



## UPSR104

Preliminary

CMOS IC

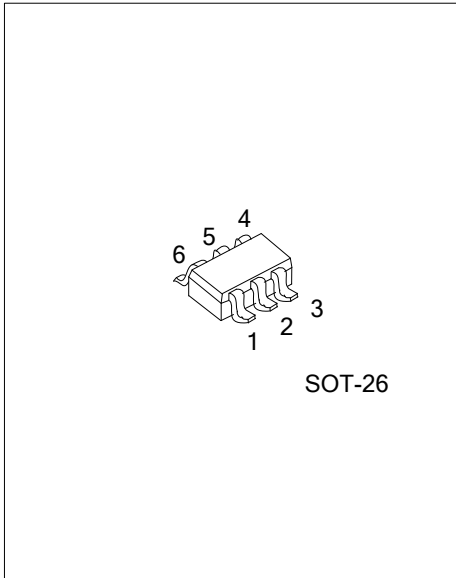
### HIGH PRECISION CC/CV PRIMARY-SIDE PWM CONTROLLER

#### DESCRIPTION

The UTC **UPSR104** is a primary controller mode charger and adapter applications. The controlled variable is transferred by an auxiliary winding from the secondary to the primary side. The device integrates PWM controller to enhance the performance of discontinuous conduction mode (DCM) flyback converters.

The UTC **UPSR104** operates in primary-side sensing and regulation. Opto-coupler and TL431 could be eliminated. It also provides off-time modulation to linearly decrease PWM frequency under light-load conditions so that low standby power can be achieved.

The UTC **UPSR104** 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,  $V_{DD}$  over voltage protection,  $V_{DD}$  clamp, OTP, leading edge blanking,  $V_{DD}$  under voltage lockout, etc.



#### FEATURES

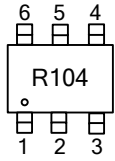
- \*  $\pm 5\%$  Constant Voltage Regulation at Universal AC input
- \* High Precision Constant Current Regulation at Universal AC input
- \* Primary-side Sensing and Regulation Without TL431 and Opto-coupler
- \* Programmable CV and CC Regulation
- \* Adjustable Constant Current and Output Power Setting
- \* Built-in Secondary Constant Current Control with Primary Side Feedback
- \* Built-in Adaptive Current Peak Regulation
- \* Built-in Primary winding inductance compensation
- \* Programmable Cable drop Compensation
- \* Power on Soft-start
- \* Built-in Leading Edge Blanking (LEB)
- \* Cycle-by-Cycle Current Limiting
- \*  $V_{DD}$  Under Voltage Lockout with Hysteresis (UVLO)
- \*  $V_{DD}$  OVP
- \*  $V_{DD}$  Clamp

#### ORDERING INFORMATION

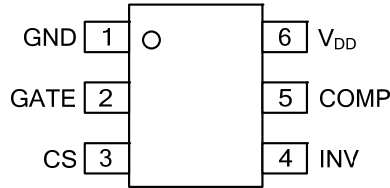
Ordering Number		Package	Packing
Lead Free	Halogen Free		
UPSR104L-AG6-R	UPSR104G-AG6-R	SOT-26	Tape Reel

<p>UPSR104G-AG6-R</p> <ul style="list-style-type: none"> <li>(1) Packing Type</li> <li>(2) Package Type</li> <li>(3) Green Package</li> </ul>	<ul style="list-style-type: none"> <li>(1) R: Tape Reel</li> <li>(2) AG6: SOT-26</li> <li>(3) G : Halogen Free and Lead Free, L: Lead Free</li> </ul>
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MARKING



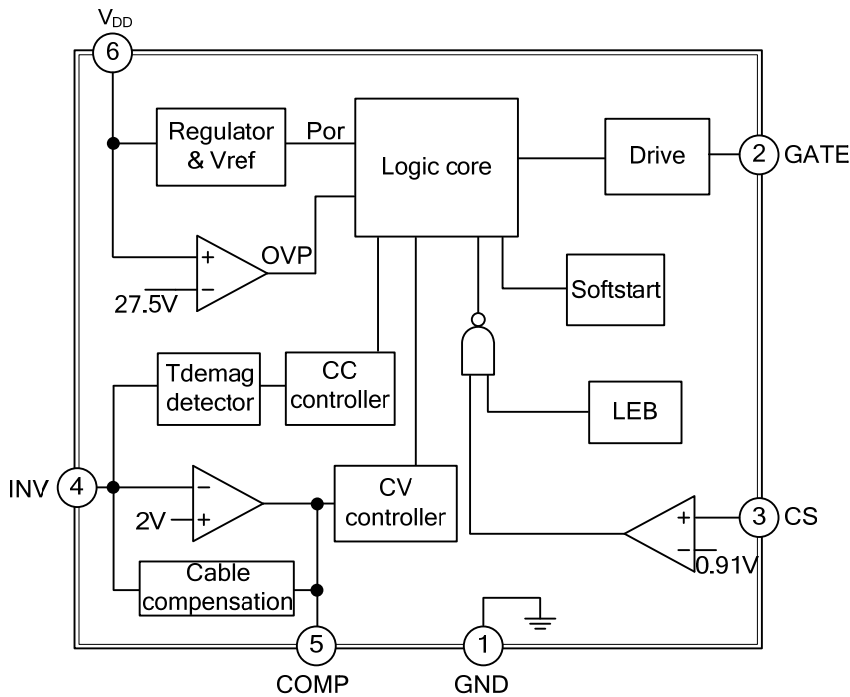
PIN CONFIGURATION



PIN DESCRIPTION

PIN NO.	PIN NAME	DESCRIPTION
1	GND	Ground
2	GATE	Totem-pole gate drive output for power MOSFET.
3	CS	Current sense input. Connected to MOSFET current sensing resistor node.
4	INV	The voltage feedback from auxiliary winding. Connected to resistor divider from auxiliary winding reflecting output voltage.
5	COMP	Loop Compensation for CV Stability
6	V <sub>DD</sub>	Power Supply

BLOCK DIAGRAM



### ■ ABSOLUTE MAXIMUM RATING

PARAMETER	SYMBOL	RATINGS	UNIT
V <sub>DD</sub> Voltage	V <sub>DD</sub>	-0.3 ~ V <sub>DD_ Clamp</sub>	V
V <sub>DD</sub> Zener Clamp Continuous Current		10	mA
COMP Voltage	V <sub>COMP</sub>	-0.3 ~ 7	V
CS Input Voltage	V <sub>CS</sub>	-0.3 ~ 7	V
INV Input Voltage	V <sub>INV</sub>	-0.3 ~ 7	V
Max Operating Junction Temperature	T <sub>J</sub>	+150	°C
Min/Max Storage Temperature	T <sub>STG</sub>	-55 ~ +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.

### ■ ELECTRICAL CHARACTERISTICS (T<sub>A</sub>=25°C, V<sub>DD</sub>=16V, unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>Supply Voltage (V<sub>DD</sub>) Section</b>						
Standby Current	I <sub>DD_ST</sub>	V <sub>DD</sub> =13V		2	5	uA
Operation Current	I <sub>DD_OP</sub>	Operation supply current, INV=2V, CS=0V, VDD=18V		1.6	3	mA
V <sub>DD</sub> Under Voltage Lockout Enter	UVLO <sub>(ON)</sub>	V <sub>DD</sub> falling	8.0	9.0	10.0	V
V <sub>DD</sub> Under Voltage Lockout Exit	UVLO <sub>(OFF)</sub>	V <sub>DD</sub> rising	13.5	14.8	16.0	V
Maximum V <sub>DD</sub> Operation Voltage	V <sub>DD_CLAMP</sub>	I <sub>DD</sub> =10mA		29		V
Over Voltage Protection Threshold	OVP	Ramp V <sub>DD</sub> until gate shut down	26	27.5	29	V
<b>Current Sense Input Section</b>						
LEB Time	T <sub>LEB</sub>			600		ns
Over Current Threshold	V <sub>TH_OC</sub>		880	910	940	mV
OCP Propagation delay	T <sub>d_OC</sub>			60		ns
Soft Start Time	T <sub>SS</sub>			17		ms
<b>Frequency Section</b>						
IC Maximum Frequency	F <sub>req_Max</sub>	(Note 1)	60	65	70	KHz
System Nominal Switch Frequency	F <sub>req_Nom</sub>			55		KHz
	F <sub>req_startup</sub>	INV=0V, Comp=5V		14		KHz
Frequency shuffling range	Δf/Freq			±6		%
<b>Error Amplifier Section</b>						
Reference Voltage for EA	V <sub>REF_EA</sub>		1.97	2	2.03	V
DC Gain of EA	Gain			60		dB
Max. Cable Compensation Current	I <sub>COMP_MAX</sub>	INV=2V, Comp=0V		37		uA
<b>Gate Drive Output Section</b>						
Output Low Level	V <sub>OL</sub>	I <sub>o</sub> =20mA			1	V
Output High Level	V <sub>OH</sub>	I <sub>o</sub> =20mA	8			V
Output Clamp Voltage Level	V <sub>clamp</sub>			16		V
Output Rising Time	T <sub>r</sub>	C <sub>L</sub> =0.5nF		220		ns
Output Falling Time	T <sub>f</sub>	C <sub>L</sub> =0.5nF		40		ns
<b>On chip OTP Section</b>						
Over Temperature protection	OTP			150		°C

Note: F<sub>req\_Max</sub> indicates IC internal maximum clock frequency. In system application, the maximum operation frequency of 65Khz nominal occurs at maximum output power or the transition point from CV to CC.

■ OPERATION DESCRIPTION

The UTC **UPSR104** is a primary controller 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. The device integrates PWM controller to enhance the performance of discontinuous conduction mode (DCM) flyback converters.

**Startup Control**

The  $V_{DD}$  pin of UTC **UPSR104** 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 **UPSR104** 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**

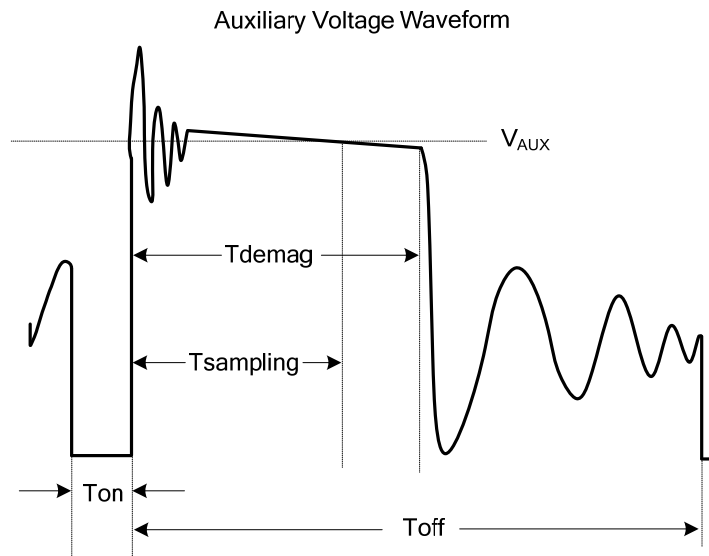
The Operating current of UTC **UPSR104** is as low as 1.6mA. Good efficiency and very low standby power can be achieved.

**Constant Voltage Operation**

The output voltage is defined by the transmission ratio between the secondary and auxiliary winding. The UTC **UPSR104** captures the auxiliary winding feedback voltage at INV pin and operates in constant-voltage (CV) mode to regulate the output voltage. The auxiliary voltage reflects the output voltage is given by:

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

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



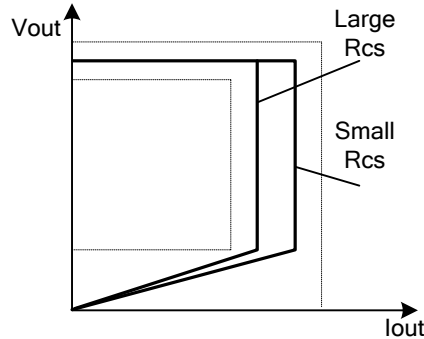
Via a resistor divider connected between the auxiliary winding and INV, the  $V_{AUX}$  is sampled at the  $T_{sampling}$  end and it is hold until the next sampling. The sampled voltage is compared with 2.0V reference voltage and the error is amplified. The error amplifier output reflects the load condition and controls the  $t_{OFF}$  time and the  $I_{PK}$  to regulate the output voltage, thus constant output voltage can be achieved.

**Constant Current Operation**

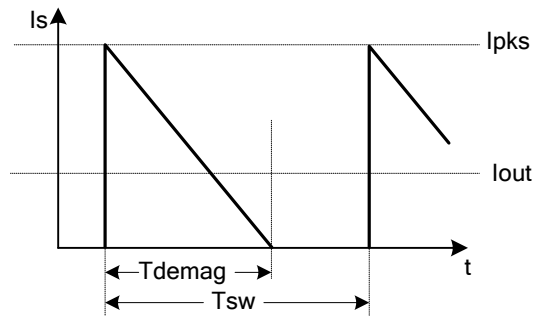
When the sampled voltage is below 2.0V reference voltage and the error amplifier output reaches its maximum, thus UTC **UPSR104** operates in constant-current (CC) mode. The CC point and maximum output power can be externally adjusted by external current sense resistor  $R_{cs}$ . The larger  $R_{cs}$ , the smaller CC point is, and the smaller output power becomes.

■ OPERATION DESCRIPTION (Cont.)

Adjustable Output Power By Changing Rcs



Secondary Current Waveform



In CC operation, the CC loop control function of UTC **UPSR104** will keep a fixed proportion between secondary inductance de-magnetization time ( $T_{demag}$ ) and switching cycle time ( $T_{sw}$ ). The fixed proportion is

$$\frac{T_{demag}}{T_{sw}} = \frac{1}{2} \tag{2}$$

Thus the output current is given by:

$$I_{out} = \frac{1}{2} \times \frac{N_p}{N_s} \times I_{pk} \times \frac{T_{demag}}{T_{sw}} = \frac{1}{4} \times \frac{N_p}{N_s} \times I_{pk} \tag{3}$$

**Programmable Cable Drop Compensation**

UTC **UPSR104** has a built-in cable voltage drop compensation to achieve good load regulation. An offset voltage is generated at INV pin by an internal current flowing into the resistor divider. The current is inversely proportional to the voltage of COMP pin. As a result, it is inversely proportional to the output load current. The voltage drop across the cable is compensated by this offset voltage at INV 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 **UPSR104**. 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 600ns leading-edge blanking is built in to avoid false-termination of the switching pulse so that the external RC filtering is no longer needed.

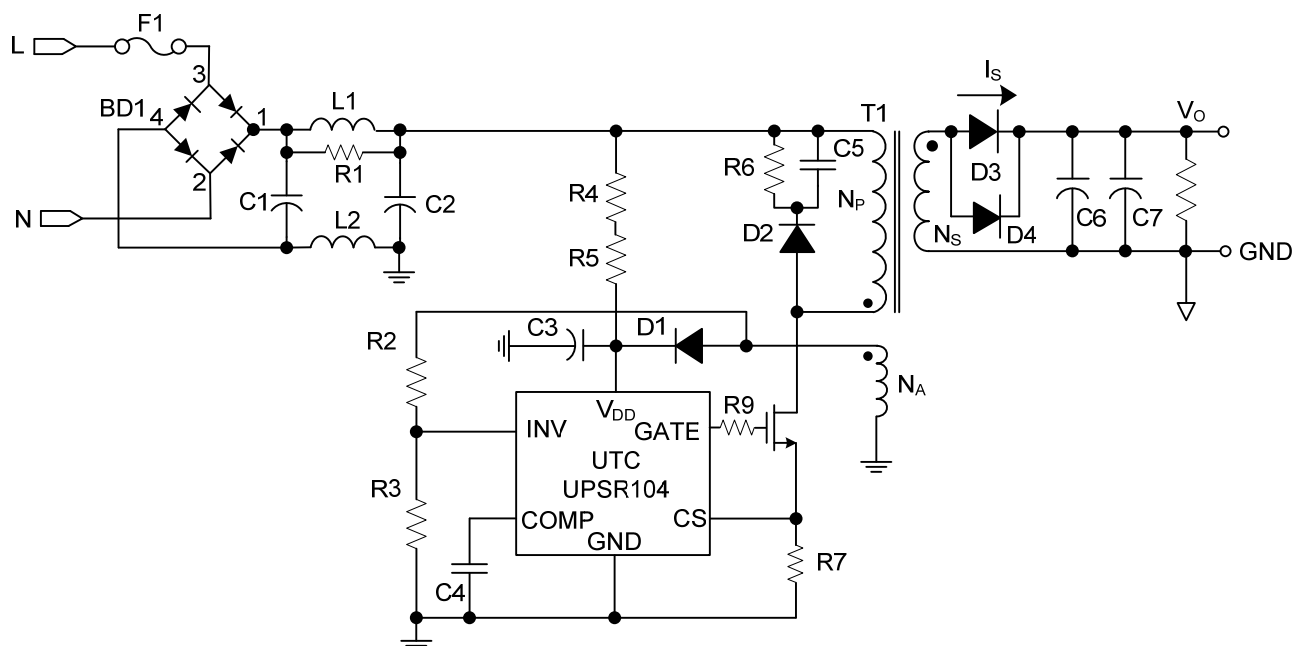
## ■ OPERATION DESCRIPTION (Cont.)

**Protection Control**

Good power supply system reliability is achieved with its comprehensive protection features including  $V_{DD}$  over-voltage protection,  $V_{DD}$  Clamp, GATE Clamp, Power on soft start, Cycle-by-cycle current limiting, short circuit protection, leading edge blanking, OTP and UVLO, etc.

$V_{DD}$  is supplied by transformer auxiliary winding output. The output of UTC **UPSR104** is shutdown when  $V_{DD}$  drops below  $V_{TH(OFF)}$  and the power converter enters power on start-up sequence thereafter.

### ■ TYPICAL APPLICATION CIRCUIT (12V / 1.25A)



### BOM

Reference	Component	Reference	Component
BD1	BD 1.5A/600V	R1	R 2.4KΩ 1206 ±5%
L1	500u H DR 6x8mm	R2	R 33KΩ 0805 ±1%
L2	4.7u H 1W	R3	R 4.3KΩ 0805 ±1%
C1	EC 10u F 400V 105°C	R4	R 1.5MΩ 1206 ±5%
C2	EC 22u F 400V 105°C	R5	R 1.5MΩ 1206 ±5%
C3	EC 4.7u F 50V 105°C	R6	R 200KΩ 1206 ±5%
C4	CC 1n F 50V 0805	R7	R 0.9Ω 1206 ±5%
C5	CC 1n F 1000V 1206	R8	R 2.7KΩ 1206 ±5%
C6	EC 680u F 16V 105°C Low-ESR	R9	R 30Ω 0805 ±5%
C7	EC 680u F 16V 105°C Low-ESR	Q1	N-MOSFET UTC 2N60
D1	Diode UTC 1N4007G	T1	EF-20
D2	Diode UTC 1N4007G	F1	FUSE 2A 250VAC
D3	Diode UTC SB3100		
D4	Diode UTC SB3100		

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