



**FEATURES**

- 5% Constant Voltage Regulation, 5% 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
- VIN Under Voltage Lockout with Hysteresis(UVLO)
- VIN OVP
- VIN Clamp

**APPLICATIONS**

Low Power AC/DC offline SMPS for

- Cell Phone Charger
- Digital Cameras Charger
- Small Power Adapter
- Auxiliary Power for PC, TV etc.
- Linear Regulator/RCC Replacement

**GENERAL DESCRIPTION**

MT6511 is a high performance offline PWM Power switch for low power AC/DC charger and adapter applications. It operates in primary-side sensing and regulation. Consequently, opto-coupler and TL431 could be eliminated. Proprietary Constant Voltage (CV) and Constant Current (CC) control is integrated as shown in the figure below.

In CC control, the current and output power setting can be adjusted externally by the sense resistor  $R_s$  at ISEN pin. In CV control, multi-mode operations are utilized to achieve high performance and high efficiency. In addition, good load regulation is achieved by the built-in cable drop compensation. Device operates in PFM in CC mode as well at large load condition and it operates in PWM with frequency reduction at light/medium load.

MT6511 offers power on soft start control and protection coverage with auto-recovery features including Cycle-by-Cycle current limiting, VIN OVP, VIN clamp and UVLO. Excellent EMI performance is achieved with frequency shuffling technique.

High precision constant voltage (CV) and constant current (CC) can be achieved by MT6511.

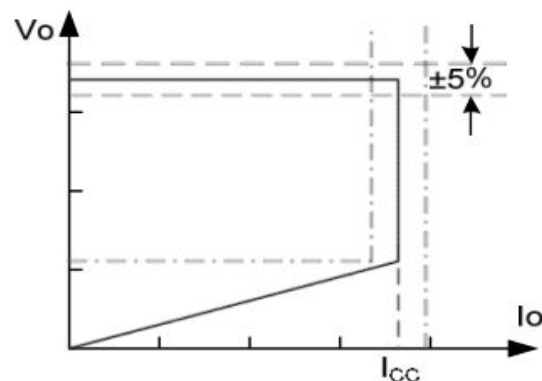
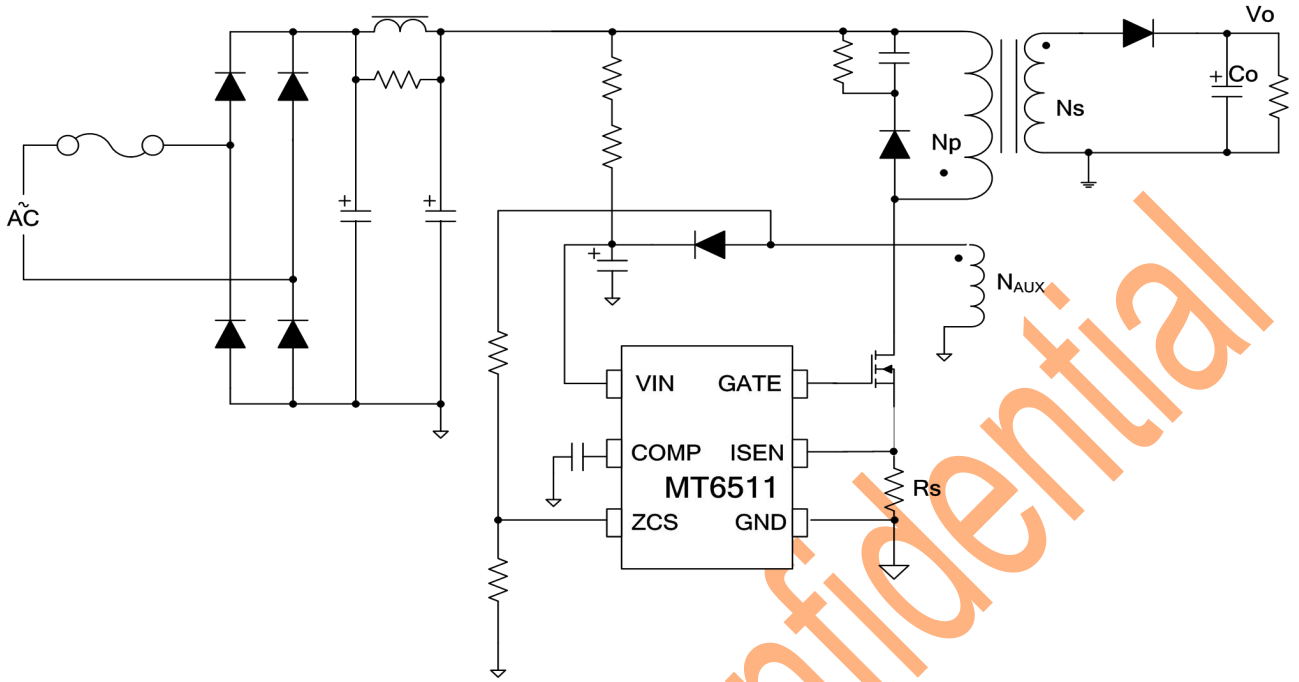


Fig.1. Typical CC/CV Curve

## TYPICAL APPLICATION

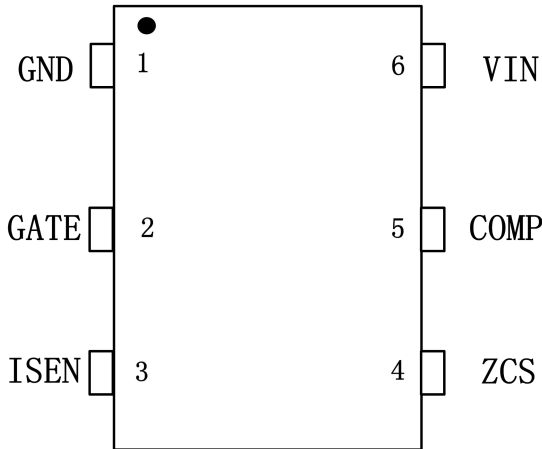


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## GENERAL INFORMATION

### Pin Configuration

The pin map is shown as below for SOT23-6



### Ordering Information

Part Number	Description
MT6511CP	SOT23-6,Pb-free,Tube
MT6511CPA	SOT23-6,Pb-free,T&R

### Package Dissipation Rating

Package	R $\theta$ JA (°C/W)
SOT23-6	200

**NOTE:** Drain Pin Connected 100mm<sup>2</sup> PCB copper clad.

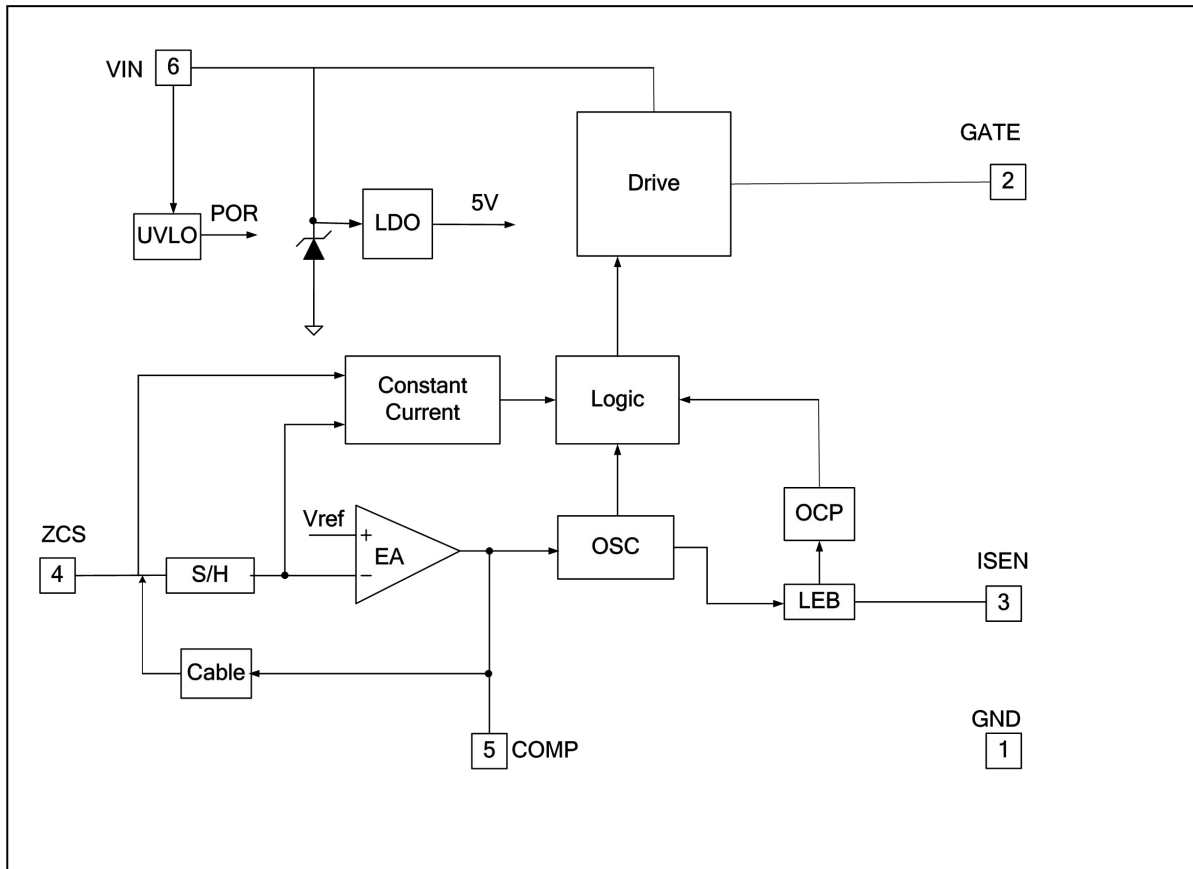
Parameter	Value
Drain Voltage (off state)	-0.3V to Bvdss
VIN Zener Clamp Continuous Current	10 mA
COMP Voltage	-0.3 to 7V
ISEN Input Voltage	-0.3 to 7V
ZCS Input Voltage	-0.3 to 7V
Min/Max Operating Junction Temperature T <sub>J</sub>	-20 to 150°C
Min/Max Storage Temperature T <sub>stg</sub>	-55 to 150°C
Lead Temperature (Soldering, 10secs)	260°C

**Note:** Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute maximum-rated conditions for extended periods may affect device reliability.

## TERMINAL ASSIGNMENTS

Pin Num	Pin Name	I/O	Description
1	GND	P	Ground
2	GATE	O	Gate driver output for power MOSFET
3	ISEN	I	Current Sense
4	ZCS	I	The voltage feedback from auxiliary winding. Connected to resistor divider From auxiliary winding reflecting output voltage. PWM duty cycle is determined by EA output and current sense signal at pin4.
5	COMP	I	Loop Compensation for CV Stability
6	VIN	P	Power Supply

## BLOCK DIAGRAM



## ELECTRICAL CHARACTERISTICS

(T<sub>A</sub> = 25°C, VIN=16V, if not otherwise noted)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
<b>Supply Voltage(VIN) Section</b>						
I <sub>DD ST</sub>	Stand by Current	VIN=13V		5	20	uA
I <sub>DD op</sub>	Operation Current	Operation supply current ZCS=2V,ISEN=0V,VIN=20V	-	2	3	mA
UVLO(OFF)	VIN Under Voltage Lock out Enter	VIN falling	8	9	10	V
UVLO(ON)	VIN Under Voltage Lockout Exit	VIN rising	13.5	14.8	16.0	V
OVP	Over voltage protection Threshold	Ramp VIN until gate shutdown	26	27.5	29	V
<b>Current Sense Input Section</b>						
TLEB	LEB time			625		ns
Vth_oc	Over current threshold		880	910	940	mV
Td_oc	OCP Propagation delay			150		ns
ZSENSE_IN	Input Impedance		50			Kohm
T <sub>ss</sub>	Soft start time			17		ms
<b>Frequency Section</b>						
Freq_Max <sup>Note1</sup>	IC Maximum frequency		55	60	65	KHz
Freq_Nom	System Nominal switch frequency			50		KHz
Freq_startup		ZCS=0V,Comp=5V		14		KHz
Δf/Freq	Frequency shuffling range			±4		%
<b>Error Amplifier section</b>						
Vref_EA	Reference voltage for EA		1.97	2	2.03	V
Gain	DC gain of EA			60		dB
I <sub>COMP_MAX</sub>	Max. Cable compensation current	ZCS=2V,Comp=0V		37.5		uA
<b>Power MOSFET Section</b>						
V <sub>clamp</sub>	Output clamp voltage			16		V
Tr	Output rising time	CL=0.5nF		650		ns
Tf	Output falling time	CL=0.5nF		40		ns

**Note:**

1. Freq\_Max indicates IC internal maximum clock frequency. In system application, the maximum operation frequency of 60Khz nominal occurs at maximum output power or the transition point from CV to CC.

## OPERATIONDESCRIPTION

MT6511 is a cost effective PWM power switch optimized for off-line low power AC/DC applications including battery chargers and adapters. It operates in primary side sensing and regulation, thus opto-coupler and TL431 are not required. Proprietary built-in CV and CC control can achieve high precision CC/CV control meeting most adapter and charger application requirements.

### Start up current and Start up control

Start up current of MT6511 is designed to be very Low so that VIN could be charged up above UVLO threshold and starts up quickly. A large value start-up resistor can therefore be used to minimize the power loss in application.

### Operating Current

The Operating current of MT6511 is as low as 2.5mA. Good efficiency is achieved with the low operating current together with 'Multi-mode' control features.

### Soft Start

MT6511 features an internal soft start to minimize the component electrical over-stress during power on start-up. As soon as VIN reaches UVLO (ON), the control algorithm will ramp peak current voltage threshold gradually from nearly zero to normal setting of 0.90V. Every restart is a soft start.

## CC/CV Operation

MT6511 is designed to produce good CC/CV control characteristic as shown in the Fig.1. In charger applications, a discharged battery charging starts in the CC portion of the curve until it is nearly full charged and smoothly switches to operate in CV portion of the curve. In an AC/DC adapter, the normal operation occurs only on the CV portion of the curve. The CC portion provides output current limiting. In CV operation, the output voltage is regulated through the primary side control. In CC operation mode, MT6511 will regulate the output current constant regardless of the output voltage drop.

### Principle of Operation

To support MT6511 proprietary CC/CV control, system needs to be designed in DCM mode for fly-back system (Refer to Typical Application Diagram on page 1).

In the DCM fly-back converter, the output voltage can be sensed via the auxiliary winding. During MOSFET turn-on time, the load current is supplied from the output filter capacitor Co. The current in the primary winding ramps up. When MOSFET turns off, the primary current transfers to the secondary at the amplitude of

$$I_s = \frac{N_p}{N_s} \times I_p \quad (1)$$

The auxiliary voltage reflects the output voltage as shown in Figure.2 and it is given by

$$V_{AUX} = \frac{N_{AUX}}{N_s} \times (V_o + \Delta V) \quad (2)$$

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

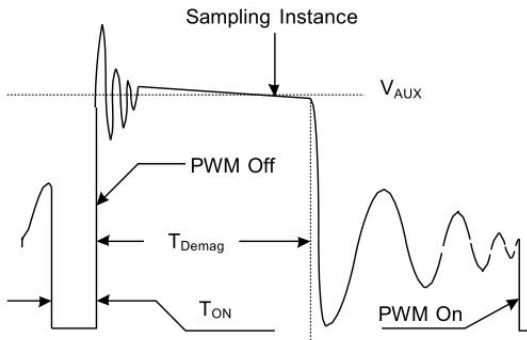


Figure 2. Auxiliary voltage waveform

Via a resistor divider connected between the auxiliary winding and ZCS (pin 3), the auxiliary voltage is sampled at the end of the demagnetization and it is hold until the next sampling. The sampled voltage is compared with  $V_{ref}$  (2.0V) and the error is amplified. The error amplifier output COMP reflects the load condition and controls the PWM switching frequency to regulate the output voltage, thus constant output voltage can be achieved. When sampled voltage is below  $V_{ref}$  and the error amplifier output COMP reaches its maximum, the switching frequency is controlled by the sampled voltage thus the output voltage to regulate the output current, thus the constant output current can be achieved.

### Adjustable CC point and Output Power

In MT6511, the CC point and maximum output power can be externally adjusted by external current sense resistor  $R_s$  at ISEN pin as illustrated in Typical Application Diagram. The output power is adjusted through CC point change. The larger  $R_s$ , the smaller CC point is, and the smaller output power becomes, and vice versa as shown in Fig.3

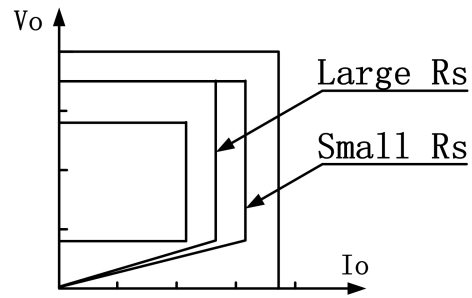


Figure 3. Adjustable output power by changing  $R_s$

### Operation switching frequency

The switching frequency of MT6511 is adaptively controlled according to the load conditions and the operation modes. No external frequency setting components are required. The operation switching frequency at maximum output power is set to 60KHz internally.

For fly-back operating in DCM, The maximum Output power is given by

$$P_{MAX} = \frac{1}{2} \times L_p \times F_{SW} \times I_p^2 \quad (3)$$

Where  $L_p$  indicate the inductance of primary winding and  $I_p$  is the peak current of primary winding. Refer to the equation 3, the change of the primary winding inductance results in the change of the maximum output power and the constant output current in CC mode. To compensate the change from variations of primary winding inductance, the switching frequency is locked by an internal loop such that the switching frequency is

$$F_{SW} = \frac{1}{2T_{Demag}} \quad (4)$$

Since  $T_{Demag}$  is inversely proportional to the inductance, as a result, the product  $L_p$  and  $f_{sw}$  is constant, thus the maximum output power and constant current in CC mode will not change as primary winding inductance changes. Up to



±10% variation of the primary winding inductance can be compensated.

totem pole gate design with right output strength control.

## Frequency shuffling for EMI improvement

The frequency shuffling (switching frequency modulation) is implemented in MT6511. The oscillation frequency is modulated so that the tone energy is spread out. The spread spectrum minimizes the conduction band EMI and therefore eases the system design.

## Current Sensing and Leading Edge Blanking

Cycle-by-Cycle current limiting is offered in MT6511 current mode PWM control. The switch current is detected by a sense resistor into the ISEN pin. An internal leading edge blanking circuit chops off the sensed voltage spike at initial internal power MOSFET on state so that the external RC filtering on sense input is no longer needed. The PWM duty cycle is determined by the current sense input voltage and the EA output voltage.

## Gate Drive

The internal power MOSFET in MT6511 is driven by a dedicated gate driver for power switch control. Too weak the gate drive strength results in higher conduction and switch loss of MOSFET while too strong gate drive compromises EMI.

A good trade-off is achieved through the built-in

## Programmable Cable drop Compensation

In MT6511, cable drop compensation is implemented to achieve good load regulation. An offset voltage is generated at ZCS by an internal current flowing into the resistor divider. The current is inversely proportional to the voltage across pin COMP, as a result, it is inversely proportional to the output load current, thus the drop due to the cable loss can be compensated. As the load current decreases from full-load to no-load, the offset voltage at ZCS will increase. It can also be programmed by adjusting the resistance of the divider to compensate the drop for various cable lines used.

## Protection Control

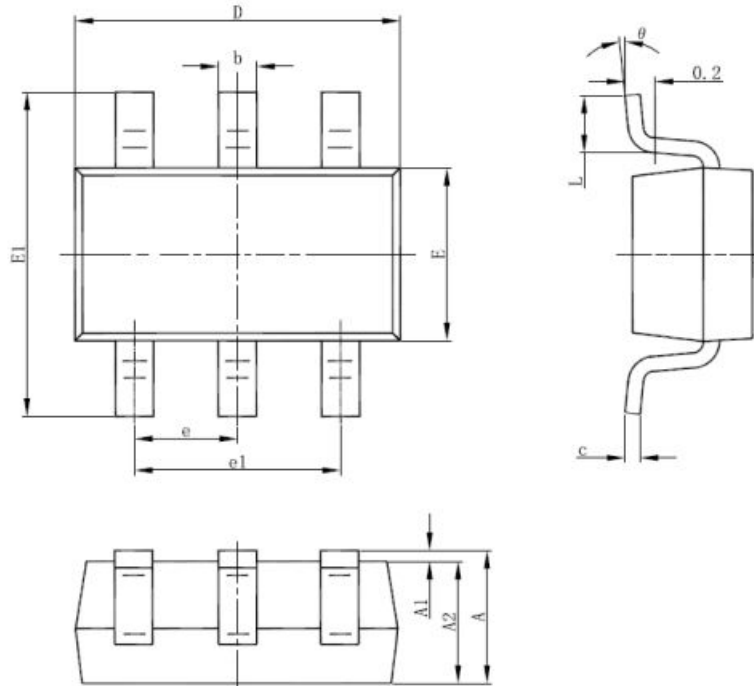
Good power supply system reliability is achieved with its rich protection features including Cycle-by-Cycle current limiting (OCP), VIN clamp, Power on Soft Start, and Under Voltage Lockout on VIN (UVLO).

VIN is supplied by transformer auxiliary winding output. The output of MT6511 is shut down when VIN drops below UVLO (OFF) limit and Switcher enters power on start-up sequence thereafter.



## PACKAGE MECHANICAL DATA

### SOT23-6L PACKAGE OUTLINE DIMENSIONS



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.000	1.450	0.039	0.057
A1	0.000	0.150	0.000	0.006
A2	0.900	1.300	0.035	0.051
b	0.300	0.500	0.012	0.020
c	0.080	0.220	0.003	0.009
D	2.800	3.020	0.110	0.119
E	1.500	1.726	0.059	0.068
E1	2.600	3.000	0.102	0.118
e	0.950(BSC)		0.037(BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
theta	0°	8°	0°	8°