



Micropower VFM Step-Up Converter

Features

- Very Low Supply Current, 22 μ A typical
- Maximum Shutdown Current of 1 μ A
- Fixed Output Voltages from 2.5V to 5.0V in steps of 100mV
- Output Voltage Accuracy \pm 5%
- Output Current up to 100mA
- Low Ripple
- Low Noise
- Very Low Start-up Voltage
- High Efficiency (typically 87% at Vout = 5V)
- Internal Soft-start
- Low External Component Count Needed
- Industry-standard SO-T-23-5 Package
- RoHS-compliant Halogen-free Package.

Description

The APE2902-3 is a high efficiency VFM Step-up DC/DC converter for small, low input-voltage or battery-powered systems with ultra-low quiescent supply current. The APE2902-3 accepts a positive input voltage from start-up voltage to V_{OUT} and converts it to a higher output voltage in the 2.5 to 5V range.

The APE2902-3 combines ultra-low quiescent supply current and high efficiency to ensure maximum battery life. High switching frequency and the internally limited peak inductor current allows the use of small, low cost inductors. Only three external components are needed: an inductor, a diode and an output capacitor.

The APE2902-3 is suitable to be used in battery powered equipment where low noise, low ripple and ultra-low supply current are required. The IC operation can be shutdown from an external pin - if EN is connected to GND, the IC operation is shut down with a supply current less than 1 μ A.

The APE2902-3 is supplied in the small SOT-23-5 package.

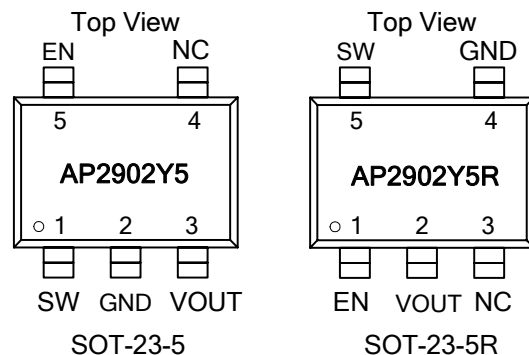
Typical applications are pagers, cameras including video cameras, cellular telephones, wireless telephones, handheld computers, battery backup supplies, and other battery-powered equipment.

Ordering Information

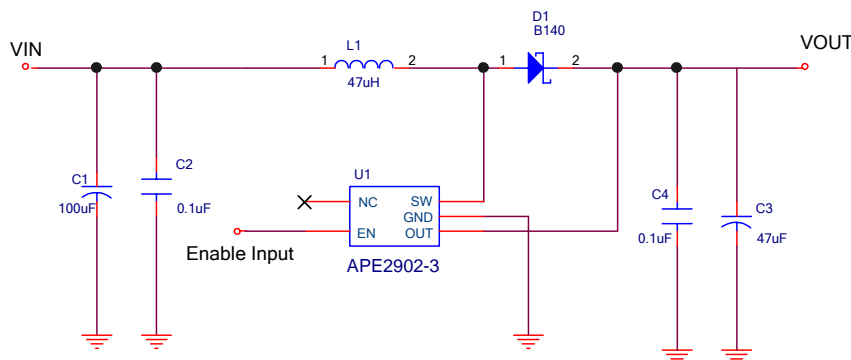
APE2902Y5x-xx-HF-3TR

Package:	Output Voltage:
Y5 : SOT-23-5	22 : 2.2V
Y5R : SOT-23-5R	25 : 2.5V
	26 : 2.6V
	at 100mV increments to
	50 : 5.0V

Pin Configuration



Typical Application Circuit





Absolute Maximum Ratings

VIN Supply Voltage(V _{IN})	5.5 V
SW Voltage(V _{SW})	5.5 V
OUT Voltage(V _{OUT})	5.5 V
EN Pin Voltage(V _{EN})	5.5 V
Power Dissipation(P _D)	(T _J -T _A) / R _{thja} W
Storage Temperature Range(T _{ST})	-40 °C to 150 °C
Operating Junction Temperature Range(T _{OP})	-20 °C to 100 °C
Thermal Resistance from Junction to Case(R _{thJC})	110 °C/W
Thermal Resistance from Junction to Ambient(R _{thJA})	250 °C/W

Note : R_{thJA} is measured with the PCB copper area of approximately 1square inch (Multi-layer).

- Note 1:** Absolute Maximum Ratings are limits beyond which damage to the device may occur. Operating Conditions are conditions under which the device functions but the specifications might not be guaranteed. For guaranteed specifications and test conditions see the Electrical Specifications.
- Note2:** The maximum power dissipation is a function of the maximum junction temperature, T_{Jmax}; total thermal resistance, R_{th(ja)} and ambient temperature T_A. The maximum allowable power dissipation at any ambient temperature is (T_{Jmax} - T_A) / R_{th(ja)}.
- Note3:** Low duty pulse techniques are used during test to maintain a junction temperature as close to ambient as possible.

Electrical Specifications

(V_{IN}=1.8V, I_{OUT}=10mA, T_A=25 °C, unless otherwise specified)

Parameter	SYM	TEST CONDITION	MIN	TYP	MAX	UNITS
Output Voltage Accuracy	ΔV _{OUT}		-5	-	5	%
Start-up Voltage(V _{IN} -V _F)(Note 1)	V _{START-UP}	I _{OUT} =1mA, V _{IN} =rising from 0 to 2V	-	0.8	1.2	V
Hold-on Voltage	V _{HOLD}	I _{OUT} =1mA, V _{IN} =falling from 2 to 0V	0.6	-	-	V
Supply Current	I _{SUPPLY}	No Load	-	22	-	uA
Shutdown Current	I _{SD}	V _{EN} =0V	-	-	1	uA
Internal Switch R _{DS(ON)}	R _{SW(DSON)}	I _{SW} =150mA	-	850	-	mΩ
Internal Leakage Current	I _{SW(leak)}	V _{SW} =4V, forced V _{OUT} =3.8V	-	-	0.5	uA
Maximum Oscillator Frequency	F _{OSC}		-	150	-	kHz
Oscillator Duty On	D _{ON}	To be measured on SW pin	-	77	-	%
Enable Input Threshold	V _{ENH}	Driver ON	0.75	-	-	V
	V _{ENL}	Driver OFF	-	-	0.2	
Enable Input Current	I _{ENH}	V _{EN} =V _{IN}	-	-	0.1	uA
	I _{ENL}	V _{EN} =0V	-	-	-0.1	
Efficiency	η	Vout=2.5V~3.0V, I _{OUT} =50mA	-	82	-	%
		Vout=3.1V~4.0V, I _{OUT} =50mA	-	83	-	%
		Vout=4.1V~5.0V, I _{OUT} =50mA	-	87	-	%

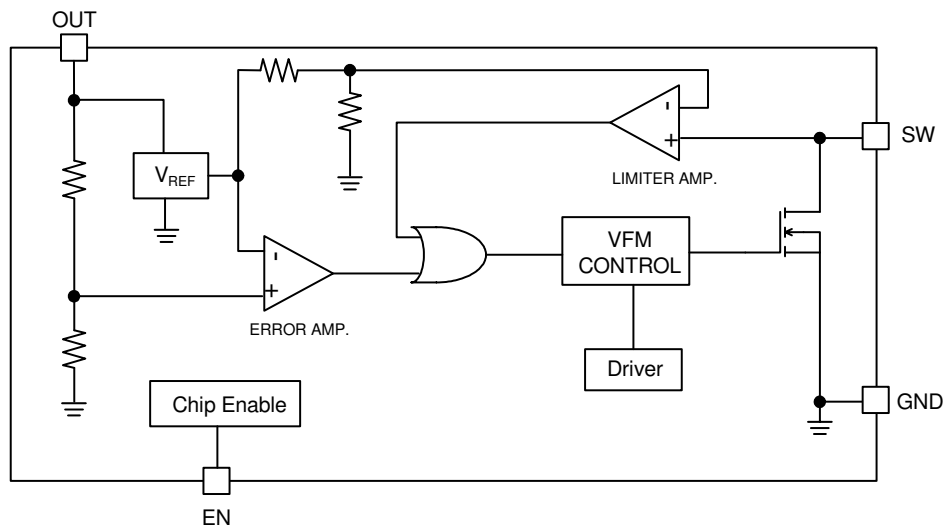
Note 1: The minimum input voltage for the IC start-up is strictly a function of the VF catch diode.



Pin Descriptions

PIN SYMBOL	PIN DESCRIPTION
SW	Switch Pin. External inductor and diode connected here.
GND	GND Pin
OUT	Output Voltage
EN	Chip Enable Pin

Block Diagram



Operation

The APE2902 architecture is built around a VFM CONTROL logic core, with switching frequency set through a built in oscillator. T_{ON} time is fixed (typical $5\mu s$) while T_{OFF} time is determined by the error amplifier output, a logic signal coming from the comparison made by the error amplifier stage between the signal coming from the output voltage divider network and the internal band-gap voltage reference (V_{ref}). T_{OFF} is at its minimum value (typical $1.7\mu s$) when heavy load conditions are encountered (clock frequency 150kHz).

An over-current condition through the internal power switch causes a voltage drop, $V_{SW} = R_{DS(ON)} \times I_{SW}$, and the V_{SW} limiter block forces the internal switch to be off, reducing the T_{ON} time and limiting internal power dissipation. In this case the switching frequency may be higher than the 150kHz set by the internal clock generator.

VFM control ensures very low quiescent current and high conversion efficiency even with very light loads. Since the output voltage pin is also used as the device supply voltage, the versions with higher output voltage see a higher internal supply voltage which results in lower power switch $R_{DS(ON)}$, slightly greater output power and higher efficiency.

Moreover, bootstrapping allows the input voltage to sag to 0.6V (at $I_{OUT} = 1mA$) once the system is started. If the input voltage exceeds the output voltage, the output will follow the input; however, the input or output voltage must not be forced above 5.5V.



Application Information

Input/Output Capacitor Selection

The output ripple voltage, as well as the efficiency, are strictly related to the behavior of these capacitors. The output ripple voltage is the product of the peak inductor current and the output capacitor ESR (equivalent series resistance). Best performances are obtained when using capacitors with good high frequency characteristics and low ESR. The best compromise for the output capacitance is to use a 47 μ F tantalum capacitor. Lower values may cause higher output ripple voltage and lower efficiency, but will not compromise the functionality of the device.

An input capacitor is required to compensate any series impedance, where present, between the supply voltage source and the input voltage of the application.

Inductor Selection

A 47 μ H inductor is recommended for most APE2902 applications. However, the inductance value is not critical, and the APE2902 will work with inductors in the 33 μ H to 120 μ H range.

Diode Selection

Schottky diodes with higher current ratings usually have lower forward voltage drop, larger diode capacitance and faster reverse recovery, which are ideal for APE2902 applications. The forward voltage drop of a Schottky diode impacts the conduction losses in the system, and the diode capacitance (C_T or C_D) impacts the switching losses. For diode selection, both forward voltage drop and diode capacitance need to be considered.

PCB layout guide

When laying out the PC board, the following suggestions should be taken to ensure proper operation of the APE2902-3.

1. The power traces, including the G_{ND} trace, the SW trace and the V_{IN} trace should be kept short, direct and wide to allow large current flow. Put enough multiple-layer pads when they need to change the trace layer.
2. Do not run any signal lines under the inductor.

THIS PRODUCT IS SENSITIVE TO ELECTROSTATIC DISCHARGE, PLEASE HANDLE WITH CAUTION.

USE OF THIS PRODUCT AS A CRITICAL COMPONENT IN LIFE SUPPORT OR OTHER SIMILAR SYSTEMS IS NOT AUTHORIZED.

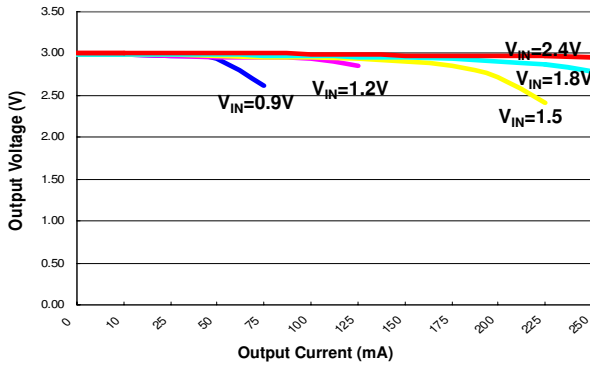
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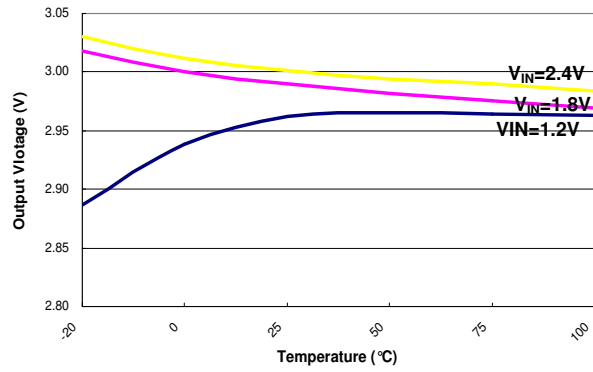


Typical Performance Characteristics

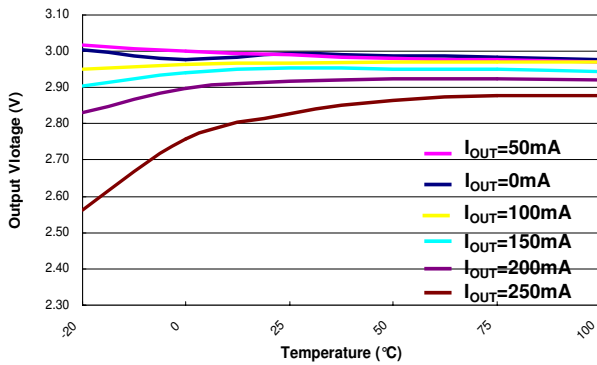
Input Voltage vs. Output Voltage, $T_A=25^\circ\text{C}$



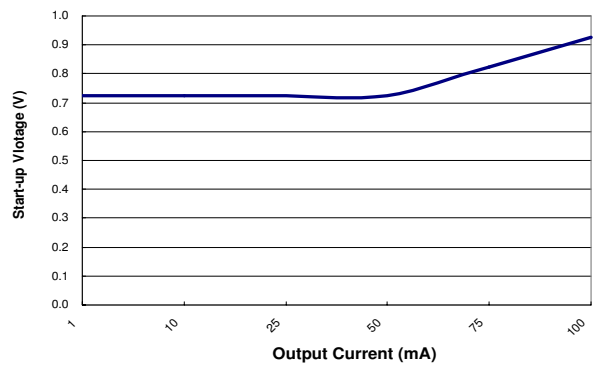
Output Voltage vs. Temperature, $I_{OUT}=50\text{mA}$



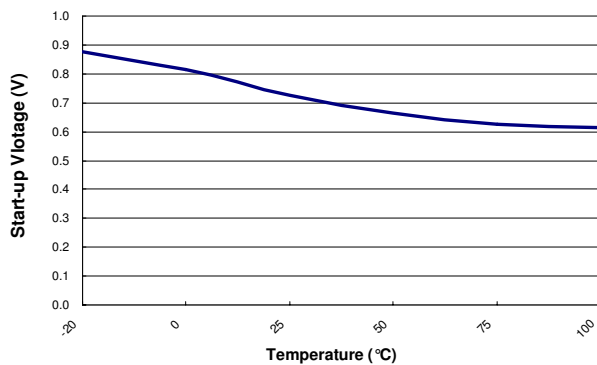
Output Voltage vs. Temperature, $V_{IN}=1.8\text{V}$



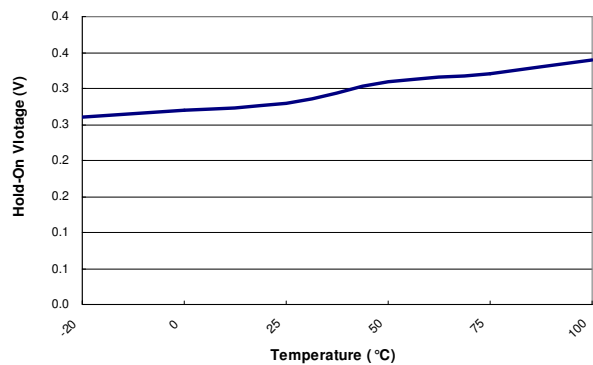
Start-up Voltage vs. Output Current



Start-up Voltage vs. Temperature, $I_{OUT}=1\text{mA}$



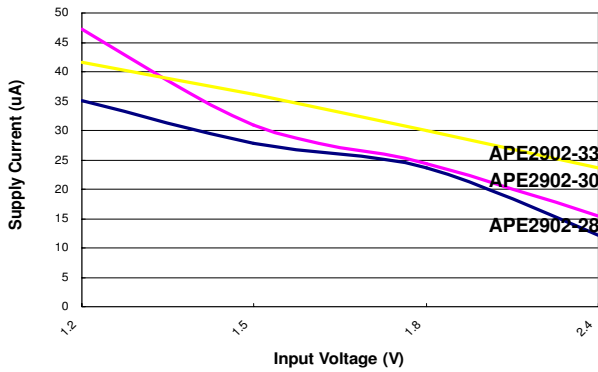
Hold-On Voltage vs. Temperature, $I_{OUT}=1\text{mA}$



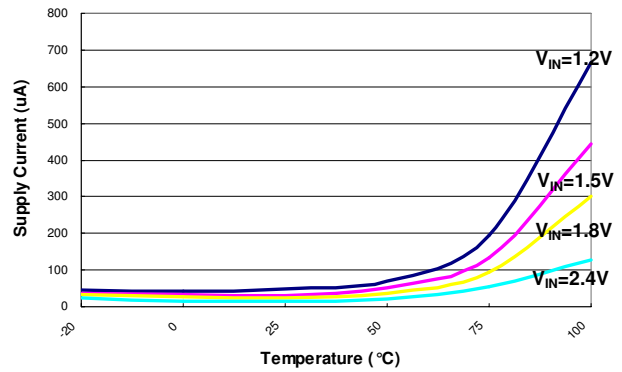


Typical Performance Characteristics (continued)

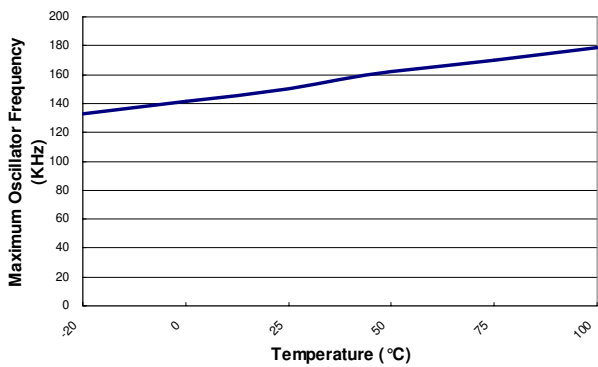
Input Voltage vs. Supply Current



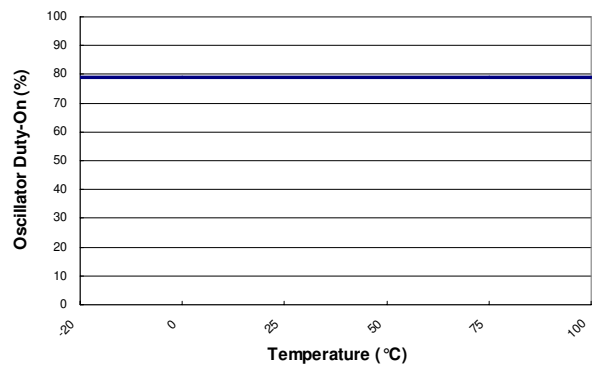
Supply Current vs. Temperature



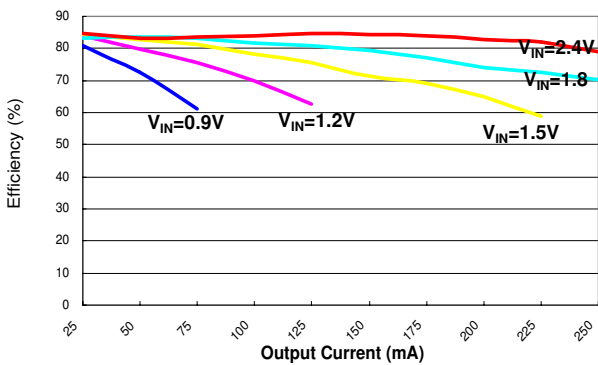
Maximum Oscillator Frequency vs. Temperature



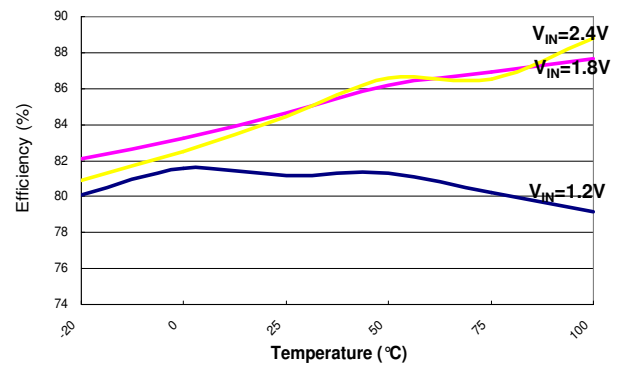
Oscillator Duty-On vs. Temperature



Efficiency vs. Output Current (APE2902Y5-30-3)



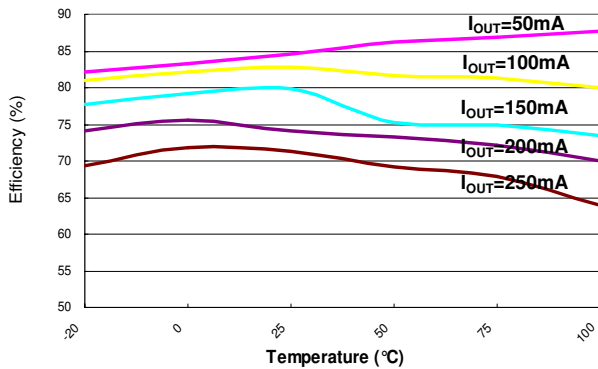
Efficiency vs. Temperature (APE2902Y5-30-3), I_{OUT}=50mA,



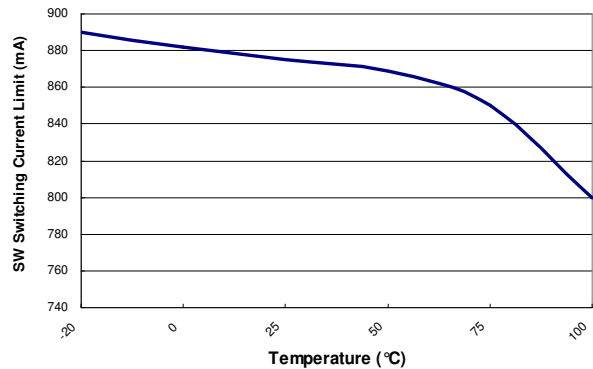


Typical Performance Characteristics (continued)

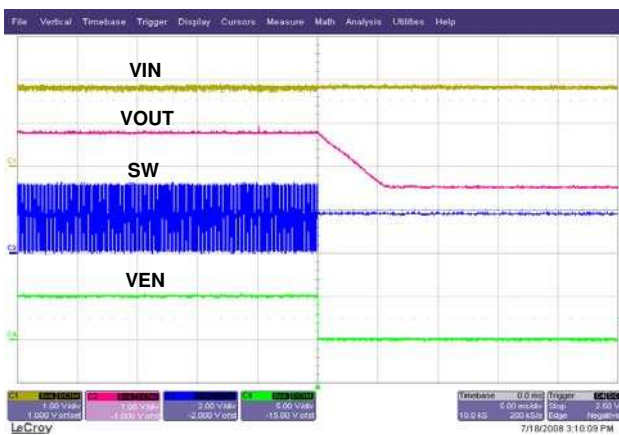
Efficiency vs. Temperature, $V_{IN}=1.8V$



SW Switching Current Limit vs. Temperature



Enable Off Sequence



$V_{IN}=1.8V$, $V_{OUT}=2.8V$, $I_{OUT}=10mA$, $EN=5$ to $0V$

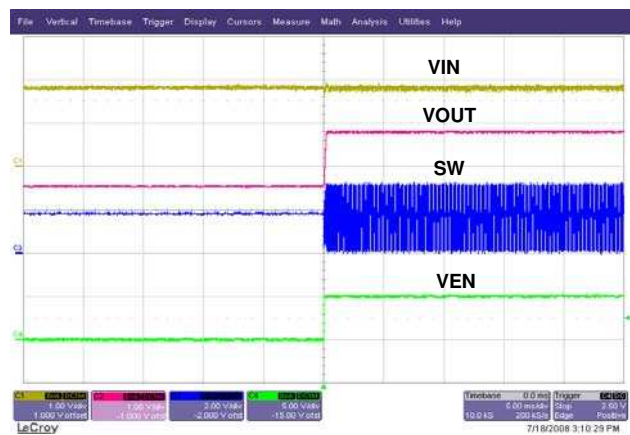
Ch1: V_{IN} , 1V/div

Ch2: V_{OUT} , 1V/div

Ch3: V_{SW} , 2V/div

Ch4: V_{EN} , 5V/div

Enable On Sequence



$V_{IN}=1.8V$, $V_{OUT}=2.8V$, $I_{OUT}=10mA$, $EN=0$ to $5V$

Ch1: V_{IN} , 1V/div

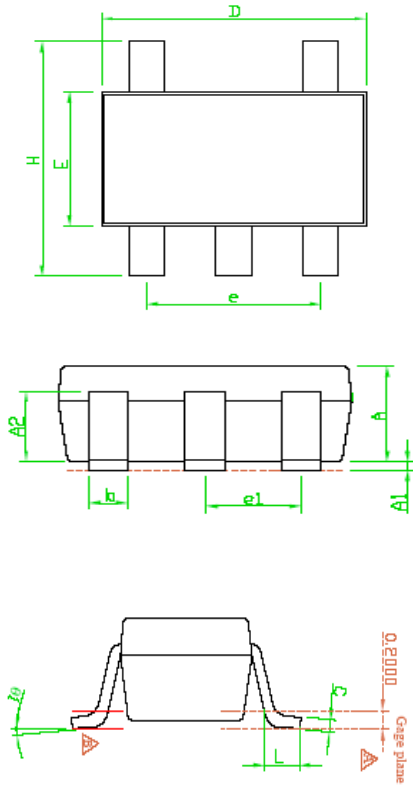
Ch2: V_{OUT} , 1V/div

Ch3: V_{SW} , 2V/div

Ch4: V_{EN} , 5V/div



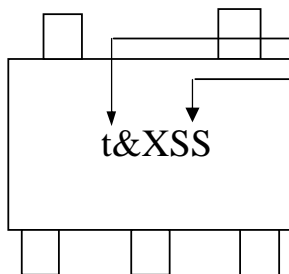
Package Dimensions: SOT-23-5



SYMBOLS	Millimeters		
	MIN	NOM	MAX
A	1.00	1.10	1.30
A1	0.00	---	0.10
A2	0.70	0.80	0.90
b	0.35	0.40	0.50
C	0.10	0.15	0.25
D	2.70	2.90	3.10
E	1.50	1.60	1.80
e	---	1.90(TYP)	---
H	2.60	2.80	3.00
L	0.37	---	---
θ1	1°	5°	9°
e2	---	0.95(TYP)	---

- Note 1 : Dimensions do not include mold flash protrusions or gate burrs.
- Note 2 : Tolerance ± 0.1000 mm (4mil) unless otherwise specified.
- Note 3 : Coplanarity 0.1000 mm
- Note 4 : Dimension L is measured in guage plane.

Part Marking



t&X = part number identification code - see table below
SS = Date/Lot Code

For details on how to interpret this date/lot code, please contact APEC

Part Number	Identification Code	Part Number	Identification Code
APE2902Y5/Y5R-2.2V	tO/tO1	APE2902Y5/Y5R-3.8V	tn/tn1
APE2902Y5/Y5R-2.5V	ta/ta1	APE2902Y5/Y5R-3.9V	to/to1
APE2902Y5/Y5R-2.6V	tb/tb1	APE2902Y5/Y5R-4.0V	tp/tp1
APE2902Y5/Y5R-2.7V	tc/tc1	APE2902Y5/Y5R-4.1V	tq/tq1
APE2902Y5/Y5R-2.8V	td/td1	APE2902Y5/Y5R-4.2V	tr/tr1
APE2902Y5/Y5R-2.9V	te/te1	APE2902Y5/Y5R-4.3V	ts/ts1
APE2902Y5/Y5R-3.0V	tf/tf1	APE2902Y5/Y5R-4.4V	tt/tt1
APE2902Y5/Y5R-3.1V	tg/tg1	APE2902Y5/Y5R-4.5V	tu/tu1
APE2902Y5/Y5R-3.2V	th/th1	APE2902Y5/Y5R-4.6V	tv/tv1
APE2902Y5/Y5R-3.3V	ti/ti1	APE2902Y5/Y5R-4.7V	tw/tw1
APE2902Y5/Y5R-3.4V	tj/tj1	APE2902Y5/Y5R-4.8V	tx/tx1
APE2902Y5/Y5R-3.5V	tk/tk1	APE2902Y5/Y5R-4.9V	ty/ty1
APE2902Y5/Y5R-3.6V	tl/tl1	APE2902Y5/Y5R-5.0V	tz/tz1
APE2902Y5/Y5R-3.7V	tm/tm1		