Low-Profile, 600mA, Synchronous Step-Down Converter with Integrated Inductor
UM3506QA QFN14 2.5×2.5

General Description

The UM3506QA is a complete power conversion module requiring only two low cost ceramic MLCC capacitors. Inductor, MOSFETs, synchronous rectifier and control IC are integrated into a tiny 2.5mm×2.5mm×1.05mm QFN package. The UM3506QA is engineered to simplify design and to minimize layout constraints. It is an ideal choice to be used to replace less efficient LDO to achieve improved efficiency in space restricted applications. The UM3506QA is capable of delivering 600mA output current over a wide input voltage range from 2.5V to 5.5V.

The UM3506QA is a high-efficiency, step-down DC-DC converter with a constant PWM frequency, current mode architecture. The UM3506QA automatically turns off the synchronous rectifier while the inductor current is low, and enters pulse skipping mode at light load condition. This can increase efficiency. The operation frequency is set to 2.25MHz at normal load condition. The UM3506QA enters shutdown mode and consumes less than 0.1µA when EN pin is pulled low.

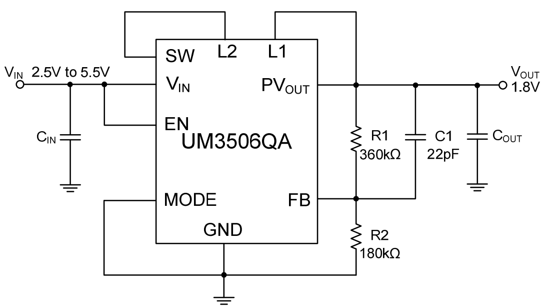
Applications

- Cellular and Smart Phones
- MCU, DSP and FPGA Core Supplies
- Wireless and DSL Modems
- Portable Game Consoles and Instruments
- PDAs, GPS
- Bluetooth Headsets
- Battery-Powered Devices

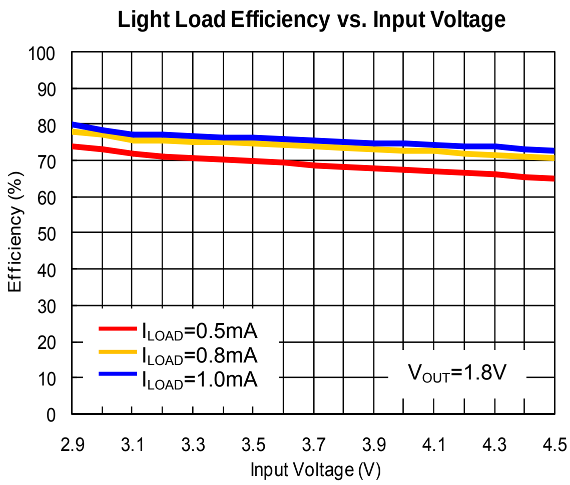
Features

- Tiny QFN Package 2.5×2.5×1.05
- Integrated Inductor
- No Schottky Diode Required
- High Efficiency: Up to 90%
- 600mA Output Current
- 0.6V Minimum Output Voltage
- 2.5V to 5.5V Input Voltage Range
- <1µA Shutdown Current
- Pulse Skipping Mode Operation
- Thermal Fault Protection

Typical Application Circuit

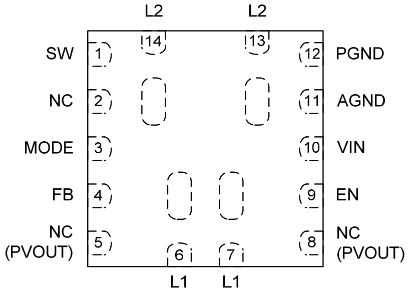


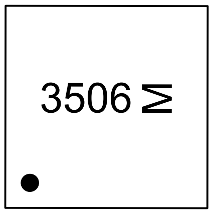
Light Load Efficiency



Pin Configurations Top View

(Top View)





M: Month Code
UM3506QA
QFN14 2.5×2.5

Pin Description

Pin Number	Symbol	Function
1	SW	This pin is the common switching node of the internal MOSFETs. It is usually connected to L2 in the PCB.
2	NC	Not internally connected, can be connected to any other network in the PCB.
3	MODE	MODE pin=high forces the device to operate in fixed-frequency PWM mode. Mode pin=low enables automatic transition from the pulse skipping mode to fixed-frequency PWM mode.
4	FB	Feedback input pin. Connect FB to the center point of the external resistor divider.
5, 8	NC (PVOUT)	Not internally connected, usually connected to power output in the PCB.
6, 7	L1	These pins are connected together inside and usually connected to NC(PVOUT) in the PCB.
9	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.
10	VIN	Power input for the MOSFET switches. Must be closely decoupled to GND with a 4.7μF or greater ceramic capacitor.
11	AGND	Analog ground. This is the ground for the internal control circuitry, and the ground return for external feedback voltage divider. It must be connected to the quiet point of the ground.
12	PGND	Power ground. Connect this pin to the ground electrode of the input and output filter capacitors closely.
13, 14	L2	These pins are connected together inside and usually connected to SW in the PCB.

Ordering Information

Part Number	Packaging Type	Marking Code	Shipping Qty
UM3506QA	QFN14 2.5×2.5	3506	3000pcs/13Inch Tape & Reel

Absolute Maximum Ratings (Note 1)

Symbol	Parameter	Value	Unit
V_{IN}, V_{OUT}	Input and Output Voltages	-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	1.5	A
T_O	Operating Temperature	-40 to +85	°C
T_{STG}	Storage Temperature Range	-65 to +150	°C
T_{REFLOW}	Reflow Temperature, MSL3 JEDEC J-STD-020C, 10 Sec	260	°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.

Electrical Characteristics (Note 2)

(V_{IN}=V_{EN}=3.6V, T_A=+25°C, C_{IN}=4.7μF, C_{OUT}=10μF, unless otherwise noted)

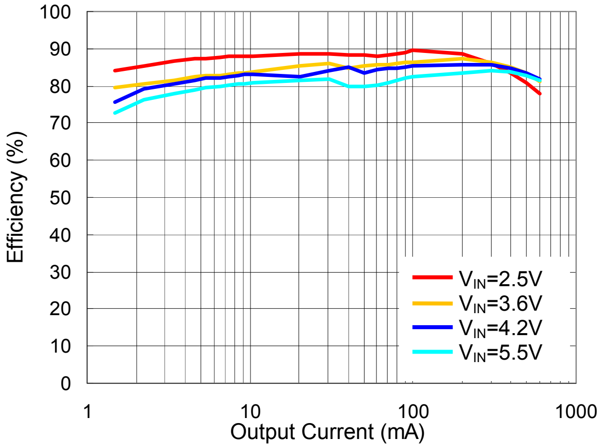
Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_{IN}	Input Voltage Range		2.5		5.5	V
V_{OUT}	Output Voltage Range		0.6		5	V
$I_{O(max)}$	Maximum Output Current		600			mA
I_Q (Active)	Input DC Supply Current (Active Mode)	V_{FB}=0.6V, I_{LOAD}=0A		60		μA
I_Q (Shutdown)	Input DC Supply Current (Shutdown Mode)	V_{EN}=0V		0.1	1.0	μA
V_{FB}	Feedback Voltage		0.5880	0.6000	0.6120	V
		T_A=-40°C~85°C	0.5830	0.6000	0.6150	
I_{FB}	FB Input Bias Current	V_{FB}=0.65V			±30	nA
f	Oscillator Frequency	V_{FB}=0.6V or V_{OUT}=100%		2.25		MHz
$R_{DS(ON)}$	$R_{DS(ON)}$ of P-CH MOSFET	V_{IN}=3.6V, I_{SW}=100mA		0.3		Ω
	$R_{DS(ON)}$ of N-CH MOSFET	V_{IN}=3.6V, I_{SW}=-100mA		0.2		Ω
	Internal Inductor DCR			0.2		Ω
I_{SWL}	SW Leakage	V_{EN}=0V, V_{IN}=5V, V_{SW}=0V or 5V		±0.01	±1	μA
V_H	EN High-Level Threshold	-40ºC≤T_A≤85ºC	1.0			V
V_L	EN Low-Level Threshold	-40ºC≤T_A≤85ºC			0.4	V
I_{ENL}	EN Leakage Current			±0.1	±1	μA
	Thermal Shutdown Temperature			160		ºC
	Thermal Shutdown Trip Point Hysteresis			25		ºC

Note2: 100% production test at +25ºC. Specifications over the temperature range are guaranteed by design and characterization.

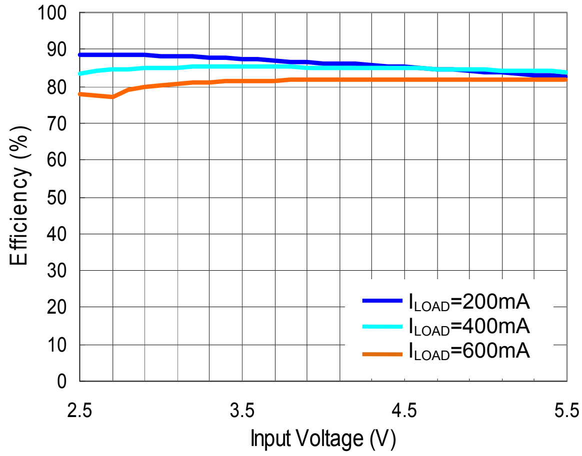
Typical Performance Characteristics

(V_{IN}=3.6V, V_{OUT}=1.8V, C_{IN}=4.7µF, C_{OUT}=10µF, T_A=+25°C, unless otherwise noted.)

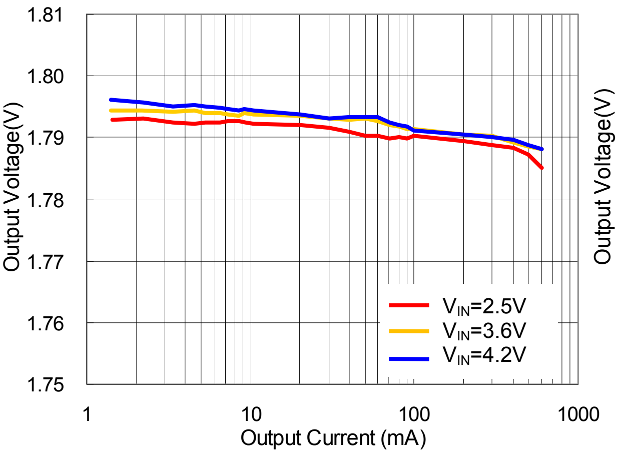
Efficiency vs. Load Current



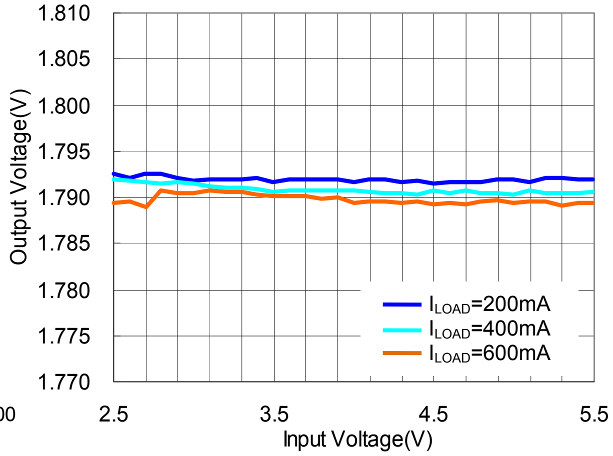
Efficiency vs. Input Voltage



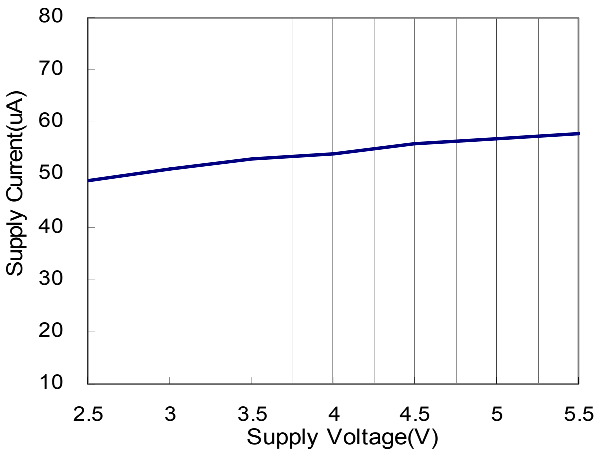
Output Voltage vs. Load Current



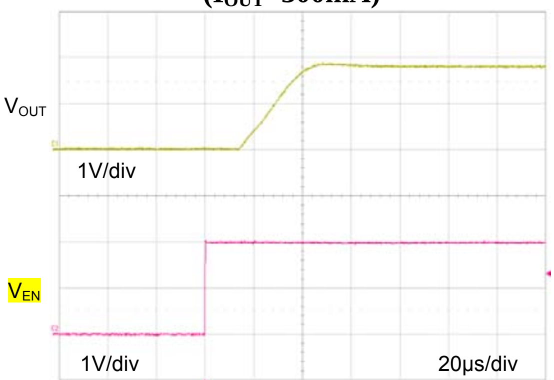
Output Voltage vs. Input Voltage



Supply Current vs. Input Voltage



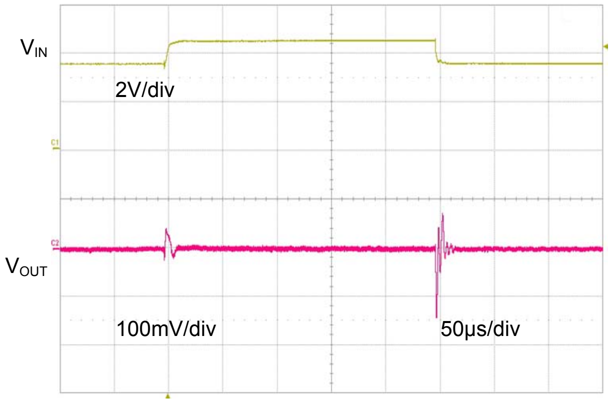
Start-up from Shutdown (I_{OUT}=300mA)



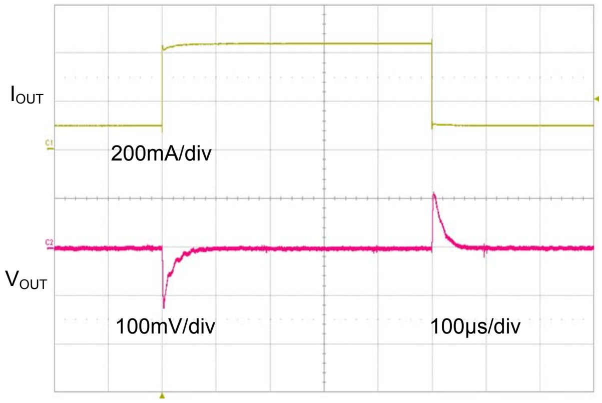
Typical Performance Characteristics (Continued)

(V_{IN}=3.6V, V_{OUT}=1.8V, C_{IN}=4.7µF, C_{OUT}=10µF, T_A=+25°C, unless otherwise noted.)

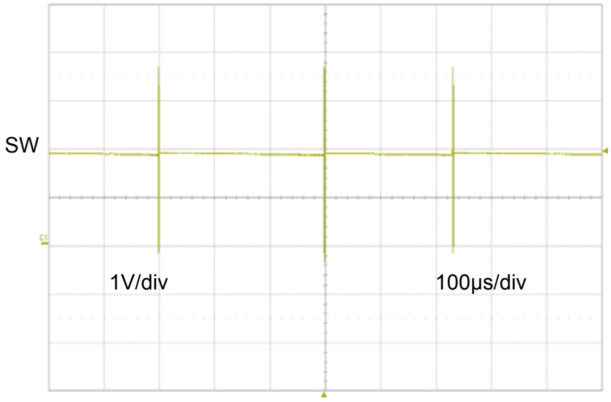
Line Transient Response
(V_{IN}=3.5V to 4.5V, I_{OUT}=300mA)



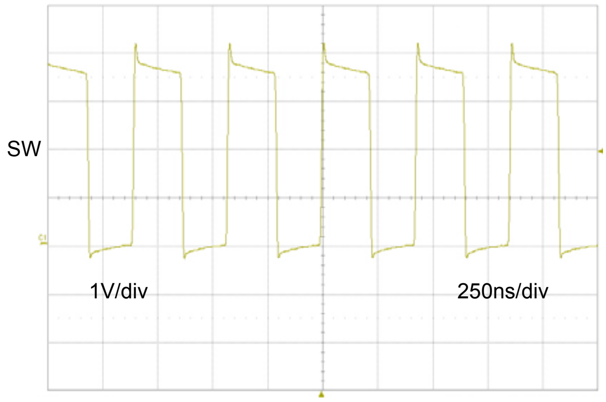
Load Transient Response
(V_{IN}=3.5V, I_{OUT}=100mA to 450mA)



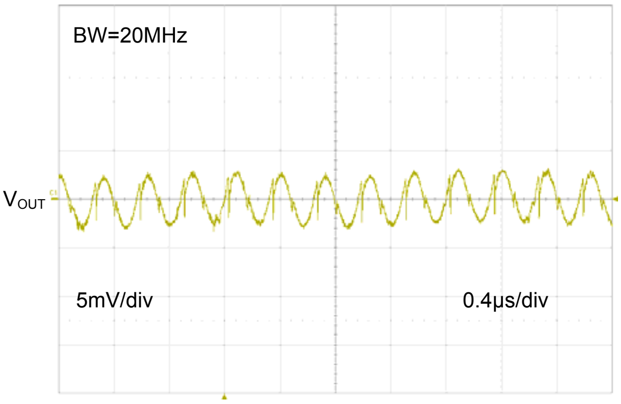
Pulse Skipping Mode Operation
(I_{OUT}=1mA)



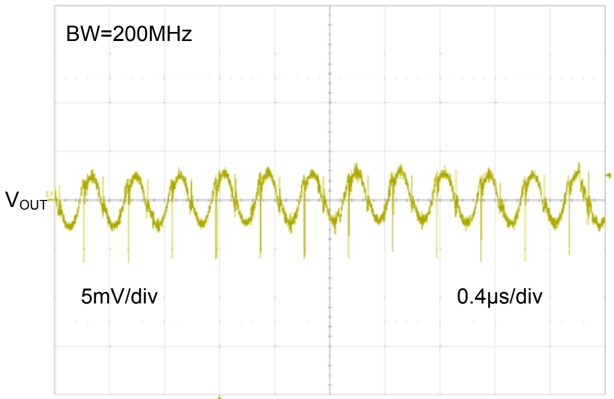
Normal Operation
(I_{OUT}=100mA)



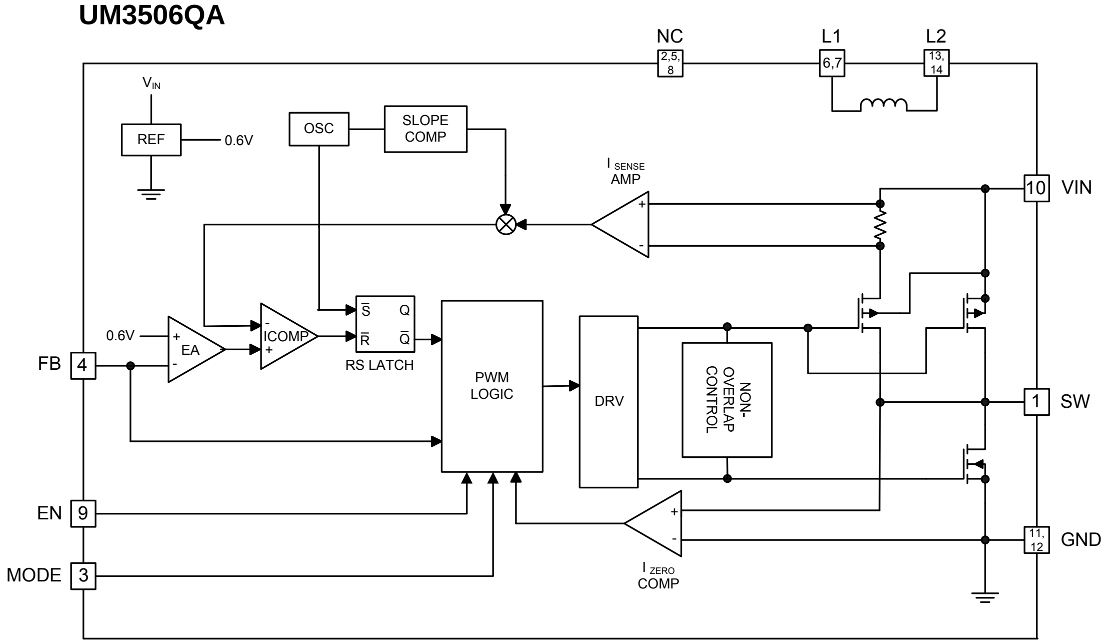
Ripple and HF Noise
(I_{OUT}=300mA)



Ripple and HF Noise
(I_{OUT}=300mA)



Block Diagram



Function Description

Integrated Inductor

The UM3506QA utilizes a low loss, multilayer inductor. The DCR of the integrated inductor is 180mΩ and the inductance is about 2.2μH. The use of an internal inductor localizes the noise associated with the output loop currents. The proprietary integrated inductor construction reduces the area of the converter’s large current loop that can reduce the radiated noise coupled into the traces of the circuit board. Furthermore, the package layout is optimized to reduce the electrical path length for the AC ripple currents that is a major source of radiated emissions from DC-DC converters. The integrated inductor significantly reduces parasitic effects that can harm loop stability, and makes layout very simple. All these lead to lower output noise and fewer influences on the input power.

Current Mode PWM Control and Current Limit

The UM3506QA uses constant frequency, current mode step-down architecture. Both the main (P-channel MOSFET) and synchronous (N-channel MOSFET) switches are internal. From the block diagram, a comparator ICOMP is used to realize current limit protection. Lossless current sensing converts the peak current signal to a voltage to sum in with the internal slope compensation. This summed signal is compared to the error amplifier output to provide a peak current control command for the PWM. The cycle-by-cycle current limit is set at 1200mA (typical). During normal operation, the internal top power MOSFET is turned on each cycle when the oscillator sets the RS latch, and turned off when the current comparator ICOMP, resets the RS latch. The peak inductor current at which ICOMP resets the RS latch, is controlled by the output of error amplifier EA. When the load current increases, it causes a slight decrease in the feedback voltage, FB, relative to the 0.6V reference, which in turn, causes the EA amplifier’s output voltage to increase until the average inductor current matches the new load current. While the top MOSFET is off, the bottom MOSFET is turned on until either the inductor current starts to

reverse, as indicated by the current reversal comparator I_{ZERO}, or the beginning of the next clock cycle.
When the output is shorted to ground, the inductor current may exceed the maximum inductor peak current if not allowed enough time to decay. To prevent the inductor current from running away, the bottom N-channel MOSFET is allowed to stay on for more than one cycle, thereby allowing the inductor current time to decay.

Pulse Skipping Mode Operation

At very light loads, the UM3506QA automatically enters Pulse Skipping Mode. In the Pulse Skipping Mode, the inductor current may reach zero or reverse on each pulse. The PWM control loop will automatically skip pulses to maintain output regulation. The bottom MOSFET is turned off by the current reversal comparator, I_{ZERO}, and the switch voltage will ring. This is discontinuous mode operation, and is normal behavior for the switching regulator.

Enable

The EN pin provides a means to shut down the converter or enable normal operation. A logic low will disable the converter and cause it to shut down. A logic high will enable the converter into normal operation. In shutdown mode, the device quiescent current will be less than 1μA. The EN pin must not be left floating.

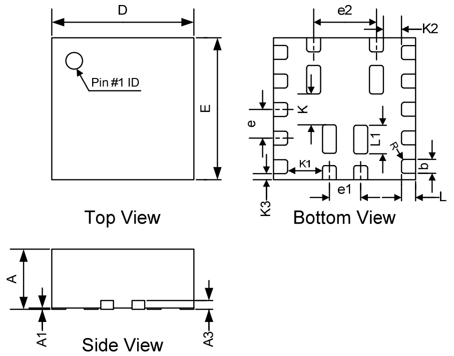
Thermal Shutdown

When excessive power is dissipated in the chip, the junction temperature rises. Once the junction temperature exceeds the thermal shutdown temperature, the thermal shutdown circuit turns off the converter's output voltage thus allowing the device to cool. When the junction temperature decreases by 25°C, the device will go through the normal startup process.

Package Information

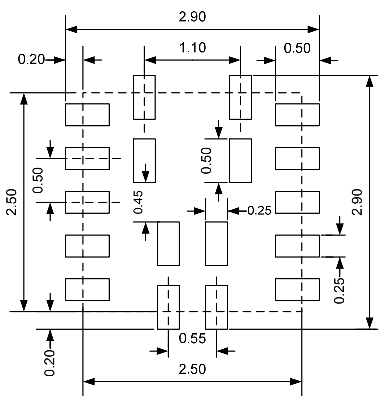
UM3506QA: QFN14 2.5×2.5

Outline Drawing



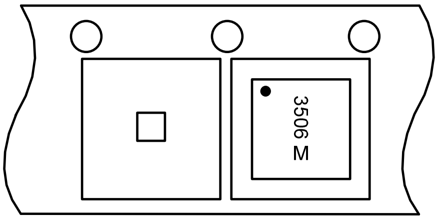
Symbol	DIMENSIONS MILLIMETERS Min	Typ	Max	INCHES Min	Typ	Max
A	1.00	1.05	1.10	0.039	0.041	0.043
A1	0.00	0.02	0.05	0.000	0.0008	0.002
A3	0.152REF			0.006REF		
b	0.20	0.25	0.30	0.008	0.010	0.012
D	2.40	2.50	2.60	0.094	0.098	0.102
E	2.40	2.50	2.60	0.094	0.098	0.102
e	0.40	0.50	0.60	0.016	0.020	0.024
e1	0.45	0.55	0.65	0.018	0.022	0.026
e2	1.00	1.10	2.250	0.039	0.043	0.047
K	0.45	0.55	0.65	0.018	0.022	0.026
K1	0.50	0.60	0.70	0.020	0.024	0.028
K2	0.225	0.325	0.425	0.009	0.013	0.017
K3	0.025	0.125	0.225	0.001	0.005	0.009
L	0.20	0.25	0.30	0.008	0.010	0.012
L1	0.45	0.50	0.55	0.018	0.020	0.022
R	0.05REF			0.002REF		

Land Pattern



NOTES:
1. Compound dimension: 2.50×2.50;
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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