# *1A, 2.25MHz, Synchronous Step-Down DC-DC Converter*

***UM3510S SOT23-6***
***UM3510DA DFN6 2.0×2.0***

## General Description

The UM3510 is a high efficiency pulse-width-modulated (PWM) synchronous step-down DC-DC converter with an input voltage range of 2.5V to 6.0V. It provides up to 1000mA output current from a single Li-ion cell. The UM3510 operates at 2.25MHz fixed switching frequency and enters Power Save Mode to maintain high efficiency at light load condition.
For low noise applications, the device can be forced into fixed frequency PWM mode by pulling the MODE pin high.
The UM3510 enters shutdown mode and consumes less than 1μA when EN pin is pulled low. Other features include lower internal reference voltage with 2% accuracy, over temperature protection and over current protection.
The UM3510 is available in SOT23-6 and 2mm×2mm 6-pin DFN packages.

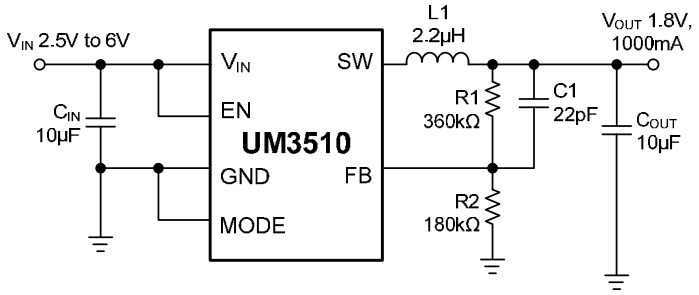
## Applications

- Cellular and Smart Phones
- Microprocessors and DSP Core Supplies
- Wireless and DSL Modems
- PDAs, GPS
- WLAN
- Portable Instruments

## Features

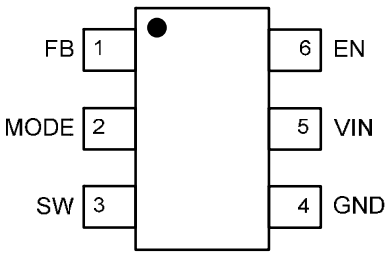
- High Efficiency: Up to 95%
- 2.25MHz Constant Switching Frequency
- 1000mA Output Current
- Integrated Main Switch and Synchronous Rectifier. No Schottky Diode Required.
- 2.5V to 6.0V Input Voltage Range
- Low Quiescent Current: 56μA
- Thermal Fault Protection
- <1μA Shutdown Current

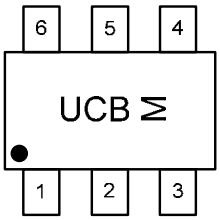
## Typical Application Circuit




## Pin Configurations

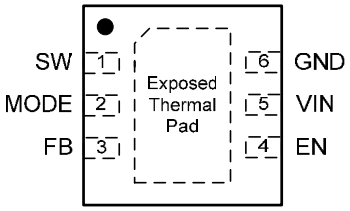
**Top View**



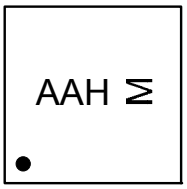




**M: Month Code**
**UM3510S**
***SOT23-6***

## Pin Configurations Top View




(Top View)




**M: Month Code**
**UM3510DA**
***DFN6 2.0×2.0***

## Ordering Information

| Part Number | Packaging Type | Marking Code | Shipping Qty |
|---|---|---|---|
| UM3510S | SOT23-6 | UCB | 3000pcs/7Inch Tape & Reel |
| UM3510DA | DFN6 2.0×2.0 | AAH | |

## Pin Description

| Pin Number | | Symbol | Function |
|---|---|---|---|
| SOT23-6 | DFN6 2.0×2.0 | | |
| 3 | 1 | SW | Power switch output. It is the switch node connection to the inductor. This pin connects to the drains of the internal P-CH and N-CH MOSFET switches. |
| 2 | 2 | MODE | MODE pin=high forces the device to operate in fixed-frequency PWM mode. Mode pin=low enables the Power Save Mode with automatic transition from PFM mode to fixed-frequency PWM mode. |
| 1 | 3 | FB | Feedback input pin. Connect FB to the center point of the external resistor divider. |
| 6 | 4 | EN | Regulator enable control input. Pulling this pin to high enables the device. Pulling this pin to low forces the device into shutdown mode. This pin must be terminated. |
| 5 | 5 | VIN | Input voltage. |
| 4 | 6 | GND | Ground. |

## Absolute Maximum Ratings (Note 1)

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{IN}$ | Input Voltage | -0.3 to +6.0 | V |
| $V_{EN}$,$V_{FB}$ | EN, FB Voltages | -0.3 to $V_{IN}$+0.3 | V |
| $V_{SW}$ | SW Voltage | -0.3 to $V_{IN}$+0.3 | V |
| $I_{SW}$ | Peak SW Sink and Source Current | 2.0 | A |
| $T_O$ | Operating Temperature | -40 to +85 | °C |
| $T_{STG}$ | Storage Temperature Range | -65 to +150 | °C |

Note 1: Stresses greater than those listed under Maximum Ratings may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

## Thermal Capabilities

| Symbol | Description | | Value | Unit |
|---|---|---|---|---|
| $\theta_{JA}$ | Thermal Resistance | SOT23-6 | 190 | ℃/W |
| | | DFN6 2×2 | 165 | ℃/W |
| $P_D$ | Power Dissipation | SOT23-6 | 0.526 | W |
| | | DFN6 2×2 | 0.606 | W |
| ΔP/℃ | Derating Factor above $T_A$=25℃ | SOT23-6 | -5.26 | mW/℃ |
| | | DFN6 2×2 | -6.06 | mW/℃ |

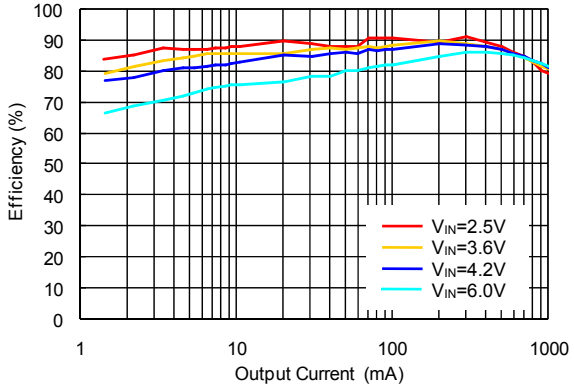
## Electrical Characteristics

($V_{IN}$=$V_{EN}$=3.6V, $T_A$=+25ºC, unless otherwise noted)

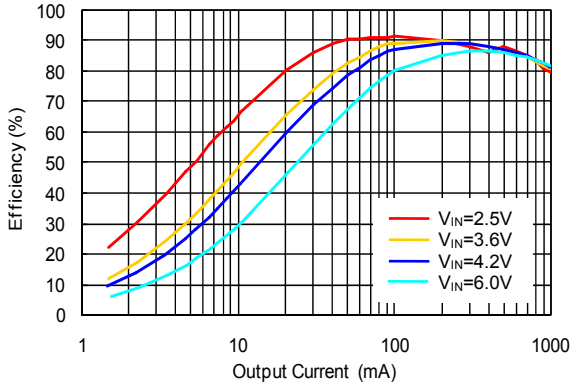
| Symbol | Parameter | Test Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **SUPPLY** | | | | | | |
| $V_{IN}$ | Input Voltage Range | | 2.5 | | 6.0 | V |
| UVLO | Under Voltage Lockout Threshold | Falling Edge | 1.8 | | 2.3 | V |
| UVLO_HYS | Under Voltage Lockout Hysteresis | | | 200 | | mV |
| $I_Q$ | Input DC Supply Current (MODE=GND) | $I_{LOAD}$=0mA | | 56 | 80 | μA |
| | Input DC Supply Current (MODE=VIN) | $I_{LOAD}$=0mA | | 5.6 | | mA |
| $I_{SD}$ | Input Supply Current (Shutdown Mode) | $V_{FB}$=0V, $V_{IN}$=6.0V | | 0.1 | 1.0 | μA |
| **OUTPUT** | | | | | | |
| $V_{FB}$ | Regulated Feedback Voltage | $T_A$=+25ºC | 0.588 | 0.600 | 0.612 | V |
| $I_{FB}$ | FB Input Bias Current | $V_{FB}$=0.65V | | | 30 | nA |
| | Output Voltage Line Regulation | 2.5V≤$V_{IN}$≤6.0V, $I_{OUT}$=10mA, MODE=$V_{IN}$/GND | | 0.10 | 0.20 | %/V |
| | Output Voltage Load Regulation | 0.1A≤$I_{OUT}$≤1A | | 0.5 | | %/A |
| $I_{O(MAX)}$ | Maximum Output Current | | 1000 | | | mA |
| $t_{SS}$ | Soft Start Time | | | 400 | | μs |
| $I_{SWL}$ | SW Leakage | $V_{EN}$=0V, $V_{IN}$=6V, $V_{SW}$=0V or 6V | | ±0.01 | ±1 | μA |
| **POWER SWITCH** | | | | | | |
| $R_{DS(ON)}$ | $R_{DS(ON)}$ of P-CH MOSFET | $V_{IN}$=3.6V, $I_{SW}$=100mA | | 0.25 | 0.30 | Ω |
| | $R_{DS(ON)}$ of N-CH MOSFET | $V_{IN}$=3.6, $I_{SW}$=-100mA | | 0.18 | 0.23 | Ω |
| $I_P$ | Peak Inductor Current | $V_{IN}$=2.5V to 6.0V | 1.6 | 1.8 | 2.0 | A |
| | Thermal Shutdown Temperature | | | 150 | | ºC |
| | Thermal Shutdown Temperature Hysteresis | | | 20 | | ºC |
| **OSILLATOR** | | | | | | |
| f | Oscillator Frequency | | 1.95 | 2.25 | 2.55 | MHz |
| **ENABLE, MODE** | | | | | | |
| $V_{IH}$ | High-Level Threshold | | 1.2 | | | V |
| $V_{IL}$ | Low-Level Threshold | | | | 0.4 | V |
| $I_I$ | Input Leakage Current | | | 0.1 | 1 | μA |

## Typical Operating Characteristics

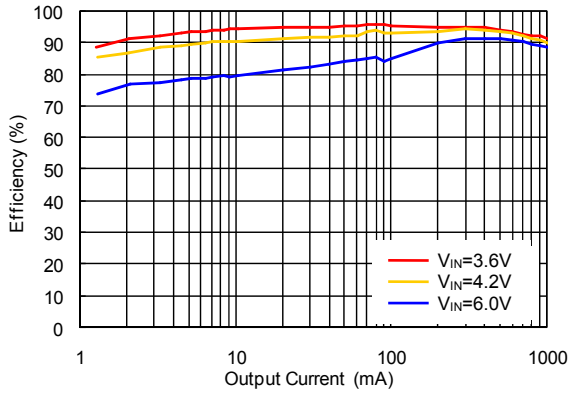
**Efficiency vs. Load Current**
**VOUT=1.8V, Power Save Mode**



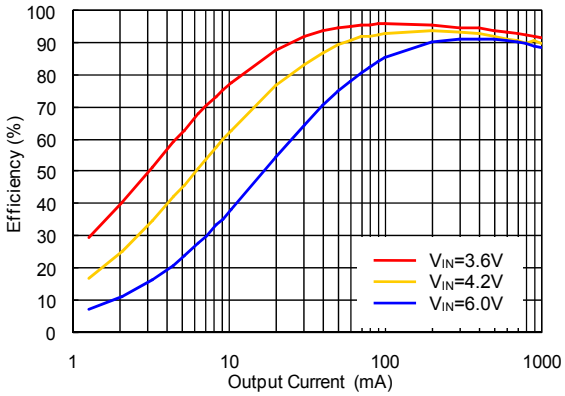

**Efficiency vs. Load Current**
**VOUT=1.8V, Forced PWM Mode**



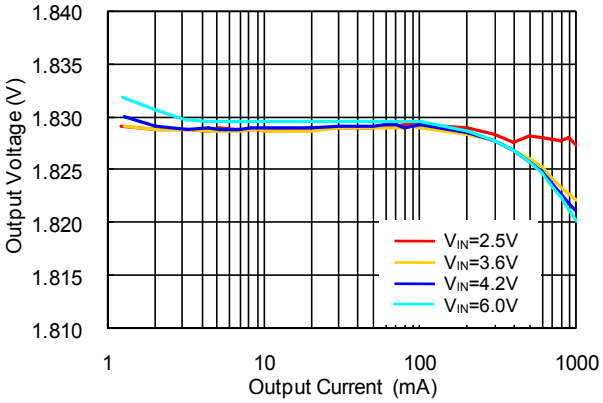

**Efficiency vs. Load Current**
**VOUT=3.3V, Power Save Mode**



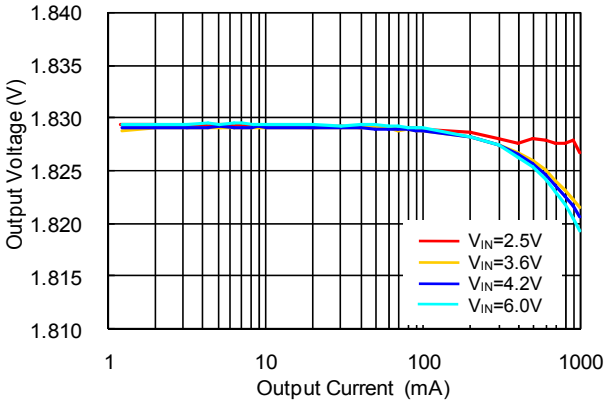

**Efficiency vs. Load Current**
**VOUT=3.3V, Forced PWM Mode**




**Output Voltage vs. Load Current**
**VOUT=1.8V, MODE=L**

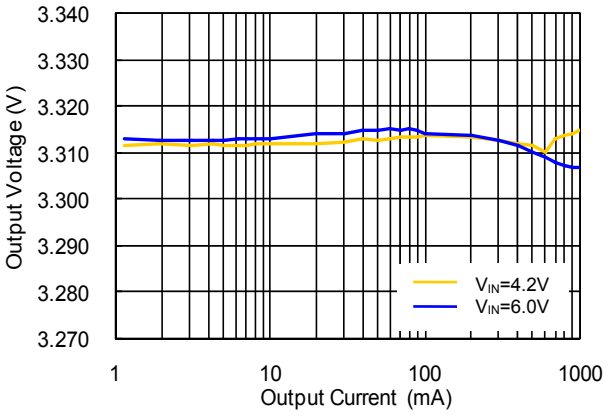



**Output Voltage vs. Load Current**
**VOUT=1.8V, MODE=H**

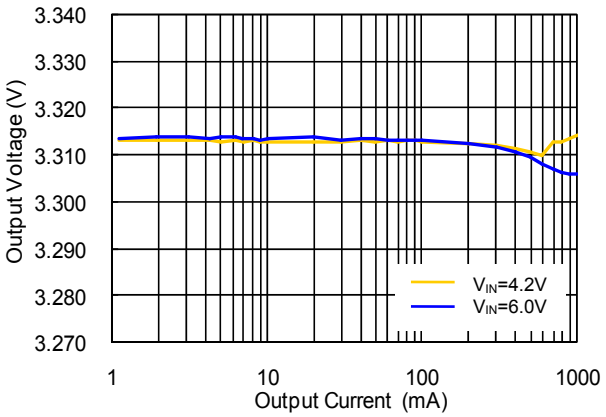


## Typical Operating Characteristics (Continued)

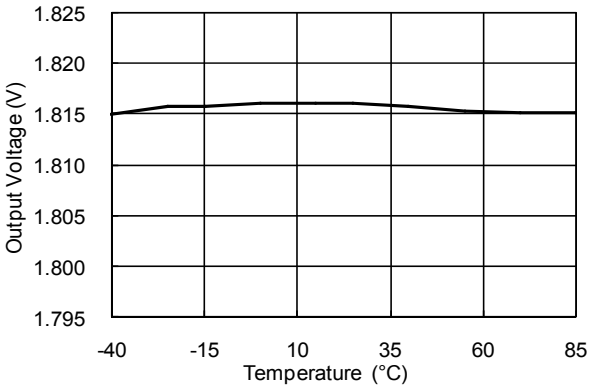
**Output Voltage vs. Load Current**
**$V_{OUT}$=3.3V, MODE=L**



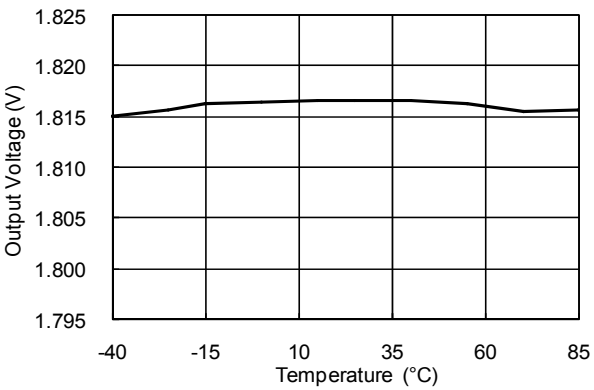

**Output Voltage vs. Load Current**
**$V_{OUT}$=3.3V, MODE=H**



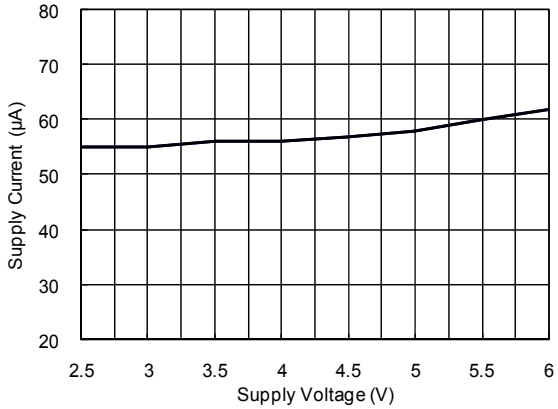

**Output Voltage vs. Temperature**
**$V_{IN}$=3.6V, MODE=L, $I_{LOAD}$=10mA**



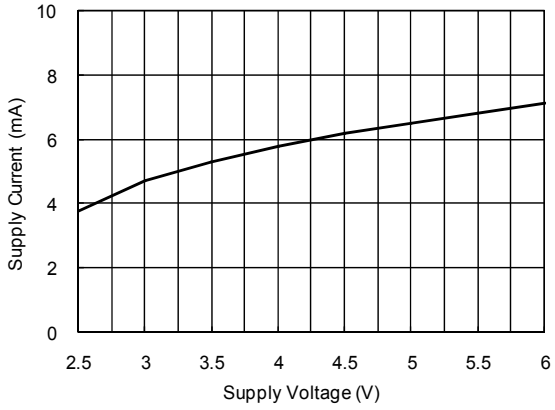

**Output Voltage vs. Temperature**
**$V_{IN}$=3.6V, MODE=H, $I_{LOAD}$=10mA**




**Supply Current vs. Supply Voltage**
**Power Save Mode, MODE=L**

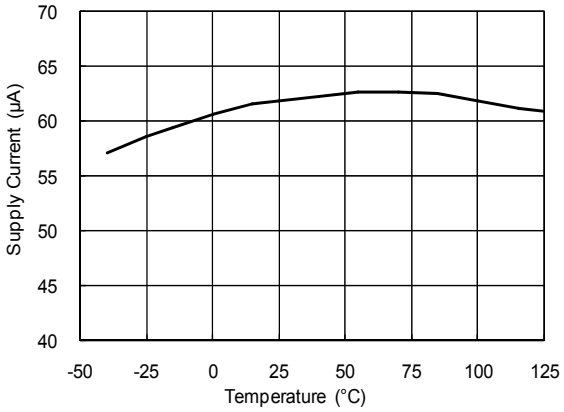



**Supply Current vs. Supply Voltage**
**Forced PWM Mode, MODE=H**

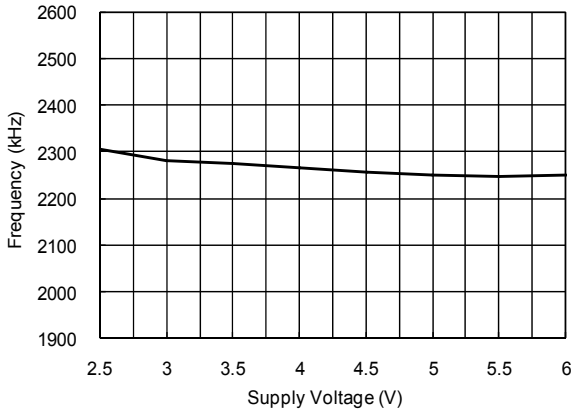


## Typical Operating Characteristics (Continued)

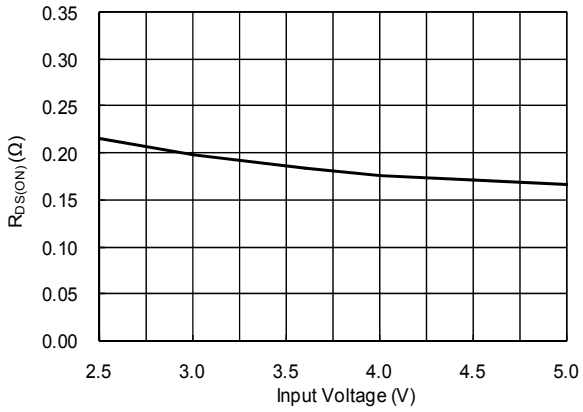
**Supply Current vs. Temperature**
**$V_{IN}$=6V, MODE=L**



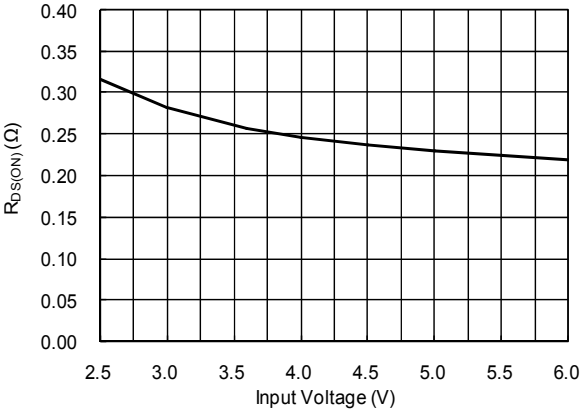

**Frequency vs. Supply Voltage**
**$V_{OUT}$=1.8V, $I_{LOAD}$=200mA**




**L-Side $R_{DS(ON)}$ vs. Input Voltage**

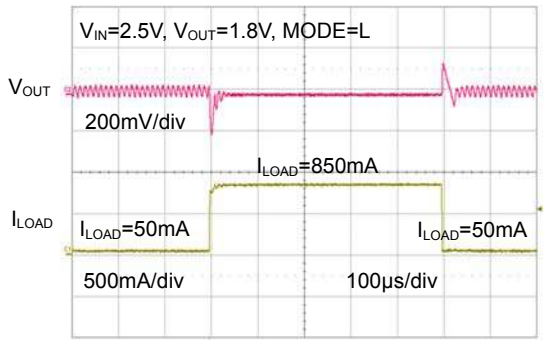



**H-Side $R_{DS(ON)}$ vs. Input Voltage**

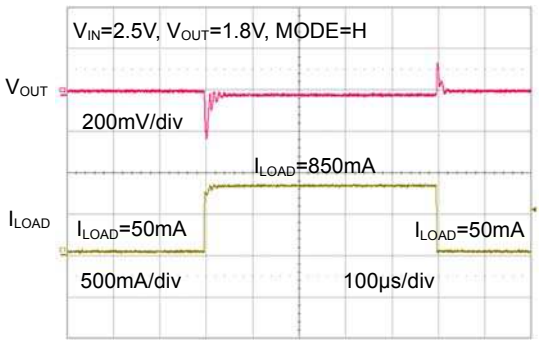


## Typical Operating Characteristics (Continued)

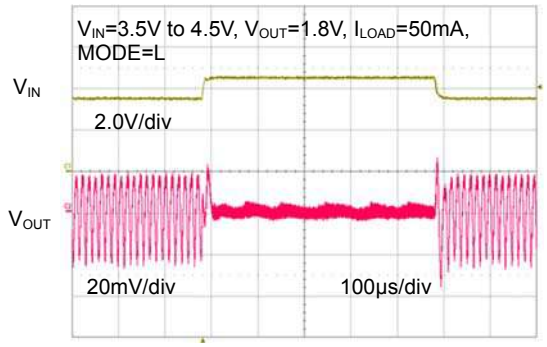
**Load Transient Response**



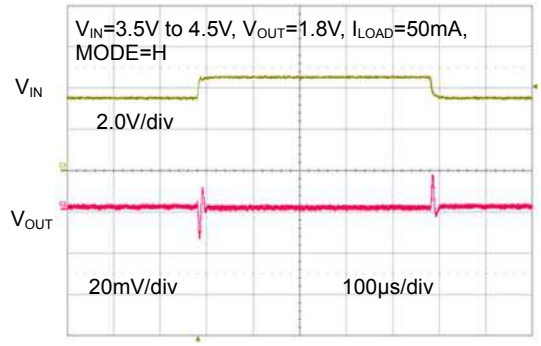

**Load Transient Response**



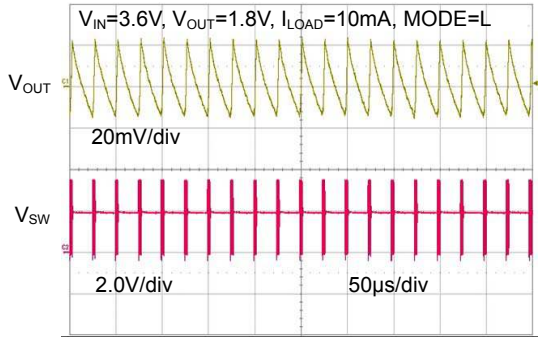

**Line Transient Response**



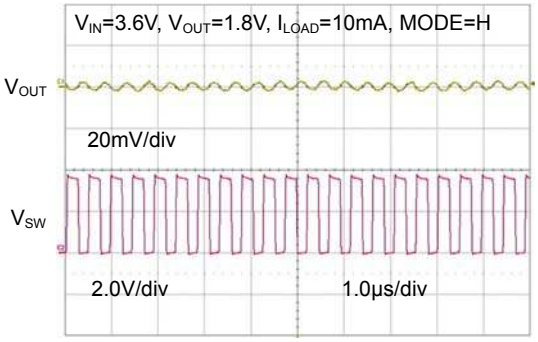

**Line Transient Response**




**PFM Mode Operation**




**PWM Mode Operation**



## Application Information

### Output Voltage Setting

The output voltage can be caculated according to the formula below with an internal reference volatge $V_{REF}$ typical 0.6V:

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

To minimize the current through the feedback divider network, the recommended value of R2 is about 180kΩ. The sum of R1 and R2 should not exceed about 1MΩ to keep the network robust against noise. An external feed forward capacitor C1 is required for optimum load transient response. The value of C1 should be in the range between 10pF and 33pF.
Route the FB line away from noise sources, such as the inductor or the SW line.

### Inductor Selection

A 1μH to 10μH inductor with DC current rating at least 25% higher than the maximum load current is recommended for most applications. For best efficiency, the inductor DC resistance shall be <200mΩ.
For most designs, the inductance value can be derived from the following equation:

$$L = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times \Delta I_L \times f_{OSC}}$$

Where $\Delta I_L$ is the inductor ripple current. Choose inductor ripple current approximately 30% of the maximum load current, 1000mA.
The maximum inductor peak current is:

$$I_{L(MAX)} = I_{LOAD} + \frac{\Delta I_L}{2}$$

The following table is a list of recommended inductors.

**List of Recommended Inductors**

| Dimension [mm³] | Inductor Type | Supplier |
|---|---|---|
| 4.5×4×3.2 | 744773022 | Würth Elektronik |
| 3×3×1.5 | LQH3NPN2R2NM0 | MURATA |
| 3×3×1.5 | LPS3015 | Coilcraft |

### Input Capacitor Selection

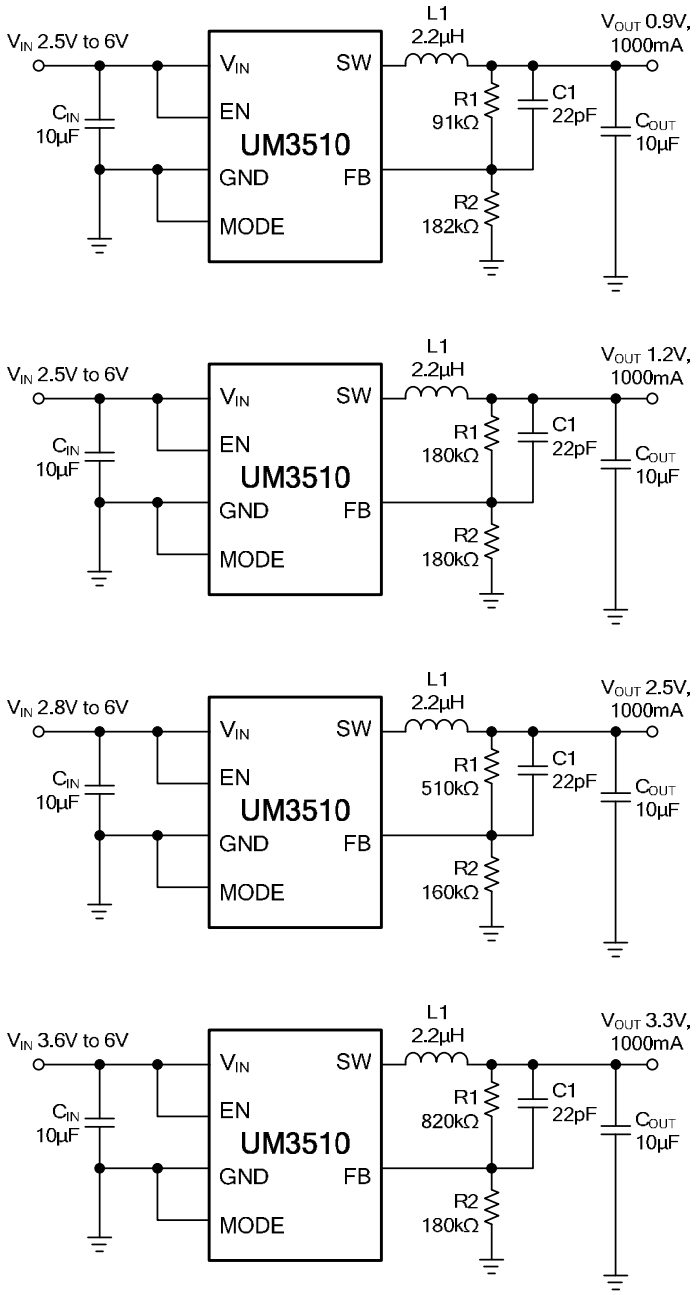
The input capacitor reduces the surge current drawn from the input and switching noise from the device. The input capacitor impedance at the switching frequency shall be less than the input source impedance to prevent high frequency switching current passing to the input. Ceramic capacitors with X5R or X7R dielectrics are highly recommended because of their low ESR and small temperature coefficients. For most applications, a 10μF capacitor is sufficient. The input capacitor can be increased without any limit for better input voltage filtering.

### Output Capacitor Selection

The output capacitor keeps output voltage ripple small and ensures regulation loop stable. The output capacitor impedance shall be low at the switching frequency. Ceramic capacitor with X5R or X7R dielectrics are recommended. The output ripple $\Delta V_{OUT}$ is approximately:

$$\Delta V_{OUT} \leq \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times f_{OSC} \times L} \times \left(ESR + \frac{1}{8 \times f_{OSC} \times C_{OUT}}\right)$$

## Typical Application Circuit




## Layout Guidance

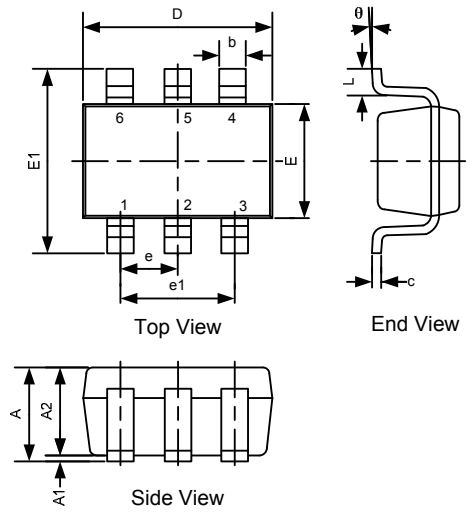
When laying out the PC board, the following suggestions should be taken to ensure proper operation of the UM3510.

1. The power traces, including the GND trace, the SW trace and the VIN trace should be kept short, direct and wide to allow large current flow.
2. Connect the input capacitor $C_{IN}$ to the VIN pin as closely as possible to get good power filter effect.
3. Keep the switching node, SW, away from the sensitive FB node.
4. Do not trace signal line under inductor.

## Package Information

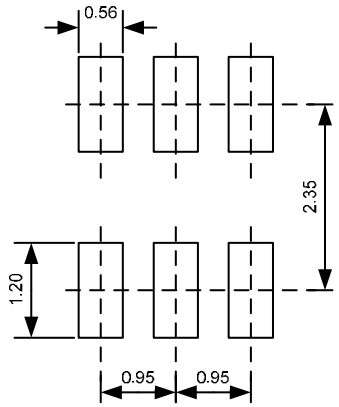
### UM3510S: SOT23-6

**Outline Drawing**



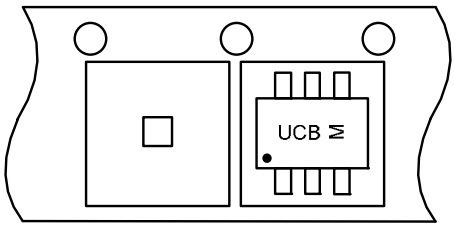

| Symbol | DIMENSIONS | | | | | |
|---|---|---|---|---|---|---|
| | MILLIMETERS | | | INCHES | | |
| | Min | Typ | Max | Min | Typ | Max |
| A | 1.013 | 1.15 | 1.40 | 0.040 | 0.045 | 0.055 |
| A1 | 0.00 | 0.05 | 0.10 | 0.000 | 0.002 | 0.004 |
| A2 | 1.00 | 1.10 | 1.30 | 0.039 | 0.043 | 0.051 |
| b | 0.30 | - | 0.50 | 0.012 | - | 0.020 |
| c | 0.10 | 0.15 | 0.20 | 0.004 | 0.006 | 0.008 |
| D | 2.82 | - | 3.10 | 0.111 | - | 0.122 |
| E | 1.50 | 1.60 | 1.70 | 0.059 | 0.063 | 0.067 |
| E1 | 2.60 | 2.80 | 3.00 | 0.102 | 0.110 | 0.118 |
| e | 0.95REF | | | 0.037REF | | |
| e1 | 1.90REF | | | 0.075REF | | |
| L | 0.30 | - | 0.60 | 0.012 | - | 0.024 |
| θ | 0° | - | 8° | 0° | - | 8° |

**Land Pattern**



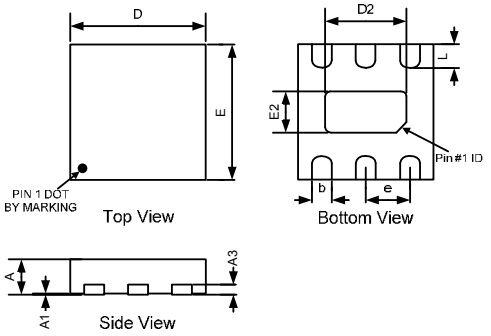

NOTES:
1. Compound dimension: 2.92×1.60；
2. Unit: mm;
3. General tolerance ±0.05mm unless otherwise specified;
4. The layout is just for reference.

**Tape and Reel Orientation**



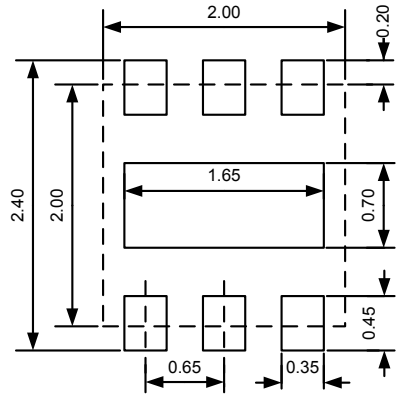
## UM3510DA DFN6 2.0×2.0

### Outline Drawing



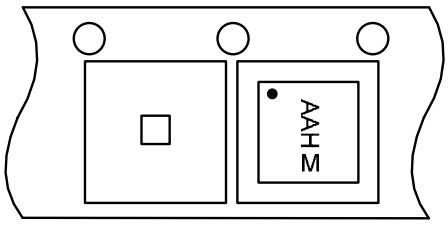

| Symbol | DIMENSIONS | | | | | |
|---|---|---|---|---|---|---|
| | MILLIMETERS | | | INCHES | | |
| | Min | Typ | Max | Min | Typ | Max |
| A | 0.55 | - | 0.80 | 0.022 | - | 0.031 |
| A1 | 0.00 | - | 0.05 | 0.000 | - | 0.002 |
| A3 | 0.20REF | | | 0.008REF | | |
| b | 0.25 | 0.30 | 0.35 | 0.010 | 0.012 | 0.014 |
| D | 1.924 | 2.00 | 2.076 | 0.076 | 0.079 | 0.082 |
| D2 | 1.35 | - | 1.75 | 0.053 | - | 0.069 |
| E | 1.924 | 2.00 | 2.076 | 0.076 | 0.079 | 0.082 |
| E2 | 0.65 | - | 1.06 | 0.026 | - | 0.042 |
| e | 0.65BSC | | | 0.026BSC | | |
| L | 0.224 | - | 0.45 | 0.009 | - | 0.018 |

### Land Pattern




NOTES:
1. Compound dimension: 2.00×2.00；
2. Unit: mm;
3. General tolerance ±0.05mm unless otherwise specified;
4. The layout is just for reference.

### Tape and Reel Orientation



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