



**MICROPOWER VFM STEP-UP DC/DC CONVERTER**

**FEATURES**

- Very Low Supply Current
- Regulated Output Voltage
- Wide Range of Output Voltage is Available from 2.2V to 5.0V by 0.1V Steps
- Output Voltage Accuracy  $\pm 5\%$
- Output Current up to 100mA
- Low Ripple and Low Noise
- Very Low Start-up Voltage
- High Efficiency ( $V_{out} = 5V$  TYP. 87%)
- Few External Components
- Low Profile: SOT-23, SOT-89 & SOT-23-5L Pb-Free

**DESCRIPTION**

The APE2903 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 APE2903 accept a positive input voltage from start-up voltage to VOUT and convert it to a higher output voltage in the 2.2V to 5V range.

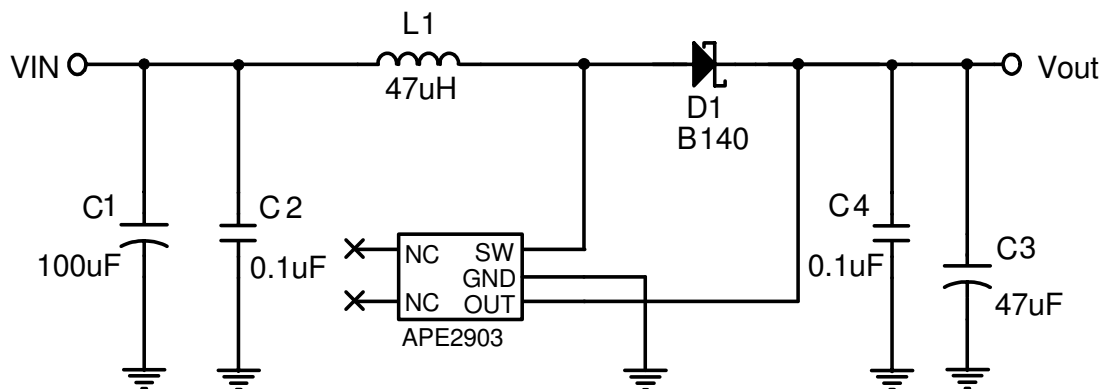
The APE2903 combine ultra low quiescent supply current and high efficiency to give maximum battery life. The high switching frequency and the internally limited peak inductor current permits the use of small, low cost inductors. Only three external components are needed an inductor a diode and an output capacitor.

The APE2903 is suitable to be used in battery powered equipment where low noise, low ripple and ultra low supply current are required. The APE2903 is available in very small package:

SOT-23, SOT-89 & SOT-23-5L.

Typical applications are pagers, cameras & video camera, cellular telephones, wireless telephones, palmtop computer, battery backup supplies, battery powered equipment.

**TYPICAL APPLICATION**



**ORDERING INFORMATION**

<b>APE2903X - XX</b>	
Package Type	VOUT
Y5 : SOT-23-5L	22 : 2.2V
N : SOT-23	25 : 2.5V
G : SOT-89	26 : 2.6V
	27 : 2.7V
	...
	50 : 5.0V

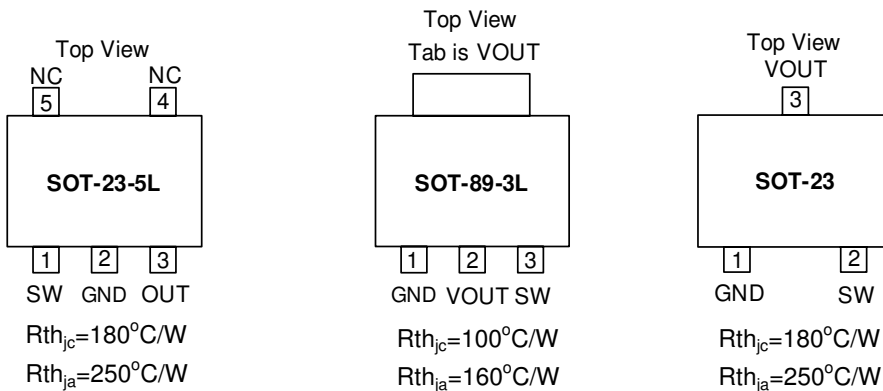


**ABSOLUTE MAXIMUM RATINGS** ( $T_A=25\text{ }^\circ\text{C}$ )

VIN Supply Voltage( $V_{IN}$ )	5.5 V
SW Voltage( $V_{SW}$ )	5.5 V
OUT Voltage( $V_{OUT}$ )	5.5 V
Power Dissipation( $P_D$ )	( $T_J-T_A$ ) / $R_{thja}$ W
Storage Temperature Range( $T_{ST}$ )	-40 $^\circ\text{C}$ To 150 $^\circ\text{C}$
Operating Junction Temperature Range( $T_{OP}$ )	-20 $^\circ\text{C}$ To + 100 $^\circ\text{C}$

Note.  $R_{thja}$  is measured with the PCB copper area of approximately 1 in<sup>2</sup>(Multi-layer) that need connect to GND pin of the APE2903.

**PACKAGE INFORMATION**



**ELECTRICAL SPECIFICATIONS**

( $V_{IN}=1.8\text{V}$ ,  $V_{OUT}=3\text{V}$ ,  $I_{OUT}=10\text{mA}$ ,  $T_A=25\text{ }^\circ\text{C}$ , unless otherwise specified)

Parameter	SYM	TEST CONDITION	MIN	TYP	MAX	UNITS
Output Voltage Accuracy	$\Delta V_{OUT}$		-5	-	5	%
Start-up Voltage( $V_{IN}-V_F$ ) (Note)	$V_{START-UP}$	$I_{OUT}=1\text{mA}$ , $V_{IN}$ =rising from 0 to 2V	-	0.65	0.9	V
Hold-on Voltage	$V_{HOLD}$	$I_{OUT}=1\text{mA}$ , $V_{IN}$ =falling from 2 to 0V	0.6	-	-	V
Supply Current	$I_{SUPPLY}$	No Load	-	22	-	$\mu\text{A}$
Internal Switch $R_{DSON}$	$R_{LX(DSON)}$	$I_{LX}=150\text{mA}$	-	850	-	$\text{m}\Omega$
Internal Leakage Current	$I_{LX(leak)}$	$V_{LX}=4\text{V}$ , Forced $V_{OUT}=3.8\text{V}$	-	-	0.5	$\mu\text{A}$
Maximum Oscillator Frequency	$F_{OSC}$		-	150	-	KHz
Oscillator Duty On	$D_{ON}$	To be measure on SW pin	-	77	-	%
Efficiency	$\eta$	$V_{OUT}=2.5\text{V}\sim 3.0\text{V}$ , $I_{OUT}=50\text{mA}$	-	82	-	%
		$V_{OUT}=3.1\text{V}\sim 4.0\text{V}$ , $I_{OUT}=50\text{mA}$	-	83	-	%
		$V_{OUT}=4.1\text{V}\sim 5.0\text{V}$ , $I_{OUT}=50\text{mA}$	-	87	-	%

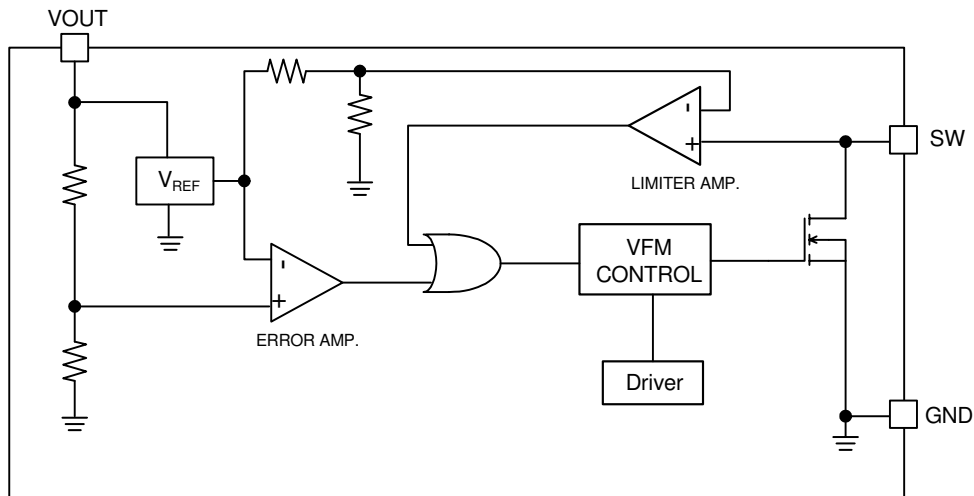
Note : The minimum input voltage for the IC start-up is strictly a function of the VF catch diode.

**PIN DESCRIPTIONS**

PIN SYMBOL	PIN DESCRIPTION
SW	Switch Pin. Connect External Inductor & Diode here.
GND	GND Pin
VOUT	Output Voltage



## BLOCK DIAGRAM



## OPERATION

The APE2903 architecture is built around a VFM CONTROL logic core, switching frequency is set through a built in oscillator.  $T_{ON}$  time is fixed (Typ. 5us) 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 ( $V_{ref}$ ).  $T_{OFF}$  reaches a minimum (Typ. 1.7us) when heavy load conditions are met (Clock frequency 150 KHz). An over current conditions, through the internal power switch, causes a voltage drop  $V_{LX} = R_{DS(on)} \times I_{SW}$  and the  $V_{LX}$  limiter block forces the internal switch to be off, so narrowing  $T_{ON}$  time and limiting internal power dissipation. In this case the switching frequency may be higher than the 150 KHz 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 present an higher internal supply voltage that 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, is strictly related to the behavior of these elements. The output ripple voltage is the product of the peak inductor current and the output capacitor Equivalent Series Resistance (ESR). Best performances are obtained with good high frequency characteristics capacitors and low ESR. The best compromise for the value of the Output Capacitance is 47 $\mu$ F Tantalum Capacitor; Lower values may cause higher Output Ripple Voltage and lower Efficiency without compromising the functionality of the device.

An Input Capacitor is required to compensate, if present, the series impedance between the Supply Voltage Source and the Input Voltage of the Application.



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## **INDUCTOR SELECTION**

A 47  $\mu$ H inductor is recommended for most APE2903 applications. However, the inductance value is not critical, and the APE2903 will work with inductors in the 33 $\mu$ H to 120 $\mu$ H.

## **DIODE SELECTION**

Schottky diodes with higher current ratings usually have lower forward voltage drop, larger diode capacitance and fast reverse recovery, it is the ideal choices for APE2903 applications. The forward voltage drop of a Schottky diode represents the conduction losses in the system, while the diode capacitance ( $C_T$  or  $C_D$ ) represents the switching losses. For diode selection, both forward voltage drop and diode capacitance need to be considered.

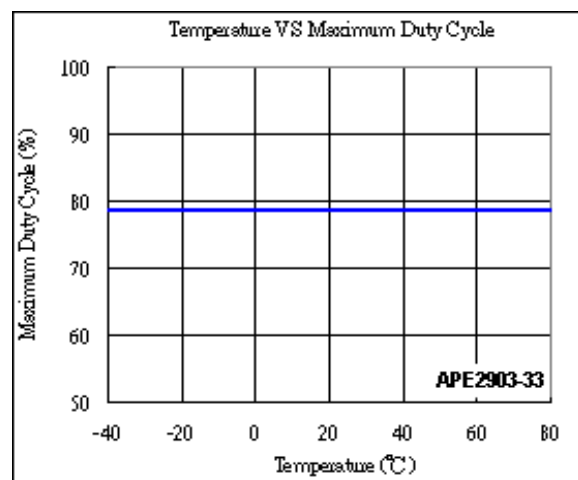
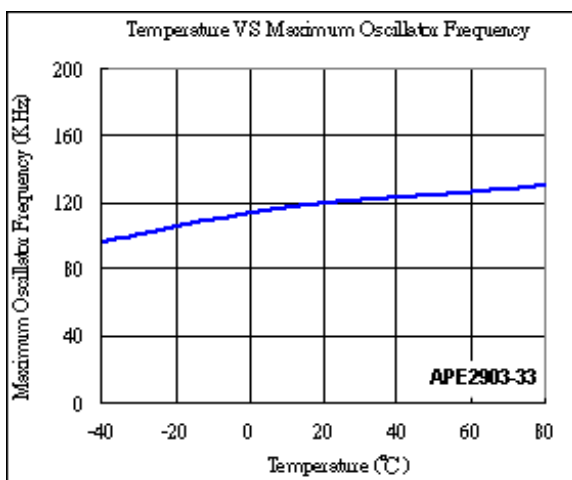
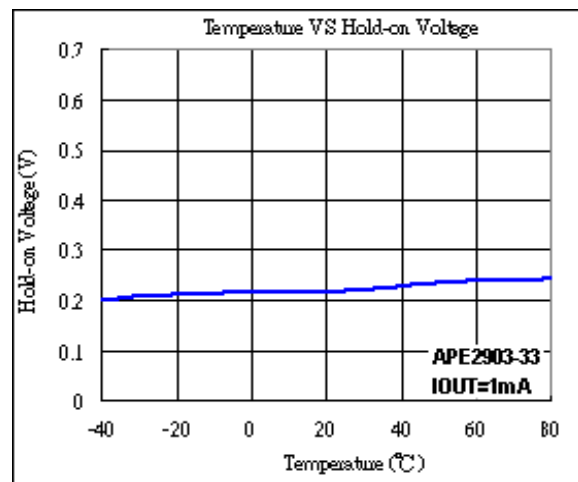
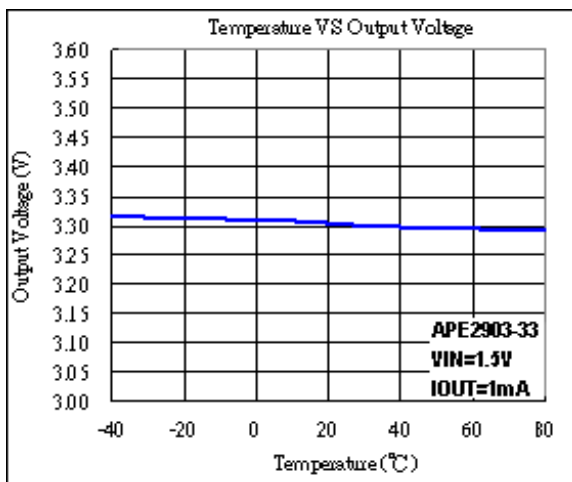
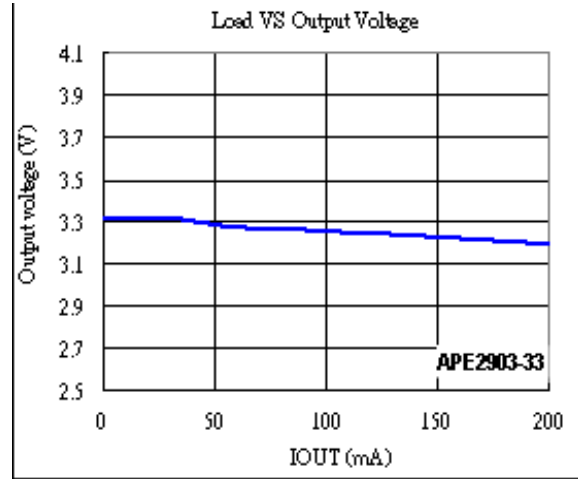
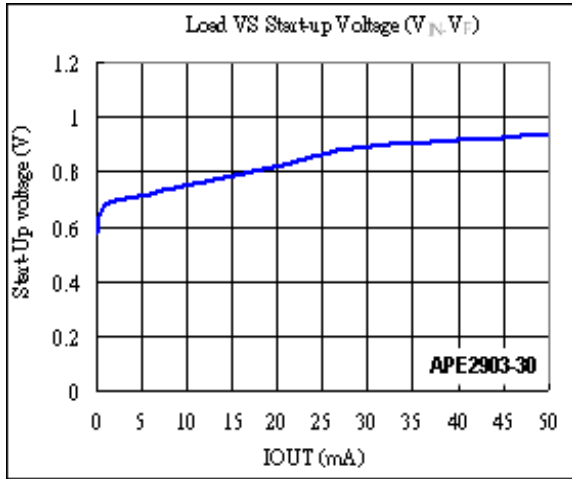
## **PCB LAYOUT GUIDE**

When laying out the PC board, the following suggestions should be taken to ensure proper operation of the APE2903. These items are also illustrated graphically in below.

1. The power traces, including the GND trace, the SW trace and the  $V_{CC}$  trace should be kept short, direct and wide to allow large current flow. Put enough multiply-layer pads when they need to change the trace layer.
2. Do not trace signal line under inductor.

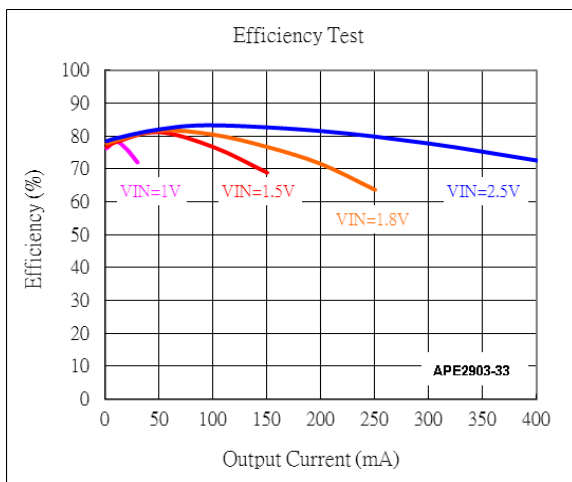
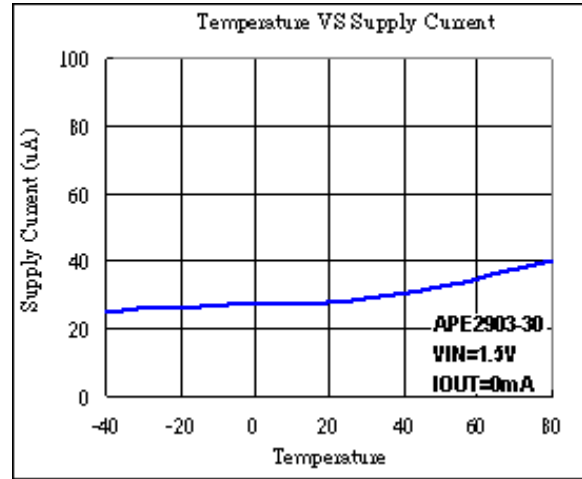
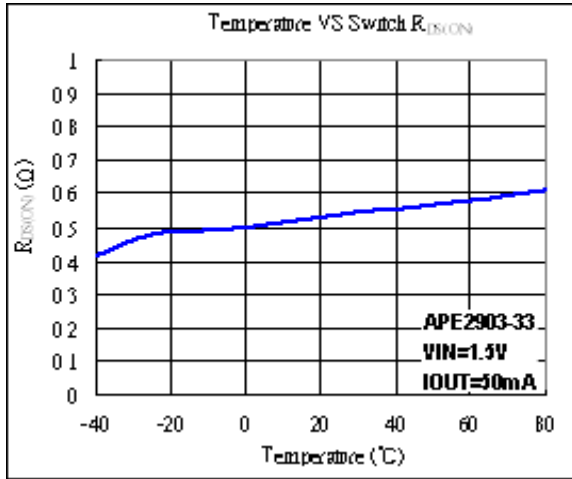


TYPICAL PERFORMANCE CHARACTERISTICS





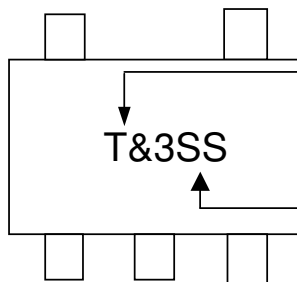
TYPICAL PERFORMANCE CHARACTERISTICS





**MARKING INFORMATION**

**SOT-23-5L**



Part Number : T&3 (see Identification Code)

Date Code : SS

SS:2004,2008,2012...

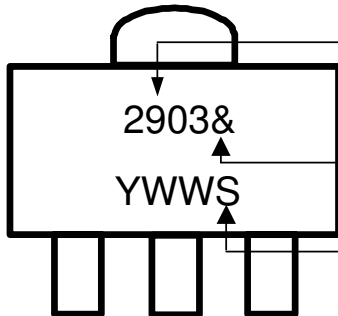
SS:2003,2007,2011...

SS:2002,2006,2010...

SS:2001,2005,2009...

Part Number	Identification Code	Part Number	Identification Code
APE2903Y5-2.2V	To3	APE2903Y5-3.8V	TN3
APE2903Y5-2.5V	TA3	APE2903Y5-3.9V	TO3
APE2903Y5-2.6V	TB3	APE2903Y5-4.0V	TP3
APE2903Y5-2.7V	TC3	APE2903Y5-4.1V	TQ3
APE2903Y5-2.8V	TD3	APE2903Y5-4.2V	TR3
APE2903Y5-2.9V	TE3	APE2903Y5-4.3V	TS3
APE2903Y5-3.0V	TH3	APE2903Y5-4.4V	TT3
APE2903Y5-3.1V	TG3	APE2903Y5-4.5V	TU3
APE2903Y5-3.2V	TF3	APE2903Y5-4.6V	TV3
APE2903Y5-3.3V	TI3	APE2903Y5-4.7V	TW3
APE2903Y5-3.4V	TJ3	APE2903Y5-4.8V	TX3
APE2903Y5-3.5V	TK3	APE2903Y5-4.9V	TY3
APE2903Y5-3.6V	TL3	APE2903Y5-5.0V	TZ3
APE2903Y5-3.7V	TM3		

**SOT-89**



Part Number

Output Voltage : (see Identification Code)

Date Code (YWWS)

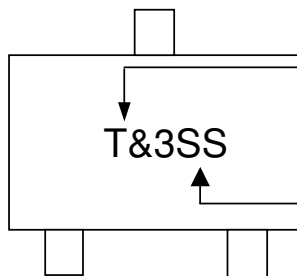
Y : Year

WW : Week

S : Sequence

Part Number	Identification Code	Part Number	Identification Code
APE2903G-2.2V	o	APE2903G-3.8V	N
APE2903G-2.5V	A	APE2903G-3.9V	O
APE2903G-2.6V	B	APE2903G-4.0V	P
APE2903G-2.7V	C	APE2903G-4.1V	Q
APE2903G-2.8V	D	APE2903G-4.2V	R
APE2903G-2.9V	E	APE2903G-4.3V	S
APE2903G-3.0V	H	APE2903G-4.4V	T
APE2903G-3.1V	G	APE2903G-4.5V	U
APE2903G-3.2V	F	APE2903G-4.6V	V
APE2903G-3.3V	I	APE2903G-4.7V	W
APE2903G-3.4V	J	APE2903G-4.8V	X
APE2903G-3.5V	K	APE2903G-4.9V	Y
APE2903G-3.6V	L	APE2903G-5.0V	Z
APE2903G-3.7V	M		

**SOT-23**



Part Number : T&3 (see Identification Code)

Date Code : SS

SS:2004,2008,2012...

SS:2003,2007,2011...

SS:2002,2006,2010...

SS:2001,2005,2009...

Part Number	Identification Code	Part Number	Identification Code
APE2903N-2.2V	To3	APE2903N-3.8V	TN3
APE2903N-2.5V	TA3	APE2903N-3.9V	TO3
APE2903N-2.6V	TB3	APE2903N-4.0V	TP3
APE2903N-2.7V	TC3	APE2903N-4.1V	TQ3
APE2903N-2.8V	TD3	APE2903N-4.2V	TR3
APE2903N-2.9V	TE3	APE2903N-4.3V	TS3
APE2903N-3.0V	TH3	APE2903N-4.4V	TT3
APE2903N-3.1V	TG3	APE2903N-4.5V	TU3
APE2903N-3.2V	TF3	APE2903N-4.6V	TV3
APE2903N-3.3V	TI3	APE2903N-4.7V	TW3
APE2903N-3.4V	TJ3	APE2903N-4.8V	TX3
APE2903N-3.5V	TK3	APE2903N-4.9V	TY3
APE2903N-3.6V	TL3	APE2903N-5.0V	TZ3
APE2903N-3.7V	TM3		