# 340kHz, 3A Synchronous DC-DC Buck Converter AP3503E

## General Description

The AP3503E is a 340kHz fixed frequency, current mode, PWM synchronous buck (step-down) DC-DC converter, capable of driving a 3A load with high efficiency, excellent line and load regulation. The AP3503E exhibits high efficiency at light load. The device integrates N-channel power MOSFET switches with low on-resistance. Current mode control provides fast transient response and cycle-by-cycle current limit.

The AP3503E employs complete protection to ensure system security. Including output Over Voltage Protection, input Under Voltage Lock Out, programmable Soft Start, Over Temperature Protection and hiccup mode Short Circuit Protection.

This IC is available in PSOP-8 package.

## Features

- Input Voltage Range: 4.5V to 18V
- Fixed 340kHz Frequency
- High Efficiency at Light Load
- High Efficiency: up to 95%
- Output Current: 3A
- Current Mode Control
- Built-in Over Current Protection
- Built-in Thermal Shutdown Function
- Built-in UVLO Function
- Built-in Over Voltage Protection
- Programmable Soft-start
- Hiccup Mode SCP

## Applications

- LCD TV
- Set Top Box
- Portable DVD
- Digital Photo Frame



PSOP-8

Figure 1. Package Type of AP3503E

## Pin Configuration

MP Package
(PSOP-8)

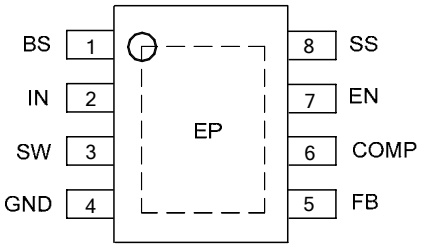



Figure 2. Pin Configuration of AP3503E (Top View)

## Pin Description

| Pin Number | Pin Name | Function |
|---|---|---|
| 1 | BS | Bootstrap pin. A bootstrap capacitor is connected between the BS pin and SW pin. The voltage across the bootstrap capacitor drives the internal high-side power MOSFET |
| 2 | IN | Supply power input pin. A capacitor should be connected between the IN pin and GND pin to keep the input voltage constant |
| 3 | SW | Power switch output pin. This pin is connected to the inductor and bootstrap capacitor |
| 4 | GND | Ground pin |
| 5 | FB | Feedback pin. This pin is connected to an external resistor divider to program the system output voltage. When the FB pin voltage exceeds 1.1V, the over voltage protection is triggered. When the FB pin voltage is below 0.3V, the oscillator frequency is lowered to realize short circuit protection |
| 6 | COMP | Compensation pin. This pin is the output of the transconductance error amplifier and the input to the current comparator. It is used to compensate the control loop. Connect a series RC network from this pin to GND. In some cases, an additional capacitor from this pin to GND pin is required |
| 7 | EN | Control input pin. EN is a digital input that turns the regulator on or off. Drive EN high/low to turn on/off the regulator. Pull up with 100kΩ resistor for automatic startup |
| 8 | SS | Soft-start control input pin. SS controls the soft-start period. Connect a capacitor from SS to GND to set the soft-start period. A 0.1μF capacitor sets the soft-start period to 15ms. To disable the soft-start feature, leave SS unconnected |
| | EP | Exposed pad. It should be connected to GND in PCB layout |

# 340kHz, 3A Synchronous DC-DC Buck Converter AP3503E

## Functional Block Diagram

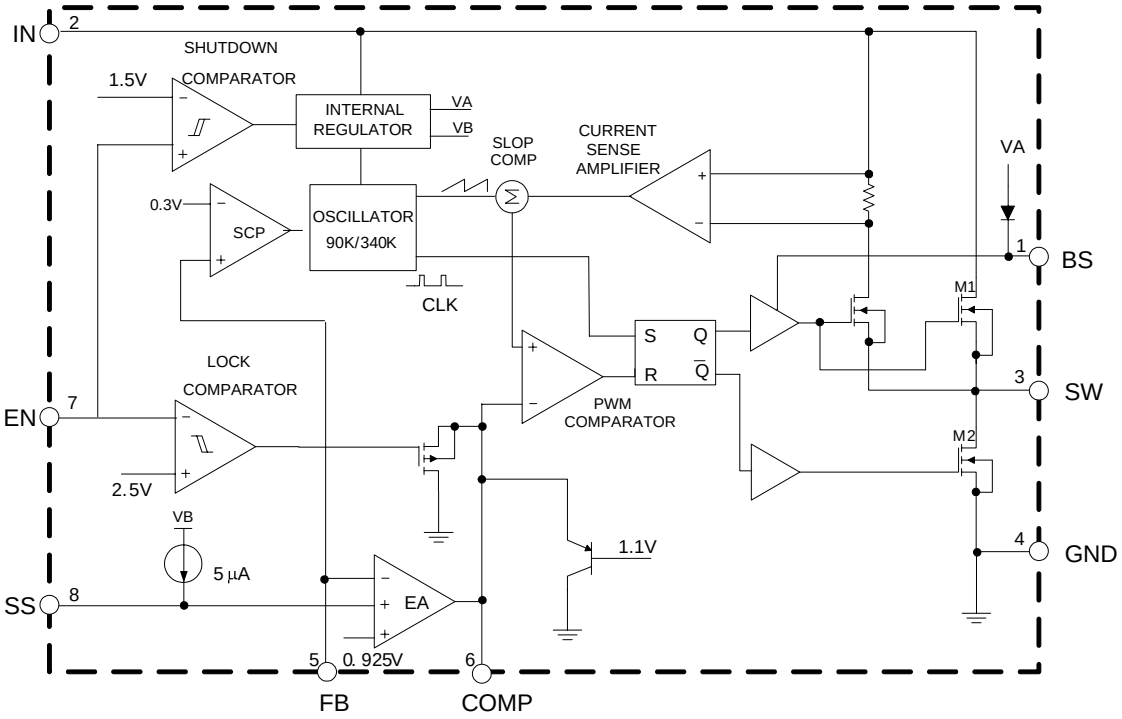
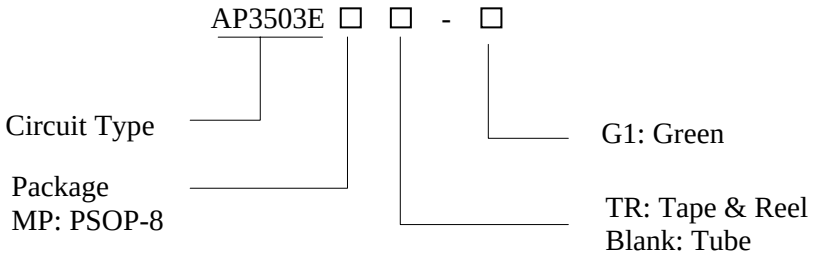



Figure 3. Functional Block Diagram of AP3503E

## Ordering Information




| Package | Temperature Range | Part Number | Marking ID | Packing Type |
|---|---|---|---|---|
| PSOP-8 | -40 to 85°C | AP3503EMP-G1 | 3503EMP-G1 | Tube |
| | | AP3503EMPTR-G1 | 3503EMP-G1 | Tape & Reel |

BCD Semiconductor's Pb-free products, as designated with "G1" suffix in the part number, are RoHS compliant and green.

## Absolute Maximum Ratings (Note 1)

| Parameter | Symbol | Value | Unit |
|---|---|---|---|
| IN Pin Voltage | $V_{IN}$ | -0.3 to 20 | V |
| EN Pin Voltage | $V_{EN}$ | -0.3 to $V_{IN}$ | V |
| SW Pin Voltage | $V_{SW}$ | 21 | V |
| BS Pin Voltage | $V_{BS}$ | -0.3 to $V_{SW}$+6 | V |
| FB Pin Voltage | $V_{FB}$ | -0.3 to 6 | V |
| COMP Pin Voltage | $V_{COMP}$ | -0.3 to 6 | V |
| SS Pin Voltage | $V_{SS}$ | -0.3 to 6 | V |
| Thermal Resistance | $\theta_{JA}$ | 60 | °C/W |
| Operating Junction Temperature | $T_J$ | 150 | °C |
| Storage Temperature | $T_{STG}$ | -65 to 150 | °C |
| Lead Temperature (Soldering, 10sec) | $T_{LEAD}$ | 260 | °C |
| ESD (Human Body Model) | $V_{HBM}$ | 2000 | V |
| ESD (Machine Model) | $V_{MM}$ | 200 | V |

Note 1: Stresses greater than those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “Recommended Operating Conditions” is not implied. Exposure to “Absolute Maximum Ratings” for extended periods may affect device reliability.

## Recommended Operating Conditions

| Parameter | Symbol | Min | Max | Unit |
|---|---|---|---|---|
| Input Voltage | $V_{IN}$ | 4.5 | 18 | V |
| Operating Ambient Temperature | $T_A$ | -40 | 85 | °C |

## Electrical Characteristics

$T_A$=25ºC, $V_{IN}$=$V_{EN}$=12V, $V_{OUT}$=3.3V, unless otherwise specified.

| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **SUPPLY VOLTAGE (IN PIN)** | | | | | | |
| Input Voltage | $V_{IN}$ | | 4.5 | | 18 | V |
| Quiescent Current | $I_Q$ | $V_{FB}$=1V, $V_{EN}$=3V | | 1.2 | 1.4 | mA |
| Shutdown Supply Current | $I_{SHDN}$ | $V_{EN}$=0V | | 0.1 | 10 | μA |
| **UNDER VOLTAGE LOCKOUT** | | | | | | |
| Input UVLO Threshold | $V_{UVLO}$ | $V_{IN}$ Rising | 3.65 | 4.00 | 4.25 | V |
| Input UVLO Hysteresis | $V_{HYS}$ | | | 200 | | mV |
| **ENABLE (EN PIN)** | | | | | | |
| EN Shutdown Threshold Voltage | | | 1.1 | 1.5 | 2 | V |
| EN Shutdown Threshold Voltage Hysteresis (Note 3) | | | | 350 | | mV |
| EN Lockout Threshold Voltage | | | 2.2 | 2.5 | 2.7 | V |
| EN Lockout Hysteresis | | | | 210 | | mV |
| **VOLTAGE REFERENCE (FB PIN)** | | | | | | |
| Feedback Voltage | $V_{FB}$ | | 0.907 | 0.925 | 0.943 | V |
| Feedback Over Voltage Threshold | $V_{FBOV}$ | | | 1.1 | | V |
| Feedback Bias Current | $I_{FB}$ | $V_{FB}$=1V | -0.1 | | 0.1 | μA |
| **MOSFET** | | | | | | |
| High-side Switch On-resistance(Note 2) | $R_{DSONH}$ | $I_{SW}$=0.2A/0.7A | | 100 | | mΩ |
| Low-side Switch On-resistance(Note 2) | $R_{DSONL}$ | $I_{SW}$=-0.2A/-0.7A | | 100 | | mΩ |
| **CURRENT LIMIT** | | | | | | |
| High-side Switch Leakage Current | $I_{LEAKH}$ | $V_{IN}$=18V, $V_{EN}$=$V_{SW}$=0V | | 0.1 | 10 | μA |
| High-side Switch Current Limit | $I_{LIMH}$ | | 4.3 | 5.6 | | A |
| Low-side Switch Current Limit | $I_{LIML}$ | Drain to Source | | 0 | | mA |
| **SWITCHING REGULATOR** | | | | | | |
| Oscillator Frequency | $f_{OSC1}$ | | 280 | 340 | 400 | kHz |
| Short Circuit Oscillator Frequency | $f_{OSC2}$ | | | 90 | | kHz |
| Max. Duty Cycle | $D_{MAX}$ | $V_{FB}$=0.85V | | 90 | | % |
| Min. Duty Cycle | $D_{MIN}$ | $V_{FB}$=1V | | | 0 | % |
| **ERROR AMPLIFIER** | | | | | | |
| Error Amplifier Voltage Gain (Note 3) | $A_{EA}$ | | | 400 | | V/V |
| Error Amplifier Transconductance | $G_{EA}$ | | | 800 | | μA/V |
| COMP to Current Sense Transconductance | $G_{CS}$ | | | 5.2 | | A/V |
| **THERMAL SHUTDOWN** | | | | | | |
| Thermal Shutdown (Note 3) | $T_{OTSD}$ | | | 160 | | ºC |
| Thermal Shutdown Hysteresis (Note 3) | $T_{HYS}$ | | | 20 | | ºC |
| **SOFT START (SS PIN)** | | | | | | |
| Soft-start Time (Note 3) | $t_{SS}$ | C4=0.1μF,$I_{OUT}$=500mA | | 15 | | ms |
| Soft-start Current | | | | 5 | | μA |

Note 2: $R_{DSON}=\frac{V_{SW1}-V_{SW2}}{I_{SW1}-I_{SW2}}$

Note 3: Not tested, guaranteed by design.

## Typical Performance Characteristics

$T_A$=25ºC, $V_{IN}$=12V, $V_{OUT}$=3.3V, unless otherwise noted.

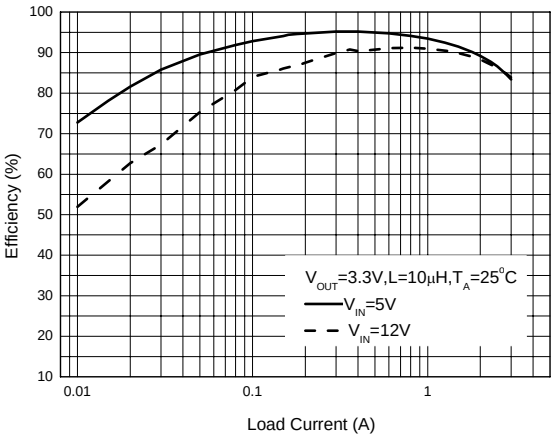



Figure 4. Efficiency vs. Load Current

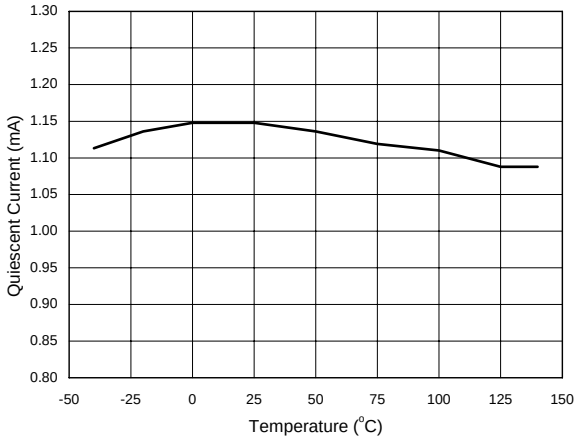



Figure 5. Quiescent Current vs. Temperature

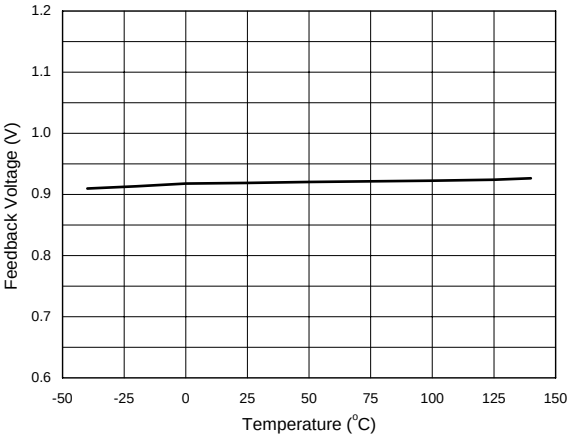



Figure 6. Feedback Voltage vs. Temperature

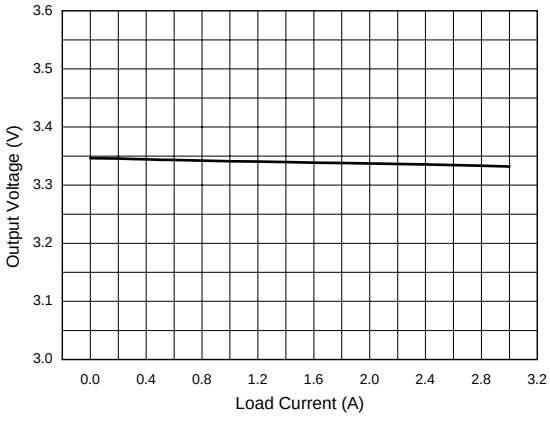



Figure 7. Output Voltage vs. Load Current

## Typical Performance Characteristics (Continued)

$T_A$=25°C, $V_{IN}$=12V, $V_{OUT}$=3.3V, unless otherwise noted.

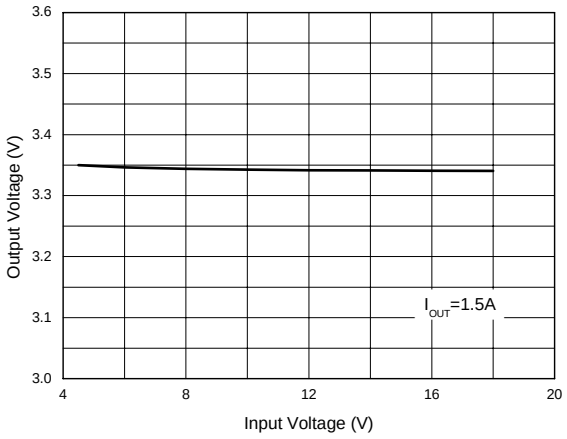



Figure 8. Output Voltage vs. Input Voltage

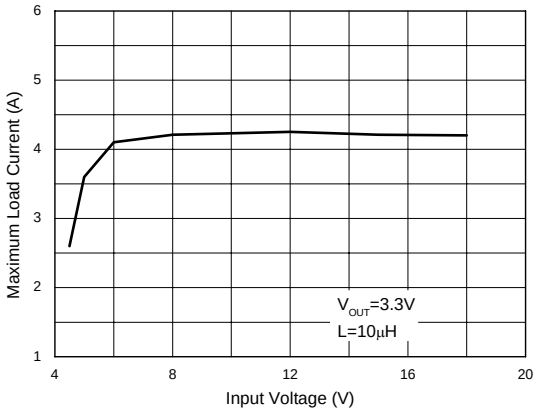
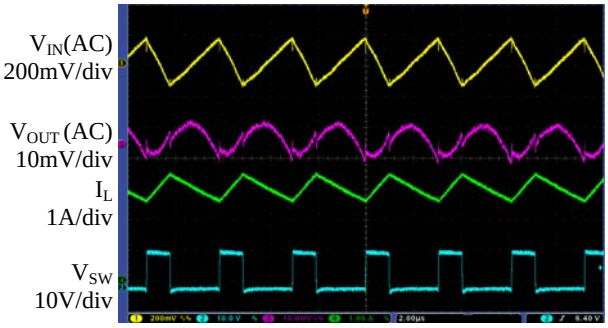
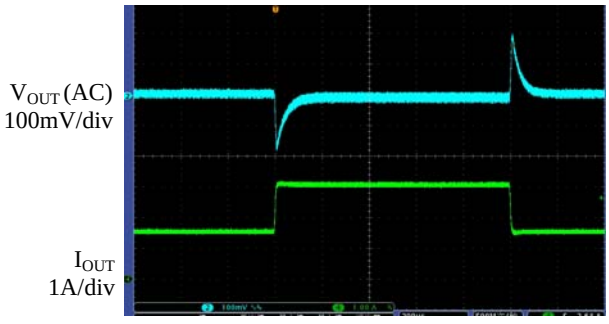



Figure 9. Maximum Load Current vs. Input Voltage




Time 2µs/div

Figure 10. Output Ripple ($I_{OUT}$=3A)




Time 200µs/div

Figure 11. Load Transient ($I_{OUT}$=1.5 to 3A)

## Typical Performance Characteristics (Continued)

$T_A$=25°C, $V_{IN}$=12V, $V_{OUT}$=3.3V, unless otherwise noted.

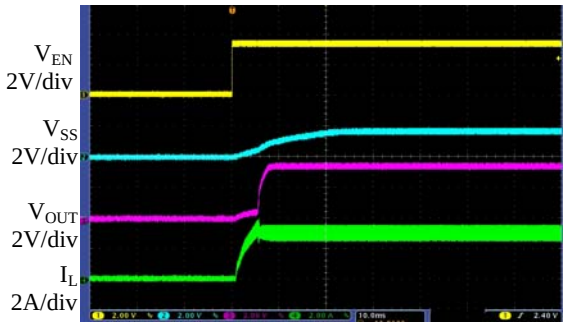



Figure 12. Enable Turn-on Characteristic
($V_{IN}$=12V, $V_{EN}$=3.3V, $V_{OUT}$=3.3V, $I_{OUT}$=3A)

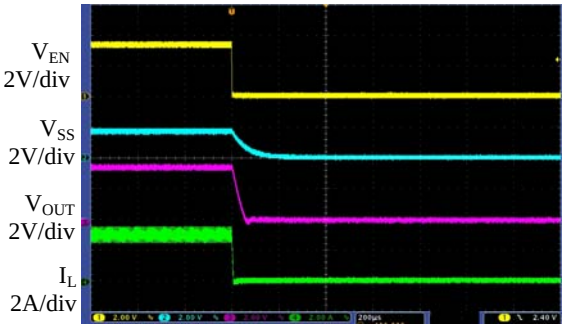



Figure 13. Enable Turn-off Characteristic
($V_{IN}$=12V, $V_{EN}$=3.3V, $V_{OUT}$=3.3V, $I_{OUT}$=3A)

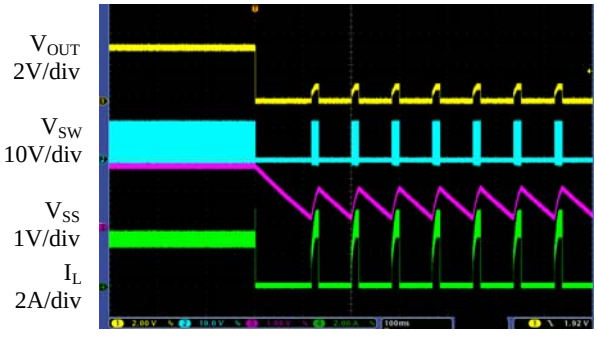



Figure 14. Short Circuit Protection ($I_{OUT}$=3A)

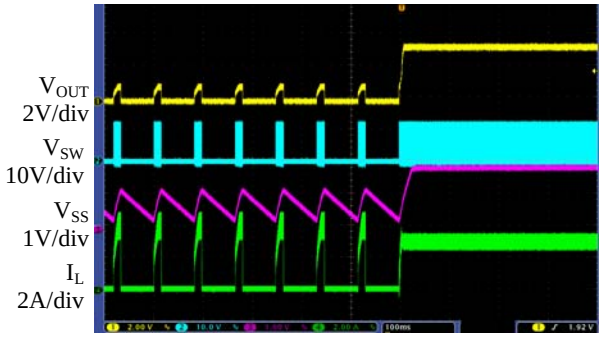



Figure 15. Short Circuit Recovery ($I_{OUT}$=3A)

## Typical Application

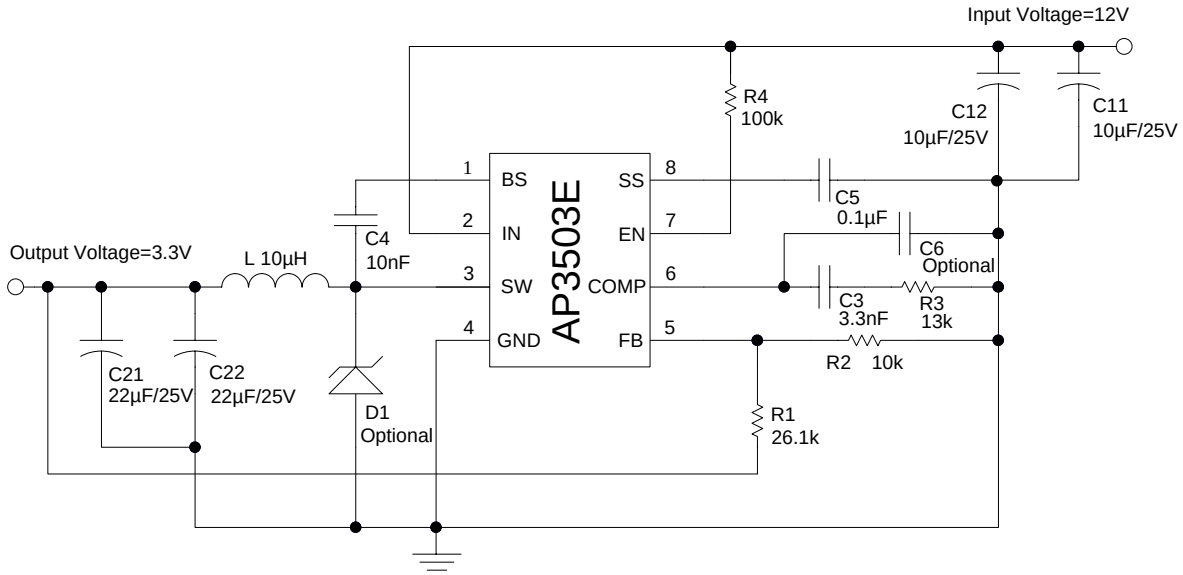
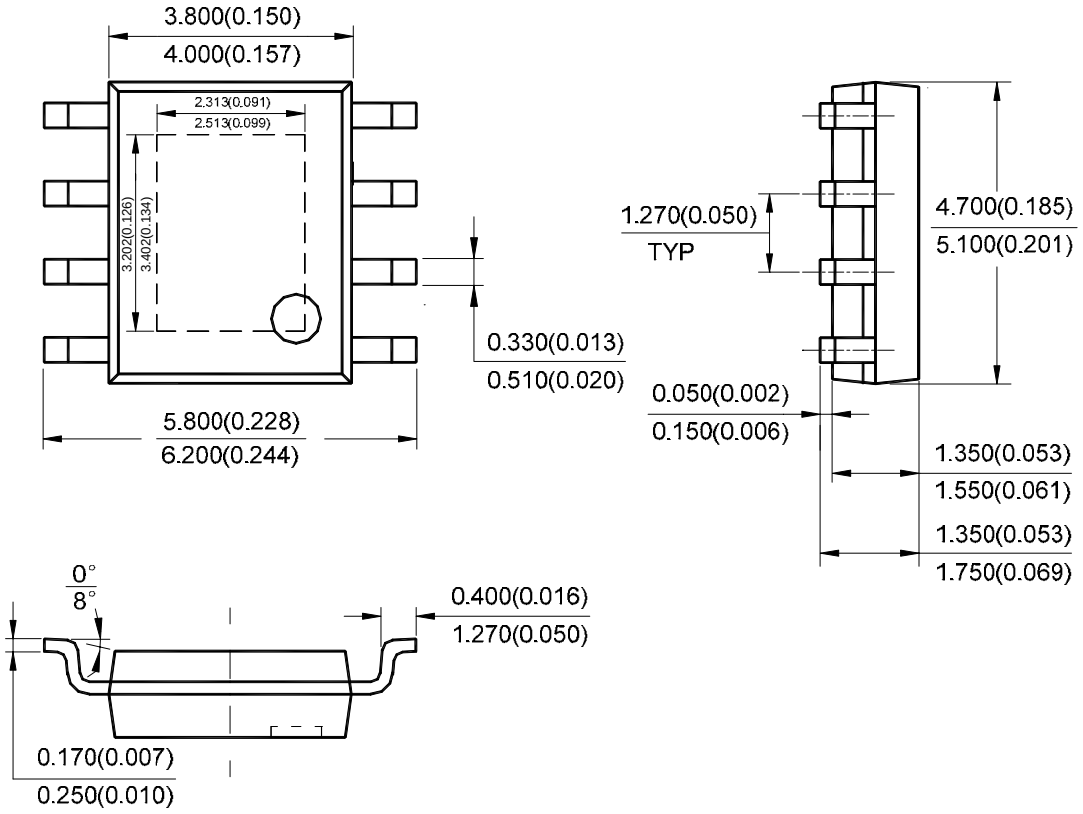



Figure 16. Typical Application of AP3503E

## Mechanical Dimensions

**PSOP-8** **Unit: mm(inch)**




Note: Eject hole, oriented hole and mold mark is optional.



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