

Description

The AP7365 is a 600mA, adjustable and fixed output voltage, low dropout linear regulator. This device includes 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 such as battery powered devices. The typical quiescent current is approximately 35µA. Built-in current-limit and thermal-shutdown functions prevent IC from damage in fault conditions.

This device is available with adjustable output from 0.8V to 5.0V, and fixed version with 0.8V, 1.0V, 1.2V, 1.5V, 1.8V, 2.0V, 2.5V, 2.8V, 3.0V, 3.3V and 3.9V outputs. Please contact your local sales office for other voltage options.

The AP7365 is available in SOT25, SOT89-3, SOT223, and U-DFN2020-6 packages.

Features

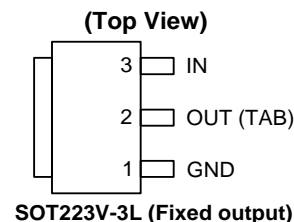
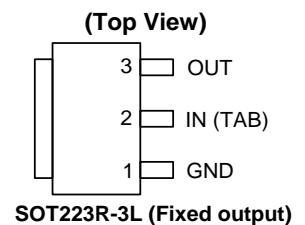
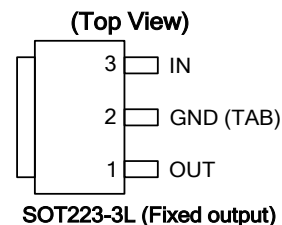
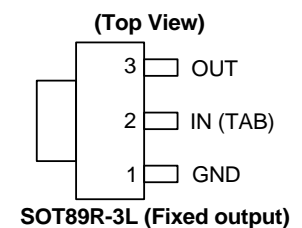
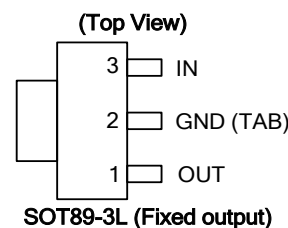
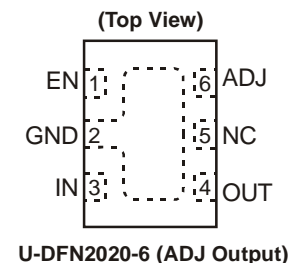
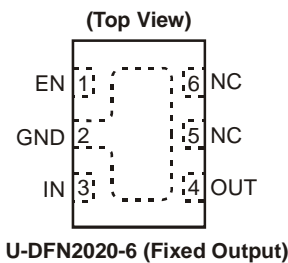
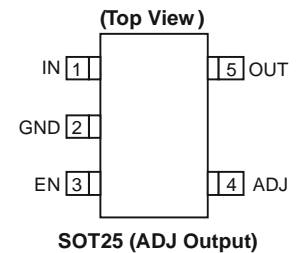
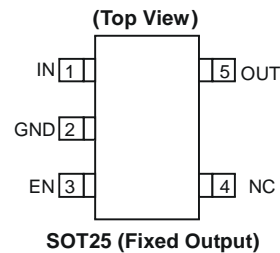
- 600mA Low Dropout Regulator with EN
- Very low I_q : 35µA
- Wide Input Voltage Range: 2V to 6V
- Wide Adjustable Output: 0.8V to 5.0V
- Fixed Output Options: 0.8V to 3.9V (0.1V step size possible)
- High PSRR: 65dB at 1kHz
- Fast Start-Up Time: 200µs
- Stable with Low ESR, 1µF Ceramic Output Capacitor
- Excellent Load/Line Transient Response
- Low Dropout: 300mV at 600mA
- Current Limit and Short Circuit Protection
- Thermal Shutdown Protection
- Ambient Temperature Range: -40°C to +85°C
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**

Applications

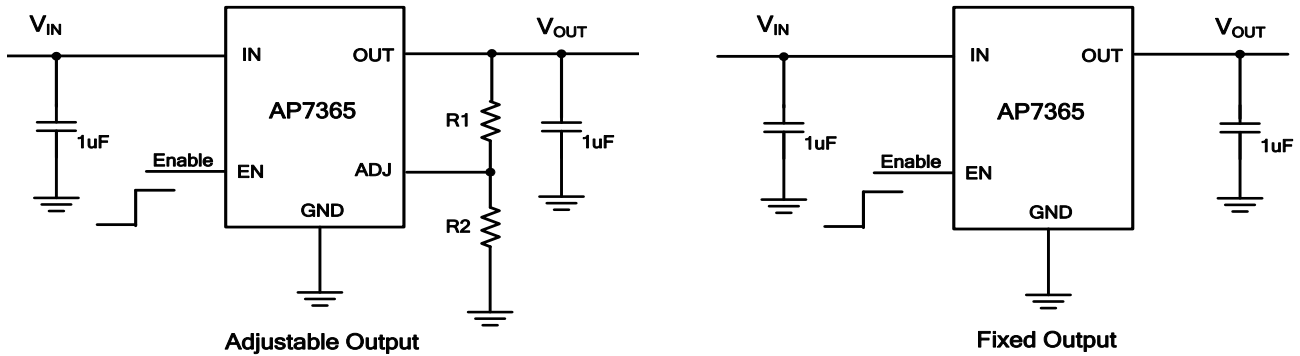
- Servers and Notebook Computers
- Low and Medium Power Applications
- FPGA and DSP Core or I/O Power
- Consumer Electronics

- Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant.
 2. See http://www.diodes.com/quality/lead_free.html for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
 3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

Pin Assignments



Typical Applications Circuit

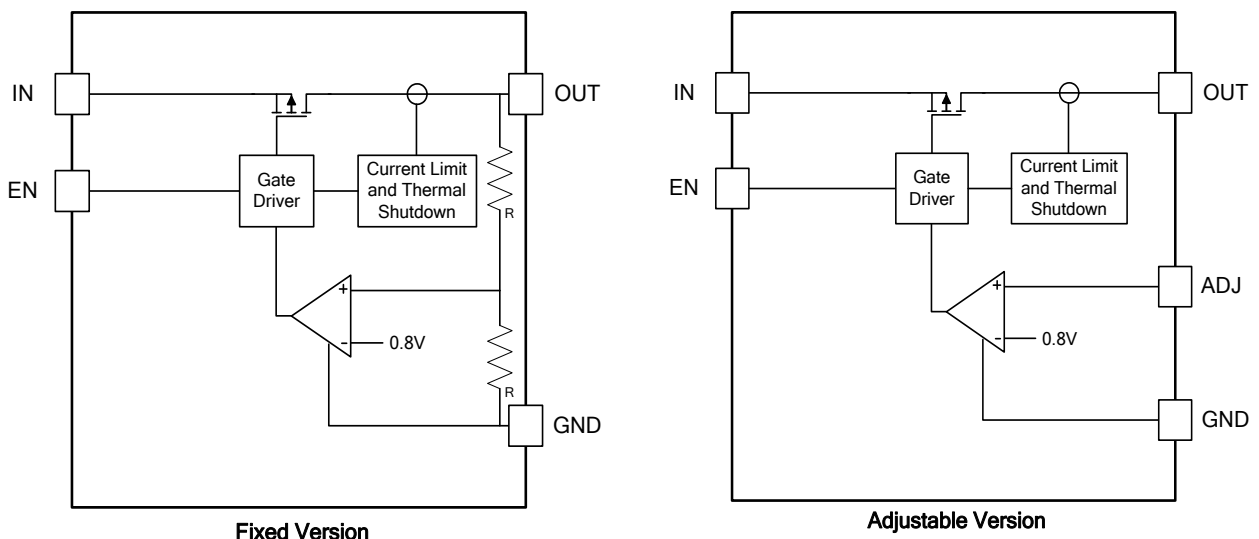


$$V_{OUT} = V_{REF} \left(1 + \frac{R_1}{R_2} \right) \text{ where } R_2 \leq 80K\Omega$$

Pin Descriptions

Pin Name	Pin Number							Functions
	SOT25 (Fixed)	SOT25 (ADJ)	U-DFN2020-6 (Fixed)	U-DFN2020-6 (ADJ)	SOT89-3 SOT223	SOT89-3R SOT223R	SOT223V	
IN	1	1	3	3	3	2	3	Voltage Input Pin. Bypass to ground through at least 1μF MLCC capacitor
GND	2	2	2	2	2	1	1	Ground
EN	3	3	1	1	—	—	—	Enable Input, Active High
ADJ	—	4	—	6	—	—	—	Output Feedback Pin
NC	4	—	5, 6	5	—	—	—	No Connection
OUT	5	5	4	4	1	3	2	Voltage Output Pin. Bypass to ground through 1μF MLCC capacitor

Functional Block Diagram



Absolute Maximum Ratings (@T_A = +25°C, unless otherwise specified.)

Symbol	Parameter	Ratings	Unit
ESD HBM	Human Body Model ESD Protection	2000	V
ESD MM	Machine Model ESD Protection	200	V
V _{IN}	Input Voltage	6.5	V
—	OUT, EN Voltage	V _{IN} +0.3	V
—	Continuous Load Current per Channel	Internal Limited	—
T _{ST}	Storage Temperature Range	-65 to +150	°C
T _J	Maximum Junction Temperature	+150	°C

Recommended Operating Conditions (@T_A = +25°C, unless otherwise specified.)

Symbol	Parameter	Min	Max	Unit
V _{IN}	Input Voltage	2	6	V
I _{OUT}	Output Current (Note 4)	0	600	mA
T _A	Operating Ambient Temperature	-40	+85	°C

Note: 4. The device maintains a stable, regulated output voltage without a load current.

Electrical Characteristics (@T_A = +25°C, V_{IN} = V_{OUT} +1V, C_{OUT} = 1μF, C_{IN} = 1μF, V_{EN} = 2V, unless otherwise specified.)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V _{REF}	ADJ Reference Voltage (Adjustable version)	I _{OUT} = 0mA	—	0.8	—	V
I _{ADJ}	ADJ Leakage (Adjustable version)	—	—	0.1	1.0	μA
V _{OUT}	Output Voltage Accuracy	T _A = -40°C to +85°C, I _{OUT} = 10% of I _{OUT-Max}	-2	—	+2	%
$\frac{\Delta V_{OUT}}{\Delta V_{IN}/V}$	Line Regulation	V _{IN} = (V _{OUT} +1V) to V _{IN-Max} , V _{EN} = V _{IN} , I _{OUT} = 1mA	—	0.02	0.20	%/V
$\Delta V_{OUT}/V_{OUT}$	Load Regulation	V _{IN} = (V _{OUT} +1V) to V _{IN-Max} , I _{OUT} = 1mA to 600mA	-1.0	—	+1.0	%
V _{DROPOUT}	Dropout Voltage (Note 5)	V _{OUT} < 2.5V, I _{OUT} = 600mA V _{OUT} ≥ 2.5V, I _{OUT} = 600mA	—	370 300	600 400	mV
I _Q	Input Quiescent Current	V _{EN} = V _{IN} , I _{OUT} = 0mA	—	35	80	μA
I _{SHDN}	Input Shutdown Current	V _{EN} = 0V, I _{OUT} = 0mA	—	0.1	1.0	μA
I _{LEAK}	Input Leakage Current	V _{EN} = 0V, OUT grounded	—	0.1	1.0	μA
t _{ST}	Start-Up Time	V _{EN} = 0V to 2.0V in 1μs, I _{OUT} = 600mA	—	200	—	μs
PSRR	PSRR (Note 6)	V _{IN} = [V _{OUT} +1V] V _{DC} + 0.5V _{ppAC} , f = 1kHz, I _{OUT} = 50mA	—	65	—	dB
I _{SHORT}	Short-Circuit Current	V _{IN} = V _{IN-Min} to V _{IN-Max} , V _{OUT} < 0.2V (fixed version) or 25% of V _{OUT} (ADJ version)	—	240	—	mA
I _{LIMIT}	Current limit	V _{IN} = V _{IN-Min} to V _{IN-Max} , V _{OUT} /R _{OUT} = 2.5A	0.8	1.4	—	A
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	—	—	145	—	°C
T _{HYS}	Thermal Shutdown Hysteresis	—	—	15	—	°C

Notes: 5. 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 input voltages above minimum V_{IN} = 2.0V.

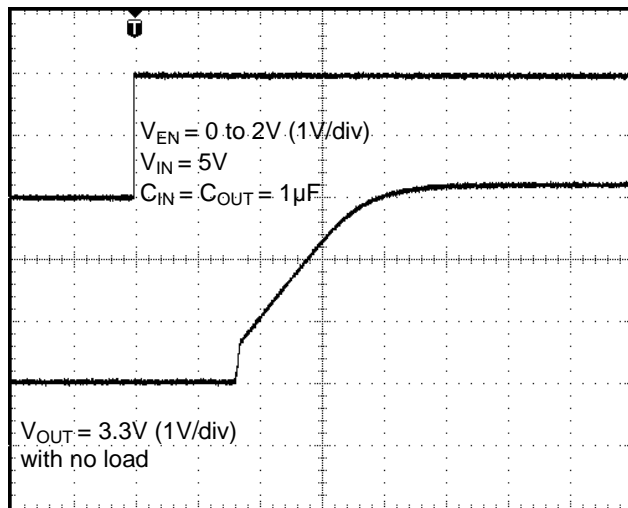
6. At V_{IN} < 2.3V, the PSRR performance may be reduced.

Electrical Characteristics (continued) (@ $T_A = +25^\circ\text{C}$, $V_{IN} = V_{OUT} + 1\text{V}$, $C_{OUT} = 1\mu\text{F}$, $C_{IN} = 1\mu\text{F}$, $V_{EN} = 2\text{V}$, unless otherwise specified.)

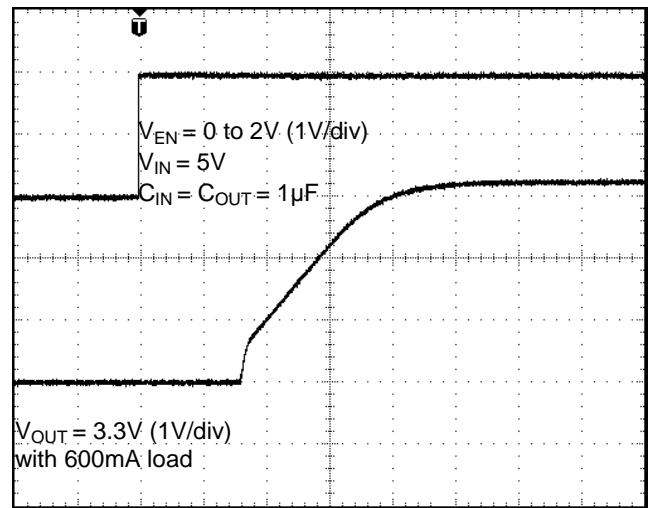
Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
θ_{JA}	Thermal Resistance Junction-to-Ambient	SOT25 (Note 7)	—	169	—	$^\circ\text{C/W}$
		U-DFN2020-6 (Note 7)	—	132	—	
		SOT89-3 (Note 7)	—	133	—	
		SOT223 (Note 7)	—	142	—	
θ_{JC}	Thermal Resistance Junction-to-Case	SOT25 (Note 7)	—	31	—	$^\circ\text{C/W}$
		U-DFN2020-6 (Note 7)	—	48	—	
		SOT89-3 (Note 7)	—	30	—	
		SOT223 (Note 7)	—	39	—	

Note: 7. Test condition for all packages: Device mounted on FR-4 substrate PC board, 1oz copper, with minimum recommended pad layout.

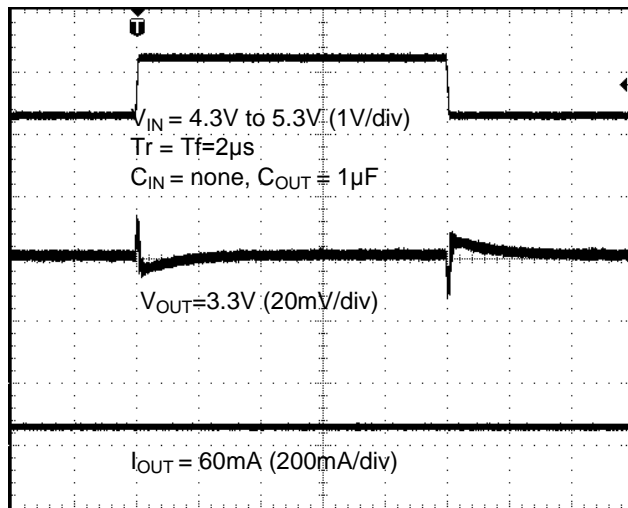
Typical Performance Characteristics



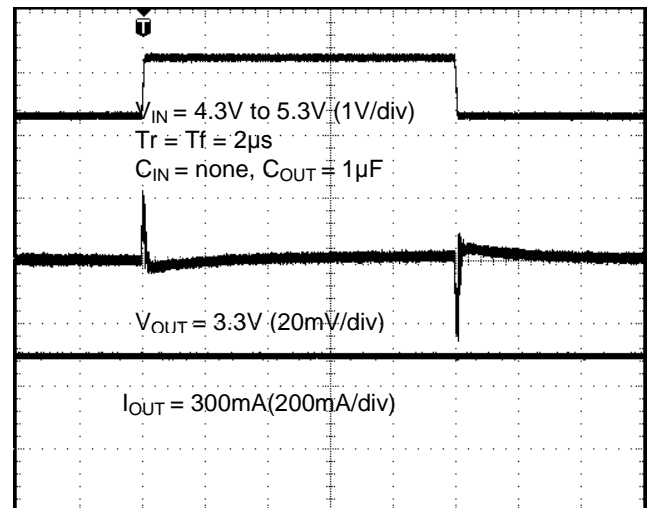
Time (40 $\mu\text{s/div}$)
Start-Up Time



Time (40 $\mu\text{s/div}$)
Start-Up Time

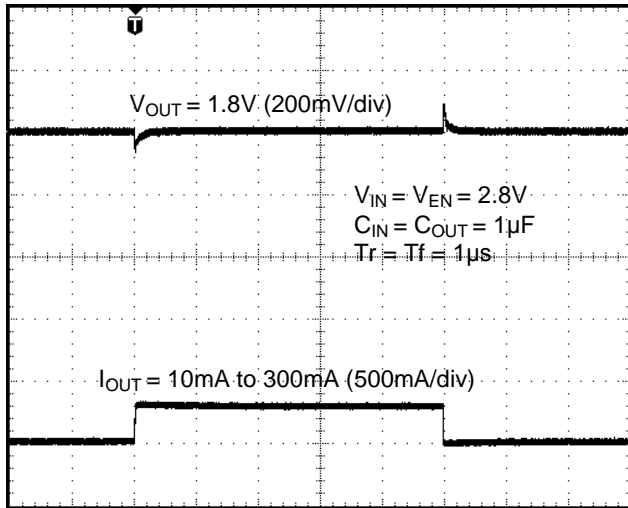


Time (40 $\mu\text{s/div}$)
Line Transient Response

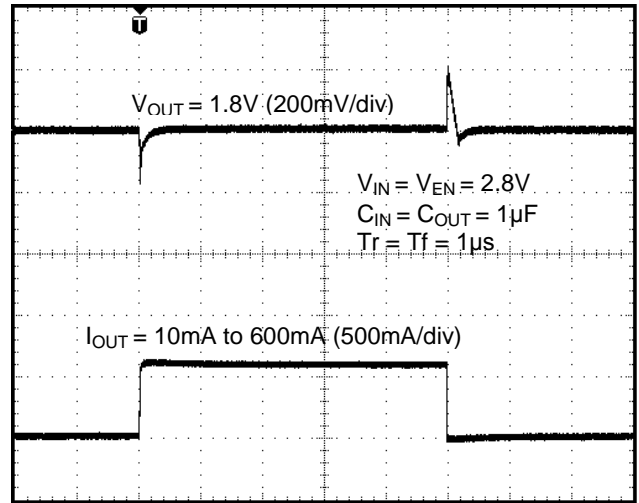


Time (40 $\mu\text{s/div}$)
Line Transient Response

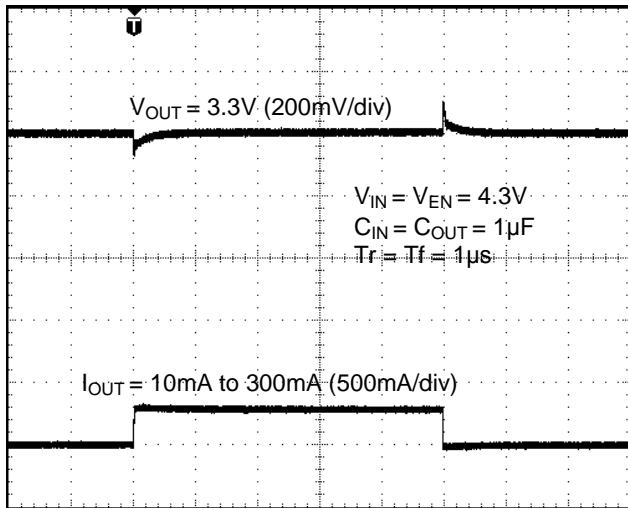
Typical Performance Characteristics (continued)



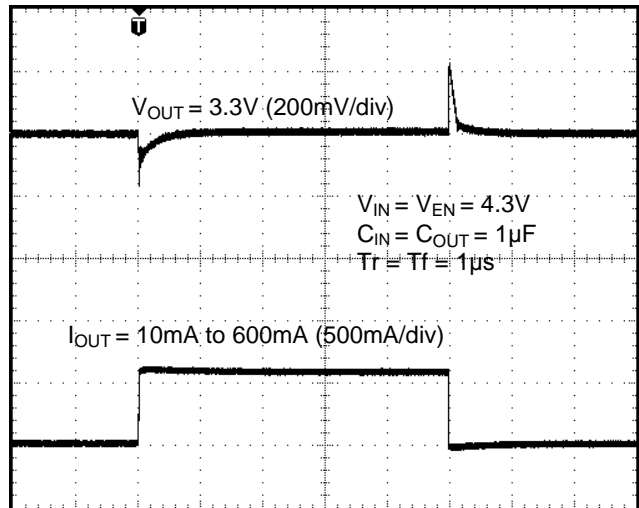
Load Transient Response
Time (100µs/div)



Load Transient Response
Time (100µs/div)

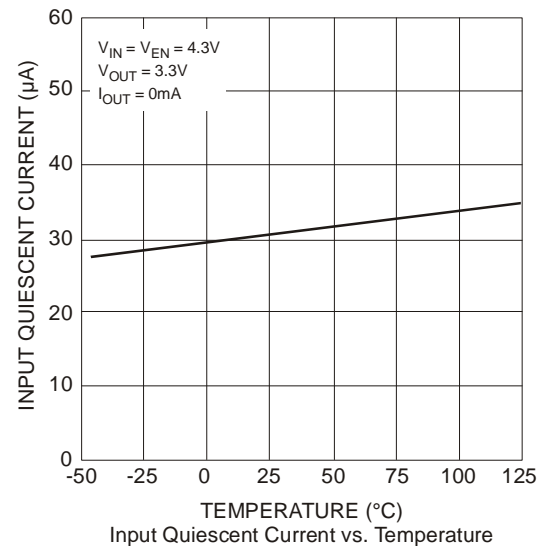
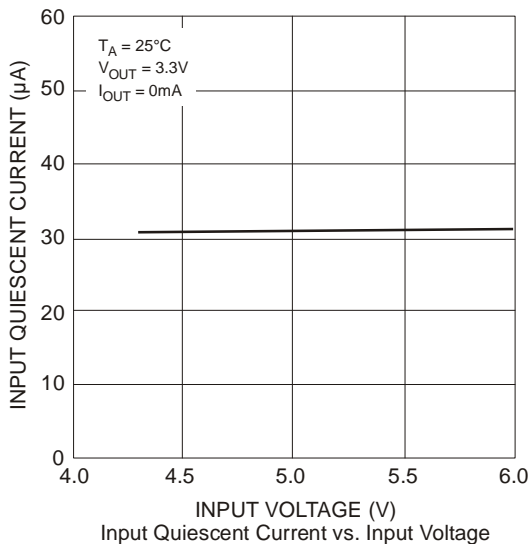
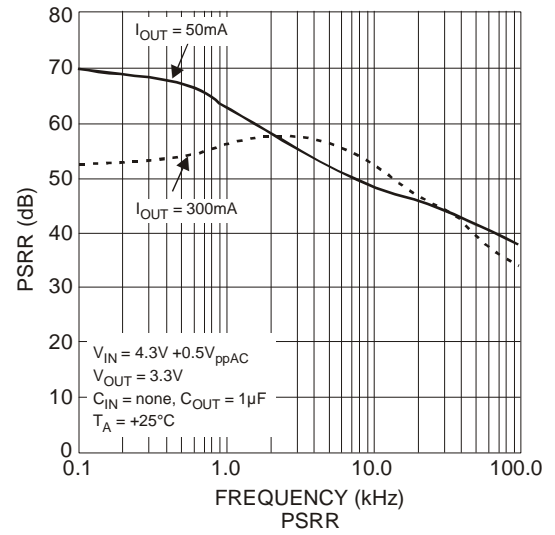
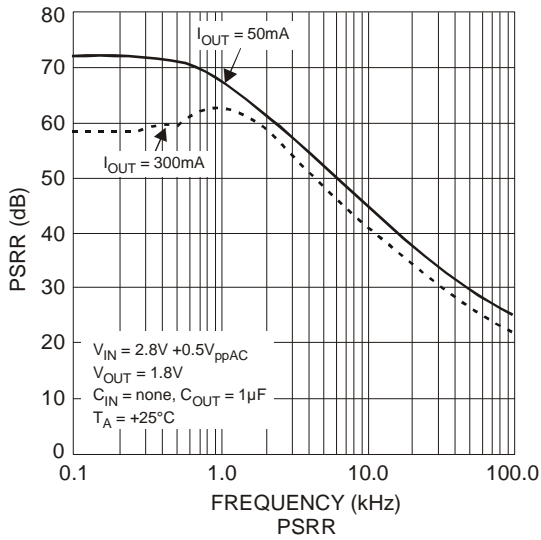
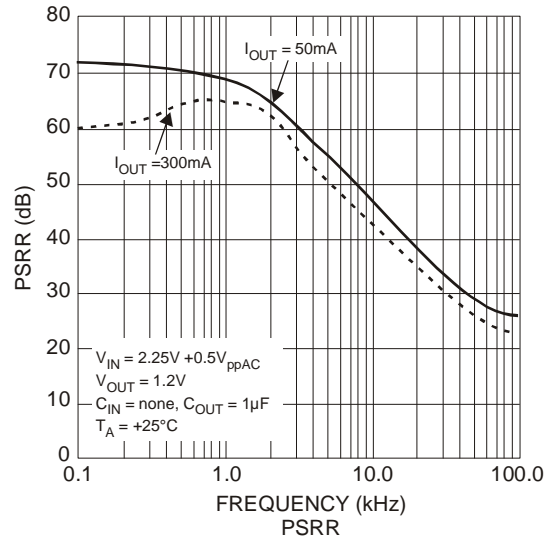
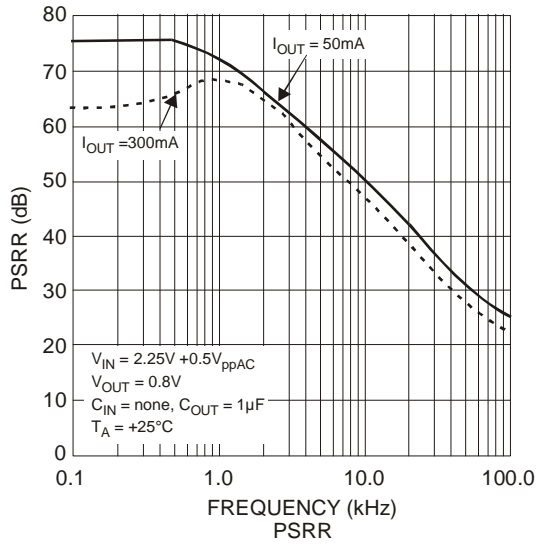


Load Transient Response
Time (100µs/div)

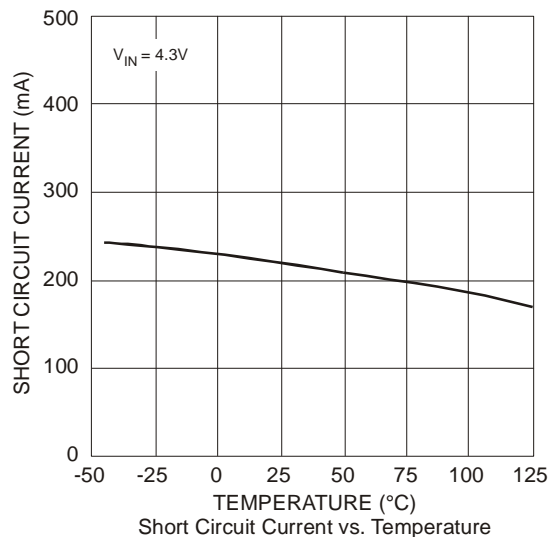
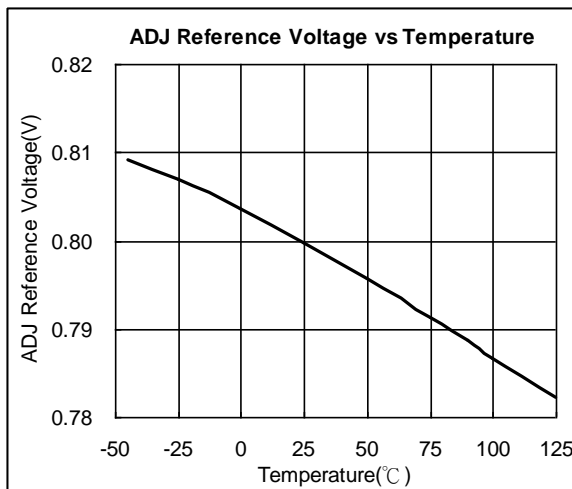
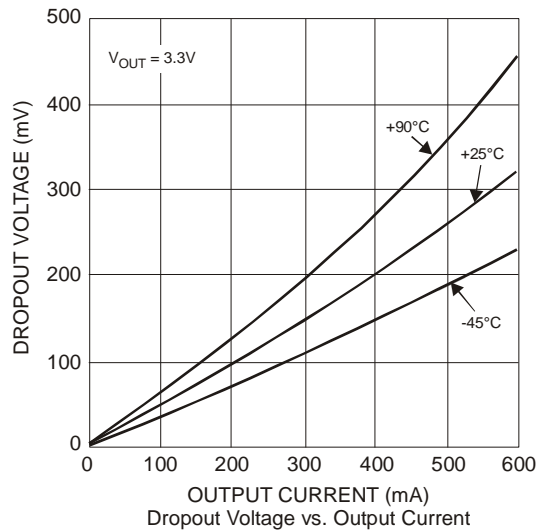
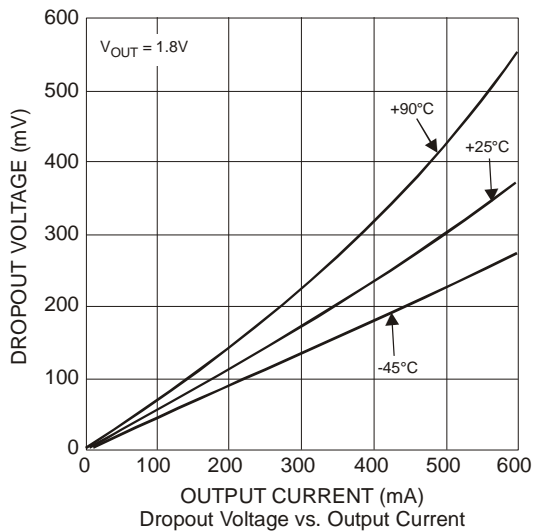
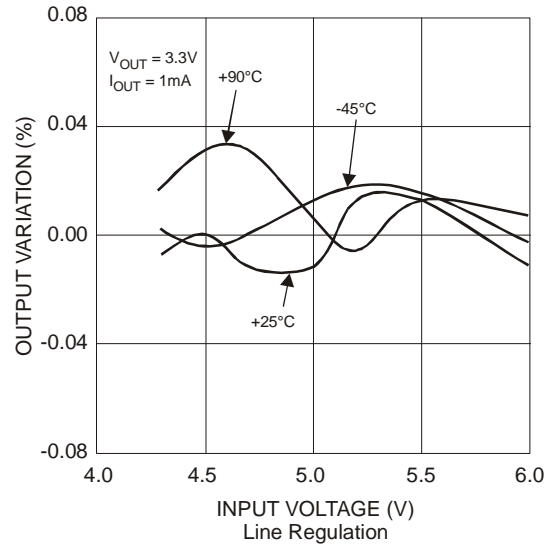
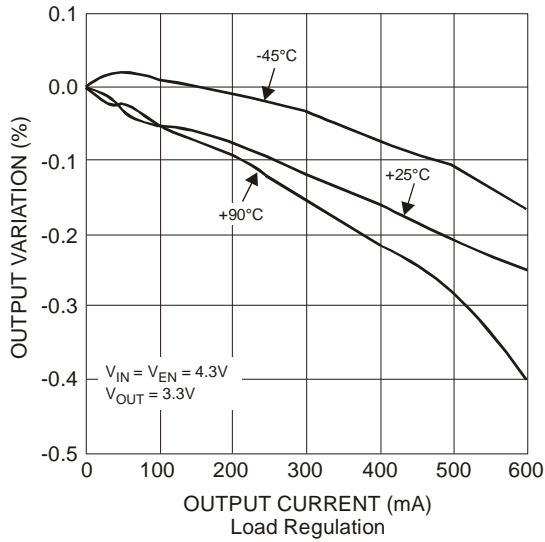


Load Transient Response
Time (100µs/div)

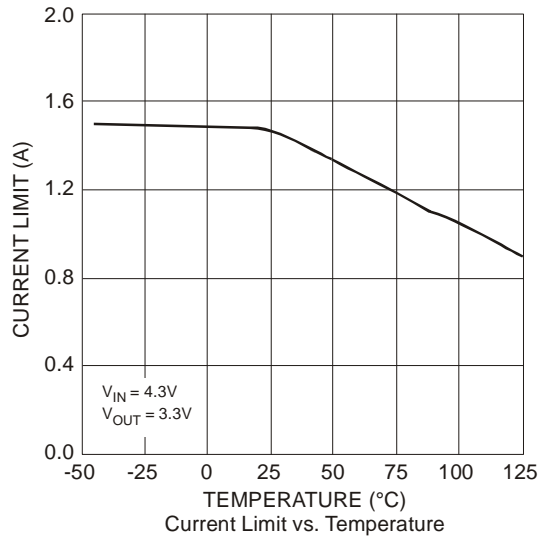
Typical Performance Characteristics (cont.)



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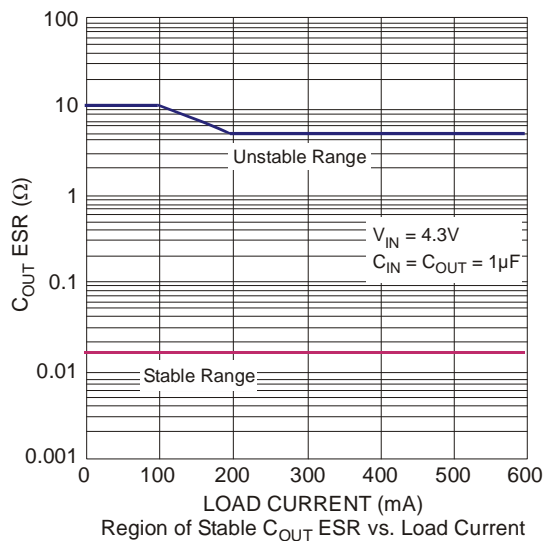
Application Information

Input Capacitor

A 1µF ceramic capacitor is recommended between 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 reduce noise. For PCB layout, a wide copper trace is required for both IN and GND pins. A lower ESR capacitor type allows the use of less capacitance, while higher ESR type requires more capacitance.

Output Capacitor

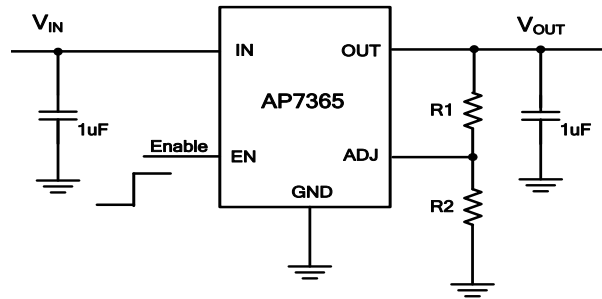
The output capacitor is required to stabilize and improve the transient response of the LDO. The AP7365 is stable with very small ceramic output capacitors. Using a ceramic capacitor value that is at least 1µF with ESR > 15mΩ on the output ensures stability. Higher capacitance values help to improve line and load transient response. The output capacitance may be increased to keep low undershoot and overshoot. Output capacitor must be placed as close as possible to OUT and GND pins.



Application Information (continued)

Adjustable Operation

The AP7365 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 $V_{REF} = 0.8V$ (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 needs to be kept smaller than 80k Ω .

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 AP7365 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 1.4A to prevent overcurrent and to protect the regulator from damage due to overheating.

Short Circuit Protection

When OUT pin is short-circuit to GND, short circuit protection will be triggered and clamp the output current to approximately 240mA. This feature protects the regulator from overcurrent and damage due to overheating.

Thermal Shutdown Protection

Thermal protection disables the output when the junction temperature rises to approximately +145 $^{\circ}C$, allowing the device to cool down. When the junction temperature reduces to approximately +130 $^{\circ}C$, 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 AP7365 is able to provide full power in as little as hundreds of microseconds, typically 200 μs , 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.

Application Information (cont.)

Fast Transient Response

Fast transient response LDO 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%, 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 LDO.

The AP7365's fast transient response from 0 to 600mA provides stable voltage supply for fast DSP and GSM chipset with fast changing load.

Low Quiescent Current

The AP7365, consuming only around 35µA for all input ranges, provides great power saving in portable and low power applications.

Wide Output Range

The AP7365, with a wide output range of 0.8V to 5.0V, provides a versatile LDO solution for many portable applications.

Power Dissipation

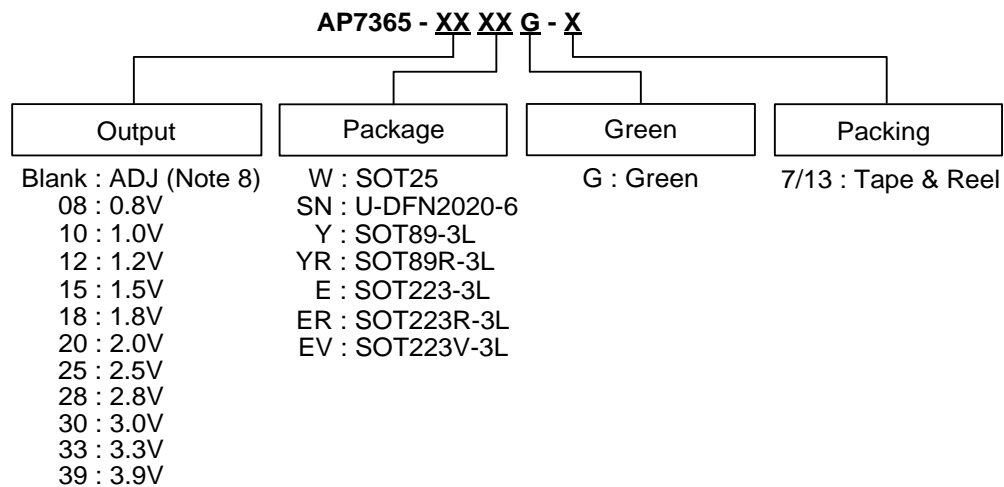
The device power dissipation and proper sizing of the thermal plane connected to the thermal pad is critical to avoid thermal shutdown and ensure reliable operation. Power dissipation of the device depends on input voltage and load conditions and can be calculated by:

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

The maximum power dissipation, handled by the device, depends on the maximum junction to ambient thermal resistance, maximum ambient temperature, and maximum device junction temperature, which can be calculated by the equation in the following:

$$P_D(\text{MAX}@T_A) = \frac{(+145^\circ\text{C} - T_A)}{R_{\theta JA}}$$

Ordering Information



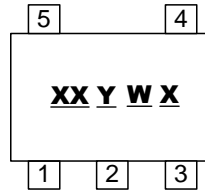
Part Number	Package Code	Packaging	7"/13" Tape and Reel	
			Quantity	Part Number Suffix
AP7365-XXWG-7	W	SOT25	3,000/Tape & Reel	-7
AP7365-XXSNG-7	SN	U-DFN2020-6	3,000/Tape & Reel	-7
AP7365-XXYG-13	Y	SOT89-3L	2,500/Tape & Reel	-13
AP7365-XXYRG-13	YR	SOT89R-3L	2,500/Tape & Reel	-13
AP7365-XXEG-13	E	SOT223-3L	2,500/Tape & Reel	-13
AP7365-XXERG-13	ER	SOT223R-3L	2,500/Tape & Reel	-13
AP7365-XXEVG-13	EV	SOT223V-3L	2,500/Tape & Reel	-13

Note: 8. Adjustable version is only available in SOT25 and U-DFN2020-6 package.

Marking Information

(1) SOT25

(Top View)

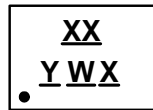


XX : Identification code
Y : Year 0~9
W : Week : A~Z : 1~26 week;
a~z : 27~52 week; z represents
52 and 53 week
X : A~Z : Green

Device	Package	Identification Code
AP7365-ADJ	SOT25	VA
AP7365-08	SOT25	VB
AP7365-10	SOT25	VC
AP7365-12	SOT25	VD
AP7365-15	SOT25	VE
AP7365-18	SOT25	VF
AP7365-20	SOT25	VG
AP7365-25	SOT25	VH
AP7365-28	SOT25	VJ
AP7365-30	SOT25	VK
AP7365-33	SOT25	VM
AP7365-39	SOT25	VN

(2) U-DFN2020-6

(Top View)

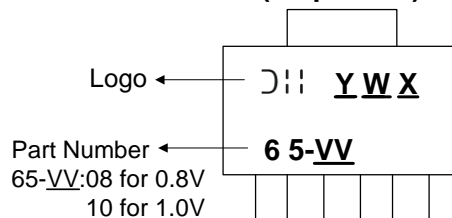


XX : Identification Code
Y : Year : 0~9
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a~z : 27~52 week; z represents
52 and 53 week
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Device	Package	Identification Code
AP7365-ADJ	U-DFN2020-6	VA
AP7365-08	U-DFN2020-6	VB
AP7365-10	U-DFN2020-6	VC
AP7365-12	U-DFN2020-6	VD
AP7365-15	U-DFN2020-6	VE

(3) SOT223-3L

(Top View)

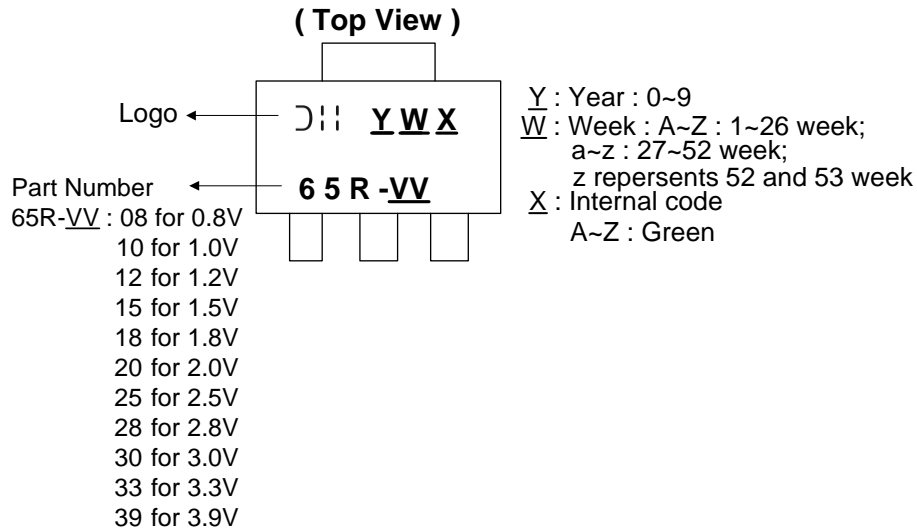


Y : Year : 0~9
W : Week : A~Z : 1~26 week;
a~z : 27~52 week;
z represents 52 and 53 week
X : Internal code
A~Z : Green

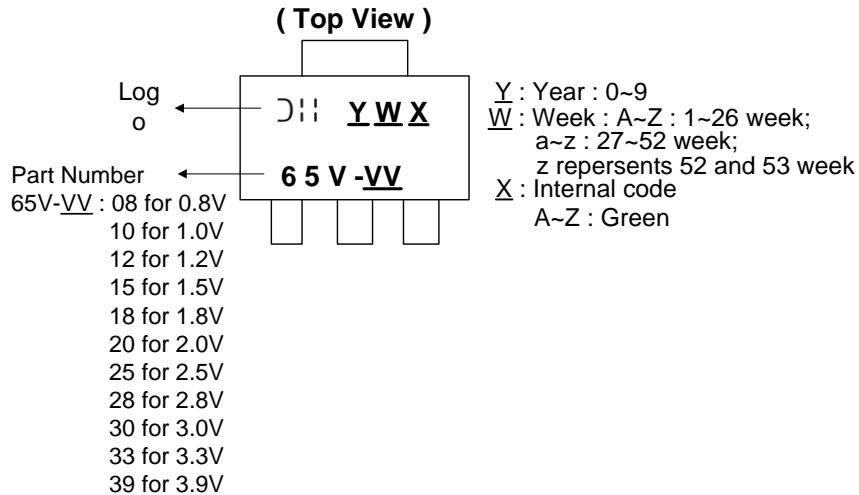
Part Number ←
65-VV:08 for 0.8V
10 for 1.0V
12 for 1.2V
15 for 1.5V
18 for 1.8V
20 for 2.0V
25 for 2.5V
28 for 2.8V
30 for 3.0V
33 for 3.3V
39 for 3.9V

Marking Information (continued)

(4) SOT223R-3L



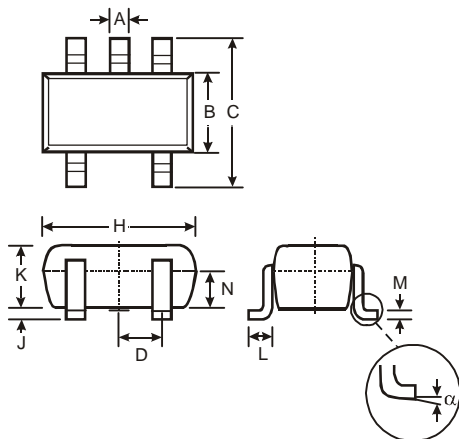
(5) SOT223V-3L



Package Outline Dimensions (All dimensions in mm.)

Please see AP02002 at <http://www.diodes.com/datasheets/ap02002.pdf> for the latest version.

(1) Package Type: SOT25

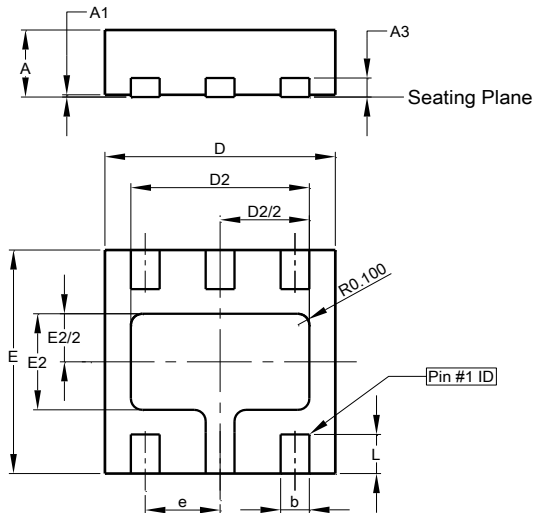


SOT25			
Dim	Min	Max	Typ
A	0.35	0.50	0.38
B	1.50	1.70	1.60
C	2.70	3.00	2.80
D	—	—	0.95
H	2.90	3.10	3.00
J	0.013	0.10	0.05
K	1.00	1.30	1.10
L	0.35	0.55	0.40
M	0.10	0.20	0.15
N	0.70	0.80	0.75
α	0°	8°	—
All Dimensions in mm			

Package Outline Dimensions (cont.) (All dimensions in mm.)

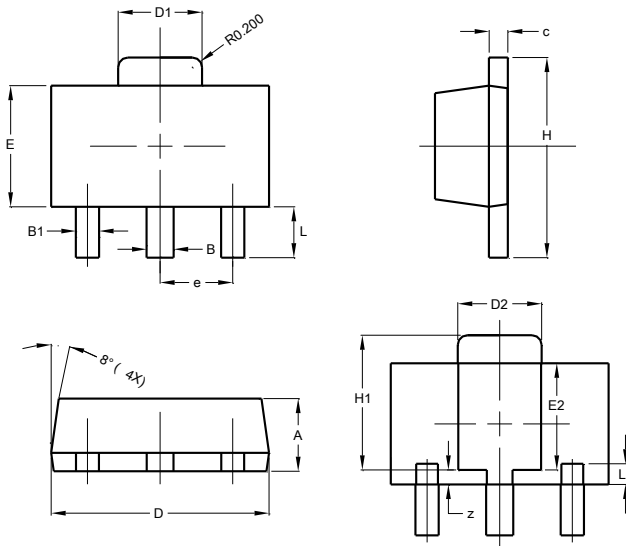
Please see AP02002 at <http://www.diodes.com/datasheets/ap02002.pdf> for the latest version.

(2) Package Type: U-DFN2020-6



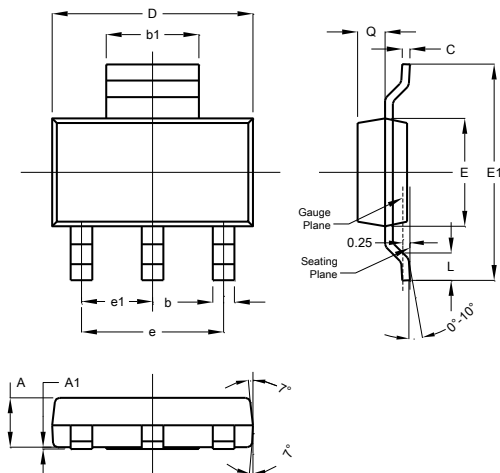
U-DFN2020-6			
Dim	Min	Max	Typ
A	0.57	0.63	0.60
A1	0	0.05	0.03
A3	-	-	0.15
b	0.20	0.30	0.25
D	1.95	2.075	2.00
D2	1.45	1.65	1.55
e	-	-	0.65
E	1.95	2.075	2.00
E2	0.76	0.96	0.86
L	0.30	0.40	0.35
All Dimensions in mm			

(3) Package Type: SOT89-3L and SOT89R-3L



SOT89			
Dim	Min	Max	Typ
A	1.40	1.60	1.50
B	0.50	0.62	0.56
B1	0.42	0.54	0.48
c	0.35	0.43	0.38
D	4.40	4.60	4.50
D1	1.62	1.83	1.733
D2	1.61	1.81	1.71
E	2.40	2.60	2.50
E2	2.05	2.35	2.20
e	-	-	1.50
H	3.95	4.25	4.10
H1	2.63	2.93	2.78
L	0.90	1.20	1.05
L1	0.327	0.527	0.427
z	0.20	0.40	0.30
All Dimensions in mm			

(4) Package Type: SOT223-3L, SOT223R-3L and SOT223V-3L

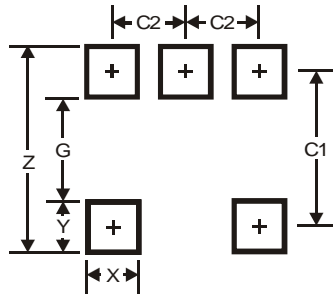


SOT223			
Dim	Min	Max	Typ
A	1.55	1.65	1.60
A1	0.010	0.15	0.05
b	0.60	0.80	0.70
b1	2.90	3.10	3.00
C	0.20	0.30	0.25
D	6.45	6.55	6.50
E	3.45	3.55	3.50
E1	6.90	7.10	7.00
e	-	-	4.60
e1	-	-	2.30
L	0.85	1.05	0.95
Q	0.84	0.94	0.89
All Dimensions in mm			

Suggested Pad Layout

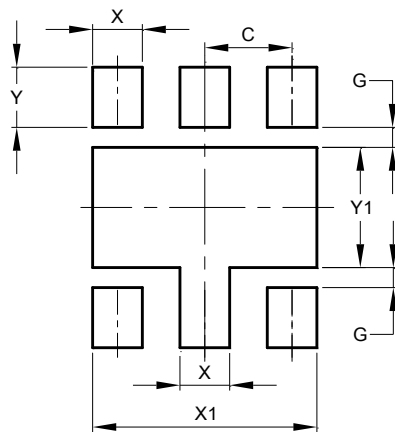
Please see AP02001 at <http://www.diodes.com/datasheets/ap02001.pdf> for the latest version.

(1) Package Type: SOT25



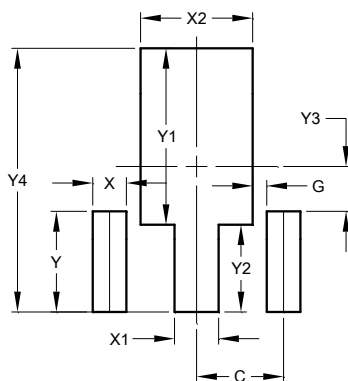
Dimensions	Value (in mm)
Z	3.20
G	1.60
X	0.55
Y	0.80
C1	2.40
C2	0.95

(2) Package Type: U-DFN2020-6



Dimensions	Value (in mm)
C	0.65
G	0.15
X	0.37
X1	1.67
Y	0.45
Y1	0.90

(3) Package Type: SOT89-3L and SOT89R-3L

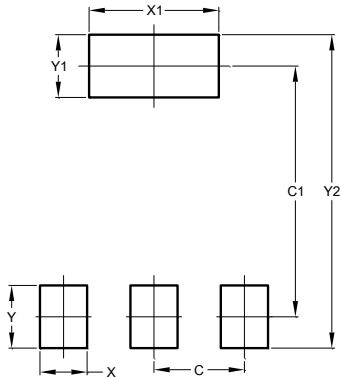


Dimensions	Value (in mm)
C	1.500
G	0.244
X	0.580
X1	0.760
X2	1.933
Y	1.730
Y1	3.030
Y2	1.500
Y3	0.770
Y4	4.530

Suggested Pad Layout (continued)

Please see AP02001 at <http://www.diodes.com/datasheets/ap02001.pdf> for the latest version.

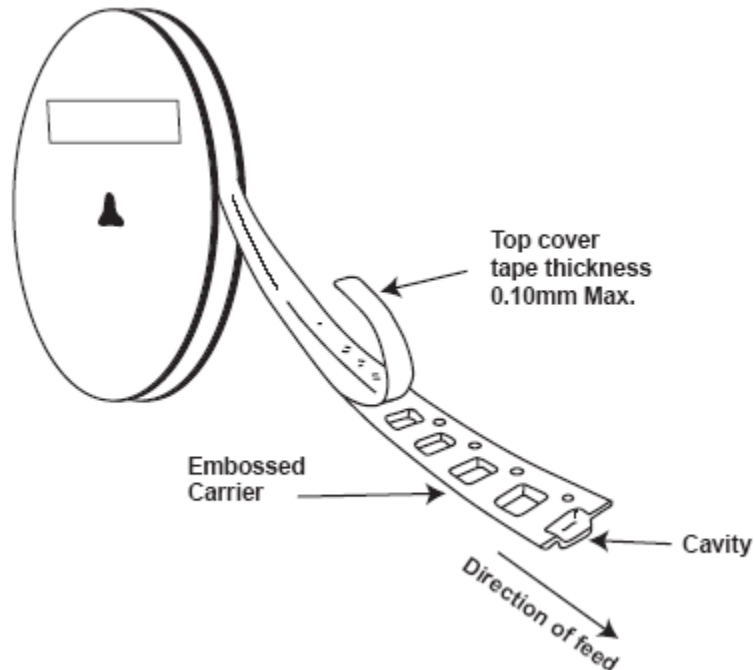
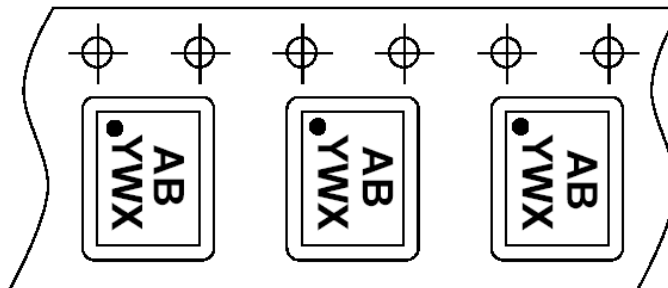
(4) Package Type: SOT223-3L, SOT223R-3L and SOT223V-3L



Dimensions	Value (in mm)
C	2.30
C1	6.40
X	1.20
X1	3.30
Y	1.60
Y1	1.60
Y2	8.00

Tape Orientation (Note 9)

For U-DFN2020-6



Note: 9. The taping orientation of the other package type can be found on our website at <http://www.diodes.com/datasheets/ap02007.pdf>.

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