

## 300mA High PSRR LDO Regulators

### DESCRIPTION

The EUP7903 is a high current, low-dropout (LDO) linear regulator with fast transient response and high PSRR. It offers high output accuracy, extremely low dropout voltage, low quiescent current and fast start-up time.

The EUP7903 is designed to work with low-ESR ceramic capacitors, reducing the amount of the PCB area necessary for power applications. Only a 1uF ceramic output capacitor can make the device stable over the whole load range.

EUP7903 can be externally set either fixed output mode or adjustable output mode. Connect FB pin to GND to select the fixed output mode. Its output is one of pre-set values: 1.25V~5V (50mV per step). Operated in the adjustable mode when the FB pin is connected to an external resistors divider, its output can be adjusted from 1.25V to 5V. Other key features include over-current protection, thermal shutdown. The device is available in the small SOT23-5 package.

### FEATURES

- 2.5V to 5.5V Input Voltage Range
- 180mV@300mA Dropout Voltage
- Excellent Transient Response
- Stable with 1uF Ceramic Output Capacitor
- 70dB PSRR at 1kHz
- Low 90μA Quiescent Current
- Low Shutdown Current : <1μA
- Output Current Limit
- Short Circuit Protection
- Output Voltage With High Accuracy:  
2% Initial Accuracy  
Fixed Output Voltage : 1.25V~5V (0.05V step)  
Adjustable Output Voltage: 1.25V~5V
- Thermal Shutdown
- Output Auto-Discharge in Shutdown
- RoHS Compliant and 100% Lead (Pb)-Free

### APPLICATIONS

- Cellular Phones
- Bluetooth portable radios and Accessories
- Battery-Powered Equipment
- Laptop, Palmtops, Notebook Computer
- PDAs
- Digital still Camera and Video Recorders

### Typical Application Circuit

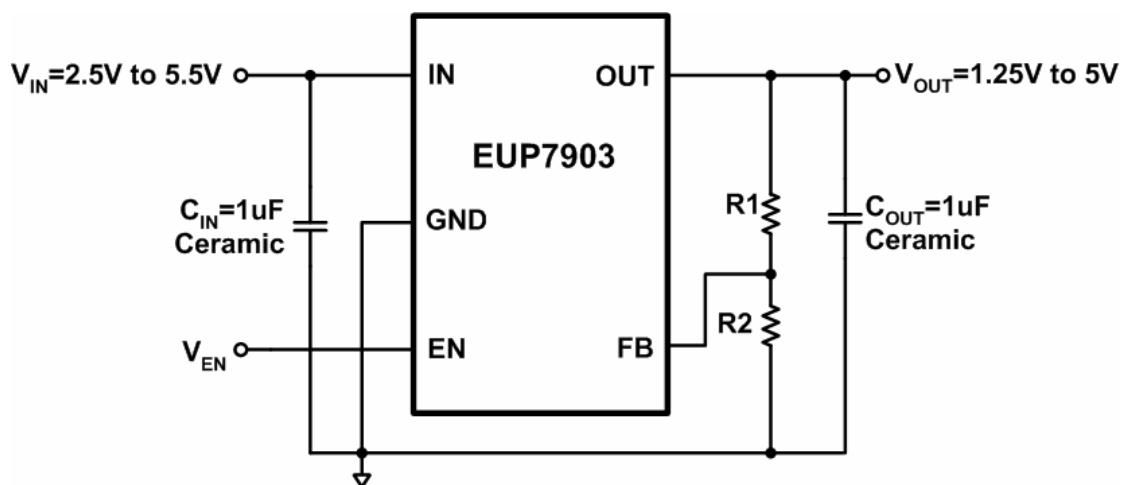


Figure. 1 Adjustable Output

Typical Application Circuit (continued)

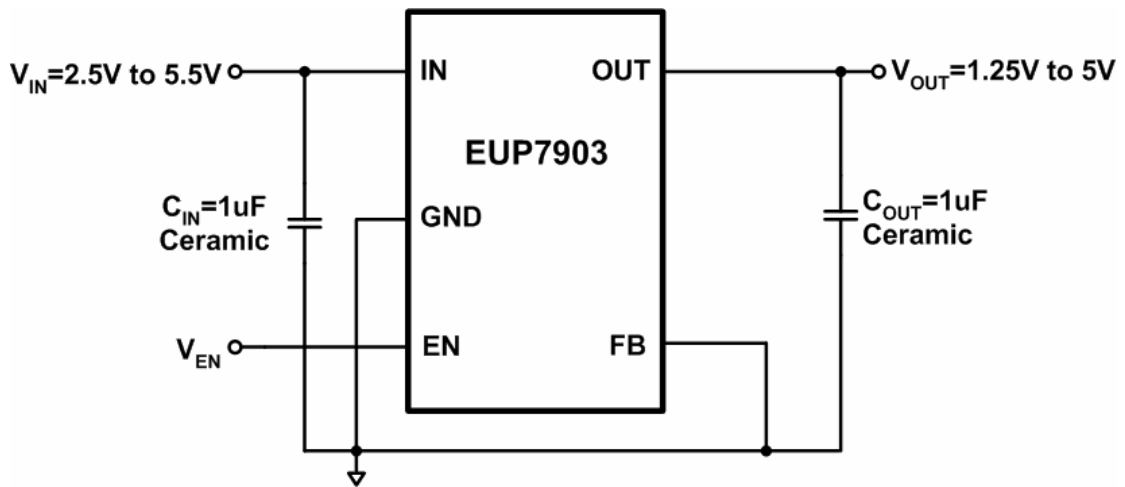


Figure. 2 Fixed Output

Block Diagram

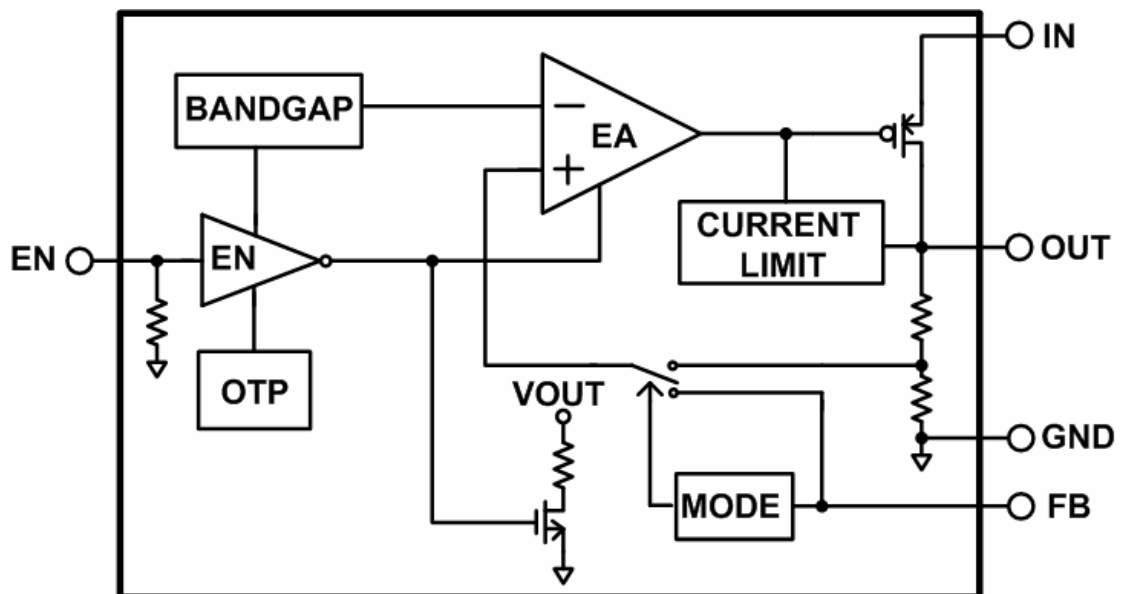


Figure. 3

**Pin Configurations**

Package Type	Pin Configurations
SOT23-5	<p style="text-align: center;"> <b>IN</b>      <b>GND</b>      <b>EN</b>  <span style="display: inline-block; width: 10px; height: 10px; border: 1px solid black; margin-right: 5px;"></span> <span style="display: inline-block; width: 10px; height: 10px; border: 1px solid black; margin-right: 5px;"></span> <span style="display: inline-block; width: 10px; height: 10px; border: 1px solid black;"></span>  <b>3</b>      <b>2</b>      <b>1</b>  <div style="border: 1px solid black; width: 100px; height: 100px; margin: 5px auto;"></div>  <span style="display: inline-block; width: 10px; height: 10px; border: 1px solid black; margin-right: 5px;"></span> <span style="display: inline-block; width: 10px; height: 10px; border: 1px solid black;"></span>  <b>4</b>      <b>5</b>  <b>OUT</b>                  <b>FB</b> </p>

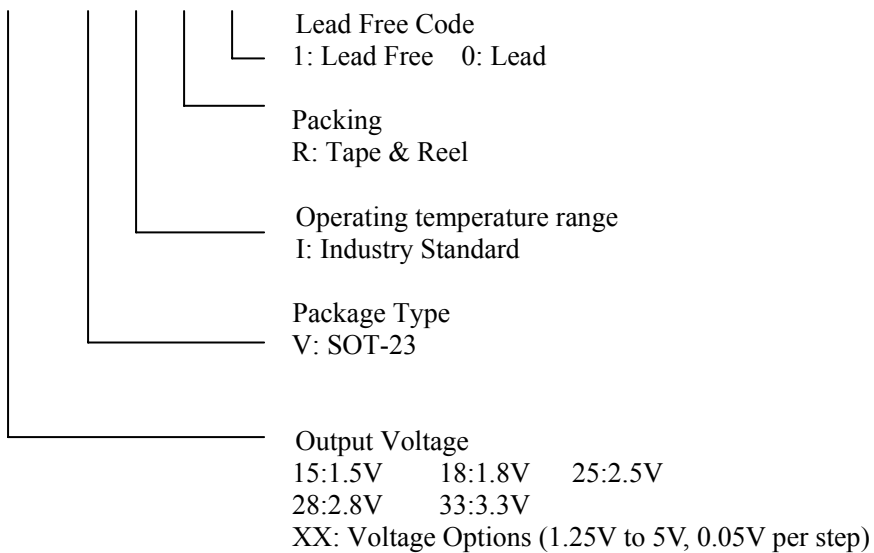
**Pin Description**

PIN	SOT23-5	DESCRIPTION
EN	1	Enable Pin. Connect this pin to ground or less than 0.4V to disable the device, connect EN to 1.5V or above to enable the device.
GND	2	Signal Ground.
IN	3	Input Supply of the LDO.
OUT	4	Output of the LDO.
FB	5	Feedback pin. This pin is the anode terminal of the error amplifier. The FB pin compares with internal reference voltage to regulate the output voltage. Connect to GND for fixed output voltage version.

**Ordering Information**

Order Number	Package Type	Marking	Operating Temperature Range
EUP7903-15VIR1	SOT23-5	xxxxx AD1C	-40 °C to +85°C
EUP7903-18VIR1	SOT23-5	xxxxx AD1D	-40 °C to +85°C
EUP7903-25VIR1	SOT23-5	xxxxx AD1B	-40 °C to +85°C
EUP7903-28VIR1	SOT23-5	xxxxx AD1E	-40 °C to +85°C
EUP7903-33VIR1	SOT23-5	xxxxx AD1H	-40 °C to +85°C
EUP7903VIR1	SOT23-5	xxxxx AD1A	-40 °C to +85°C
EUP7903-XXVIR1	SOT23-5	xxxxx xxxx	-40 °C to +85°C

EUP7903 -



Note : Every EUP7903 version can operate at adjustable mode by connecting FB pin to an external resistor divider.

## Absolute Maximum Ratings (1)

■	$V_{IN}, V_{EN}$ -----	-0.3V to 6V
■	$V_{OUT}$ -----	-0.3V to ( $V_{IN}+0.3V$ )
■	Junction Temperature -----	+150
■	Storage Temperature Range -----	-65 to +150
■	Lead Temperature -----	+260
■	Thermal Resistance $\theta_{JA}$ (SOT23-5) -----	220 /W
■	ESD Rating	
	Human Body Model -----	2kV

## Recommend Operating Conditions (2)

■	$V_{IN}$ -----	2.5V to 5.5V
■	$V_{EN}$ -----	0V to 5.5V
■	Operating Temperature Range -----	-40 to +85

Note (1): Stress beyond those listed under “Absolute Maximum Ratings” may damage the device.

Note (2): The device is not guaranteed to function outside the recommended operating conditions.

## Electrical Characteristics

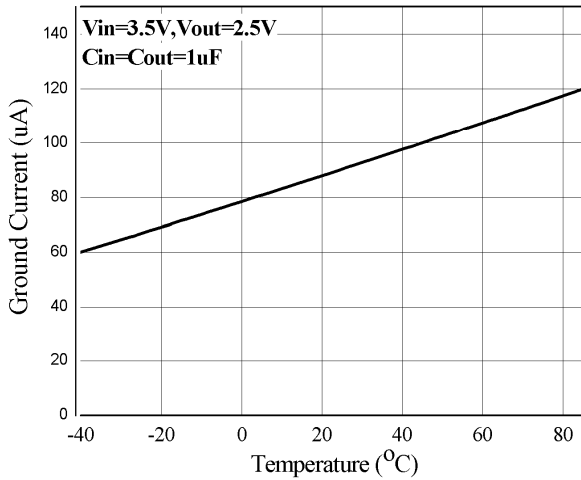
$T_A=25^\circ\text{C}$ ,  $V_{IN}=V_{OUT}+1V$ , or  $V_{IN}=2.5V$  for  $V_{OUT}<1.5V$  unless otherwise specified.

Symbol	Parameter	Conditions	EUP7903			Unit
			Min.	Typ.	Max.	
<b>Input Voltage</b>						
$V_{IN}$	Input Voltage		2.5		5.5	V
$I_Q$	Quiescent Current	$V_{EN}=3.5V, I_{OUT}=0mA$		90	130	$\mu A$
$I_{SHDN}$	Shutdown Current	$V_{EN}=0V$		0.1	1	$\mu A$
PSRR	Power Supply Ripple Rejection	$V_{IN}=V_{NOM}+1V_{P-P}, f=100Hz,$ $I_{LOAD}=10mA$		75		dB
$V_{FB}$	FB Pin Voltage		1.225	1.25	1.275	V
<b>Enable</b>						
$V_{ENH}$	Enable High Voltage	Over temperature range	1.5			V
$V_{ENL}$	Disable Low Voltage	Over temperature range			0.4	V
$I_{EN}$	EN Input Current	$V_{IN}=3.5V, V_{EN}=3.5V$ or 0V	-1	0.2	1	$\mu A$
$T_{ST}$	Start-up Time	$V_{IN}=3.5V, V_{OUT}=2.5V$		40		$\mu s$
<b>Output voltage</b>						
$V_{OUT}$	Output Voltage Accuracy	$V_{IN}=V_{OUT}+1V, I_{OUT}=10mA$	-2		+2	%
		$V_{IN}=V_{OUT}+1V, I_{OUT}=10mA,$ $T_A=-40$ to +85	-3		+3	%
$V_{LNR}$	Output Line Regulation	$V_{OUT}+0.5V < V_{IN} < 5.5V, I_{OUT}=10mA$		0.01	0.1	%/V
$V_{LDR}$	Output Load Regulation	$1mA < I_{OUT} < 300mA,$ $V_{IN}=V_{NOM}+1.0V$		10	16	mV
$V_{DROD}$	Dropout Voltage (3) (Applied for $V_{OUT} \geq 2.3V$ )	$I_{OUT}=300mA$		180	240	mV
$I_{OUTMAX}$	Maximum Output Current		300			mA
<b>Protection</b>						
$I_{LIMIT}$	Current Limit		330	500		mA
$T_{SD}$	Thermal Shutdown Temperature	No Load, $V_{IN}=V_{EN}=5V$		155		
$T_{SDHYS}$	Thermal Shutdown Hysteresis	No Load, $V_{IN}=V_{EN}=5V$		30		

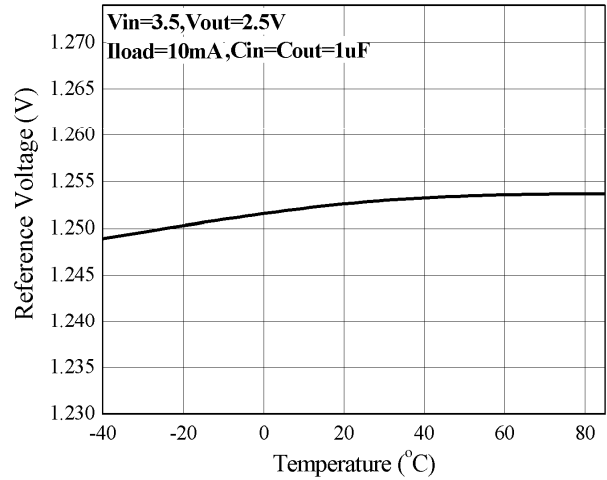
Note (3): Dropout is defined as  $V_{IN}-V_{OUT}$  when  $V_{OUT}$  is 2% below the value of  $V_{OUT}$  for  $V_{IN}=V_{OUT}+0.5V$ .

Typical Characteristics

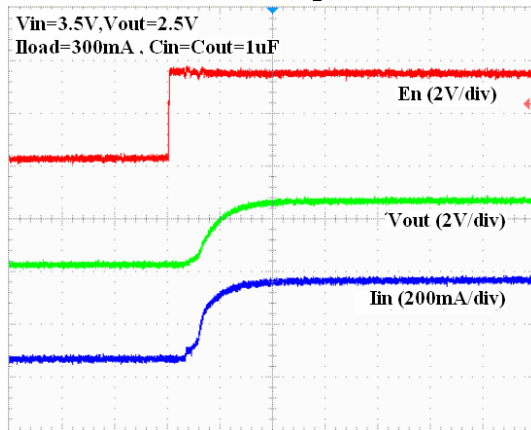
Ground Current vs Temperature



Reference Voltage vs Temperature

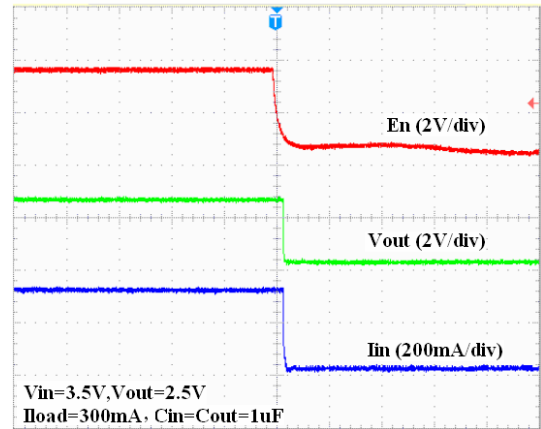


Start Up



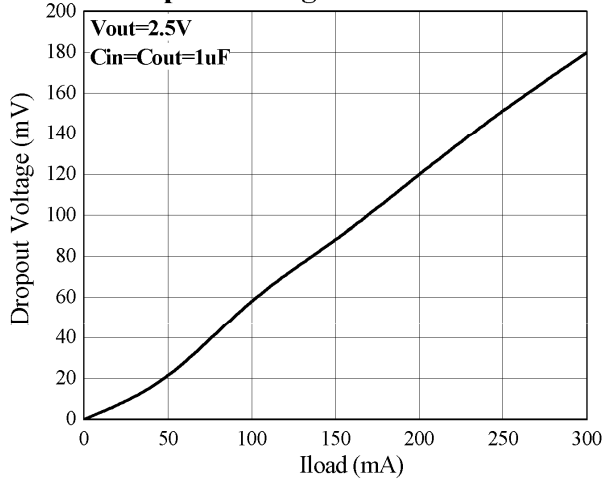
Time (40µs/div)

Shutdown

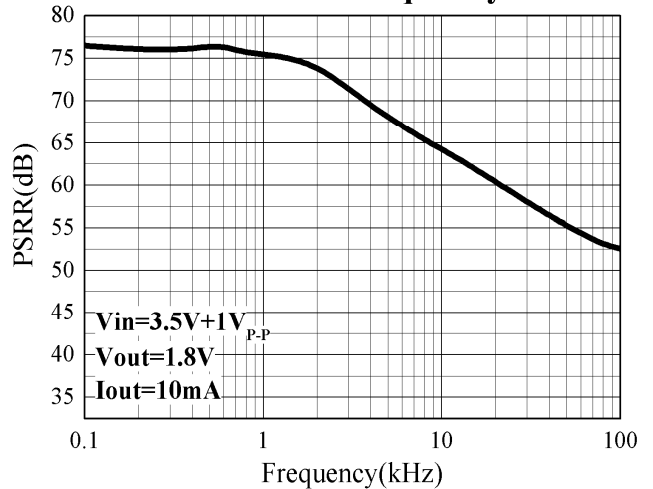


Time (4ms/div)

Dropout Voltage vs Load Current

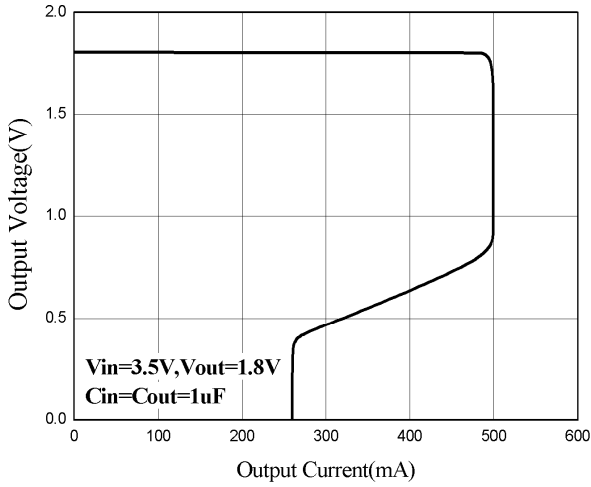


PSRR vs Frequency

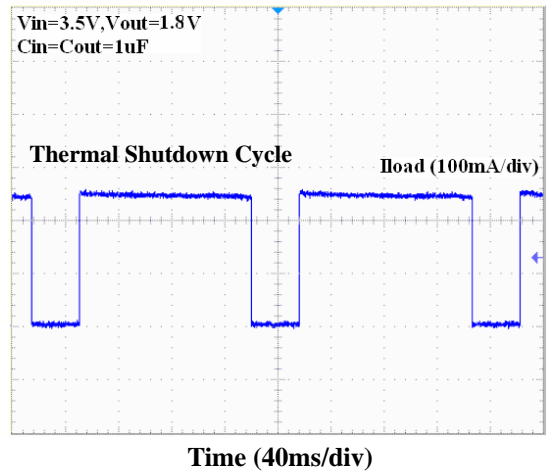


Typical Characteristics (continued)

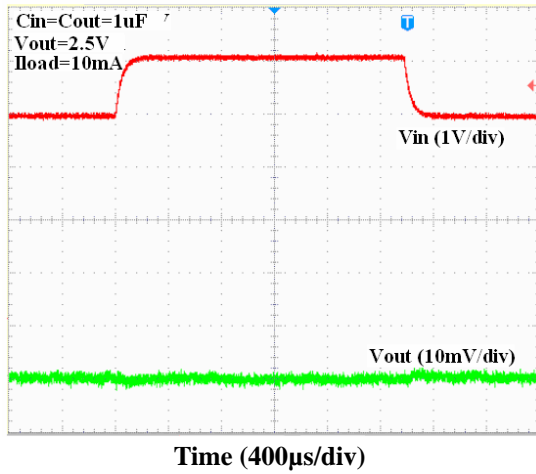
Overcurrent Protection



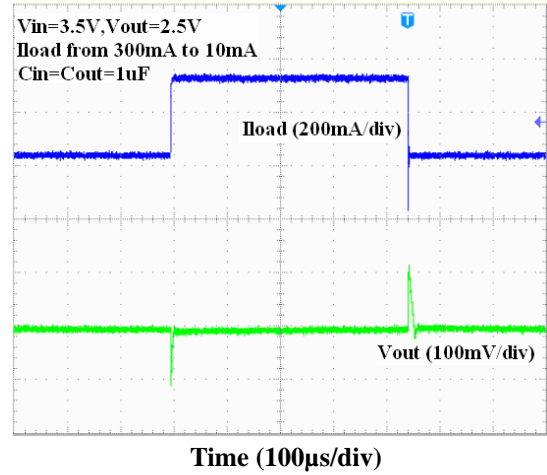
Short Circuit Current



Line Transient



Load Transient



## Detailed Function Description

The EUP7903 is a high output current, low dropout linear regulator with fast transient response and high PSRR. It offers high output accuracy, extremely low dropout voltage, low quiescent current and fast start-up time. It is designed to work with low-ESR ceramic capacitor, reducing the amount of the PCB area. Only a 1 $\mu$ F ceramic capacitor can make the device stable over the whole load range.

As shown in the function block diagram, the EUP7903 is composed of the bandgap reference voltage, the error amplifier, P-channel MOSFET pass transistor, internal resistor divider and some additional protection circuits. The reference voltage, connected to the cathode terminal of the error amplifier, compares with the feedback voltage to regulate the output voltage to make it constant over the whole load range. If the feedback voltage is lower than the reference voltage, the pass transistor gate is pulled low to increase its conductivity. This allows more current to flow to the output and increases the output voltage. If the feedback voltage is higher than the reference voltage, the pass transistor allows less current to flow to the output. The feedback point is the output of the internal or external resistor divider connected to the VOUT pin.

### Enable/Shutdown

The EUP7903 is disabled when the EN pin is connected to ground or the voltage less than 0.4V, and the quiescent current is less than 1 $\mu$ A. Connect EN pin to 1.5V or higher to enable the device.

### Output Soft stop

When the regulator is disabled, an internal 400 $\Omega$  resistor is connected between V<sub>OUT</sub> and GND. To discharge output capacitor C<sub>OUT</sub>.

### Adjustable Output Voltage

EUP7903 has a wide output voltage range. The output voltage is programmed by an external resistor divider as shown in Figure 1. The output voltage can be calculated by the following equation:

$$V_{OUT} = \left(1 + \frac{R_1}{R_2}\right) \times V_{REF} \quad (\text{EQ.1})$$

Where V<sub>REF</sub> is the internal reference voltage, which is 1.25V in EUP7903.

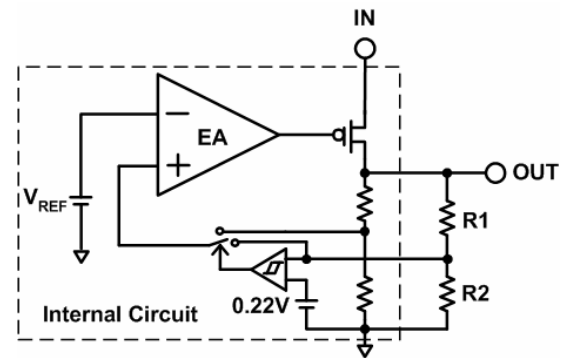


Figure. 4 Output Voltage Select Circuit

### Fixed Output Voltage

When the FB voltage is less than 220mV, EUP7903 will operate in the fixed output mode, its output is one of pre-set values: 1.25V~5V. There is no external component needed to set the output voltage.

### Current Limit

The EUP7903 includes a current limit circuit to monitor the gate voltage of the pass transistor to limit the output current. When the output current is higher than the over-current limit, the circuit will clamp the gate voltage of the pass transistor to limit the output current. The typical output current limit is 500mA.

### Thermal Shutdown

The EUP7903 monitors internal temperature. When the junction temperature exceeds 155 $^{\circ}$ C, the over temperature protection (OTP) circuit turn off the pass transistor until the device is cooled down by 30 $^{\circ}$ C. Then the pass transistor resumes. For continue operation, do not exceed absolute maximum junction temperature.

### Application Information

#### Resistor Select

Choose R2=100k to optimize accuracy, power supply rejection, noise and power consumption. And the R1 can be chosen by:

$$R_1 = R_2 \left( \frac{V_{OUT}}{V_{REF}} - 1 \right) \quad (\text{EQ.2})$$

where V<sub>REF</sub> is the internal reference voltage, which is 1.25V in EUP7903.

#### External Capacitor

The EUP7903 requires external capacitors for stability. It is specifically designed to work with low-ESR capacitors requiring minimum PCB area.

#### Input capacitor

A 1 $\mu$ F ceramic capacitor or higher is required between the VIN pin and the GND pin. Place it as close as possible to the device. There are no requirements for the ESR on the input capacitor, but the tolerance and temperature coefficient must be considered when selecting the capacitor to ensure the capacitance is 1 $\mu$ F over the whole operating temperature range.



## Output capacitor

The EUP7903 is designed specifically to work with very small ceramic output capacitors. A 1uF to 10uF capacitor with 5m to 500m ESR range is suitable for the most EUP7903 applications. The ESR of a typical 1uF ceramic capacitor is around 20mΩ, which easily meets the ESR requirement for stability.

## Capacitor characteristics

More consideration should be taken when selecting the capacitor because its capacitance can vary with temperature. The capacitor type X7R or X5R, which operates over a temperature range of -40 to +85, will only vary within ±15%. However Z5U or T5V temperature characteristics. Their capacitance can drop by more than 50% as the temperature goes from 25 to 85. Therefore the capacitor type X7R or X5R is recommended in applications where the ambient temperature will change significantly above or below 25.

## No load Stability

The EUP7903 will remain stable and in regulation with no external load. This is special important in CMOS RAM keep-alive applications.

## Thermal Considerations

Thermal protection limits power dissipation in EUP7903. When the device junction temperature exceeds 155°C, the OTP circuit starts the thermal shutdown function and turns the pass transistor off. The pass transistor turns on again after the junction temperature cools down 30°C.

For continuous operation, do not exceed absolute maximum junction temperature 150°C. The power dissipation definition in device is:

$$P_D = (V_{IN} - V_{OUT}) \times I_{OUT} + V_{IN} \times I_Q \quad (EQ.3)$$

The maximum power dissipation depends on the thermal resistance of IC package, PCB layout, the rate of surroundings airflow and temperature difference between junction and ambient. The maximum power dissipation can be calculated by following formula :

$$P_{D(MAX)} = (T_{J(MAX)} - T_A) / \theta_{JA} \quad (EQ.4)$$

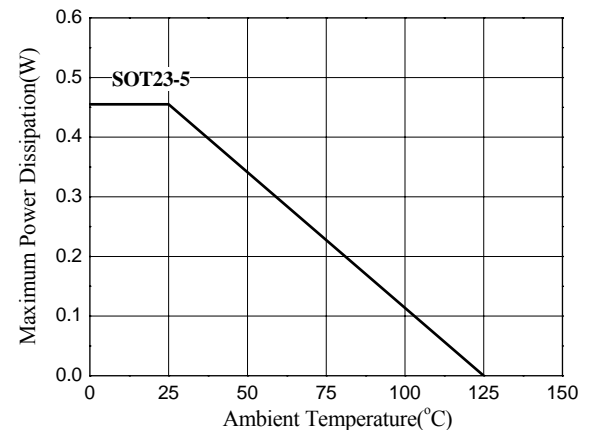
Where  $T_{J(MAX)}$  is the maximum operation junction temperature 125°C,  $T_A$  is the ambient temperature and the  $\theta_{JA}$  is the junction to ambient thermal resistance.

For recommended operating conditions specification of EUP7903, where  $T_{J(MAX)}$  is the maximum junction temperature of the die (125°C) and  $T_A$  is the operated ambient temperature. The junction to ambient thermal resistance  $\theta_{JA}$  is layout dependent. For SOT-23-5 package, the thermal resistance  $\theta_{JA}$  is 220°C/W on the standard thermal test board. The maximum power dissipation at  $T_A = 25^\circ\text{C}$  can be calculated by following formula :

$$P_{D(MAX)} = (125^\circ\text{C} - 25^\circ\text{C}) / 220 = 0.445\text{W} \quad (EQ.5)$$

for SOT23-5 package

The maximum power dissipation depends on operating ambient temperature for fixed  $T_{J(MAX)}$  and thermal resistance  $\theta_{JA}$ . For EUP7903 packages, the Figure 5 of derating curves allows the designer to see the effect of rising ambient temperature on the maximum power allowed.

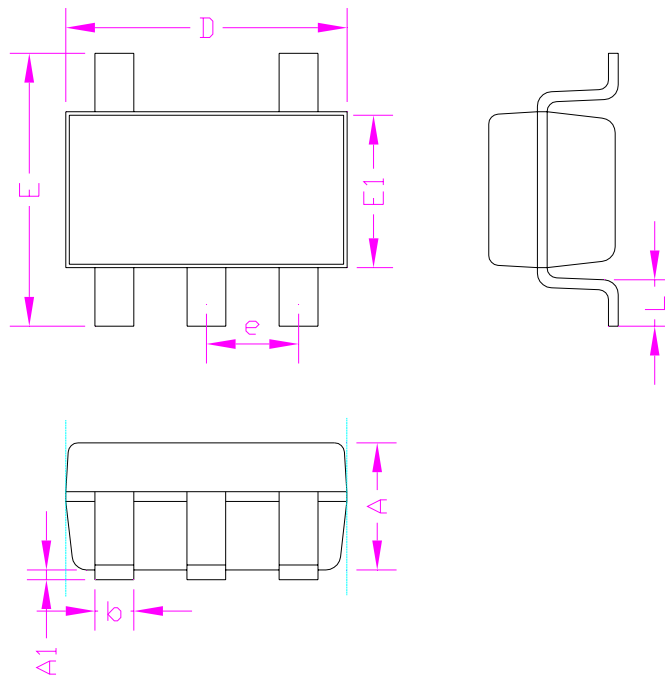


**Figure 5. Power Dissipation for EUP7903 Package**

The EUP7903 is available in the SOT23-5 package.

Packaging Information

SOT23-5



SYMBOLS	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	-	1.30	-	0.052
A1	0.00	0.15	0.000	0.006
D	2.90		0.114	
E1	1.60		0.063	
E	2.60	3.00	0.102	0.118
L	0.30	0.60	0.012	0.024
b	0.30	0.50	0.012	0.020
e	0.95		0.037	