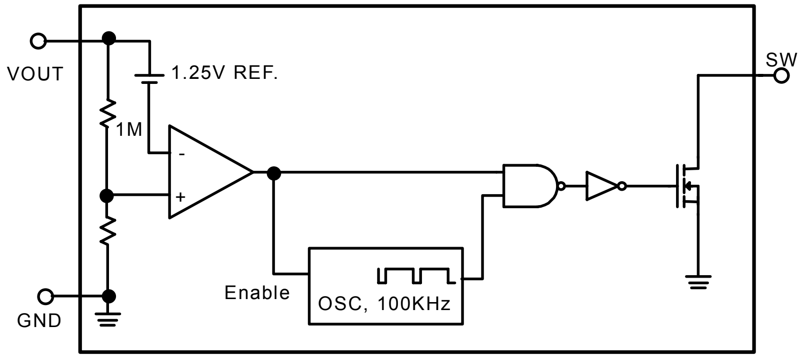


Fig. 64 Line Transient Response
($L_1=100\mu H$, $C_2=47\mu F$)

BLOCK DIAGRAM



PIN DESCRIPTIONS

PIN 1 : GND - Ground. Must be low impedance; solder directly to ground plane.

PIN 2 : VOUT - IC supply pin. Connect VOUT to the regulator output.

PIN 3 : SW –Drain of the internal N-channel MOSFET switch.

APPLICATION INFORMATION

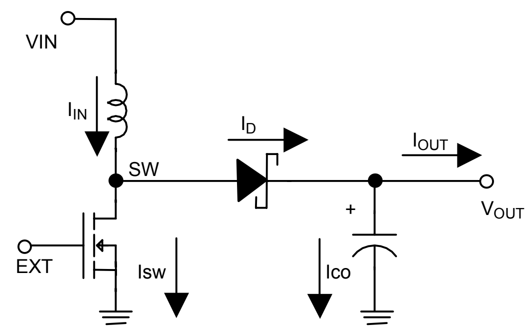
GENERAL DESCRIPTION

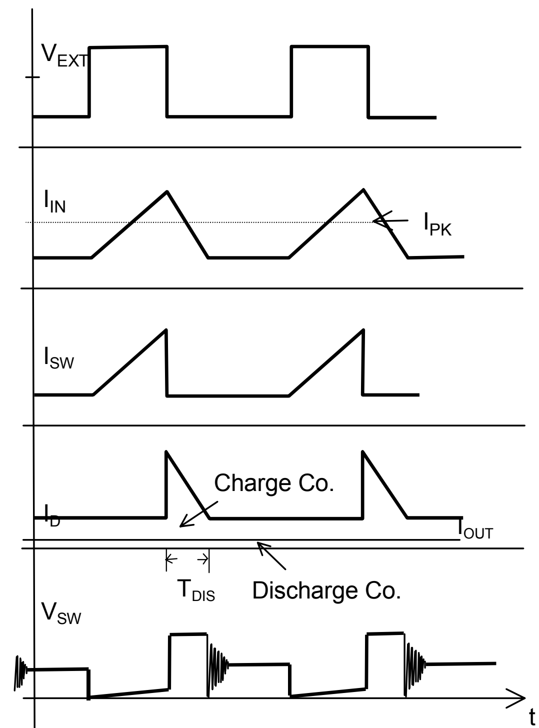
The SS6642G PFM (pulse frequency modulation) controller IC combines a switch-mode regulator, N-channel power MOSFET, precision voltage reference, and voltage detector in a single monolithic device. It offers extremely low quiescent current, high efficiency, and very low gate threshold voltage to ensure start-up with low battery voltage (0.8V typ.). Designed to maximize battery life in portable products, it minimizes switching losses by only switching as needed to service the load.

PFM controllers transfer a discrete amount of energy per cycle and regulate the output voltage by modulating the switching frequency with a constant turn-on time. Switching frequency depends on load, input voltage, and inductor value, and it can range up to 100KHz. The SW on-resistance is typically 1.9 to 2.2Ω to minimize switch losses.

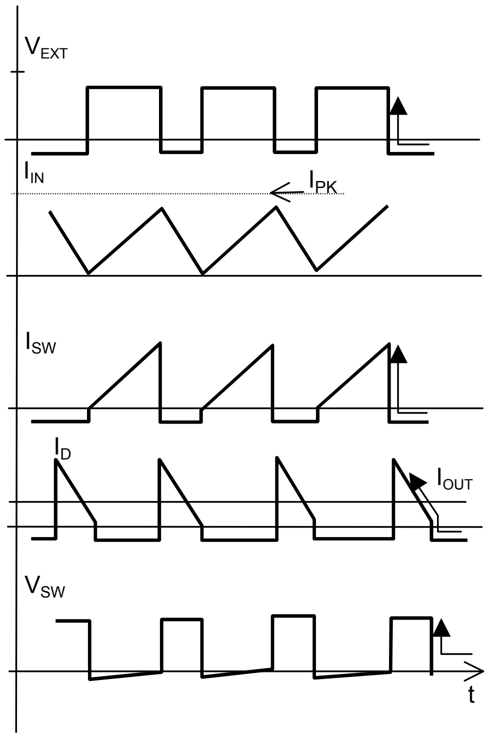
When the output voltage drops, the error comparator enables the 100kHz oscillator that turns on the MOSFET for around 7.5us and off for 2.5us. Turning on the MOSFET allows inductor current to ramp up, storing energy in a magnetic field. When the MOSFET turns off, inductor current is forced through the diode to the output capacitor and load. As the stored energy is depleted, the current ramps down until the diode turns off. At this point, the inductor may ring due to residual energy and stray capacitance. The output capacitor stores charge when the current flowing through the diode is high, and releases it when the current is low, thereby maintaining a steady voltage across the load.

As the load increases, the output capacitor discharges faster and the error comparator initiates cycles sooner, increasing the switching frequency. The maximum duty cycle ensures adequate time for energy transfer to the output during the second half of each cycle. Depending on the circuit, a PFM controller can operate in either discontinuous mode or continuous conduction mode. Continuous conduction mode means that the inductor current does not ramp down to zero during each cycle.





Discontinuous Conduction Mode



Continuous Conduction Mode

Continuous Conduction Mode

At the boundary between continuous and discontinuous modes, output current (I_{OB}) is determined by

$$I_{OB} = \left(\frac{V_{IN}}{V_{OUT}}\right) * \frac{1}{2} * \frac{V_{IN}}{L} * T_{ON} * (1-x)$$

where Vd is the diode drop,

$$x = (R_{ON} + R_S) * \frac{T_{ON}}{L}$$

R_{ON}= Switch turn-on resistance, R_S= Inductor DC resistance

T_{ON} = Switch ON time

In the discontinuous mode, the switching frequency (Fsw) is

$$Fsw = \frac{2 * (L) * (V_{OUT} + V_D - V_{IN}) * (I_{OUT})}{V_{IN}^2 \times T_{ON}^2}(1+x)$$

In the continuous mode, the switching frequency is

$$f_{SW} = \frac{1}{T_{ON}} \frac{(V_{OUT} + V_D - V_{IN})}{(V_{OUT} + V_D - V_{SW})} * [1 + \frac{x}{2}(\frac{V_{IN} - V_{SW}}{V_{OUT} + V_D - V_{SW}})] \cong \frac{1}{T_{ON}}\left(\frac{V_{OUT} + V_D - V_{IN}}{V_{OUT} + V_D - V_{SW}}\right)$$

where Vsw = switch drop and is proportional to output current.

Inductor Selection

To operate as an efficient energy transfer element, the inductor must fulfill three requirements. First, the inductance must be low enough for the inductor to store adequate energy under the worst-case condition of minimum input voltage and switch ON time. Second, the inductance must also be high enough so that the maximum current rating of the SS6642 and the inductor are not exceeded at the other worst-case condition of maximum input voltage and ON time. Lastly, the inductor must have sufficiently low DC resistance so excessive power is not lost as heat in the windings. Unfortunately, this is inversely related to physical size.

Minimum and maximum input voltage, output voltage and output current must be established in advance and then the inductor can be selected.

In discontinuous mode operation, at the end of the switch ON time, peak current and energy in the inductor build according to

$$I_{PK} = \left(\frac{V_{IN}}{R_{ON} + R_s}\right) * \left(1 - \exp(-\frac{R_{ON} + R_s}{L} * T_{ON})\right)$$

$$\cong \left(\frac{V_{IN}}{L}\right) * (T_{ON}) * \left(1 - \frac{x}{2}\right)$$

$$\cong \frac{V_{IN}}{L} T_{ON} \qquad \text{(simple loss equation),}$$

where $x = (R_{ON} + R_S) * \frac{T_{ON}}{L}$

$$E_L = \frac{1}{2} L \times Ipk^2$$

The power supplied by the inductor per cycle must be equal to or greater than

$$P_L/f_{SW} = (V_{OUT} + V_D - V_{IN}) * (I_{OUT}) * (\frac{1}{f_{SW}})$$

in order for the converter to regulate the output.

When loading is over IOB, the PFM controller operates in continuous mode. Inductor peak current can be derived from

$$I_{PK} = \left(\frac{V_{OUT} + V_D - V_{SW}}{V_{IN} - V_{SW}} - \frac{x}{2}\right) * I_{OUT} + \left(\frac{V_{IN} - V_{SW}}{2L}\right) * T_{ON} * \left(1 - \frac{x}{2}\right)$$

Valley current (Iv) is

$$I_V = \left(\frac{V_{OUT} + V_D - V_{SW}}{V_{IN} - V_{SW}} - \frac{x}{2}\right) * I_{OUT} - \left(\frac{V_{IN} - V_{SW}}{2L}\right) * T_{ON} * \left(1 - \frac{x}{2}\right)$$

Table 1 Indicates resistance and height for each coil.

Power Inductor Type		Inductance (μH)	Resistance (Ω)	Rated Current (A)	Height (mm)
Coilcraft SMT Type (www.coilcraft.com)	DS1608	22	0.10	0.7	2.9
Coilcraft SMT Type (www.coilcraft.com)	DS1608	47	0.18	0.5	2.9
Coilcraft SMT Type (www.coilcraft.com)	DS1608	100	0.38	0.3	2.9
Coilcraft SMT Type (www.coilcraft.com)	DO3316	22	0.08	2.7	5.2
Coilcraft SMT Type (www.coilcraft.com)	DO3316	47	0.14	1.8	5.2
Sumida SMT Type CD54		47	0.25	0.7	4.5
Sumida SMT Type CD54		100	0.50	0.5	4.5
Hold SMT Type PM54		47	0.25	0.7	4.5
Hold SMT Type PM54		100	0.50	0.5	4.5
Hold SMT Type PM75		33	0.11	1.2	5.0

Capacitor Selection

A poor choice for an output capacitor can result in poor efficiency and high output ripple. Ordinary aluminum electrolytics, while inexpensive may have unacceptably poor ESR and ESL. There are low-ESR aluminum capacitors for switch mode DC-DC converters which work much better than general types. Tantalum capacitors provide still better performance but are more expensive. OSCON capacitors have extremely low ESR and small size. If capacitance is reduced, output ripple will increase.

Most of the input supply is applied to the input bypass capacitor, so the capacitor voltage rating should be at least 1.25 times greater than the maximum input voltage.

Diode Selection

Speed, forward drop, and leakage current are the three main considerations in selecting a rectifier diode. Best performance is obtained with Schottky rectifier diodes such as the 1N5819. SSC also has Schottkies for surface-mount. For lower output power a 1N4148 can be used, although efficiency and start-up voltage will suffer substantially.

Component Power Dissipation

Operating in discontinuous mode, power loss in the winding resistance of the inductor can be approximated to

$$PD_L = \frac{2}{3}\left(\frac{T_{ON}}{L}\right) * (R_D) * \left(\frac{V_{OUT} + V_F}{V_{OUT}}\right) * (P_{OUT})$$

where $P_{OUT}=V_{OUT} * I_{OUT}$; R_S=Inductor DC R;

V_D = Diode drop.

The power dissipated in the MOSFET switch is

$$PD_{SW} = \frac{2}{3}\left(\frac{T_{ON}}{L}\right) * (R_{ON}) * \left(\frac{V_{OUT} + V_D - V_{IN}}{V_{OUT}}\right) * (P_{OUT})$$

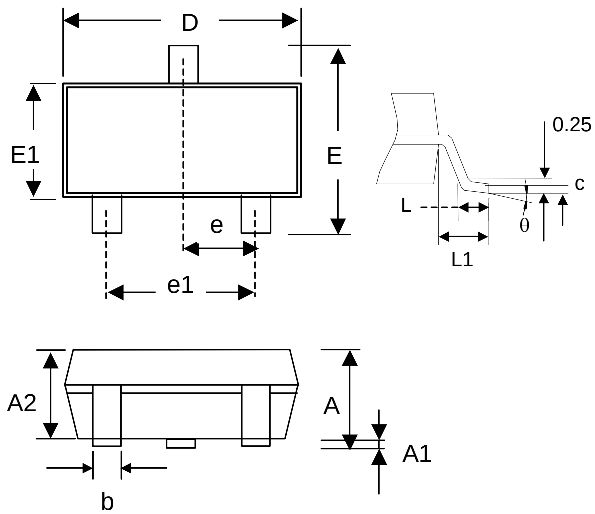
The power dissipated in the rectifier diode is

$$PDd = \left(\frac{V_D}{V_{OUT}}\right) * (P_{OUT})$$

PHYSICAL DIMENSIONS (unit: mm)

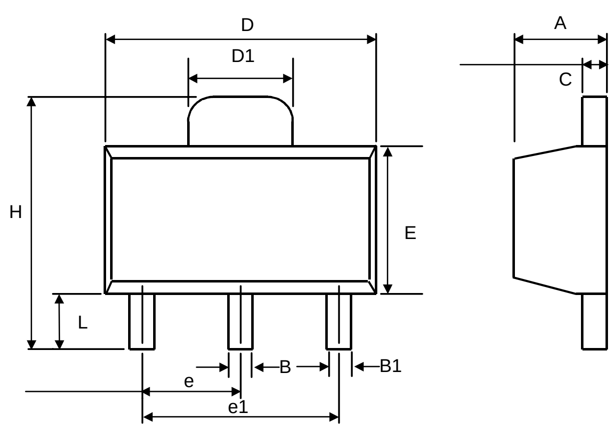
All package options are Pb-free, RoHS compliant.

SOT-23 (GU)



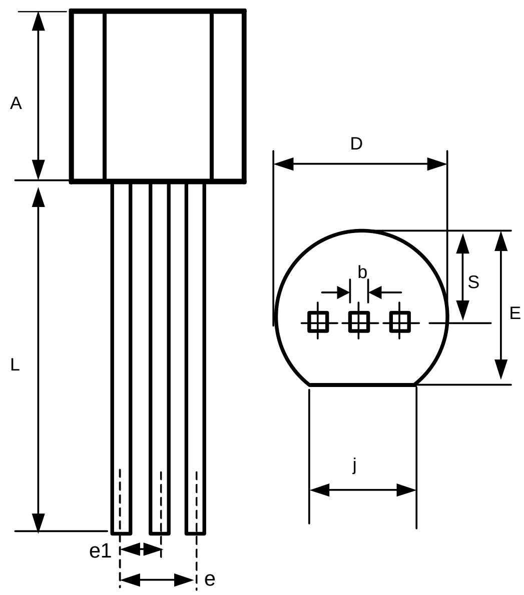
SYMBOL	MIN	MAX
A	0.95	1.45
A1	0.05	0.15
A2	0.90	1.30
b	0.30	0.50
c	0.08	0.22
D	2.80	3.00
E	2.60	3.00
E1	1.50	1.70
e	0.95 BSC	
e1	1.90 BSC	
L	0.30	0.60
L1	0.60 REF	
θ	0°	8°

SOT-89 (GX)



SYMBOL	MIN	MAX
A	1.40	1.60
B	0.44	0.56
B1	0.36	0.48
C	0.35	0.44
D	4.40	4.60
D1	1.50	1.83
E	2.29	2.60
e	1.50 BSC	
e1	3.00 BSC	
H	3.94	4.25
L	0.89	1.20

TO-92 (GZ)



SYMBOL	MIN	MAX
A	4.32	5.33
b	0.36	0.47
D	4.45	5.20
E	3.18	4.19
e	2.42	2.66
e1	1.15	1.39
j	3.43	-
L	12.70	-
S	2.03	2.66