



YOUSHANG SEMICONDUCTOR

设计研发新型功率器件

各类小信号开关

中低压及高压大电流等场效应管

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Description

The NK-AP7366EA 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 60 μ A. Built-in current-limit and thermal-shutdown functions prevent IC from damage in fault conditions.

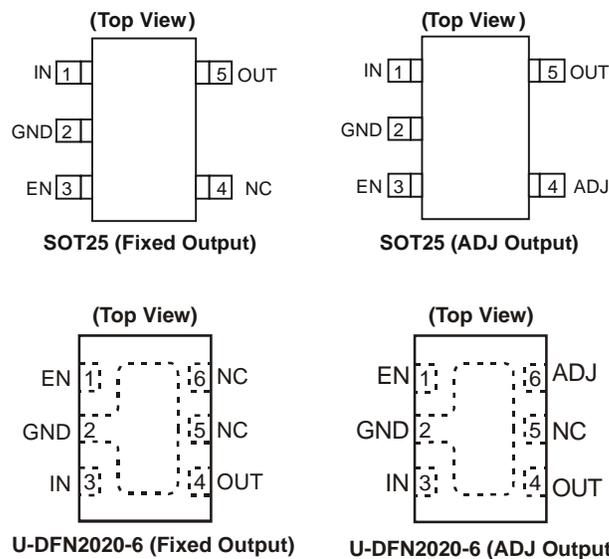
This device is available with adjustable output from 0.8V to 5.0V, and fixed version with 1.0V, 1.2V, 1.5V, 1.8V, 2.0V, 2.5V, 2.8V, 3.0V, 3.3V, 3.6V and 3.9V outputs. Please contact your local sales office for other voltage options.

The NK-AP7366EA is available in SOT25 and U-DFN2020-6 packages.

Features

- 600mA Low Dropout Regulator with EN
- Low I_Q : 60 μ A
- 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: 150 μ s
- Stable with Low ESR, 1 μ F 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 $^{\circ}$ C to +85 $^{\circ}$ C

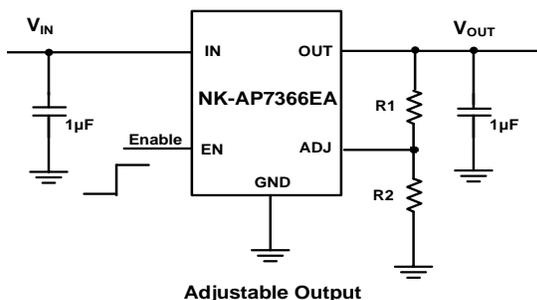
Pin Assignments



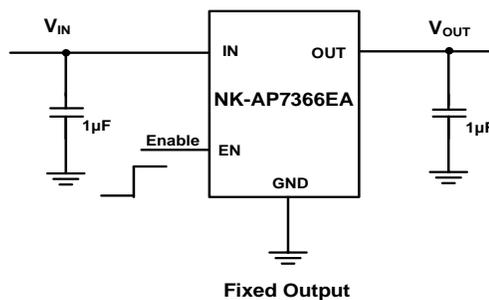
Applications

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

Typical Applications Circuit



Adjustable Output



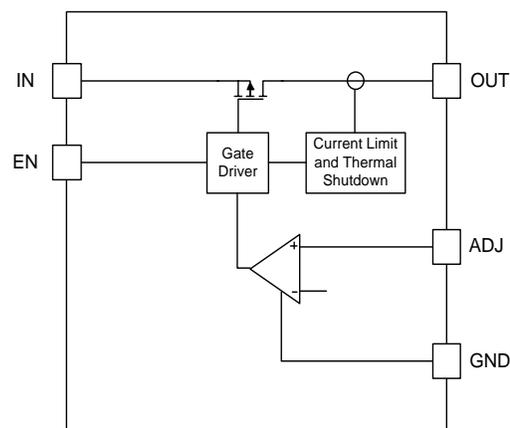
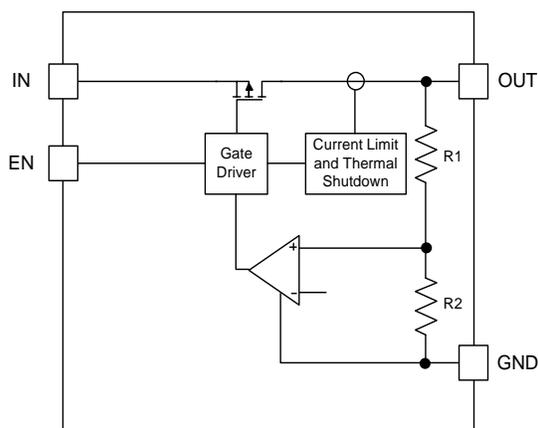
Fixed Output

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

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 Internal Connection. Leaving this pin floating does not affect the chip functionality.
OUT	5	5	4	4	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 CDM	Charge 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 (@ $T_A = +25^\circ\text{C}$, $V_{IN} = V_{OUT} + 1\text{V}$, $C_{OUT} = 1\mu\text{F}$, $C_{IN} = 1\mu\text{F}$, $V_{EN} = V_{IN}$, unless otherwise specified.)

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

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 $V_{IN} = 2.2\text{V}$.

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

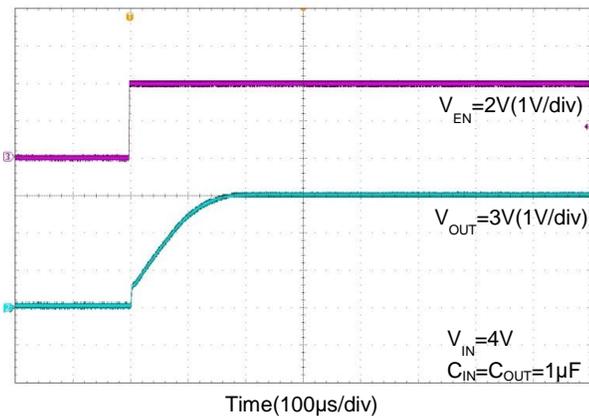
Electrical Characteristics (continued) (@T_A = +25°C, V_{IN} = V_{OUT} + 1V, C_{OUT} = 1μF, C_{IN} = 1μF, V_{EN} = V_{IN}, unless otherwise specified.)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
R _{ENPD}	EN Pull-Down Resistor	—	—	3	—	MΩ
R _{PD}	Output Discharge Resistor	V _{OL} = 1V	—	100	—	Ω
$\frac{\Delta V_{OUT}}{\Delta T_A V_{OUT}}$	Output Voltage Temperature Coefficient	I _{OUT} = 100mA, -40°C ≤ T _A ≤ +85°C	—	±100	—	ppm/°C
θ _{JA}	Thermal Resistance Junction-to-Ambient (Note 7)	SOT25	—	139	—	°C/W
		U-DFN2020-6	—	46.2	—	
θ _{JC}	Thermal Resistance Junction-to-Case (Note 7)	SOT25	—	38.8	—	°C/W
		U-DFN2020-6	—	13	—	

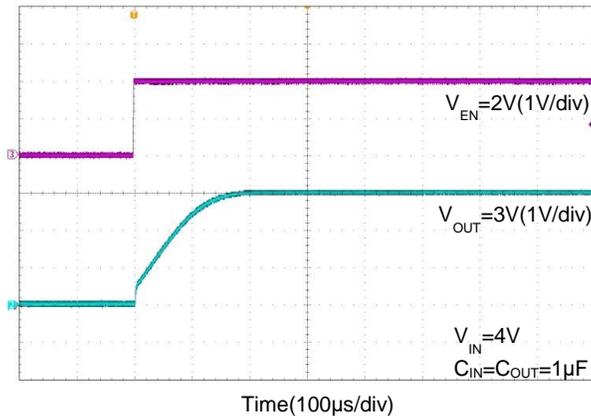
Note: 7. Ratings apply to ambient temperature at +25°C. The JEDEC STD.51 High-K board design used to derive this data was a 3 inch x 3 inch multilayer board with 1oz. internal power and ground planes and 2oz. copper traces on the top and bottom of the board.

Typical Performance Characteristics

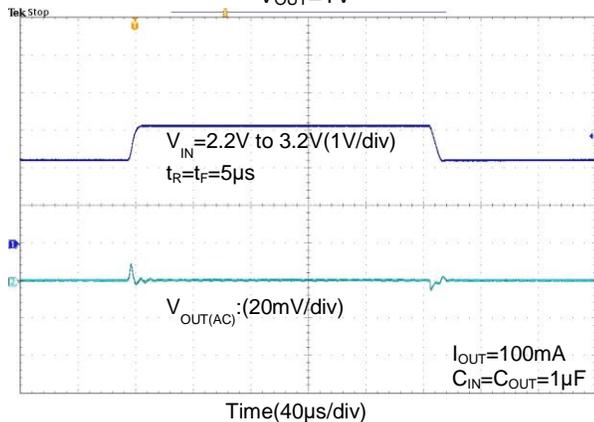
Start-up Time
 $I_{OUT}=50\text{mA}$



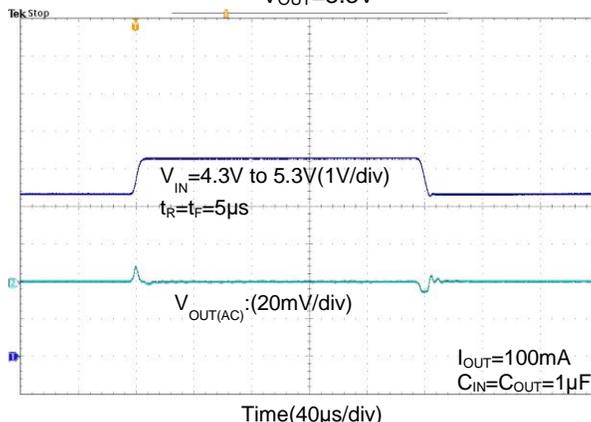
Start-up Time
 $I_{OUT}=100\text{mA}$



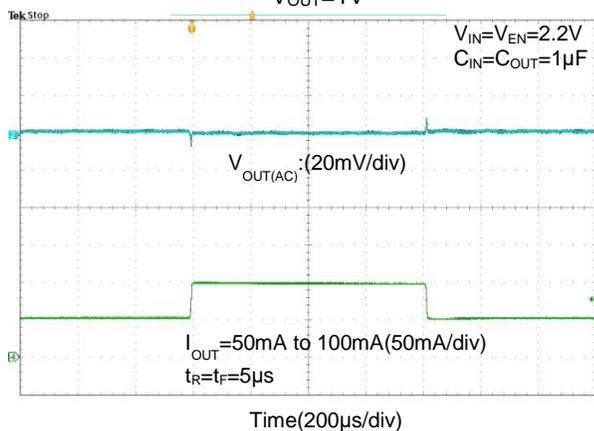
Line Transient Response
 $V_{OUT}=1\text{V}$



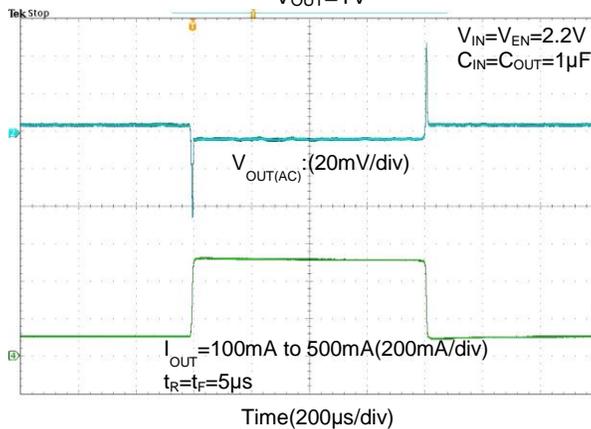
Line Transient Response
 $V_{OUT}=3.3\text{V}$



Load Transient Response
 $V_{OUT}=1\text{V}$



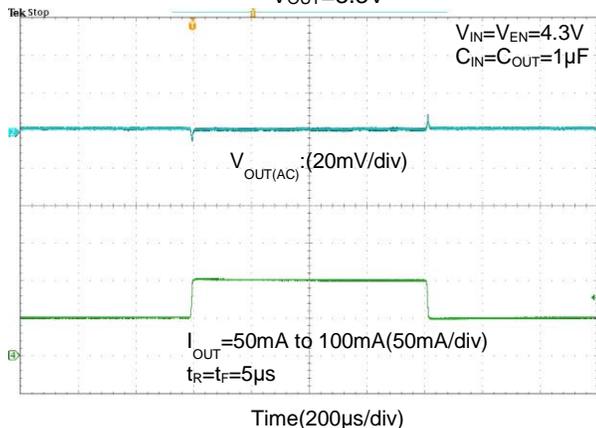
Load Transient Response
 $V_{OUT}=1\text{V}$



Typical Performance Characteristics (continued)

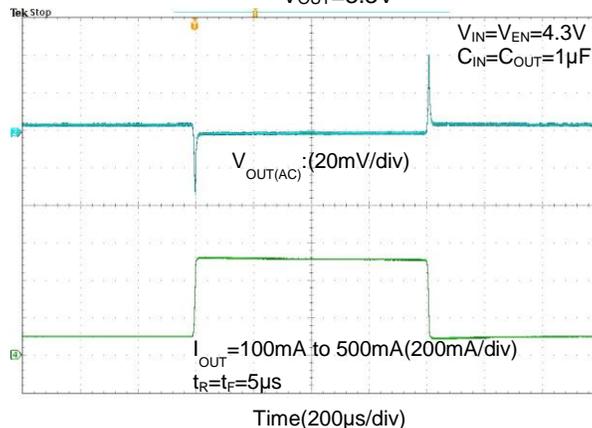
Load Transient Response

$V_{OUT}=3.3V$



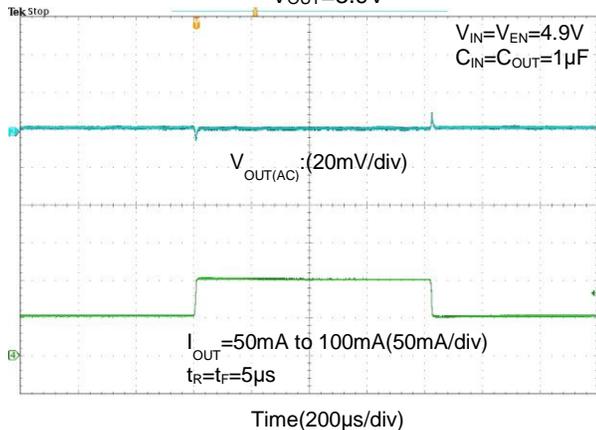
Load Transient Response

$V_{OUT}=3.3V$



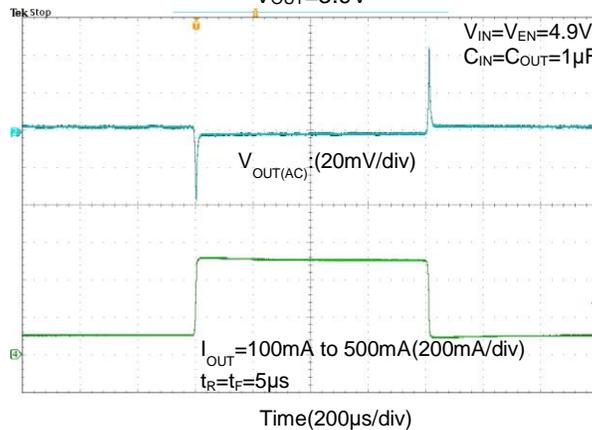
Load Transient Response

$V_{OUT}=3.9V$

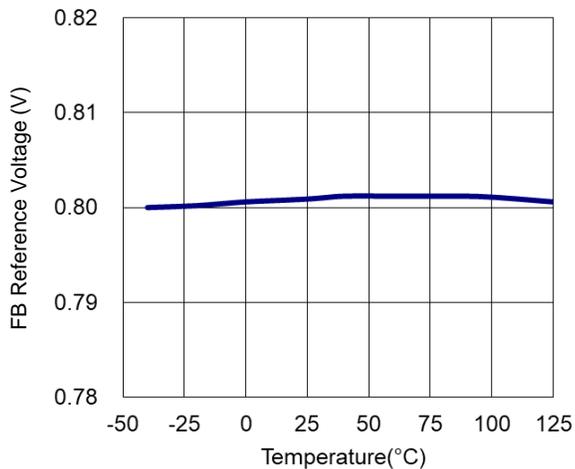


Load Transient Response

$V_{OUT}=3.9V$

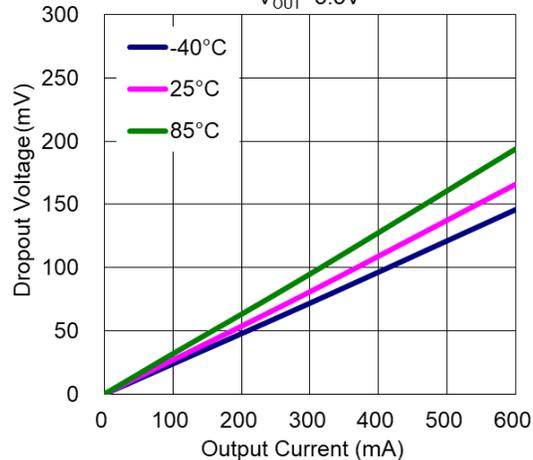


FB Reference Voltage vs. Temperature

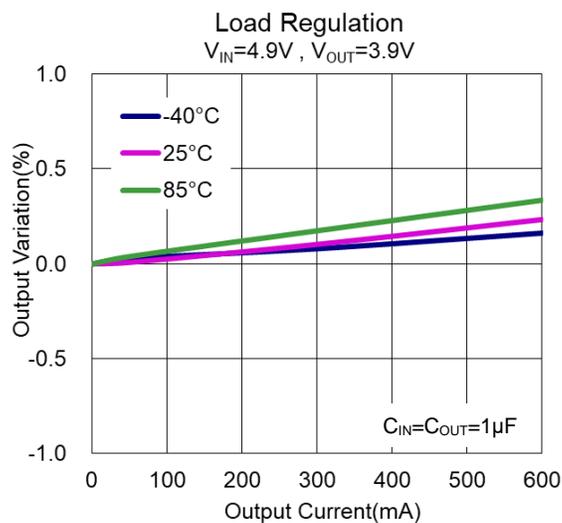
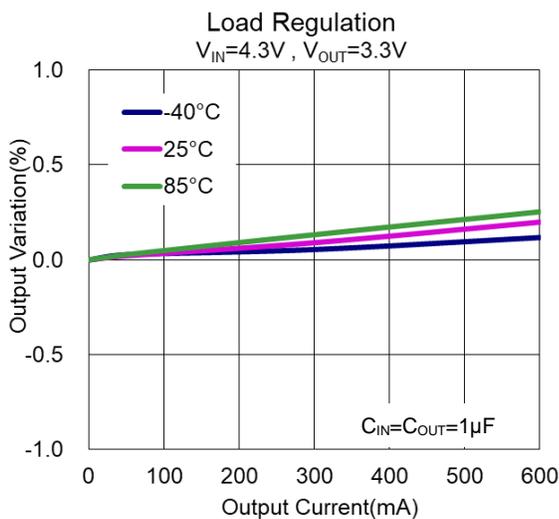
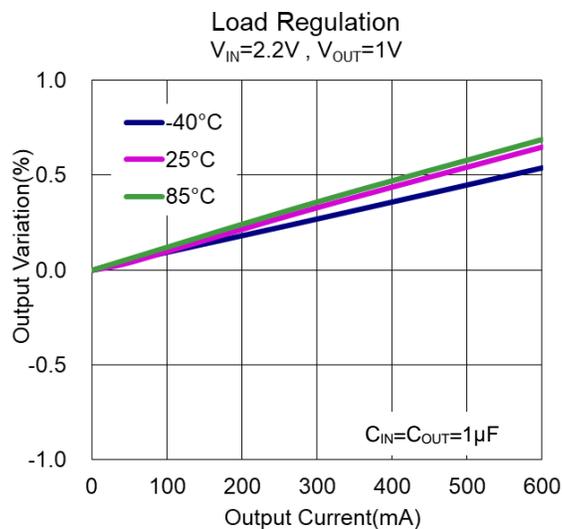
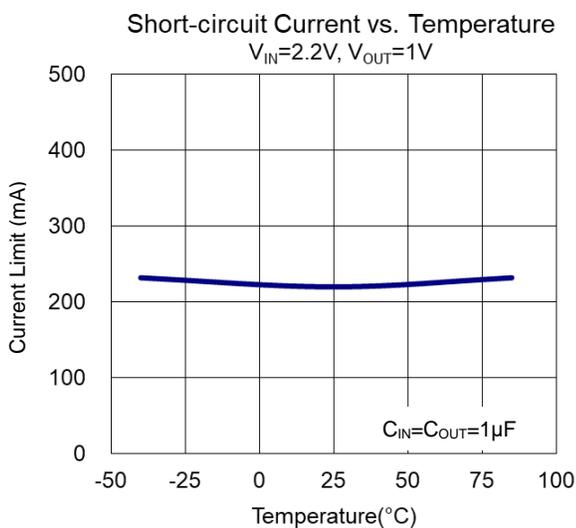
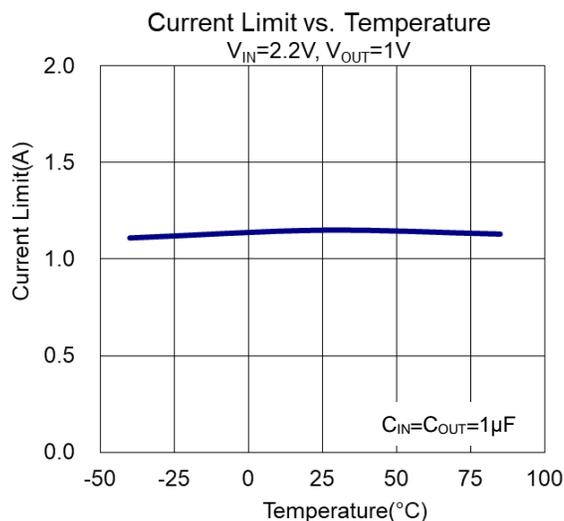
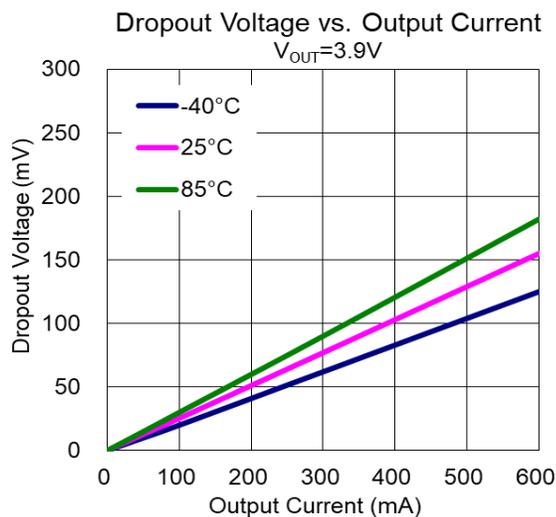


Dropout Voltage vs. Output Current

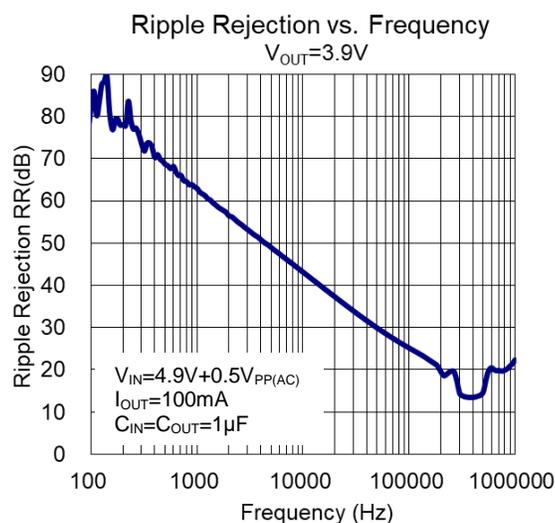
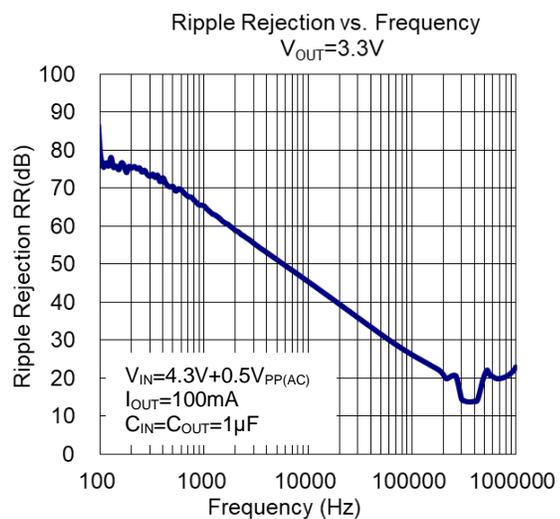
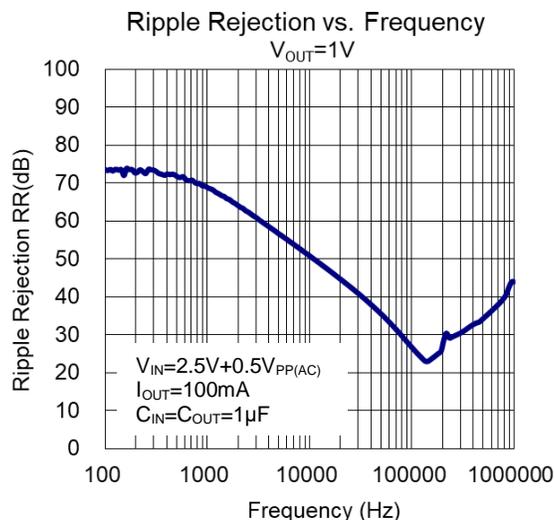
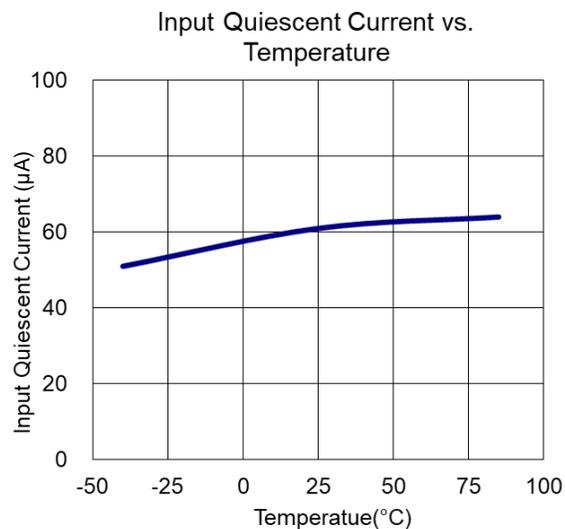
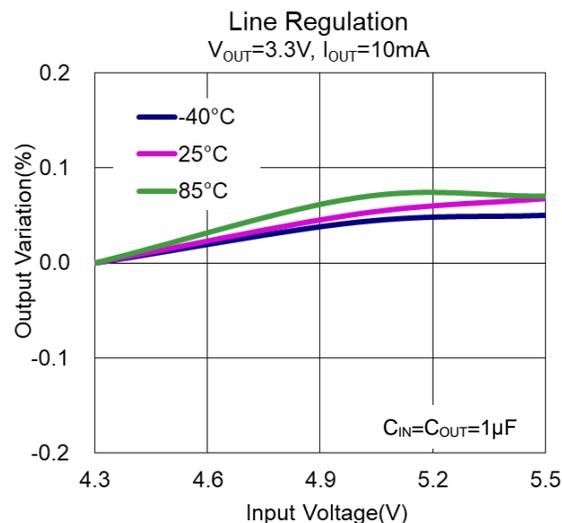
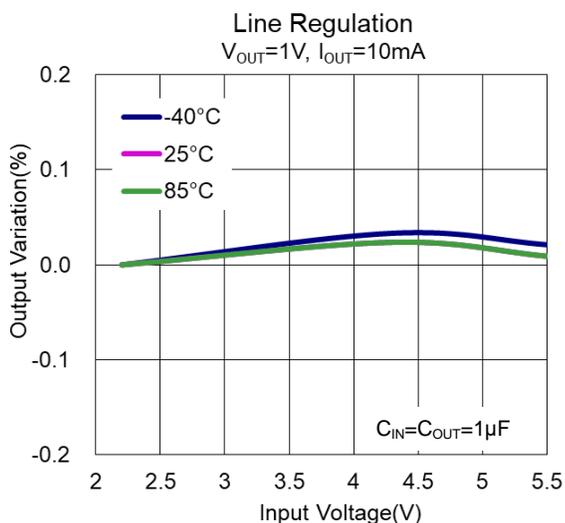
$V_{OUT}=3.3V$



Typical Performance Characteristics (continued)



Typical Performance Characteristics (continued)



Application Information

Input Capacitor

A 1 μ F 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 ensure 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.

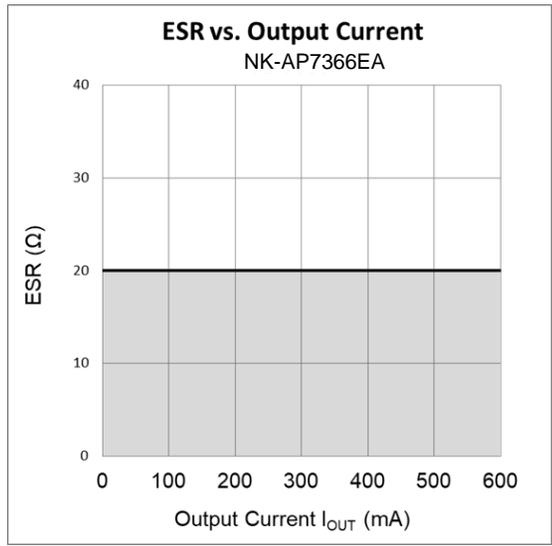
Output Capacitor

The output capacitor is required to stabilize and improve the transient response of the LDO. The NK-AP7366EA is stable with very small ceramic output capacitors. Using a ceramic capacitor value that is at least 1 μ F 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.

ESR vs. Output Current

Ceramic type output capacitor is recommended for this series; however, the other output capacitors with low ESR also can be used. The relations between I_{OUT} (Output Current) and ESR of an output capacitor are shown below. The stable region for the safety operating temperature (-40°C to +85°C) is marked as the gray area in the graph.

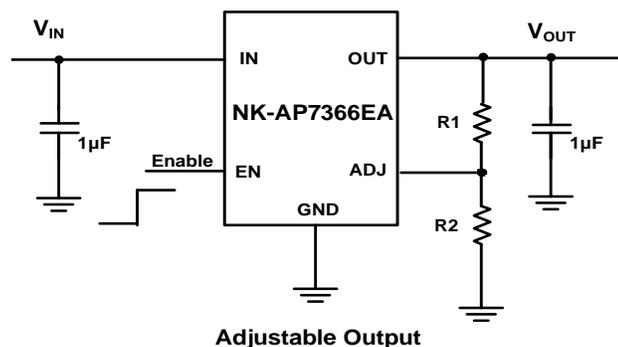
Measurement conditions: Frequency Band: 10Hz to 2MHz, Temperature: -40°C to +85°C.



Application Information (continued)

Adjustable Operation

The NK-AP7366EA 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 NK-AP7366EA 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 over-current 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 over-current 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 NK-AP7366EA 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 extending battery life for mobile phones and other portable devices.

Low Quiescent Current

The NK-AP7366EA, 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:

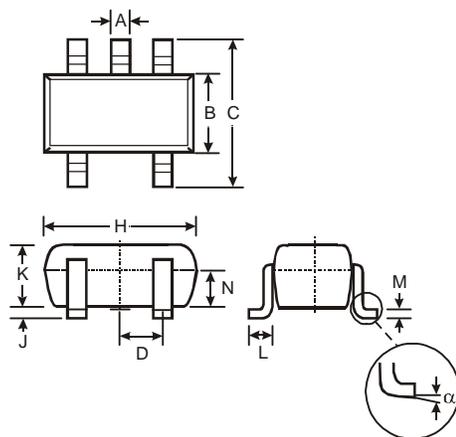
$$P_D = (V_{IN} - V_{OUT}) \times I_{OUT}$$

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.

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

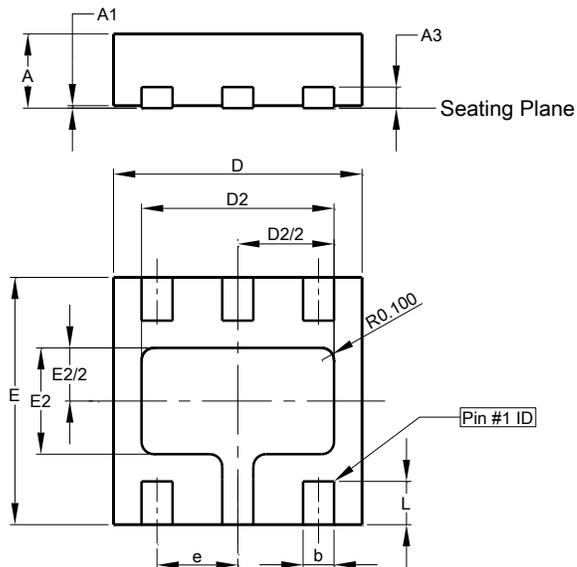
Package Outline Dimensions

(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			

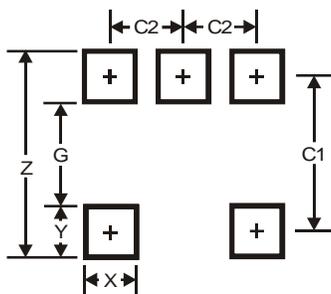
(2) Package Type: U-DFN2020-6



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			

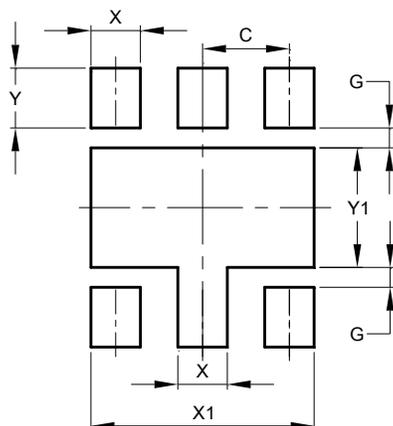
Suggested Pad Layout

(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

Mechanical Data

- Moisture Sensitivity: Level 1 Per J-STD-020
- Terminals:
 - SOT25: Finish - Matte Tin Plated Leads, Solderable per MIL-STD-202, Method 208 [Ⓔ]
 - U-DFN2020-6: Finish - NiPdAu over Copper Leads, Solderable per MIL-STD-202, Method 208 [Ⓔ]
- Weight:
 - SOT25: 0.015 grams (Approximate)
 - U-DFN2020-6: 0.007 grams (Approximate)

Tape Orientation (Note 8)

For U-DFN2020-6

