UNISONIC TECHNOLOGIES CO., LTD

USRB02   Preliminary   *LINEAR INTEGRATED CIRCUIT*

HIGH PRECISION CC/CV PRIMARY SIDE SWITCH

■ **DESCRIPTION**

The UTC **USRB02** is a primary controller for charger and adapter applications. The controlled variable is transferred by an auxiliary winding from the secondary to the primary side. The device operates in Pulse Frequency Modulation (PFM) in CC mode as well at large load condition and it operates in Pulse Width Modulation (PWM) with frequency reduction at light/medium load condition.

The UTC **USRB02** operates in primary-side sensing and regulation. Opto-coupler and TL431 could be eliminated. It also eliminates the need of loop compensation circuitry while maintaining stability.

The UTC **USRB02** achieves high precision CV/CC regulation and high power efficiency. It offers comprehensive protection coverage with auto-recovery features including Cycle-by-cycle current limiting, output over voltage protection, V_{DD} over voltage protection, feedback loop open protection, short circuit protection, leading edge blanking, OTP, V_{DD} under voltage lockout, etc.
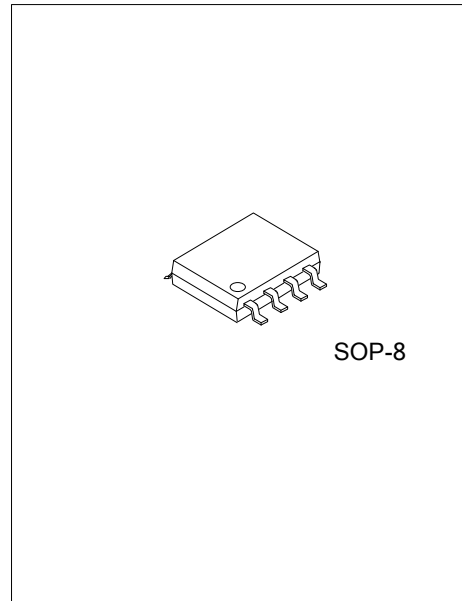
SOP-8

■ **FEATURES**

* ±5% constant voltage regulation at universal AC input
* Primary side control without TL431 and opto-coupler
* High precision constant current regulation at universal AC input
* Programmable CV and CC regulation
* Eliminates control loop compensation circuitry
* Flyback topology in DCM operation
* Random frequency modulation to reduce system EMI
* Built-in power NPN
* Multi-mode operation for efficiency improving

* Programmable cable drop compensation
* Built-in leading edge blanking
* Built-in primary winding inductance compensation
* Built-in line voltage compensation
* Audio noise free operation
* Open circuit protection
* Output over voltage protection
* VDD over voltage protection
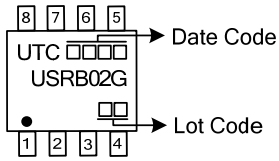* Short circuit protection
* Over temperature protection

■ **ORDERING INFORMATION**

Ordering Number	Package	Packing
USRB02G-S08-R	SOP-8	Tape Reel

USRB02G-S08-R

    (1)Packing Type   (1) R: Tape Reel

    (2)Package Type   (2) S08: SOP-8

    (3)Green Package   (3) G: Halogen Free and Lead Free

■ MARKING

```
 8  7  6  5
UTC ☐☐☐☐  ──► Date Code
 USRB02G
           ☐☐  ──► Lot Code
●
 1  2  3  4
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■ PIN CONFIGURATION

```
V_DD  1  ○           8  GND

FB    2              7  GND

NC    3              6  C

CS    4              5  C
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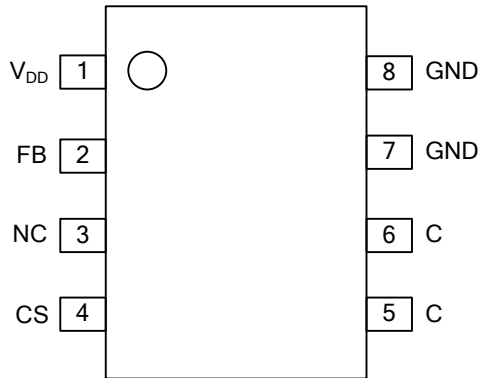
■ PIN DESCRIPTION

PIN NO.	PIN NAME	DESCRIPTION
1	V_{DD}	Power supply
2	FB	The voltage feedback from the auxiliary winding
3	NC	NC
4	CS	Current sense input
5~6	C	The collector of the power NPN
7~8	GND	Ground

■ BLOCK DIAGRAM

USRB02
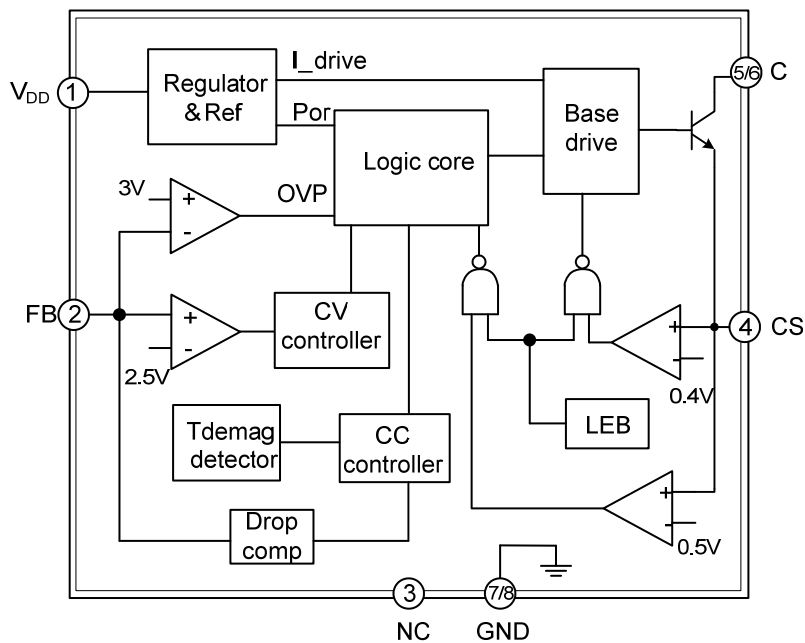
■ **ABSOLUTE MAXIMUM RATING**

PARAMETER	SYMBOL	RATINGS	UNIT
V_{DD} Voltage		-0.3~30	V
C Voltage		-0.3~700	V
CS Input Voltage		-0.3~7	V
FB Input Voltage		-0.3~7	V
Junction Temperature	T_J	-40~150	°C
Storage Temperature	T_{STG}	-55~150	°C
Lead Temperature (Soldering, 10 secs)	T_{OPR}	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.

■ **THERMAL DATA**

PARAMETER	SYMBOL	RATINGS	UNIT
Junction to Ambient	θ_{JC}	150	°C/W

■ **ELECTRICAL CHARACTERISTICS** (T_A=25°C, VDD=15V, if not otherwise noted)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Supply Voltage (V_{DD}) Section						
Start up Current	I_{ST}	V_{DD}= $V_{TH (ON)}$-1V		5	15	µA
Static Current	I_{OP}			0.72	1.0	mA
Turn-off Threshold Voltage	$V_{TH(OFF)}$		6.5	7.1	7.8	V
Turn-on Threshold Voltage	$V_{TH (ON)}$		18.4	19.4	20.4	V
V_{DD} Over Protect Voltage	V_{DD_OVP}		26.5	28	29.5	V
Operating Voltage					26	V
Current Sense Input Section						
LEB Time	T_{LEB}			0.5		µS
Minimum Over Current Threshold	Vth_ocp_min		485	500	515	mV
Maximum Over Current Threshold	Vth_ocp_max			555		mV
Minimum CS threshold	Vcs_mini			100		mV
Maximum Ton	Ton_max			50		uS
OCP Propagation Delay	T_{D_OC}	From OCP Comparator to Base Drive		100		nS
FB Input Section						
Reference Voltage for Feedback Threshold	V_{FB}		2.475	2.5	2.525	V
Minimum Toff	Tpause_min			2.0		uS
Minimum frequency	F_min		720	800	880	Hz
Maximum Cable Compensation Current	Icable			48		µA
Output over voltage threshold	V_ovp		2.85	3.00	3.15	V
Power BJT Section						
Collector-emitter breakdown voltage	V_{CEO}	I_C=10mA, I_B=0	450			V
Collect Peak Current	I_C			0.6		A
Collector-Base Breakdown Voltage	V_{CBO}	I_C=10mA	700			V
On Chip Over Temperature Section						
Over Temperature Protection	T_otp			165		°C
Over Temperature Protection recovery point	T_otp_rec			130		°C

◼ OPERATION DESCRIPTION

The UTC **USRB02** is a primary control unit for switch mode charger and adapter applications. It operates in primary-side sensing and regulation. Opto-coupler and TL431 could be eliminated. Proprietary built-in CV and CC control can achieve high precision CV/CC performance. It uses Pulse Frequency Modulation (PFM) and Pulse Width Modulation (PWM) method to build discontinuous conduction mode (DCM) flyback power supplies.

Startup control

The V_{DD} pin of UTC **USRB02** is connected to the line input through a resistor. A large value startup resistor can be used to minimize the power loss in application because the start current of UTC **USRB02** is very low. When the V_{DD} voltage reaches $V_{TH (ON)}$, the internal startup circuit is disabled and the IC turns on.

Operating Current

The Operating current of UTC **USRB02** is as low as 720μA. Good efficiency and very low standby power can be achieved.

Constant Voltage Operation

The output voltage is defined by the transmission ratio between the secondary and auxiliary winding. The UTC **USRB02** captures the auxiliary winding feedback voltage at FB pin and operates in constant-voltage (CV) mode to regulate the output voltage. The auxiliary voltage reflects the output voltage is given by:

$$V_{AUX} = \frac{N_A}{N_S} \times (V_O + \Delta V) \qquad\qquad (1)$$

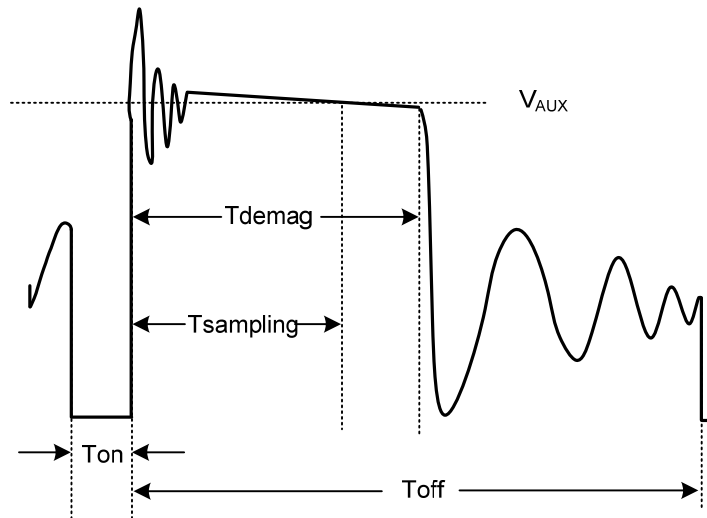Where $\triangle V$ indicates the drop voltage of the output diode.

Figure 2. Auxiliary voltage waveform

Via a resistor divider connected between the auxiliary winding and FB, the V_{AUX} is sampled at the Tsampling end and it is hold until the next sampling. The sampled voltage is compared with 2.5V reference voltage and the error is amplified. The error amplifier output reflects the load condition and controls the Toff time to regulate the output voltage, thus constant output voltage can be achieved.

Constant Current Operation

When the sampled voltage is below 2.5V reference voltage and the error amplifier output reaches its maximum, thus UTC **USRB02** operates in constant-current (CC) mode. The CC point and maximum output power can be externally adjusted by external current sense resistor Rcs. The larger Rcs, the smaller CC point is, and the smaller output power becomes.
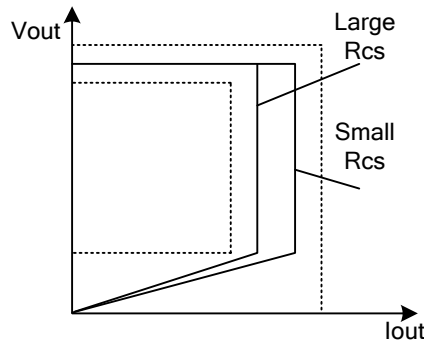
■ **OPERATION DESCRIPTION (Cont.)**

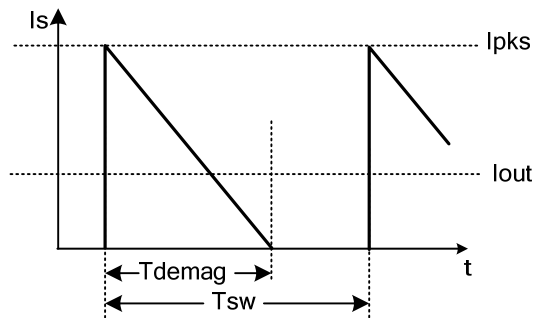Figure3. Adjustable output power by changing Rcs

Figure4. Secondary current waveform

In CC operation, the CC loop control function of UTC **USRB02** will keep a fixed proportion between secondary inductance de-magnetization time (Tdemag) and switching cycle time (Tsw). The fixed proportion is

$$\frac{T_{demag}}{T_{SW}} = \frac{1}{2} \qquad (2)$$

Thus the output current is given by:

$$I_{out} = \frac{1}{2} \times \frac{N_P}{N_S} \times I_{PK} \times \frac{T_{demag}}{T_{SW}} = \frac{1}{4} \times \frac{N_P}{N_S} \times I_{PK} \qquad (3)$$

Programmable Cable drop Compensation

UTC **USRB02** has a built-in cable voltage drop compensation to achieve good load regulation. An offset voltage is generated at FB pin by an internal current flowing into the resistor divider. it is inversely proportional to the output load current. The voltage drop across the cable is compensated by this offset voltage at FB pin. It can also be programmed by adjusting the resistance of the divider to compensate the drop for various cable lines used.

Current Sensing and Leading Edge Blanking

Cycle-by-cycle current limiting is offered in UTC **USRB02**. The switch current is detected by a sense resistor into the CS pin. When the power switch is turned on, a turn-on spike will occur on this resistor. A 500ns leading-edge blanking is built in to avoid false-termination of the switching pulse so that the external RC filtering is no longer needed.

■ **OPERATION DESCRIPTION (Cont.)**

Protection Control

Good power supply system reliability is achieved with its comprehensive protection features including V_{DD} over voltage protection, Output over voltage protection, OTP, feedback loop open protection, Cycle-by-cycle current limiting, short circuit protection, leading edge blanking and UVLO, etc.

V_{DD} is supplied by transformer auxiliary winding output. The output of UTC **USRB02** is shutdown when V_{DD} drops below $V_{TH(OFF)}$ and the power converter enters power on start-up sequence thereafter.

■ **TYPICAL APPLICATION CIRCUIT** (5V/1A)
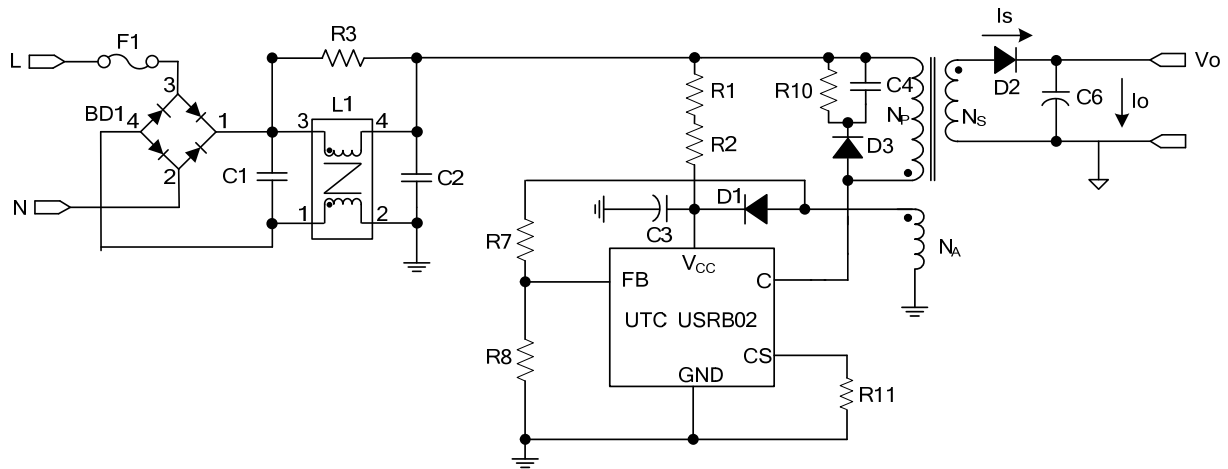
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Reference	Component	Reference	Component
BD1	BD 1A/600V	R3	R 2.4kΩ 1206 ±5%
L1	CHOKE	R1,R2	R 2M2Ω 1206 ±5%
C1	EC 4.7u F 400V 105°C	R10	R 200kΩ 1206 ±5%
C2	EC 4.7u F 400V 105°C	R7	R 18kΩ 0805 ±1%
C3	EC 4.7u F 50V 105°C	R8	R 4.3kΩ 0805 ±1%
C4	CC 1n F 1000V 1206	R11	R 1.2Ω 1206 ±5%
C6	EC 680u F 25V 105°C	T1	EE-16
D1,D3	Diode UTC 1N4007	F1	FUSE 1A 250VAC
D2	Diode UTC SB340		

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