AP7331

300mA, LOW QUIESCENT CURRENT, FAST TRANSIENT LOW DROPOUT LINEAR REGULATOR

Description

The AP7331 is a 300mA, adjustable and fixed output voltage, low dropout linear regulator. The device included pass element, error amplifier, band-gap, current limit and thermal shutdown circuitry. The device is turned on when EN pin is set to logic high level.

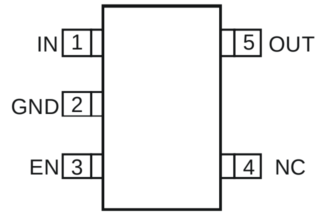
The characteristics of low dropout voltage and low quiescent current make it suitable for low power applications, for example, battery powered devices. The typical quiescent current is approximately 65µA.

Built-in current-limit and thermal-shutdown functions prevent IC from damage in fault conditions.

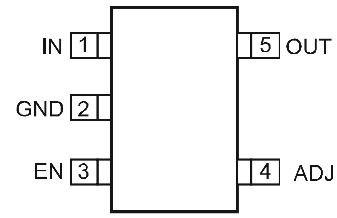
The AP7331 is available in SOT25 and DFN2020-6 packages.

Pin Assignments

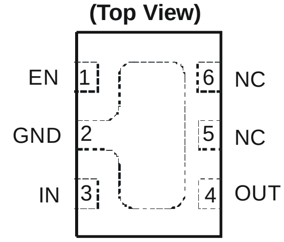
SOT25 (Fixed Output)
(Top View)



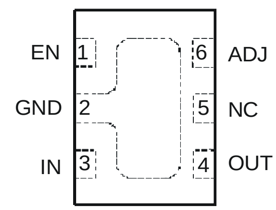
SOT25 (ADJ Output)
(Top View)



DFN2020-6 (Fixed Output)
(Top View)



DFN2020-6 (ADJ Output)
(Top View)



Features

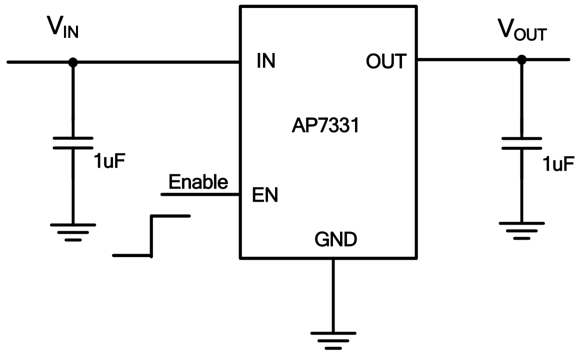
- 300mA Low Dropout Regulator with EN
- Very low I_Q over full load: 65µA
- Wide input voltage range: 2V to 6V
- Wide adjustable output: 0.8V to 5.0V
- Fixed output options: 1.0V to 3.3V
- PSRR: 65dB typical at 100Hz
- Fast start-up time: 80µs
- Stable with low ESR, 1µF ceramic output capacitor
- Excellent Load/Line Transient Response
- Low dropout: 300mV typical at 300mA
- Current limit protection
- Short circuit protection
- Thermal shutdown protection
- Ambient temperature range: -40ºC to 85°C
- SOT25 and DFN2020-6: Available in “Green” Molding Compound (No Br, Sb)
- Lead Free Finish/RoHS Compliant (Note 1)

Applications

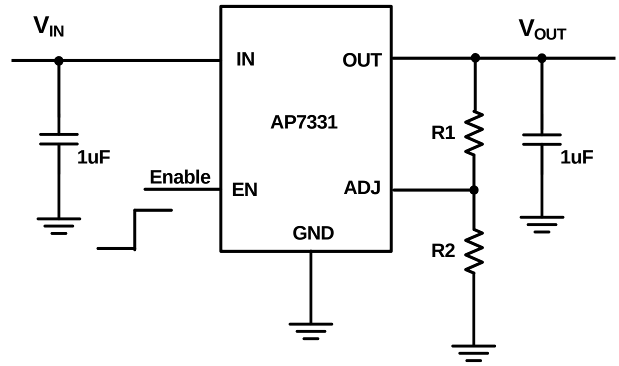
- XDSL Routers
- Wireless LAN Cards
- Desktop and Notebook Computers
- Battery Powered Equipments

Notes: 1. EU Directive 2002/95/EC (RoHS). All applicable RoHS exemptions applied. Please visit our website at http://www.diodes.com/products/lead_free.html

Typical Application Circuit



Fixed Output



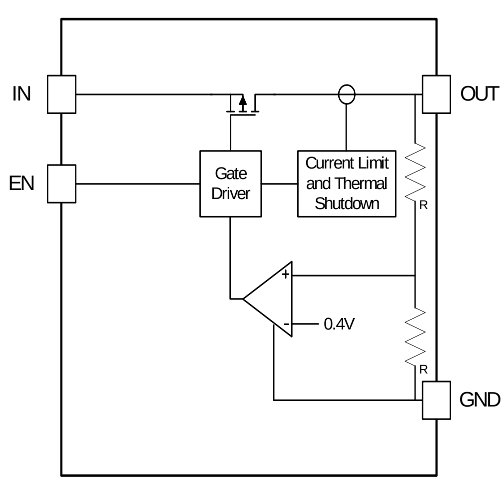
Adjustable Output

$$V_{OUT} = V_{REF}\left(1+\frac{R_1}{R_2}\right)$$

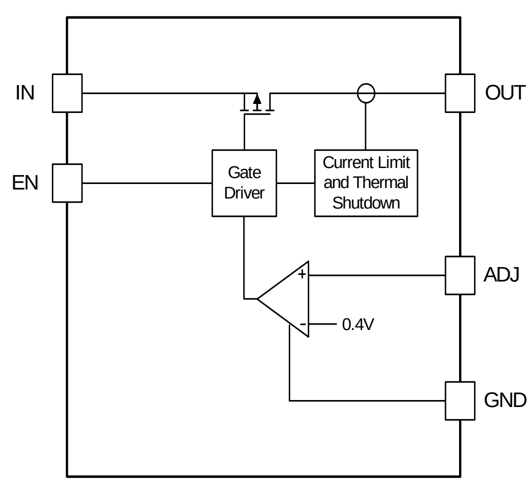
Pin Descriptions

Pin Name	Pin Number				Description
	SOT25 (fixed)	DFN2020-6 (fixed)	SOT25 (adj)	DFN2020-6 (adj)	
IN	1	3	1	3	Voltage input pin. Bypass to ground through at least 1μF capacitor
GND	2	2	2	2	Ground
EN	3	1	3	1	Enable input, active high
ADJ	-	-	4	6	Output feedback pin
NC	4	5, 6	-	5	No connection
OUT	5	4	5	4	Voltage output pin. Bypass to ground through 1μF ceramic capacitor

Functional Block Diagram



Fixed Version



Adjustable Version

Absolute Maximum Ratings

Symbol	Parameter		Ratings	Units
ESD HBM	Human Body Model ESD Protection		6	kV
ESD MM	Machine Model ESD Protection		400	V
V_{IN}	Input Voltage		7	V
	EN Voltage		V_{IN} + 0.3	V
	Continuous Load Current		Internal Limited	
T_{OP}	Operating Junction Temperature Range		-40 ~ 125	°C
T_{ST}	Storage Temperature Range		-65 ~150	°C
P_D	Power Dissipation (Note 2)	SOT25	640	mW
		DFN2020-6	740	mW
T_J	Maximum Junction Temperature		150	°C

Recommended Operating Conditions

Symbol	Parameter	Min	Max	Unit
V_{IN}	Input voltage	2	6	V
I_{OUT}	Output Current (Note 3)	0	300	mA
T_A	Operating Ambient Temperature	-40	85	°C

Notes: 2. Ratings apply to ambient temperature at 25°C
3. The device maintains a stable, regulated output voltage without a load current.

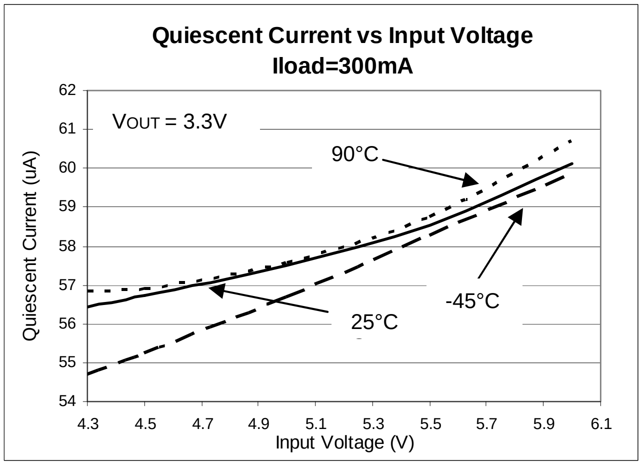
Electrical Characteristics

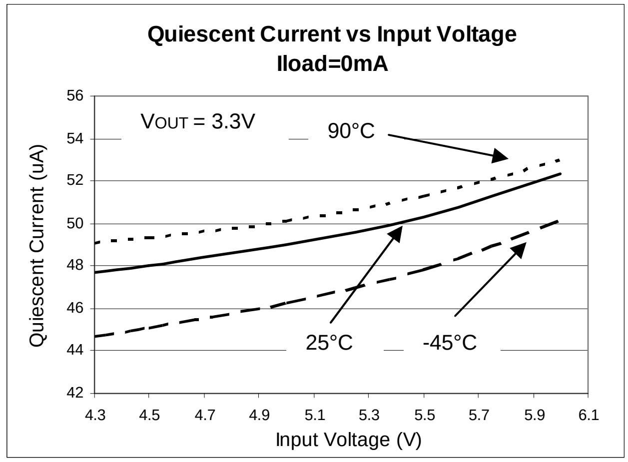
($T_A = 25^oC$, $V_{IN} = V_{OUT}$ +1V, C_{IN} = 1uF, C_{OUT} = 1uF, V_{EN} = 2V, unless otherwise stated)

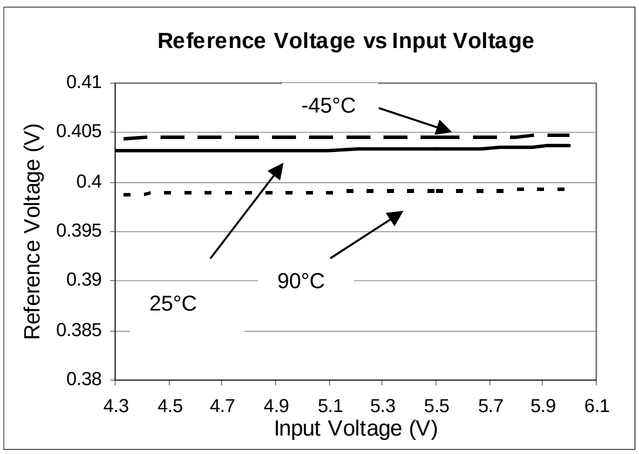
Symbol	Parameter	Test Conditions	Min	Typ.	Max	Unit
I_Q	Input Quiescent Current	$V_{EN} = V_{IN}$, I_{OUT} = 0mA	—	55	75	µA
		$V_{EN} = V_{IN}$, I_{OUT} = 300mA		65	85	
I_{SHDN}	Input Shutdown Current	V_{EN} = 0V, I_{OUT} = 0mA	—		1	µA
I_{LEAK}	Input Leakage Current	V_{EN} = 0V, OUT grounded	—		1	µA
$V_{Dropout}$	Dropout Voltage (Note 4)	I_{OUT} = 300mA		300	550	mV
V_{REF}	ADJ Reference Voltage (Adjustable version)	I_{OUT}= 0mA		0.4		V
I_{ADJ}	ADJ Leakage (Adjustable version)		—		1	µA
V_{OUT}	Output Voltage Accuracy	$T_A = -40^oC$ to 85^oC, I_{OUT} = 30mA	-2		2	%
$\Delta V_{OUT} / \Delta V_{IN}/V$	Line Regulation	$V_{IN} = (V_{OUT}$ +1V) to V_{IN-Max}, $V_{EN} = V_{IN}$, I_{OUT} = 1mA		0.01	0.20	%/V
$\Delta V_{OUT} / V_{OUT}$	Load Regulation	$V_{IN} = (V_{OUT}$ +1V) to V_{IN-Max}, I_{OUT} from 1mA to 300mA	-0.6		0.6	%
t_{ST}	Start-up Time	V_{EN} = 0V to 2.0V, V_{OUT} = 1V, I_{OUT} = 300mA		80		µs
PSRR	PSRR	$V_{IN} = [V_{OUT} +1V]V_{DC} + 0.5V_{ppAC}$, f = 100Hz, I_{OUT} =30mA		65		dB
I_{SHORT}	Short-circuit Current	$V_{IN} = V_{IN-Min}$ to V_{IN-Max}, V_{OUT} < 0.2V		100		mA
I_{LIMIT}	Current Limit	V_{OUT}/R_{OUT} = 1A	400	600		mA
V_{IL}	EN Input Logic Low Voltage	$V_{IN} = V_{IN-Min}$ to V_{IN-Max}			0.4	V
V_{IH}	EN Input Logic High Voltage	$V_{IN} = V_{IN-Min}$ to V_{IN-Max}	1.4			V
I_{EN}	EN Input Current	V_{IN} = 0V or V_{IN-Max}	-1		1	µA
T_{SHDN}	Thermal Shutdown Threshold			140		°C
T_{HYS}	Thermal Shutdown Hysteresis			15		°C
θ_{JA}	Thermal Resistance Junction-to-Ambient	SOT25 (Note 5)		190		^{o}C/W
		DFN2020-6 (Note 6)		167		^{o}C/W

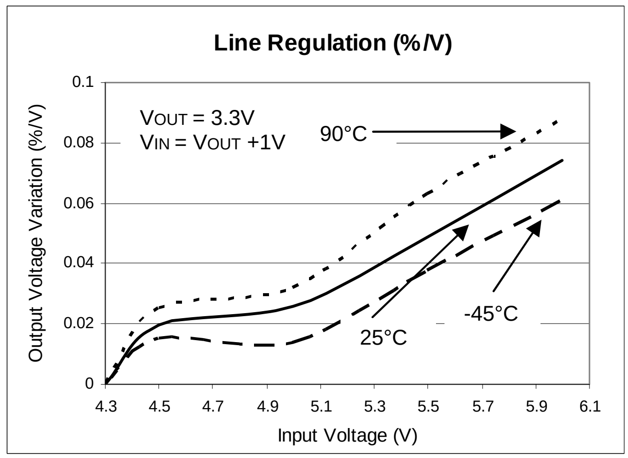
Notes: 4. Dropout voltage is the voltage difference between the input and the output at which the output voltage drops 2% below its nominal value. This parameter only applies to output voltages above 1.8V.
5. Test conditions for SOT25: Device mounted on FR-4 substrate PCB, with minimum recommended pad layout, 2oz copper, single sided
6. Test conditions for DFN2020-6: Device mounted on FR-4 substrate PCB, with minimum recommended pad layout, 2oz copper, double sided, bottom layer is a copper plane.

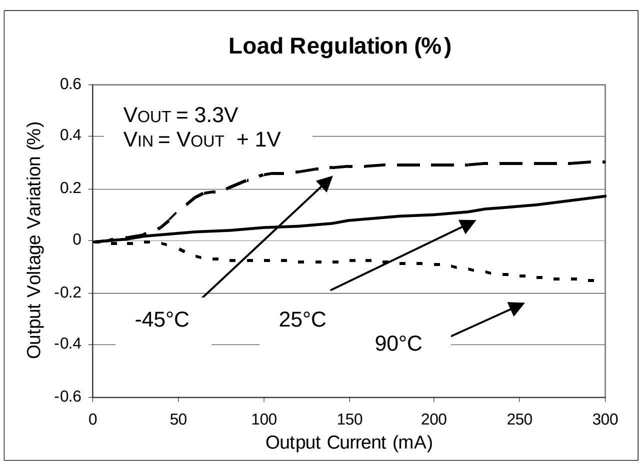
Typical Characteristics

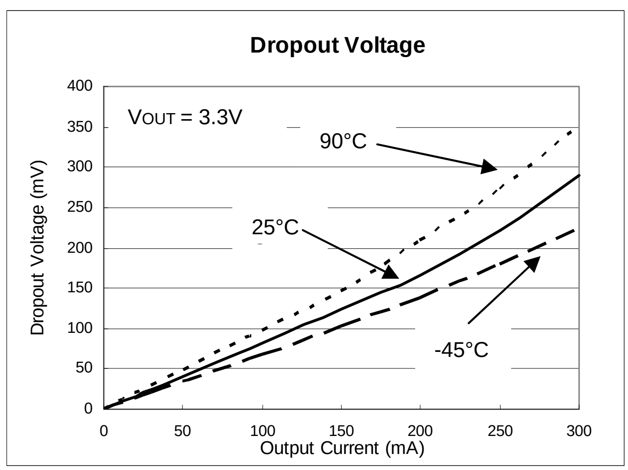




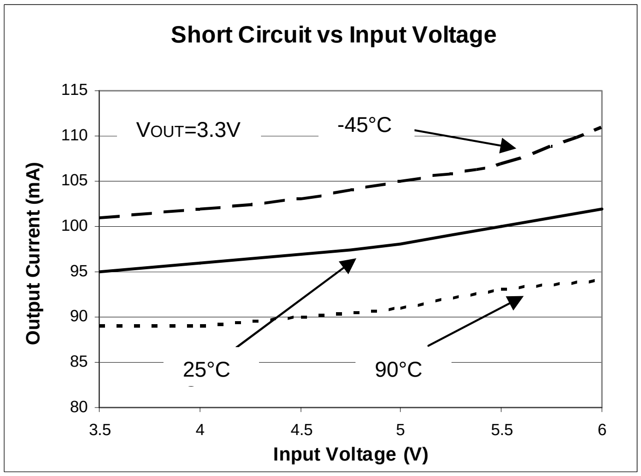


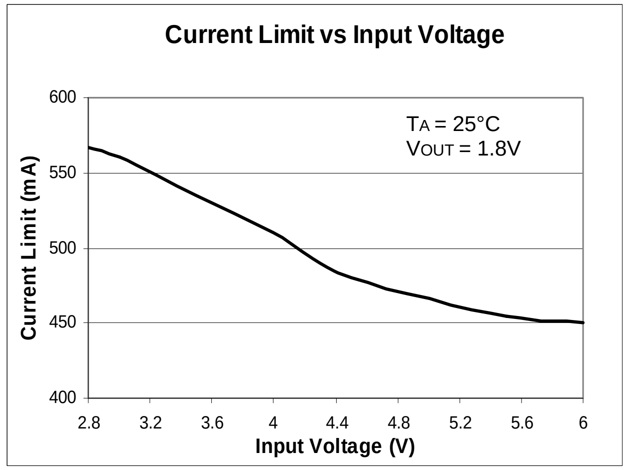


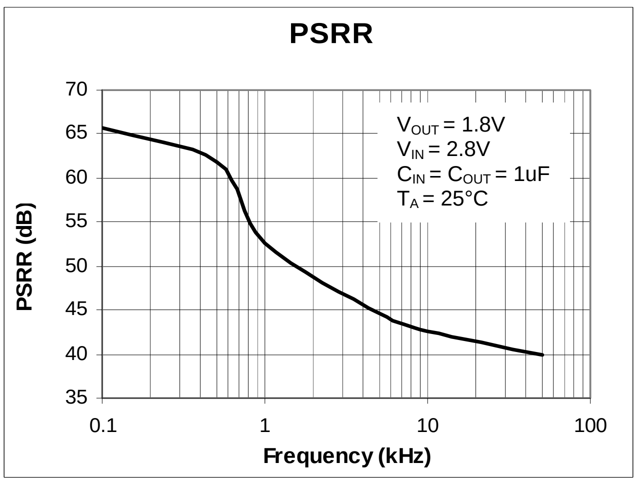


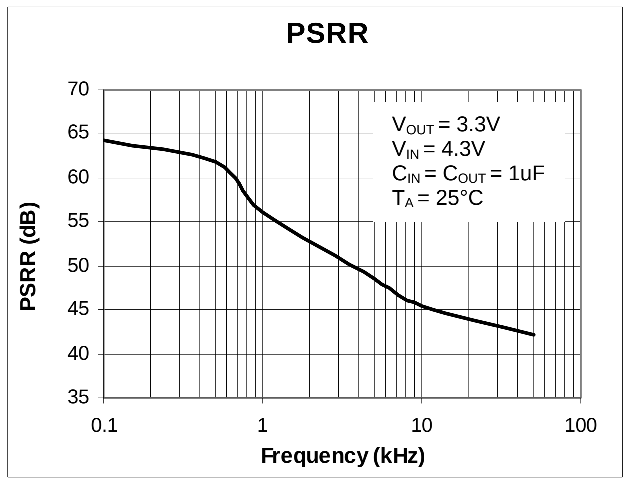


Typical Characteristics (Continued)



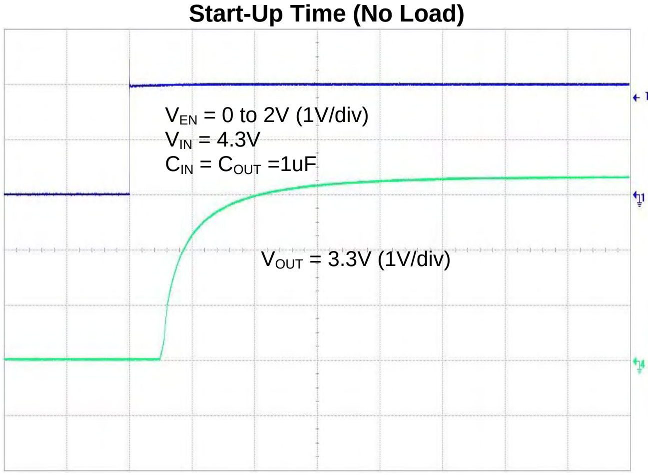






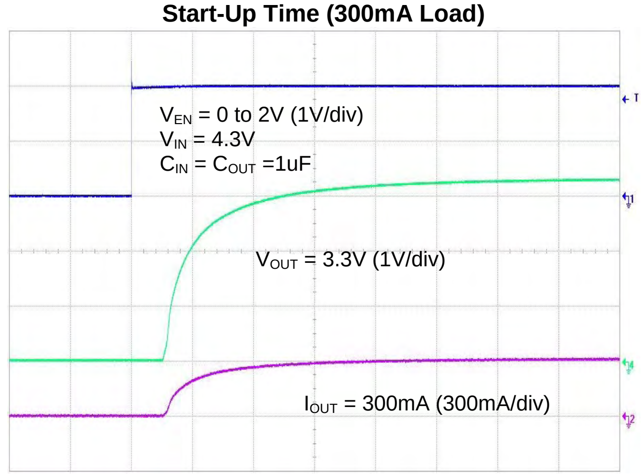
Typical Characteristics (Continued)

Start-Up Time (No Load)



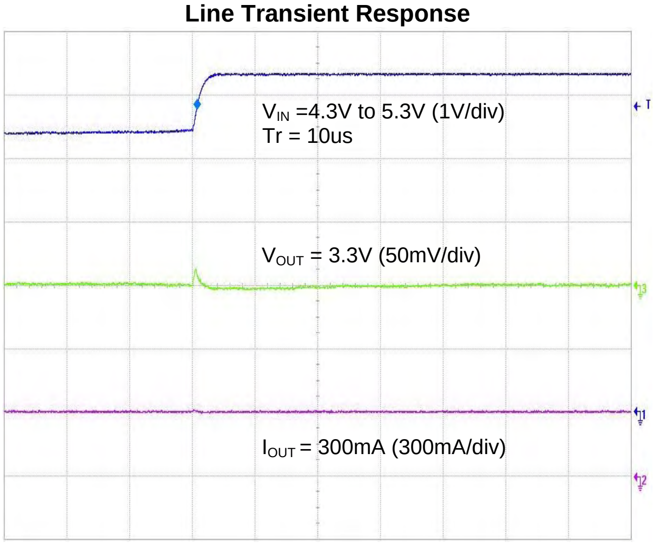
Time (50us/div)

Start-Up Time (300mA Load)



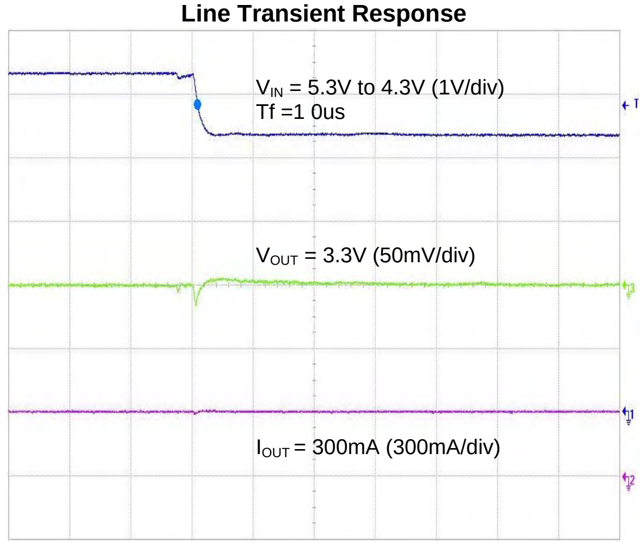
Time (50us/div)

Line Transient Response



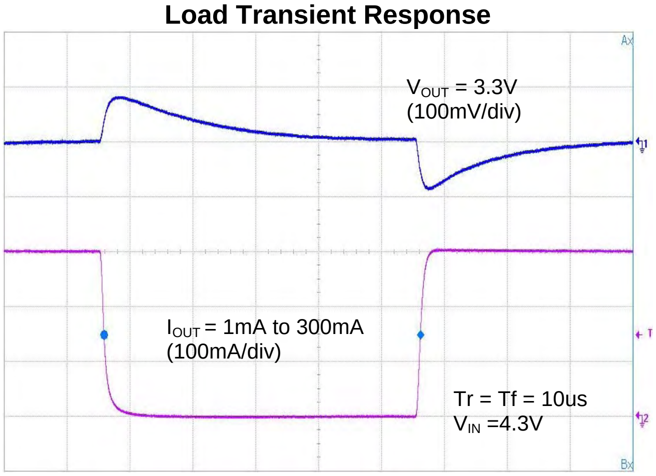
Time (50us/div)

Line Transient Response



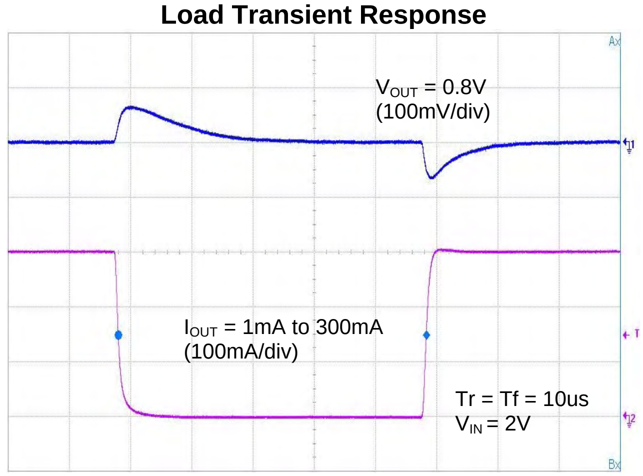
Time (50us/div)

Load Transient Response



Time (100us/div)

Load Transient Response



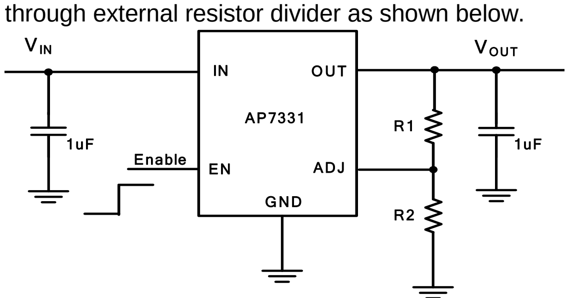
Time (100us/div)

Application Note

Input Capacitor
A 1μF ceramic capacitor is recommended to connect between V_{IN} and GND pins to decouple input power supply glitch and noise. The amount of the capacitance may be increased without limit. This input capacitor must be located as close as possible to the device to assure input stability and less noise. For PCB layout, a wide copper trace is required for both V_{IN} and GND. A lower ESR capacitor allows the use of less capacitance, while higher ESR type requires more capacitance.

Output Capacitor
The output capacitor is required to stabilize and help transient response for LDO. The AP7331 is stable with very small ceramic output capacitors. The recommended capacitance is from 1μF to 4.7μF, Equivalent Series Resistance (ESR) is from 10mΩ to 200mΩ, and temperature characteristic is X7R or X5R. Higher capacitance values help to improve load/line transient response. The output capacitance may be increased to keep low undershoot/overshoot. Place output capacitor as close as possible to OUT and GND pins, and keep the leads as short as possible.

Adjustable Operation
The AP7331 provides output voltage from 0.8V to 5.0V through external resistor divider as shown below.



The output voltage is calculated by:

$$V_{OUT} = V_{REF}\left(1+\frac{R_1}{R_2}\right)$$

Where V_{REF}=0.4V (the internal reference voltage)

Rearranging the equation will give the following that is used for adjusting the output to a particular voltage:

$$R_1 = R_2\left(\frac{V_{OUT}}{V_{REF}}-1\right)$$

To maintain the stability of the internal reference voltage, R_2 need to be kept smaller than 125kΩ.

No Load Stability
Other than external resistor divider, no minimum load is required to keep the device stable. The device will remain stable and regulated in no load condition.

ON/OFF Input Operation
The AP7331 is turned on by setting the EN pin high, and is turned off by pulling it low. If this feature is not used, the EN pin should be tied to IN pin to keep the regulator output on at all time. To ensure proper operation, the signal source used to drive the EN pin 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}.

Current Limit Protection
When output current at OUT pin is higher than current limit threshold, the current limit protection will be triggered and clamp the output current to approximately 600mA to prevent over-current and to protect the regulator from damage due to overheating.

Short Circuit Protection
When OUT pin is short-circuit to GND or OUT pin voltage is less than 200mV, short circuit protection will be triggered and clamp the output current to approximately 100mA. This feature protects the regulator from over-current and damage due to overheating.

Thermal Shutdown Protection
Thermal protection disables the output when the junction temperature rises to approximately +140°C, allowing the device to cool down. When the junction temperature reduces to approximately +125°C the output circuitry is enabled again. Depending on power dissipation, thermal resistance, and ambient temperature, the thermal protection circuit may cycle on and off. This cycling limits the heat dissipation of the regulator, protecting it from damage due to overheating.

Ultra Fast Start-up
After enabled, the AP7331 is able to provide full power in as little as tens of microseconds, typically 80µs, without sacrificing low ground current. This feature will help load circuitry move in and out of standby mode in real time, eventually extend battery life for mobile phones and other portable devices.

Fast Transient Response
Fast transient response LDOs can extend battery life. TDMA-based cell phone protocols such as Global System for Mobile Communications (GSM) have a transmit/receive duty factor of only 12.5 percent, enabling power savings by putting much of the baseband circuitry into standby mode in between transmit cycles. In baseband circuits, the load often transitions virtually instantaneously from 100µA to 100mA. To meet this load requirement, the LDO must react very quickly without a large voltage drop or overshoot — a requirement that cannot be met with conventional, general-purpose LDOs.

Application Note (Continued)

Fast Transient Response (Continued)

The AP7331's fast transient response from 0 to 300mA provides stable voltage supply for fast DSP and GSM chipset with fast changing load.

Small Overshoot and Undershoot

The AP7331 has small and controlled overshoot and undershoot in load and line transitions. This helps to protect supplied circuit from damage and operation error caused by glitches. This feature also permits the usage of small value output decoupling capacitor with AP7331.

Low Quiescent Current

The AP7331, consuming only around 65µA for all input range and output loading, provides great power saving in portable and low power applications.

Wide Output Range

The AP7331, with a wide output range of 0.8V to 5.0V, provides a versatile LDO solution for many portable applications.

Ordering Information

AP7331 - XX XX G - 7

Output	Package	Green	Packing
Blank : ADJ	W : SOT25	G : Green	7 : Tape & Reel
10 : 1.0V	SN : DFN2020-6		
12 : 1.2V			
15 : 1.5V			
18 : 1.8V			
20 : 2.0V			
25 : 2.5V			
28 : 2.8V			
30 : 3.0V			
33 : 3.3V			

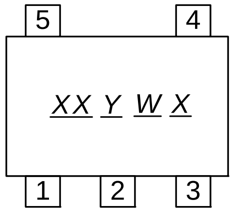
Device	Package Code	Packaging (Note 7)	7" Tape and Reel	
			Quantity	Part Number Suffix
AP7331-XXWG-7	W	SOT25	3000/Tape & Reel	-7
AP7331-XXSNG-7	SN	DFN2020-6	3000/Tape & Reel	-7

Note: 7. Pad layout as shown on Diodes Inc. suggested pad layout document AP02001, which can be found on our website at http://www.diodes.com/datasheets/ap02001.pdf.

Marking Information

1. SOT25

(Top View)

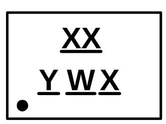


XX : Identification code
Y : Year 0~9
W : Week : A~Z : 1~26 week;
a~z : 27~52 week; z represents
52 and 53 week
X : A~Z : Green

Device	Package	Identification Code
AP7331-ADJ	SOT25	QJ
AP7331-10	SOT25	QK
AP7331-12	SOT25	QL
AP7331-15	SOT25	QM
AP7331-18	SOT25	QN
AP7331-20	SOT25	QT
AP7331-25	SOT25	QP
AP7331-28	SOT25	QQ
AP7331-30	SOT25	QR
AP7331-33	SOT25	QS

2. DFN2020-6

(Top View)



XX : Identification Code
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a~z : 27~52 week; z represents
52 and 53 week
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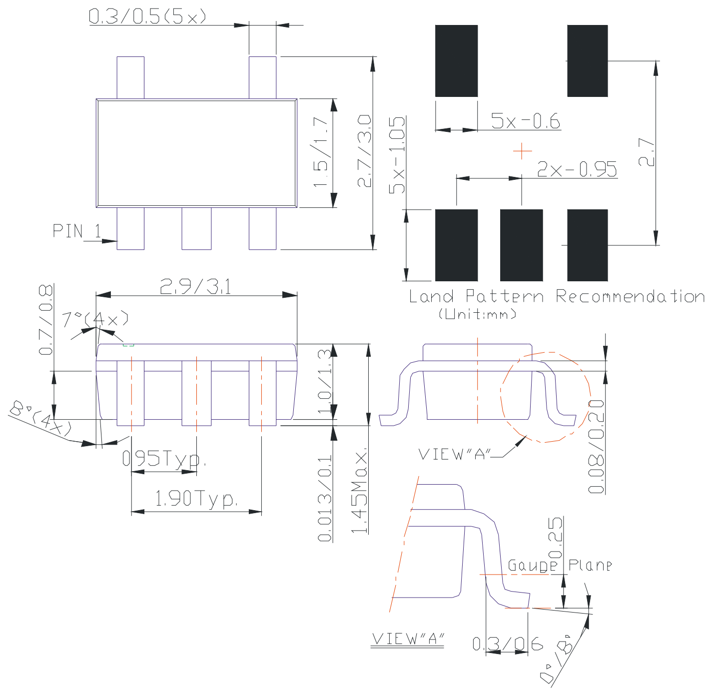
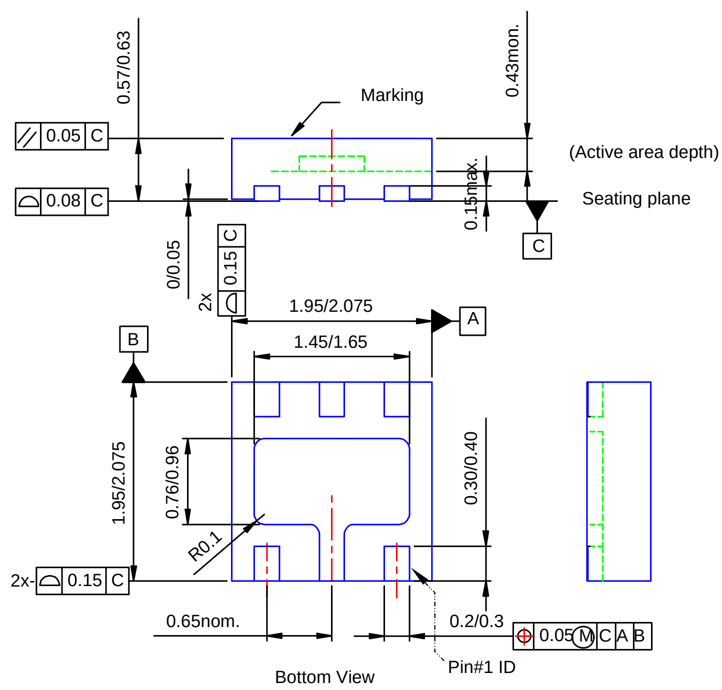
Device	Package	Identification Code
AP7331-ADJ	DFN2020-6	QJ
AP7331-10	DFN2020-6	QK
AP7331-12	DFN2020-6	QL
AP7331-15	DFN2020-6	QM
AP7331-18	DFN2020-6	QN
AP7331-20	DFN2020-6	QT
AP7331-25	DFN2020-6	QP
AP7331-28	DFN2020-6	QQ
AP7331-30	DFN2020-6	QR
AP7331-33	DFN2020-6	QS

Package Outline Dimensions (All Dimensions in mm)

1. Package Type: SOT25

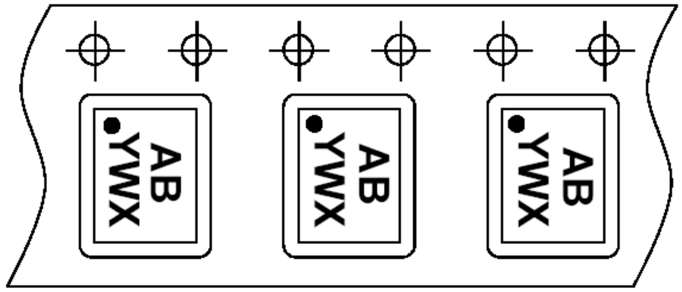


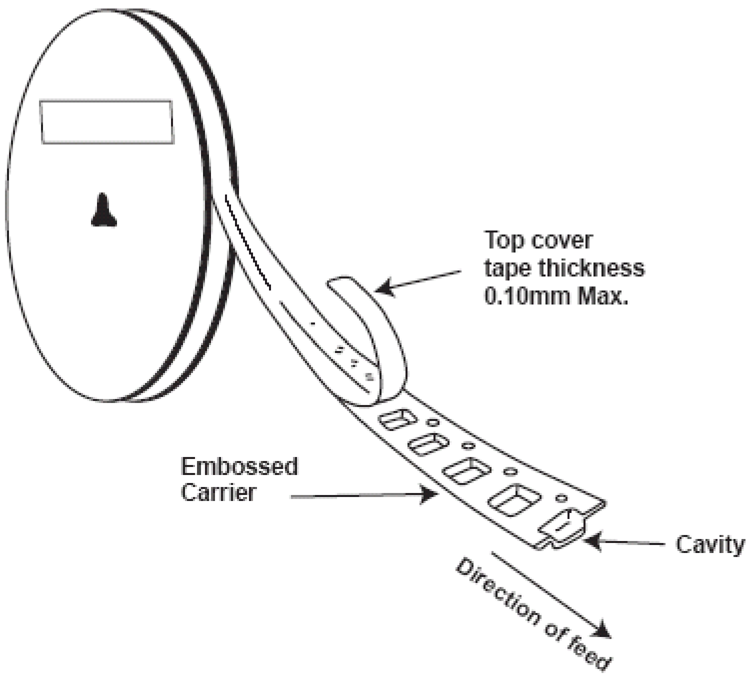
2. Package Type: DFN2020-6



Tape Orientation (Note 8)

DFN2020-6





Notes: 8. The taping orientation of the other package type can be found on our website at http://www.diodes.com/datasheets/ap02007.pdf