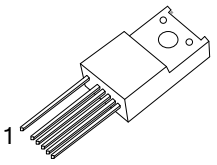
CURRENT MODE PWM POWER SWITCH



TO-220F-6

■ DESCRIPTION

The UTC **US3706** combines a dedicated current mode PWM controller with a high voltage power MOSFET. Low V_{DD} startup current make the power reliable on startup design and a large value resistor could be used in the startup circuit to minimize the standby power. At no load condition, the IC operates in power-saving mode for lower standby power, decreasing frequency for Higher conversion efficiency at light load condition.

The UTC **US3706** offers complete protection coverage with automatic self-recovery feature including Cycle-by-Cycle current limiting (OCP), over load protection (OLP), over temperature protection (OTP), over voltage protection and V_{DD} under voltage lockout (UVLO).

The internal slope compensation improves system stability at high PWM duty cycle output. Leading-edge blanking on current sense input removes the signal glitch, which offering minimal external component count in the design. Excellent EMI performance is achieved with UTC proprietary frequency hopping technique (ZL201020615247.1) together with soft driver control. Audio noise is eliminated due to switch frequency more than 20kHz during operation.

The **US3706** has such applications as: battery charger, power adaptor, set-top box power supplies, ink jet printers, open-frame SMPS.

■ FEATURES

* UTC proprietary frequency hopping technology for Improved EMI performance.
* Power-saving mode for high light-load and standby efficiency
* Soft Start
* Dynamic peak current limiting for constant output power
* Built-in synchronized slope compensation
* OLP,OVPand OTP for higher security
* Fixed switch frequency 65kHz
* Low start-up current
* Cycle-by-cycle Current Limiting
* Under voltage lockout (UVLO)
* Leading edge blanking on source input
* Few external components required

■ ORDERING INFORMATION

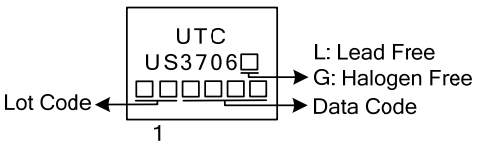
Ordering Number		Package	Packing
Lead Free	Halogen Free		
US3706L-TF6-T	US3706G-TF6-T	TO-220F-6	Tube

US3706L-TF6-T
(1)Packing Type
(2)Package Type
(3)Green Package

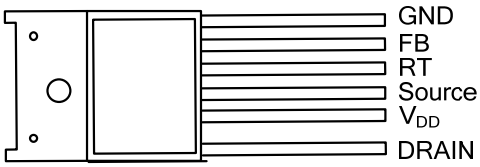
(1) T: Tube
(2) TF6: TO-220F-6
(3) L: Lead Free, G: Halogen Free and Lead Free

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■ MARKING



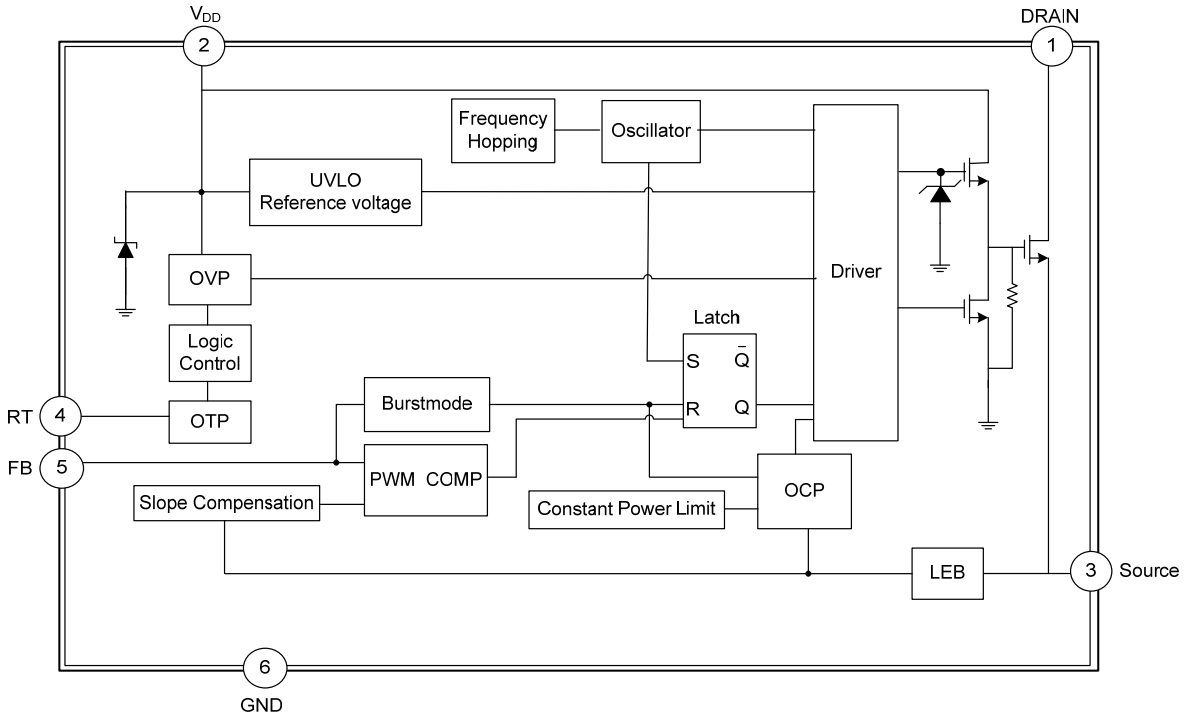
■ PIN CONFIGURATION



■ PIN DESCRIPTION

PIN NO.	PIN NAME	DESCRIPTION
1	DRAIN	HV MOSFET Drain Pin. The Drain pin is connected to the primary lead of the transformer.
2	V_{DD}	Supply voltage
3	Source	HV MOSFET Source Pin.
4	RT	Connected through a NTC resistor to ground for over temperature protection.
5	FB	Feedback input pin. The PWM duty cycle is determined by voltage level into this pin and the current-sense signal at Pin 3.
6	GND	Ground

■ BLOCK DIAGRAM



■ ABSOLUTE MAXIMUM RATING

PARAMETER	SYMBOL	RATINGS	UNIT
V_{DD} Voltage		-0.3~30	V
FB Input Voltage		-0.3~7	V
Source Input Voltage		-0.3~7	V
Operating Junction Temperature	T_J	150	°C
Storage Temperature	T_{STG}	-55~150	°C
Lead Temperature (Soldering, 10secs)	T_L	260	°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.

■ ELECTRICAL CHARACTERISTICS (T_A=25°C , V_{DD}=16V, R_T=100KΩ, unless otherwise noted)

PARAMETER		SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
SUPPLY SECTION							
Start Up Current		I_{STR}	V_{DD} = $V_{DD(ON)}$-0.1V		2.5	20	μA
IC Operating current		I_{OP}	V_{FB}=3.5V		2.4	3.0	mA
V_{DD} Zener Clamp current		V_{CLAMP}	I_{VDD}=10mA	26	27.5	29	V
UNDER-VOLTAGE LOCKOUT SECTION							
Start Threshold Voltage		$V_{DD(ON)}$		12	13.5	15	V
Min. Operating Voltage		$V_{DD(MIN)}$		7	8	9	V
CONTROL SECTION							
V_{FB} Open Loop Voltage Level		$V_{FB-OPEN}$		4.9	5.1	5.3	V
Burst-Mode Out FB Voltage		$V_{FB(OUT)}$	V_{SENSE} =0		1.6		V
Reduce-Frequency end FB Voltage		$V_{FB(END)}$	V_{SENSE} =0		2.2		V
Burst-Mode Enter FB Voltage		$V_{FB(IN)}$	V_{SENSE} =0		1.5		V
Switch Frequency	Normal	F_{SW}	V_{FB}=3.5V	55	60	65	KHz
	Power-Saving		Before enter burst mode	17	22	27	KHz
Duty Cycle		D_{MAX}	V_{FB}=3.5V, V_{SENSE}=0	70	77	85	%
Frequency Hopping		$F_{J(SW)}$		-4		+4	%
Frequency V_{DD} Stability		F_{DV}	V_{DD}=12V~20V			5	%
Frequency Temperature Stability		F_{DT}	T=-20~100°C			10	%
Feedback Resistor		R_{FB}		17	20	23	KΩ
PROTECTION SECTION							
V_{CC} Over Voltage Protection Threshold		V_{OVP}	V_{FB}=3.5V	22.5	23	24.5	V
FB PIN Over Load Protection Threshold		V_{OLP}		4.6	4.8	5.0	V
Power Limiting Debounce Time		T_{D_PL}		100	125	150	mS
Soft start time		T_{SS}		1	2	3	mS
CURRENT LIMITING SECTION							
Peak Current Flat Threshold Voltage		V_{CS-F}	V_{FB}=4.2V, Duty≥60%		0.8		V
Peak Current Valley Threshold Voltage		V_{CS-V}	V_{FB}=4.2V, Duty=0%		0.7		V
Lead Edge Blanking Time		T_{LEB}			350		ns
RT SECTION							
Output current of RT pin		I_{RT}		90	100	110	uA
Threshold voltage for OTP		V_{TH_OTP}		0.9	1	1.1	V
Mosfet Section							
MOSFET Drain-Source Breakdown Voltage		BVdss		600			V
Static Drain to Source On Resistance		Rdson			1.5		Ω

■ OPERATION DESCRIPTION

The UTC **US3706** is a low power off-line SMPS Switcher optimized for off-line flyback converter. It integrates many useful designs into one controller for low-power switch-mode power supplies. The following descriptions highlight some of the features of the **US3706** series.

Startup Current and Start up Control

The start-up current is only 2.5μA. Low start-up current allows a start-up resistor with a high resistance and a low-wattage to supply the start-up power for the controller. For AC/DC adaptor with universal input range design, a 2.5~3MΩ, 1/8W startup resistor could be used together with a V_{DD} capacitor to provide a fast startup and low power dissipation solution.

Power-Saving Mode Operation

The proprietary Power-Saving Mode function provides linearly decreasing the switching frequency under light-load conditions for higher efficiency. The feedback voltage, which is sampled from the voltage feedback loop, is taken as the reference. Once the feedback voltage dropped below the threshold voltage, the switching frequency starts to decrease. This Power-Saving Mode function dramatically reduces power consumption under light-load conditions. The 22KHz minimum frequency control also eliminates the audio noise at any loading conditions.

At zero load condition, the magnitude of power loss is in proportion to the number of switching events within a fixed period of time. Reducing switching events leads to the reduction on the power loss and thus conserves the energy. The **US3706** enter burst mode at standby condition to minimize the switching loss and reduces the standby power consumption. Power supplies using the **US3706** can easily meet even the strictest regulations regarding standby power consumption.

Switch Frequency Set

The maximum switch frequency is fixed to 60KHz. Switch frequency is modulated by output power P_{OUT} during IC operating. At no load or light load condition, most of the power dissipation in a switching mode power supply is from switching loss on the MOSFET transistor, the core loss of the transformer and the loss on the snubber circuit. The magnitude of power loss is in proportion to the number of switching events within a fixed period of time. So lower switch frequency at lower load, which more and more improve IC's efficiency at light load. At from no load to light load condition, The IC will operate at from Burst mode to Reducing Frequency Mode. The relation curve between f_{SW} and $P_{OUT}/P_{OUT\ (MAX)}$ as followed Fig.1.

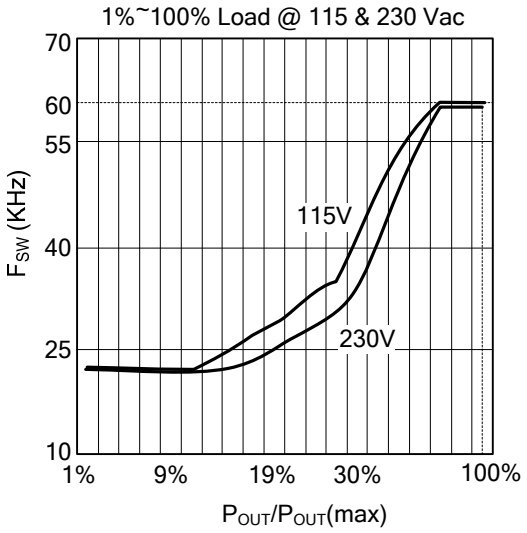


Fig.1 The relation curve between f_{SW} and relative output power $P_{OUT}/ P_{OUT\ (MAX)}$

■ OPERATION DESCRIPTION (Cont.)

Frequency Hopping For EMI Improvement

The Frequency hopping is implemented in the IC; there are two oscillators built-in the IC. The first oscillator is to set the normal switching frequency; the switching frequency is modulated with a period signal generated by the 2nd oscillator. The relation between the first oscillator and the 2nd oscillator as followed Fig.2. So the tone energy is evenly spread out, the spread spectrum minimizes the conduction band EMI and therefore eases the system design in meeting stringent EMI requirement.

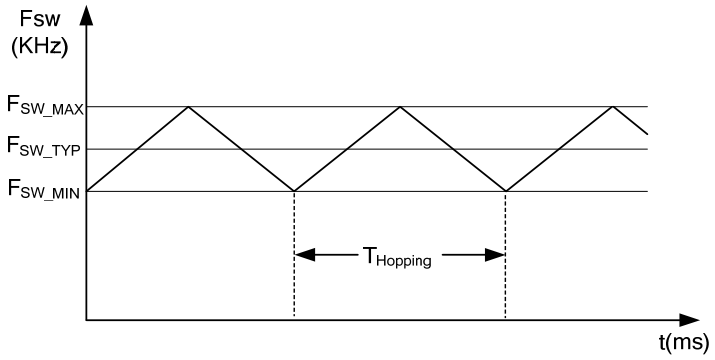


Fig.2 Frequency Hopping

Built-in Slope Compensation

Built-in slope compensation circuit greatly improves the close loop stability at CCM and prevents the sub-harmonic oscillation.

Leading-Edge Blanking

Each time the power MOSFET is switched on, a turn-on spike will inevitably occur at the sense-resistor. To avoid premature termination of the switching pulse, a 400ns leading-edge blanking time is built in. Conventional RC filtering can therefore be omitted. During this blanking period, the current-limit comparator is disabled and it cannot switch off the power MOSFET.

Under Voltage Lockout (UVLO)

The turn-on and turn-off thresholds of the **US3706** are fixed internally at $V_{DD(ON)}$/$V_{DD(MIN)}$ During start-up, the hold-up capacitor must be charged to $V_{DD(ON)}$ through the start-up resistor, so that the **US3706** will be enabled. The hold-up capacitor will continue to supply V_{DD} until power can be delivered from the auxiliary winding of the main transformer. V_{DD} must not drop below $V_{DD(MIN)}$ during this start-up process. This UVLO hysteresis window ensures that hold-up capacitor will be adequate to supply V_{DD} during start-up.

■ OPERATION DESCRIPTION (Cont.)

Protection Controls

The IC takes on more protection functions such as OVP, OLP and OTP etc. In case of those failure occurs for continual blanking time, the power MOSFET is shut down. Power MOSFET is reset after failure is eliminated.

OVP

The OVP will shut down the switching of the power MOSFET whenever V_{DD} >V_{OVP}. The OVP event as followed Fig.3.

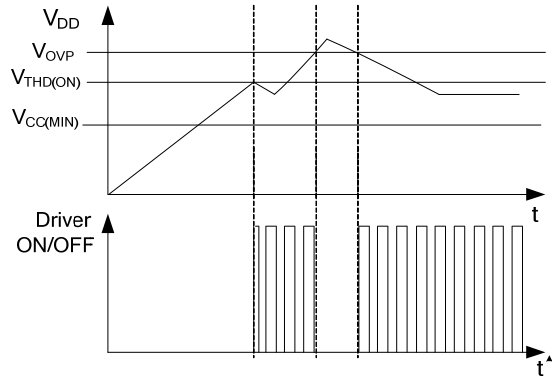


Fig.3 OVP case

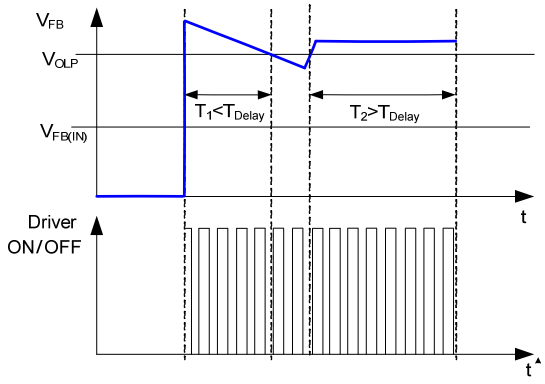


Fig.4 OLP case

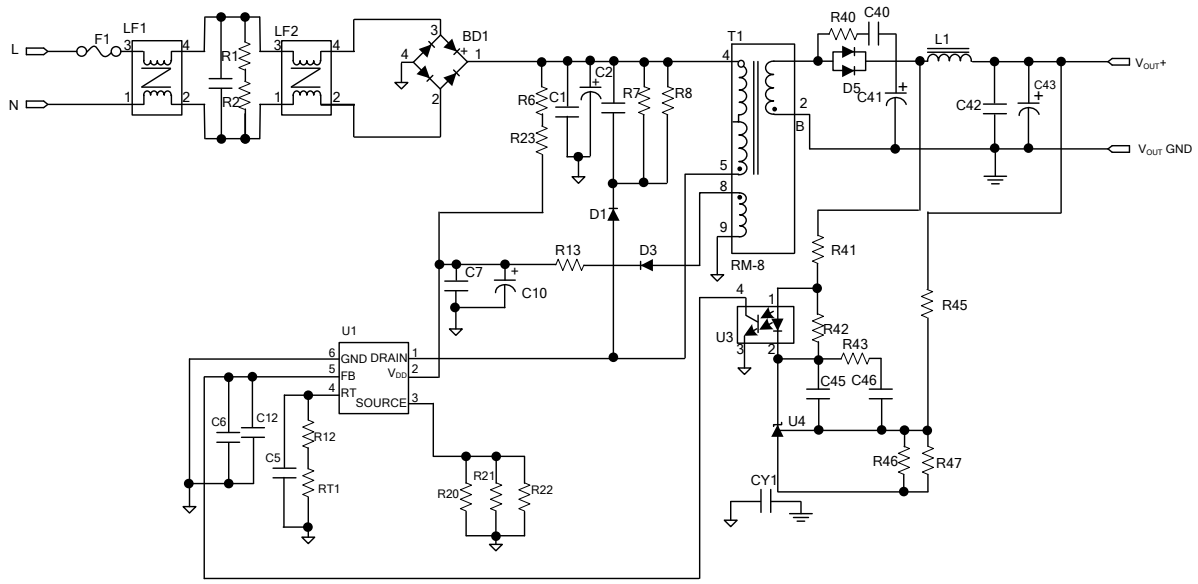
OLP

OLP will shut down driver when V_{FB}> V_{OLP} for continual a blanking time. The OLP event as followed Fig.4.

OTP

OTP will shut down driver when the NTC resistor temperature T_J>$T_{(THR)}$.

■ TYPICAL APPLICATION CIRCUIT



BOM

Reference	Component	Reference	Component
BD1	2A_600V	R6, R2	Resistor, chip,1.5M, 1/4W,±5%, SMD1206
C2	Capacitor, aluminum electrolytic,33uF/400V, 105℃,±20%	R7, R8	Resistor, chip,180K, 1/4W,±5%, SMD1206
C3	Capacitor, ceramic, 1000pF/1KV, NPO, SMD1206	R13	Resistor, chip,4.7-, 1/8W,±5%, SMD0805
C6	Capacitor, ceramic, 1nF/50V, X7R, SMD0805	R18	Resistor, chip,1K, 1/8W,±5%, SMD0805
C10	Capacitor, aluminum electrolytic,10uF/50V; 105℃,±20%	R20, R21	Resistor, chip, 1.8-, 1/4W,±5%, SMD1206
C7, C46	Capacitor, ceramic, 0.1uF/50V, X7R, SMD0805	R40	Resistor, chip, 47-, 1/4W,±5%, SMD1206
C11	Capacitor, ceramic, 68pF/50V, X7R, SMD0805	R41	Resistor, chip,820-, 1/10W,±5%, SMD0603
C43	Capacitor, aluminum electrolytic, 680uF/25V, 105℃,±20%	R42	Resistor, chip,2.2K, 1/10W,±5%, SMD0603
C45	Capacitor, ceramic, 10NF/50V, X7R, SMD0805	R43	Resistor, chip,300-, 1/10W,±1%, SMD0603
CX1	Capacitor, X2, 0.33uF/275VAC, 105℃ ,±20%	R45	Resistor, chip,39K, 1/10W,±1%, SMD0603
CY1	Capacitor, Y1, 1000pF/400V, 105℃,±20%	R47	Resistor, chip,10K, 1/10W,±1%, SMD0603
C40	Capacitor, ceramic, 100pF/200V, ±20%, SMD1206	T1	Transformer, RM-8
D1	Diode , fast recovery, 1N4007, 1.0A/1000V	U1	IC, PWM controller, UTC US3706, TO-220F-6
D3	Diode , fast recovery, BAV20WG, SOT-123	U4	IC, TL431 SOT-23
D5	Diode, MGBR20L60CG, 20A/60V,TO-220	U3	IC, Opto-Coupler, LTV-357-T-C, SMD
F1	Fuse, 3.15A / 250V	No Component	C1, C41, C42, C5, R1, R2, R3, R5, R12, R22, R47
LF1, LF2	choke	PCB	32mmX71mmX1.6mm

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