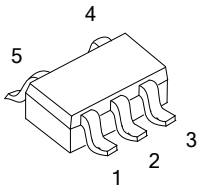
ULTRA LOW NOISE, 150mA LINEAR REGULATOR FOR RF/ANALOG CIRCUITS REQUIRES NO BYPASS CAPACITOR



SOT-25

■ DESCRIPTION

The **LR9500** is a linear regulator capable of supplying 150 mA output current. Designed to meet the requirements of RF/Analog circuits, the **LR9500** device provides low noise, high PSRR, low quiescent current, and low line transient response figures. Using new innovative design techniques the **LR9500** offers class-leading device noise performance without a noise bypass capacitor.

The device is designed to work with 0.47 µF input and output ceramic capacitors. (No Bypass Capacitor is required)

This device is available with 1.5V, 1.8V, 2.0V, 2.5V, 2.7V, 2.8V, 3.0V, 3.3V, 4.0V and 4.5V outputs. Please contact your local sales office for any other voltage options.

■ FEATURES

* Stable with 0.47 µF Ceramic Input and Output Capacitors
* No Noise Bypass Capacitor Required
* Logic Controlled Enable
* Thermal-Overload and Short-Circuit Protection
* −40°C to +125°C Junction Temperature Range for Operation
*Input Voltage Range, 2.5V to 5.5V
*Output Voltage Range, 1.5V to 4.5V
*Output Current, 150 mA
*Low Output Voltage Noise, 6.5 μV_{RMS}
*PSRR, 75 dB at 1 kHz
*Output Voltage Tolerance, ± 2%
*Virtually Zero IQ (Disabled), <1 µA
*Very Low IQ (Enabled), 25 µA
*Startup Time, 150 µs
*Low Dropout, 80 mV (Typ.)

■ ORDERING INFORMATION

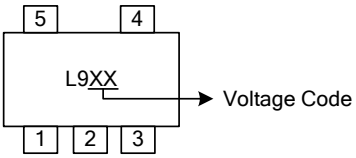
Ordering Number		Package	Packing
Lead Free	Halogen Free		
LR9500L-xx-AF5-R	LR9500G-xx-AF5-R	SOT-25	Tape Reel

Note: xx: Output Voltage, refer to Marking Information.

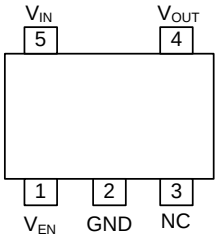
LR9500G-xx-AF5-R

(1)Packing Type	(1) R: Tape Reel
(2)Package Type	(2) AF5: SOT-25
(3)Output Voltage Code	(3) xx: refer to Marking Information
(4)Green Package	(4) G: Halogen Free and Lead Free, L: Lead Free

■ MARKING INFORMATION

PACKAGE	VOLTAGE CODE		MARKING
SOT-25	15: 1.5V 18:1.8V 20: 2.0V 25: 2.5V 27: 2.7V	28: 2.8V 30: 3.0V 33: 3.3V 40: 4.0V 45: 4.5V	

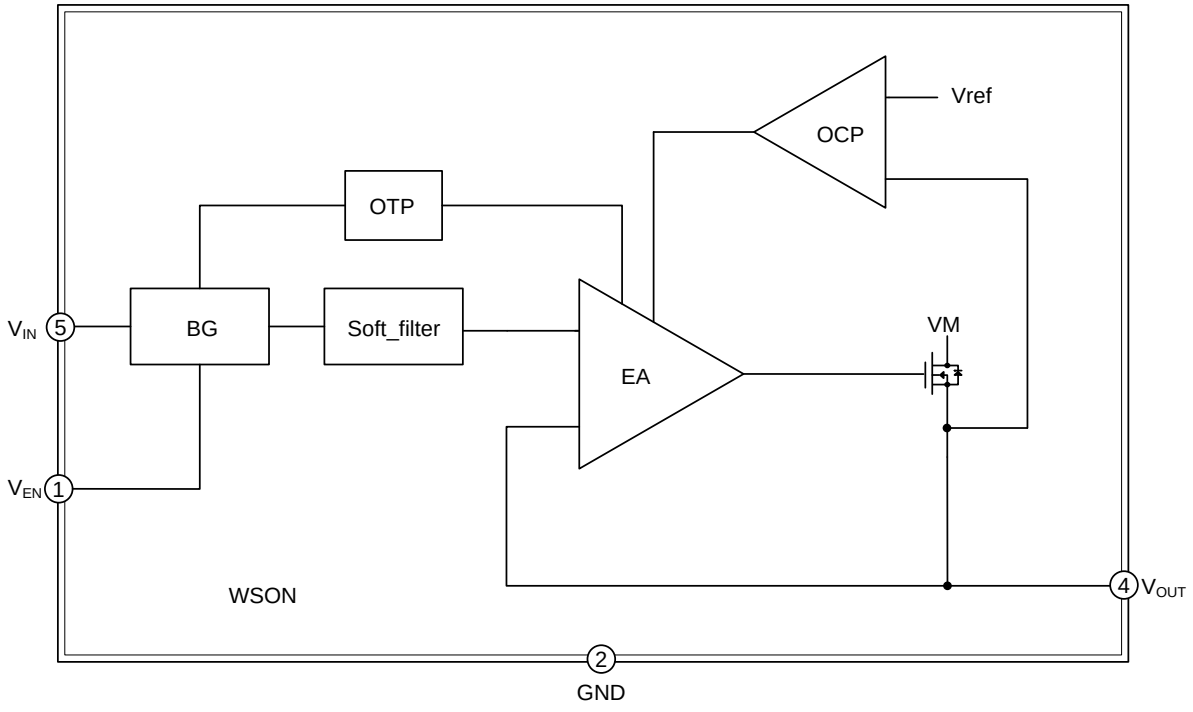
■ PIN CONFIGURATION



■ PIN DESCRIPTION

PIN NO.	PIN NAME	DESCRIPTION
1	V_{EN}	Enable input; disables the regulator when ⩽ 0.4V. Enables the regulator when ⩾ 1.2V. An internal 1 MΩ pulldown resistor connects this input to ground.
2	GND	Device ground
3	NC	No connect
4	V_{OUT}	Output voltage. A 0.47 µF Low ESR capacitor should be connected to this Pin. Connect this output to the load circuit.
5	V_{IN}	Input voltage supply. A 0.47 µF capacitor should be connected at this input.

■ BLOCK DIAGRAM



■ ABSOLUTE MAXIMUM RATING

PARAMETER	SYMBOL	RATINGS	UNIT
Input Voltage	V_{IN}	6.0	V
Output Voltage	V_{OUT}	6.0	V
Enable Input Voltage	V_{EN}	6.0	V
Power Dissipation (Note 2)	P_D	Internally Limited	A
Junction Temperature	T_J	+150	°C
Storage Temperature Range	T_{STG}	-65 ~ +150	°C

Notes: 1. Absolute maximum ratings are those values beyond which the device could be permanently damaged. Absolute maximum ratings are stress ratings only and functional device operation is not implied.
2. Internal thermal shutdown circuitry protects the device from permanent damage.

■ OPERATING RATINGS

PARAMETER	SYMBOL	RATINGS	UNIT
Input Voltage Range	V_{IN}	2.5 ~ 5.5	V
Maximum Enable Voltage Range	V_{EN}	0 ~ 5.5	V
Recommended Load Current		0 ~ 150	mA
Junction Temperature Range	T_J	-40 ~ +125	°C
Ambient Temperature Range	T_A	-40 ~ +85	°C

■ ELECTRICAL CHARACTERISTICS

(Limits in standard typeface are for T_A = 25ºC. Limits in boldface type apply over the full operating junction emperature range (-40 ºC≤T_J≤+125 ºC). Unless otherwise noted, specifications apply to the **LR9500** Typical Application Circuit with: V_{IN}= $V_{OUT\ (NOM)}$ + 1.0V, V_{EN}= 1.2V, C_{IN}= C_{OUT}= 0.47 μF, I_{OUT} = 1.0 mA.(Note 1, 2))

PARAMETER	SYMBOL	TEST CONDITION	MIN	TYP	MAX	UNIT
POWER SUPPLIES (V_M, V_{CC})						
Input Voltage	V_{IN}		2.5		5.5	V
Output Voltage Tolerance	ΔV_{OUT}	V_{IN}=($V_{OUT\ (nom)}$+1.0V) ~ 5.5V, I_{OUT}=1mA ~ 150mA	-2		2	%
Line Regulation		V_{IN}=($V_{out\ (nom)}$+1.0V) ~ 5.5V, I_{OUT}=1mA		0.05		%/V
Load Regulation		I_{OUT}=1mA ~150mA		0.001		%/mA
Load Current	I_{LOAD}	(Note 3)	0			mA
Maximum Output Current			150			
Quiescent Current (Note 4)	I_Q	V_{EN}=1.2V,I_{OUT}=0mA		25	50	μA
		V_{EN}=1.2V,I_{OUT}=150mA		160	230	μA
		V_{EN}=0.3V (Disabled)		0.003	1.0	μA
Ground Current (Note 5)	I_G	I_{OUT}=0mA (V_{OUT}=2.5V)		30		uA
Dropout Voltage (Note 6)	V_{DO}	I_{OUT}=150mA		80	150	mV
Short Circuit Current Limit	I_{SC}	(Note 7)		300		mA
Power Supply Rejection Ratio (Note 8)	PSRR	f=100Hz~10kHz, I_{OUT}=150mA		65		dB
		f=50kHz, I_{OUT}=150mA		52		dB
		f=100kHz, I_{OUT}=150mA		40		dB

■ ELECTRICAL CHARACTERISTICS (Cont.)

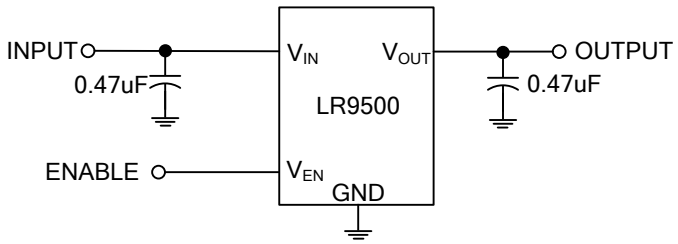
PARAMETER	SYMBOL	TEST CONDITION		MIN	TYP	MAX	UNIT
Output Noise Voltage (Note 8)	e_n	BW=10Hz to 100kHz, V_{IN}=4.2V	I_{OUT}=0mA		7		μV_{RMS}
			I_{OUT}=1mA		10		
			I_{OUT}=150mA		6.5		
Thermal Shutdown	$T_{SHUTDOWN}$	Temperature			160		°C
		Hysteresis			20		
LOGIN INPUT THRESHOLDS							
Low Input Threshold (V_{EN})	V_{IL}	V_{IN}=2.5V ~ 5.5V				0.4	V
High Input Threshold (V_{EN})	V_{IH}	V_{IN}=2.5V ~ 5.5V		1.2			V
Input Current at V_{EN} Pin (Note 9)	I_{EN}	V_{EN}=5.5V, V_{IN}=5.5V			5.5		µA
		V_{EN}=0V, V_{IN}=5.5V			0.001		

Notes: 1. All voltages are with respect to the potential at the GND pin.
2. Min and Max limits are specified by design, test, or statistical analysis. Typical numbers are not ensured, but do represent the most likely norm.
3. The device maintains a stable, regulated output voltage without a load current.
4. Quiescent current is defined here as the difference in current between the input voltage source and the load at V_{OUT}.
5. Ground current is defined here as the total current flowing to ground as a result of all input voltages applied to the device.
6. Dropout voltage is the voltage difference between the input and the output at which the output voltage drops to 100 mV below its nominal value. This parameter only applies to output voltages above 2.5V.
7. Short Circuit Current is measured with V_{OUT} pulled to 0v and V_{IN} worst case = 6.0V.
8. This specification is specified by design.
9. There is a 1 MΩ resistor between V_{EN} and ground on the device.

■ OUTPUT & INPUT CAPACITOR, RECOMMENDED SPECIFICATIONS

PARMMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Input Capacitance	C_{IN}	Capacitance for stability	0.33	0.47		µF
Output Capacitance	C_{OUT}		0.33	0.47	10	µF
Output/Input Capacitance	ESR		5		500	mΩ

■ TYPICAL APPLICATION CIRCUIT



■ EXTERNAL CAPACITORS

Like any low-dropout regulator, the **LR9500** requires external capacitors for regulator stability. The **LR9500** is specifically designed for portable applications requiring minimum board space and smallest components. These capacitors must be correctly selected for good performance.

■ INPUT CAPACITOR

An input capacitor is required for stability. The input capacitor should be at least equal to or greater than the output capacitor. It is recommended that a 0.47 µF capacitor be connected between the **LR9500** input pin and ground. This capacitor must be located a distance of not more than 1 cm from the input pin and returned to a clean analogue ground. Any good quality ceramic, tantalum, or film capacitor may be used at the input.

Important

To ensure stable operation it is essential that good PCB practices are employed to minimize ground impedance and keep input inductance low. If these conditions cannot be met, or if long leads are to be used to connect the battery or other power source to the **LR9500**, then it is recommended to increase the input capacitor to at least 2.2 µF. Also, tantalum capacitors can suffer catastrophic failures due to surge current when connected to a low-impedance source of power (like a battery or a very large capacitor). If a tantalum capacitor is used at the input, it must be ensured by the manufacturer to have a surge current rating sufficient for the application.

There are no requirements for the ESR (Equivalent Series Resistance) on the input capacitor, but tolerance and temperature coefficient must be considered when selecting the capacitor to ensure the capacitance will remain 0.47 µF ±30% over the entire operating temperature range.

■ OUTPUT CAPACITOR

The **LR9500** is designed specifically to work with very small ceramic output capacitors. A ceramic capacitor (dielectric types X5R or X7R) in the 0.47 µF to 10 µF range, and with ESR between 5 mΩ to 500 mΩ, is suitable in the **LR9500** application circuit. For this device the output capacitor should be connected between the V_{OUT} pin and a good ground connection and should be mounted within 1 cm of the device.

It may also be possible to use tantalum or film capacitors at the device output, V_{OUT}, but these are not as attractive for reasons of size and cost (see the CAPACITOR CHARACTERISTICS section below).

The output capacitor must meet the requirement for the minimum value of capacitance and have an ESR value that is within the range 5 mΩ to 500 mΩ for stability.

■ CAPACITOR CHARACTERISTICS

The **LR9500** is designed to work with ceramic capacitors on the input and output to take advantage of the benefits they offer. For capacitance values in the range of 0.47 µF to 4.7 µF, ceramic capacitors are the smallest, least expensive and have the lowest ESR values, thus making them best for eliminating high frequency noise. The ESR of a typical 0.47 µF ceramic capacitor is in the range of 20 mΩ to 40 mΩ, which easily meets the ESR requirement for stability for the **LR9500**.

The temperature performance of ceramic capacitors varies by type and manufacturer. Most large value ceramic capacitors (≥ 2.2 µF) are manufactured with Z5U or Y5V temperature characteristics, which results in the capacitance dropping by more than 50% as the temperature goes from 25°C ~ 85°C.

A better choice for temperature coefficient in a ceramic capacitor is X7R. This type of capacitor is the most stable and holds the capacitance within ±15% over the temperature range. Tantalum capacitors are less desirable than ceramic for use as output capacitors because they are more expensive when comparing equivalent capacitance and voltage ratings in the 0.47 µF to 4.7 µF range.

Another important consideration is that tantalum capacitors have higher ESR values than equivalent size ceramics. This means that while it may be possible to find a tantalum capacitor with an ESR value within the stable range, it would have to be larger in capacitance (which means bigger and more costly) than a ceramic capacitor with the same ESR value. It should also be noted that the ESR of a typical tantalum will increase about 2:1 as the temperature goes from 25°C down to −40°C, so some guard band must be allowed.

■ NO-LOAD STABILITY

The **LR9500** will remain stable and in regulation with no external load.

■ ENABLE CONTROL

The **LR9500** may be switched ON or OFF by a logic input at the ENABLE pin. A high voltage at this pin will turn the device on. When the enable pin is low, the regulator output is off and the device typically consumes 3nA. However if the application does not require the shutdown feature, the V_{EN} pin can be tied to V_{IN} to keep the regulator output permanently on. In this case the supply voltage must be fully established 500 µs or less to ensure correct operation of the startup circuit. Failure to comply with this condition may cause a delayed startup time of several seconds.

A 1MΩ pulldown resistor ties the V_{EN} input to ground, this ensures that the device will remain off when the enable pin is left open circuit. To ensure proper operation, the signal source used to drive the V_{EN} input must be able to swing above and below the specified turn-on/off voltage thresholds listed in the Electrical Characteristics section under V_{IL} and V_{IH}.