

FEATURES

- Constant-Current (CC) and Constant-Voltage (CV) Control with Primary Side Control
- Eliminates Opto-Coupler and TL431
- External Power NPN Transistor for Low Cost
- Adjustable Base Driver Improve System EMI (TC220T/1T/1P)
- Adjustable Cable compensation for all Loading (TC220E/1E/1P)
- Built-in Line Compensation
- Charger Status Indicator in Primary Side (TC221E/1T)
- Cycle-by-Cycle Current Limiting
- Over Voltage Protection (OVP)
- Over Temperature Protection (OTP)
- Open Circuit Protection
- Short Circuit Protection
- Pb-Free Device

TYPICAL APPLICATION

- Adapter/Charger for Cell/Cordless Phones, PDAs, MP3 and Other Portable Apparatus
- Standby and Auxiliary Power Supplies Set Top Boxes (STB)

DESCRIPTION

The TC2xxx controller device is optimized for high-performance, low power switching mode power supply applications. The TC2xxx facilitates CC/CV charger design by eliminating an opto-coupler and TL431. Its highly integrated functions such as Under Voltage Lockout (UVLO), Leading Edge Blanking (LEB), external adjustable base driver and cable compensation offer the users a high efficiency and low cost solution for AC/DC power applications.

Furthermore, TC2xxx features fruitful protections like OTP (Over Temperature Protection), OVP (Over Voltage Protection), and Open Circuit Protection, Short Circuit Protection to eliminate the external protection circuits and provide reliable operation. TC2xxx is available in SOT23-5, SOT23-6 and SOP8 packages.

Part #	Cable Compensation	Driving Capability	Charging Status LED driver
TC219E	Default	Default	X
TC220E	Programmable	Default	X
TC220T	Default	Programmable	X
TC221E	Programmable	Default	√
TC221T	Default	Programmable	√
TC221P	Programmable	Programmable	X

Table1: T C 2 x x x Series

TYPICAL APPLICATION CIRCUIT

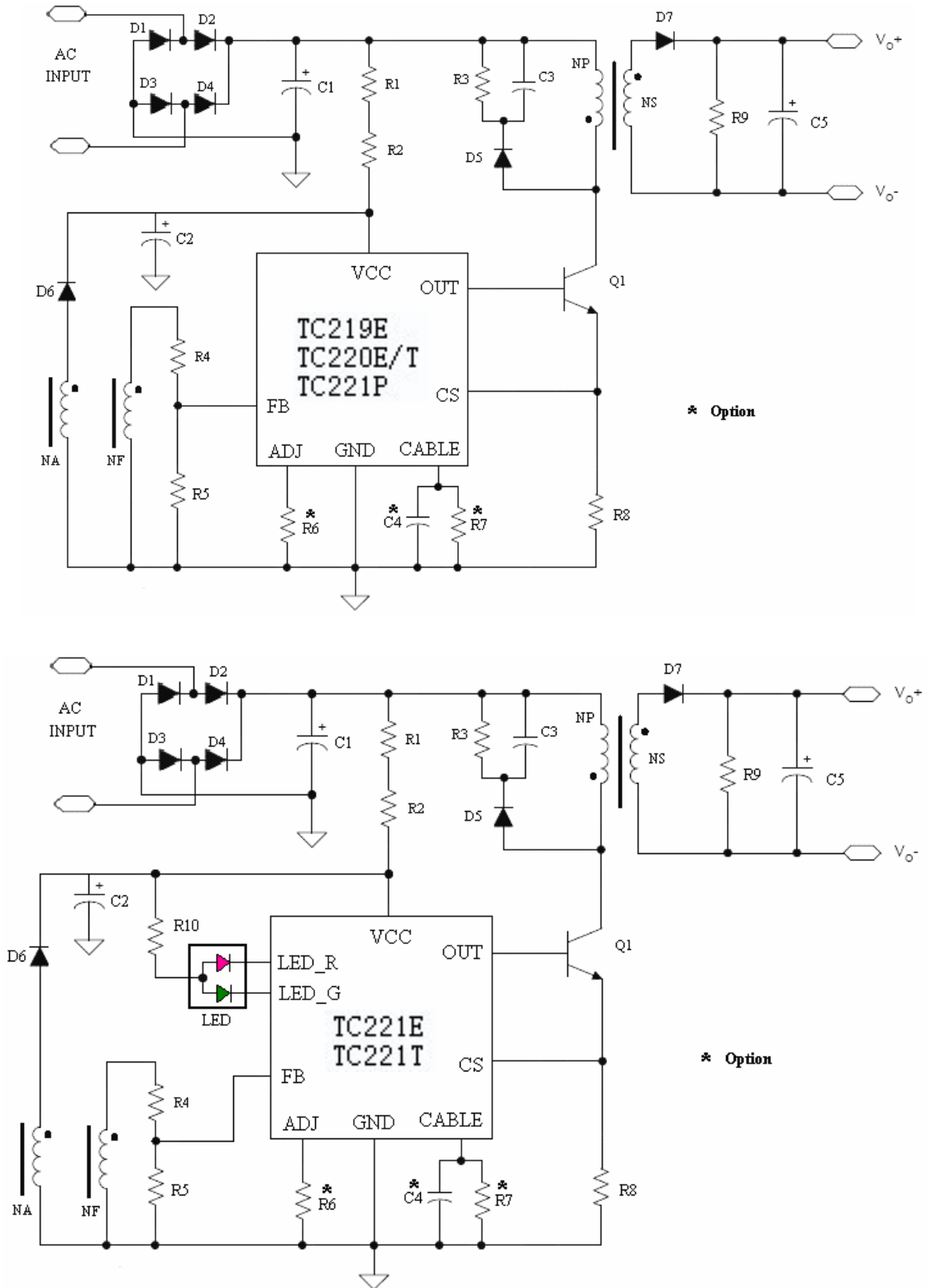
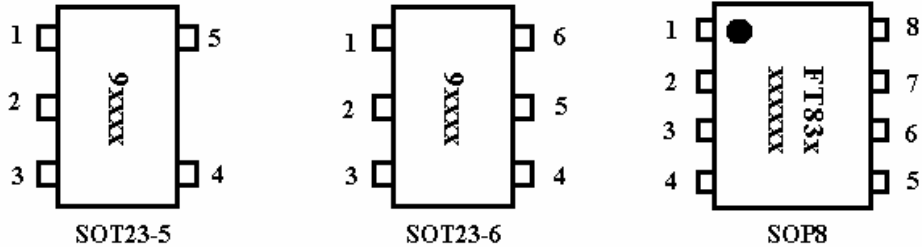


Figure 1: Typical Application Circuit

ABSOLUTE MAXIMUM RATINGS

FB to GND.....	-0.3V to +9V
CS to GND.....	-0.3V to +9V
VCC to GND.....	-0.3V to +18V
OUT to GND.....	-0.3V to +9V
LED_R to GND.....	-0.3V to +18V
LED_G to GND.....	-0.3V to +18V
CABLE to GND.....	-0.3V to +9V
ADJ to GND.....	-0.3V to +9V
Operating Temperature Range.....	-40°C to +125°C
Junction Temperature.....	-40°C to +150°C
Storage Temperature Range	-60°C to +150°C
ESD Protection HBM.....	2000V
MM.....	500V

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

PIN CONFIGURATION

Figure 2: Pin Assignments

Pat NO.	Package	Pin Definition							
		1	2	3	4	5	6	7	8
TC219E	SOT23-5	CS	FB	GND	OUT	VCC			
TC220E	SOT23-6	CS	FB	GND	OUT	VCC	CABLE		
TC220T	SOT23-6	CS	FB	GND	OUT	VCC	ADJ		
TC221E	SOP8	LED_G	LED_R	VCC	OUT	GND	FB	CS	CABLE
TC221T	SOP8	LED_G	LED_R	VCC	OUT	GND	FB	CS	ADJ
TC221P	SOP8	ADJ	NC	VCC	OUT	GND	FB	CS	CABLE

Table 2: Pin Definition
TERMINAL DEFINITION

Pin	Description
GND	Ground.
FB	Output voltage feedback pin
CS	Primary current sense
VCC	Supply voltage
OUT	NPN switch base driver
LED_R	Connect to red LED for indicating charging state
LED_G	Connect to green LED for indicating charge completed state
CABLE	Adjust cable compensation by an external resistor and capacitor to GND
ADJ	Adjust base driver current by an external resistor to GND

Table 3

ORDERING INFORMATION

Product	Ordering Information
TC219E	TC219E
TC220E	TC220E
TC220T	TC220T
TC221E	TC221E
TC221T	TC221T
TC221P	TC221P

Table 4

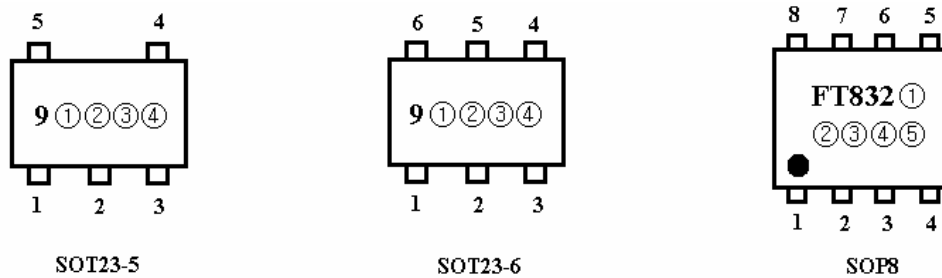
MARKING RULE

Figure 3: Marking Rule

SOT23-5/6:

- ①: Represents Version (A or T)
- ②: Represents package (a: SOT23-5; t: SOT23-6)
- ③④: for internal reference

SOP8:

- ①: Represents Version (A, T or P)
- ②③④⑤: for internal reference

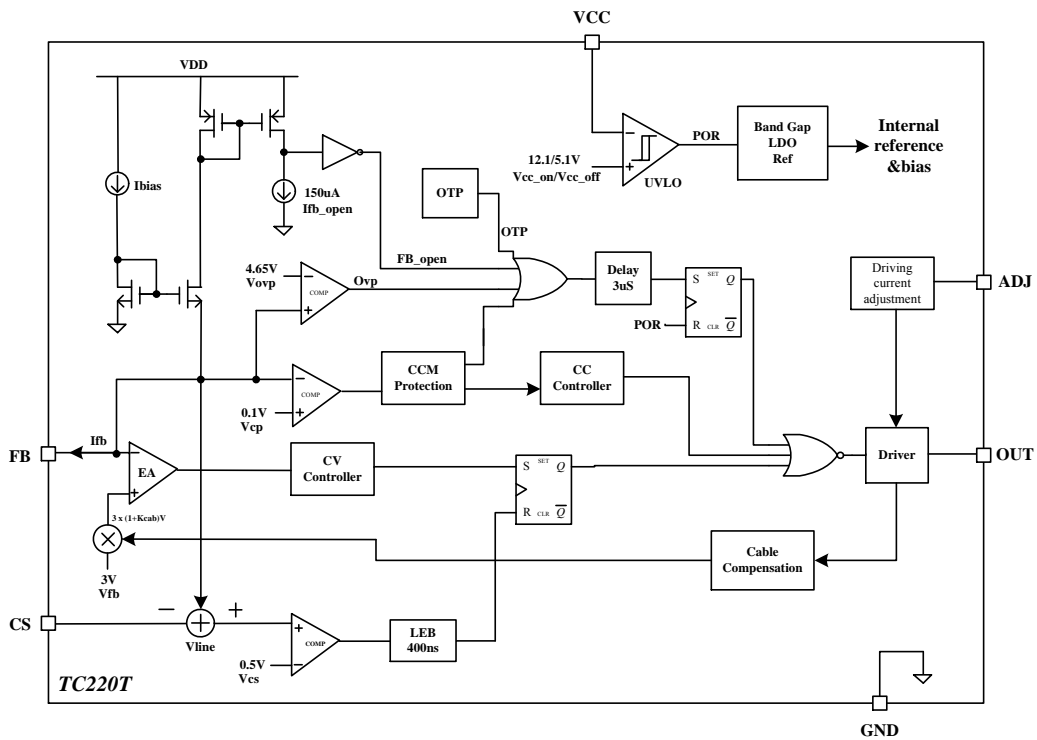


Figure 6: TC220T Block Diagram

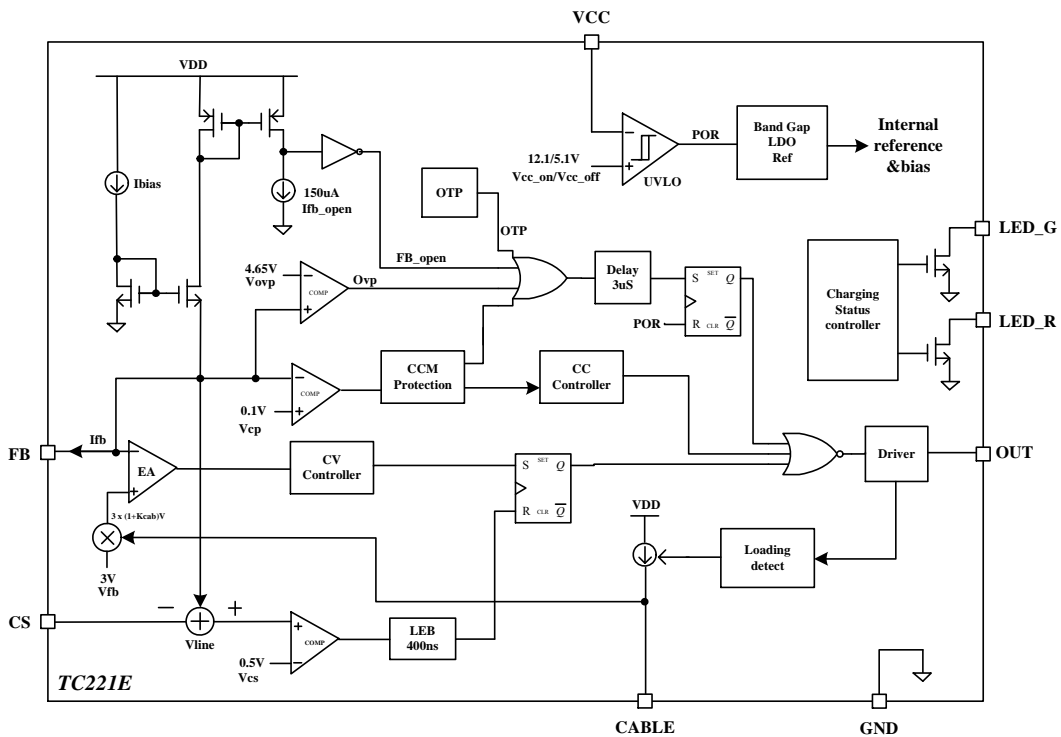


Figure 7: TC221E Block Diagram

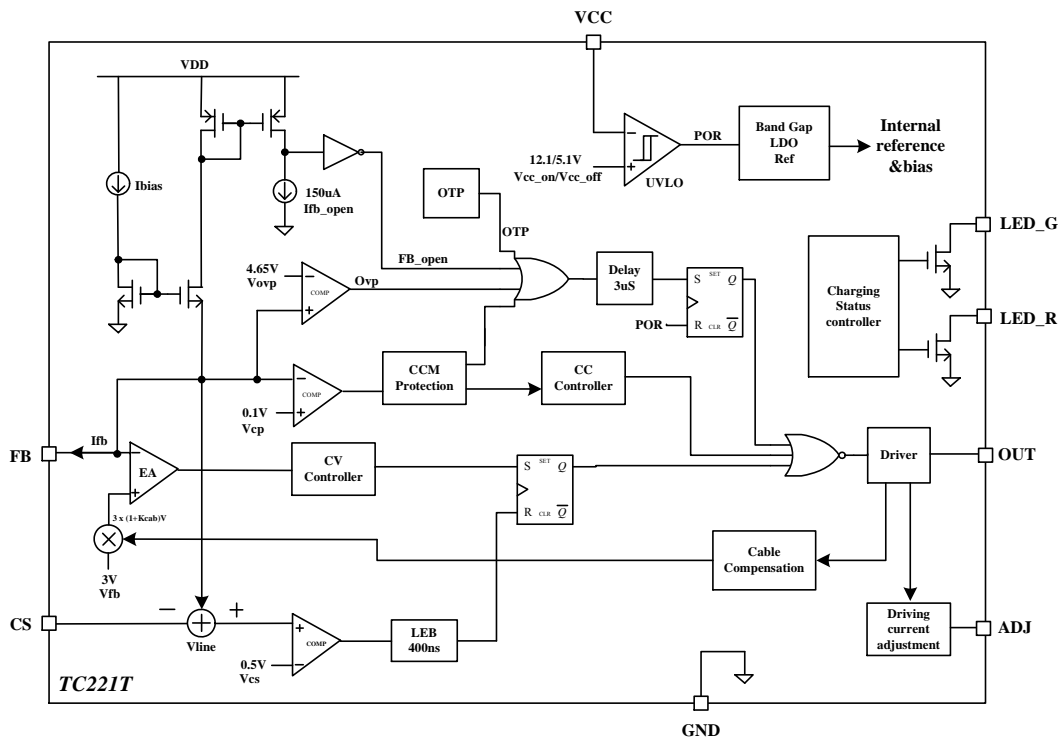


Figure8: TC221T Block Diagram

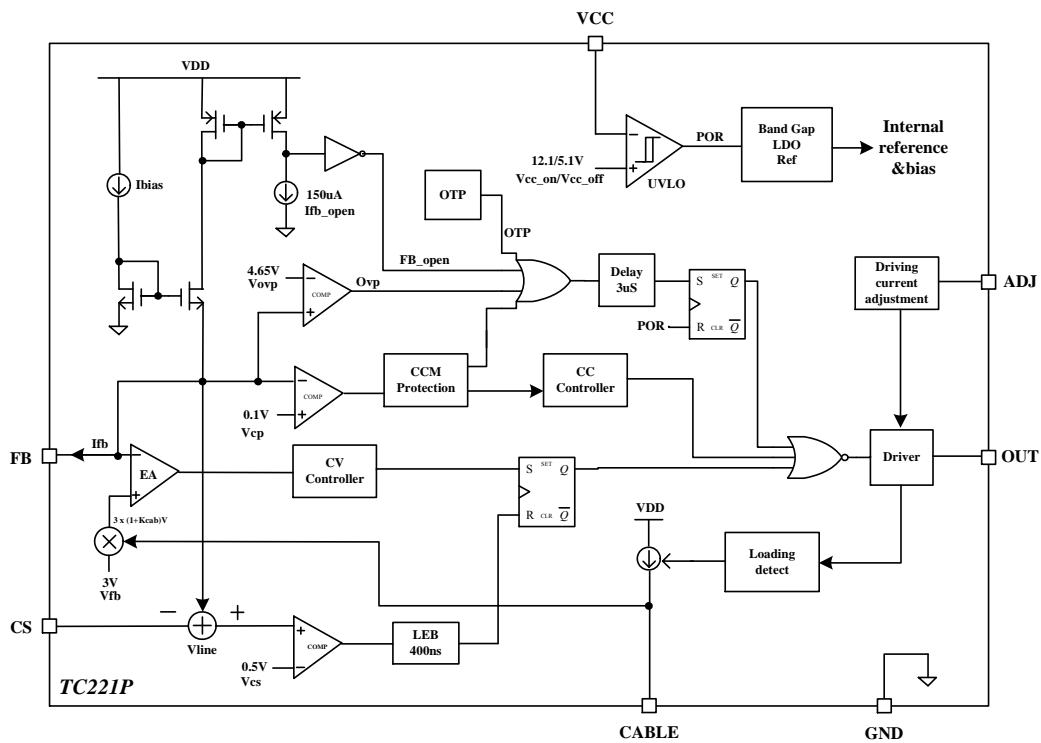


Figure 9: TC221P Block Diagram

ELECTRICAL CHARACTERISTICS

 (For typical values $T_j=25^{\circ}\text{C}$, $V_{cc}=14\text{V}$, unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Current Sense					
Maximum Current Threshold	Vcs_max	0.49	0.5	0.51	V
Pre-drive Current Threshold	Vcs_pre	0.44	0.45	0.46	V
Vcs_limit Temperature Stability (-40°C~125°C)			1		%
Leading Edge Blanking Duration	Tleb		400		ns
Propagation Delay (OUT=1.0nF to GND)	Tpd			200	ns
Feedback Section					
Feedback Voltage Threshold	Vfb	2.95	3	3.05	V
FB Pin minimum current	Ifb_open		50		μA
OVP Protection Threshold Level	Vovp	4.55	4.65	4.75	V
CCM protection Threshold Level	Vcp		0.1		V
Supply Section					
Start Up Threshold Voltage	Vcc_on	10.5	12.1	13.5	V
Under Voltage Lockout Voltage	Vcc_off	4.8	5.1	5.6	V
VCC Start Up Current	Istart_up		28		uA
Operating Current	Iop		1		mA
Protection Section					
Feedback Loop Open Protection	Ifb_open		150		uA
Over Temperature Protection	Tsd		140		°C

Table 5

ELECTRICAL CHARACTERISTICS (continues)

Characteristic	IC	Symbol	Min	Typ	Max	Unit
Base Drive						
Output Maximum Sink current		Isink	50			mA
Output Maximum Source current ($I_{source}=3.5/R_{ADJ}\times 10e+6$)	TC219E/0E/1E	Isource		23		mA
	TC220T/1T/1P			Isource		mA
Compensation Section						
Line Compensation (Ifb=1mA)		Vline		60		mV
Percentage of Output Cable Resistance Compensation ($K_{cab}=F_{op}^{*1}\times R7^{*2}\times 1.8\times 10e-12$)	TC219E/0T/1T	Kcab		4		%
	TC220E/1E/1P			Kcab		%
LED Section						
Threshold level of the red LED lighting turn to green LED lighting	TC220E	Frg ^{*3}		8		kHz
	TC221T	Frg ^{*3}		8		kHz
Threshold level of the green LED lighting turn to green LED lighting	TC221E	Cgr ^{*5}		1.1		V
	TC221T	Fgr ^{*4}		15		kHz
The Maximum Sink current for LED_R		Imr			10	mA
The Maximum Sink current for LED_G		Img			10	mA
The Leakage current for LED_R		Ikr			1	uA
The Leakage current for LED_G		Ikg			1	uA

Table 6

^{*1} (F_{op}): Switching Frequency at Full Load Condition

^{*2} (R7): Resistor connected between Pin CABLE and GND

^{*3} (Frg): Operation Frequency

^{*4} (Fgr): Operation Frequency

^{*5} (Cgr): Cable Pin Voltage

FUNCTIONAL DESCRIPTION

Operating Description

TC2xxx series are cost effective and high-performance AC-DC power supply controller for off-line low power AC-DC applications including battery chargers and adaptors. Without secondary feedback circuit, the constant voltage (CV) and constant current (CC) control can be achieved accurately.

Start up Control

Start-up current of TC2xxx is very low so that a start-up resistor with high resistance and low-wattage is allowed to supply the start-up power for the controller. The large value startup resistor can minimize the power loss in application and starts up quickly. A 1.5Mo, 0.25W start-up resistor and a 10uF/25V Vdd hold-up capacitor are sufficient for an AC-to DC power adapter.

Operating current

The operating current of TC2xxx series is as low as 1mA. Good efficiency is achieved with the low operating current together with valley turn on of the external power NPN transistor. Low operating current also reduces the Vcc hold-up capacitance requirement.

Constant voltage (CV) and constant current (CC) Operation

The TC2xxx can accurately achieve CV/CC characteristic output without secondary side voltage and current-feedback circuits. It operates in CV mode to regulate the output voltage by capturing the auxiliary winding feedback voltage at FB pin. The auxiliary winding feedback voltage is proportional to secondary winding, so it provides controller the feedback signal from secondary side and achieves constant-voltage output. In CC mode, the controller detects the secondary discharger peak current and the discharger time, which determines the off-time of the base driver to make the output average current constant. In the CV or CC mode, the primary side peak current is constant if the Res is settled.

Leading edge blanking

Each time the power NPN transistor is switched on, a turn-on spike occurs 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 disabling and cannot switch off the base driver.

Under voltage lockout (UVLO)

TC2xxx turn-on [Vcc(on)] and turn-off [Vcc(off)] are 12.1V and 5.1V. During start-up, the hold-up capacitor must to be charged to 12.1V through the start-up resistor. The hold-up capacitor continues to supply Vcc until power can be delivered from the auxiliary winding of the transformer. Vcc must not drop below 5.1V during this start-up process. This UVLO hysteresis window ensures that hold-up capacitor is sufficient to supply Vcc during start-up.

Protection control

With rich protection features of TC2xxx series, a good power supply system reliability is achieved. The protection features including cycle by cycle current limiting, Vcc over voltage protection and clamp, short circuit protection, feedback loop open protection, over temperature protection and under voltage lockout on Vcc.

Base driver

To minimize loss in the primary power NPN and prevent from second breakdown, the driving current is carefully controlled. The driving current also can be programmable externally in product TC220T, TC221T and TC221P, other products have a default driving current.

Output cable compensation

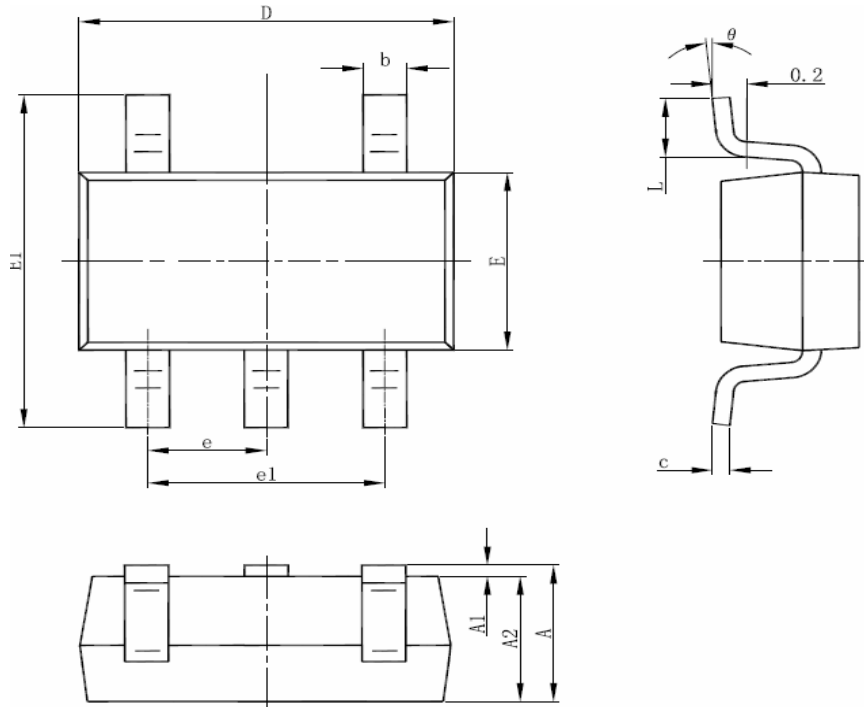
The output cable compensation provides a constant output voltage at the end of the cable over the entire load range in constant voltage mode. As the converter load increase from no-load to the peak power point, the voltage drop introduced across the output cable is compensated by increasing the feedback pin reference voltage. The correct degree of compensation can be adjustable externally in product TC220E, TC221E and TC221P. With this feature, user can conveniently determine the correct degree of compensation based on the cable selected. TC219E, TC220T and TC221T have a default correct degree of compensation, which can simplify schematic.

LED Charge Indicator

A proprietary LED charge indicator is integrated in TC221E and TC221T. In charger application, TC221E and TC221T can indicate the charge status by connecting red LED and green LED to LED_R pin and LED_G pin. The red LED indicates charging, the green LED light means the completion of charging.

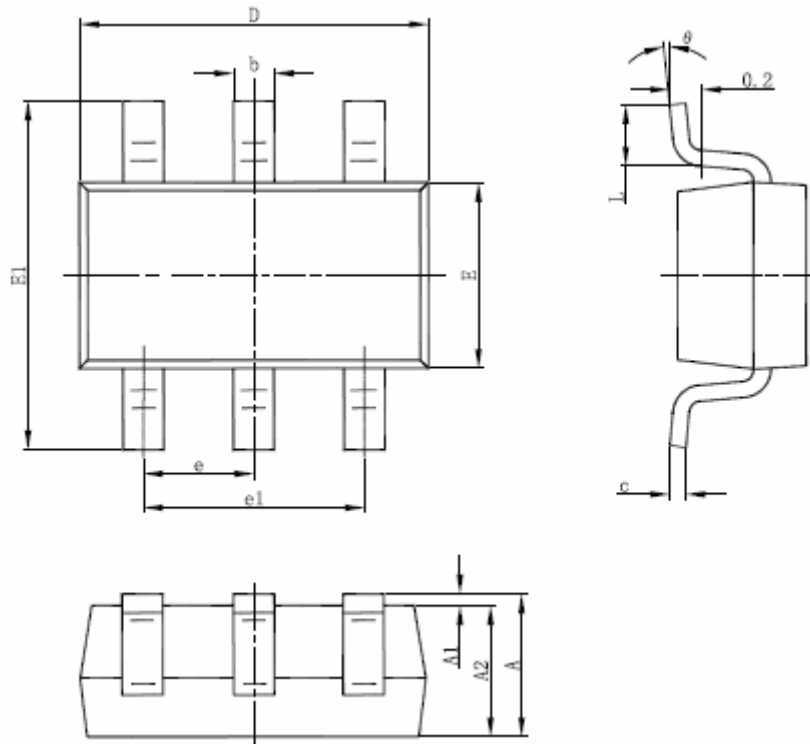
PACKAGE INFORMATION

SOT23-5 Package



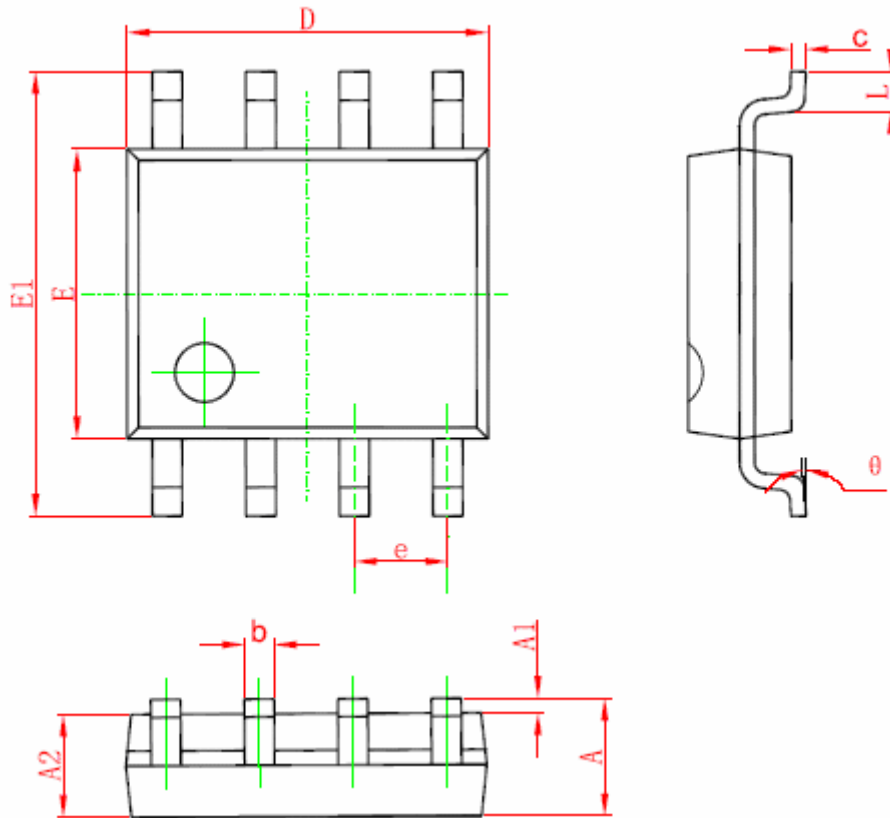
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.95 (BSC)		0.037 (BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	6°

SOT23-6 Package



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 (BSC)		0.037 (BSC)	
e1	1.800	2.000		0.079
L	0.300	0.600		0.024
θ	0°	8°	0°	8°

SOP8 Package



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.270 (BSC)		0.050 (BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

APPENDIX A: REVISION HISTORY

Version A0: Original data sheet for the TC2xxx Series.