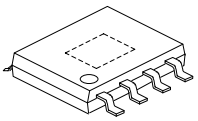
FAST TURN-OFF INTELLIGENT CONVERTER



HSOP-8

■ DESCRIPTION

The UTC **UD16501** is a high frequency synchronous rectified step-down switch mode converter with built in internal power MOSFETs. It offers a very compact solution to achieve 5A continuous output current over a wide input supply range with excellent load and line regulation. The UTC UD16501 has synchronous mode operation for higher efficiency over output current load range.

Current mode operation provides fast transient response and eases loop stabilization.

Full protection features include OCP and thermal shut down.

■ FEATURES

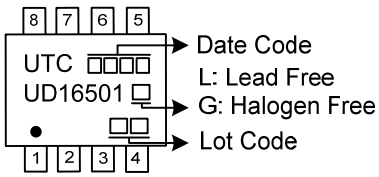
* Wide 4.5V to 24V Operating Input Range
* 5A Load Current
* 70mΩ / 25mΩ Low Rds(on) Internal Power MOSFETs
* Low Quiescent Current
* High Efficiency Synchronous Mode Operation
* Fixed 500kHz Switching Frequency
* Frequency Sync from 200kHz to 2MHz External Clock
* AAM Power Save Mode
* Internal Soft Start
* OCP Protection and Hiccup
* Thermal Shutdown
* Output Adjustable from 0.8V

■ ORDERING INFORMATION

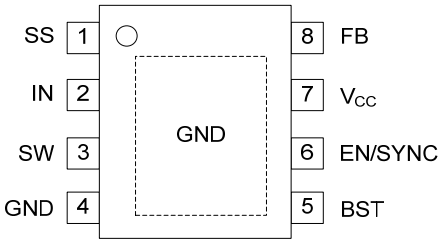
Ordering Number		Package	Packing
Lead Free	Halogen Free		
UD16501L-SH2-R	UD16501G-SH2-R	HSOP-8	Tape Reel

UD16501G-SH2-R (1)Packing Type (2)Package Type (3)Green Package	(1) R: Tape Reel (2) SH2: HSOP-8 (3) G: Halogen Free and Lead Free, L: Lead Free

■ MARKING



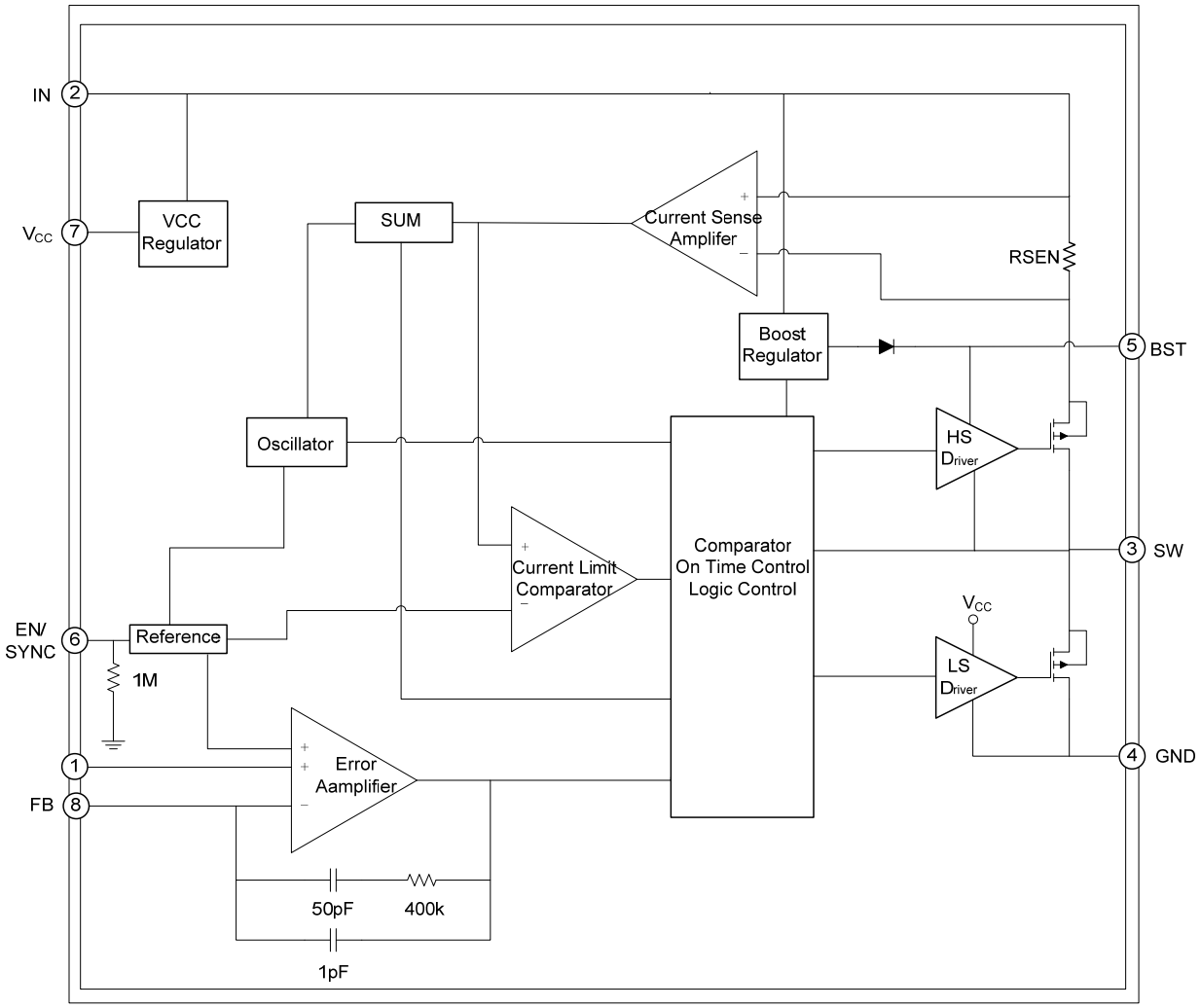
■ PIN CONFIGURATION



■ PIN DESCRIPTION

PIN NO.	PIN NAME	DESCRIPTION
1	SS	Soft Start. Connect on external capacitor to program the soft start time for the switch mode regulator.
2	IN	Supply Voltage. The IN pin supplies power for internal MOSFET and regulator. The UTC **UD16501G** operates from a +4.5V to +16V input rail. Low ESR, and low inductance capacitor C1 is needed to decouple the input rail. Use wide PCB trace to make the connection.
3	SW	Switch Output. Connect this pin to the inductor and bootstrap capacitor. This pin is driven up to the V_{IN} voltage by the high-side switch during the on-time of the PWM duty cycle. The inductor current drives the SW pin negative during the off-time. The on-resistance of the low-side switch and the internal body diode fixes the negative voltage. Use wide PCB traces and multiple vias to make the connection.
4	GND	System Ground. This pin is the reference ground of the regulated output voltage. For this reason care must be taken in PCB layout. Suggested to be connected to GND with copper and vias.
5	BST	Bootstrap. A capacitor connected between SW and BST pins are required to form a floating supply across the high-side switch driver.
6	EN/SYNC	EN=1 to enable the UTC **UD16501**. External clock can be applied to EN pin for changing switching frequency.
7	V_{CC}	Internal 5V LDO output. The driver and cont rol circuits are powered from this voltage. Decouple with 0.1μF-0.22μF cap. And the capacitance should be no more than 0.22μF.
8	FB	Feedback. An external resistor divider from t he output to GND, tapped to the FB pin, sets the output voltage. To prevent current limit run away during a short circuit fault condition the frequency fold-back comparator lowers the oscillator frequency when the FB voltage is below 400mV. It is recommended to place the resistor divider as close to FB pin as possible. Vias should be avoided on the FB traces.

■ BLOCK DIAGRAM



■ ABSOLUTE MAXIMUM RATING

PARAMETER	SYMBOL	RATINGS	UNIT
Input Supply Voltage	V_{IN}	17	V
SW Voltage	V_{SW}	17	V
Boost Voltage	V_{BST}	V_{SW}+6	V
All Other Pins Voltage		6.5	V
Junction Temperature	T_J	+150	°C
Storage Temperature	T_{STG}	-65 ~ +150	°C

Note: Absolute maximum ratings are those values beyond which the device could be permanently damaged. Absolute maximum ratings are stress ratings only and functional device operation is not implied.

■ RECOMMENDED OPERATING CONDITIONS

PARAMETER	SYMBOL	RATINGS	UNIT
Input Supply Voltage	V_{IN}	4.5 ~ 16	V
Output Voltage	V_{OUT}	0.807V ~ V_{IN}-3	V
Ambient Temperature	T_A	-40 ~ +125	°C

Note: If out of its operation conditions, the device is not guaranteed to function.

■ THERMAL DATA

PARAMETER	SYMBOL	RATINGS	UNIT
Junction To Ambient	θ_{JA}	143	°C/W
Junction to Case	θ_{JC}	50	°C/W

■ ELECTRICAL CHARACTERISTICS (V_{IN}=12V, T_A=25°C, unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Supply Current (Shutdown)	I_{IN}	V_{EN}=0V			1	μA
Supply Current(Quiescent)	I_Q	V_{EN}=2V, V_{FB}=1V		0.6	1	mA
HS Switch On Resistance	$HS_{RDS(ON)}$	V_{BST}-S_W=5V		70		mΩ
LS Switch On Resistance	$LS_{RDS(ON)}$	V_{CC}=5V		25		mΩ
Switch Leakage	SW_{LKG}	V_{EN}=0V,V_{SW}=12V			1	μA
Current Limit	I_{LIMIT}	Duty Cycle=40%	7	9		A
Oscillator Frequency	f_{SW}	V_{FB}=750mV	430	500	580	kHz
Maximum Duty Cycle	D_{MAX}	V_{FB}=700mV	90	95		%
Minimum On Time	T_{ON_MIN}			60		ns
Sync Frequency Range	f_{SYNC}		0.2		2	MHz
Feedback Voltage	V_{FB}		791	807	823	mV
Feedback Current	I_{FB}	V_{FB}=800mV		10	50	nA
Soft-Start Current	I_{SS}		8	11	14	μA
EN Rising Threshold	V_{EN_RISING}		1.2	1.4	1.6	V
EN Falling Threshold	$V_{EN\_FallING}$		1.1	1.25	1.4	V
EN Input Current	I_{EN}	V_{EN}=2V		2		μA
		V_{EN}=0V		0		μA
EN Turn Off Delay	$E_{NTd-off}$			8		μs
V_{IN} Under Voltage Lockout Threshold-Rising	I_{NUVVth}		3.7	3.9	4.1	V
V_{IN} Under Voltage Lockout Threshold-Hysteresis	I_{NUVHYS}			650		mV
Regulator V_{CC}	V_{CC}			5		V
Load Regulation	V_{CC}	I_{CC}=5mA		3		%
Thermal Shutdown				150		°C
Thermal Shutdown hysteresis				20		°C

■ FUNCTION DESCRIPTION

The UTC **UD16501** is a high frequency synchronous rectified step-down switch mode converter with built in internal power MOSFETs. It offers a very compact solution to achieve 5A continuous output current over a wide input supply range with excellent load and line regulation.

The UTC **UD16501** operates in a fixed frequency, peak current control mode to regulate the output voltage. A PWM cycle is initiated by the internal clock. The integrated high-side power MOSFET is turned on and remains on until its current reaches the value set by the COMP voltage. When the power switch is off, it remains off until the next clock cycle starts. If, in 90% of one PWM period, the current in the power MOSFET does not reach the COMP set current value, the power MOSFET will be forced to turn off.

■ DETAILED DESCRIPTION

Internal Regulator

Most of the internal circuitries are powered from the 5V internal regulator. This regulator takes the V_{IN} input and operates in the full V_{IN} range. When V_{IN} is greater than 5V, the output of the regulator is in full regulation. When V_{IN} is lower than 5V, the output decreases, a 0.1uF ceramic capacitor for decoupling purpose is required.

Error Amplifier

The error amplifier compares the FB pin voltage with the internal 0.807V reference (REF) and outputs a current proportional to the difference between the two. This output current is then used to charge or discharge the internal compensation network to form the COMP voltage, which is used to control the power MOSFET current. The optimized internal compensation network minimizes the external component counts and simplifies the control loop design.

Enable/SYNC control

EN is a digital control pin that turns the regulator on and off. Drive EN high to turn on the regulator, drive it low to turn it off. There is an internal 1MEG resistor from EN to GND thus EN can be floated to shut down the chip. Also EN pin voltage was clamped to around 6.5V by an internal zener-diode. Please use large enough pull up resistor connecting between V_{IN} and EN to limit the EN input current which should be less than 100uA. Generally, around 100k resistor should be large enough for all the applications.

Connecting the EN pin directly to a voltage source without any pull up resistor requires limiting the amplitude of the voltage source to ≤6V to prevent damage to the Zener diode.

The chip can be synchronized to external clock range from 200kHz up to 2MHz through this pin 2ms right after output voltage is set, with the internal clock rising edge synchronized to the external clock rising edge.

Under-Voltage Lockout (UVLO)

The UTC **UD16501** has under-voltage lock-out protection (UVLO). When the VCC voltage is higher than the UVLO rising threshold voltage, The UTC **UD16501** will be powered up. It shuts off when the VCC voltage is lower than the UVLO falling threshold voltage. This is non-latch protection.

UVLO comparator monitors the output voltage of the internal regulator, VCC. The UVLO rising threshold is about 3.9V while its falling threshold is consistent 3.25V. If an application requires a higher under-voltage lockout (UVLO), use the EN pin to adjust the input voltage UVLO by using two external resistors. It is recommended to use the enable resistors to set the UVLO falling threshold (VSTOP) above 4.5V. The rising threshold (VSTART) should be set to provide enough hysteresis to allow for any input supply variations.

Soft-Start

The UTC **UD16501** employs soft start (SS) mechanism to ensure smooth output during power-up. When the EN pin becomes high, an internal current source (11μA) charges up the SS capacitor. The SS capacitor voltage takes over the REF voltage to the PWM comparator. The output voltage smoothly ramps up with the SS voltage. Once the SS voltage reaches the same level as the REF voltage, it keeps ramping up while V_{REF} takes over the PWM comparator. At this point, the soft start finishes and it enters into steady state operation.

If the output is pre-biased to a certain voltage during startup, the IC will disable the switching of both high-side and low-side switches until the voltage on the internal soft-start capacitor exceeds the sensed output voltage at the FB pin.

The SS capacitor value can be determined as follows: $$C_{SS}(nF) = \frac{T_{SS}(ms) \times I_{SS}(uA)}{V_{REF}(V)}$$

If the output capacitors have large capacitance value, it's not recommended to set the SS time too small. Otherwise, it's easy to hit the current limit during SS. A minimum value of 4.7nF should be used if the output capacitance value is larger than 330 μF.

■ DETAILED DESCRIPTION (Cont.)

Power Save Mode for Light Load Condition

The UTC **UD16501** has AAM (Advanced Asynchronous Modulation) power save mode for light load. The AAM voltage is set at 0.4V internally. Under the heavy load condition, the V_{COMP} is higher than VAAM. When clock goes high, the high-side power MOSFET turns on and remains on until V_{IL} sense reaches the value set by the COMP voltage. The internal clock resets every time when VCOMP is higher than V_{AAM}.

Under the light load condition, the value of V_{COMP} is low. When V_{COMP} is less than V_{AAM} and V_{FB} is less than V_{REF}, V_{COMP} ramps up until it exceeds V_{AAM}, during this time, the internal clock is blocked, thus the UTC **UD16501** skips some pulses for PFM (Pulse Frequency Modulation) mode and achieves the light load power save.

When the load current is light, the inductor peak current is set internally which is about 1A for V_{IN}=12V, VOUT=3.3V, and L=3.3 μH.

Over-Current-Protection and Hiccup

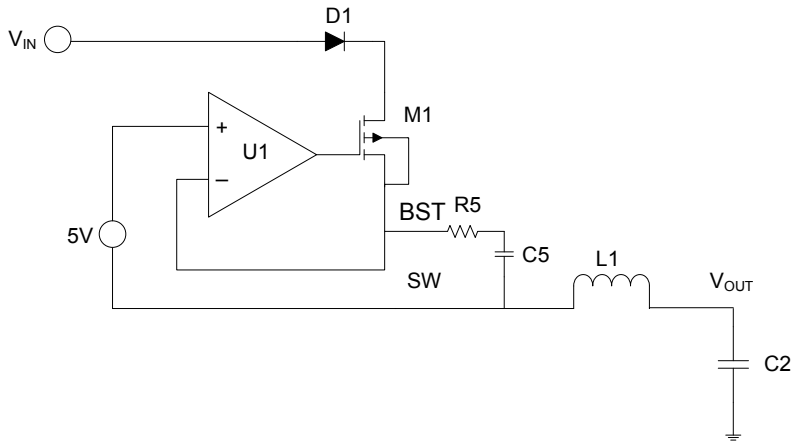
The UTC **UD16501** has cycle-by-cycle over current limit when the inductor current peak value exceeds the set current limit threshold. Meanwhile, output voltage starts to drop until FB is below the Under-Voltage (UV) threshold, typically 50% below the reference. Once a UV is triggered, the UTC **UD16501** enters hiccup mode to periodically restart the part. This protection mode is especially useful when the output is dead-short to ground. The average short circuit current is greatly reduced to alleviate the thermal issue and to protect the regulator. The UTC UD16501 exits the hiccup mode once the over current condition is removed.

Thermal Shutdown

Thermal shutdown is implemented to prevent the chip from operating at exceedingly high temperatures. When the silicon die temperature is higher than 150°C, it shuts down the whole chip. When the temperature is lower than its lower threshold, typically 130°C, the chip is enabled again.

Floating Driver and Bootstrap Charging

The floating power MOSFET driver is powered by an external bootstrap capacitor. This floating driver has its own UVLO protection. This UVLO's rising threshold is 2.2V with a hysteresis of 150mV. The bootstrap capacitor voltage is regulated internally by V_{IN} through D1, R5, C5, L1 and C2. If (V_{IN}-V_{SW}) is more than 5V, U2 will regulate M3 to maintain a 5V BST voltage across C5



Startup and Shutdown

If both V_{IN} and EN are higher than their appropriate thresholds, the chip starts. The reference block starts first, generating stable reference voltage and currents, and then the internal regulator is enabled. The regulator provides stable supply for the remaining circuitries.

Three events can shut down the chip: EN low, VIN low and thermal shutdown. In the shutdown procedure, the signaling path is first blocked to avoid any fault triggering. The COMP voltage and the internal supply rail are then pulled down. The floating driver is not subject to this shutdown command.

■ TYPICAL APPLICATION CIRCUIT