DIODES INCORPORATED

NOT RECOMMENDED FOR NEW DESIGN
USE AP7366EA

Lead-free Green

AP7366

600mA, LOW QUIESCENT CURRENT FAST TRANSIENT LOW DROPOUT LINEAR REGULATOR

Description

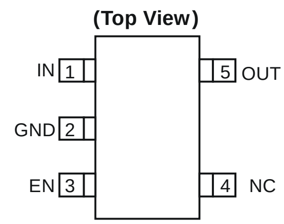
The DIODES™ AP7366 is a 600mA, adjustable and fixed output voltage, low-dropout linear regulator. This device includes pass element, error amplifier, band-gap, current limit and thermal-shutdown circuitry. The device is turned on when EN pin is set to logic-high level.

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 60µA. Built-in current-limit and thermal-shutdown functions prevent IC from damage in fault conditions.

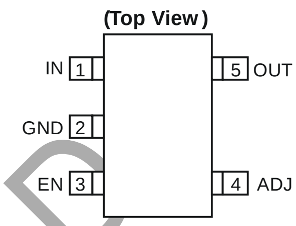
This device is available with adjustable output from 0.8V to 5.0V, and fixed version with 1.0V, 1.2V, 1.5V, 1.8V, 2.0V, 2.5V, 2.8V, 3.0V, 3.3V, 3.6V and 3.9V outputs. Please contact your local sales office for other voltage options.

The AP7366 is available in SOT25 and U-DFN2020-6 packages.

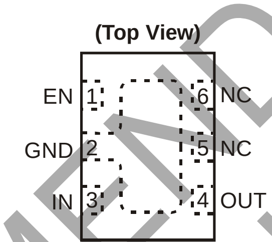
Pin Assignments



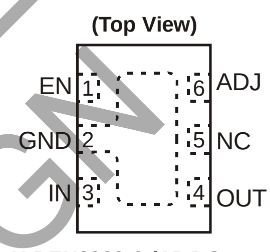
SOT25 (Fixed Output)



SOT25 (ADJ Output)



U-DFN2020-6 (Fixed Output)



U-DFN2020-6 (ADJ Output)

Features

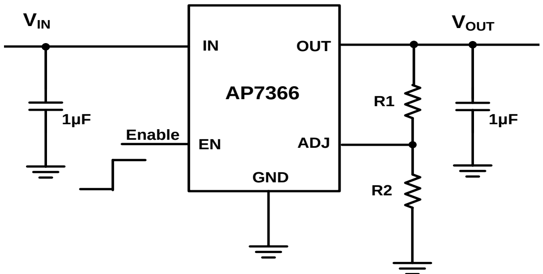
- 600mA Low-Dropout Regulator with EN
- Low I_Q: 60µA
- Wide Input Voltage Range: 2.2V to 6V
- Wide Adjustable Output: 0.8V to 5.0V
- Fixed Output Options: 1.0V, 1.2V, 1.5V, 1.8V, 2.0V, 2.5V, 2.8V, 3.0V, 3.3V, 3.6V, 3.9V
- High PSRR: 75dB at 1kHz
- Fast Start-Up Time: 150µs
- Stable with Low ESR, 1µF 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)**
- **For automotive applications requiring specific change control (i.e. parts qualified to AEC-Q100/101/104/200, PPAP capable, and manufactured in IATF 16949 certified facilities), please contact us or your local Diodes representative.**
  https://www.diodes.com/quality/product-definitions/

Applications

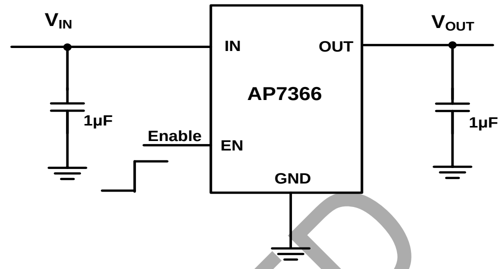
- Servers and notebook computers
- Low and medium power applications
- FPGA and DSP core or I/O power
- Consumer electronics

Notes: 1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
2. See https://www.diodes.com/quality/lead-free/ 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.

Typical Applications Circuit



Adjustable Output



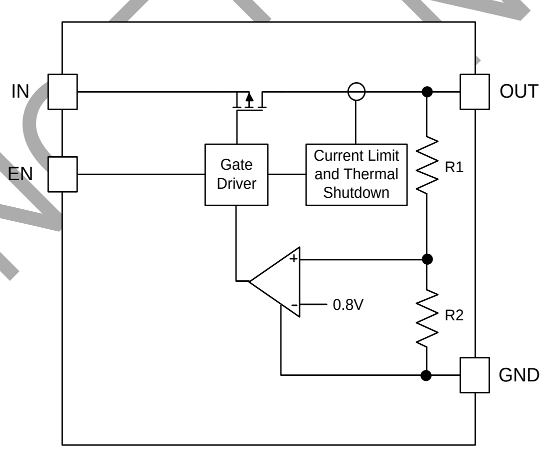
Fixed Output

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

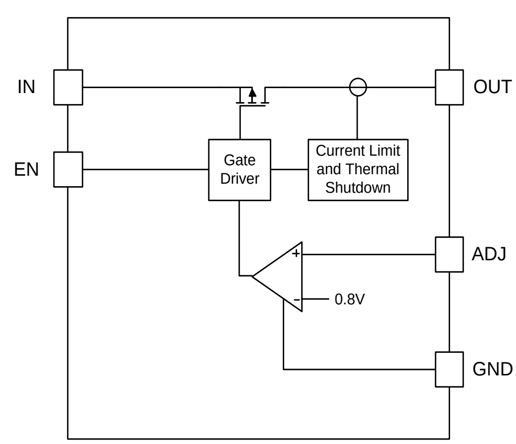
Pin Descriptions

Pin Name	Pin Number				Functions
	SOT25 (Fixed Output)	SOT25 (ADJ Output)	U-DFN2020-6 (Fixed Output)	U-DFN2020-6 (ADJ Output)	
IN	1	1	3	3	Voltage Input Pin. Bypass to ground through at least 1μF MLCC capacitor
GND	2	2	2	2	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	Voltage Output Pin. Bypass to ground through 1μF MLCC capacitor

Functional Block Diagram



Fixed Output



Adjustable Output

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

Symbol	Parameter	Ratings	Unit
ESD HBM	Human Body Model ESD Protection	2000	V
ESD CDM	Charged Device Model	±1000	V
V_{IN}	Input Voltage	6.5	V
—	OUT, EN Voltage	V_{IN} +0.3	V
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	2.2	6	V
V_{OUT}	Output Voltage	0.8	5	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} = V_{IN}, unless otherwise specified.)

Symbol	Parameter	Test Conditions		Min	Typ	Max	Unit
V_{REF}	ADJ Reference Voltage (Adjustable Version)	I_{OUT} = 10mA		0.788	0.8	0.812	V
I_{ADJ}	ADJ Leakage (Adjustable Version)	—		—	0.1	0.5	µA
I_Q	Input Quiescent Current	V_{EN} = V_{IN}, I_{OUT} = 0mA		—	60	80	µA
V_{OUT}	Output Voltage Accuracy	I_{OUT} = 10mA	1.0V ≦ V_{OUT} < 1.5V	V_{OUT} - 0.015	V_{OUT}	V_{OUT} + 0.015	V
			1.5V ≦ V_{OUT} ≦ 3.9V	V_{OUT} * 0.99	V_{OUT}	V_{OUT} * 1.01	%
I_{SHDN}	Input Shutdown Current	V_{EN} = 0V, I_{OUT} = 0mA		-1.0	0.05	1.0	µA
ΔV_{OUT} /ΔV_{IN}/V_{OUT}	Line Regulation	V_{IN} = (V_{OUT} +1V) to 5.5V, I_{OUT} = 10mA	T_A = +25°C	—	0.01	0.1	%/V
			-40°C ≦ T_A ≦ +85°C	—	—	0.2	
ΔV_{OUT}/V_{OUT}	Load Regulation	I_{OUT} = 1mA to 600mA	1.2V < V_{OUT} ≦ 3.9V	-1.0	—	+1.0	%
			1.0V ≦ V_{OUT} ≦ 1.2V	-1.5	—	+1.5	
$V_{DROPOUT}$	Dropout Voltage (Note 5)	V_{OUT} = 1.0V, I_{OUT} = 300mA		—	650	900	mV
		V_{OUT} = 1.2V, I_{OUT} = 300mA		—	480	700	
		V_{OUT} = 1.5V, I_{OUT} = 300mA		—	200	340	
		V_{OUT} = 1.8V, I_{OUT} = 300mA		—	160	250	
		V_{OUT} = 2.0V, I_{OUT} = 300mA		—	140	200	
		V_{OUT} = 2.5V, I_{OUT} = 300mA		—	125	190	
		V_{OUT} = 2.8V, I_{OUT} = 300mA		—	115	180	
		V_{OUT} = 3.0V, I_{OUT} = 300mA		—	110	170	
		V_{OUT} = 3.3V, I_{OUT} = 300mA		—	105	160	
		V_{OUT} = 3.6V, I_{OUT} = 300mA		—	105	160	
		V_{OUT} = 3.9V, I_{OUT} = 300mA		—	100	150	
$V_{DROPOUT}$	Dropout Voltage (Note 5)	V_{OUT} = 1.0V, I_{OUT} = 600mA		—	850	1200	mV
		V_{OUT} = 1.2V, I_{OUT} = 600mA		—	800	1000	
		V_{OUT} = 1.5V, I_{OUT} = 600mA		—	450	700	
		V_{OUT} = 1.8V, I_{OUT} = 600mA		—	320	420	
		V_{OUT} = 2.0V, I_{OUT} = 600mA		—	285	400	
		V_{OUT} = 2.5V, I_{OUT} = 600mA		—	250	380	
		V_{OUT} = 2.8V, I_{OUT} = 600mA		—	230	350	
		V_{OUT} = 3.0V, I_{OUT} = 600mA		—	220	330	
		V_{OUT} = 3.3V, I_{OUT} = 600mA		—	210	320	
		V_{OUT} = 3.6V, I_{OUT} = 600mA		—	210	320	
		V_{OUT} = 3.9V, I_{OUT} = 600mA		—	190	290	
PSRR	PSRR (Note 6)	f = 1kHz, I_{OUT} = 100mA		—	75	—	dB
		f = 10kHz, I_{OUT} = 100mA		—	55	—	dB
I_{SHORT}	Short-Circuit Current	V_{IN} = V_{OUT} + 1V, Output Voltage <15% of V_{OUT}		—	250	—	mA
t_{ST}	Start-Up Time	V_{OUT} = 0V to 3.0V, R_L = 30Ω		—	150	—	µs
I_{LIMIT}	Current Limit	V_{IN} = V_{OUT} + 1V		0.66	1.0	—	A
V_{IL}	EN Input Logic-Low Voltage	V_{IN} = V_{IN-Min} to V_{IN-Max}		—	—	0.3	V
V_{IH}	EN Input Logic-High Voltage	V_{IN} = V_{IN-Min} to V_{IN-Max}		1.0	—	V_{IN}	V
I_{EN}	EN Input Leakage Current	V_{IN} = 5.5V or V_{EN} = 0V		-0.1	—	+0.1	µA
T_{SHDN}	Thermal Shutdown Threshold	—		—	+150	—	°C
T_{HYS}	Thermal Shutdown Hysteresis	—		—	+20	—	°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.

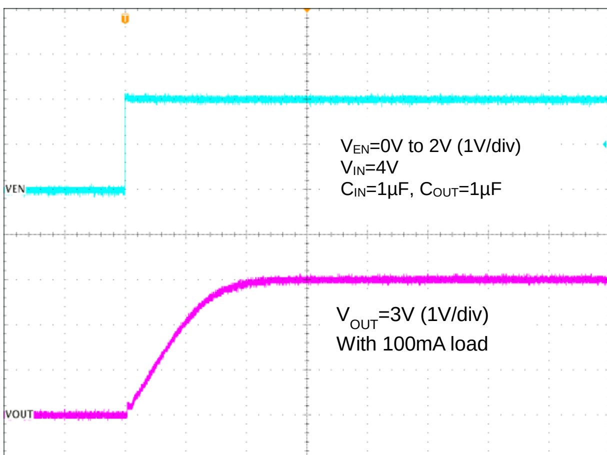
Electrical Characteristics (continued) (@T_A = +25°C, V_{IN} = V_{OUT} +1V, C_{OUT} = 1µF, C_{IN} = 1µF, V_{EN} = V_{IN}, unless otherwise specified.)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
R_{ENPD}	EN Pulldown Resistor	—	—	3	—	MΩ
R_{PD}	Output Discharge Resistor	V_{OL} = 1V	—	100	—	Ω
$\Delta V_{OUT}/\Delta T_A/V_{OUT}$	Output Voltage Temperature Coefficient	I_{OUT} = 100mA, -40°C ≤ T_A ≤ +85°C	—	±100	—	ppm/°C
θ_{JA}	Thermal Resistance Junction-to-Ambient	SOT25 (Note 7)	—	169	—	°C/W
		U-DFN2020-6 (Note 7)	—	132	—	
θ_{JC}	Thermal Resistance Junction-to-Case	SOT25 (Note 7)	—	31	—	°C/W
		U-DFN2020-6 (Note 7)	—	48	—	

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

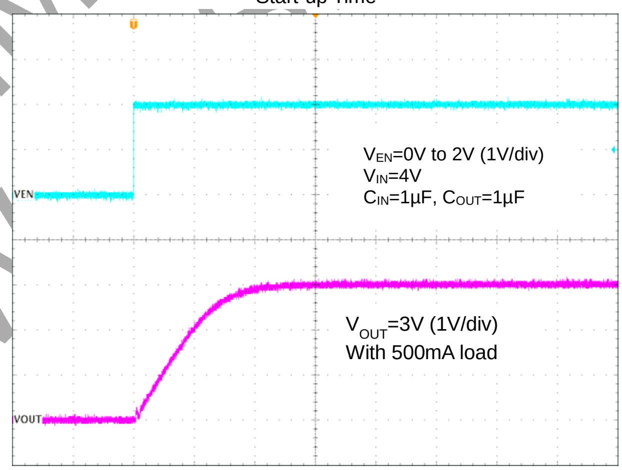
Typical Performance Characteristics

Start-up Time



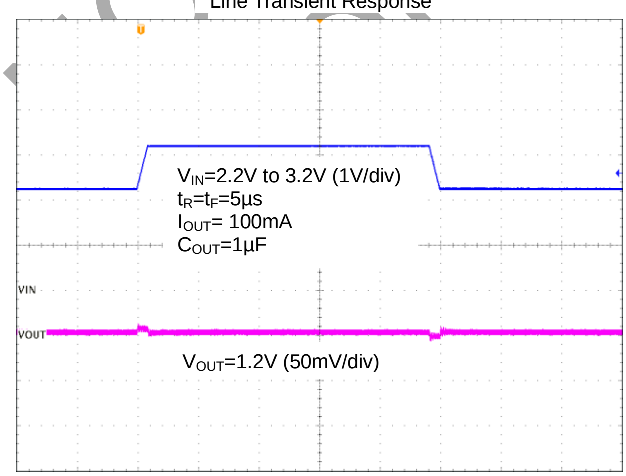
Time (100µs/div)

Start-up Time



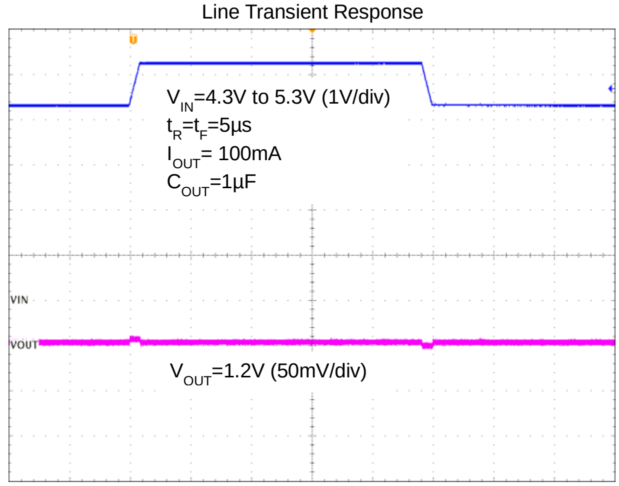
Time (100µs/div)

Line Transient Response



Time (40µs/div)

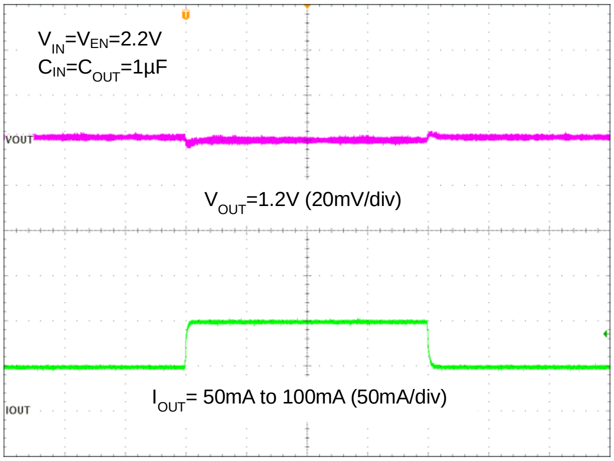
Line Transient Response



Time (40µs/div)

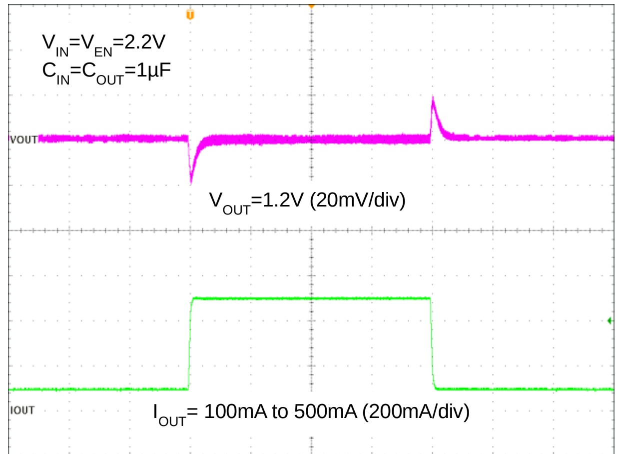
Typical Performance Characteristics (continued)

Load Transient Response



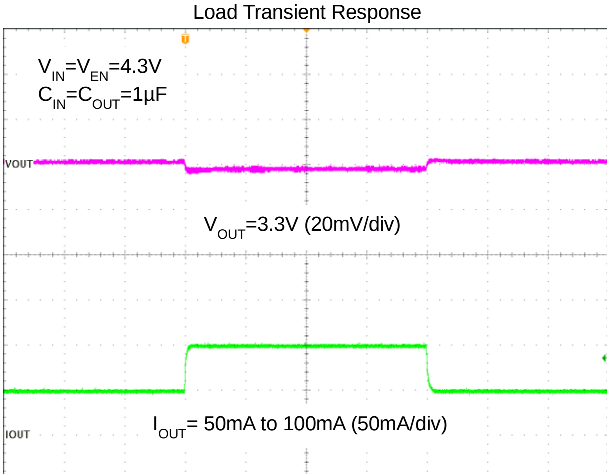
Time (200µs/div)

Load Transient Response



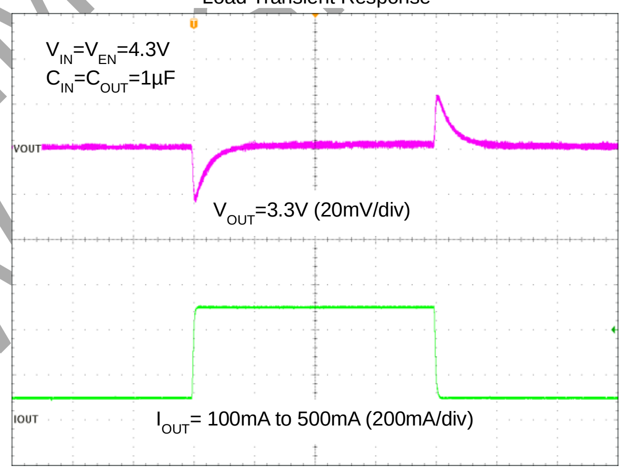
Time (200µs/div)

Load Transient Response



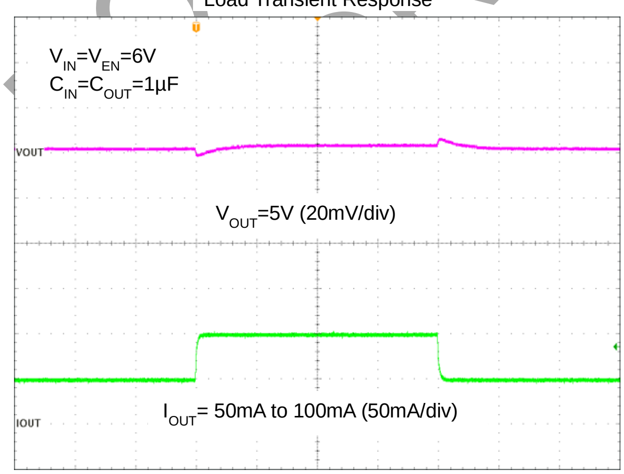
Time (200µs/div)

Load Transient Response



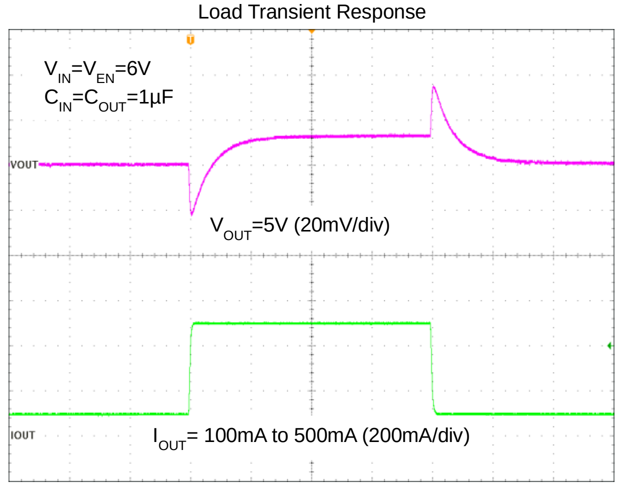
Time (200µs/div)

Load Transient Response



Time (200µs/div)

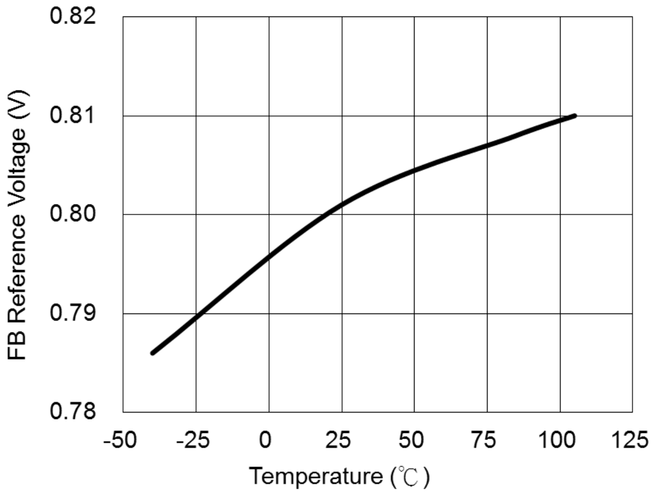
Load Transient Response



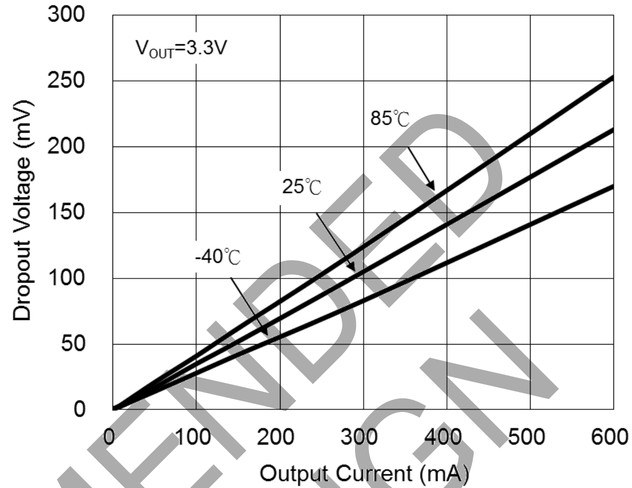
Time (200µs/div)

Typical Performance Characteristics (continued)

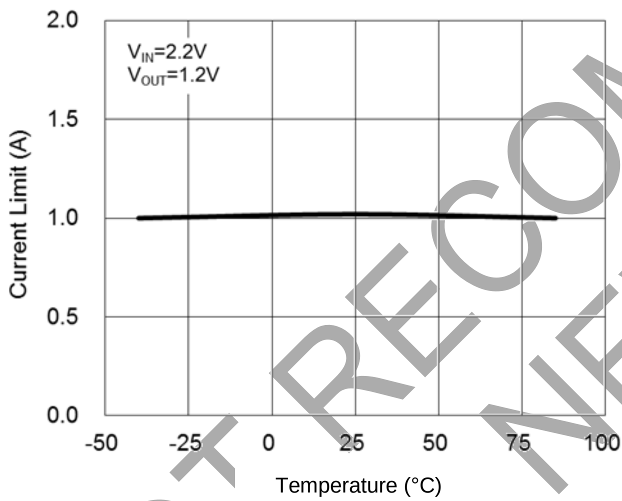
FB Reference Voltage vs. Temperature



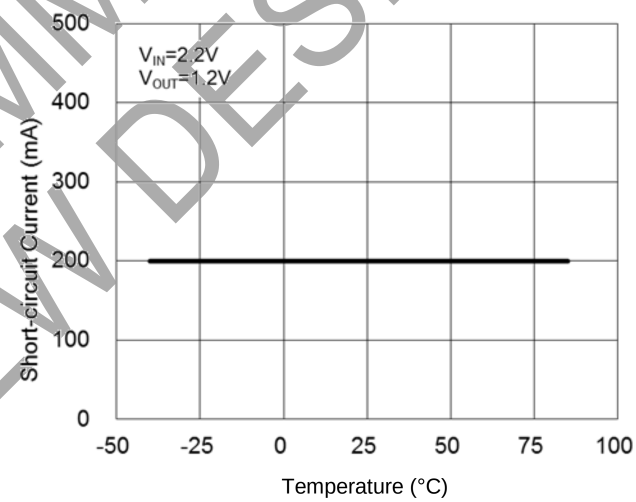
Dropout Voltage vs. Output Current



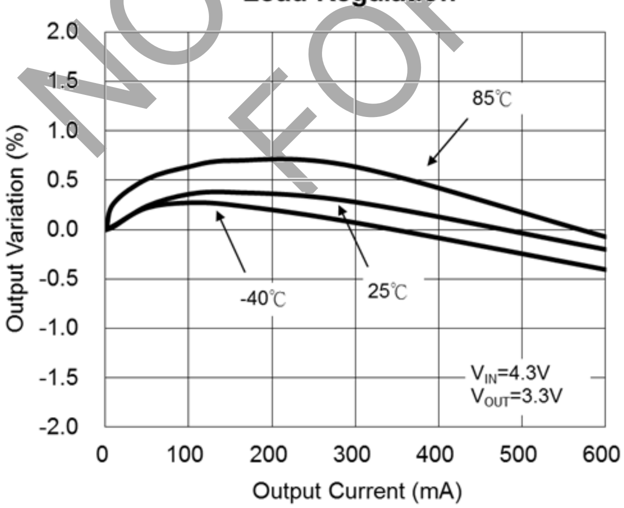
Current Limit vs. Temperature



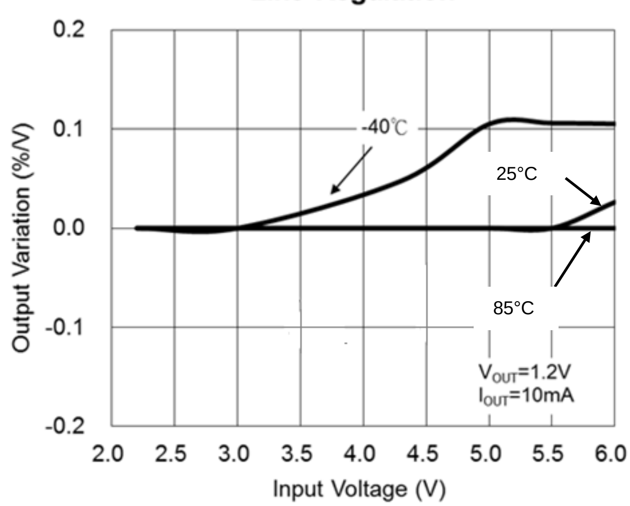
Short-circuit Current vs. Temperature



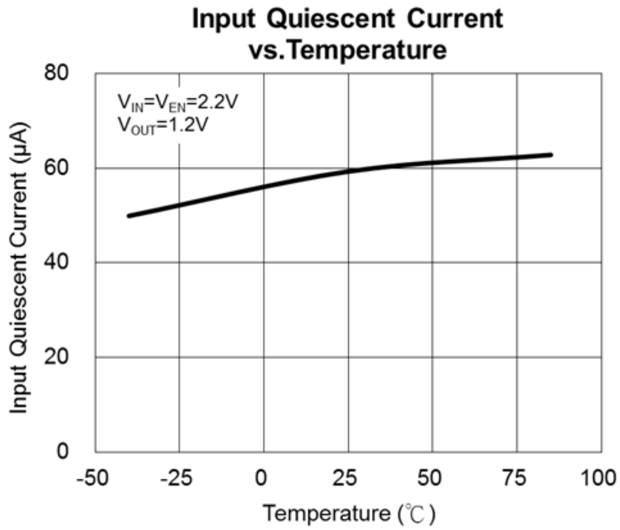
Load Regulation

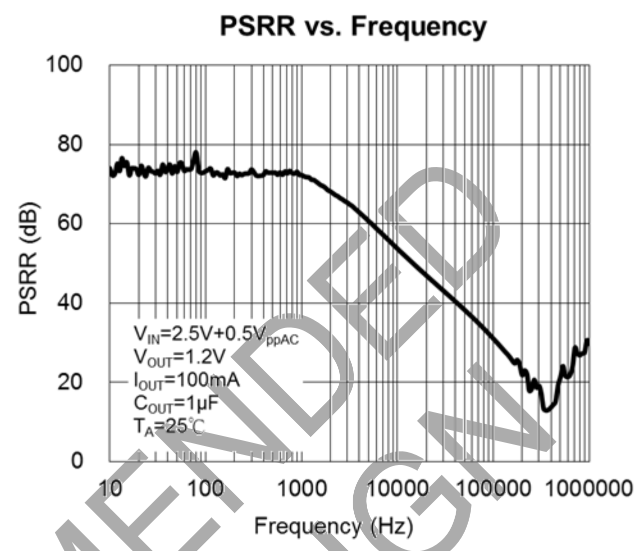


Line Regulation



Typical Performance Characteristics (continued)





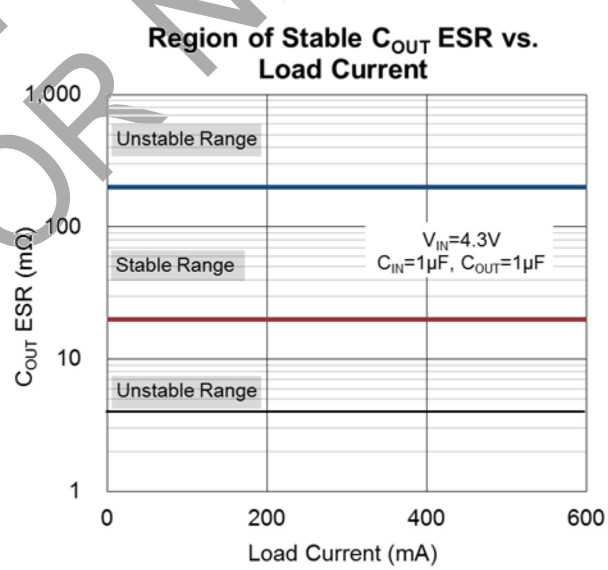
Application Information

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

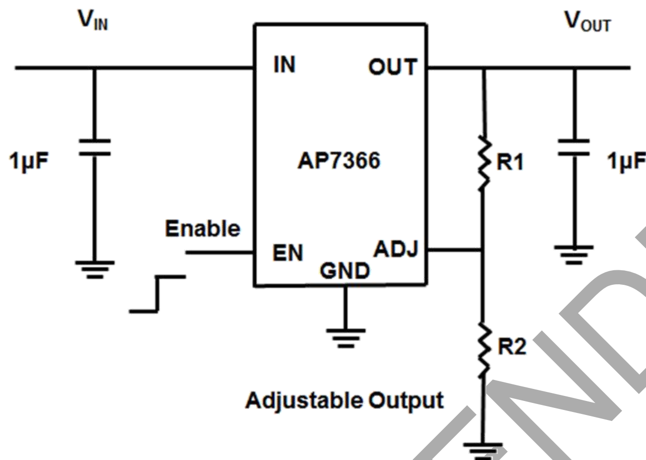
The output capacitor is required to stabilize and improve the transient response of the LDO. The AP7366 is stable with very small ceramic output capacitors. Using a ceramic capacitor value that is at least 2.2μF with 10mΩ ≦ ESR ≦ 300mΩ on the output ensures stability. Higher capacitance values help to 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 AP7366 provides output voltage from 0.8V to 5.0V through external resistor divider as shown below.



Adjustable Output

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, R2 needs to be kept smaller than 80kΩ.

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 AP7366 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 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 250mA. Full current is restored when the output voltage exceeds 15% of V_{OUT}. 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 +150°C, allowing the device to cool down. When the junction temperature reduces to approximately +130°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.

Application Information (continued)

Ultra Fast Start-Up

After enabled, the AP7366 is able to provide full power in as little as tens of microseconds, typically 200µs, 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.

Low Quiescent Current

The AP7366, consuming only around 60µA for all input range, provides great power saving in portable and low-power applications.

Power Dissipation

The device power dissipation and proper sizing of the thermal plane that is 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:

$$P_D(\max @ T_A) = \frac{(+150°C - T_A)}{R_{\theta JA}}$$

Ordering Information

AP7366 - X X - X

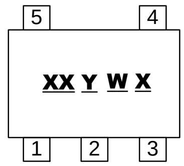
Output	Package	Packing
Blank : ADJ	W5 : SOT25	7 : 7'' Tape & Reel
10 : 1.0V	SN : U-DFN2020-6	
12 : 1.2V		
15 : 1.5V		
18 : 1.8V		
20 : 2.0V		
25 : 2.5V		
28 : 2.8V		
30 : 3.0V		
33 : 3.3V		
36 : 3.6V		
39 : 3.9V		

Part Number	Package Code	Package	Packing	
			Qty.	Carrier
AP7366-W5-7	W5	SOT25	3,000	7'' Tape & Reel
AP7366-XXW5-7	W5	SOT25	3,000	7'' Tape & Reel
AP7366-SN-7	SN	U-DFN2020-6	3,000	7'' Tape & Reel
AP7366-XXSN-7	SN	U-DFN2020-6	3,000	7'' Tape & Reel

Marking Information

(1) SOT25

(Top View)

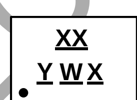


XX : Identification code
Y : Year 0~9
W : Week : A~Z : 1~26 week;
a~z : 27~52 week; z represents
52 and 53 week
X : Internal code

Part Number	Package	Identification Code
AP7366-W5-7	SOT25	Y2
AP7366-10W5-7	SOT25	Y4
AP7366-12W5-7	SOT25	Y5
AP7366-15W5-7	SOT25	Y6
AP7366-18W5-7	SOT25	Y7
AP7366-20W5-7	SOT25	Y8
AP7366-25W5-7	SOT25	Y9
AP7366-28W5-7	SOT25	YC
AP7366-30W5-7	SOT25	YD
AP7366-33W5-7	SOT25	YE
AP7366-36W5-7	SOT25	WZ
AP7366-39W5-7	SOT25	YF

(2) U-DFN2020-6

(Top View)



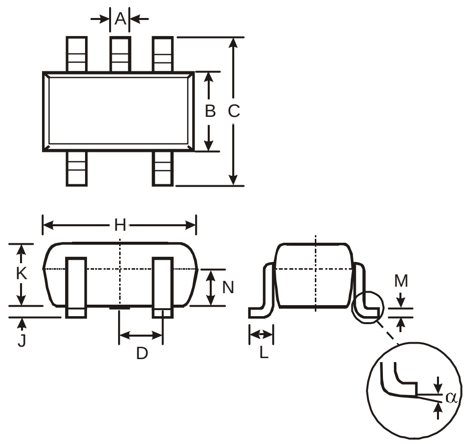
XX : Identification Code
Y : Year : 0~9
W : Week : A~Z : 1~26 week;
a~z : 27~52 week; z represents
52 and 53 week
X : Internal code

Part Number	Package	Identification Code
AP7366-SN-7	U-DFN2020-6	Y2
AP7366-10SN-7	U-DFN2020-6	Y4
AP7366-12SN-7	U-DFN2020-6	Y5
AP7366-15SN-7	U-DFN2020-6	Y6
AP7366-18SN-7	U-DFN2020-6	Y7
AP7366-20SN-7	U-DFN2020-6	Y8
AP7366-25SN-7	U-DFN2020-6	Y9
AP7366-28SN-7	U-DFN2020-6	YC
AP7366-30SN-7	U-DFN2020-6	YD
AP7366-33SN-7	U-DFN2020-6	YE
AP7366-36SN-7	U-DFN2020-6	WZ
AP7366-39SN-7	U-DFN2020-6	YF

Package Outline Dimensions

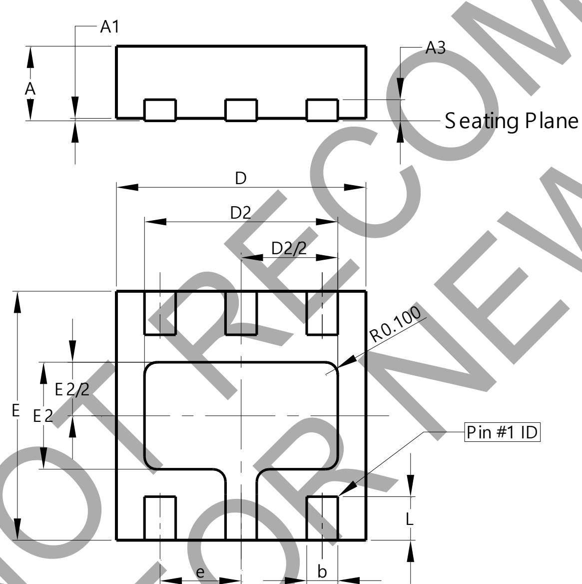
Please see http://www.diodes.com/package-outlines.html for the latest version.

(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			

(2) Package Type: U-DFN2020-6

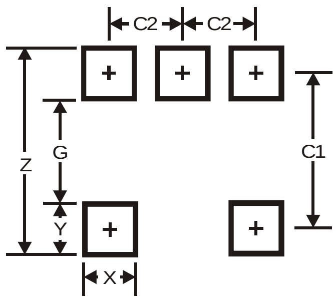


U-DFN2020-6			
Dim	**Min**	**Max**	**Typ**
A	0.57	0.63	0.60
A1	0	0.05	0.03
A3	-	-	0.15
b	0.20	0.30	0.25
D	1.95	2.075	2.00
D2	1.45	1.65	1.55
e	-	-	0.65
E	1.95	2.075	2.00
E2	0.76	0.96	0.86
L	0.30	0.40	0.35
All Dimensions in mm			

Suggested Pad Layout

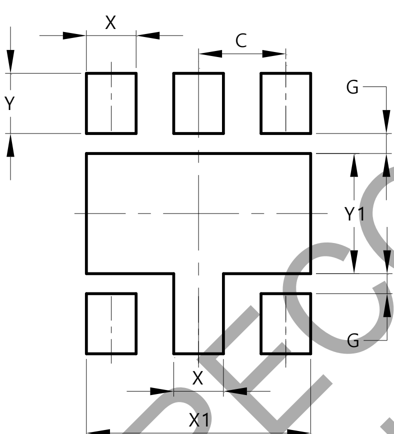
Please see http://www.diodes.com/package-outlines.html for the latest version.

(1) Package Type: SOT25



Dimensions	Value
Z	3.20
G	1.60
X	0.55
Y	0.80
C1	2.40
C2	0.95

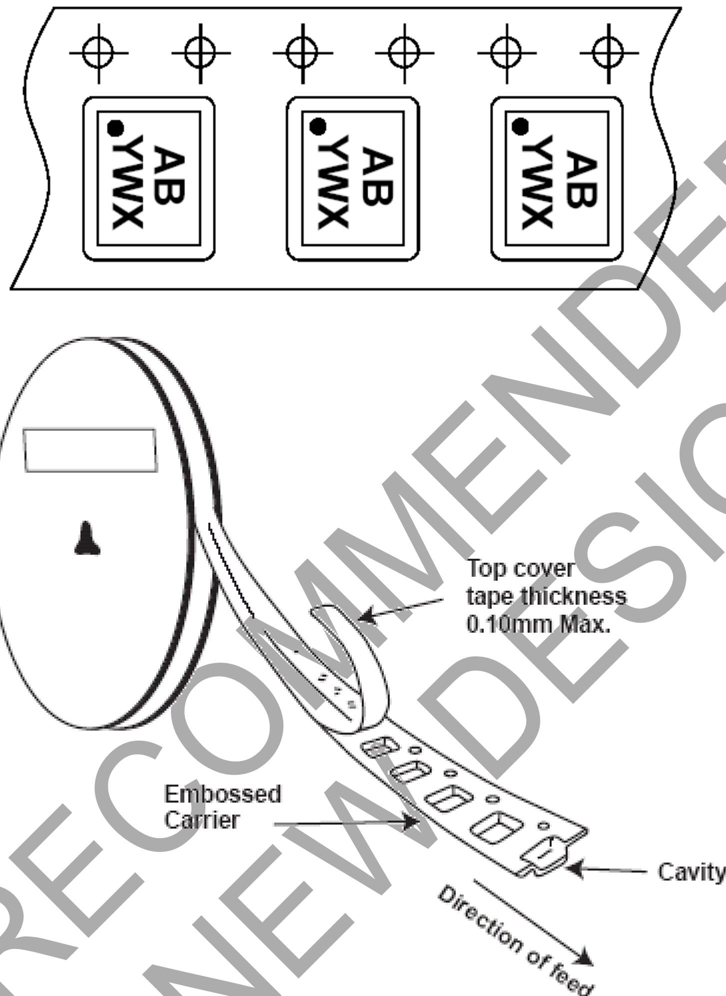
(2) Package Type: U-DFN2020-6



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

Tape Orientation (Note 8)

For U-DFN2020-6



Note: 8. The taping orientation of the other package type can be found on our website at http://www.diodes.com/package-outlines.html.

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