

2 μ A, 300mA Low Dropout Voltage Linear Regulator

General Description

The RT9078 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 μ 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 100nA (typical).

The RT9078 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 300mA).

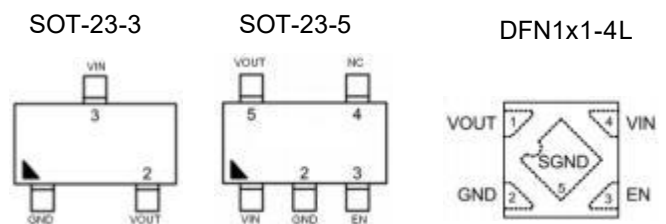
Features

- 2 μ A Ground Current at no Load
- $\pm 2\%$ Output Accuracy
- 300mA Output Current
- 100nA Disable Current (by option)
- Wide Operating Input Voltage Range: 1.2V to 5.5V
- Dropout Voltage: 0.36V at 300mA / V_{OUT} 3.3V
- Support Fixed Output Voltage 1.2V, 1.5V, 1.6V, 1.8V, 1.85V, 2.5V, 2.8V, 3.0V, 3.3V
- Stable with Ceramic or Tantalum Capacitor
- Current Limit Protection
- Over-Temperature Protection
- SOT-23-3 , SOT-23-5 , DFN1x1-4LPackages Available

Applications

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

Pin Configurations



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Ordering Information

RT9078-XX

Description	Symbol	Description	Marking	Marking	Marking
Output Voltage	12	V _{OUT} = 1.2V	RT9078-12GJ5=CX12T	RT9078-12GJ3=65BX	RT9078-12GJ4=2812
	15	V _{OUT} = 1.5V	RT9078-15GJ5=CX15T	RT9078-15GJ3=65E9	RT9078-15GJ4=2815
	18	V _{OUT} = 1.8V	RT9078-18GJ5=21183T	RT9078-18GJ3=65K5	RT9078-18GJ4=2718
	1H	V _{OUT} = 1.85V	RT9078-1HGJ5=AAAI		
	25	V _{OUT} = 2.5V	RT9078-25GJ5=CX25T	RT9078-25GJ3=65T5	RT9078-25GJ4=B5X
	28	V _{OUT} =2.8V	RT9078-28GJ5=CX28T	RT9078-28GJ3=54FK	RT9078-28GJ4=B8X
	30	V _{OUT} =3.0V	RT9078-30GJ5=CX30T	RT9078-30GJ3=65Z5	RT9078-30GJ4=B0X
	33	V _{OUT} =3.3V	RT9078-33GJ5=23333L	RT9078-33GJ3=662K	RT9078-33GJ4=2833
Package type	GJ3	SOT-23-3			
	GJ5	SOT-23-5			
	GJ4	DFN1x1-4L			

 RT9078-12GJ5 (For SOT-23-5 with **SNS** pin)

Description	Symbol	Description
Output Voltage	12	V _{OUT} = 1.2V
Package type	GJ5	SOT-23-5

 Notes : V_{OUT} = (R1 + R2) / R2 X 1.2V , And **R2 < 24K Ω** .

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Description of Functional Pins

RT9078

Pin No				Pin Name	Pin Function
SOT-23-3	SOT-23-5	DFN1x1	DFN2x2		
1	2	2	3	GND	Ground
2	5	1	1	VOUT	Output of the Regulator
3	1	4	6	VIN	Input of Supply Voltage.
	3	3	4	EN	Enable Control Input.
	4		2,5	NC	No internal connection
		Exposed Pad	Exposed Pad	SGND	Substrate of Chip. Leave floating or tie to GND.

RT9078 (For SOT-23-5 with **SNS** pin)

Pin No	Pin Name	Pin Function
SOT-23-5		
1	VIN	Input of Supply Voltage.
2	GND	Ground
3	EN	Enable Control Input.
4	SNS	Sense of Output Voltage.
5	VOUT	Output of the Regulator

Typical Application Circuit

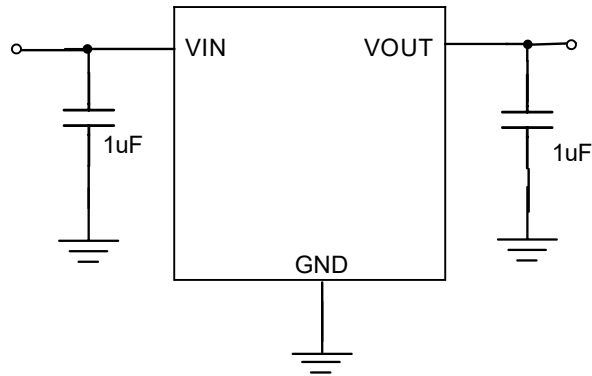


Figure 1: Application circuit of Fixed V_{OUT} LDO

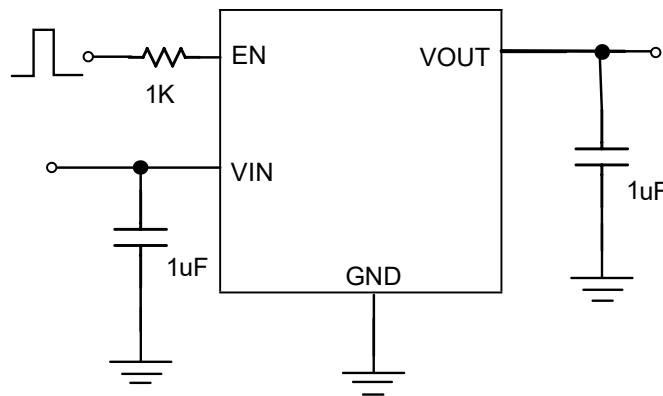


Figure 2: Application circuit of Fixed V_{OUT} LDO with enable function

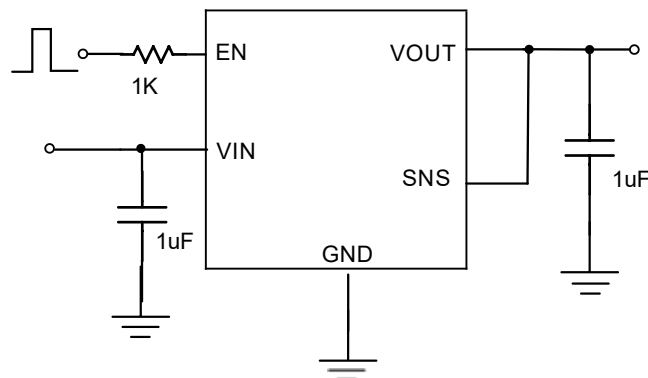


Figure 3: Application circuit of Fixed V_{OUT} LDO with enable and **sense** functions

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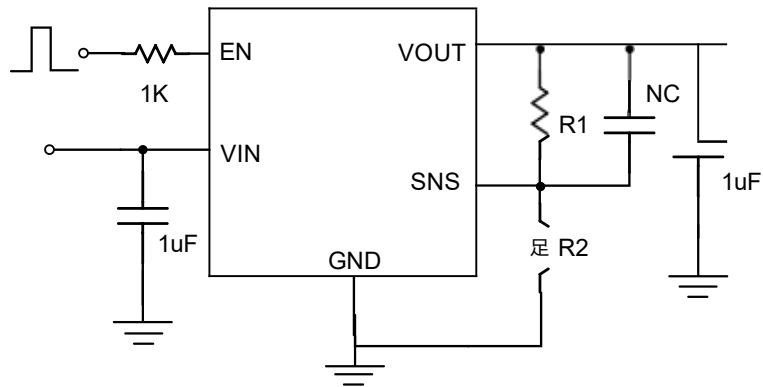
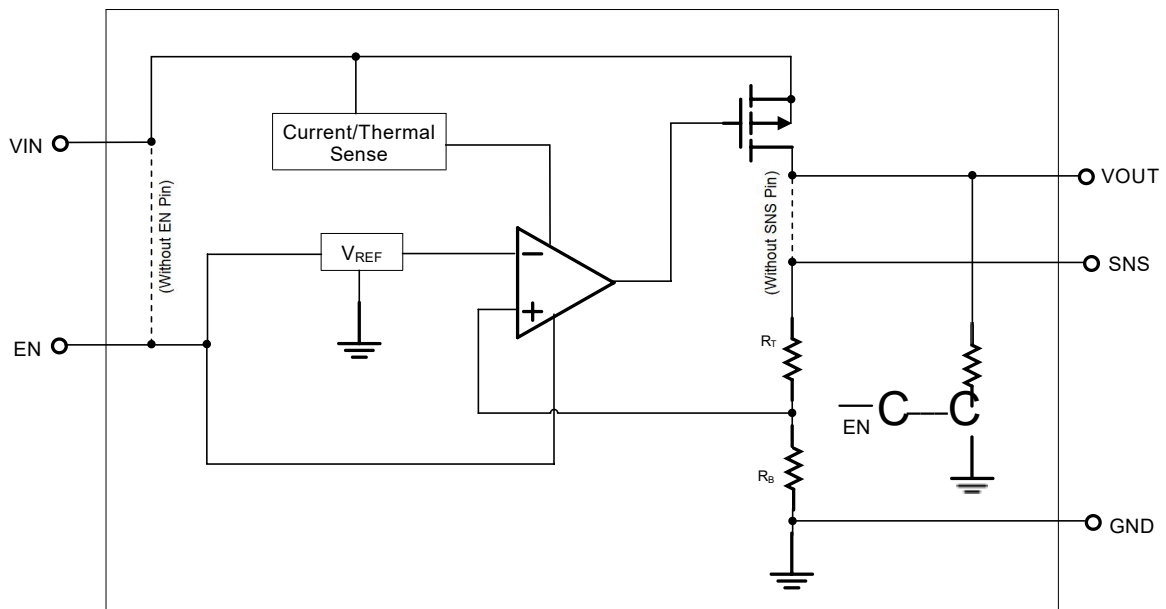


Figure 4: Application circuit of Adjustable V_{OUT} LDO with enable and **sense** functions

Function Block Diagram



2 μ A, 300mA Low Dropout Voltage Linear Regulator

Absolute Maximum Ratings (Note 1)

VIN to GND -----	-0.3V to 7V
VOUT, EN to GND -----	0.3V to 6V
VOUT to VIN -----	6V to 0.3V
Package Thermal Resistance (Note 2)	
SOT-23-5, SOT-23-3, θ_{JA} -----	200 °C /W
DFN1x1-4L, θ_{JA} -----	195 °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

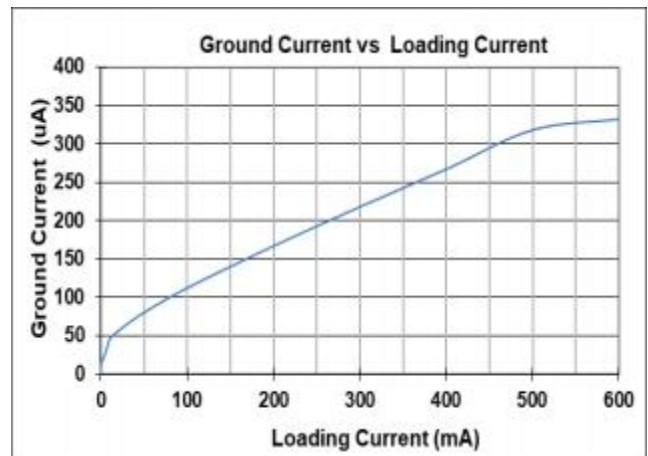
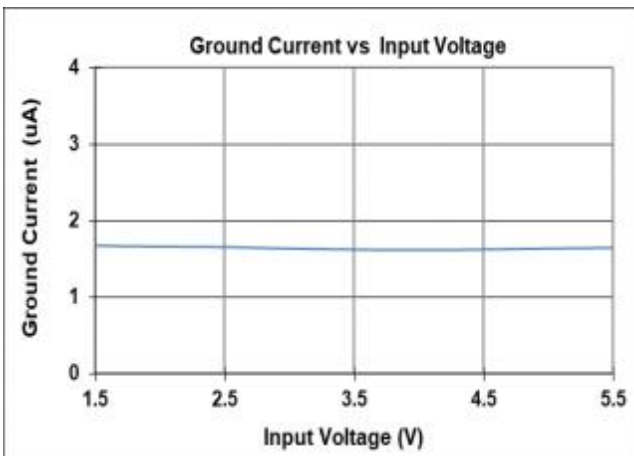
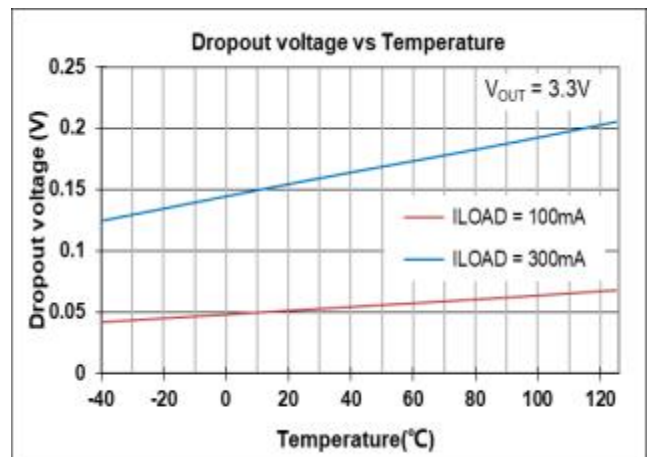
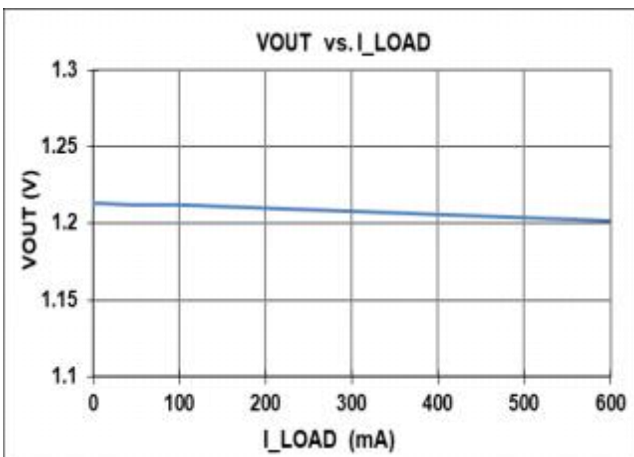
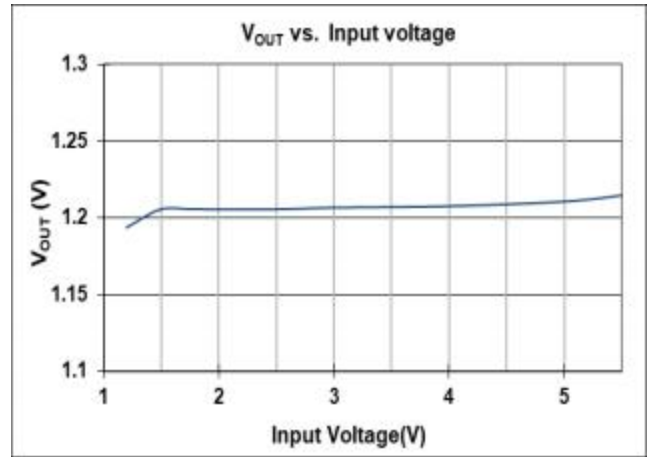
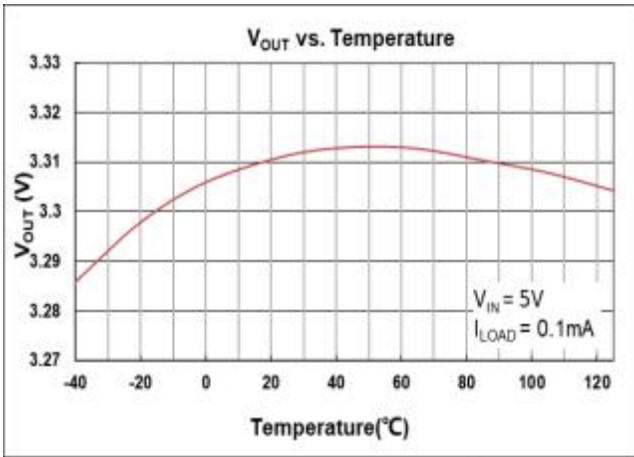
2 μ A, 300mA Low Dropout Voltage Linear Regulator

Electrical Characteristics

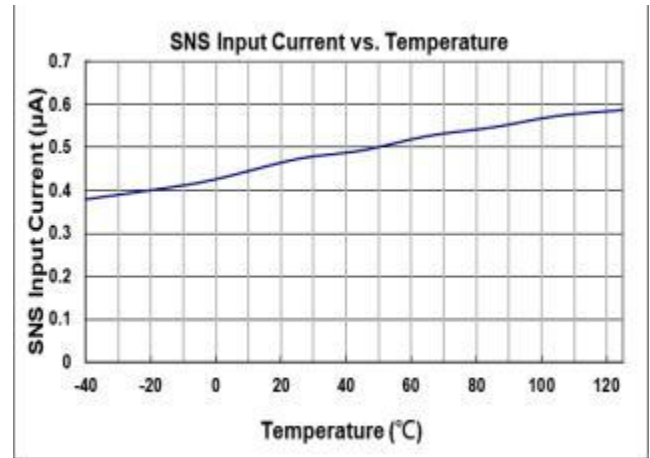
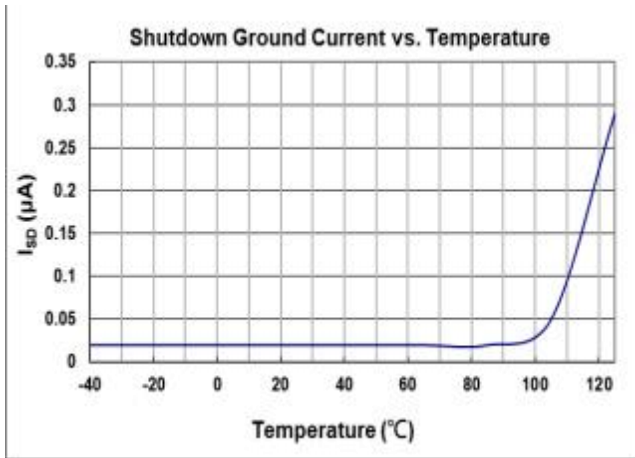
($V_{IN} = 5V$, $V_{EN} = 5V$ $T_A = 25^\circ C$ unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit	
Supply Voltage	V_{IN}		1.2	--	5.5	V	
DC Output Voltage Accuracy		$I_{LOAD} = 0.1mA$	-2		2	%	
SNS Input Current	I_{SNS}	$SNS = V_{OUT}$		0.5		μA	
Dropout Voltage ($I_{LOAD} = 300mA$) (Note 3)	V_{DROP_3V}	$V_{OUT} \geq 3V$		0.36		V	
	$V_{DROP_2.8V}$	$V_{OUT} = 2.8V$		0.45			
	$V_{DROP_2.5V}$	$V_{OUT} = 2.5V$		0.45			
	$V_{DROP_1.8V}$	$V_{OUT} = 1.8V$		0.57			
	$V_{DROP_1.5V}$	$V_{OUT} = 1.5V$		0.71			
	$V_{DROP_1.2V}$	$V_{OUT} = 1.2V$		0.9			
Ground Current	I_q	$I_{LOAD} = 0mA$		2		μA	
Shutdown Ground Current	I_{SD}	$V_{EN} = 0V$, $V_{OUT} = 0V$		0.1	0.5	μA	
Enable Threshold Voltage	V_{IH}	EN Rising	1.0			V	
	V_{IL}	EN Falling			0.4		
EN Input Current	I_{EN}	$V_{EN} = 5V$		10	100	nA	
Line Regulation	$\Delta LINE$	$I_{LOAD} = 30mA$, $1.5V \leq V_{IN} \leq 5.5V$ or $(V_{OUT} + 0.2V) \leq V_{IN} \leq 5.5V$		0.2		%	
Load Regulation	$\Delta LOAD$	$10mA \leq I_{LOAD} \leq 0.3A$		0.2		%	
Output Current Limit	I_{LIM}	$V_{OUT} = 0V$	201	300		mA	
Power Supply Rejection Ratio ($I_{LOAD} = 5mA$)	PSRR	$V_{OUT} = 1.2V$, $V_{IN} = 2V$	$f = 100Hz$	--	80	--	dB
			$f = 1kHz$	--	75	--	
Output Voltage Noise (BW = 10Hz to 100kHz, $C_{OUT} = 1\mu F$.)		$V_{IN} = 3.5V$ $I_{LOAD} = 0.1A$	$V_{OUT} = 1.2V$	--	80	--	μV_{RMS}
			$V_{OUT} = 2.8V$	--	120	--	
Thermal Shutdown Temperature	T_{SD}	$I_{LOAD} = 10mA$		--	155	--	$^\circ C$
Thermal Shutdown Hysteresis	ΔT_{SD}			--	15	--	$^\circ C$
Discharge Resistance	R_{DC}	$EN = 0V$, $V_{OUT} = 0.1V$	--	30	--	Ω	

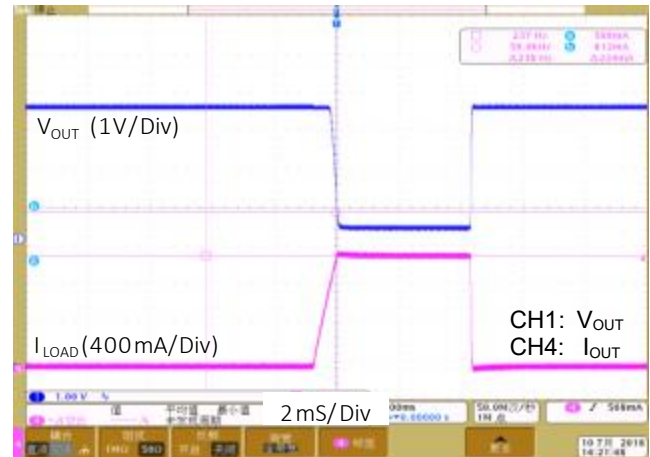
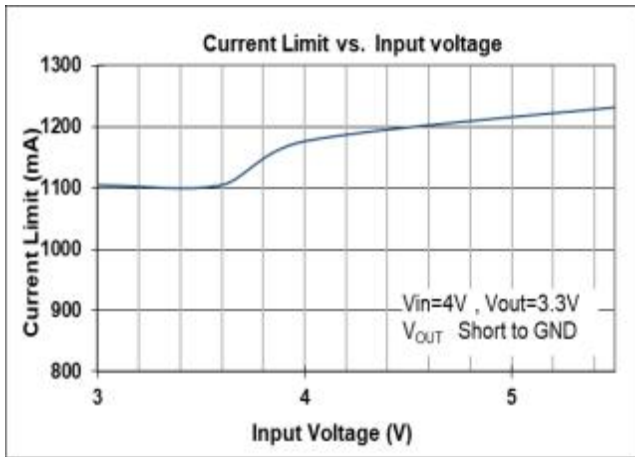
Typical Characteristics



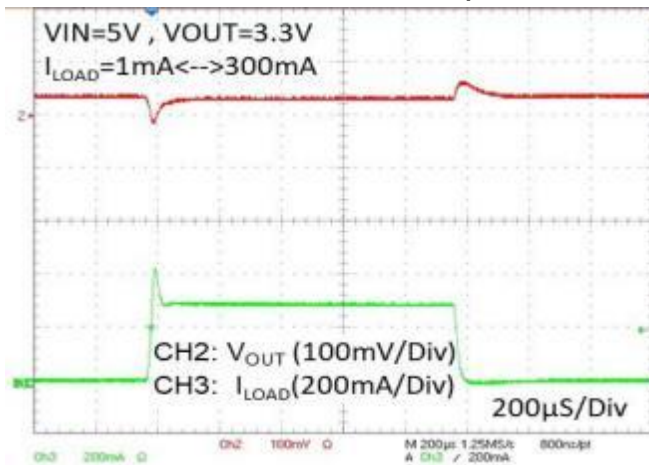
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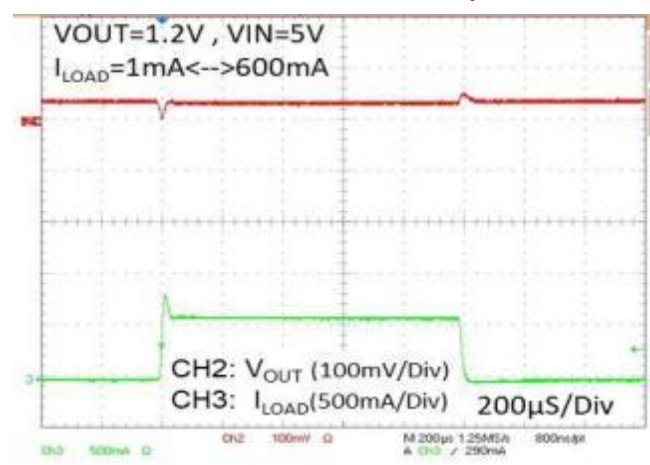
Current Limit Response



Load Transient Response I

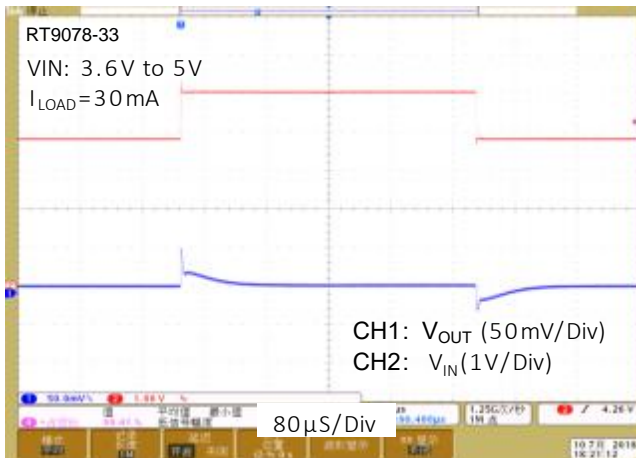


Load Transient Response II

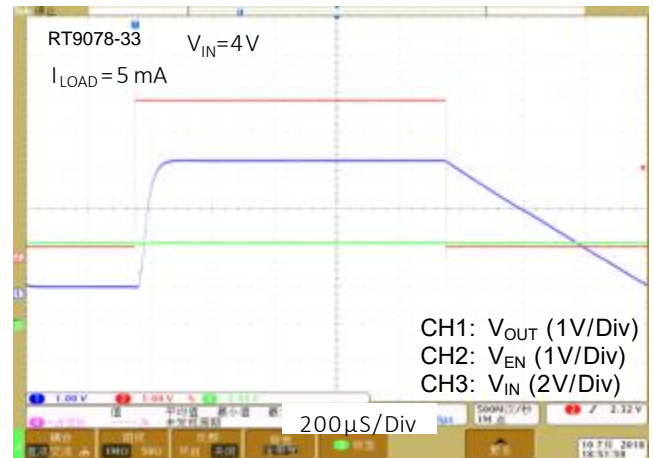


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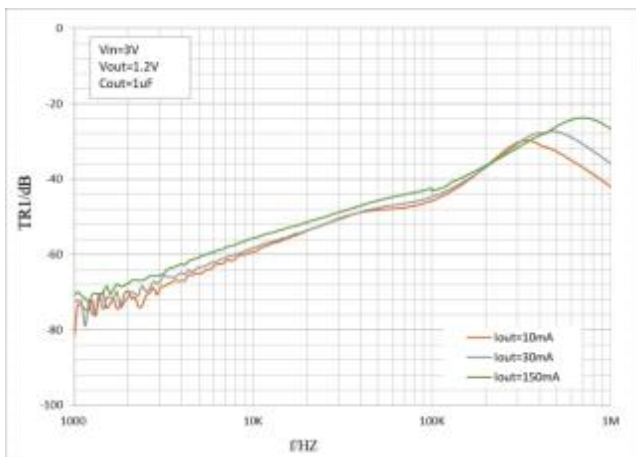
Line Transient Response



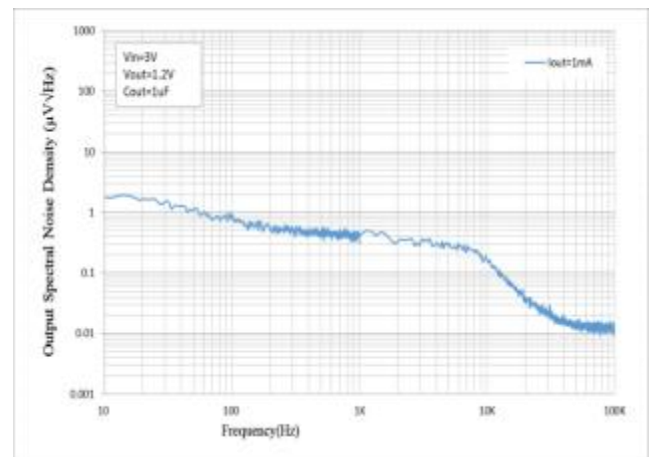
V_{OUT} Turn On/Off by EN



PSRR vs. Frequency



Noise Density Spectrum



Application Guideline

Input and Output Capacitor Requirements

The external input and output capacitors of RT9078 series must be properly selected for stability and performance. Use a 1μF or larger input capacitor and place it close to the IC's V_{IN} 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 V_{OUT} and GND pins. Increasing capacitance and decreasing ESR can improve the circuit's PSRR and line transient response.

Current Limit

The RT9078 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 RT9078 series use a PMOS pass transistor to achieve low dropout. When ($V_{IN} - V_{OUT}$) is less than the dropout voltage (V_{DROPO}), the PMOS pass device is in the linear region of operation and the input-to-output resistance is the $R_{DS(ON)}$ of the PMOS pass element. V_{DROPO} 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 ($V_{IN} - V_{OUT}$) approaches dropout condition.

Adjustable Output Voltage Application

The RT9078 by SNS pin also can work as an adjustable output voltage LDO. Figure 1 gives the connections for the adjustable output voltage application. The resistor divider from V_{OUT} 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_{SNS} is determined by the output voltage selections in the ordering information of RT9078-12 .

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 RT9078 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.

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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:

$T_A=25^{\circ}\text{C}$, DS-Tech PCB,

The max PD (Max) = ($125^{\circ}\text{C} - 25^{\circ}\text{C}$) / (200°C/W) = 0.5W for SOT-23-3 / SOT-23-5 packages.

The max PD (Max) = ($125^{\circ}\text{C} - 25^{\circ}\text{C}$) / (195°C/W) = 0.51W for DFN1x1-4L 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:

$$\text{PD} = (\text{VIN} - \text{VOUT}) \times \text{IOUT}$$

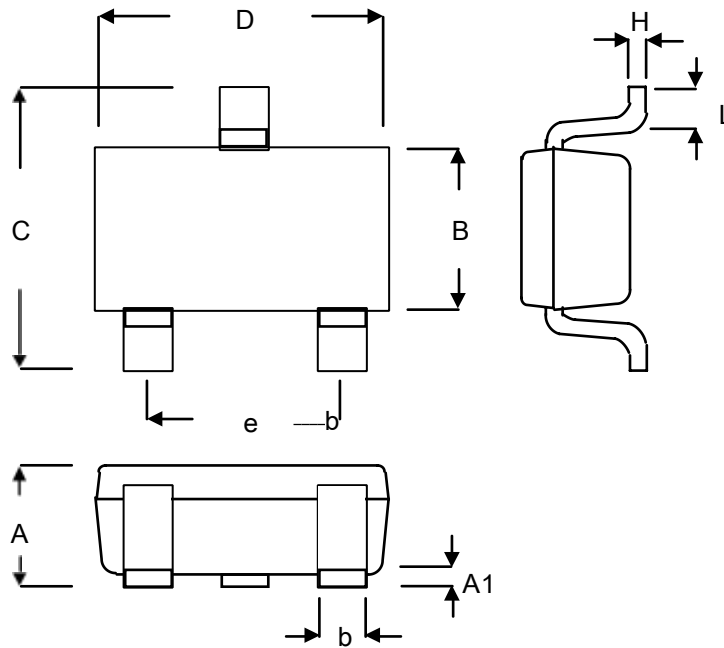
Layout Consideration

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 RT9078 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.

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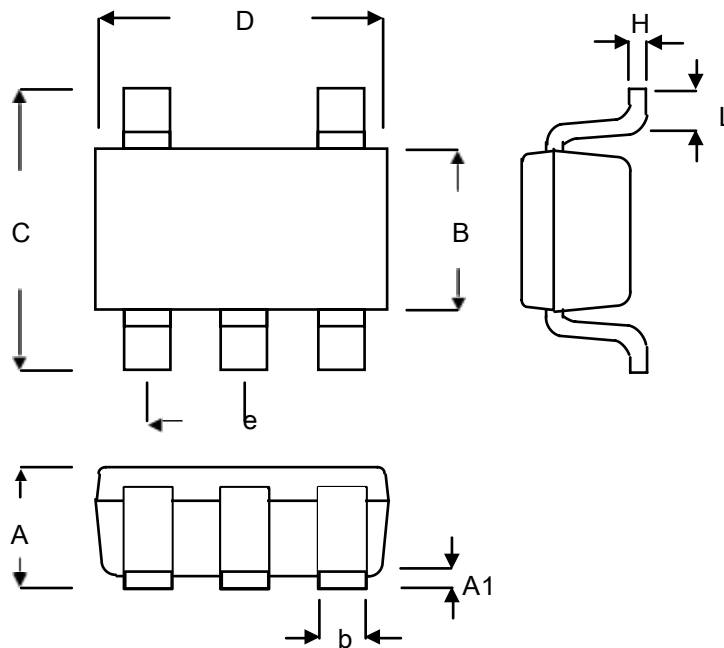
Package Information:



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	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

SOT-23-3L

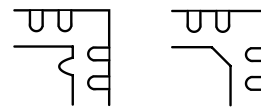
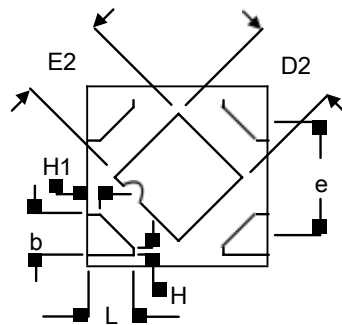
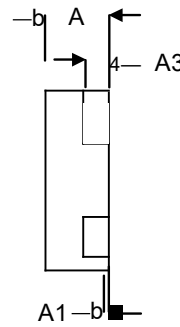
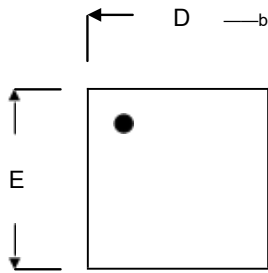
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B	1.397	1.803	0.055	0.071
b	0.250	0.560	0.010	0.022
C	2.591	2.997	0.102	0.118
D	2.692	3.099	0.106	0.122
e	0.838	1.041	0.033	0.041
H	0.080	0.254	0.003	0.010
L	0.300	0.610	0.012	0.024

SOT-23-5L

2 μ A, 300mA Low Dropout Voltage Linear Regulator



DETAILA

PIN #1 ID and Tie Bar Mark Options

Note : The configuration of the Pin #1 identifier is optional , but must be located within the zone indicated.

Symbol	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	0.300	0.400	0.012	0.016
A1	0.000	0.050	0.000	0.002
A3	0.117	0.162	0.005	0.006
b	0.175	0.280	0.007	0.011
D	0.900	1.100	0.035	0.043
D2	0.430	0.550	0.017	0.022
E	0.900	1.100	0.035	0.043
E2	0.430	0.550	0.017	0.022
e	0.650		0.026	
L	0.200	0.300	0.008	0.012
H	0.039		0.002	
H1	0.064		0.003	

DFN1x1-4L