优尚

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

0755-83047638
ysbdt@szyoushang.cn
www.szyoushang.cn

企业微信二维码　　企业QQ二维码

## Description

The NK-AP7583Q/AQ series are 300mA LDO for automotive battery-powered applications. The NK-AP7583Q features 2.5μA quiescent current at light loads. Therefore, the NK-AP7583Q/AQ are suitable solution to supply always-power-on components, such as microcontroller (MCUs) and controller area network (CAN) transceivers.

The NK-AP7583Q/AQ have features of wide input-voltage range, high accuracy, low dropout voltage, current limit and ultra-low quiescent current, which make it ideal for automotive applications. The NK-AP7583AQ has power-good indicator.
The IC consists of a voltage reference, an error amplifier, a resistor network for setting output voltage, a current-limit circuit for current protection, and a chip-enable circuit.

The NK-AP7583Q/AQ both have 3.3V and 5V fixed output-voltage version, and adjustable version.

The NK-AP7583Q/AQ are available in the MSOP-8EP, W-DFN2020-6 (SWP) (Type A1) and TO252-4 (Type C).

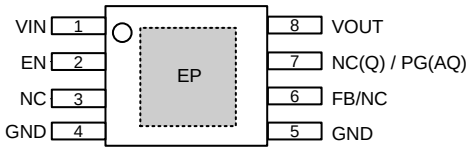
## Features

- Wide Input-Voltage Range: 3V to 42V
- Maximum Output Current: 300mA
- Low Dropout Voltage: $V_{DROP}$ = 320mV @$I_{OUT}$ = 300mA (typ)
- Low Quiescent Current:
  - NK-AP7583Q is 2.5μA (typ)
  - NK-AP7583AQ is 3μA (typ)
- High Output-Voltage Accuracy: ±1.5%
- Compatible with Low ESR Ceramic Capacitor
- Excellent Line/Load Regulation
- Thermal Shutdown Function
- Short Current Protection Function
- Output Current Limit
- NK-AP7583AQ with Power-Good (PG) Output for Supply Monitoring and for Sequencing of Other Supplies

## Pin Assignments

NK-AP7583Q/AQ

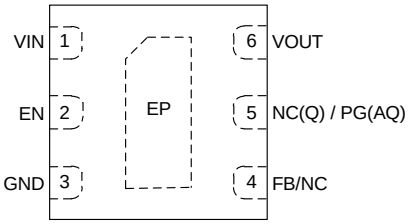
**(Top View)**




**MSOP-8EP**

NK-AP7583Q/AQ

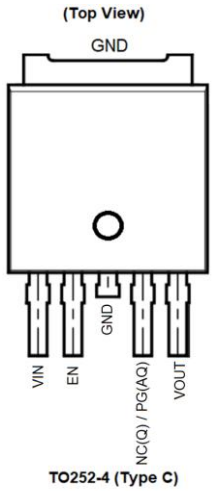
**(Top View)**




**W-DFN2020-6 (SWP) (Type A1)**

NK-AP7583Q/AQ

**(Top View)**

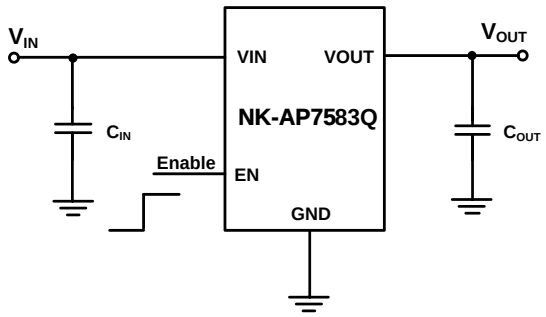



**TO252-4 (Type C)**

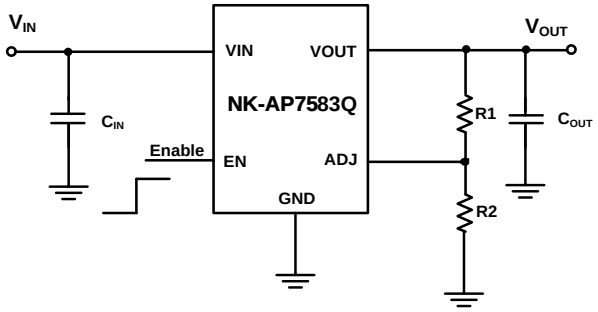
## Applications

- Powering MCUs and CAN/LIN transceivers
- Automotive head units
- EV and HEV battery management systems
- Body control modules
- Transmission control units (TCU)

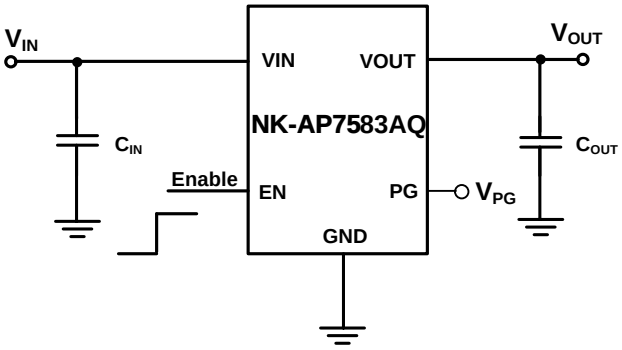
## Typical Applications Circuit



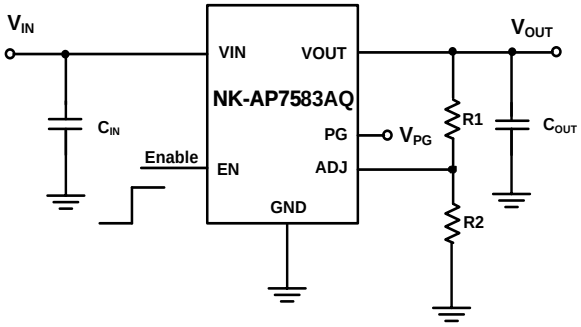

NK-AP7583Q Fixed Version




NK-AP7583Q Adjustable Output




NK-AP7583AQ Fixed Version

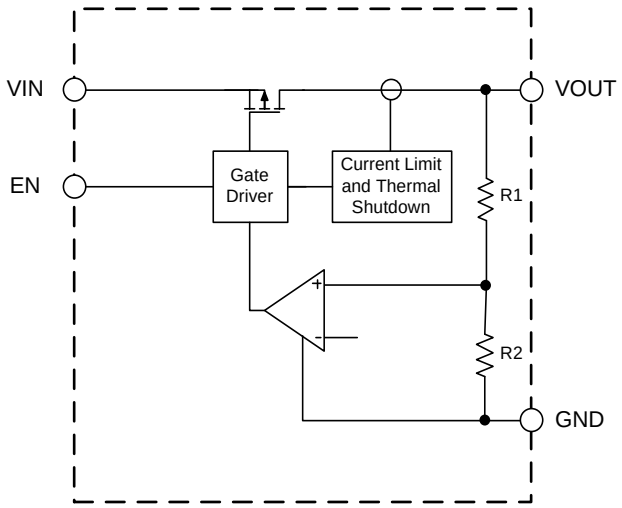



NK-AP7583AQ Adjustable Output

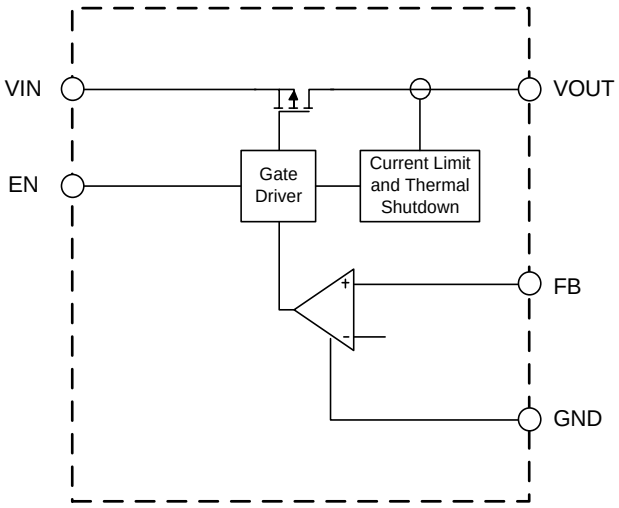
## Pin Descriptions

| Pin Number | | | Pin Name | Function |
|---|---|---|---|---|
| NK-AP7583Q/AQ MSOP-8EP | W-DFN2020-6 (SWP) (Type A1) NK-AP7583Q/AQ | NK-AP7583Q/AQ (Type C) TO252-4 | | |
| 1 | 1 | 1 | VIN | Input voltage |
| 2 | 2 | 2 | EN | Enable input, active high |
| 3, 7(Q) | 5(Q) | 4(Q) | NC | Not connected internally. Recommend connection to GND to maximize PCB copper for thermal dissipation. |
| 7(AQ) | 5(AQ) | 4(AQ) | PG | Power-good pin with one internal pull high resistor. When the $V_{OUT}$ is below the PG threshold, the PG pin is driven low; when the $V_{OUT}$ exceeds the threshold, the PG pin goes into a high-impedance state. |
| 4, 5 | 3 | 3 | GND | Ground |
| 6 | 4 | — | FB/NC | Adjustable voltage version only – a resistor divider from this pin to the OUT pin and ground sets the output voltage. |
| 8 | 6 | 5 | VOUT | Regulated output voltage |
| EP | EP | — | Exposed Pad | In PCB layout, prefer to use large copper area to cover this pad for better thermal dissipation, then connect this area to GND or leave it open. However, do not use it as GND electrode function alone. |

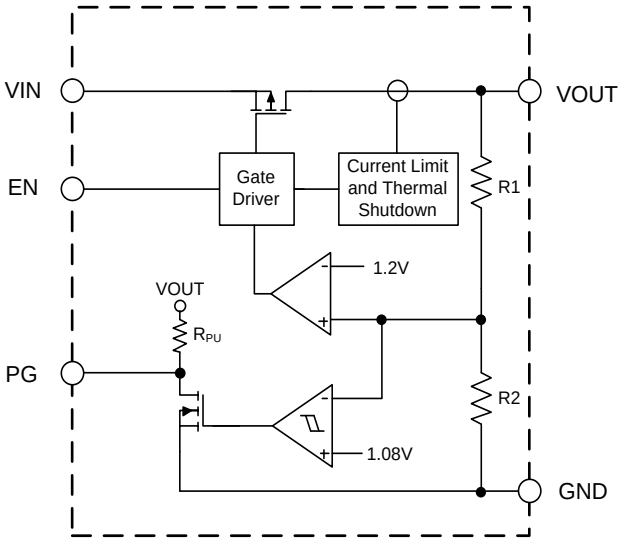
## Functional Block Diagram



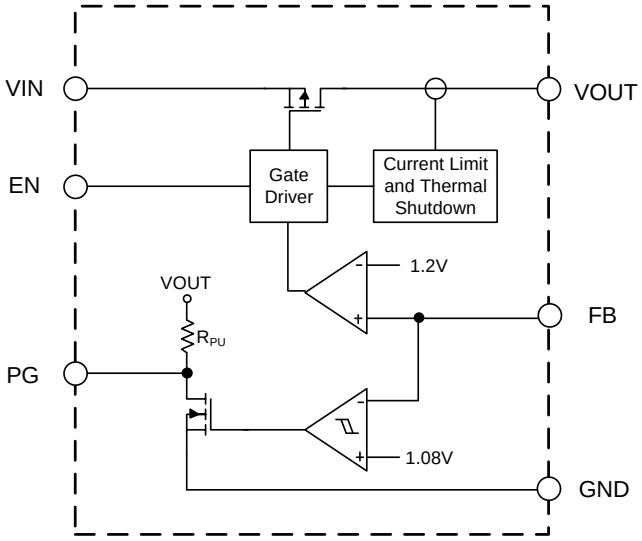

NK-AP7583Q Fixed Version with EN




NK-AP7583Q Adjustable Version




NK-AP7583AQ Fixed Version




NK-AP7583AQ Adjustable Version

## Absolute Maximum Ratings (Note 4) (@$T_A$ = +25°C, unless otherwise specified.)

| Symbol | Parameter | Rating | | Unit |
|---|---|---|---|---|
| $V_{IN}$ | Supply Input Voltage | -0.3 to 45 | | V |
| $V_{OUT}$ | Regulated Output Voltage | -0.3 to 7 | | V |
| $I_{OUT}$ | Output Current | 300 | | mA |
| $T_{LEAD}$ | Lead Temperature (Soldering, 10sec) | +260 | | ºC |
| $T_J$ | Operating Junction Temperature | +150 | | ºC |
| $\theta_{JA}$ | Thermal Resistance (Junction to Ambient) | MSOP-8EP | 36.1 | °C/W |
| | | W-DFN2020-6 (SWP) (Type A1) | 80.4 | |
| | | TO252-4 (Type C) | 27.2 | |
| $\theta_{JC}$ | Thermal Resistance (Junction to Case) | MSOP-8EP | 6.532 | °C/W |
| | | W-DFN2020-6 (SWP) (Type A1) | 26.4 | |
| | | TO252-4 (Type C) | 7.5 | |
| $T_{STG}$ | Storage Temperature Range | -40 to +150 | | °C |
| CDM | ESD (Charged Device Model) | ±1500 | | V |
| HBM | ESD (Human Body Model) | ±2000 | | V |

Notes: 4. a). Stresses beyond those listed under *Absolute Maximum Ratings* can cause permanent damage to the device. These are stress ratings only and functional operation of the device at these conditions is not implied. Exposure to absolute-maximum-rated conditions for extended period can affect device reliability.

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

## Recommended Operating Conditions

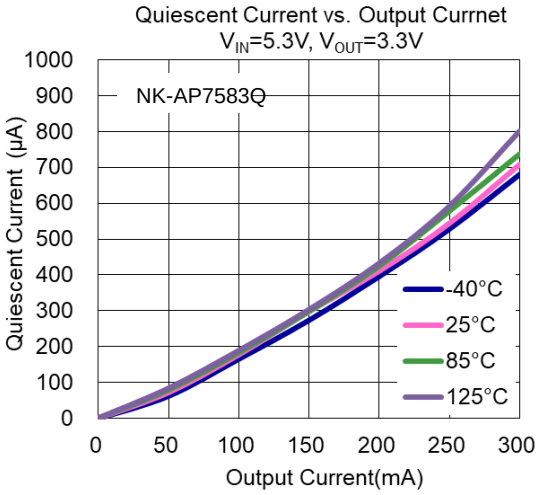
| Symbol | Parameter | Min | Max | Unit |
|---|---|---|---|---|
| $V_{IN}$ | Supply Input Voltage | 3.0 | 42 | V |
| $V_{OUT}$ | Supply Output Voltage | 1.2 | 5 | V |
| $T_J$ | Operating Junction Temperature | -40 | +125 | °C |

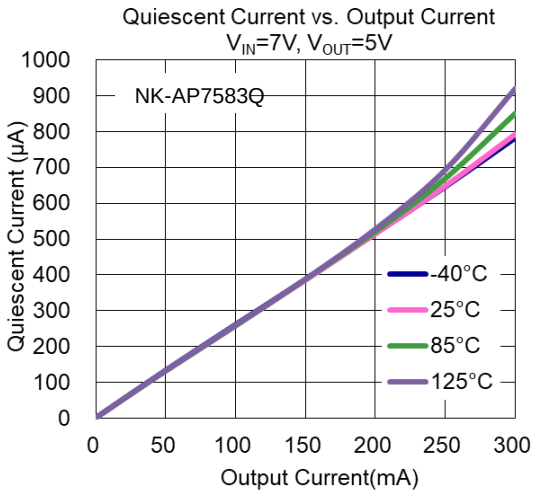
## Electrical Characteristics (-40°C ≤ $T_J$ ≤ +125°C, $I_{OUT}$ = 1mA, $C_{IN}$ = $C_{OUT}$ = 10μF ceramic capacitor, $V_{IN}$ = 14V)

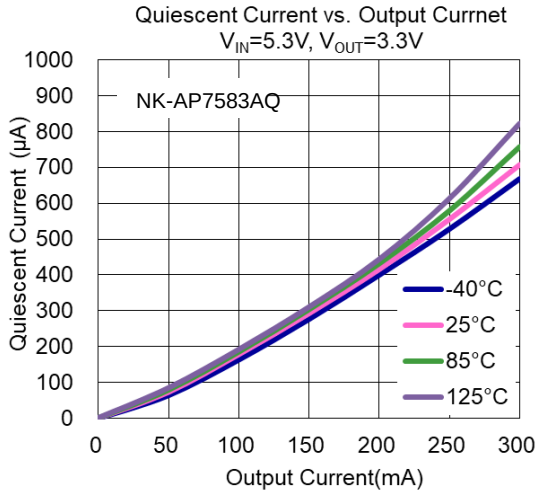
| Symbol | Parameter | | Test Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| $V_{OUT}$ | Output Voltage | | Variation from Specified $V_{OUT}$ | $V_{OUT}$* 98.5% | — | $V_{OUT}$* 101.5% | V |
| $V_{IN}$ | Input Voltage | | — | 3.0 | — | 42 | V |
| $V_{FB}$ | Feedback Reference Voltage | | — | 1.183 | 1.207 | 1.231 | V |
| $I_{LIMIT}$ | Current Limit | | $V_{OUT}$ Short to 90% x $V_{OUT}$ | 310 | 510 | 690 | mA |
| $\Delta V_{OUT}/\Delta V_{IN}$ | Line Regulation | | $V_{IN}$ = $V_{OUT}$ + 1V to 40V, $I_{OUT}$ = 1mA | -10 | — | 10 | mV |
| $\Delta V_{OUT}/V_{OUT}$ | Load Regulation | | 1mA ≤ $I_{OUT}$ ≤ 300mA | -20 | — | 20 | mV |
| $V_{DROP}$ | Dropout Voltage (Note 5) | | $I_{OUT}$ = 300mA @$V_{OUT}$ = 3.3V | — | 450 | 700 | mV |
| | | | $I_{OUT}$ = 300mA @$V_{OUT}$ = 5V | — | 320 | 500 | mV |
| $I_Q$ | Quiescent Current | NK-AP7583Q | $I_{OUT}$ = 0 | — | 2.5 | 4.0 | μA |
| | | NK-AP7583AQ | $I_{OUT}$ = 0 | — | 3 | 6 | μA |
| $I_{SHUTDOWN}$ | Shutdown Current | | EN = 0 | — | 0.3 | 0.5 | μA |
| $V_{IL}$ | EN Input Logic-Low Voltage | | — | 0 | — | 0.3 | V |
| $V_{IH}$ | EN Input Logic-High Voltage | | — | 1.7 | — | $V_{IN}$ | V |
| $\Delta V_{OUT}/(V_{OUT}x\Delta T)$ | Output Voltage Temperature Coefficient | | $I_{OUT}$ = 100μA, -40°C ≤ $T_J$ ≤ +125°C | — | ±100 | — | ppm/°C |
| $T_{OTSD}$ | Thermal Shutdown Temperature | | — | — | +175 | — | °C |
| $T_{HYOTSD}$ | Thermal Shutdown Hysteresis | | — | — | +20 | — | °C |
| PSRR | Power-Supply Rejection Ratio | | $V_{(Ripple)}$ = 0.5$V_{PP}$, $I_{OUT}$ = 10mA, frequency = 100Hz, $C_{OUT}$ = 2.2μF | — | 70 | — | dB |
| UVLO | VIN Undervoltage Detection | | Ramp VIN up until the Output Turns on | 2.1 | 2.4 | 2.7 | V |
| | | | Hysteresis | — | 0.2 | — | V |
| $I_{FB}$ | FB Leakage Current | | FB = 0 (Adjustable Version) | -10 | — | 20 | nA |
| NK-AP7583AQ | | | | | | | |
| $t_D$ | Output Voltage Turn-On Delay Time | | $V_{EN}$ High to $V_{OUT}$ Rising 10% | — | 0.8 | — | ms |
| $t_{SS}$ | Output Voltage Ramp Up Time | | $V_{OUT}$ Rising 10% to 90% | — | 200 | — | μs |
| $t_{PG}$ | PG React Time | | $V_{OUT}$ 90% to PG Active | — | 30 | — | μs |
| $t_{PGF}$ | PG Off Deglitch Time | | $V_{FB}$ Falling to PG Low | — | 3 | — | μs |
| | | | EN Goes Low to PG Low | | | | |
| $V_{PGR}$ | PG Rising Threshold | | $V_{FB}$ Rising | 90 | — | 94 | % |
| $V_{PGF}$ | PG Falling Threshold | | $V_{FB}$ Falling | 88 | — | 92 | % |
| $V_{PGS}$ | PG Sinking Voltage | | Sinking Current = 5mA | — | — | 0.4 | V |

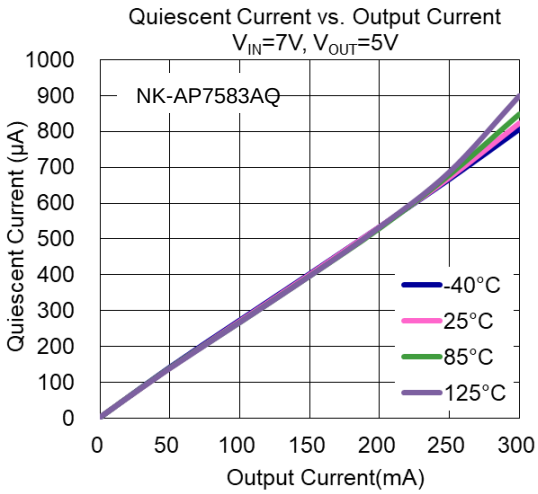
Note: 5. Dropout voltage is the voltage difference between the input and the output at which the output voltage drops 2% below its nominal value.

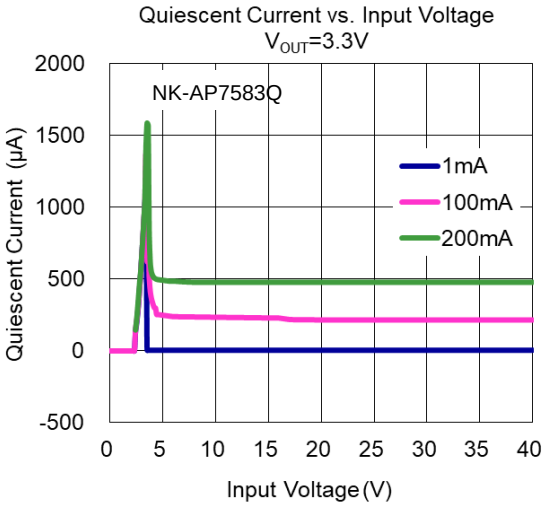
## Typical Characteristics ($C_{IN}$ = $C_{OUT}$ = 10μF)

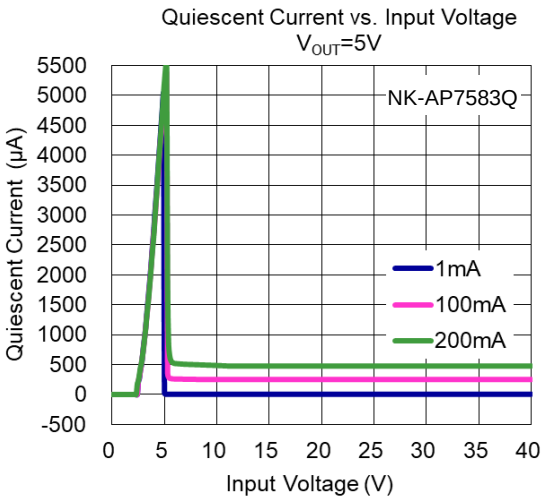


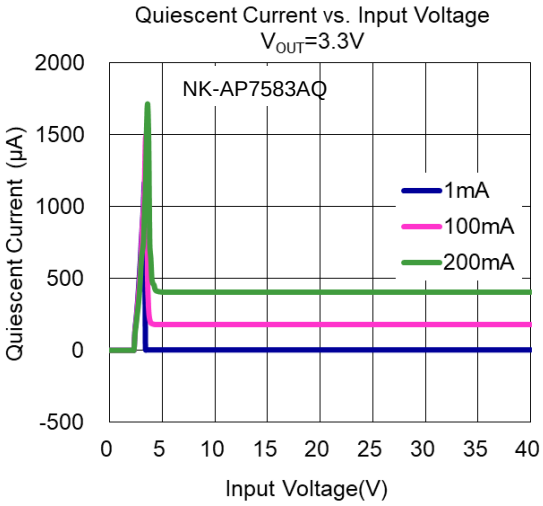



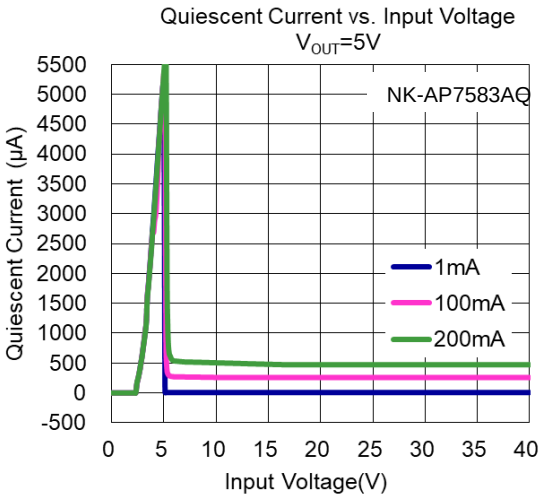



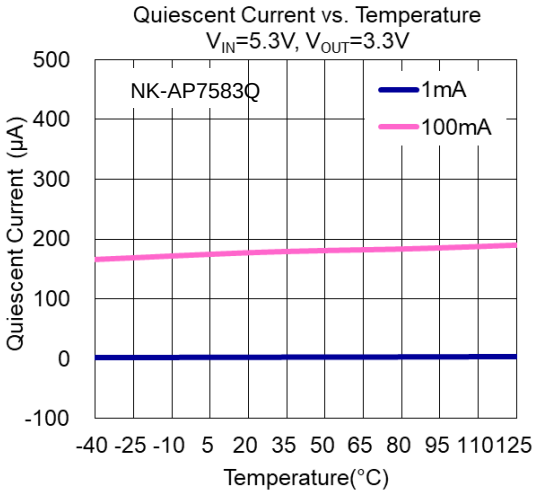



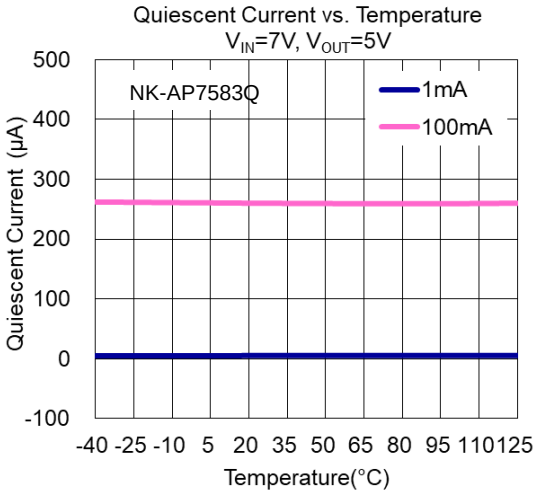



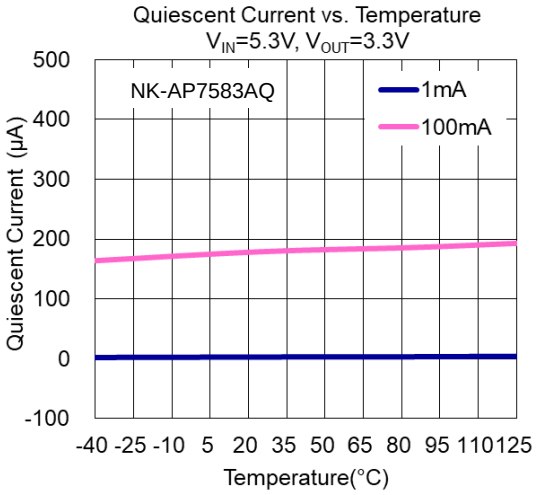
## Typical Characteristics ($C_{IN}$ = $C_{OUT}$ = 10μF) (continued)

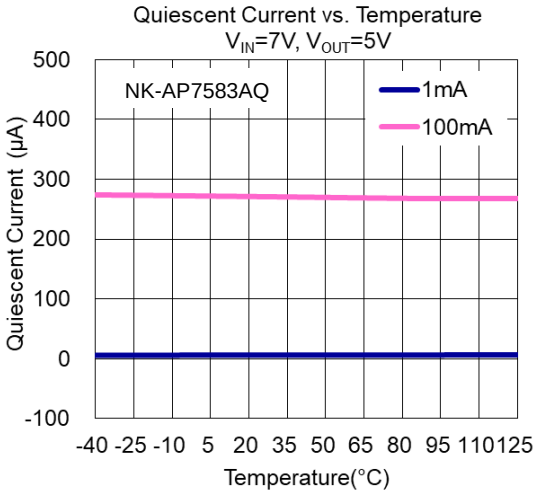


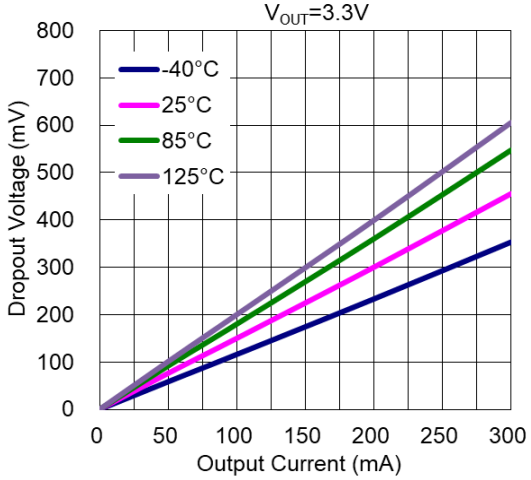



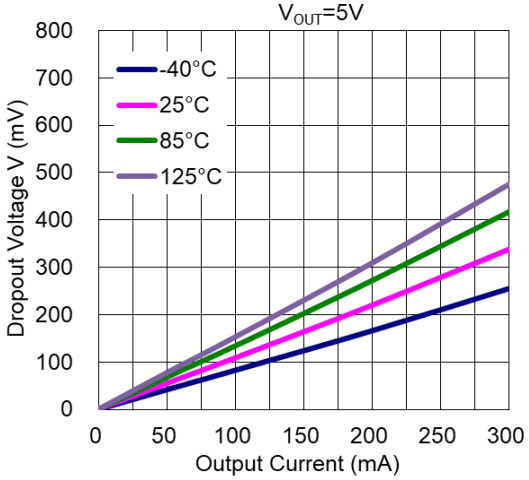



## Typical Characteristics ($C_{IN}$ = $C_{OUT}$ = 10μF) (continued)

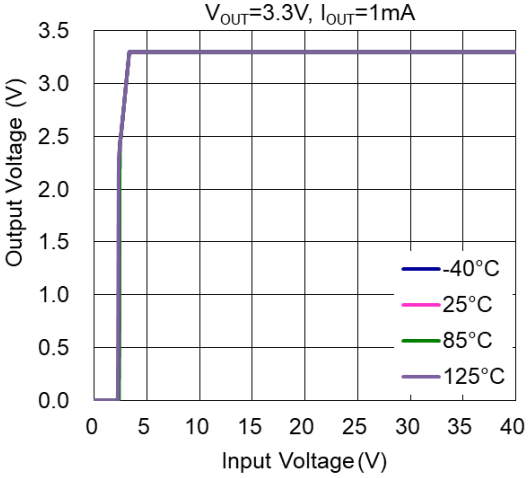
Dropout Voltage vs. Output Current
$V_{OUT}$=3.3V



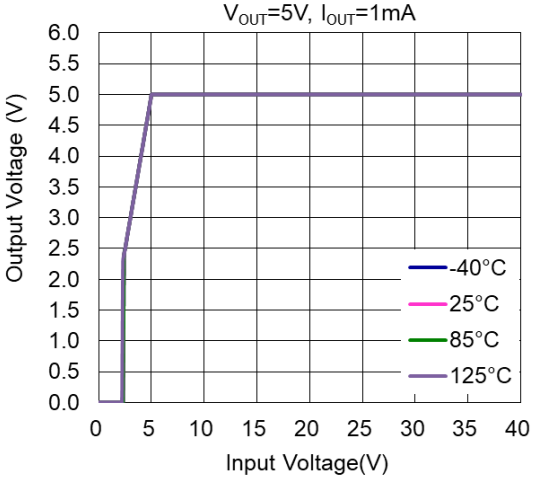

Dropout Voltage vs. Output Current,
$V_{OUT}$=5V



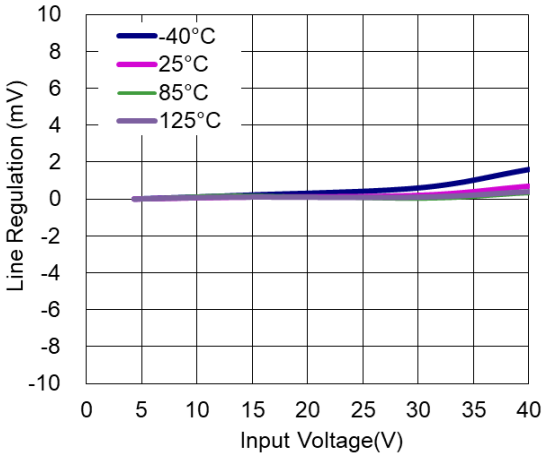

Output Voltage vs. Input Voltage
$V_{OUT}$=3.3V, $I_{OUT}$=1mA



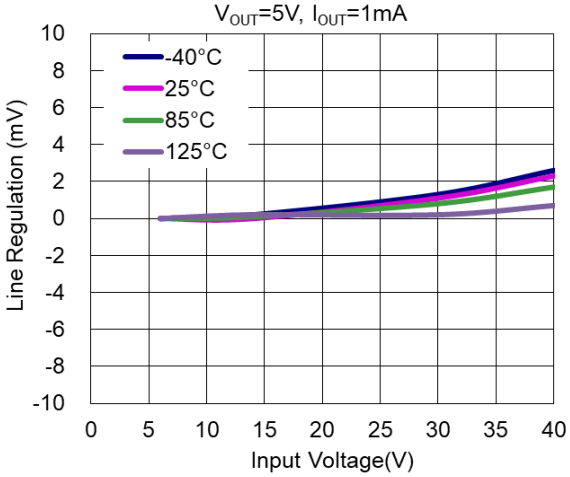

Output Voltage vs. Input Voltage
$V_{OUT}$=5V, $I_{OUT}$=1mA




Line Regulation vs. Input Voltage
$V_{OUT}$=3.3V, $I_{OUT}$=1mA

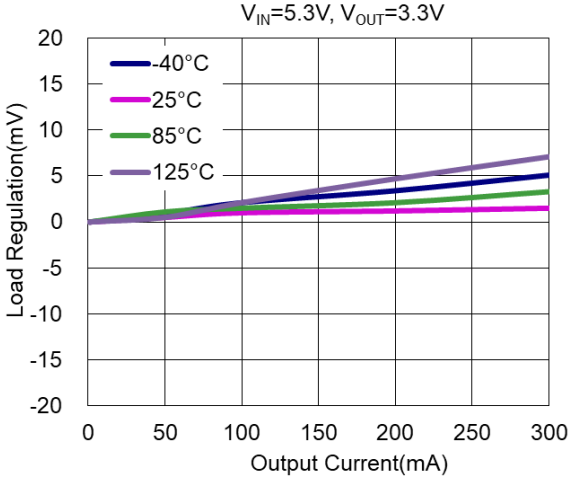



Line Regulation vs. Input Voltage
$V_{OUT}$=5V, $I_{OUT}$=1mA

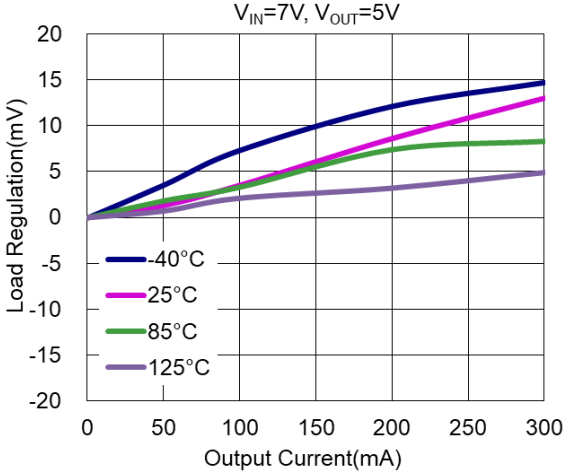


## Typical Characteristics ($C_{IN}$ = $C_{OUT}$ = 10μF) (continued)

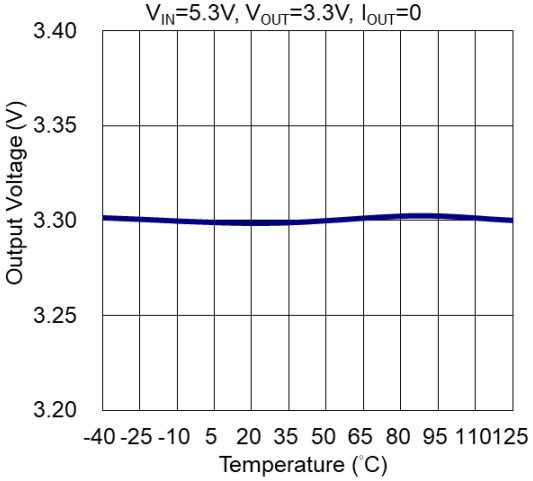
Load Regulation vs. Output Current
$V_{IN}$=5.3V, $V_{OUT}$=3.3V



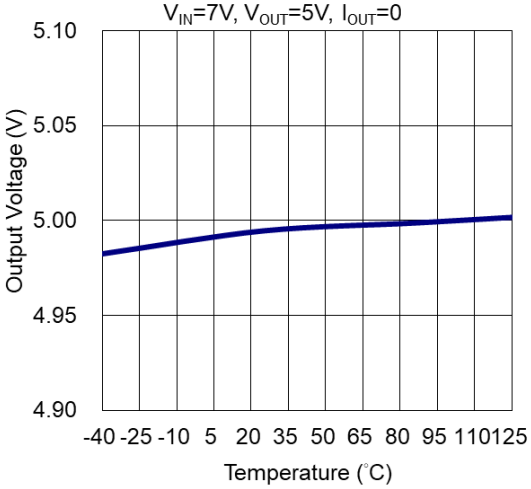

Load Regulation vs. Output Current
$V_{IN}$=7V, $V_{OUT}$=5V



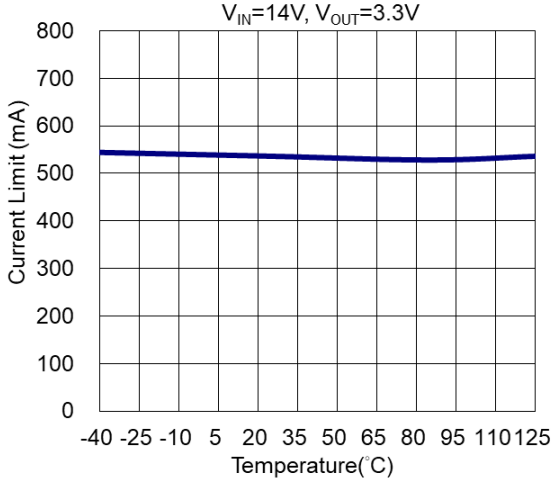

Output Voltage vs. Temperature
$V_{IN}$=5.3V, $V_{OUT}$=3.3V, $I_{OUT}$=0



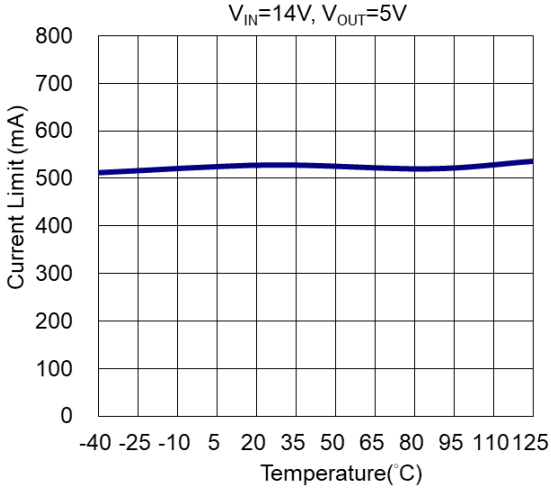

Output Voltage vs. Temperature
$V_{IN}$=7V, $V_{OUT}$=5V, $I_{OUT}$=0




Current Limit vs. Temperature
$V_{IN}$=14V, $V_{OUT}$=3.3V



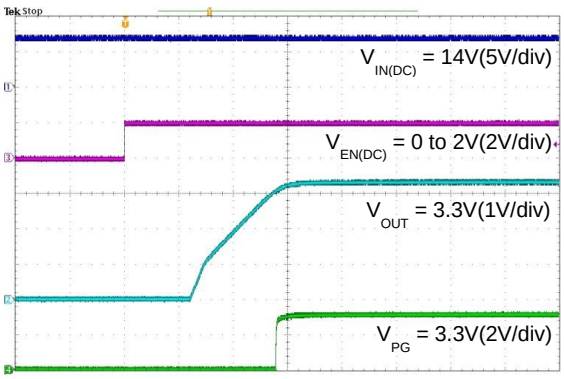

Current Limit vs. Temperature
$V_{IN}$=14V, $V_{OUT}$=5V



## Typical Characteristics ($C_{IN}$ = $C_{OUT}$ = 10μF) (continued)

Enable Turn-on Response

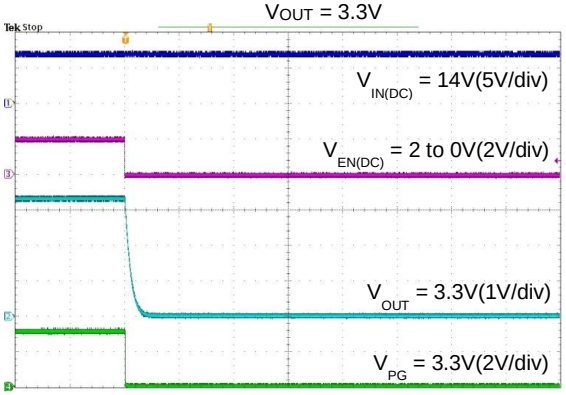
$V_{OUT}$ = 3.3V




Time (1ms/div)

Enable Turn-off Response

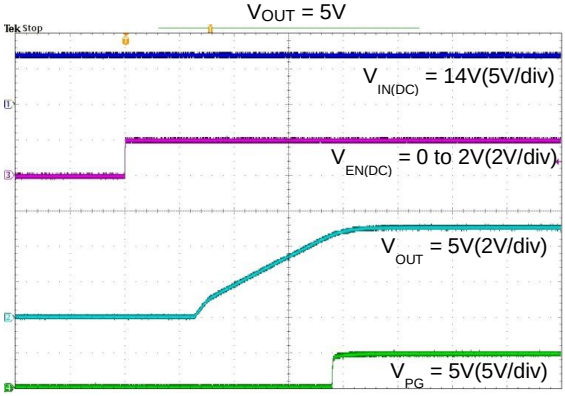
$V_{OUT}$ = 3.3V




Time (1ms/div)

Enable Turn-on Response

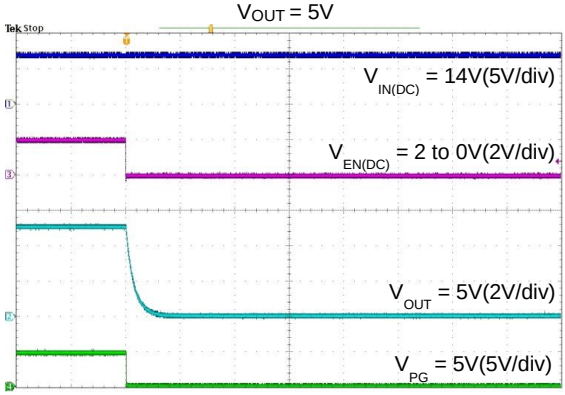
$V_{OUT}$ = 5V




Time (1ms/div)

Enable Turn-off Response

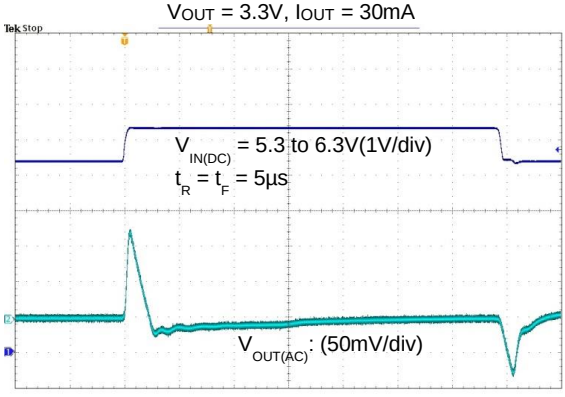
$V_{OUT}$ = 5V




Time (1ms/div)

Line-Transient Response

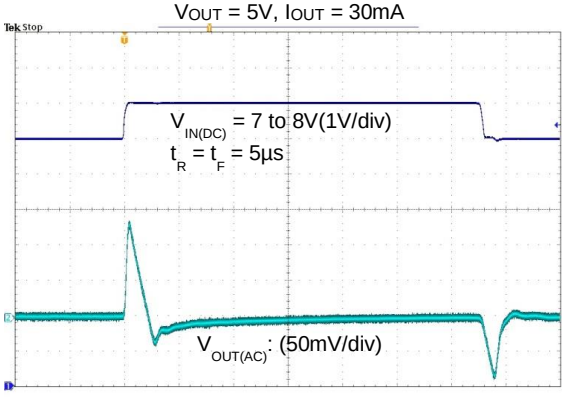
$V_{OUT}$ = 3.3V, $I_{OUT}$ = 30mA




Time (80μs/div)

Line-Transient Response

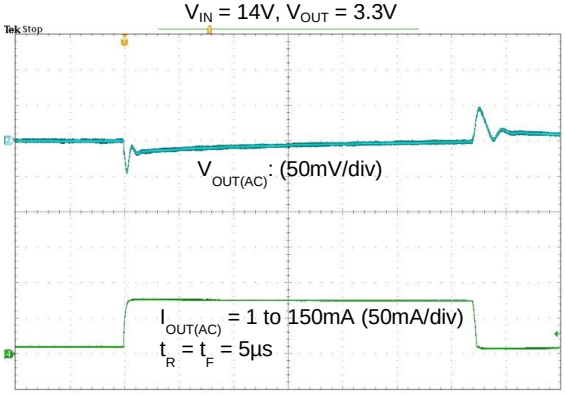
$V_{OUT}$ = 5V, $I_{OUT}$ = 30mA




Time (80μs/div)

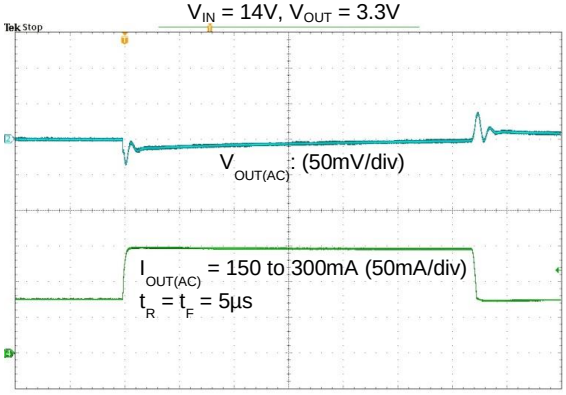
## Typical Characteristics ($C_{IN}$ = $C_{OUT}$ = 10μF) (continued)

Load-Transient Response
$V_{IN}$ = 14V, $V_{OUT}$ = 3.3V



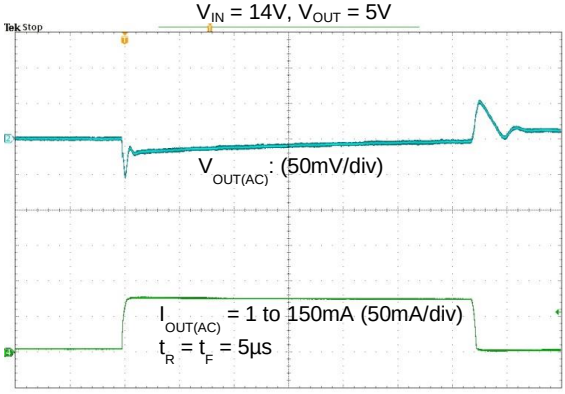

Time (80μs/div)

Load-Transient Response
$V_{IN}$ = 14V, $V_{OUT}$ = 3.3V



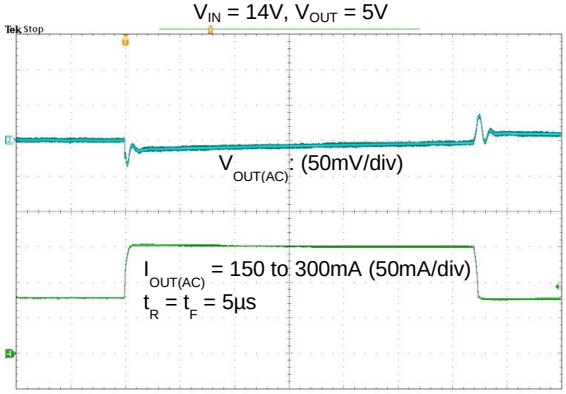

Time (80μs/div)

Load-Transient Response
$V_{IN}$ = 14V, $V_{OUT}$ = 5V



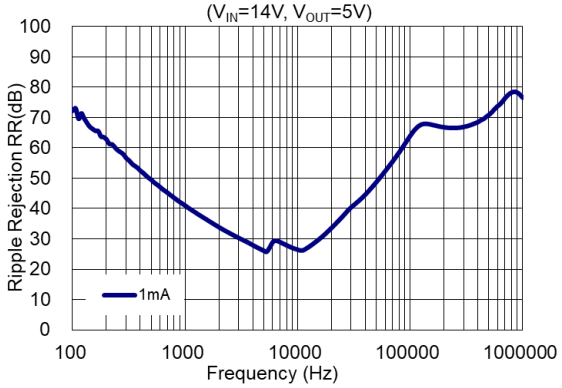

Time (80μs/div)

Load-Transient Response
$V_{IN}$ = 14V, $V_{OUT}$ = 5V

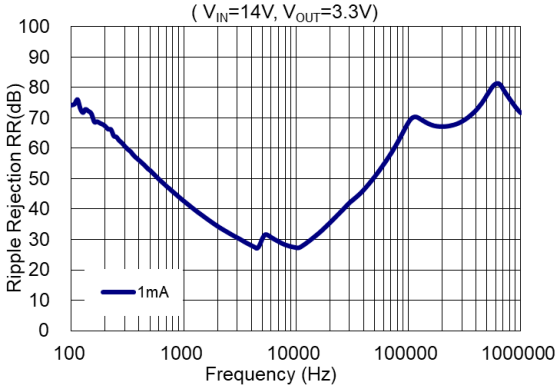



Time (80μs/div)

Ripple Rejection vs Frequency
($V_{IN}$=14V, $V_{OUT}$=5V)




Ripple Rejection vs Frequency
( $V_{IN}$=14V, $V_{OUT}$=3.3V)



## Application Information

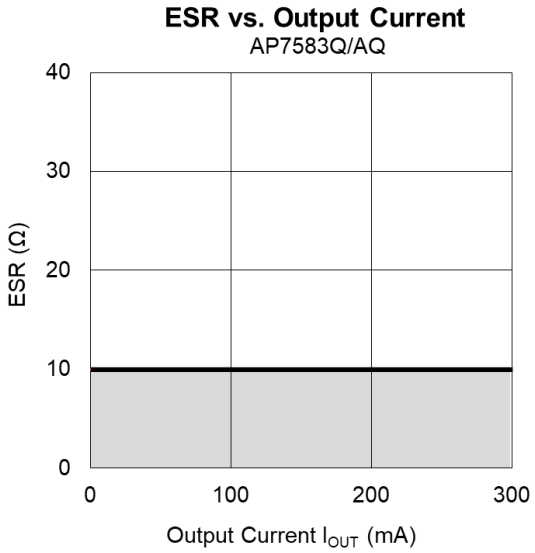
**Input Capacitor**

A 10μF 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**

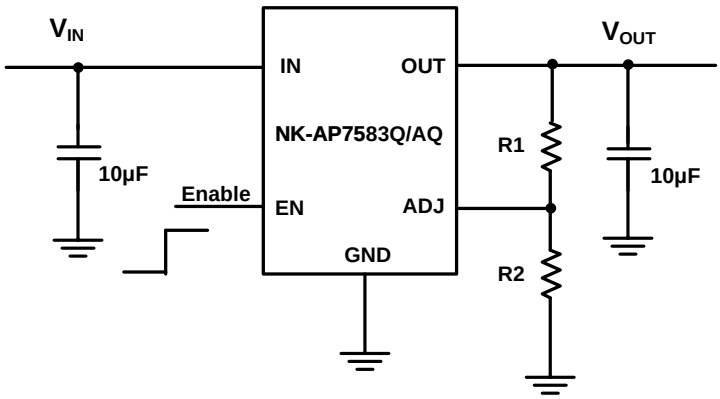
Ceramic type output capacitor is recommended for this series; however, the other output capacitors with low ESR also can be used. One 10μF output capacitor is suggested, the NK-AP7583Q/AQ series LDO would have stable output capacitance range from 4.7μF to 100μF. The relations between $I_{OUT}$ (Output Current) and ESR of an output capacitor are shown below. The stable region for the safety operating temperature (-40°C to +125°C) is marked as the gray area in the graph.

Measurement conditions: Frequency Band: 10Hz to 2MHz, Temperature: -40°C to +125°C.




**Adjustable Operation**

The NK-AP7583Q/AQ provide output voltage from 1.2V to 5.0V through external resistor divider as shown below:




Adjustable Output

## Application Information (continued)

The output voltage is calculated by:

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

Where $V_{REF}$ = 1.2V (the internal reference voltage).

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

$$R1 = R2\left(\frac{V_{OUT}}{V_{REF}}-1\right)$$

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 NK-AP7583Q/AQ are 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.

**Power-Good**

The power-good (PG) pin is an open-drain output with one internal resistor. When the $V_{OUT} \geq V_{PGR}$, the PG output is high-impedance; if the $V_{OUT}$ drops to below $V_{PGF}$, or the device is disabled, the PG pin is pulled to low by an internal MOSFET.

**Thermal Shutdown Protection**

Thermal protection disables the output when the junction temperature rises to approximately +175°C, allowing the device to cool down. When the junction temperature reduces to approximately +155°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.

**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:

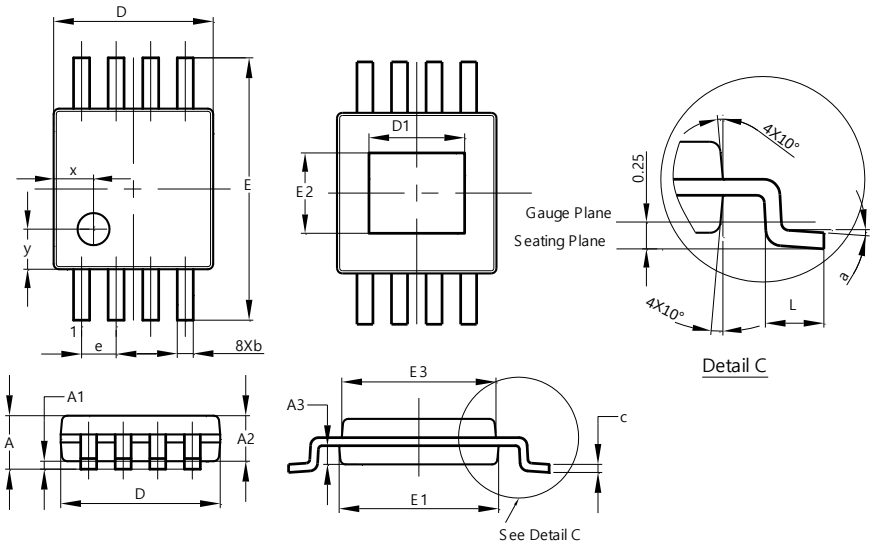
$P_D = (V_{IN} - V_{OUT}) \times I_{OUT}$

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:

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

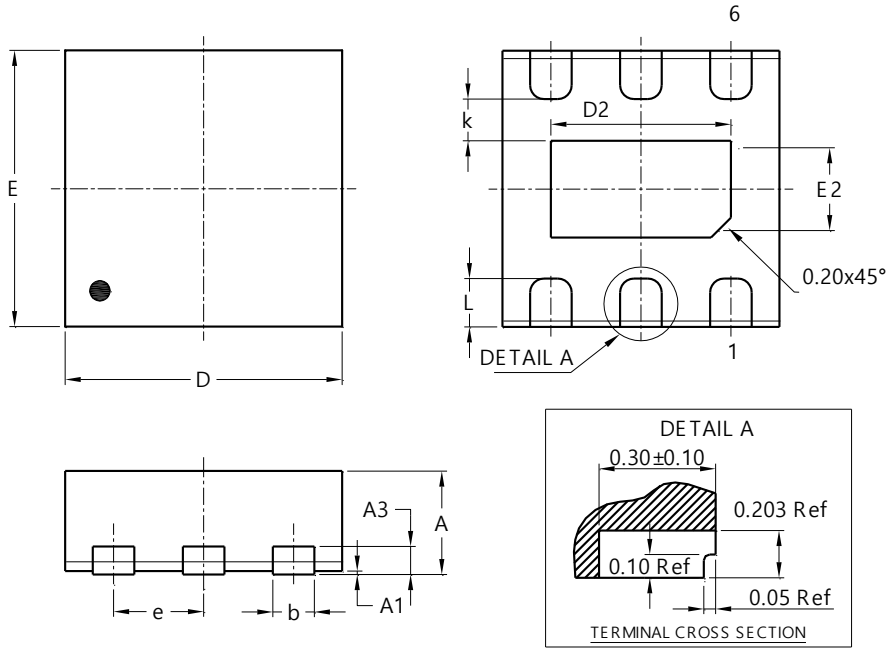
## Package Outline Dimensions

### (1) MSOP-8EP




| MSOP-8EP | | | |
|---|---|---|---|
| **Dim** | **Min** | **Max** | **Typ** |
| **A** | - | 1.10 | - |
| **A1** | 0.05 | 0.15 | 0.10 |
| **A2** | 0.75 | 0.95 | 0.86 |
| **A3** | 0.29 | 0.49 | 0.39 |
| **b** | 0.22 | 0.38 | 0.30 |
| **c** | 0.08 | 0.23 | 0.15 |
| **D** | 2.90 | 3.10 | 3.00 |
| **D1** | 1.60 | 2.00 | 1.80 |
| **E** | 4.70 | 5.10 | 4.90 |
| **E1** | 2.90 | 3.10 | 3.00 |
| **E2** | 1.30 | 1.70 | 1.50 |
| **E3** | 2.85 | 3.05 | 2.95 |
| **e** | - | - | 0.65 |
| **L** | 0.40 | 0.80 | 0.60 |
| **a** | 0° | 8° | 4° |
| **x** | - | - | 0.750 |
| **y** | - | - | 0.750 |
| **All Dimensions in mm** | | | |

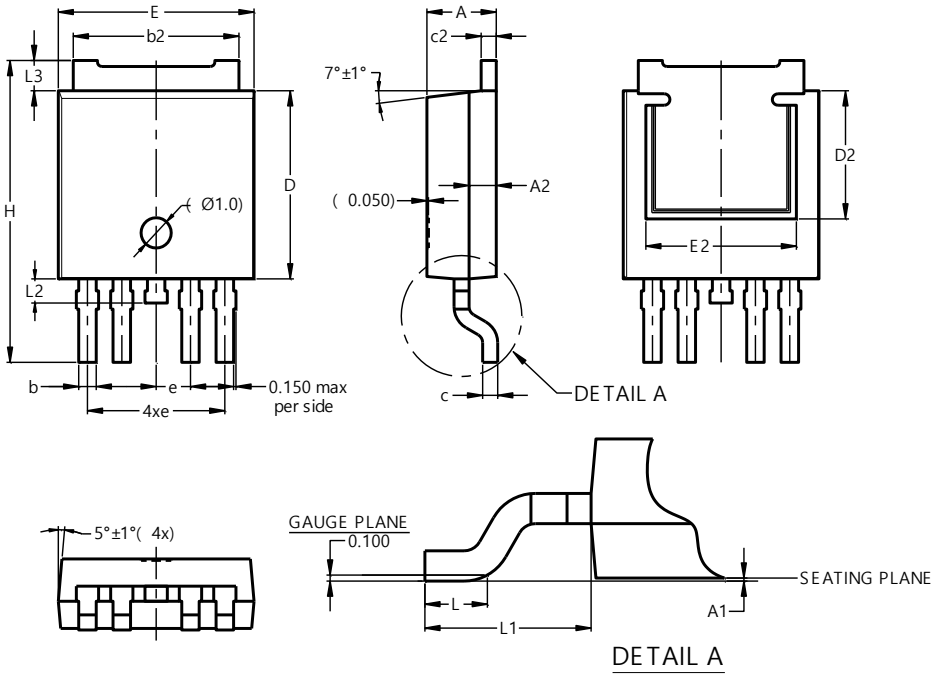
### (2) W-DFN2020-6 (SWP) (Type A1)




| W-DFN2020-6 (SWP) (Type A1) | | | |
|---|---|---|---|
| **Dim** | **Min** | **Max** | **Typ** |
| **A** | 0.70 | 0.80 | 0.75 |
| **A1** | 0.00 | 0.05 | 0.02 |
| **A3** | 0.203 REF | | |
| **b** | 0.25 | 0.35 | 0.30 |
| **D** | 2.00 BSC | | |
| **D2** | 1.35 | 1.45 | 1.40 |
| **E** | 2.00 BSC | | |
| **E2** | 0.55 | 0.65 | 0.60 |
| **e** | 0.65 BSC | | |
| **k** | 0.20 | — | — |
| **L** | 0.20 | 0.40 | 0.30 |
| **All Dimensions in mm** | | | |

## Package Outline Dimensions (continued)

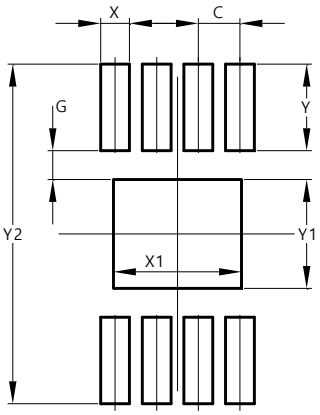
**(3) TO252-4 (Type C)**




| TO252-4 (Type C) | | | |
|---|---|---|---|
| Dim | Min | Max | Typ |
| A | 2.20 | 2.35 | -- |
| A1 | 0.00 | 0.15 | -- |
| A2 | 0.80 | 1.00 | -- |
| b | 0.50 | 0.70 | 0.60 |
| b2 | 5.30 | 5.70 | -- |
| c | 0.46 | 0.58 | -- |
| c2 | 0.46 | 0.58 | -- |
| D | 6.02 | 6.22 | -- |
| D2 | 4.24REF | | |
| e | 1.14BSC | | |
| E | 6.45 | 6.65 | -- |
| E2 | 5.00REF | | |
| H | 9.48 | 10.48 | 9.98 |
| L | 0.60 | -- | -- |
| L1 | 2.76REF | | |
| L2 | 0.65 | 0.95 | 0.80 |
| L3 | 0.90 | 1.10 | 1.00 |
| All Dimensions in mm | | | |

## Suggested Pad Layout

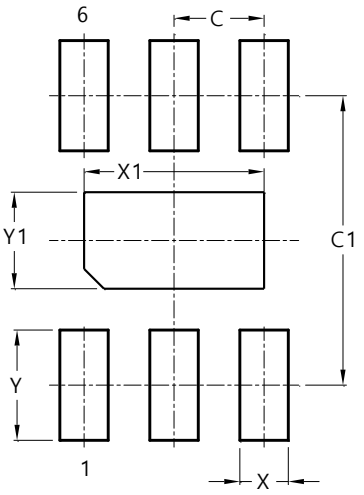
**(1) MSOP-8EP**




| Dimensions | Value (in mm) |
|---|---|
| C | 0.650 |
| G | 0.450 |
| X | 0.450 |
| X1 | 2.000 |
| Y | 1.350 |
| Y1 | 1.700 |
| Y2 | 5.300 |

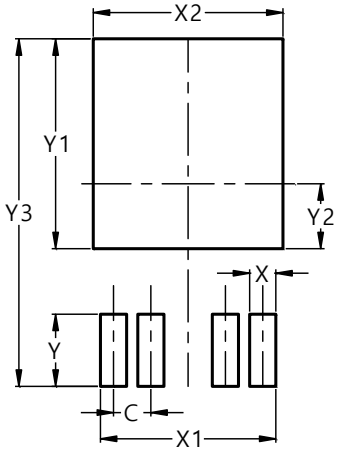
## Suggested Pad Layout (continued)

**(2) W-DFN2020-6 (SWP) (Type A1)**




| Dimensions | Value (in mm) |
|---|---|
| C | 0.650 |
| C1 | 2.100 |
| X | 0.350 |
| X1 | 1.400 |
| Y | 0.800 |
| Y1 | 0.600 |

**(3) TO252-4 (Type C)**




| Dimensions | Value (in mm) |
|---|---|
| C | 1.140 |
| X | 0.800 |
| X1 | 5.360 |
| X2 | 5.800 |
| Y | 2.200 |
| Y1 | 6.400 |
| Y2 | 1.980 |
| Y3 | 10.600 |

## Mechanical Data

- Moisture Sensitivity:
  - MSOP-8EP: Level 1 Per J-STD-020
  - W-DFN2020-6 (SWP) (Type A1): Level 1 Per J-STD-020
  - TO252-4 (Type C): Level 3 Per J-STD-020
- Terminals: Finish - Matte Tin Plated Leads, Solderable per MIL-STD-202, Method 208 e3
- Weight:
  - MSOP-8EP: 0.024 grams (Approximate)
  - W-DFN2020-6 (SWP) (Type A1): 0.01 grams (Approximate)
  - TO252-4 (Type C): 0.343 grams (Approximate)