

## 24V, 500mA Low Dropout Voltage Linear Regulator

### Features

- Wide Input Voltage Range: 2V to 24V
- 1.5 $\mu$ A Ground Current at no Load
- $\pm 1\%$  Output Accuracy
- 500mA Output Current
- 100nA Disable Current
- Dropout Voltage: 0.35V at 100mA /  $V_{OUT}$  5V
- Fixed Output Voltage: 1.8V, 3.3V and 5V
- Adjustable Output Voltage Available by Specific Application
- Stable with Ceramic or Tantalum Capacitor
- Current Limit Protection
- Over-Temperature Protection
- SOT23-3L, SOT23-5, SOT-89-3 package

### Applications

- Portable, Battery Powered Equipment
- Low Power Microcontrollers
- Laptop, Palmtops and PDAs
- Wireless Communication Equipment
- Audio/Video Equipment
- Car Navigation Systems
- Industrial Controls
- Weigh Scales
- Meters and Home Automation

### General Description

The HCR2416 series are a group of low-dropout (LDO) voltage regulators offering the benefits of wide input voltage range, low dropout voltage, low power consumption, and miniaturized packaging.

Quiescent current of only 1.5 $\mu$ 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 a shutdown mode by pulling the EN pin low. The shutdown current in this mode goes down to only 100nA ( typical ).

The HCR2416 series of linear regulators are stable with the ceramic output capacitor over its wide input range from 2V to 24V and the entire range of output load current (0mA to 500mA). The HCR2416 has 1.8V, 3.3V and 5.0V fixed voltage versions and adjustable voltage version.

The HCR2416 is available in the SOT23-3L, SOT23-5, SOT89-3, SOT89-3(L-Type) and SOT89-3(R-Type) packages. It operates over an ambient temperature range from -40°C to +85°C.



SOT23-3L



SOT23-5

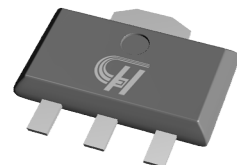
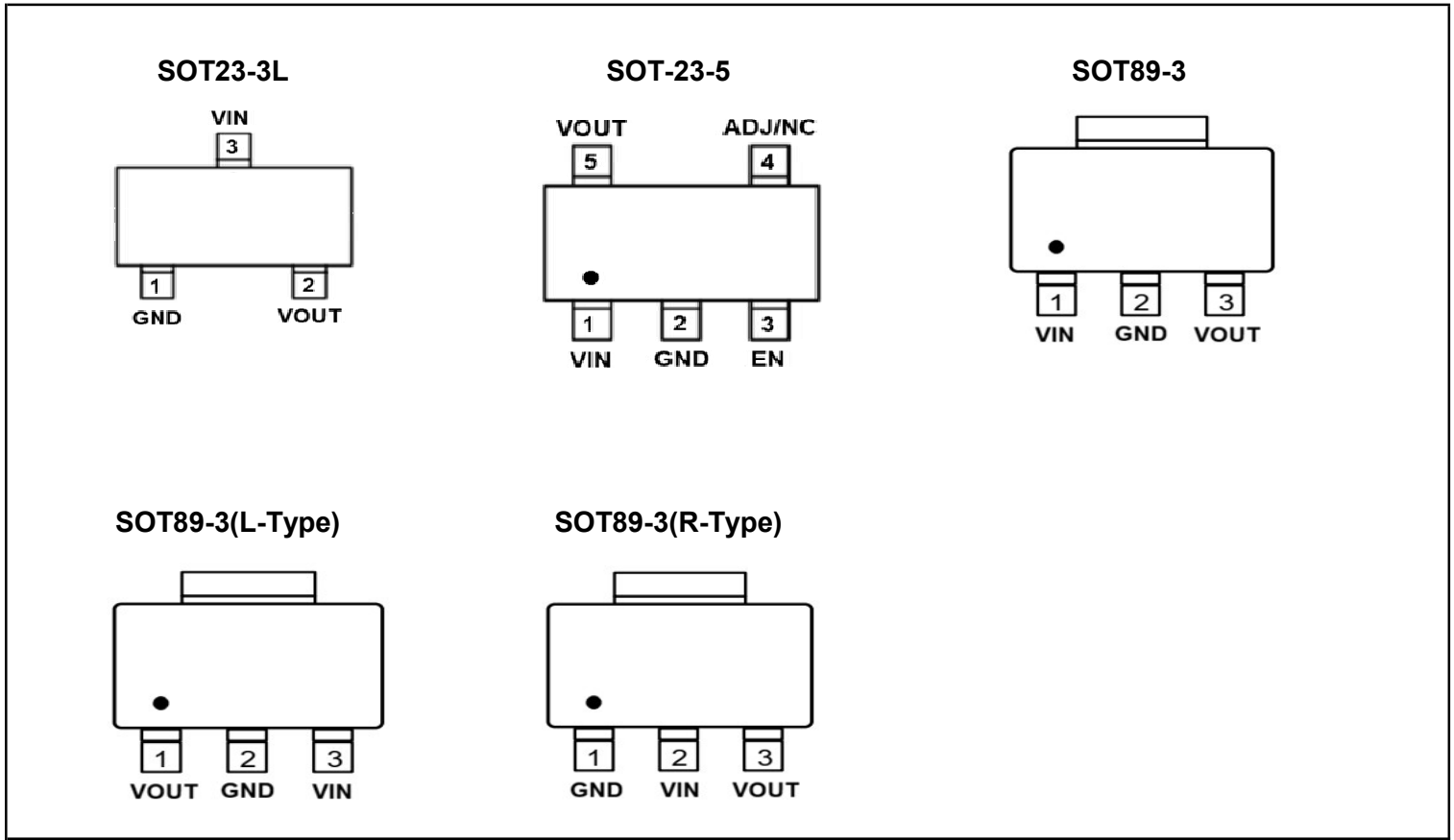
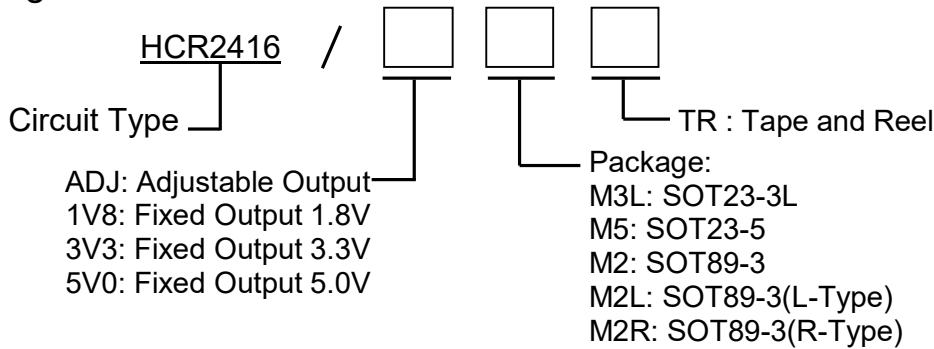
SOT89-3/SOT89-3(L-Type)  
/SOT89-3(R-Type)

Figure 1. Package Type of HCR2416

**24V, 500mA Low Dropout Voltage Linear Regulator**
**Pin Configuration**

**Figure 2. Pin Configuration of HCR2416 (Top View )**
**Pin Description**

SOT23-3L	SOT-23-5	SOT-89-3	SOT89-3 (L-Type)	SOT89-3 (R-Type)	Pin Name	Pin Function
1	2	2	2	1	GND	Ground
2	5	3	1	3	VOUT	Regulated Output Voltages
3	1	1	3	2	VIN	Supply Input Voltage
-	3	-	-	-	EN	Enable Control Input
-	4	-	-	-	NC	No internal Connected for fixed Version
-	4	-	-	-	ADJ	Adjust Output for ADJ Version, $V_{OUT} = (R1+R2)/R2 \times 1.8V$ , And $R2 < 36K\Omega$ .

**24V, 500mA Low Dropout Voltage Linear Regulator**
**Ordering Information**


Standard	Voltage	Marking ID	Package	MSL	Tape & Reel
HCR2416/1V8M3LTR	1.8V	18S3	SOT23-3L	MSL3	3000pcs, Tape&Reel
HCR2416/3V3M3LTR	3.3V	33S3	SOT23-3L	MSL3	3000pcs, Tape&Reel
HCR2416/5V0M3LTR	5.0V	50S3	SOT23-3L	MSL3	3000pcs, Tape&Reel
HCR2416/ADJM5TR <sup>note1</sup>	ADJ	ADJS5	SOT23-5	MSL3	3000pcs, Tape&Reel
HCR2416/1V8M5TR	1.8V	18S5	SOT23-5	MSL3	3000pcs, Tape&Reel
HCR2416/3V3M5TR	3.3V	33S5	SOT23-5	MSL3	3000pcs, Tape&Reel
HCR2416/5V0M5TR	5.0V	50S5	SOT23-5	MSL3	3000pcs, Tape&Reel
HCR2416/1V8M2TR	1.8V	18A3	SOT89-3	MSL3	1000pcs, Tape&Reel
HCR2416/3V3M2TR	3.3V	33A3	SOT89-3	MSL3	1000pcs, Tape&Reel
HCR2416/5V0M2TR	5.0V	50A3	SOT89-3	MSL3	1000pcs, Tape&Reel
HCR2416/1V8M2LTR	1.8V	18A3L	SOT89-3 (L-Type)	MSL3	1000pcs, Tape&Reel
HCR2416/3V3M2LTR	3.3V	33A3L	SOT89-3 (L-Type)	MSL3	1000pcs, Tape&Reel
HCR2416/5V0M2LTR	5.0V	AAFPxx	SOT89-3 (L-Type)	MSL3	1000pcs, Tape&Reel
HCR2416/1V8M2RTR	1.8V	18A3R	SOT89-3 (R-Type)	MSL3	1000pcs, Tape&Reel
HCR2416/3V3M2RTR	3.3V	33A3R	SOT89-3 (R-Type)	MSL3	1000pcs, Tape&Reel
HCR2416/5V0M2RTR	5.0V	50A3R	SOT89-3 (R-Type)	MSL3	1000pcs, Tape&Reel

Note1. ADJ = (R1+R2)/R2X1.8V, and R2<36KΩ

**24V, 500mA Low Dropout Voltage Linear Regulator**
**Absolute Maximum Ratings** <sup>Note 2</sup>

Parameter	Symbol	Value		Unit
Supply Input Voltage (VIN to GND)	VIN	-0.3 to 30		V
Enable Input Voltage (EN to GNG)	VEN	-0.3 to 30		V
ADJ to GND	VADJ	-0.3 to 6.0		V
VOUT to GND	VOUT	HCR2416/ADJ		V
		HCR2416/1V8		
		HCR2416/3V3		
		HCR2416/5V0		
VOUT to VIN	-	-28 to 0.3		V
Power Dissipation	PD	SOT23-3L	0.45	W
		SOT23-5	0.45	W
		SOT89-3	0.83	W
Thermal Resistance (No Heatsink)	$\theta_{JA}$ <sup>note3</sup>	SOT23-3L	220	°C / W
Thermal Resistance (No Heatsink)	$\theta_{JA}$ <sup>note3</sup>	SOT23-5	220	°C / W
Thermal Resistance (No Heatsink)	$\theta_{JA}$ <sup>note3</sup>	SOT89-3	120	°C / W
Lead Temperature(Soldering, 10sec)	TLEAD	+260		°C
Operating Junction Temperature	TJ	+150		°C
Storage Temperature Range	TSTG	-40 to 150		°C
ESD ( Machine Mode )	MM	200		V
ESD ( Human Body Mode )	HBM	2000		V

Note 2: Stresses greater than those listed under " Absolute Maximum Ratings " may cause permanent damage to the device. There are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under " Recommended Operating Conditions " is not implied. Exposure to " Absolute Maximum Ratings "for extended periods may affect device reliability .

3:  $\theta_{JA}$  is measured with the component mounted on a 2-Layer FR-4 PCB board with 1.5cmX1.5cm thermal sink pad in free air.

**Recommended Operating Conditions**

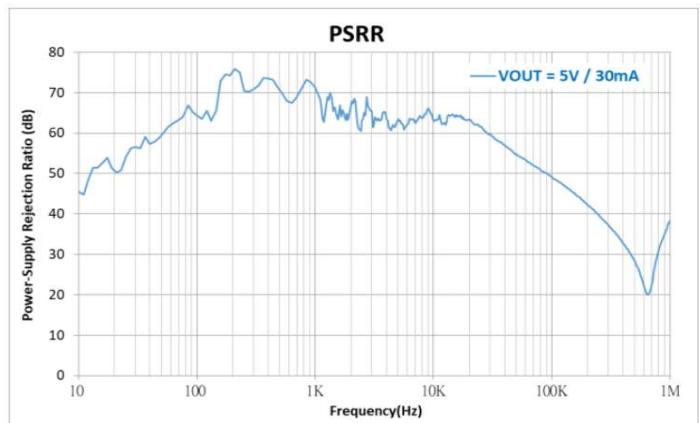
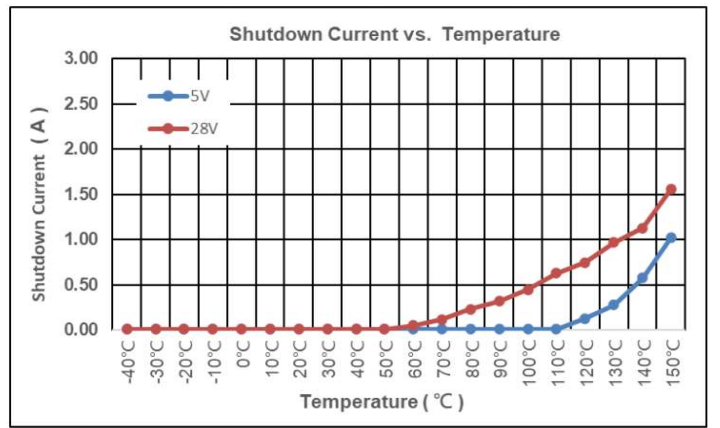
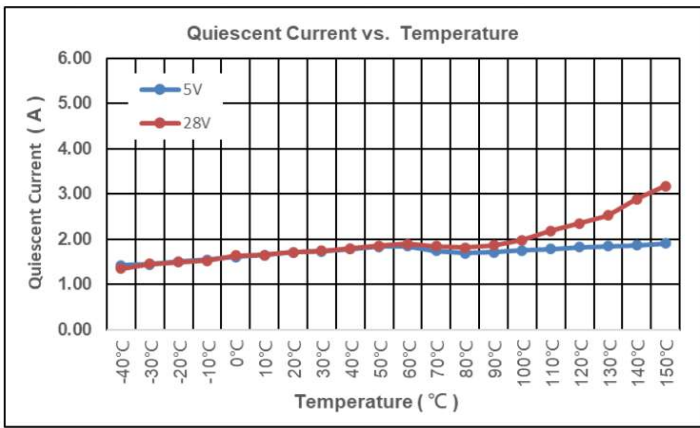
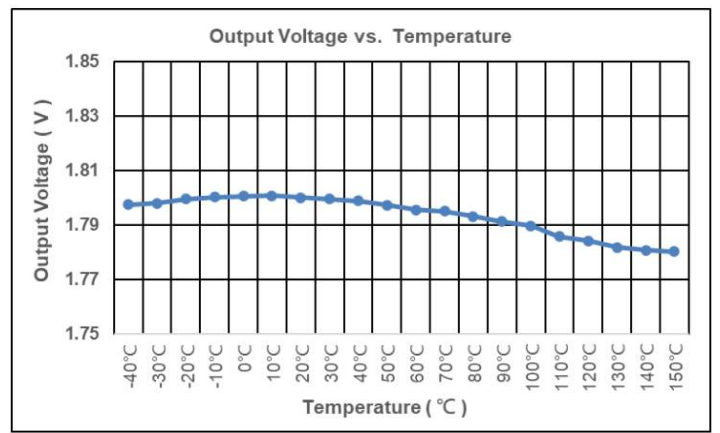
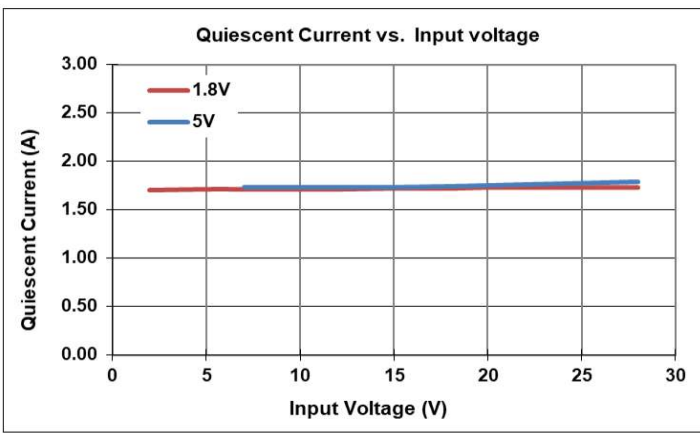
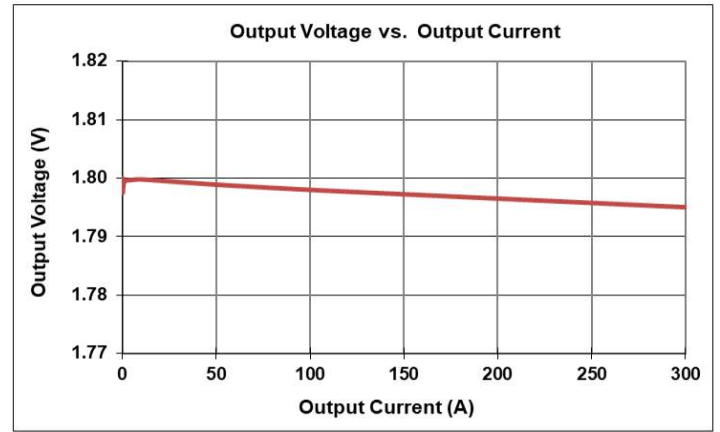
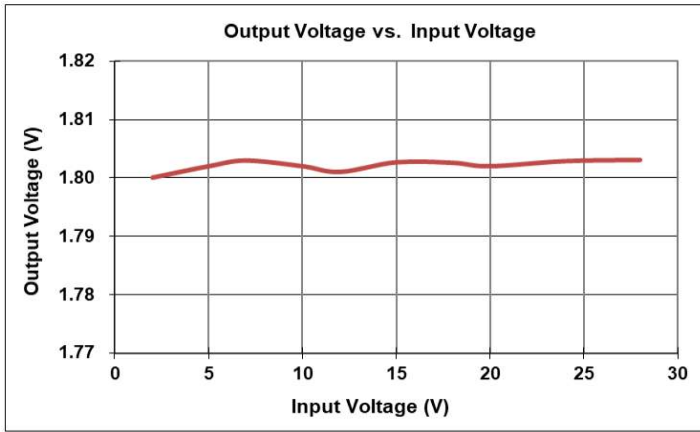
Parameter	Symbol	Min	Max	Unit
Supply Input Voltage	VIN	2.0	24.0	V
Junction Ambient Temperature	TJ	-40	+125	°C
Operating Ambient Temperature	Ta	-40	+85	°C

**24V, 500mA Low Dropout Voltage Linear Regulator**
**Electrical Characteristics**

(Vin=15V, VEN=5V, TA=25 °C, unless other-wise specified.)

Parameter	Symbol	Condition	Min	Type	Max	Unit
Input Voltage	VIN	-	2.0	-	24	V
DC Output Voltage Accuracy	VOUT	ILOAD=0.1mA	VOUT X 99%	-	VOUT X 101%	V
Output Peak Load Current	IOUT	VIN=VOUT+1.8V	-	500	-	mA
Output Current Limit	ILIM	VOUT=0	501	700	-	mA
Line Regulation	ΔLINE	ILOAD=1mA, 10V≤VIN≤20V	-	0.5	-	%
Load Regulation	ΔLOAD	10mA≤ILOAD≤200mA	-	0.3	-	%
Dropout Voltage	VDROP	VOUT≥5V, ILOAD=100mA	-	350	-	mV
		VOUT=3.3V, ILOAD=100mA	-	420	-	
		VOUT=1.8V, ILOAD=100mA	-	500	-	
Ground Current <sup>note4</sup>	IQ	VIN>VOUT, ILOAD=0mA	-	1.5	-	uA
Shutdown Ground Current	ISD	VOUT= 0V VEN=0V	-	0.1	0.5	uA
ADJ Input Current	IADJ	ADJ=VOUT VOUT≤5V	-	0.7	-	uA
Power Supply Rejection Ration	PSRR	VOUT=5V, ILOAD=30mA, VIN=12V, f=1KHz	-	70	-	dB
EN Input Current	IEN	VEN=24V	-	10	100	nA
Enable Threshold Voltage	VIH	EN Rising	1.1	-	-	V
	VIL	EN Falling	-	-	0.4	V
Thermal Shutdown Temperature	TSD	ILOAD=10mA	-	160	-	°C
Thermal Shutdown Hysteresis	ΔTSD		-	15	-	°C

Note 4. When VIN > VOUT, the quiescent current is the normal specification value, but when VIN≤VOUT, the quiescent current will be greater than the specification value.

**24V, 500mA Low Dropout Voltage Linear Regulator**
**Electrical Characteristics**


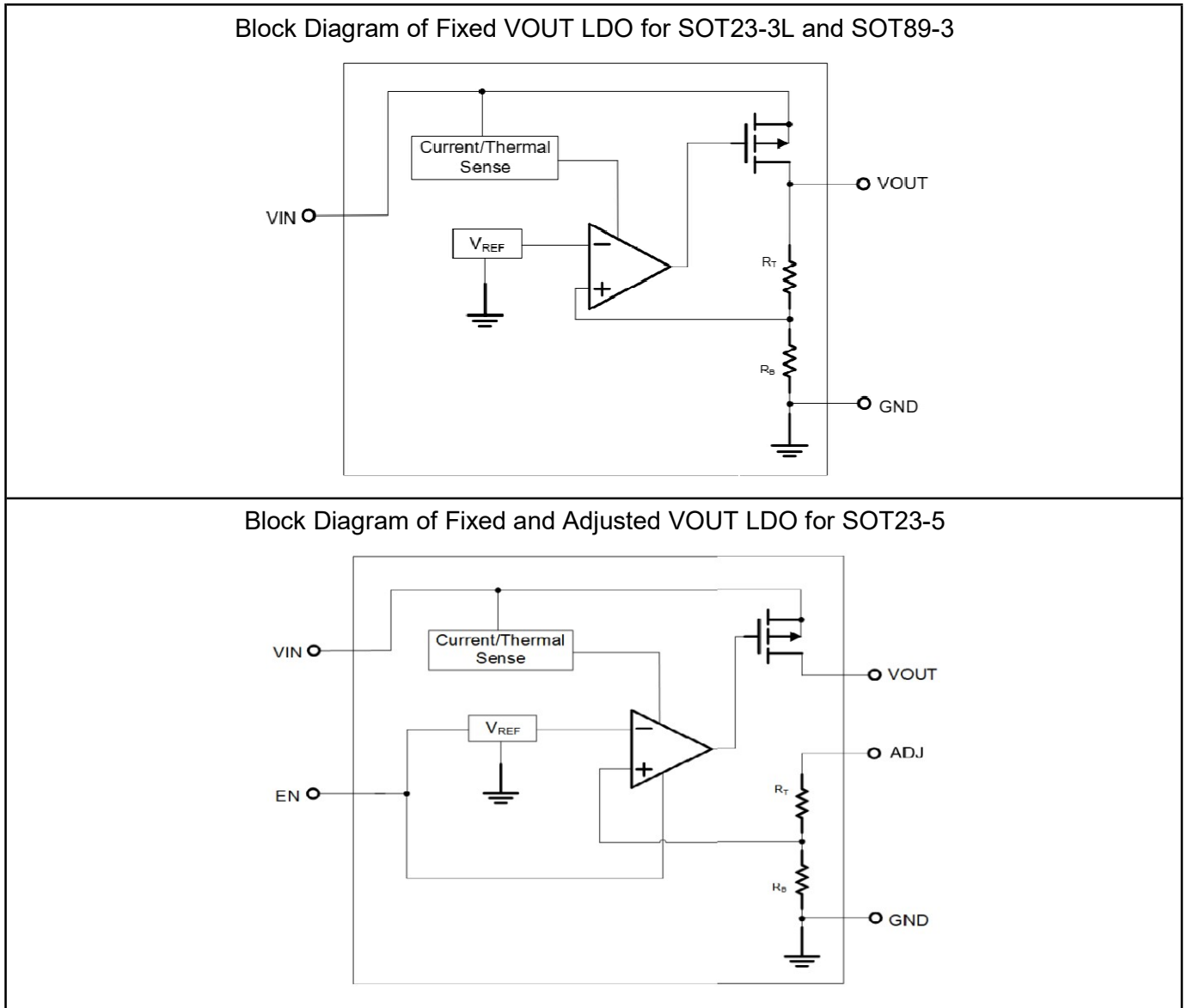
**24V, 500mA Low Dropout Voltage Linear Regulator**
**Functional Block Diagrams**


Figure 3. Functional Block Diagrams

**Typical Application Circuits**

-Fixed VOUT LDO for SOT23-3L and SOT89-3

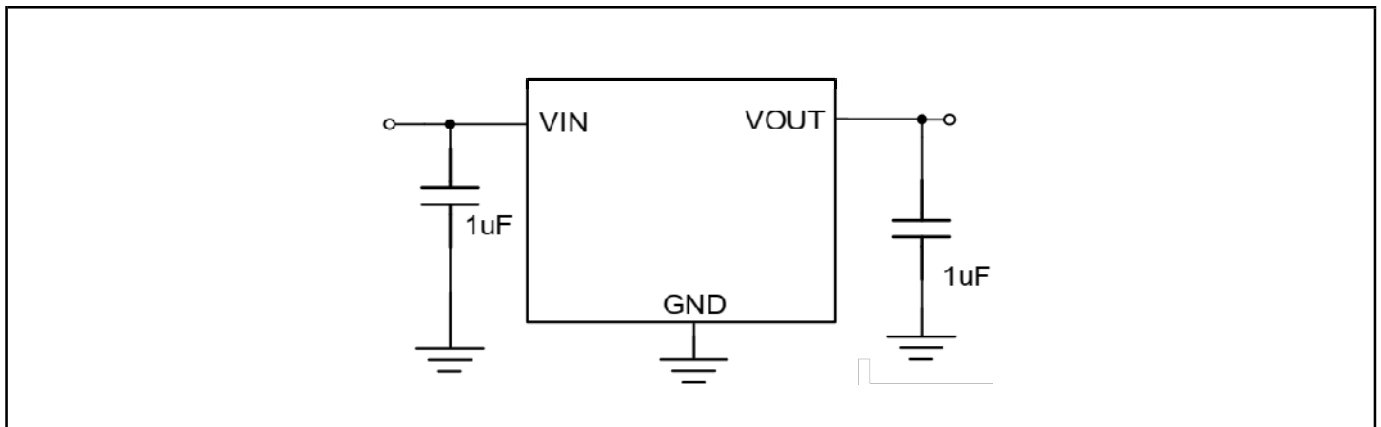


Figure 4. Application circuit of Fixed VOUT LDO for SOT23-3L and SOT89-3

**24V, 500mA Low Dropout Voltage Linear Regulator**
**Typical Application Circuits(Con.)**

- Fixed VOUT LDO with enable function for SOT23-5

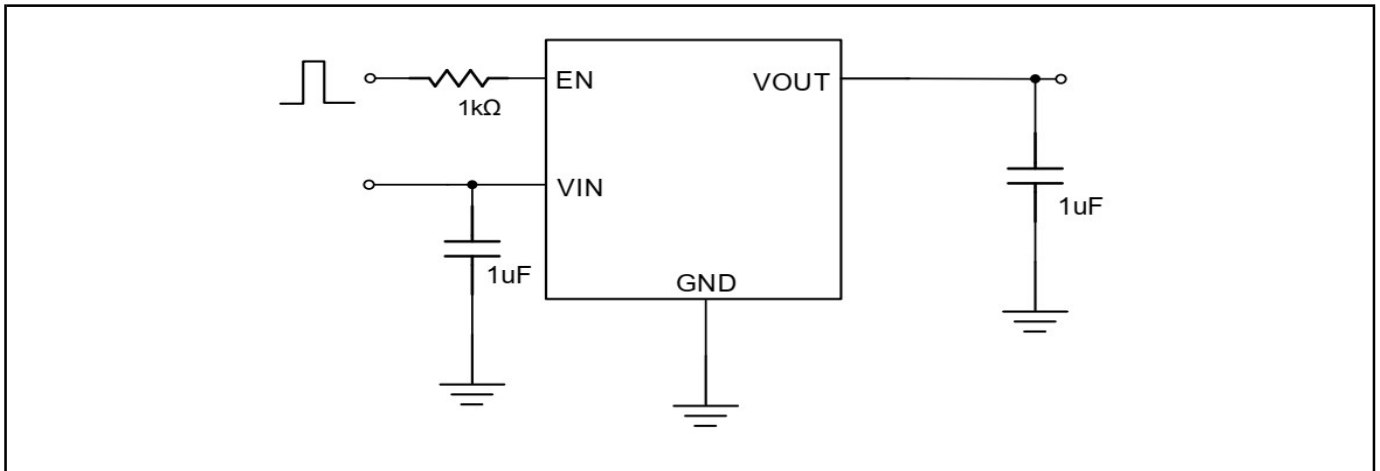


Figure 5. Fixed VOUT LDO with enable function for SOT23-5

- Fixed VOUT LDO with enable and Adjustable function

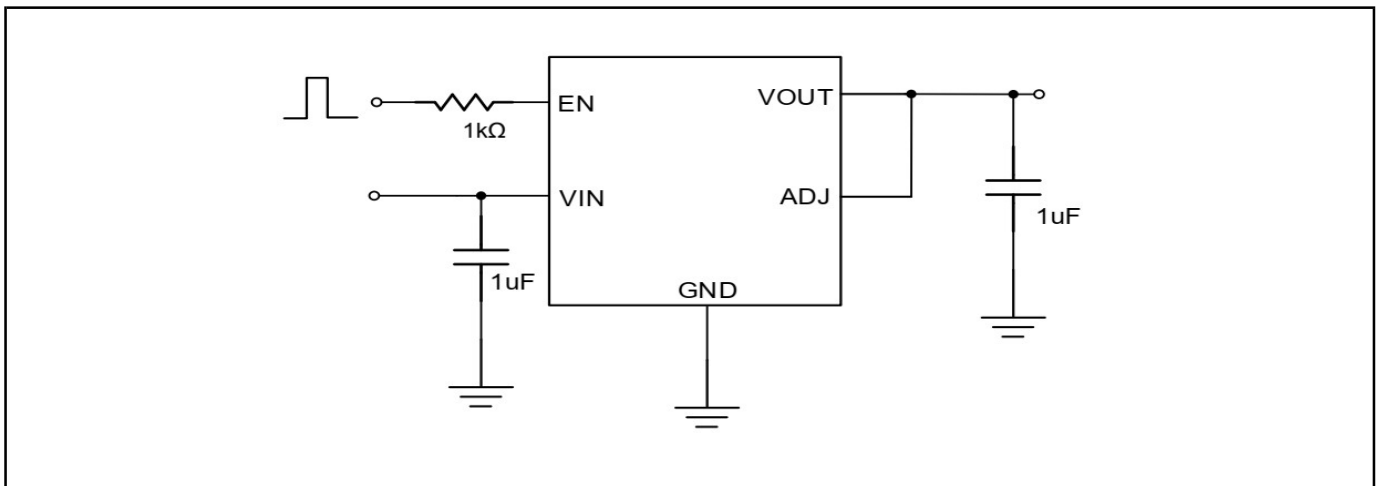


Figure 6. Fixed VOUT LDO with enable and Adjustable function for SOT23-5

- Adjustable output voltage LDO application circuit by HCR2416/ADJM5

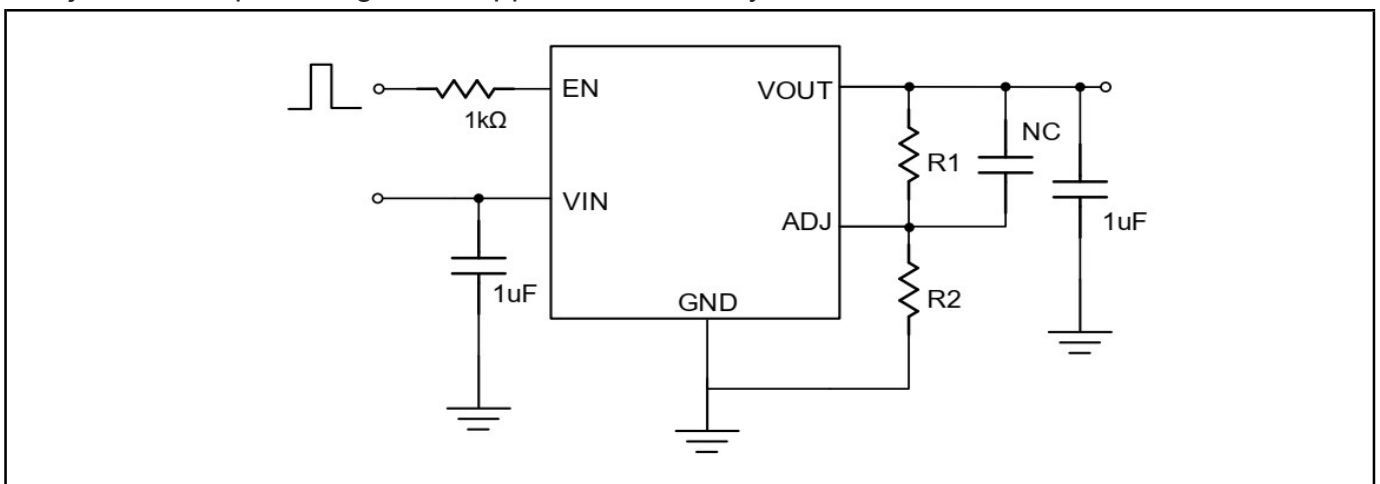


Figure 7. Adjustable output voltage LDO application circuit by HCR2416/ADJM5

## 24V, 500mA Low Dropout Voltage Linear Regulator

### Application Guideline

#### Input and Output Capacitor Requirements

The external input and output capacitors of HCR2416 series must be properly selected for stability and performance. Use a 1 $\mu$ F or larger input capacitor and place it close to the IC's VIN and GND pins. Any output capacitor meeting the minimum 1m $\Omega$  ESR (Equivalent Series Resistance) and effective capacitance between 1 $\mu$ F and 22 $\mu$ F 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 HCR2416 series contain the current limiter of output power transistor, which monitors and controls the transistor, limiting the output current to 700mA. The output can be shorted to ground indefinitely without damaging the part.

#### Dropout Voltage

The HCR2416 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 R<sub>DS(ON)</sub> 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 HCR2416-ADJ with ADJ pin also can work as an adjustable output voltage LDO. Figure 7 gives the connections for the adjustable output voltage application. The resistor divider from VOUT to ADJ sets the output voltage when in regulation.

The voltage on the ADJ pin sets the output voltage and is determined by the values of R1 and R2. In order 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 ADJ pin. A current greater than 50 $\mu$ A 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:

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

where V<sub>ADJ</sub> is determined by the output voltage selections in the ordering information of HCR2416ADJ-18. The maximum adjustable output voltage is 5V. Generally, to maximize the available adjustable output voltage range, HCR2416ADJ-18 is recommended (V is 1.8V in formula 1 now)。

The minimum recommended 50 $\mu$ A in the resistor divider makes the application no longer a 1.5 $\mu$ A low quiescent LDO.

#### OTP (Over Temperature Protection)

The over temperature protection function of HCR2416 series will turn off the P-MOSFET when the junction temperature exceeds 160°C (typ.). Once the junction temperature cools down by approximately 15°C, the regulator will automatically resume operation.

## 24V, 500mA Low Dropout Voltage Linear Regulator

### Application Guideline(Con.)

#### 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 package, PCB layout, rate of surrounding airflow, and difference between junction and ambient temperature. The maximum power dissipation can be calculated as below:

$T_A=25^{\circ}\text{C}$ , HCRSEMI PCB,

The max PD (Max) =  $(125^{\circ}\text{C} - 25^{\circ}\text{C}) / (220^{\circ}\text{C}/\text{W}) = 0.45\text{W}$  for SOT23-3L / SOT23-5 packages.

The max PD (Max) =  $(125^{\circ}\text{C} - 25^{\circ}\text{C}) / (120^{\circ}\text{C}/\text{W}) = 0.83\text{W}$  for SOT89-3 package

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:

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

#### Layout Consideration

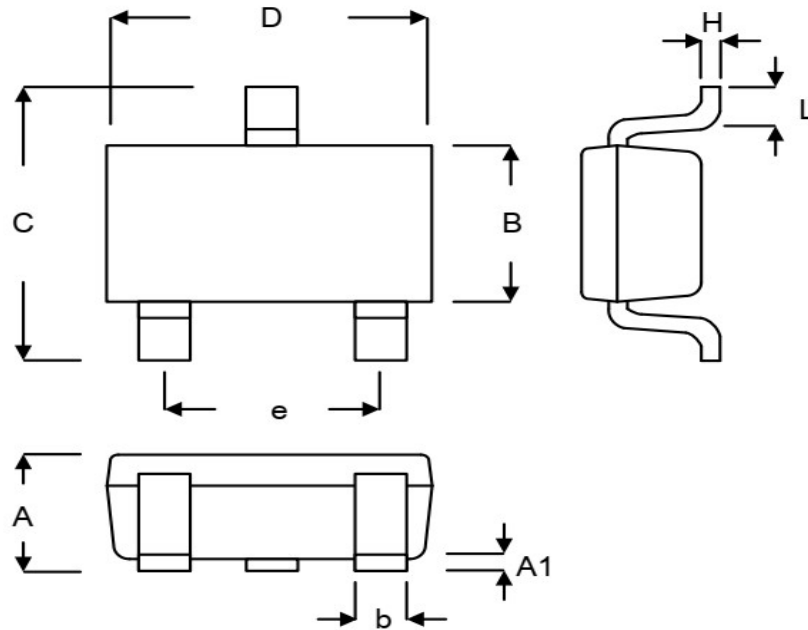
By placing input and output capacitors on the same side of the PCB as the LDO, and placing them as close as is practical to the package can achieve the best performance. The ground connections for input and output capacitors must be back to the HCR2416 ground pin using as wide and as short of a copper 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.

**24V, 500mA Low Dropout Voltage Linear Regulator**
**Mechanical Dimensions**

Package: SOT23-3L (M3L)

unit: mm (inch)



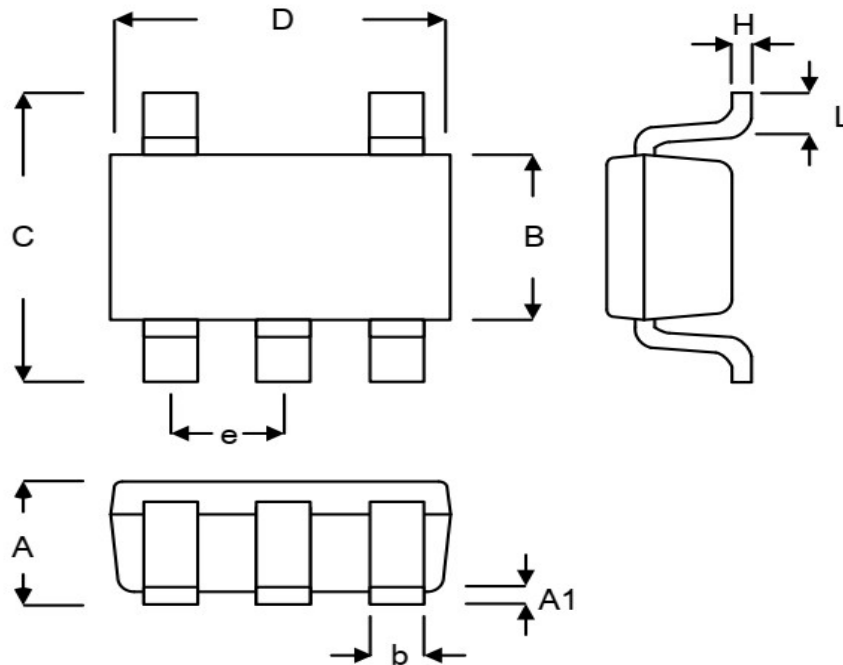
Symbol	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	0.889	1.295	0.035	0.051
A1	0.000	0.152	0.000	0.006
B	1.397	1.803	0.055	0.071
b	0.250	0.560	0.010	0.022
C	2.591	2.997	0.102	0.118
D	2.692	3.099	0.106	0.122
e	1.803	2.007	0.071	0.079
H	0.080	0.254	0.003	0.010
L	0.300	0.610	0.012	0.024

**24V, 500mA Low Dropout Voltage Linear Regulator**

## Mechanical Dimensions(Con.)

Package: SOT23-5 (M5)

unit: mm (inch)



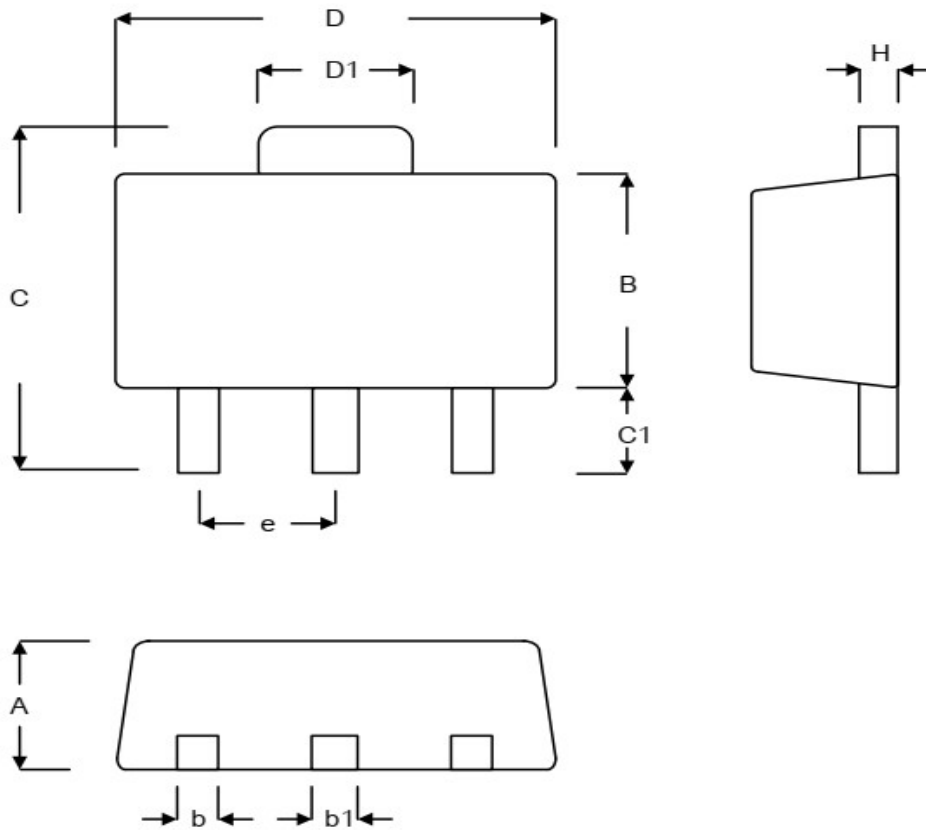
Symbol	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	0.889	1.295	0.035	0.051
A1	0.000	0.152	0.000	0.006
B	1.397	1.803	0.055	0.071
b	0.250	0.560	0.010	0.022
C	2.591	2.997	0.102	0.118
D	2.692	3.099	0.106	0.122
e	0.838	1.041	0.033	0.041
H	0.080	0.254	0.003	0.010
L	0.300	0.610	0.012	0.024

**24V, 500mA Low Dropout Voltage Linear Regulator**

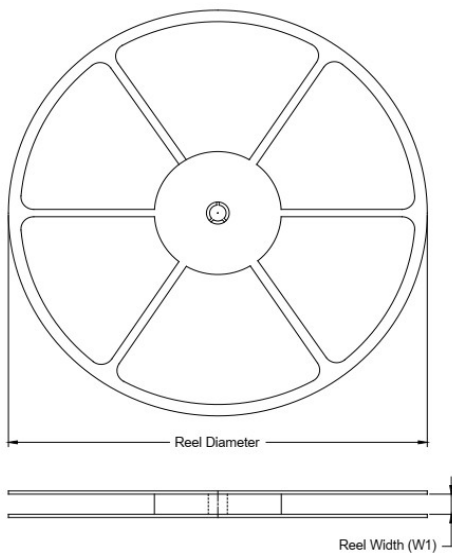
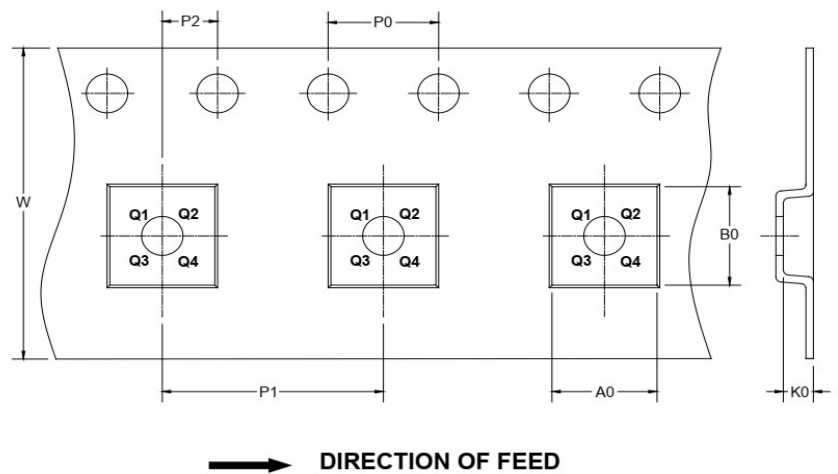
## Mechanical Dimensions(Con.)

Package: SOT89-3 (M2)

unit: mm (inch)



Symbol	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	1.397	1.600	0.055	0.063
b	0.356	0.483	0.014	0.019
B	2.388	2.591	0.094	0.102
b1	0.406	0.533	0.016	0.021
C	3.937	4.242	0.155	0.167
C1	0.787	1.194	0.031	0.047
D	4.394	4.597	0.173	0.181
D1	1.397	1.753	0.055	0.069
e	1.448	1.549	0.057	0.061
H	0.356	0.432	0.014	0.017

**24V, 500mA Low Dropout Voltage Linear Regulator**
**Tape and Reel Information**
**Reel Dimensions**

**Tape Dimensions**


Note: The picture is only for reference. Please make the object as the standard.

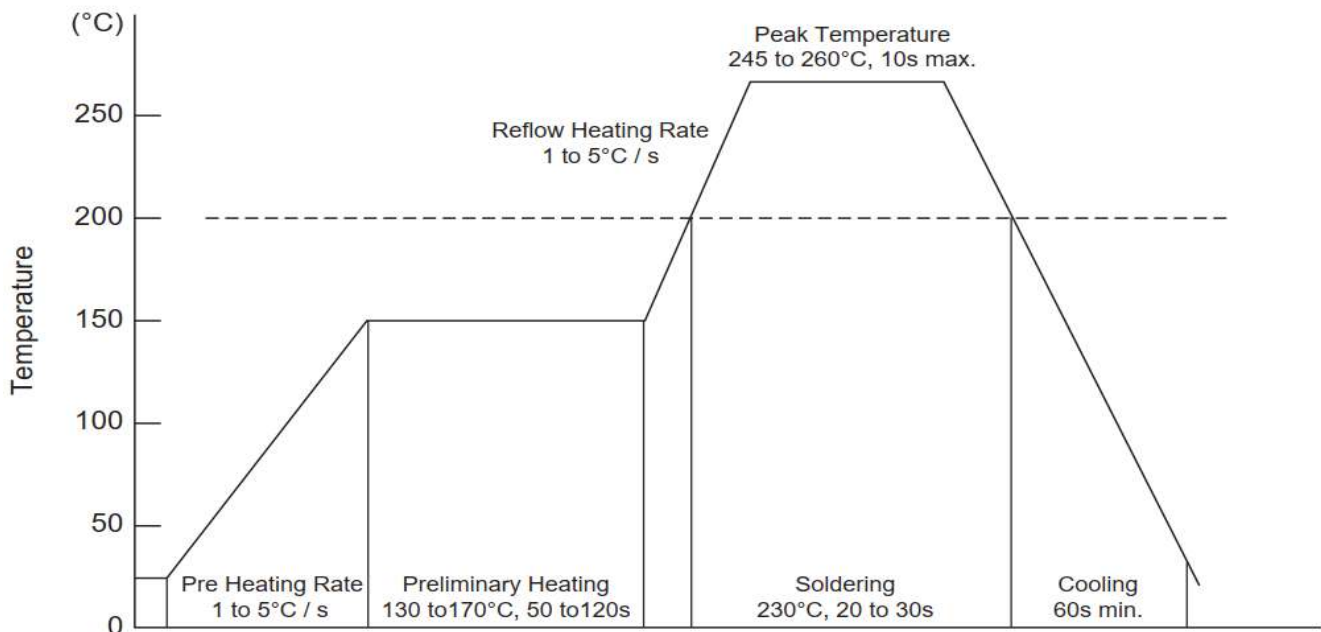
**Key Parameter list of tape and reel**

Package Type	Reel Diameter	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
SOT23-3L	7"	9.5	3.20	3.20	1.40	4.0	4.0	2.0	8.0	Q3
SOT23-5	7"	9.5	3.20	3.20	1.40	4.0	4.0	2.0	8.0	Q3
SOT89-3	7"	13.2	4.85	4.45	1.85	4.0	8.0	2.0	12.0	Q3

## 24V, 500mA Low Dropout Voltage Linear Regulator

### Conditions of Soldering and Storage

#### • Recommended condition of reflow soldering



Recommended peak temperature is over 245°C, if peak temperature is below 245°C, you may adjust the following parameters:

- \* Time length of peak temperature (longer)
- \* Time length of soldering (longer)
- \* Thickness of solder paste (thicker)

#### • Conditions of hand soldering

- \* Temperature : 300°C
- \* Time : 3s max
- \* Times : one time

#### • Storage conditions

- \* Temperature  
5 to 40°C
- \* Humidity  
30 to 80% RH
- \* Recommended period  
One year after manufacturing