VS6214 Series Low-dropout Regulators

1 Introduction

The VS6214 series is a High speed LDO regulator that features high accuracy, low noise, high ripple rejection, low dropout and low power consumption. The series consists of a voltage reference, an error amplifier, a driver transistor, a current limiter, a phase compensation circuit. The inrush current protection limits the inrush current from input pin (V_{IN}) to output pin (V_{OUT}) to charge C_{OUT} capacitor.

The output can be turned off by controlling the EN pin on the chip, and the power consumption after turning off is only below 0.1 μA.

The VS6214 series provides a fixed voltage version with multiple output voltage points for selection. The fixed voltage version does not require external resistors, and the VS6214 series can use ceramic capacitors.

2 Available Packages

PARTNUMBER	PACKAGE
VS6214 Series	SOT-23
	SOT-23-3L
	SOT-23-5L
	DFNWB1×1-4L

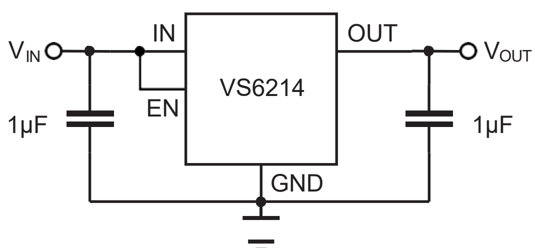
Note: For all available packages, please refer to the part *Orderable Information*.

3 Features

- Power Supply Rejection Ratio:
  - 90dB@1kHz
  - 75dB@10kHz
- Output Noise Voltage:
  - 30 × V_{OUT} μV_{RMS} (10Hz ~ 100kHz)
- Inrush Current Protection
- Input Voltage Range: 1.9V ~ 5.5V
- Fixed Output Voltage:
  - Available from 1.0V to 5.0V
- Output Tolerance: ±1%
- Output Current: up to 300mA
- Dropout Voltage: 135mV@300mA
- Output active discharge
- Enable Control
- Complete protection:
  - Current limiting protection
  - Thermal Shutdown

4 Applications

- Battery-powered Equipment
- Cellular and Smart Phones
- Digital Still and Video Cameras
- Laptop, Palmtops and PDA
- Portable Audio Video Equipment
- Radio Control System



Typical Application Circuit

7 Specifications

7.1 Absolute Maximum Ratings

(T_A = 25°C, unless otherwise specified)[1]

<table>
<tr><th colspan="3">CHARACTERISTIC</th><th>SYMBOL</th><th>VALUE</th><th>UNIT</th></tr>
<tr><td colspan="3">Input voltage range[2]</td><td>V_{IN}</td><td>-0.3 ~ 6.0</td><td>V</td></tr>
<tr><td colspan="3">Output voltage range[2]</td><td>V_{OUT}</td><td>V_{SS}-0.3 ~ V_{IN} + 0.3 ≤ 6</td><td>V</td></tr>
<tr><td colspan="3">Enable、BIAS input voltage range[2]</td><td>V_{EN},V_{BIAS}</td><td>V_{SS}-0.3 ~ V_{IN} +0.3</td><td>V</td></tr>
<tr><td rowspan="4">Maximum power dissipation</td><td rowspan="4">VS6214 Series</td><td>SOT-23</td><td rowspan="4">$P_{D\ Max}$</td><td rowspan="4">Internally Limited[3]</td><td rowspan="4">W</td></tr>
<tr><td>SOT23-3L</td></tr>
<tr><td>DFNWB1×1-4L</td></tr>
<tr><td>SOT-23-5L</td></tr>
<tr><td colspan="3">Maximum junction temperature</td><td>T_J</td><td>150</td><td>℃</td></tr>
<tr><td colspan="3">Storage temperature</td><td>T_{STG}</td><td>-40 ~ +150</td><td>℃</td></tr>
<tr><td colspan="3">Soldering temperature & time</td><td>T_{solder}</td><td>260℃, 10s</td><td>-</td></tr>
</table>

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute maximum rated conditions for extended periods may affect device reliability.

(2) All voltages are with respect to network ground terminal.

(3) Refer to *Thermal Information* for details.

7.2 Recommended Operating Conditions

PARAMETER	SYMBOL	MIN.	NOM.	MAX.	UNIT
Input voltage	V_{IN}	1.9		5.5	V
Operating junction temperature	T_J	-40		125	°C

7.3 ESD Ratings

ESD RATINGS		SYMBOL	VALUE	UNIT
Electrostatic discharge[4]	Human body model	$V_{ESD-HBM}$	2000	V

(4) ESD testing is conducted in accordance with the relevant specifications formulated by the Joint Electronic Equipment Engineering Commission (JEDEC). The human body model (HBM) electrostatic discharge test is based on the JS-001-2017 test standard, using a 100pF capacitor and discharging to each pin of the device through a resistance of 1.5kΩ.

7 Specifications

7.4 Thermal Information

THERMAL METRIC(5)	SYMBOL	VS6214 Series		UNIT
Junction-to-ambient thermal resistance	$R_{\Theta JA}$	**DFNWB1×1-4L**	**SOT-23-5L**	°C/W
		220.0	249.5	
		SOT-23	**SOT23-3L**	
		-	260	
Junction-to-case thermal resistance	$R_{\Theta JC}$	**DFNWB1×1-4L**	**SOT-23-5L**	°C/W
		115.8	64.8	
		SOT-23	**SOT23-3L**	
		-	67.2	
Reference maximum power dissipation for continuous operation	$P_{D\ Ref}$	**DFNWB1×1-4L**	**SOT-23-5L**	W
		0.45	0.4	
		SOT-23	**SOT23-3L**	
		-	0.38	

(5) Thermal metric is measured in still air with $T_A = 25°C$ and mounted on a 1 in^2 FR-4 substrate PCB covered with 2 ounces of copper.

7 Specifications

7.5 Electrical Characteristics

VS6214 Series (V_{IN}= $V_{OUT\ (NOM)}$ + 1V, C_{IN} = 1μF, C_{OUT} = 1μF, T_A = 25°C, unless otherwise specified)

CHARACTERISTIC	SYMBOL	TEST CONDITIONS		MIN.	TYP.(6)	MAX.	UNIT
Input voltage	V_{IN}	T_A = 25°C		1.9	-	5.5	V
DC output tolerance	-	T_J = 25°C, I_{OUT} = 1mA		-1	-	+1	%
Output current	I_{OUT}(7)	-		-	300	-	mA
Output current limit	I_{CL}	V_{OUT} = $V_{OUT\ (NOM)}$ (8)* 90%		-	600		mA
Line regulation	LNR(9)	V_{IN} = V_{OUT} + 1V to 6.0V, I_{OUT} =10mA		-	0.01	0.3	%/V
Load regulation	LDR	1mA ≤ I_{OUT} ≤ 300mA		-	25	50	mV
Dropout voltage	V_{DO}(10)	I_{OUT} = 300mA	1.2V ≤ V_{OUT} < 1.8V	-	400	800	mV
			1.8V ≤ V_{OUT} < 2.5V	-	220	330	mV
			2.5V ≤ V_{OUT} < 3.3V	-	140	210	mV
			V_{OUT} ≥ 3.3V	-	120	180	mV
Quiescent current	I_Q	I_{OUT} = 0mA		15	45	90	μA
Shutdown current	I_{SHDN}	V_{EN} ≤ 0.4V		-	0.01	1	μA
EN high	$V_{EN(H)}$	Turn on, stable output voltage		1	-	-	V
EN low	$V_{EN(L)}$	Turn off, output voltage is 0		-	-	0.4	
EN Pull down current	I_{EN}	V_{EN} = 5.5V		-	0.05	1	μA
Output noise voltage	Noise	f = 10Hz-100kHz, I_{OUT} = 300mA		-	30 × V_{OUT}	-	μVrms
Power supply rejection ratio	PSRR	I_{OUT} = 10mA, V_{IN} = 3.8V, V_{OUT} = 2.8V	f = 1k	-	90	-	dB
			f = 10k	-	75	-	
			f = 100k	-	60	-	
			f = 1M	-	62	-	
Thermal shutdown	T_{SD}	-		-	150	-	℃
Thermal shutdown hysteresis	ΔT_{SD}	-		-	20	-	℃
C_{OUT} auto-discharge resistance	R_{DIS}	V_{EN} < 0.4		-	500	-	Ω
Inrush Current	I_{RUSH}	V_{IN} = 5.5V, V_{EN} = 0 → 5.5V		-	200	-	mA
Load Transient	-	I_{OUT} = 1 mA to 300 mA in 1 us V_{OUT} = 2.8V		-	-30	-	mV
	-	I_{OUT} = 300mA to 1mA in 1 us V_{OUT} = 2.8V		-	+29	-	

7 Specifications

7.5 Electrical Characteristics (continued)

Note:

(6) Typical numbers are at 25°C and represent the most likely norm.

(7) Maximum output current is affected by the PCB layout, metal trace width, number of layers, ambient temperature and other environmental factors. Thermal limitations of the system must be carefully considered.

(8) $V_{OUT\ (NOM)}$: nominal voltage;

(9) The line regulation is calculated by the following formula:

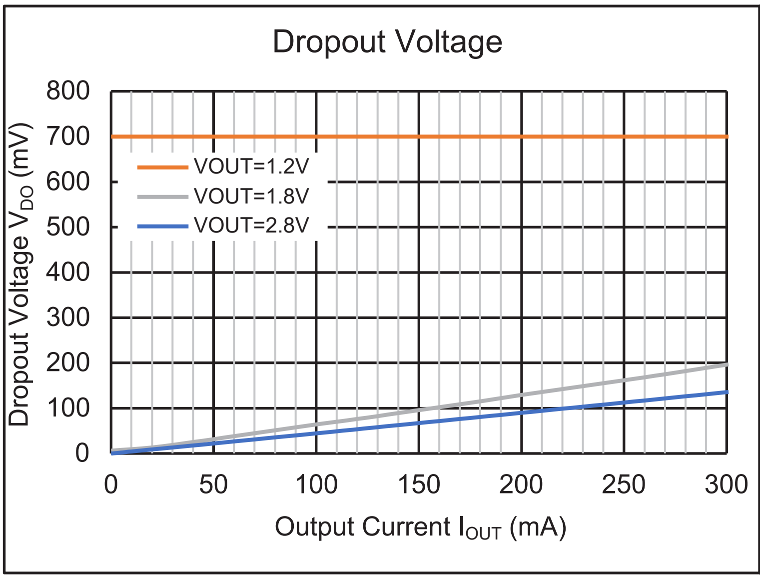
$$\square\square\square = \frac{\Delta V_{OOUT}}{V_{OOUT} \times \Delta V_{IN}}$$

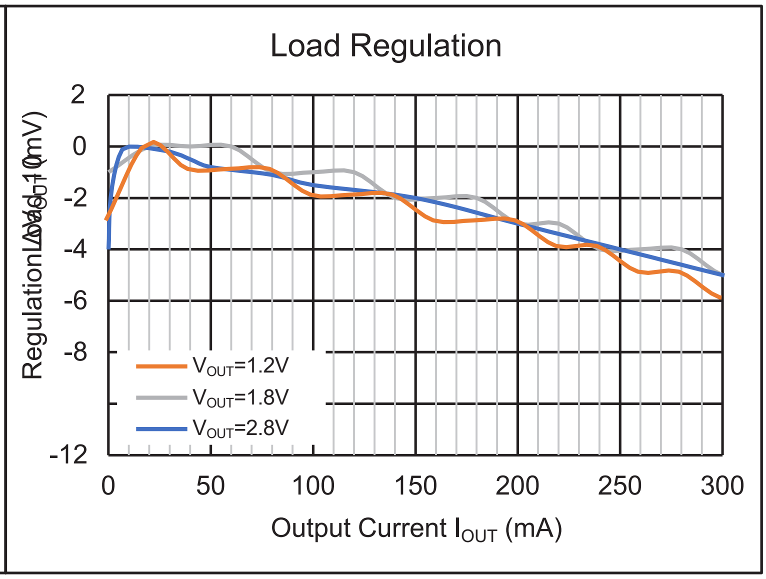
Where, ΔV_{OUT} is the variation of the output voltage, ΔV_{IN} is the variation of the input voltage.

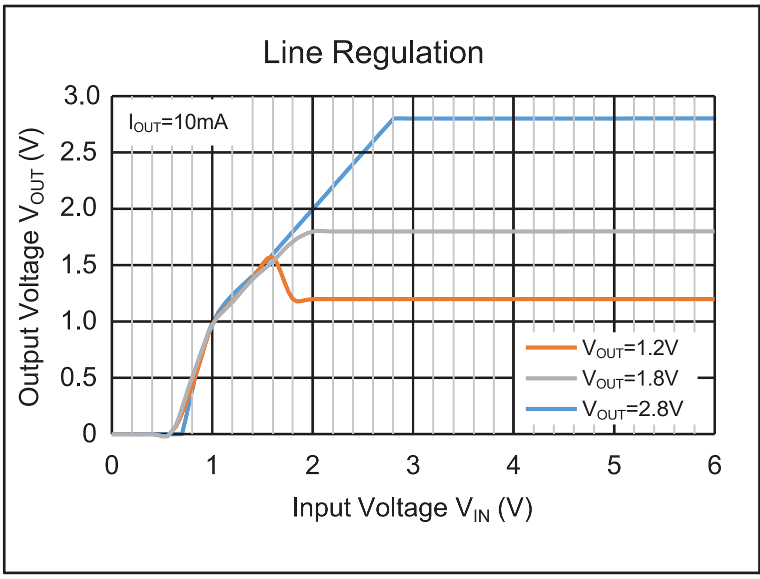
(10) Test the difference of output voltage and input voltage when input voltage is decreased gradually till output voltage equals to 98% of V_{OUT} Normal.

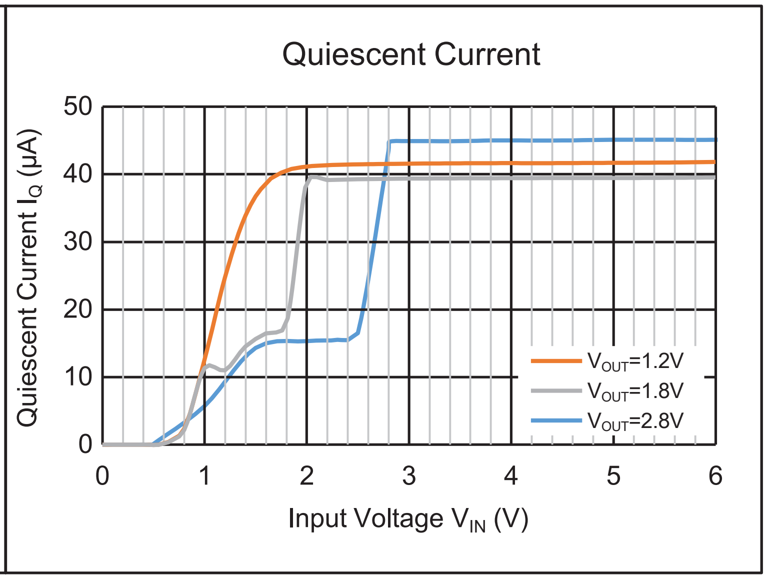
7.6 Typical Characteristics

VS6214 Series (V_{IN}= $V_{OUT\ (NOM)}$ + 1V, C_{IN} = 1μF, C_{OUT} = 1μF, T_A = 25°C, unless otherwise specified)





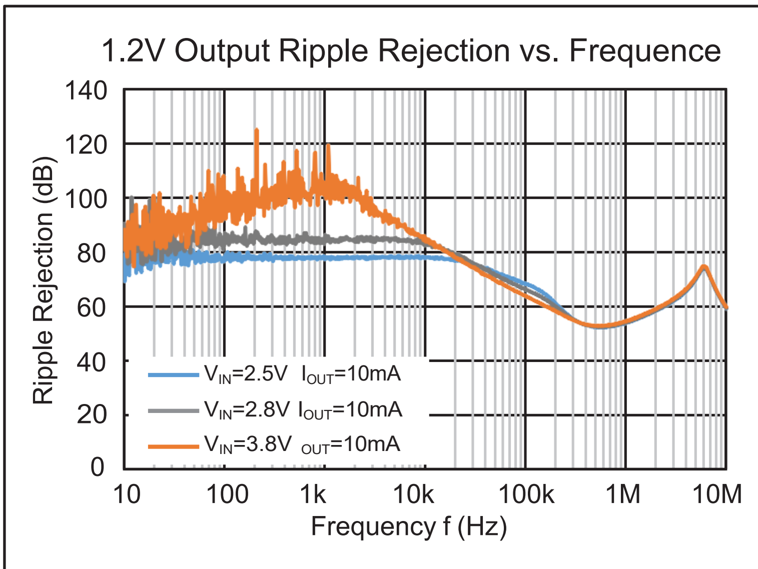


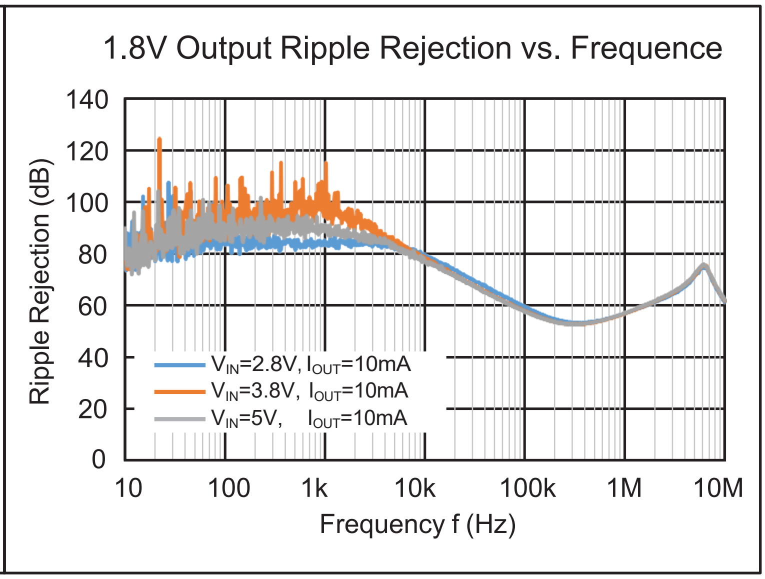


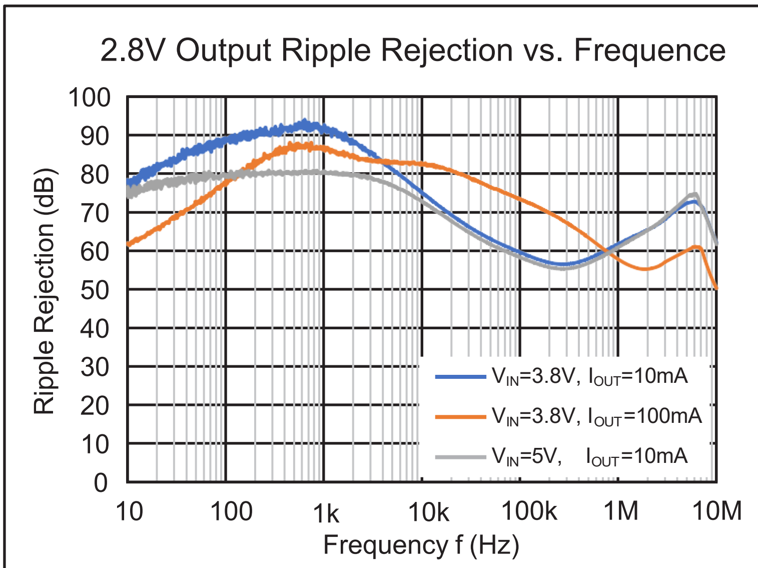
7 Specifications

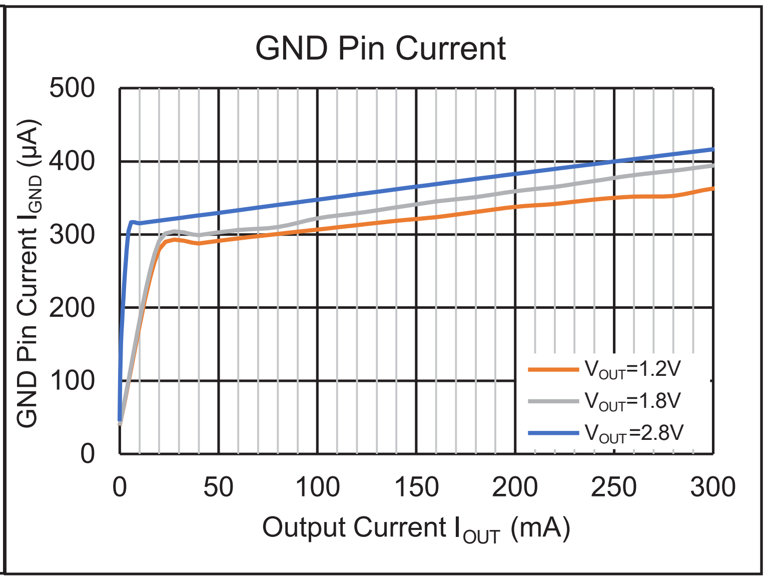
7.6 Typical Characteristics (continued)

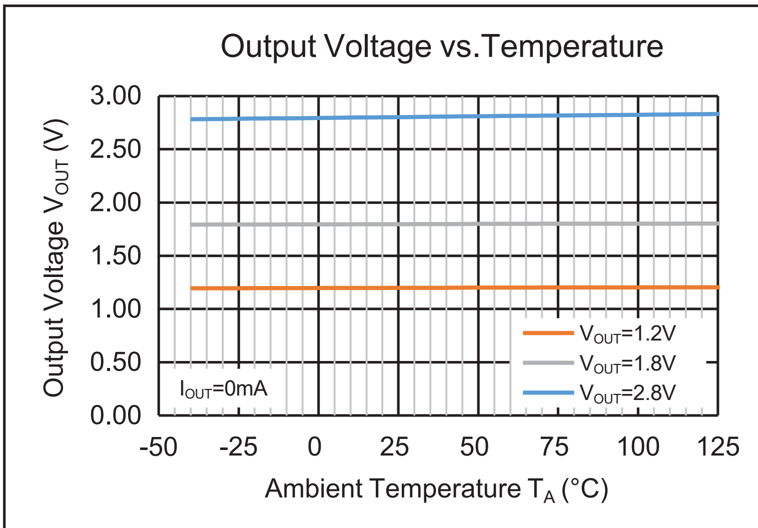
VS6214 Series (V_{IN}= $V_{OUT\ (NOM)}$ + 1V, C_{IN} = 1μF, C_{OUT} = 1μF, T_A = 25°C, unless otherwise specified)

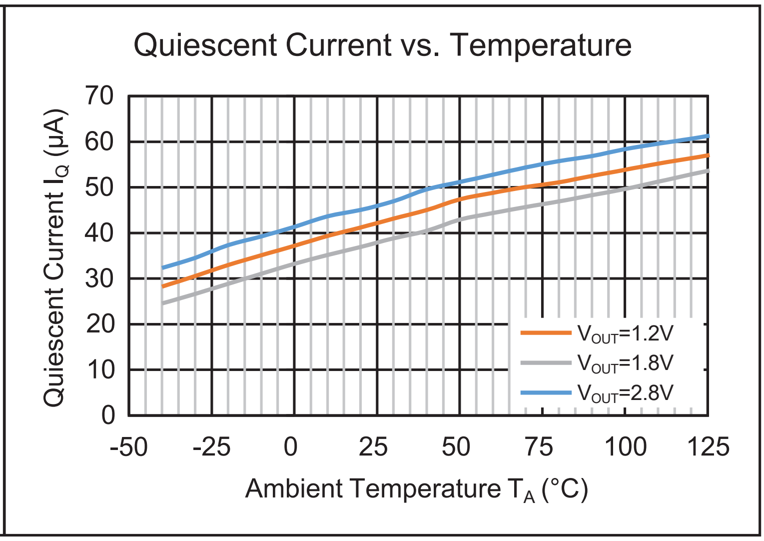








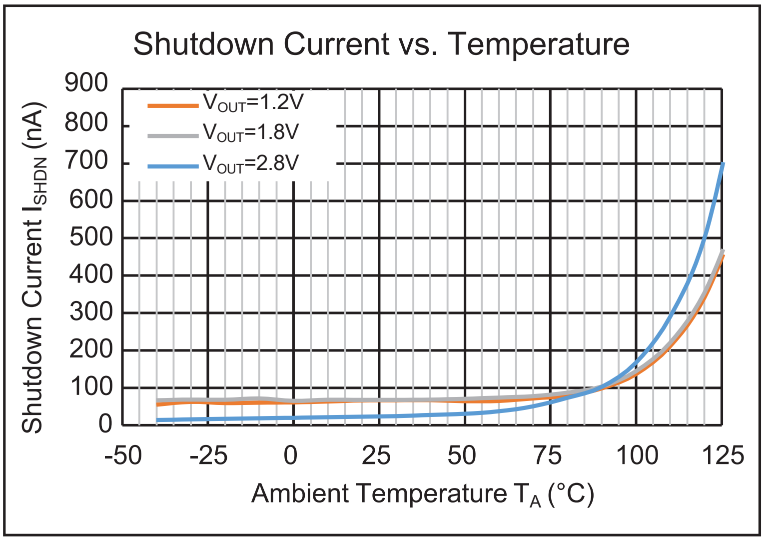




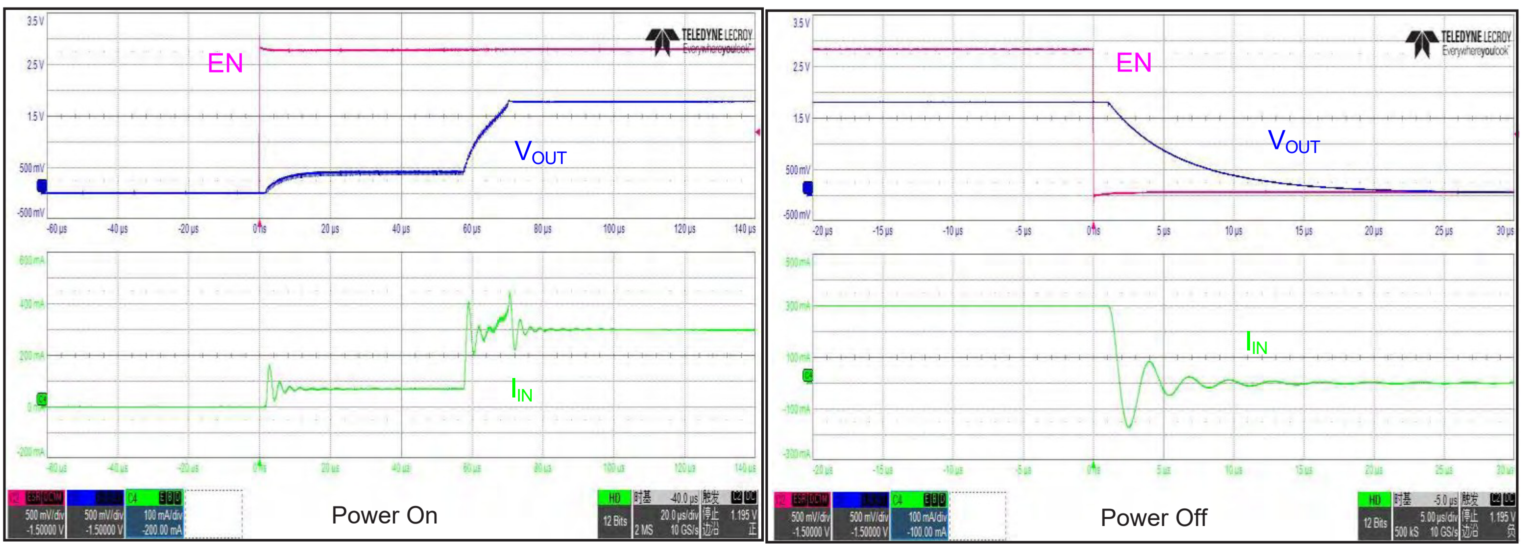
7 Specifications

7.6 Typical Characteristics (continued)

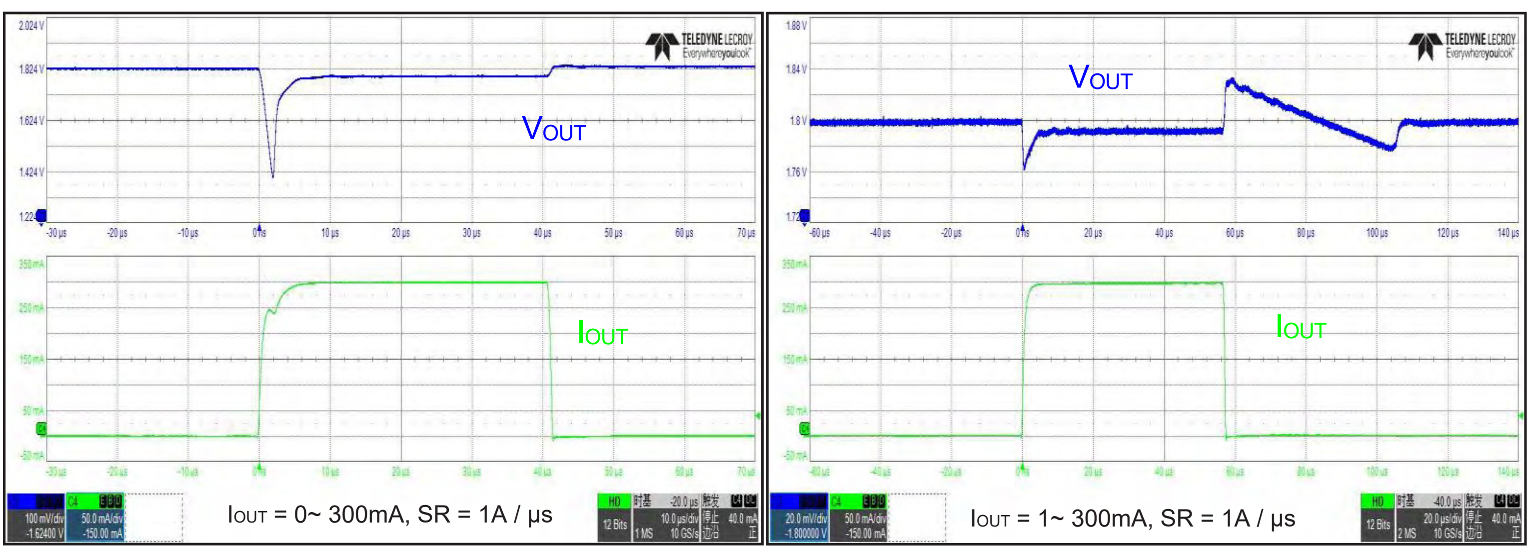
VS6214 Series (V_{IN}= $V_{OUT\ (NOM)}$ + 1V, C_{IN} = 1μF, C_{OUT} = 1μF, T_A = 25°C, unless otherwise specified)



Inrush Current Response Time (V_{OUT}=1.8V,V_{IN} = V_{EN} = 2.8V, I_{OUT}=300mA)



Load Transient (V_{OUT}=1.8V,V_{IN} = V_{EN} = 2.8V)

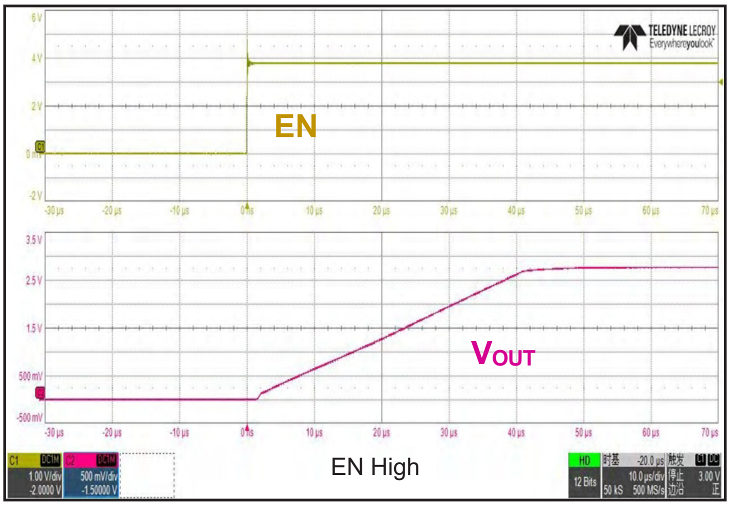


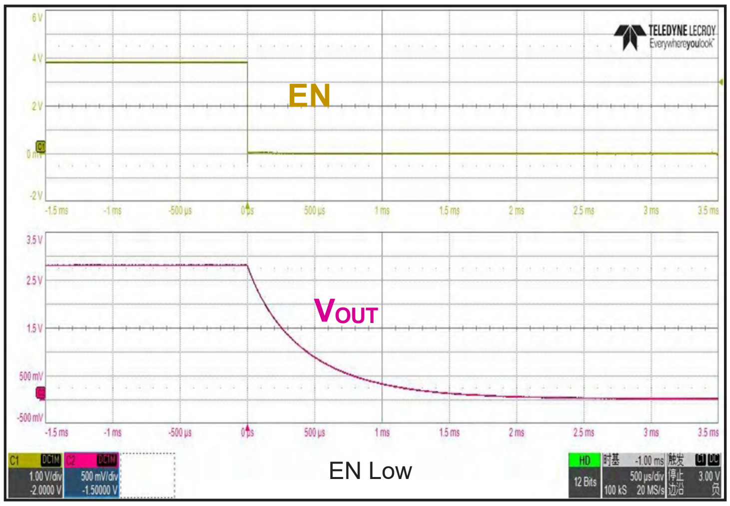
7 Specifications

7.6 Typical Characteristics (continued)

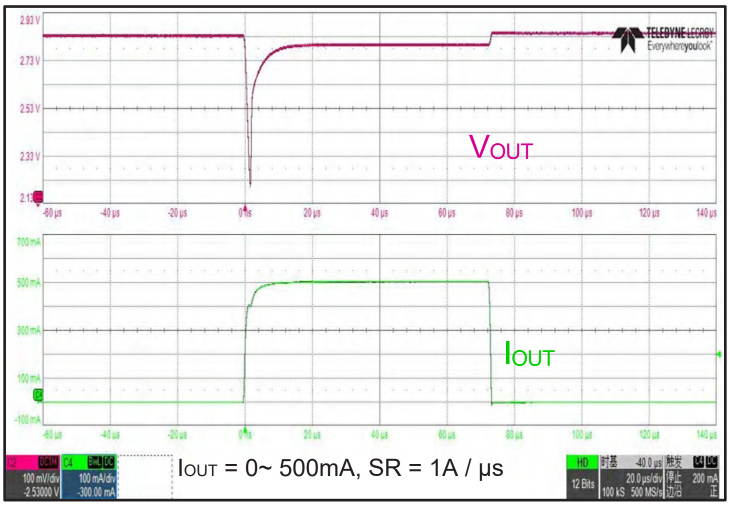
VS6214 Series (V_{IN}= $V_{OUT\ (NOM)}$ + 1V, C_{IN} = 1μF, C_{OUT} = 1μF, T_A = 25°C, unless otherwise specified)

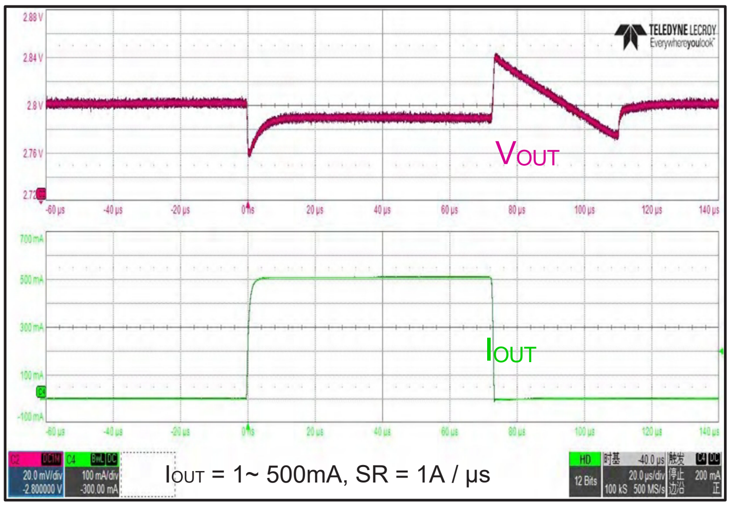
EN Response (V_{OUT} = 2.8V, V_{IN} = 3.8V, V_{EN} = 0 ~ 3.8V, I_{OUT} = 0mA)



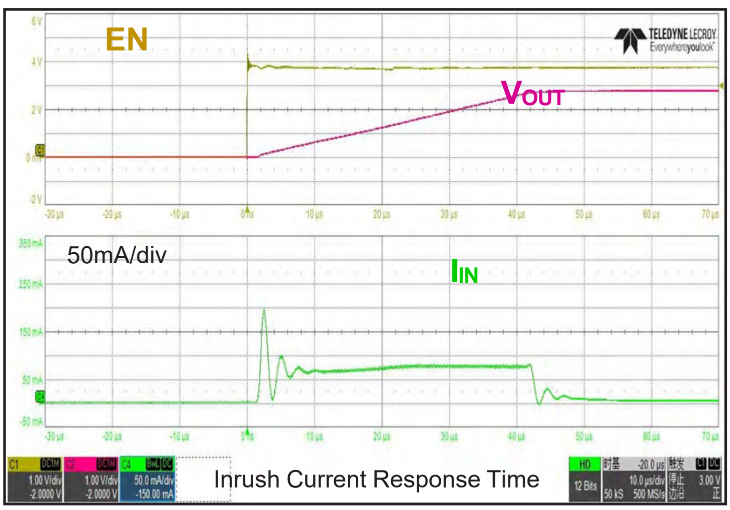


Load Transient (V_{OUT}=2.8V, V_{IN} = V_{EN} = 3.8V)





Inrush Current Response Time (V_{OUT}=2.8V, V_{IN} = V_{EN} = 3.8V, I_{OUT} = 0mA)

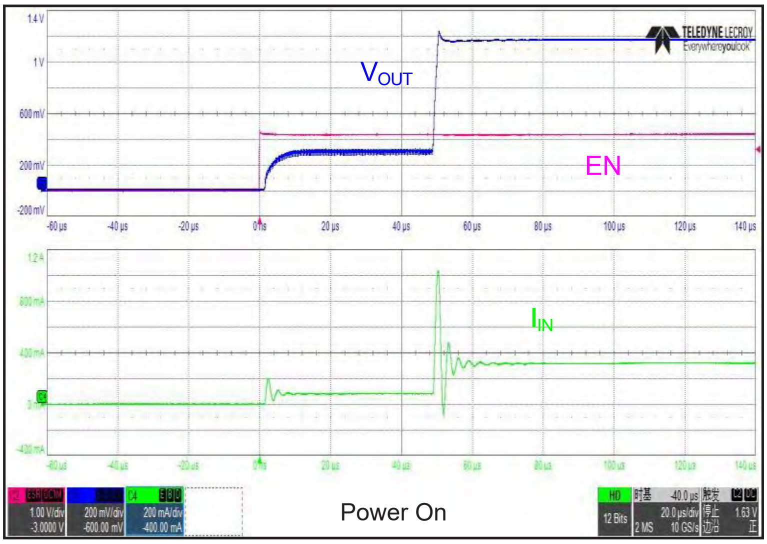


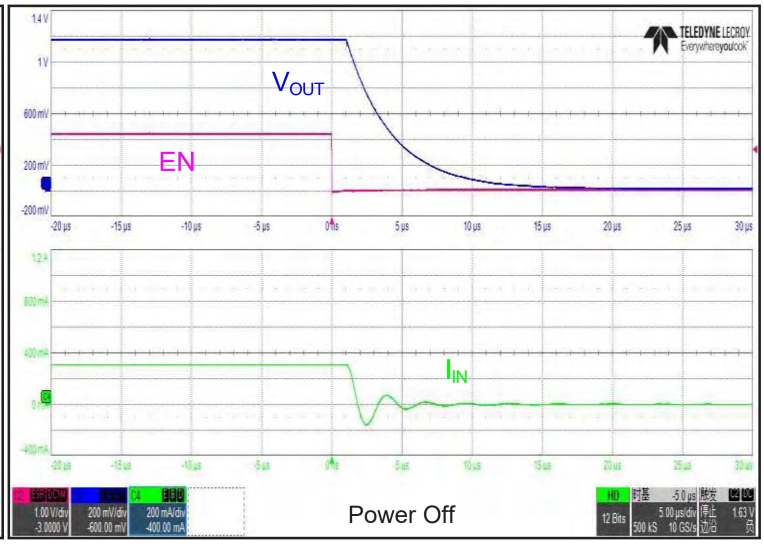
7 Specifications

7.6 Typical Characteristics (continued)

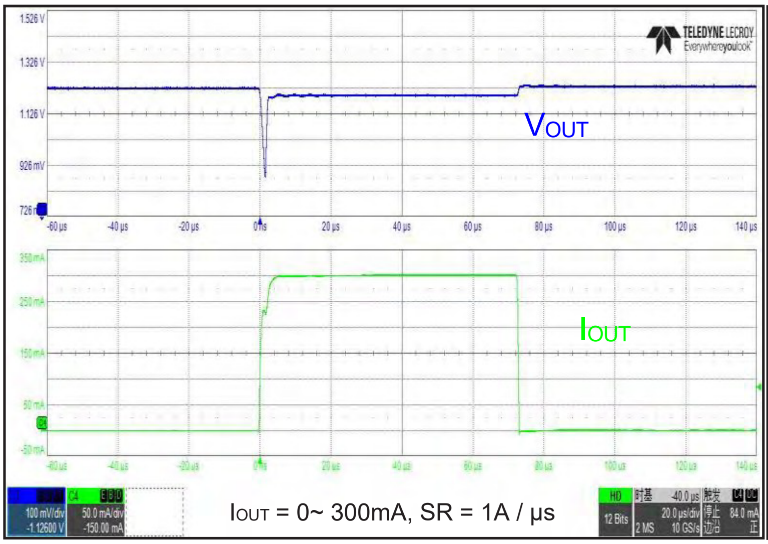
VS6214 Series (V_{IN}= $V_{OUT\ (NOM)}$ + 1V, C_{IN} = 1μF, C_{OUT} = 1μF, T_A = 25°C, unless otherwise specified)

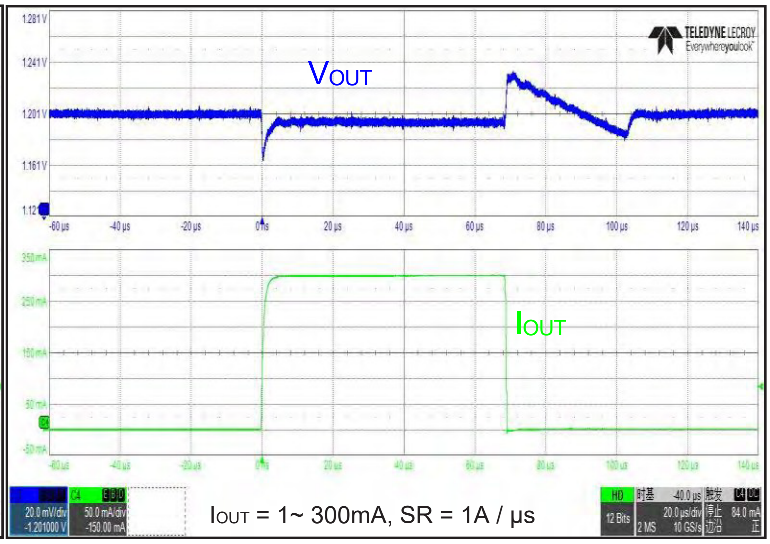
Inrush Current Response Time (V_{OUT}=1.2V,V_{IN} = V_{EN} = 2.2V, I_{OUT}=300mA)



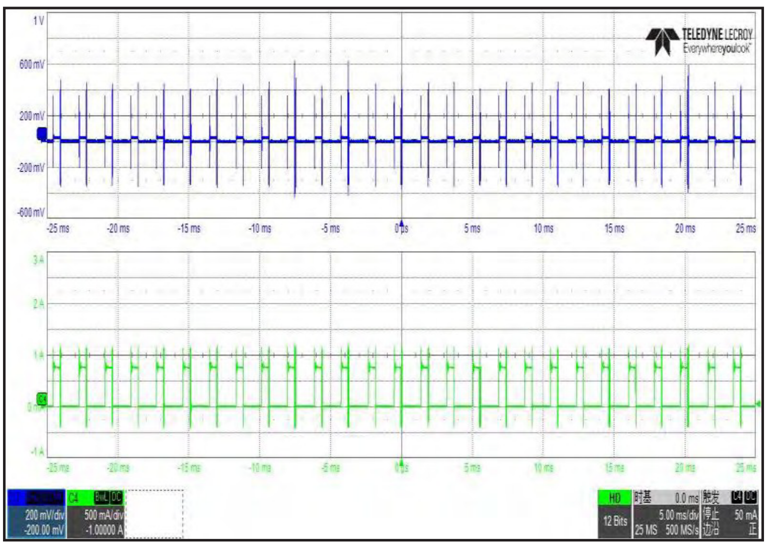


Load Transient (V_{OUT}=1.2V,V_{IN} = V_{EN} = 2.2V)

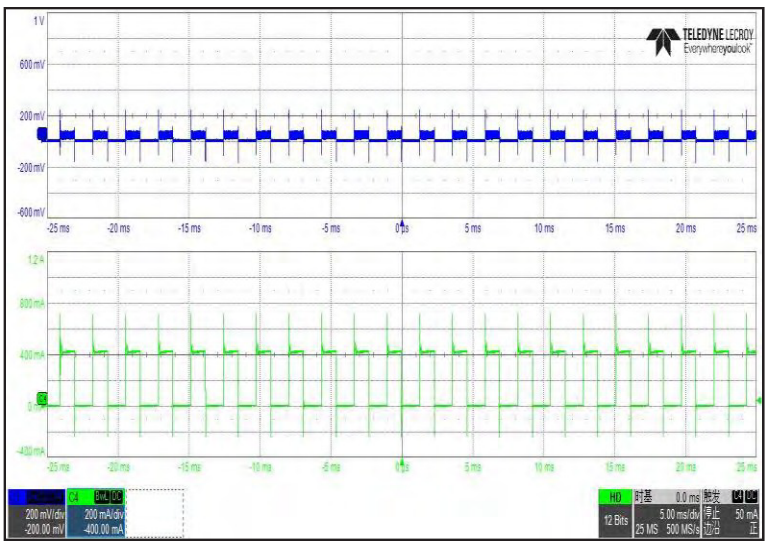




Short-Circuit Response (V_{OUT} = 1.2V, V_{EN} = V_{IN})



Short-Circuit Response (V_{OUT} = 1.8V, V_{EN} = V_{IN})

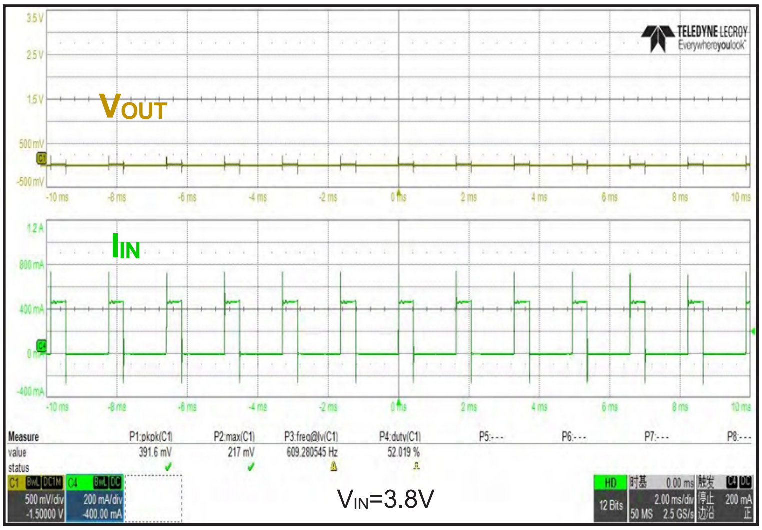


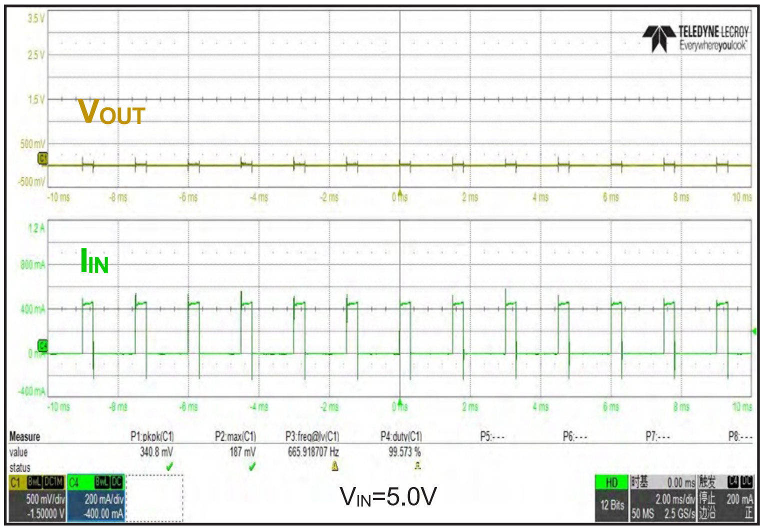
7 Specifications

7.6 Typical Characteristics (continued)

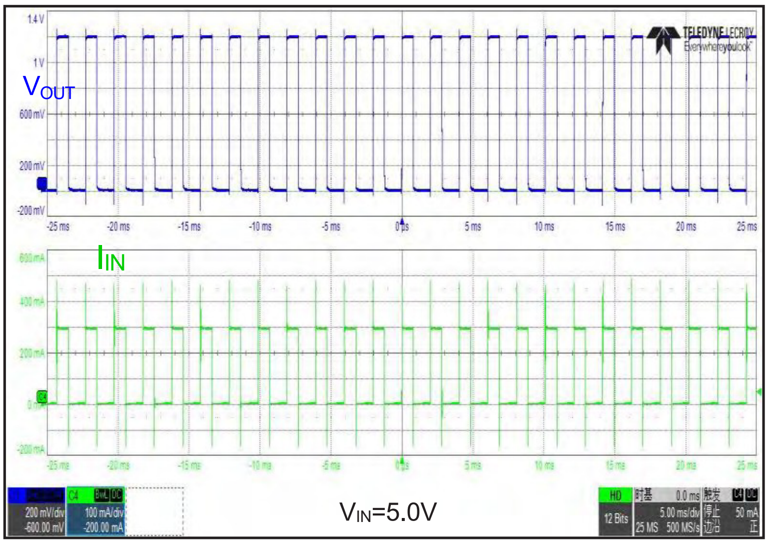
VS6214 Series (V_{IN}= $V_{OUT\ (NOM)}$ + 1V, C_{IN} = 1μF, C_{OUT} = 1μF, T_A = 25°C, unless otherwise specified)

Short-Circuit Response (V_{OUT} = 2.8V, V_{EN} = V_{IN})

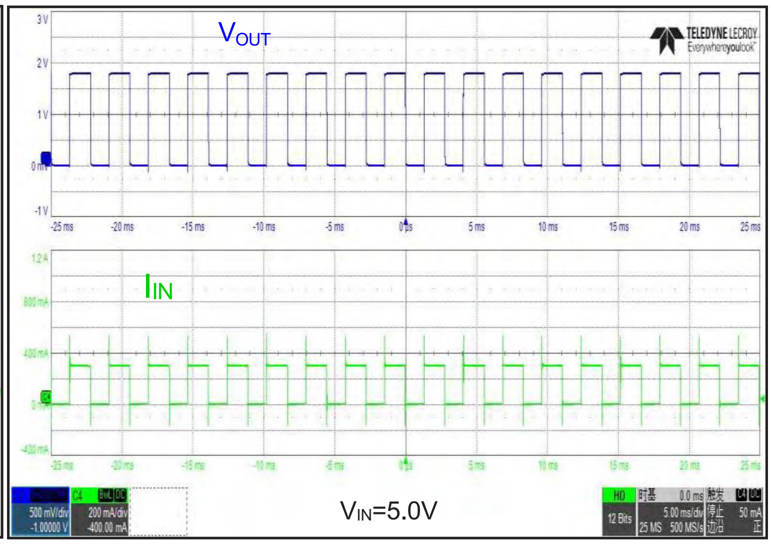




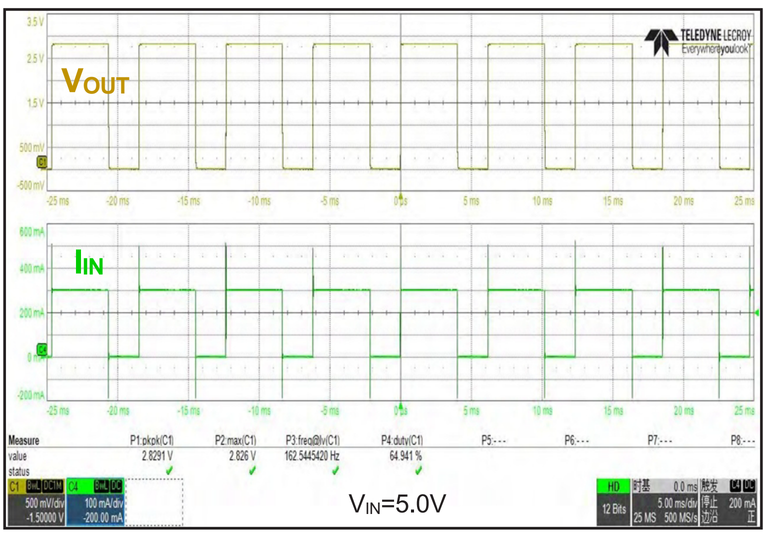
Thermal Shutdown (V_{OUT} = 1.2V, I_{OUT} = 300mA)



Thermal Shutdown (V_{OUT} = 1.8V, I_{OUT} = 300mA)



Thermal Shutdown (V_{OUT} = 2.8V, I_{OUT} = 300mA)



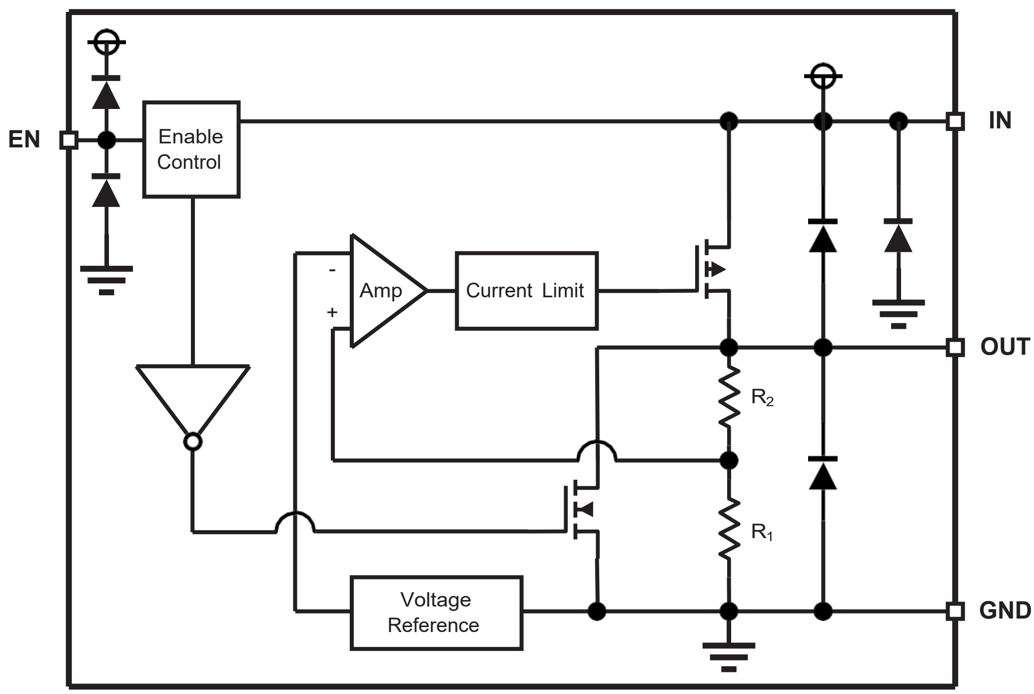
8 Detailed Description

8.1 Description

The VS6214 series is a High speed LDO regulator that features high accuracy, low noise, high ripple rejection, low dropout and low power consumption. The series consists of a voltage reference, an error amplifier, a driver transistor, a current limiter, a phase compensation circuit. The inrush current protection limits the inrush current from input pin (V_{IN}) to output pin (V_{OUT}) to charge C_{OUT} capacitor.

The output can be turned off by controlling the EN pin on the chip, and the power consumption after turning off is only below 0.1 μA.

8.2 Function Block Diagram



8 Detailed Description

8.3 Description

Dropout Voltage

Dropout voltage (V_{DO}) refers to the minimum voltage difference between input and output (V_{IN} - V_{OUT}) to make the device output voltage reach the rated range at rated current. When the dropout voltage condition required by the device is reached, the internal MOSFET will be fully turned on, at this time, the MOSFET is equivalent to a switch for regulation.

The V_{DO} increases with the increase of load current. Since V_{IN} - V_{OUT} must be no less than the V_{DO}, the V_{DO} indirectly specifies the minimum input voltage of devices under different load current conditions. If the V_{IN} - V_{OUT} is less than the V_{DO}, the performance of the device may deteriorate (see *Operation in Dropout Mode* for details).

Enable Operation

The enable pin will turn the regulator on or off. The threshold limits are covered in the Electrical characteristics table in this data sheet. If the enable function is not to be used then the pin should be connected to V_{IN}.

Current Limitation

The internal Current Limitation circuitry allows the device to supply the full nominal current and surges but protects the device against Current Overload or Short.

Thermal Protection

Internal thermal shutdown (TSD) circuitry is provided to protect the integrated circuit in the event that the maximum junction temperature is exceeded. When TSD activated, the regulator output turns off. When cooling down under the low temperature threshold, device output is activated again. This TSD feature is provided to prevent failures from accidental overheating. Activation of the thermal protection circuit indicates excessive power dissipation or inadequate heatsinking. For reliable operation, junction temperature should be limited to +150°C maximum.

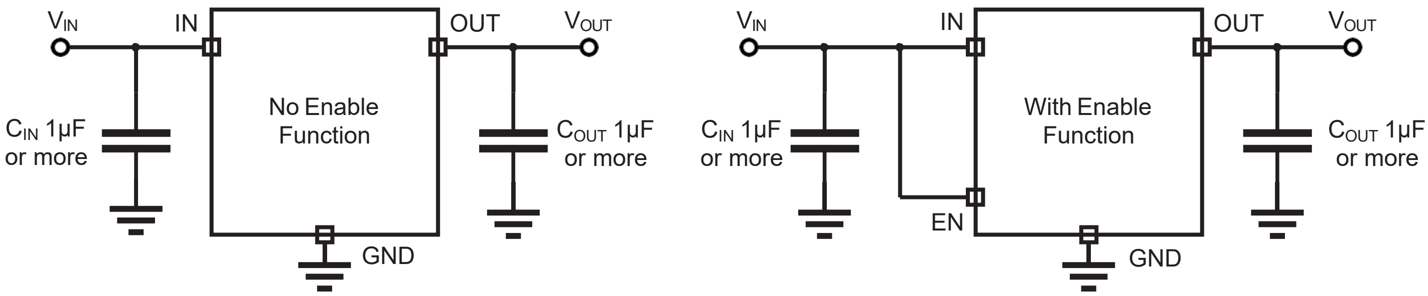
Inrush Current Protection

The inrush current protection circuit is built in the VS6214.

When the IC starts to operate, the protection circuit limits the inrush current from input pin (V_{IN}) to output pin (V_{OUT}) to charge C_{OUT} capacitor.

9 Application and Implementation

9.1 Typical Application Circuits



9.2 Application Information

Selection of Bypass Capacitances

For the VS6214 series, it is recommended to use 1µF input C_{IN} and output C_{OUT} ceramic capacitors.

Type of Capacitors:

Since any leakage of the capacitor will increase the quiescent power consumption of the whole circuit, attention should be paid to selecting capacitors with low leakage. When designing the circuit of portable equipment including VS6214 series, due to the shortage of tantalum capacitors, it is a good choice to use small size, low equivalent series resistance (ESR) and high RMS current capacity multilayer ceramic capacitors (MLCC) in the DC to DC voltage conversion. The designer must choose the appropriate capacitor type for circuit design: X7R- Ceramic capacitors of X5R- and COG- rated dielectric materials can provide relatively good capacitance stability within the temperature range, Y5V- type capacitors are not recommended because of large changes in capacitance values. However, no matter which type of ceramic capacitor is selected, the effective capacitance may vary with the operating voltage and temperature. The designer must consider the influence of the change of the effective value of capacitance according to the circuit design and application conditions.

Input Capacitors C_{IN}:

It is recommended to use a 1µF capacitor at the input pin of the device, and the position of the input capacitor should be as close to the device input pin as possible.

For the VS6214 series, the input capacitor is not necessary to maintain the output stability, but it can offset the reactive input source and improve the transient response, input ripple and PSRR performance of the device. It should be noted that although many types of capacitors can be used for input bypass, using ceramic capacitors for input filtering may cause problems. Due to the self-resonance and high Q characteristics of some types of ceramic capacitors, under certain starting conditions, applying voltage steps to ceramic capacitors may lead to large current surges (such as directly connecting the input pin of LDO to the power supply), which may cause some energy stored in the parasitic inductance of the power lead. When the stored energy is transferred from these inductors to ceramic capacitors, large voltage spikes may occur in the circuit. These voltage spikes are easily twice the step amplitude of the input voltage, and are likely to bring potential risks to the normal operation and reliability of the device. Therefore, the selection of ceramic capacitors as input capacitors must be careful. Adding 3Ω resistors and X5R- type ceramic capacitors will minimize voltage transients during startup. A higher value capacitor may be necessary if large, fast rise time load or line transients are anticipated or if the device is located several inches from the input power source.

9 Application and Implementation

9.2 Application Information (continued)

Selection of Bypass Capacitances (continued)

Output Capacitors C_{OUT}:

Recommended 1μF output ceramic capacitor to keep the device output stable, and the capacitor position should be as close to the device pin as possible.

For VS6214 series, the device needs an output capacitor to achieve loop stability. As with any regulator, a larger output capacitance reduces the peaks during a load transient but slows down the response time of the device. The proper capacitor can help to obtain better dynamic performance.

Transient Response

Transient response refers to the change of system output from initial state to stable state under the action of typical signal input. For LDO, the designer should pay attention to the possible impact of linear transient response and load transient response on the system: linear transient response refers to the transient response of output to change when the input voltage changes, while load transient response refers to the transient response of output to change when the output current changes. The specific phenomenon is that the output voltage of the device will have a short spike, especially when the input voltage or output current changes greatly in a short time. This change is not only related to the performance of the chip itself, but also related to the change of output current, change rate and output capacitance:

1. When the output current increases, the output voltage of the device will decrease to a certain extent, and the larger output current will provide a higher current discharge path for the output capacitor, which will affect the peak value generated by the transient spike and reduce the peak value;
2. The output current or input voltage changes relatively slowly, and the output change of the device is relatively small, affecting the spike caused by the change;
3. The use of large input and output capacitors can reduce the spike caused by transient response to a certain extent to improve the transient performance, but large output capacitors can also affect the response time of devices.

Operation in Dropout Mode

The VS6214 series is internally integrated with a P-MOSFET to achieve low dropout voltage. The voltage difference between the input and the output V_{IN} - V_{OUT} of the device must not be lower than the corresponding dropout voltage VDO to ensure that the output voltage tolerance is within the rated range of the data sheet. The dropout voltage will increase with the increase of load current. When the V_{IN} - V_{OUT} is less than the V_{DO}, the P-MOSFET inside the device is in a linear state, the resistance from the input pin to the output pin is equal to the resistance from the drain to the source of the P-MOSFET, and the device functions like a resistor. When operating in this state, the response time of the error amplifier inside the device will be limited, which will seriously degrade the transient performance of the device, when the external circuit has a transient change, the deviation of the output voltage will become larger than the normal operating state. In addition, the PSRR and noise performance of the device will be worse than that under normal operating conditions.