

## 2 $\mu$ A, 600mA Low Dropout Voltage Linear Regulator

### General Description

The HM6233 series are a group of low-dropout (LDO) voltage regulators offering the benefits of wide input voltage range from 1.2V to 5.5V, low dropout voltage, low power consumption, and miniaturized packaging.

Quiescent current of only 2 $\mu$ A makes these devices ideal for powering the battery-powered, always-on systems that require very little idle-state power dissipation to a longer service life. There is an option of shutdown mode by selecting the parts with the EN pin and pulling it low. The shutdown current in this mode goes down to only 10nA (typical).

The HM6233 series of linear regulators are stable with the ceramic output capacitor over its wide input range from 1.2V to 5.5V and the entire range of output load current (0mA to 600mA).

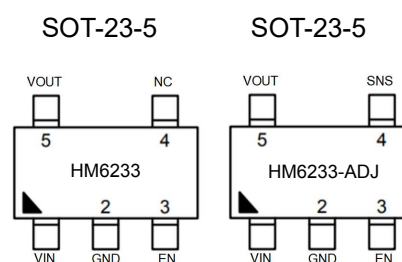
### Features

- 2 $\mu$ A Ground Current at no Load
- $\pm 2\%$  Output Accuracy
- 600mA Output Current
- 10nA Disable Current (by option)
- Wide Operating Input Voltage Range: 1.2V to 5.5V
- Dropout Voltage: 0.32V at 600mA/ VOUT 3.3V
- Support Fixed Output Voltage 0.8V, 0.9V, 1.2V, 1.5V, 1.8V, 2.5V, 2.8V, 3.0V, 3.3V
- Adjustable Output Voltage Available by Specific Application
- Stable with Ceramic or Tantalum Capacitor
- Current Limit Protection
- Over-Temperature Protection
- SOT-23-5 Packages Available

### Applications

- Portable, Battery Powered Equipment
- Low Power Microcontrollers
- Laptop, Palmtops and PDAs
- Wireless Communication Equipment
- Audio/Video Equipment
- Car Navigation Systems

### Pin Configurations



### Ordering Information

## HM6233B-AA BB

Designator	Description	Symbol	Description
AA	Output Voltage	08	$V_{OUT} = 0.8V$
		..	..
		..	..
		..	..
		33	$V_{OUT} = 3.3V$
BB	Package type	MR	SOT-23-5

## HM6233A-AA BB (For SOT-23-5 with SNS pin)

Designator	Description	Symbol	Description
AA	Output Voltage	08	$V_{OUT} = 0.8V$
		..	..
		..	..
		..	..
		33	$V_{OUT} = 3.3V$
BB	Package type	MR	SOT-23-5

## Description of Functional Pins

### HM6233

Pin No	Pin No	Pin Name
2	GND	Ground
5	VOUT	Output of the Regulator
1	VIN	Input of Supply Voltage.
3	EN	Enable Control Input.
4	NC	No internal connection

### HM6233-ADJ (For SOT-23-5 with **SNS** pin)

Pin No	Pin Name	Pin Function
2	GND	Ground
5	VOUT	Output of the Regulator
1	VIN	Input of Supply Voltage.
3	EN	Enable Control Input.
4	SNS	Sense of Output Voltage 0.8V

## Typical Application Circuit

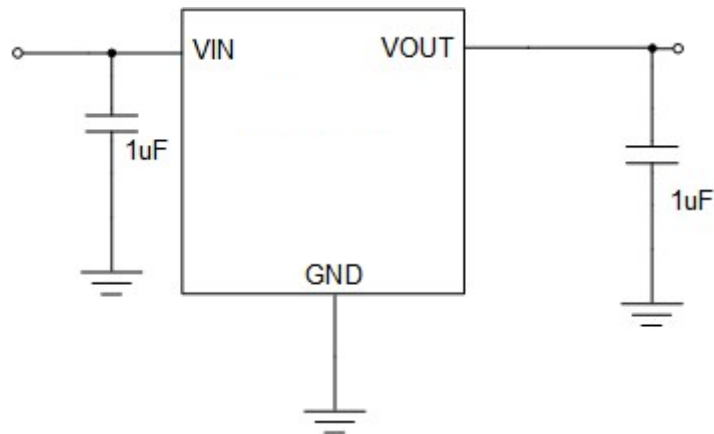


Figure 1: Application circuit of Fixed V<sub>OUT</sub> LDO

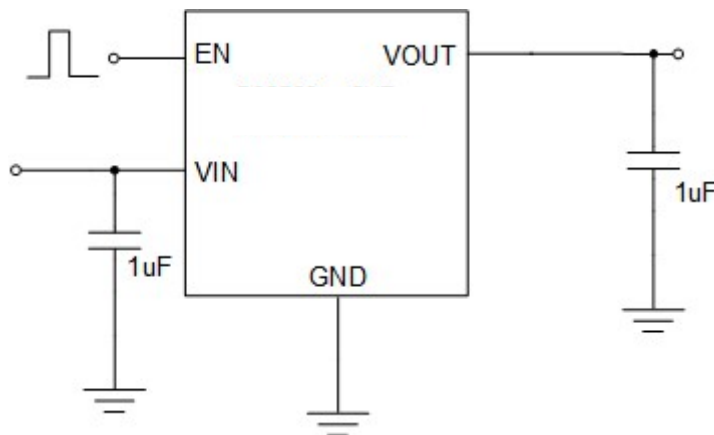


Figure 2: Application circuit of Fixed V<sub>OUT</sub> LDO with enable function

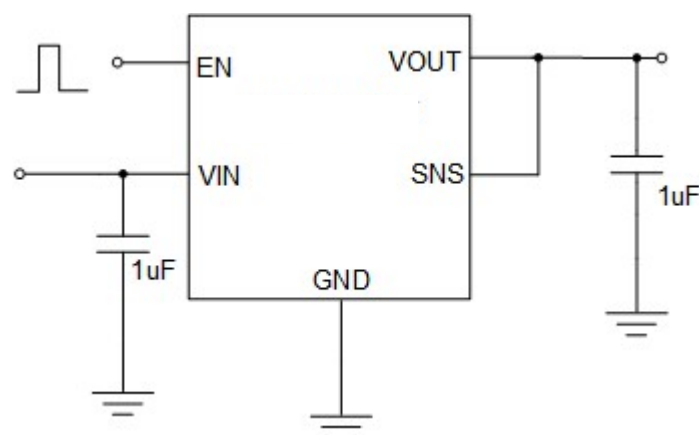


Figure 3: Application circuit of Fixed V<sub>OUT</sub> LDO with enable and **sense** functions

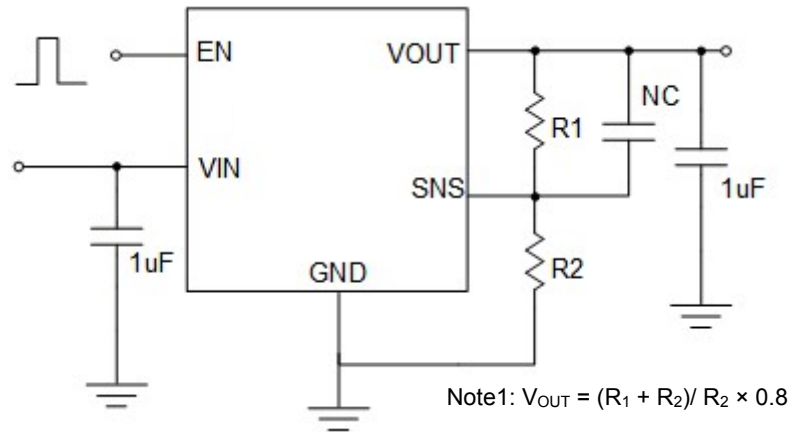
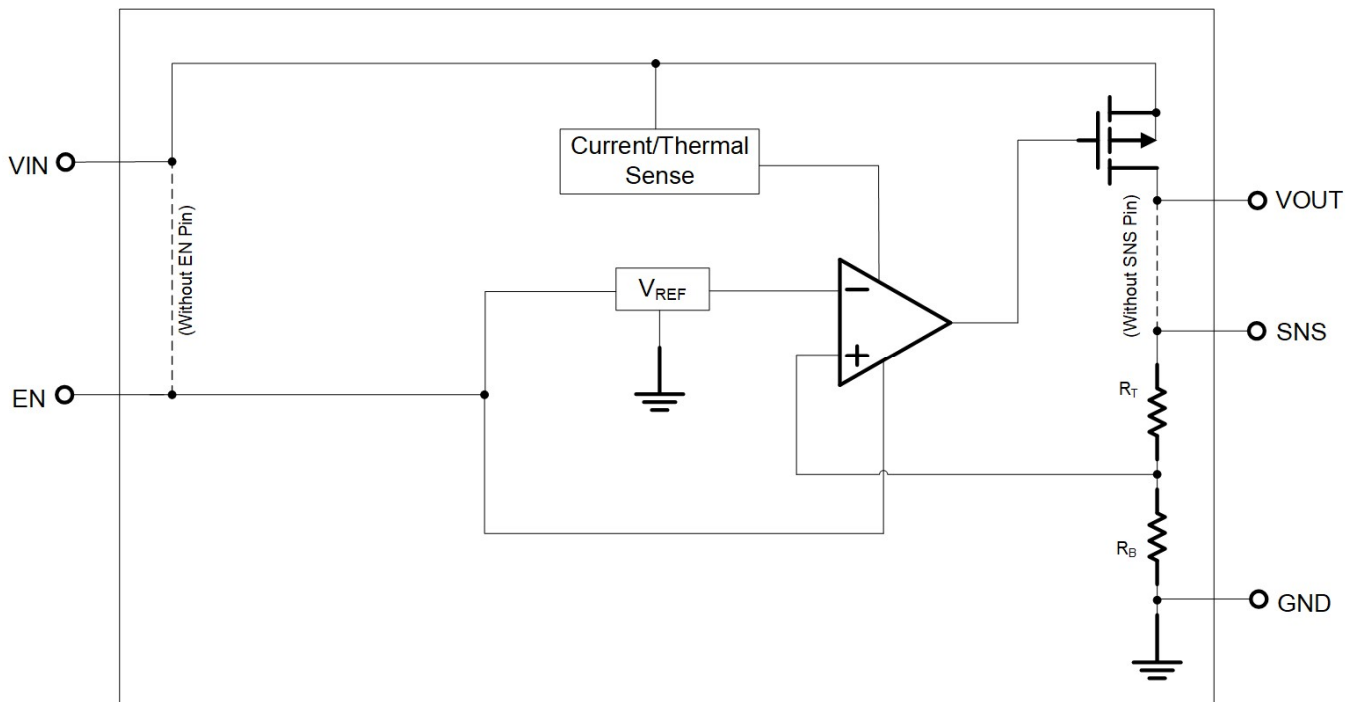


Figure 4: Adjustable output voltage LDO application circuit by HM6233-08S5

## Function Block Diagram



## Absolute Maximum Ratings (Note 1)

VIN to GND	-0.3V to 6.5V
VOOUT, EN, SNS to GND	-0.3V to 6V
VOOUT to VIN	-6V to 0.3V
Package Thermal Resistance (Note 2)	
SOT-23-5, $\theta_{JA}$	200 °C /W
Lead Temperature (Soldering, 10 sec.)	260 °C
Junction Temperature	150 °C
Storage Temperature Range	-60 °C to 150 °C
ESD Susceptibility	
HBM	2KV
MM	200V
CDM	2KV

## Recommended Operating Conditions

Input Voltage VIN	1.2V to 5.5V
Junction Temperature Range	-40 °C to 125 °C
Ambient Temperature Range	-40 °C to 85 °C

## Electrical Characteristics

( $V_{IN} = 5V$ ,  $V_{EN} = 5V$   $T_A = 25^\circ C$  unless otherwise specified)

Parameter	Symbol	Test Conditions		Min	Typ	Max	Unit
Supply Voltage	V <sub>IN</sub>			1.2	--	5.5	V
DC Output Voltage Accuracy		I <sub>LOAD</sub> =0.1mA		-2		2	%
Dropout Voltage (I <sub>LOAD</sub> =600mA) (Note 3)	V <sub>DROP_3V</sub>	V <sub>OUT</sub> ≥ 3V		--	0.32		V
	V <sub>DROP_2.8V</sub>	V <sub>OUT</sub> = 2.8V			0.36		
	V <sub>DROP_2.5V</sub>	V <sub>OUT</sub> = 2.5V			0.36		
	V <sub>DROP_1.8V</sub>	V <sub>OUT</sub> = 1.8V			0.57		
	V <sub>DROP_1.5V</sub>	V <sub>OUT</sub> = 1.5V			0.71		
	V <sub>DROP_1.2V</sub>	V <sub>OUT</sub> = 1.2V			0.8		
	V <sub>DROP_0.9V</sub>	V <sub>OUT</sub> = 0.9V			1.05		
Ground Current	I <sub>Q</sub>	I <sub>LOAD</sub> = 0mA			2		μA
Shutdown Ground Current	I <sub>SD</sub>	V <sub>EN</sub> = 0V, V <sub>OUT</sub> = 0V			0.01	0.5	μA
V <sub>OUT</sub> Shutdown Leakage Current	I <sub>LEAK</sub>				0.01	0.5	
SNS Input Current	I <sub>SNS</sub>	SNS = V <sub>OUT</sub>			0.7		μA
Enable Threshold Voltage	V <sub>IH</sub>	EN Rising				2	V
	V <sub>IL</sub>	EN Falling		0.6			
EN Input Current	I <sub>EN</sub>	V <sub>EN</sub> = 5V			10	100	nA
Line Regulation	ΔLINE	I <sub>LOAD</sub> =30mA, 1.5V ≤ V <sub>IN</sub> ≤ 5.5V or (V <sub>OUT</sub> + 0.2V) ≤ V <sub>IN</sub> ≤ 5.5V			0.2		%
Load Regulation	ΔLOAD	10mA ≤ I <sub>LOAD</sub> ≤ 0.6A			0.5		%
Output Current Limit	I <sub>LIM</sub>	V <sub>OUT</sub> =0		601	1100		mA
Power Supply Rejection Ratio (I <sub>LOAD</sub> =5mA)	PSRR	V <sub>OUT</sub> =1.2V, V <sub>IN</sub> = 2V	f = 100Hz	--	80	--	dB
			f = 1kHz	--	75	--	
Output Voltage Noise (BW = 10Hz to 100kHz, C <sub>OUT</sub> =1μF,)		V <sub>IN</sub> = 3.5V I <sub>LOAD</sub> =0.1A	V <sub>OUT</sub> =0.9V	--	40	--	μV <sub>RM</sub> s
			V <sub>OUT</sub> =2.8V	--	50	--	
Thermal Shutdown Temperature	T <sub>SD</sub>	I <sub>LOAD</sub> =10mA		--	155	--	°C
Thermal Shutdown Hysteresis	ΔT <sub>SD</sub>			--	15	--	°C

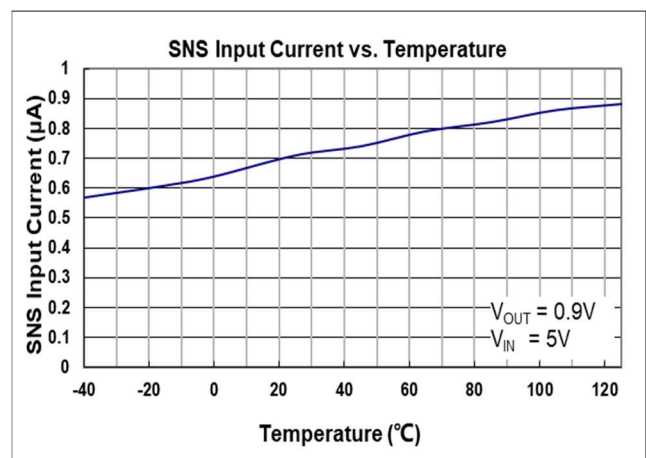
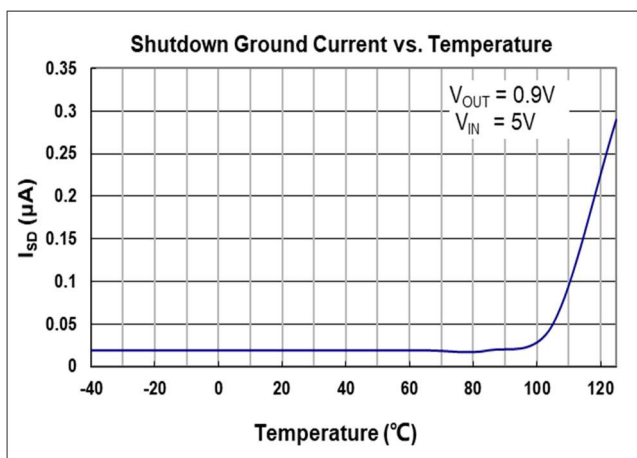
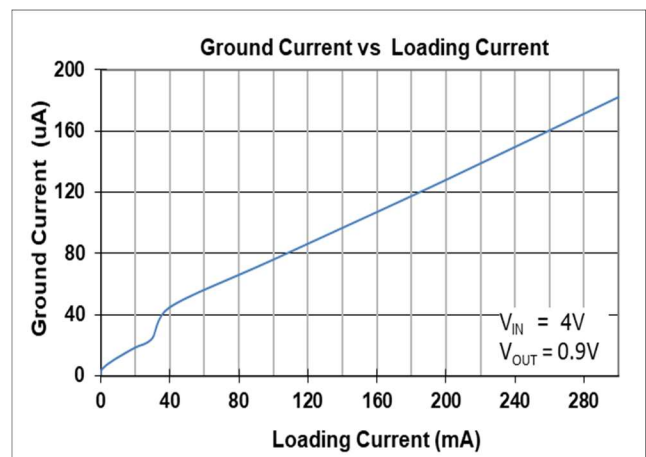
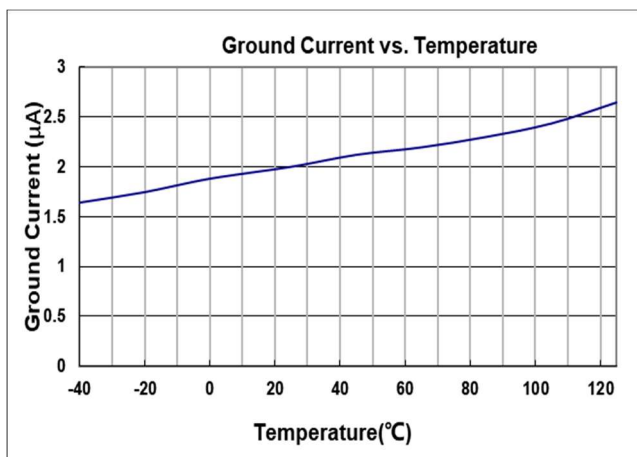
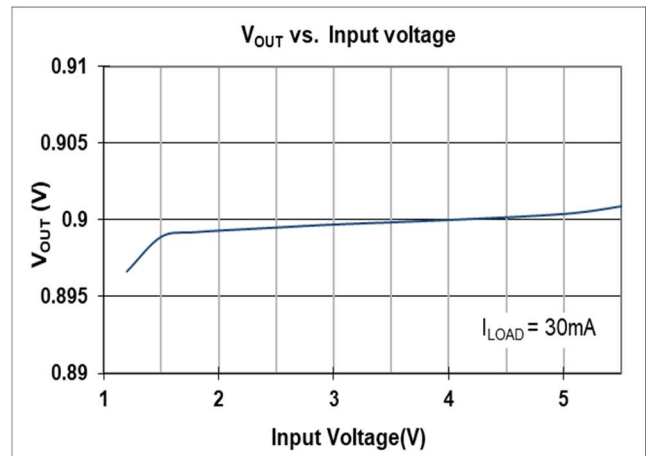
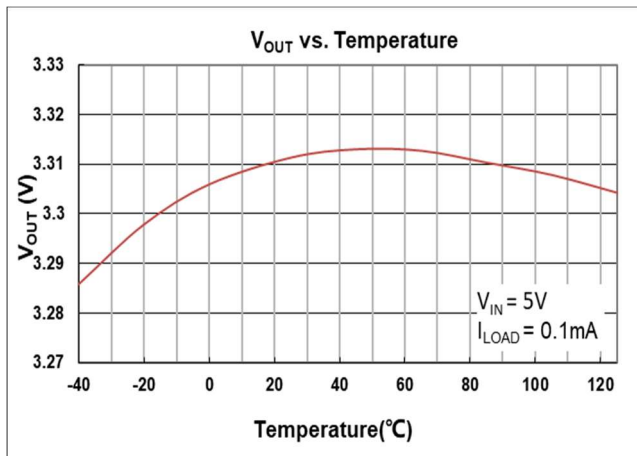
**Note 1.** Stresses beyond those listed “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions may affect device reliability.

**Note 2.**  $\theta_{JA}$  is measured at  $T_A = 25^{\circ}\text{C}$  on a DS-Tech EVB board.

**Note 3.**  $V_{\text{DROP}} = V_{\text{IN}} - V_{\text{OUT}}$  when the  $V_{\text{OUT}}$  is 98% of its target value.



## Typical Characteristics



## Application Guideline

### Input and Output Capacitor Requirements

The external input and output capacitors of HM6233 series must be properly selected for stability and performance. Use a 1μF or larger input capacitor and place it close to the IC's VIN and GND pins. Any output capacitor meeting the minimum 1mΩ ESR (Equivalent Series Resistance) and effective capacitance between 1μF and 22μF requirement may be used. Place the output capacitor close to the IC's VOUT and GND pins. Increasing capacitance and decreasing ESR can improve the circuit's PSRR and line transient response.

### Current Limit

The HM6233 series contain the current limiter of output power transistor, which monitors and controls the transistor, limiting the output current to 1100mA (typical). The output can be shorted to ground indefinitely without damaging the part.

### Dropout Voltage

The HM6233 series use a PMOS pass transistor to achieve low dropout. When (VIN – VOUT) is less than the dropout voltage (V<sub>DROP</sub>), the PMOS pass device is in the linear region of operation and the input-to-output resistance is the RDS(ON) of the PMOS pass element. V<sub>DROP</sub> scales approximately with the output current because the PMOS device behaves as a resistor in dropout condition.

As any linear regulator, PSRR and transient response are degraded as (VIN – VOUT) approaches dropout condition.

### Adjustable Output Voltage Application

The HM6233 with SNS pin also can work as an

adjustable output voltage LDO. Figure 4 gives the connections for the adjustable output voltage application. The resistor divider from VOUT to SNS sets the output voltage when in regulation.

The voltage on the SNS pin sets the output voltage and is determined by the values of R1 and R2. To keep a good temperature coefficient of output voltage, the values of R1 and R2 should be selected carefully to ignore the temperature effect of input current at the SNS pin. A current greater than 50μA in the resistor divider is recommended to meet the above requirement. The adjustable output voltage can be calculated using the formula given in equation 1:

$$V_{OUT} = \frac{R1+R2}{R2} \times V_{SNS} \quad (1)$$

where V<sub>SNS</sub> is determined by the output voltage selections in the ordering information of HM6233-XXS5. The maximum adjustable output voltage is 5V. Generally, to maximize the available adjustable output voltage range, HM6233-08 is recommended (V<sub>SNS</sub> is 0.8V in formula 1 now).

The minimum recommended 50μA in the resistor divider makes the application no longer a 2μA low quiescent LDO.

### OTP (Over Temperature Protection)

The over temperature protection function of HM6233 series will turn off the P-MOSFET when the junction temperature exceeds 155°C (typ.). Once the junction temperature cools down by approximately 15°C, the regulator will automatically resume operation.

### Thermal Application

For continuous operation, do not exceed the absolute maximum junction temperature. The maximum power dissipation depends on the thermal resistance of the IC

for SOT-23-5 packages.

Power dissipation (PD) is equal to the product of the output current and the voltage drop across the output pass element, as shown in the equation below:

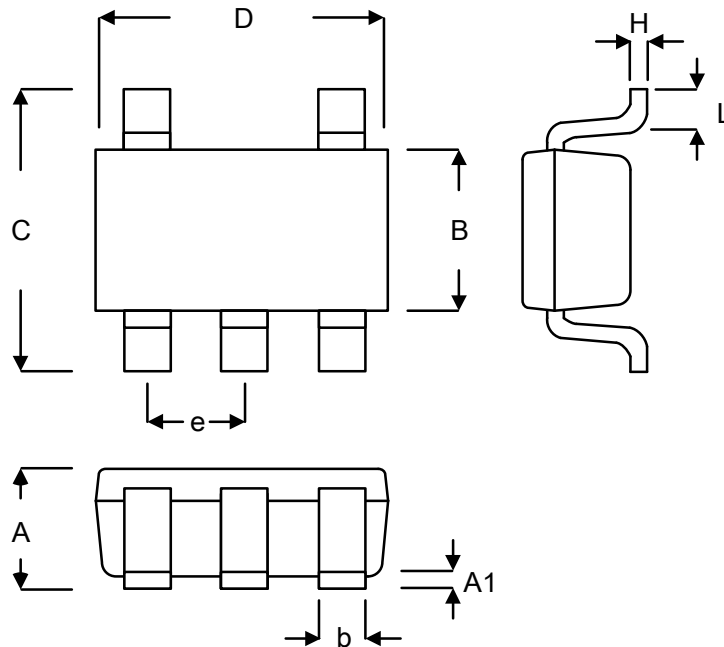
$$PD = (V_{IN} - V_{OUT}) \times I_{OUT}$$

## Layout Consideration

By placing input and output capacitors on the same side of the PCB as the LDO, and placing them as close as is practical to the package can achieve the best performance. The ground connections for input and output capacitors must be back to the HM6233 ground pin using as wide and as short of a copper trace as is practical.

Connections using long trace lengths, narrow trace widths, and/or connections through via must be avoided. These add parasitic inductances and resistance that results in worse performance especially during transient conditions.

Package Information:



Symbol	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	0.889	1.295	0.035	0.051
A1	0.000	0.152	0.000	0.006
B	1.397	1.803	0.055	0.071
b	0.250	0.560	0.010	0.022
C	2.591	2.997	0.102	0.118
D	2.692	3.099	0.106	0.122
e	0.838	1.041	0.033	0.041
H	0.080	0.254	0.003	0.010
L	0.300	0.610	0.012	0.024

SOT-23-5L