CR2402

LDO

Data Sheet

40V 250mA Ultralow-Quiescent-Current LDO General

Version: V1.3

1. General Description

The CR2402 ultra-low quiescent current regulator features low dropout voltage and low current in the standby mode. With less than 1.5μA quiescent current at no load, the CR2402 is ideally suited for standby micro-control-unit systems, especially for always-on applications like E-meters, fire alarms, smoke detectors and other battery operated systems. The CR2402 retains all of the features that are common to low dropout regulators including a low dropout PMOS pass device, short circuit protection, and thermal shutdown.

The CR2402 has a 40-V maximum operating voltage limit, a -40°C to 100°C junction operating temperature range, and ±2% output voltage tolerance. The CR2402 is available in SOT235, SOT893, SOT233 surface mount packages.

2. Ordering Information

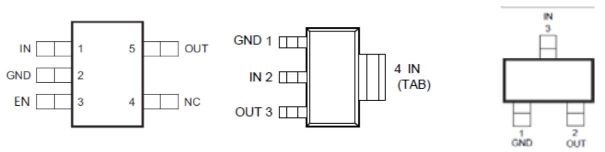
Part Number	Package	XX : Voltage
CR2402_XX_235	SOT23-5	33 : 3.3V 50 : 5.0V
CR2402_XX_893A	SOT89-3	
CR2402_XX_233C	SOT23-3	

3. Features

- VIN Range up to 40V
- Output Voltage Tolerances of ±2%
- Output Current of 250 mA
- Ultra Low Quiescent Current (IQ = 1.5 μA)
- Dropout Voltage Typically 1200 mV at IOUT = 250 mA
- Internal Thermal Overload Protection
- Internal Short-Circuit Current Limit
- Ceramic Capacitor Stable

4. Applications

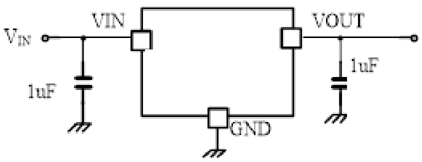
- E-meters, Water Meters and Gas Meters
- Fire Alarm, Smoke Detector
- Appliances and White Goods

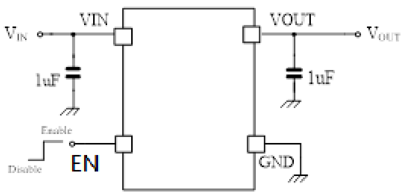


SOT23-5 SOT89-3 SOT23-3

5. Pin Configuration

6. Typical Application Circuit



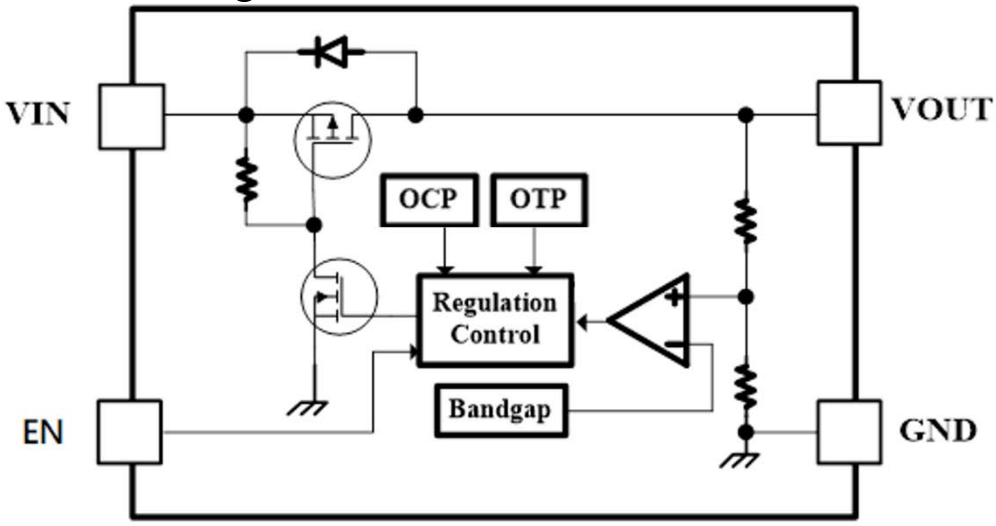


7. List of Contents

8. Pin Assignment

Pin Name	Pin No. SOT235	Pin No. SOT893	Pin Function
VOUT	5	3	Output Voltage Pin
GND	2	1	Ground
VIN	1	2	Input Voltage pin.
EN	3	--	Enable

9. Function Block Diagram



10. Absolute Maximum Ratings (Note1)

- V_{IN} -- -0.3V to +45V
- V_{EN} -- -0.3V to V_{IN}
- V_{OUT} -- -0.3V to +6V
- Power Dissipation, PD@T_A=25°C, SOT23-5---0.4W
- Thermal Resistance, θ_{JA}, SOT23-5--250°C/W
- Power Dissipation, PD@T_A=25°C, SOT89-3---1.8W
- Thermal Resistance, θ_{JA}, SOT89-3---55°C/W
- Junction Temperature-- 125°C
- Lead Temperature (Soldering, 10 sec.)-- 300°C
- Storage Temperature -- –65°C to 150°C

11. Recommended Operating Conditions

- Input Voltage, V_{IN} -- +2.7V to +40V
- Junction Temperature -- -40°C to 100°C
- Ambient Temperature-- -40°C to 85°C

12. Electrical Characteristics

V_{IN}=12V, I_{OUT}=1mA, C_{IN}=C_{OUT}=1uF, T_J=25°C, unless otherwise specified

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Output Voltage	V_{OUT}		-2%		2%	V
Line Regulation	$\triangle V_{LINE}$	V_{IN}=V_{OUT} + 1V to 40V, V_{OUT}=3.3V		0.06	0.36	%
Load Regulation	$\triangle V_{LOAD}$	I_{OUT}= 1mA to 100mA, V_{IN}=V_{OUT}+2V, V_{OUT}=3.3V		0.60	0.90	%
		I_{OUT}= 1mA to 250mA, V_{IN}=V_{OUT}+2V, V_{OUT}=3.3V		1.5	2.42	
Dropout Voltage	V_{DROP}	I_{OUT}=100mA, V_{OUT}=3.3V		400		mV
		I_{OUT}=250mA V_{OUT}=3.3V		1200		mV
Quiescent Current	I_Q	T_J= 25°C		1.5	4.0	uA
Current Limit	I_{CL}		270	340		mA
Enable high level	V_{ENHI}		0.9			V
Enable low level	V_{ENLO}				0.4	V
Enable pin pull high current	I_{EN}			0.1		uA
Thermal Shutdown	T_{SD}			140		°C
Thermal Shutdown Hysteresis	T_{HY}			20		°C

13. Typical Characteristics

V_{IN}=12V, I_{OUT}=1mA, V_{OUT}=3.3V, C_{IN}=C_{OUT}=1uF, T_J=25℃, unless otherwise specified

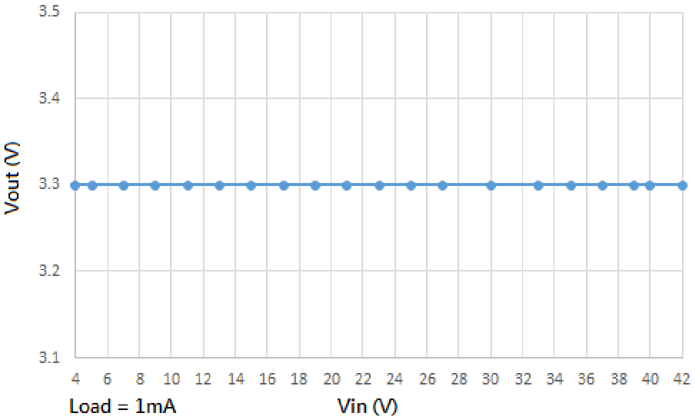


Fig 1. Vout vs Vin

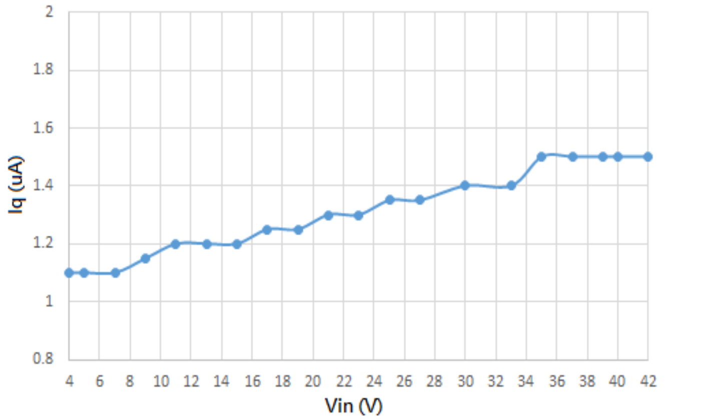


Fig 2. Iq vs Vin

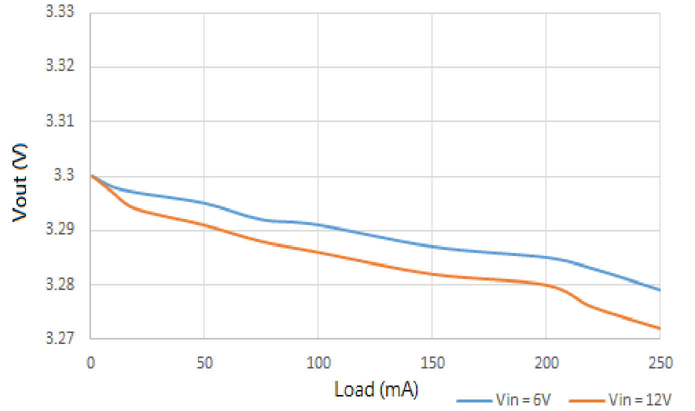


Fig 3. Vout vs Load

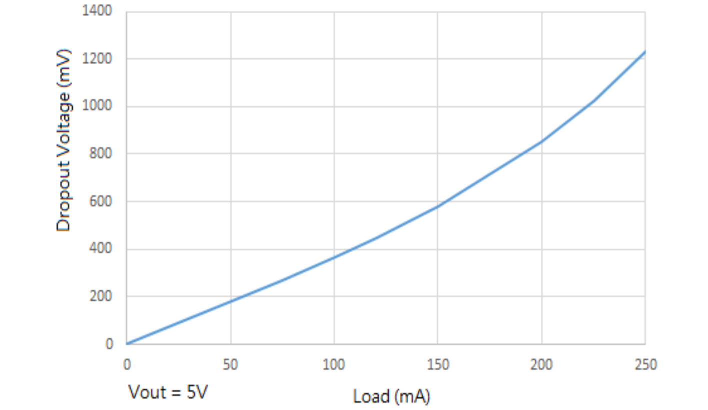


Fig 4. Dropout vs Load

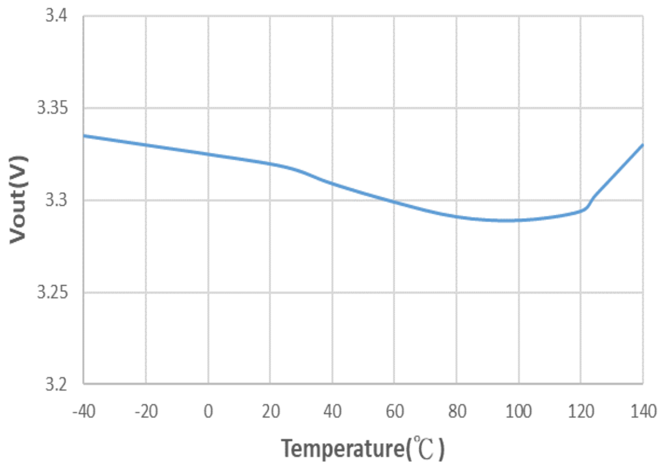


Fig 5. Vout (3.3V) vs Temperature

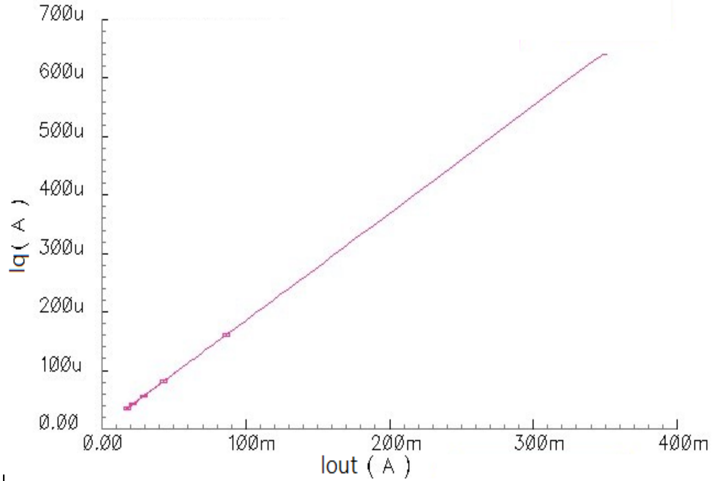
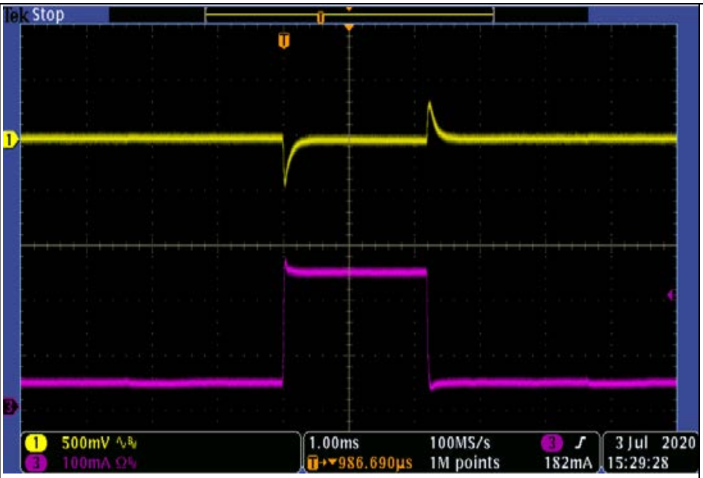
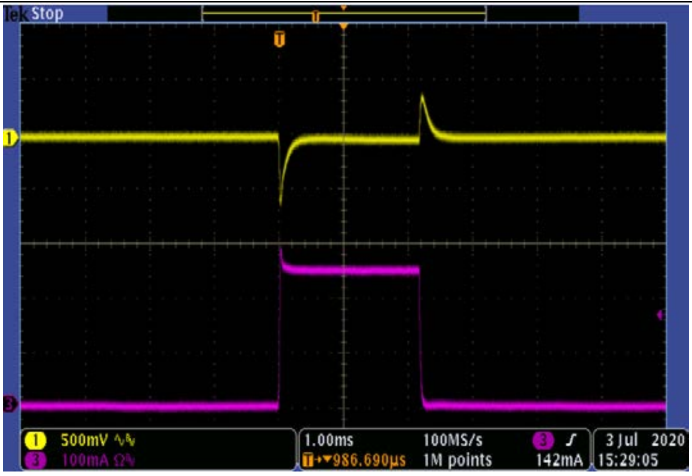


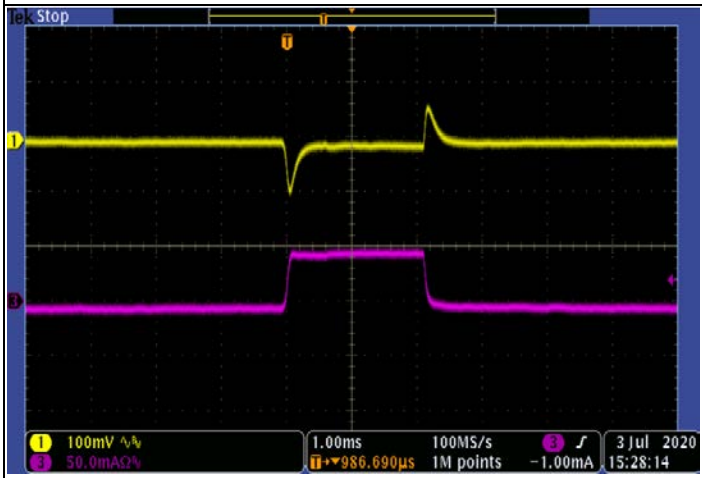
Fig 6. Iq vs Load



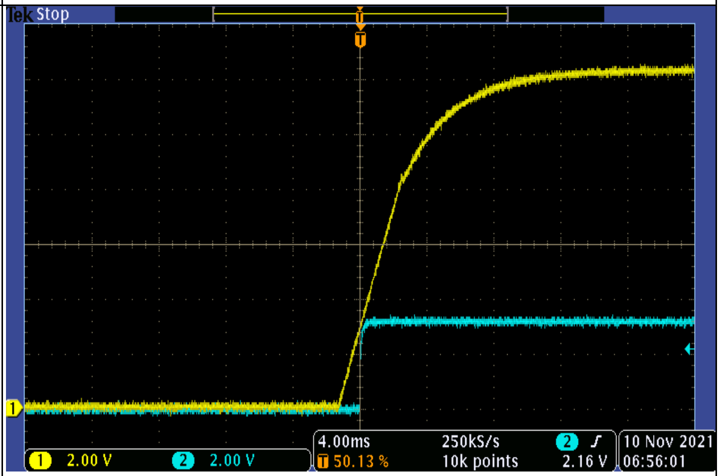
CH1: V_{OUT}, CH3: I_{OUT}
Fig 7. Vout Load Transient (50 to 250mA)



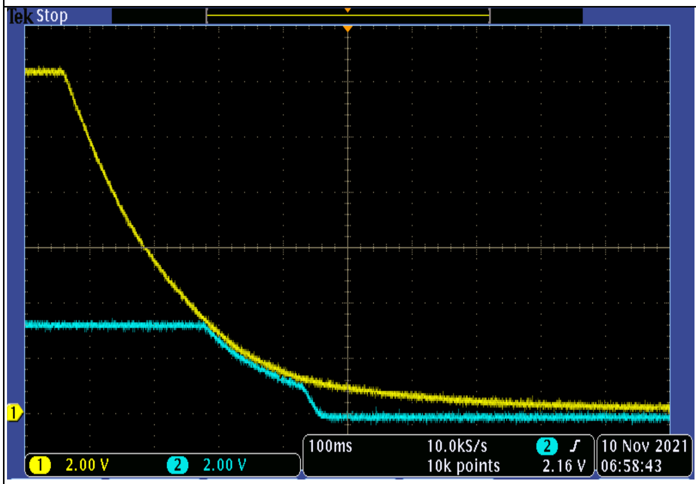
CH1: V_{OUT}, CH3: I_{OUT}
Fig 8. Vout Load Transient (1 to 250mA)



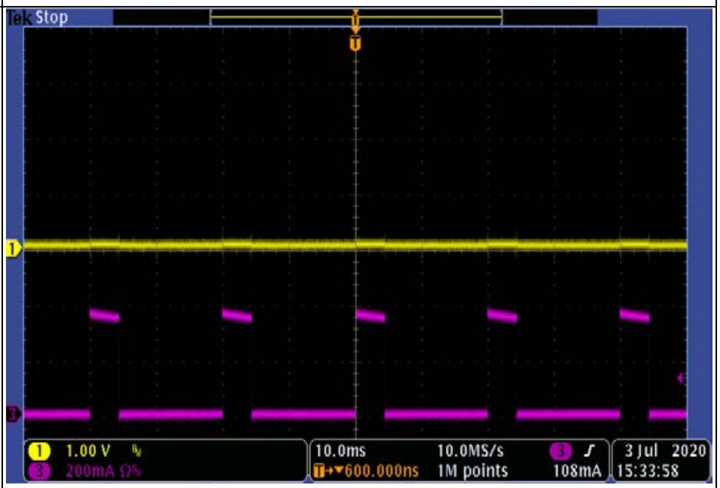
CH1: V_{OUT}, CH3: I_{OUT}
Fig 9. Vout Load Transient (0 to 50mA)



CH1: V_{IN}, CH2: V_{OUT}
Fig 10. Vin Start up



CH1: V_{IN}, CH2: V_{OUT}
Fig 11. Vin power off



CH1: V_{OUT}, CH3: I_{OUT}
Fig 12. Vout Short to GND

14. IC Operation Information

14.1. Basic Operation

The CR2402 is a high input voltage linear regulator specifically designed to minimize external components. The input voltage range is from 2.7V to 36V. The minimum required output capacitance for stable operation is 1μF effective capacitance after consideration of the temperature and voltage coefficient of the capacitor.

14.2. Enable and Shutdown Operation

The CR2402 goes into shutdown mode when the EN pin is in a logic low condition. In this condition, the pass transistor, error amplifier, and bandgap are all turned off, reducing the supply current to only 0.1uA (max.). If the shutdown mode is not required, the EN pin can be directly tied to VIN pin to keep the LDO on.

14.3. Over-Temperature Protection (OTP)

The over-temperature protection function will turn off the P-MOSFET when the junction temperature exceeds 140℃ (typ.). Once the junction temperature cools down by approximately 20℃ (typ.), the regulator will automatically resume operation.

14.4. Current-limit Protection

The CR2402 provides current limit function to prevent the device from damages during overload or shorted-circuit condition. This current is detected by an internal sensing transistor.

14.5. Error Amplifier

The Error Amplifier compares the internal reference voltage with the output feedback voltage from the internal divider, and controls the Gate voltage of P-MOSFET to support good line regulation and load regulation at output voltage.

15. IC Application Information

Like any low dropout linear regulator, the CR2402's external input and output capacitors must be properly selected for stability and performance. Use a 1μF (X5R or X7R) 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 larger than 1μF (X5R or X7R) 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.

15.1. Enable Operation

The CR2402 has an EN pin to turn on or turn off the regulator, When the EN pin is in logic high, the regulator will be turned on. The shutdown current is almost 0μA typical. The EN pin may be directly tied to V_{IN} to keep the part on. The Enable input is CMOS logic and cannot be left floating.

15.2. Current Limit

The CR2402 contains an independent current limiter, which monitors and controls the pass transistor's gate voltage, limiting the output current to 0.34A (typ.). The output can be shorted to ground indefinitely without damaging the part.

15.3. Dropout Voltage

The dropout voltage refers to the voltage difference between the VIN and VOUT pins while operating at specific output current. The dropout voltage V_{DROP} can also be expressed as the voltage drop on the pass-FET at specific output current (I_{RATED}) while the pass-FET is fully operating at ohmic region and the pass-FET can be characterized as an resistance $R_{DS(ON)}$. Thus the dropout voltage can be defined as ($V_{DROP} = V_{VIN} - V_{VOUT} = R_{DS(ON)} \times I_{RATED}$). For normal operation, the suggested LDO operating range is ($V_{VIN} > V_{VOUT} + 2V$) for good transient response and PSRR ability. Conversely, operating at the ohmic region will degrade these performance severely.

15.4. Minimum Operating Input Voltage (VIN)

The CR2402 does not include any dedicated UVLO circuitry. The CR2402 at least 2.7V. The output voltage is not regulated until VIN has reached at least the greater of 2.7 V or

(VOUT + 2V)

15.5. Thermal Considerations

For continuous operation, do not exceed 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 by the following formula :

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

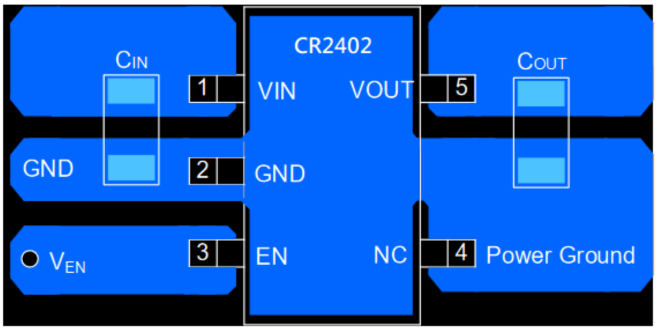
$P_{D(MAX)} = (T_{J(MAX)} - T_A) / \theta_{JA}$ where $T_{J(MAX)}$ is the maximum junction temperature, T_A is the ambient temperature, and θ_{JA} is the junction to ambient thermal resistance. For recommended operating condition specifications the maximum junction temperature is 125°C and T_A is the ambient temperature. The junction to ambient thermal resistance, θ_{JA}, is layout dependent. For SOT893 package, the thermal resistance, θ_{JA}, is 55°C/W on a two-layer Chip1 evaluation board. For SOT235 package, the thermal resistance, θ_{JA}, is 250°C/W on a standard JEDEC 51-7 four-layer thermal test board. The maximum power dissipation at T_A = 25°C can be calculated by the following formula :

$P_{D(MAX)}$ = (125°C − 25°C) / (55°C/W) = 1.8W for SOT893 package

$P_{D(MAX)}$ = (125°C − 25°C) / (250°C/W) = 0.4W for SOT235 package The maximum power dissipation depends on the operating ambient temperature for fixed $T_{J(MAX)}$ and thermal resistance, θ_{JA}. The derating curve in Figure(below) allows the designer to see the effect of rising ambient temperature on the maximum power dissipation.

15.6. Layout Considerations

The dynamic performance of the CR2402 is dependent on the layout of the PCB. PCB layout practices that are adequate for typical LDOs may degrade the PSRR, noise, or transient performance of the CR2402. Best performance is achieved by placing CIN and COUT on the same side of the PCB as the CR2402, and as close to the package as possible is practical. The ground connections for C_{IN} and C_{OUT} must be back to the CR2402 ground pin using a copper trace as wide and short as possible. Connections using long trace lengths, narrow trace widths, and/or connections through vias must be avoided. These added parasitic inductances and resistance may result in inferior performance especially during transient conditions.

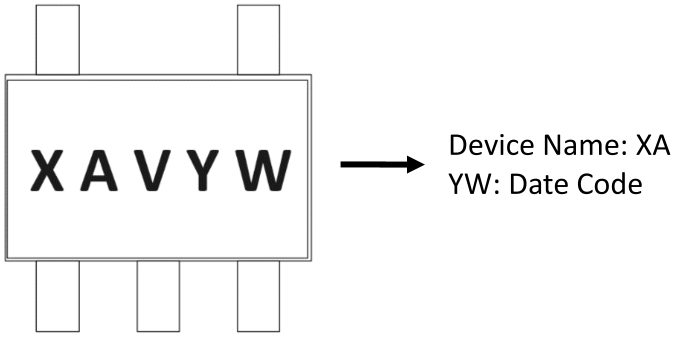


GND Pin (2) connect to second layer ground path by Via to increase cooling area directly.

SOT-23-5

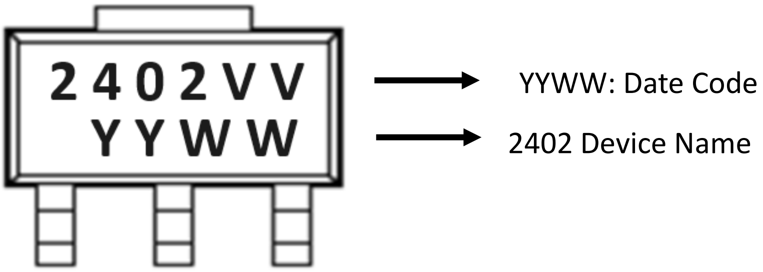
16. Ordering & Marking Information

Device Name: CR2402 for SOT23-5

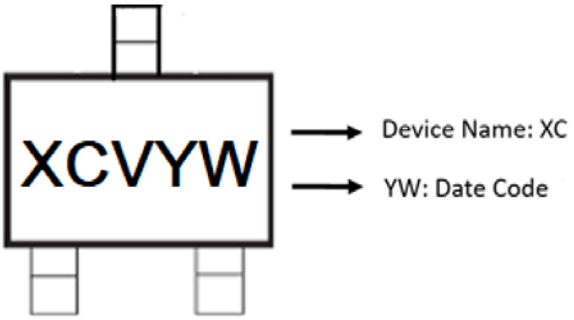


V	Output Voltage
3	3.3V
5	5V

Device Name: CR2402 for SOT89-3



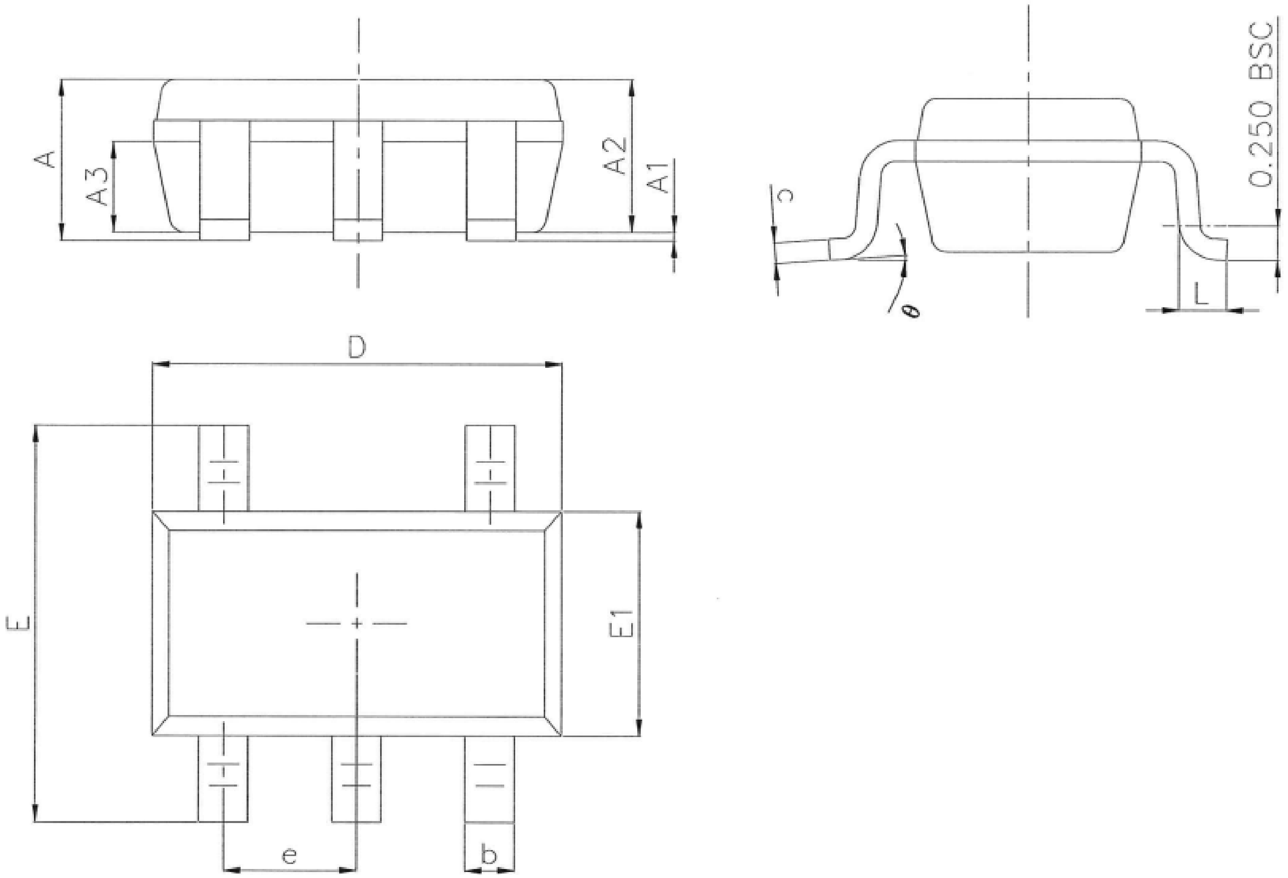
VV	Output Voltage
33	3.3V
50	5V



V	Output Voltage
3	3.3V
5	5V

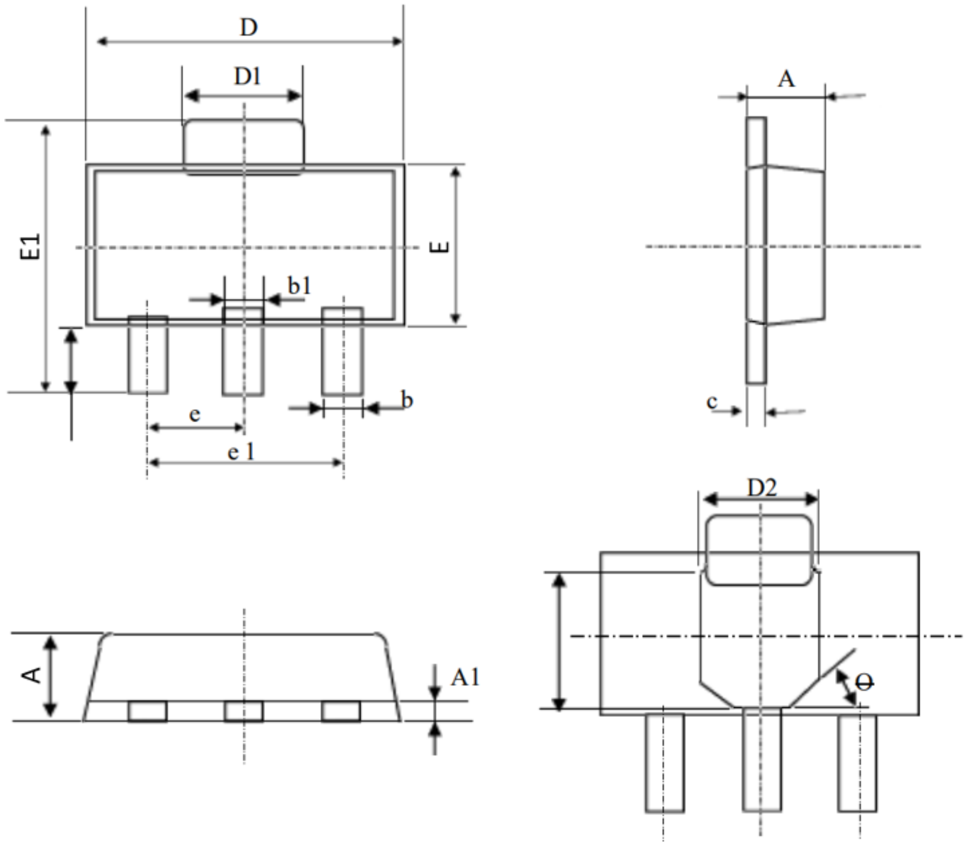
17. Package Information

17.1. SOT23-5



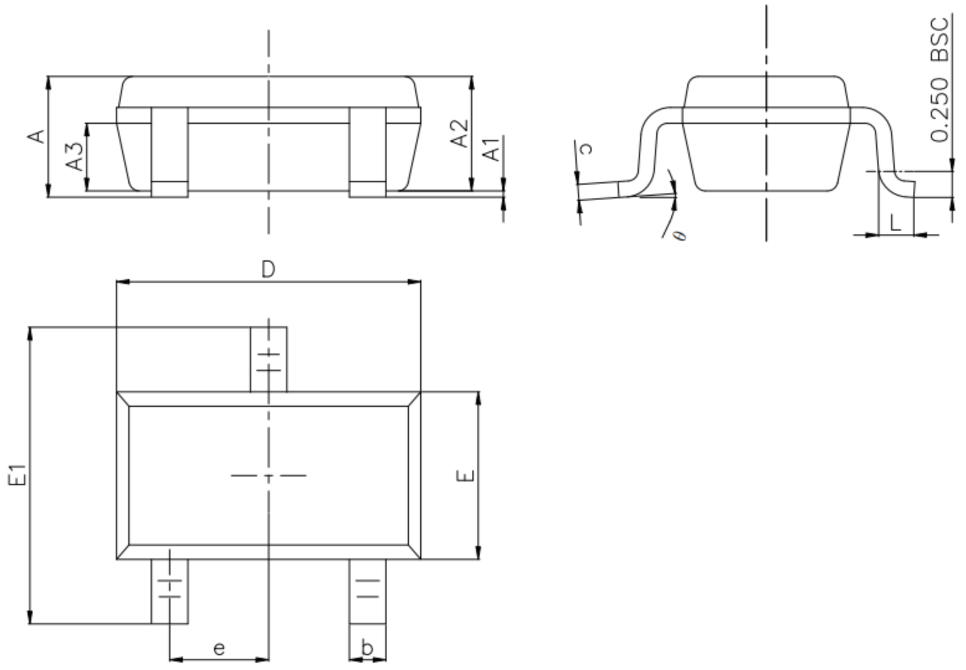
Symbol	Dimension in mm			Dimension in inch		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	1.050	1.150	1.250	0.041	0.045	0.049
A1	0.000	0.060	0.100	0.000	0.002	0.004
A2	1.000	1.100	1.200	0.039	0.043	0.047
A3	0.550	0.650	0.750	0.022	0.026	0.030
D	2.820	2.920	3.020	0.111	0.115	0.119
E	2.650	2.800	2.950	0.104	0.110	0.116
E1	1.510	1.610	1.700	0.059	0.063	0.067
b	0.300	0.400	0.500	0.012	0.016	0.020
e	0.95BSC			0.037BSC		
θ	0°	4°	8°	0°	4°	8°
L	0.300	0.420	0.570	0.012	0.017	0.022
c	0.100	0.152	0.200	0.004	0.006	0.008

17.2. SOT89-3



Symbol	Dimension in mm			Dimension in inch		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	1.400	1.500	1.600	0.055	0.059	0.063
A1	0.300	0.400	0.500	0.012	0.016	0.020
L	0.800	1.000	1.200	0.031	0.039	0.047
b	0.350	0.400	0.450	0.014	0.016	0.018
b1	0.400	0.480	0.550	0.016	0.019	0.022
c	0.300	0.400	0.500	0.012	0.016	0.020
D	4.400	4.500	4.600	0.173	0.177	0.181
D1	1.600	1.700	1.800	0.063	0.067	0.071
D2	1.720			0.068		
E	2.400	2.500	2.600	0.094	0.098	0.102
E1	3.940	4.100	4.250	0.155	0.161	0.167
E2	1.900			0.075		
e	1.500			0.059		
e1	3.000			0.118		
θ	45°			45°		

17.3. SOT23-3



Symbol	Dimension in mm			Dimension in inch		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	1.050	1.150	1.250	0.041	0.045	0.049
A1	0.000	0.060	0.100	0.000	0.002	0.004
A2	1.000	1.100	1.200	0.039	0.043	0.047
A3	0.550	0.650	0.750	0.022	0.026	0.030
D	2.820	2.920	3.020	0.111	0.115	0.119
E1	1.510	1.610	1.700	0.059	0.063	0.067
E	2.650	2.800	2.950	0.104	0.110	0.116
b	0.300	0.400	0.500	0.012	0.016	0.020
e	0.950BSC			0.037BSC		
θ	0°	4°	8°	0°	4°	8°
L	0.300	0.420	0.570	0.012	0.017	0.022
c	0.100	0.152	0.200	0.004	0.006	0.008

18. Revision History

Rev	Descriptions	Date
V1.1	Initial version preliminary released	2024/08/26
V1.2	1. Add Revision History table 2. Modify the errors in the minimum, maximum, and nominal dimensions. 3. Correct the order errors of dimensions **E1** and **E**.	2024/11/08
V1.3	1. Add SOT23-3 &SOT89-3 package and related information. 2. Correct the error in voltage labeling in the ordering information. 3. Update document Layout Configuration	2024/11/27

19. Disclaimers

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