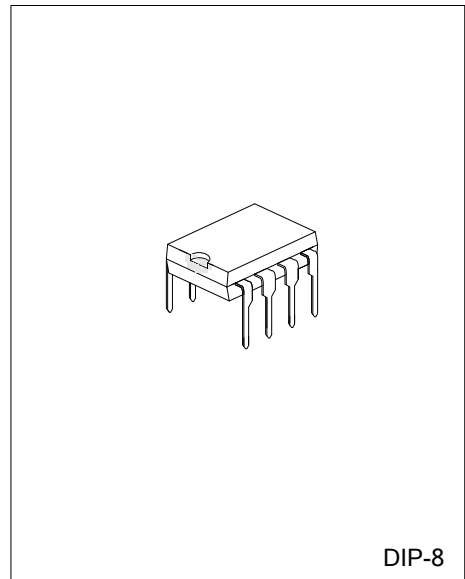# UNISONIC TECHNOLOGIES CO., LTD

UPS1602　　　　　　　　　　　　　　　　　　　*LINEAR INTEGRATED CIRCUIT*

HIGH PERFORMANCE CURRENT MODE POWER SWITCH

■　**DESCRIPTION**

The UTC **UPS1602** is designed to provide several special enhancements to satisfy the needs, for example, power-saving mode for low standby power (<0.3w), frequency hopping , constant output power limiting , slope compensation ,over current protection (ocp), over voltage protection (ovp), over load protection (olp), under voltage lock out (uvlo), short Circuit Protection (SCP) and Over Temperature Protection (OTP), etc. IC will be shut down or can auto-restart in those situations.
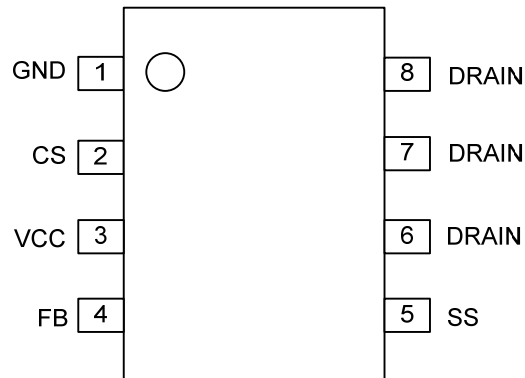
DIP-8

■　**FEATURES**

* Low startup current (about 22µA)
* Fixed switching frequency(Norm. is 68KHz)
* Frequency hopping for Improved EMI Performance.
* Lower than 0.3W Standby Power Design
* Linearly decreasing frequency to 26KHz during light load
* Soft start
* Internal Slope Compensation
* Constant Power Limiting for universal AC input Range
* Gate Output Maximum Voltage Clamp(15V)
* Max duty cycle 74%
* Over temperature protection
* Overload protection
* Over voltage protection
* Leading edge blanking
* Cycle-by-Cycle current limiting
* Under Voltage Lock Out
* Short Circuit Protection

■　**ORDERING INFORMATION**

Ordering Number		Package	Packing
Lead Free	Halogen Free	DIP-8	Tube
UPS1602L-D08-T	UPS1602G-D08-T		

UPS1602L-D08-T

(1) Packing Type　　(1) T: Tube

(2) Package Type　　(2) D08: DIP-8

(3) Lead Plating　　(3) G: Halogen Free, L: Lead Free

■ **PIN CONFIGURATION**

```
         ┌─────────────────┐
GND  1  │   ◯             │  8  DRAIN
         │                 │
CS   2  │                 │  7  DRAIN
         │                 │
VCC  3  │                 │  6  DRAIN
         │                 │
FB   4  │                 │  5  SS
         └─────────────────┘
```

■ **PIN DESCRIPTION**

PIN NO.	SYMBOL	DESCRIPTION
1	GND	Ground
2	CS	Controller current sense input
3	V_{CC}	Supply voltage
4	FB	Feedback
5	SS	Soft-start，connect Capacitor C_{softs} to GND
6、7、8	DRAIN	Power MOSFET drain

■ **BLOCK DIAGRAM**
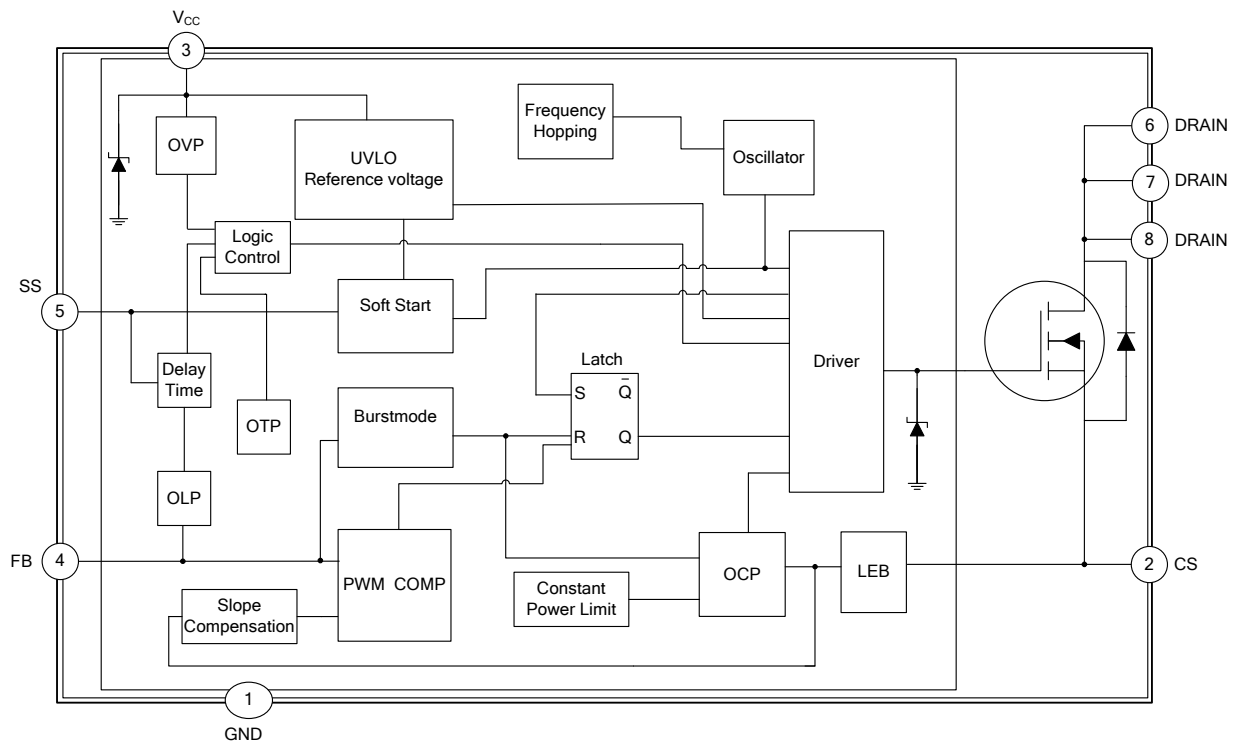
Notes: OLP (Over Load Protection)
OVP (Over Voltage Protection)
OTP (Over Temperature Protection)
OCP (Over Current Protection)
UVLO (Under Voltage Latch-Out)
LEB (Led Edge Blanking)
SS (Soft Start)

UPS1602

■ **ABSOLUTE MAXIMUM RATINGS** (Ta＝25°C, unless otherwise specified)

PARAMETER	SYMBOL	RATINGS	UNIT
Supply Voltage	V_{CC}	30	V
Input Voltage to FB Pin	V_{FB}	-0.3 ~ 6.2	V
Input Voltage to CS Pin	V_{CS}	-0.3 ~ 2.8	V
Junction Temperature	T_J	+150	°C
Operating Temperature	T_{OPR}	-40 ~ +125	°C
Storage Temperature	T_{STG}	-50 ~ +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
Supply Voltage	V_{CC}	8.6 ~ 22	V

■ **ELECTRICAL CHARACTERISTICS** (Ta＝25°C, V_{CC}=15V, unless otherwise specified)

PARAMETER		SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
SUPPLY SECTION							
Start Up Current		I_{STR}	V_{CC} = $V_{CC(ON)}$-0.1V		22	45	µA
Supply Current with switch		I_{OFF}	V_{SS} = 0, I_{FB} = 0		7	9	mA
		I_{ON}	V_{SS} = 4.8V, I_{FB} = 0		7	9	mA
UNDER-VOLTAGE LOCKOUT SECTION							
Start Threshold Voltage		$V_{THD(ON)}$		13.5	14.2	15	V
Min. Operating Voltage		$V_{CC(MIN)}$		7.5	8.2	9	V
Hysteresis		$V_{CC(HY)}$			6		V
INTERNAL VOLTAGE REFERENCE							
Reference Voltage		V_{REF}	measured at pin V_{FB}	6.3	6.5	6.7	V
CONTROL SECTION							
V_{FB} Operating Level		V_{MIN}		0.5			V
		V_{MAX}				4.4	
Burst-Mode Out FB Voltage		$V_{FB(OUT)}$	V_{CS} =0		1.7		V
Reduce-Frequency end FB Voltage		$V_{FB(END)}$	V_{CS} =0		1.6		V
Burst-Mode Enter FB Voltage		$V_{FB(IN)}$	V_{CS} =0		1.5		V
Switch Frequency	Normal	$F_{(SW)}$	V_{FB} = 4V	61	68	75	kHz
	Power-Saving		Before enter burst mode	20		40	kHz
Duty Cycle		D_{MAX}	V_{FB}=4.4V, V_{CS} =0	68	74	80	%
		D_{MIN}	V_{FB}<0.5V	0			%
Frequency Hopping		$F_{J(SW)}$		±1.5	±3	±4.5	kHz
Frequency Variation VS V_{CC} Deviation		F_{DV}	V_{CC}=10 to 20V			5	%
Frequency Variation VS Temperature Deviation		F_{DT}	T=-40 to 105°C			5	%
Feedback Resistor		R_{FB}	V_{FB}=0V	16	21	26	kΩ
Soft-Start Time		T_{SS}	C_{SS}=0.47µF	9.9	11.2	12.6	ms
PROTECTION SECTION							
OVP threshold		V_{OVP1}	V_{SS} <3.5V,V_{FB}>5V		19		V
		V_{OVP2}	V_{SS} =4.8V, V_{FB}=3V		28		V
OLP threshold		$V_{FB(OLP)}$	V_{CS}=0, SS-PIN OPEN	4.7	4.9	5.1	V
Delay Time Of OLP		T_{D-OLP}	C_{SS}=0.47µF	55	62	70	ms
OTP threshold		$T_{(THR)}$		120	135	150	°C
OVP Disable threshold		$V_{SS\,(DEACT)}$	V_{FB}>5V, V_{CC} = 22V	3.9	4.1	4.3	V
OLP Enable threshold		$V_{SS\,(ACT)}$	V_{FB}>5V	5.1	5.4	5.7	V

UPS1602

LINEAR INTEGRATED CIRCUIT

■ **ELECTRICAL CHARACTERISTICS(Cont.)**

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
CURRENT LIMITING SECTION						
Peak Current Limitation	V_{CS}	V_{FB}=4.4V		0.86	1	V
Threshold Voltage For I_{VIN} =60µA	$V_{SENSE-L}$	I_{VIN}=60µA		0.77		V
POWER MOS-TRANSISTOR SECTION						
Drain-Source Breakdown Voltage	V_{DSS}	V_{GS}=0V, I_D=250µA	600			V
Turn-on voltage between gate and source	V_{TH}	V_{DS}=V_{GS}, I_D=250µA	2		4	V
Drain-Source Diode Continuous Source Current	I_S				2	A
Static Drain-Source On-State Resistance	$R_{DS(ON)}$	V_{GS}=10V, I_D=1A		3.8	5	Ω
Rise Time	t_R	V_{DD} = 300V, I_D =2.4A RG = 25Ω (Note 1,2)		25	60	ns
Fall Time	t_F			25	60	ns

Note: 1. Pulse Test: Pulse width≤300µs, Duty cycle≤2%
2. Essentially independent of operating temperature

■ **FUNCTIONAL DESCRIPTION**

The internal reference voltages and bias circuit work at $V_{CC} > V_{THD\ (ON)}$, and shutdown at $V_{CC} < V_{CC\ (MIN)}$.

(1) Soft-Start

When every IC power on, driver output duty cycle will be decided by voltage V_{SS} on soft-start capacitor and V_{CS} on current sense resistor at beginning. After V_{SS} reach 4.2V, the whole soft-start phase end, and driver duty cycle depend on V_{FB} and V_{CS}. The relation among V_{SS}, V_{FB} and V_{OUT} as followed FIG.3.

Furthermore, soft-start phase should end before V_{CC} reach $V_{CC\ (MIN)}$ during V_{CC} power on. Otherwise, if soft-start phase remain not end before V_{CC} reach $V_{CC\ (MIN)}$ during V_{CC} power on, IC will enter auto-restart phase and not set up V_{OUT}. So the value of C_{SS} should be between 0.1μF and 4.7μF.

Finally soft-start also set OVP1 active phase. OVP1 active phase between 0 and $V_{SS\ (DEACT)}$, OVP1 will not be sensed after V_{SS} reach $V_{SS\ (DEACT)}$. The Soft-start phase T_{SS}: $T_{SS} = 23.8 \times C_{SS}$ (ms) (Example: C_{SS}=0.47μF, then T_{SS}=23.8×0.47=11.2ms).
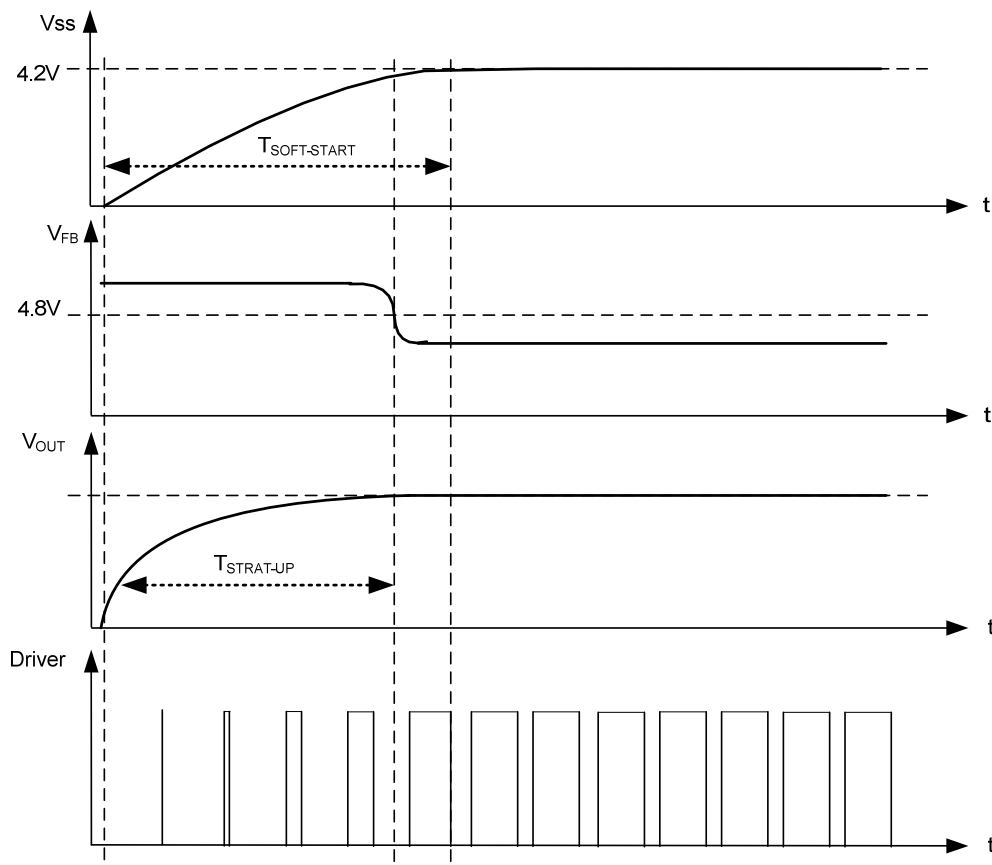
FIG.3 Soft-start phase

■ **FUNCTIONAL DESCRIPTION(Cont.)**

(2) Switch Frequency Set

The maximum switch frequency is set to 68kHz. 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 subber 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.4.
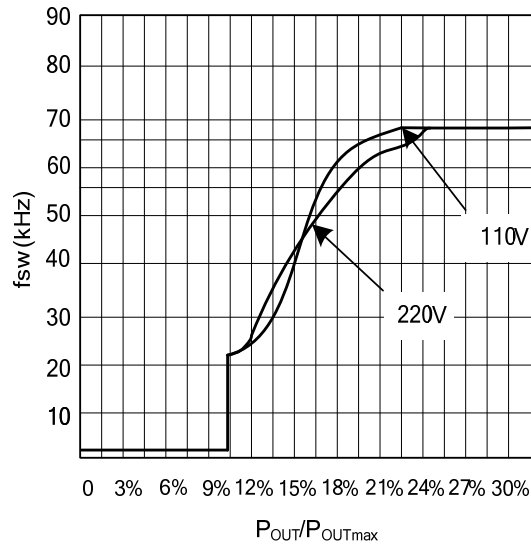
FIG.4 The relation curve between f_{SW} and relative output power $P_{OUT}/P_{OUT\ (MAX)}$

(3) Internal Synchronized Slope Compensation

Built-in slope compensation circuit adds voltage ramp onto the current sense input voltage for PWM generation, this greatly improves the close loop stability at CCM and prevents the sub-harmonic oscillation and thus reduces the output ripple voltage.

(4) 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.5. 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.
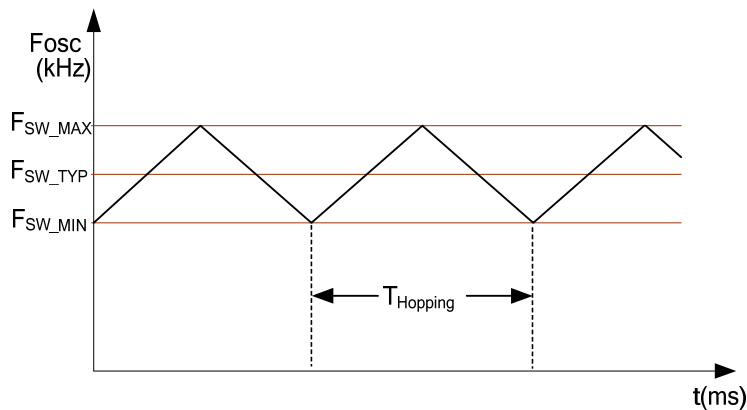

FIG.5 Frequency Hopping

■ FUNCTIONAL DESCRIPTION(Cont.)

(5) Constant Output Power Limit

When the SENSE voltage, across the sense resistor R_S, reaches the threshold voltage, around 1V, the output GATE drive will be turned off after a small propagation delay t_D. This propagation delay will introduce an additional current proportional to $t_D \times V_{IN}/Lp$. Since the propagation delay is nearly constant regardless of the input line voltage V_{IN}. Higher input line voltage will result in a larger additional current and hence the output power limit is also higher than that under low input line voltage. To guarantee the output power is a constant for universal input AC voltage, there is a dynamic peak limit circuit to compensate the system delay T_{D-OC} that the system delay brings on. $I_{PEAK-MAX}=0.8V/R_{SENSE}(V_{IN}=264VAC)$,$I_{PEAK-MAX}=1V/R_{SENSE}(V_{IN}=85VAC)$. This proprietary compensation ensures a constant output power limit for wide AC input voltage from 90VAC to 264VAC.

(6) Protection section

The IC takes on more protection functions such as OLP, OVP and OTP etc. In case of those failure modes for continual blanking time, the driver is shut down. At the same time, IC enters auto-restart, V_{CC} power on and driver is reset after V_{CC} power on again.

OLP

After soft-start phase end, IC will shutdown driver if over load state occurs for continual T_{D-OLP}. OLP function will not inactive during soft-start phase. OLP case as followed FIG. 6. The test circuit as followed FIG.8. $T_{D-OLP}=5.53 \times T_{SS}$.

OVP

There are two kinds of OVP circuits, the first OVP function are enabled only when $V_{SS} < V_{SS\ (DEACT)}$ & $V_{FB} > V_{FB\ (OLP)}$ during soft-start phase. During above condition, driver will be shutdown if over voltage state occurs ($V_{CC} > V_{OVP1}$) for continual a blanking time. The first OVP function will not inactive after soft-start phase. The second OVP will shutdown the switching of the power MOSFET whenever $V_{CC} > V_{OVP2}$. The first OVP case as followed FIG.7. The test circuit as followed FIG. 9.
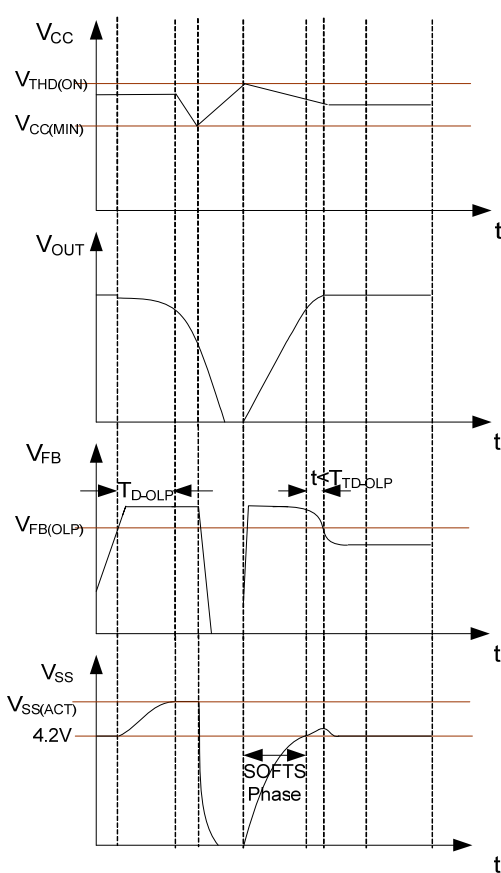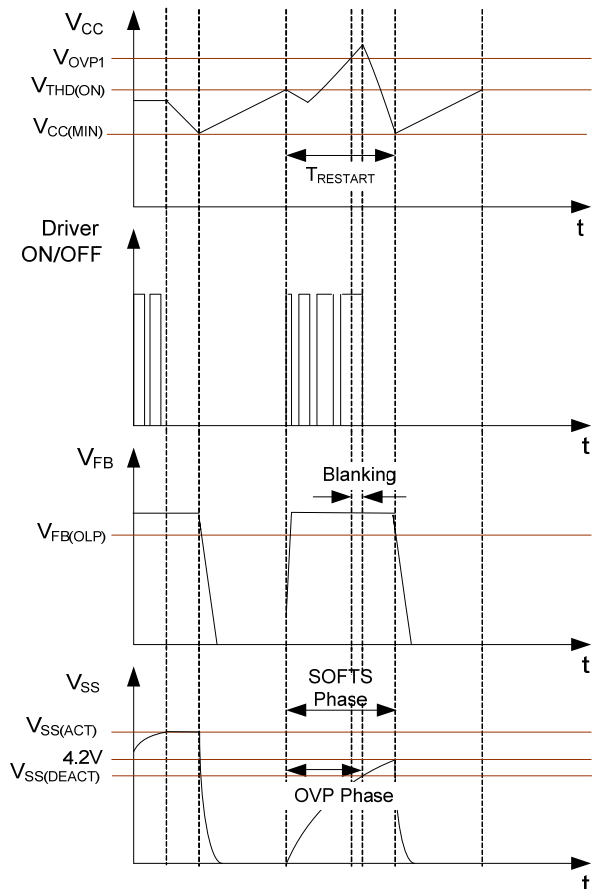

FIG.6 OLP case

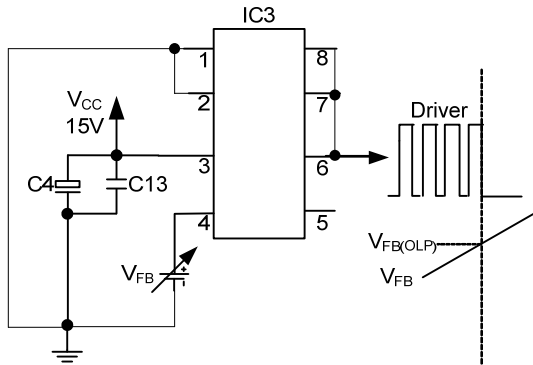FIG.7 OVP case

■ **FUNCTIONAL DESCRIPTION(Cont.)**
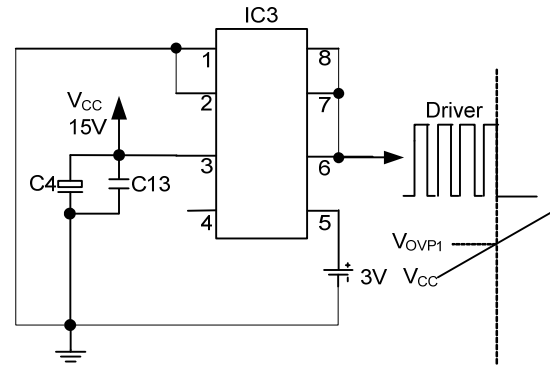

FIG.8 OLP test circuit

FIG.9 OVP test circuit

OTP

OTP will shut down driver when junction temperature $T_J > T_{(THR)}$ for continual a blanking time.

(7) Driver Output Section

The driver-stage drives the gate of the MOSFET and is optimized to minimize EMI and to provide high circuit efficiency. This is done by reducing the switch on slope when reaching the MOSFET threshold. This is achieved by a slope control of the rising edge at the driver's output. The output driver is clamped by an internal 15V Zener diode in order to protect power MOSFET transistors against undesirable gate over voltage.

(8) Inside power switch MOS transistor

Specific power MOS transistor parameter is as "POWER MOS TRANSISTOR SECTION" in electrical characteristics table.
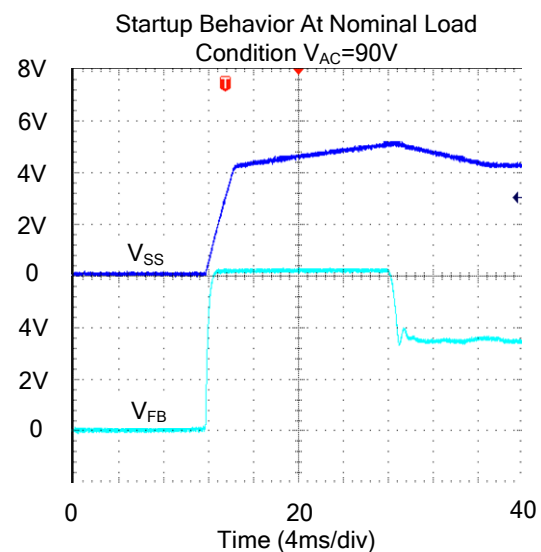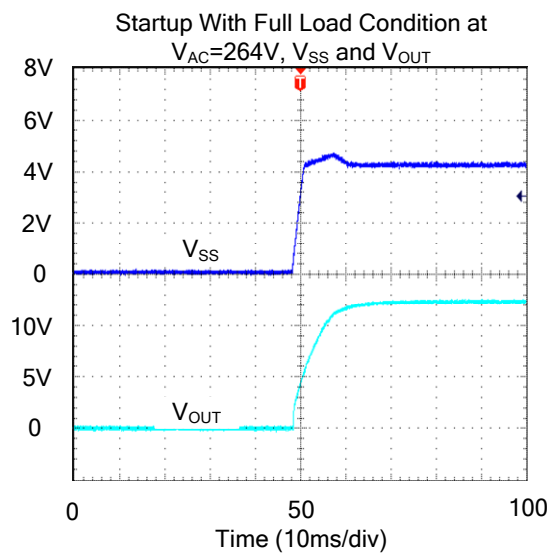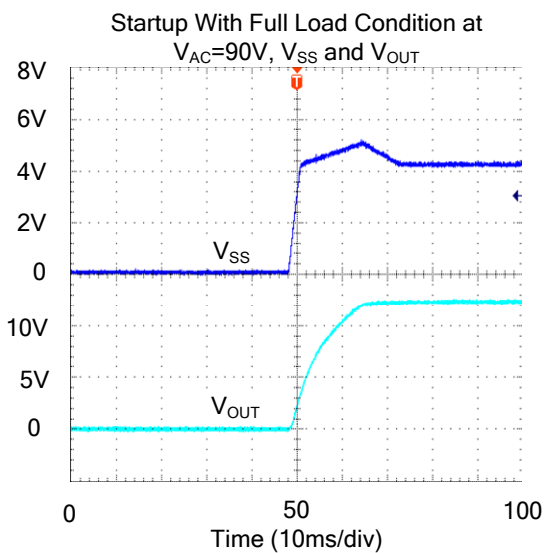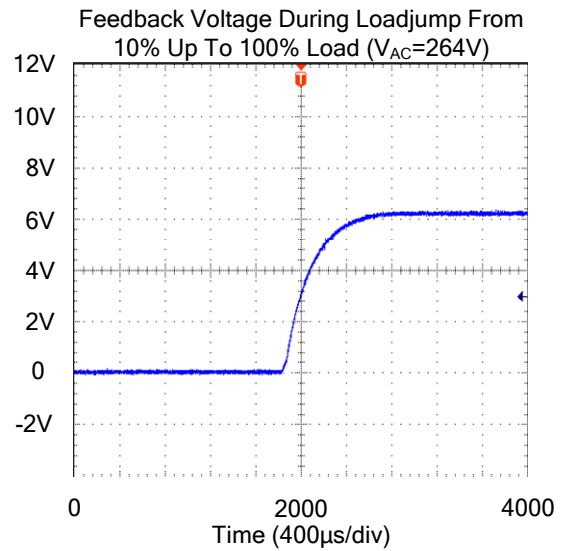
UPS1602

■ **TYPICAL APPLICATION CIRCUIT**
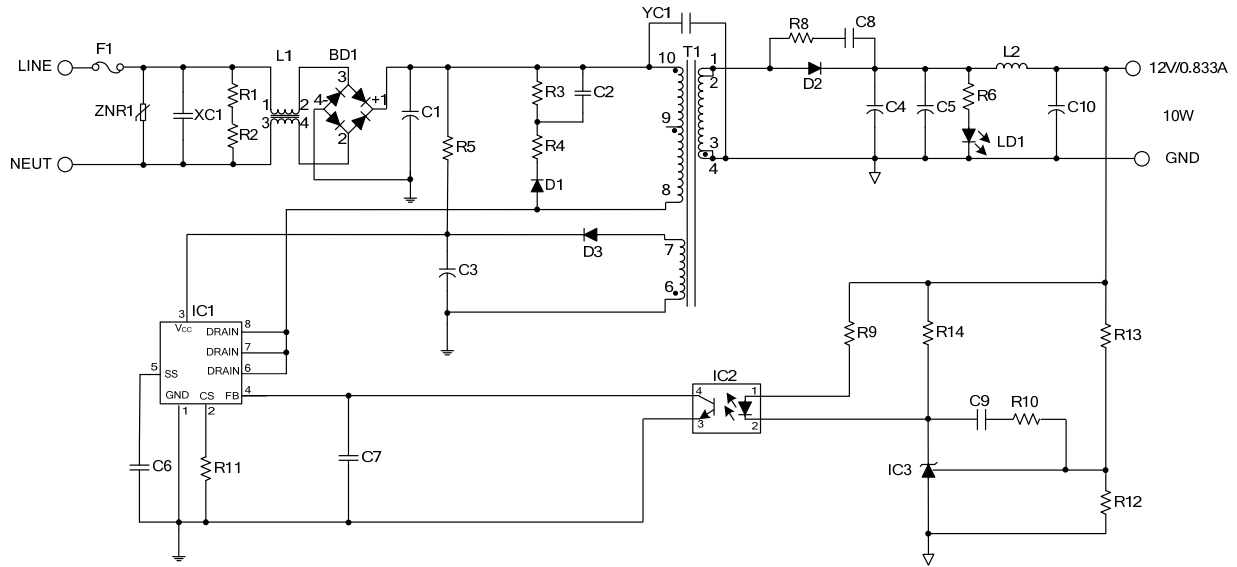
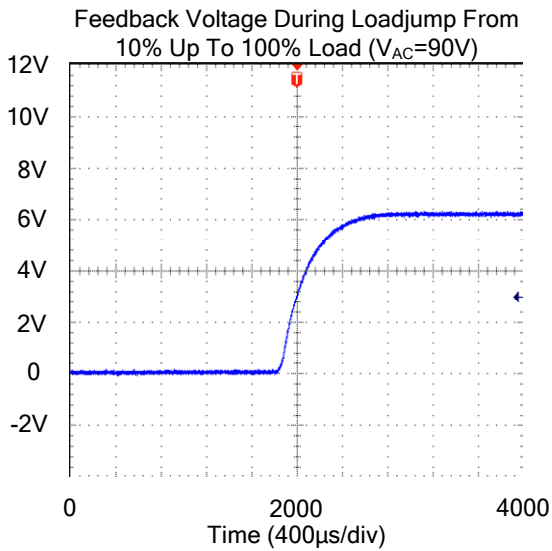

FIG.10 UTC UPS1602 Typical Application Circuit

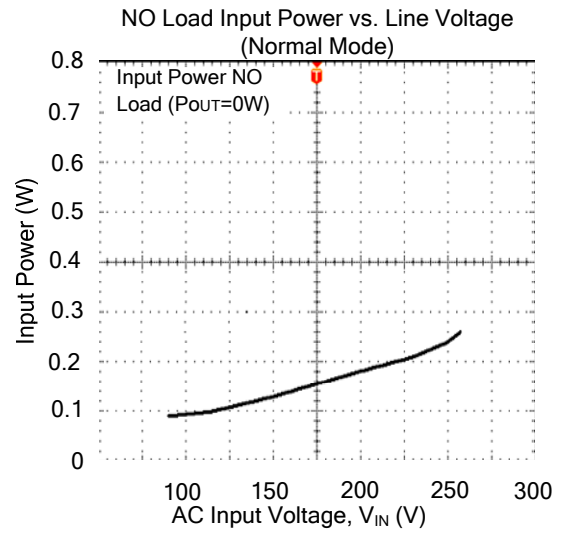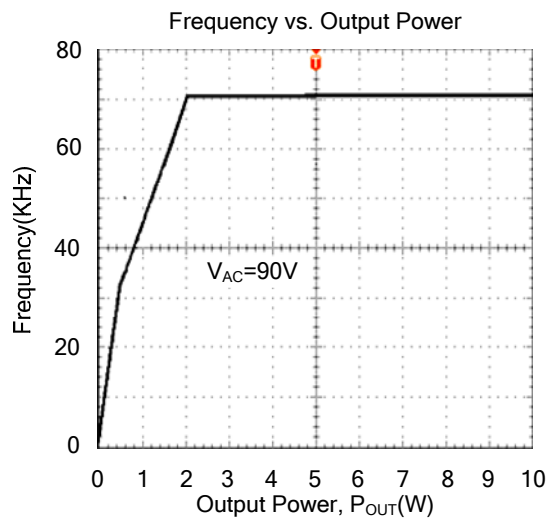**Table1. Components reference description for UPS1602 application circuit**

DESIGNATOR	PART TYPE		DESIGNATOR	PART TYPE		DESIGNATOR	PART TYPE
C1	22μF		R4	100		D3	RS1D
C2	0.001μF		R5	1MΩ		IC1	**UPS1602**
C3	22μF		R6	10K		IC2	PC-817
C4	330μF		R8	15Ω		IC3	TL431
C5	330μF		R9	560Ω		YC1	222
C6	0.1μF		R10	1KΩ		T1	EE22
C7	0.01μF		R11	1.5Ω		L1	UU9.8
C8	0.001μF		R12	3.9KΩ		L2	2uH
C9	0.1μF		R13	15KΩ		LD1	LED
C10	220μF		R14	1.8KΩ		F1	1A/250V
R1	2.2MΩ		D1	FR107		ZNR1	7D471K
R2	2.2MΩ		D2	SB3100		BD1	DI106
R3	68KΩ					XC1	154

UPS1602

LINEAR INTEGRATED CIRCUIT

■ **TYPICAL CHARACTERISTICS**

Feedback Voltage During Loadjump From 10% Up To 100% Load (V_{AC}=90V)

Feedback Voltage During Loadjump From 10% Up To 100% Load (V_{AC}=264V)

Startup With Full Load Condition at V_{AC}=90V, V_{SS} and V_{OUT}

Startup With Full Load Condition at V_{AC}=264V, V_{SS} and V_{OUT}

Startup Behavior At Nominal Load Condition V_{AC}=90V

Startup Behavior At Nominal Load Condition V_{AC}=264V

■ **TYPICAL CHARACTERISTICS(Cont.)**

Frequency vs. Output Power

$V_{AC}=90V$

NO Load Input Power vs. Line Voltage
(Normal Mode)

Input Power NO Load ($P_{OUT}=0W$)