ZHEJIANG UNIU-NE Technology CO.,LTD

浙 江 宇 力 微 新 能 源 科 技 有 限 公 司

# U6116 Data Sheet

V 1.1

## General Description

U6116 is a high performance Primary Side Regulation (PSR) controller with high precision CV/CC control ideal for charger applications. The IC can also support Quasi-Resonant(QR) Buck constant current topology for LED lighting if SEL pin is short to GND.In CV mode, U6116 adopts Multi Mode Control which uses the hybrid of AM (Amplitude Modulation) mode and (Frequency Modulation) FM mode to improve system efficiency and reliability.In CC mode.the IC uses PFM control with line and load CC compensation.The IC can achieve audio noise free operation and optimized dynamic response.The built-in Cable Drop Compensation (CDC) function can provide excellent CV performance.U6116 integrates functions and protections of Under Voltage Lockout (UVLO), VDD over Voltage Protection (VDD OVP),Cycle-by-cycle Current Limiting (OCP), Short Load Protection (SLP), Gate Clamping,and VDD Clamping.

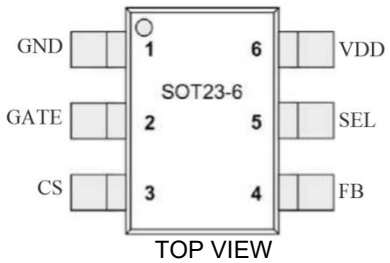
## Applications

- Battery Chargers for Cellular Phones
- AC/DC Power Adapter
- LED Drivers

## Key Features

- Support Flyback and Buck Topology:
  Flyback PSR Control (SEL= Floating)
  QR-Buck CC Control (SEL= GND)
- Multi Mode PSR Control
- Audio Noise Free Operation for PSR
- Optimized Dynamic Response for PSR
- Low Standby Power <70mW
- ±4% CC and CV Regulation
- Programmable Cable Drop Compensation： (CDC) in PSR CV Mode
- Built-in AC Line & Load CC Compensation
- Build in Protections:
  Short Load Protection (SLP)
  On-Chip Thermal Shutdown (OTP)
  Cycle-by-Cycle Current Limiting
  Leading Edge Blanking (LEB)
  Pin Floating Protection
- VDD UVLO OVP & Clamp
- Package (SOT23-6)

## Package Information

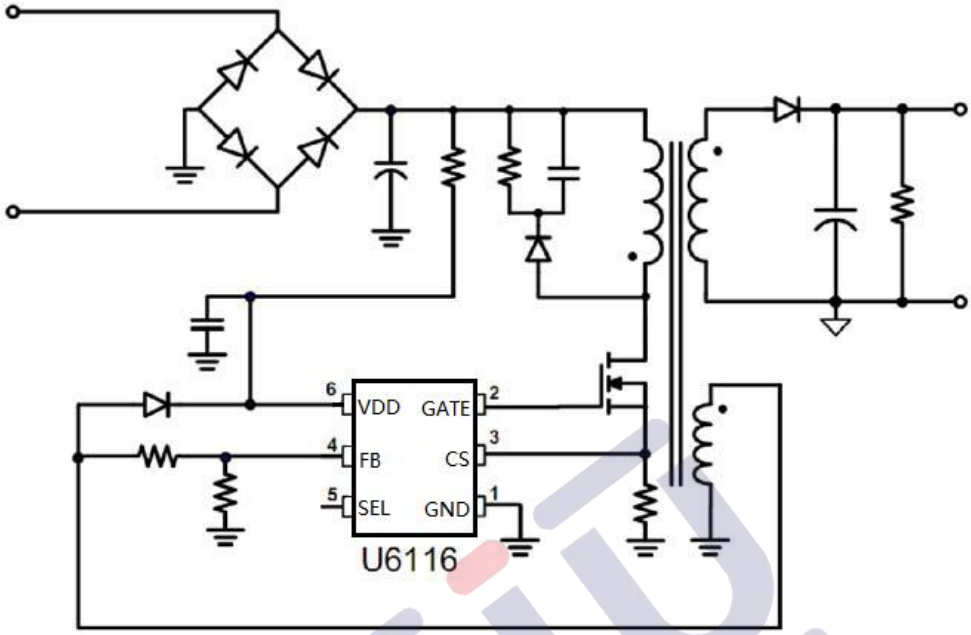


TOP VIEW

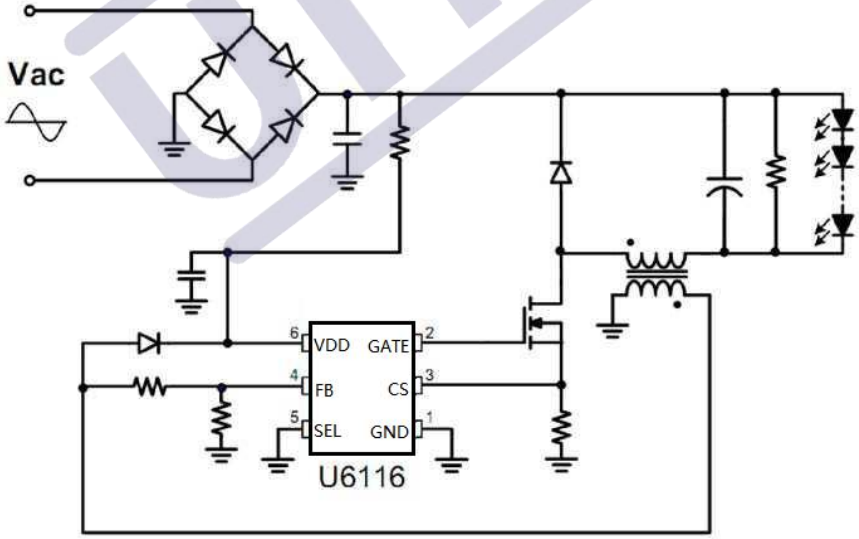
## Pin Configuration

| Pin Number | Pin Name | Function |
|---|---|---|
| 1 | GND | The Ground of the IC |
| 2 | GATE | Gate Driver for External MOSFET Switch |
| 3 | CS | Current Sense Input Pin |
| 4 | FB | System feedback pin which regulates both the output voltage in CV mode and output current in CC mode based on the flyback voltage of the auxiliary winding |
| 5 | SEL | Select Buck or Flyback configuration. Leave this pin floating for Flyback PSR control, while tying to GND for QR-Buck control |
| 6 | VDD | Power Supply Pin of the Chip |

## Typical Application Circuit

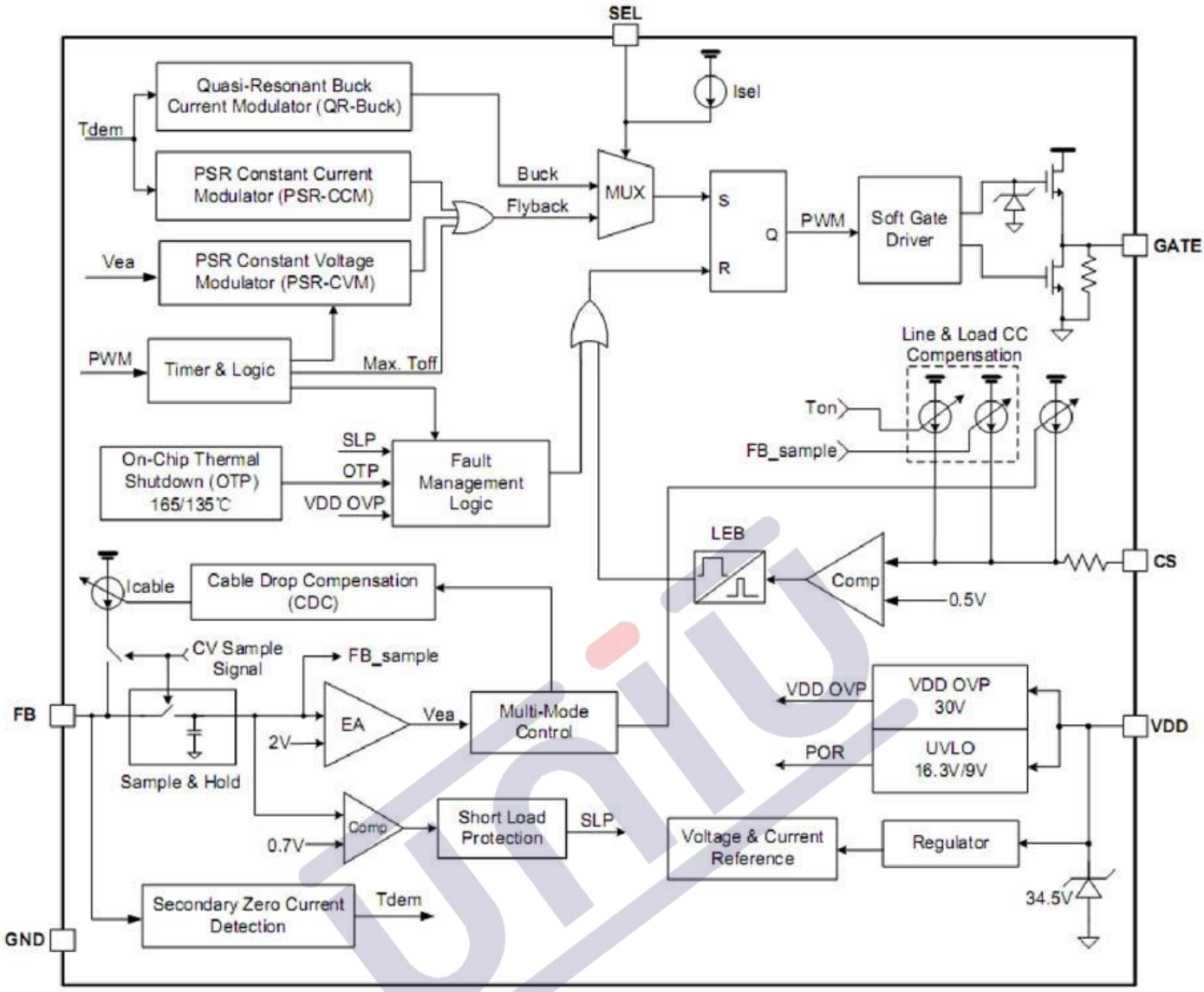



**(Charger Application)**




**(LED Lighting Application)**

## Block Diagram




## Absolute Maximum Ratings (Note 1)

| Parameter | Value | Unit |
|---|---|---|
| VDD DC Supply Voltage | 34.5 | V |
| VDD DC Clamp Current | 10 | mA |
| GATE pin | 20 | V |
| CS, SEL voltage range | -0.3 to 7 | V |
| FB voltage range | -0.7 to 7 | V |
| Package Thermal Resistance (SOT-26) | 250 | ℃/W |
| Maximum Junction Temperature | 150 | ℃ |
| Operating Temperature Range | -40 to 85 | ℃ |
| Storage Temperature Range | -65 to 150 | ℃ |
| Lead Temperature (Soldering, 10sec.) | 260 | ℃ |
| ESD Capability, HBM (Human Body Model) | 3 | kV |
| ESD Capability, MM (Machine Model) | 250 | V |

## Electrical Characteristics(ta = 25°c, unless otherwise specified)

| Parameter | Symbol | Test Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **Supply Voltage Section(VDD Pin)** | | | | | | |
| Start-up current into VDD pin | $I_{VDD\_ST}$ | | — | 2 | 20 | uA |
| Operation Current | $I_{VDD\_OP}$ | VFB=3V,GATE=0.5nF, VDD=20V | — | 1 | 1.5 | mA |
| Standby Current | $L_{VDD\_standby}$ | | — | 0.5 | 1 | mA |
| VDD Under Voltage Lockout Exit | $V_{DD\_ON}$ | | 15 | 16.3 | 17.5 | V |
| VDD Under Voltage Lockout Enter | $V_{DD\_OFF}$ | | 8 | 9 | 10 | V |
| VDD OVP Threshold | $V_{DD\_OVP}$ | | 28 | 30 | 32 | V |
| VDD Zener Clamp Voltage | $V_{DD\_Clamp}$ | I($V_{DD}$ ) = 7 mA | 32.5 | 34.5 | 36.5 | V |
| **Control Function Section (FB Pin)** | | | | | | |
| Internal Error Amplifier (EA) Reference Input | $V_{FB\_REF}$ | | 1.97 | 2.0 | 2.03 | V |
| Short Load Protection (SLP) Threshold | $V_{FB\_SLP}$ | | — | 0.7 | — | V |
| Short Load Protection (SLP) Debounce Time | $T_{FB\_SHORT}$ | | — | 10 | — | ms |
| Demagnetization Comparator Threshold | $V_{FB\_DEM}$ | | — | 25 | — | mV |
| Minimum OFF time | $T_{Off\_min}$ | (Note 3) | — | 2 | — | us |
| Maximum OFF time | $T_{Off\_max}$ | | — | 5 | — | ms |
| Maximum Cable Drop compensation current | $I_{cable\_max}$ | | — | 63 | — | uA |
| **Current Sense Input Section (CS Pin)** | | | | | | |
| CS Input Leading Edge Blanking Time | $T_{LEB}$ | | — | 500 | — | ns |
| Current limiting threshold | $V_{cs(max)}$ | | 490 | 500 | 510 | mV |
| Over Current Detection and Control Delav | $T_{D\_OCP}$ | GATE=0.5nF | — | 100 | — | ns |
| **GATE Driver Section (GATE Pin) (Note 3)** | | | | | | |
| CS Input Leading Edge Blanking Time | $V_{G\_Clamp}$ | VDD=24V | — | 16 | — | V |
| Output Rising Time | $T_{\_R}$ | GATE=0.5nF | — | 700 | — | ns |
| Output Falling Time | $T_{\_F}$ | GATE=0.5nF | — | 40 | — | ns |
| **Flyback or Buck Selection Section (SEL Pin)** | | | | | | |
| SEL Pin Floating Voltage | $V_{SEL(floating)}$ | (Note 3) | — | 5.7 | — | V |
| Internal SEL Pin Pull up Current | $I_{SEL}$ | (Note 3) | — | 35 | — | uA |
| **Over Temperature Protection** | | | | | | |
| Thermal Shutdown | $T_{SD}$ | (Note 3) | | 165 | | ℃ |
| Thermal Recovery | $T_{RC}$ | (Note 3) | | 135 | | ℃ |

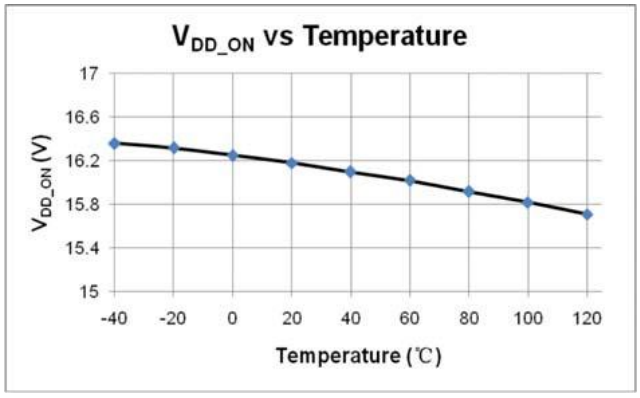
Note:

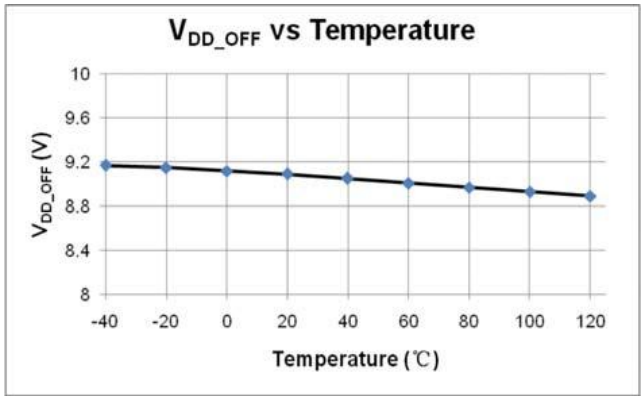
1.Stresses listed as the above "Maximum Ratings" may cause permanent damage to the device.These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to maximum rating conditions for extended periods may remain possibility to affect device reliability.

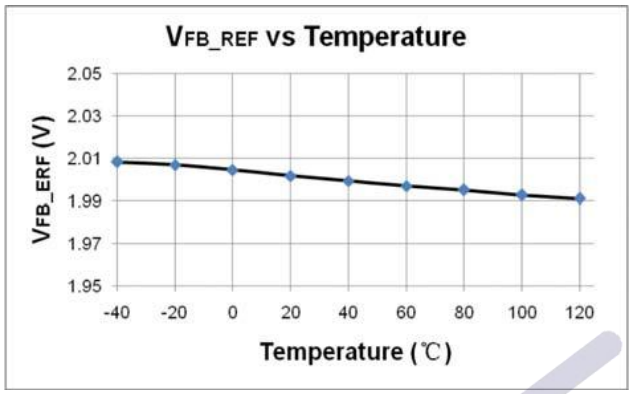
2.The device is not guaranteed to function outside its operating conditions.

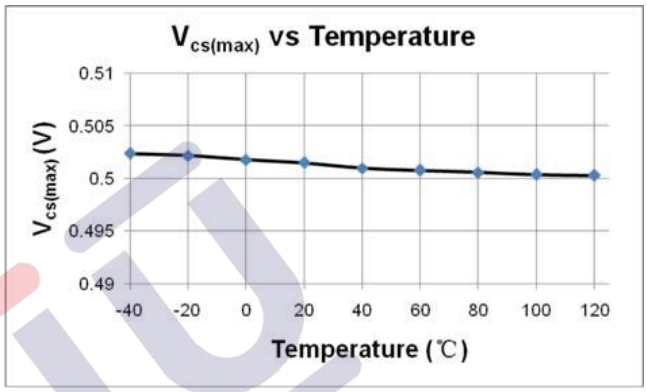
3.Guaranteed by the Design.

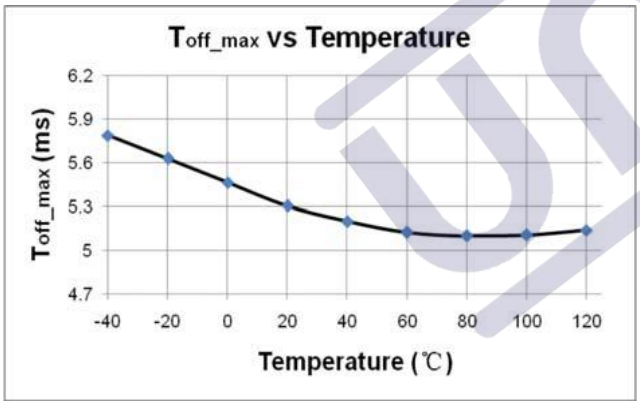
## Characterization Plots

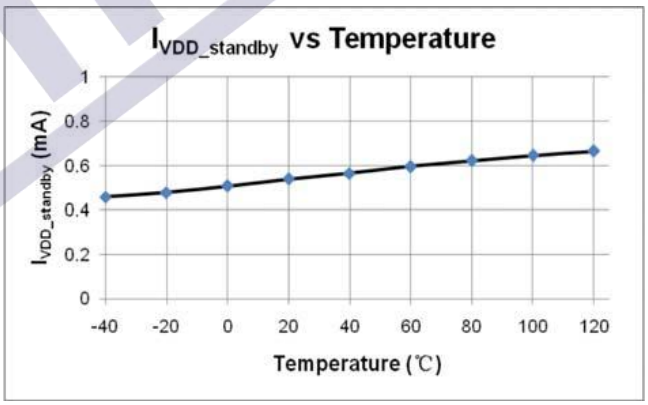


# Peration Description

U6116 is a high performance, multi mode, highly integrated DCM (Discontinuous Conduction Mode) Primary Side Regulation (PSR) controller. The built-in high precision CV/CC control with high level protection features makes it suitable for offline small power converter applications.

## System Start-Up Operation

Before the IC starts to work, it consumes only startup current (typically 2uA) which allows a large value startup resistor to be used to minimize the power loss and the current flowing through the startup resistor charges the VDD hold-up capacitor from the high voltage DC bus. When VDD reaches UVLO turn-on voltage of 16.3V (typical), U6116 begins switching and the IC operation current is increased to be 1mA (typical). The hold-up capacitor continues to supply VDD before the auxiliary winding of the transformer takes the control of VDD voltage.

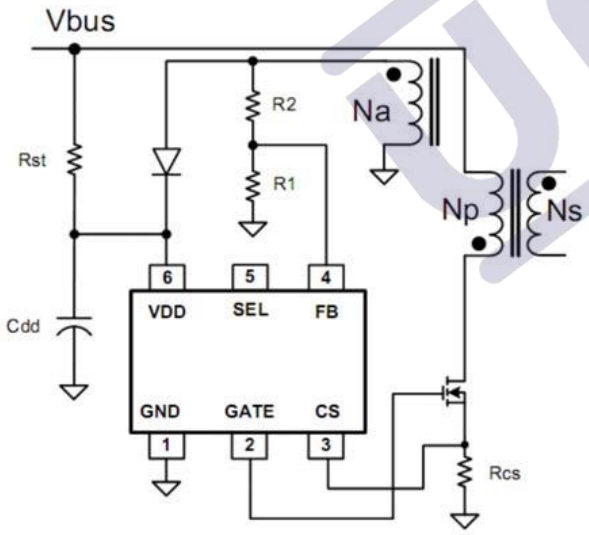



Fig.1

Once U6116 enters very low frequency FM (Frequency Modulation) mode, the operating current is reduced to be 0.5mA typically, which helps to reduce the standby power loss.

## PSR Constant Voltage Modulation (PSR-CCM)

In primary side control, the output voltage is sensed on the auxiliary winding during the transfer of transformer energy to the secondary. Fig.2 illustrates the CV sampling signal timing waveform in U6116. As shown in Fig.2, it is clear that there is a down slope representing a decreasing total rectifier Vf and its voltage drop as the secondary current decreases to zero. To achieve an accurate representation of the secondary output voltage on the auxiliary winding, the CV sampling signal blocks the leakage inductance reset and ringing. When the CV sampling process is over, the internal sample/hold (S&H) circuit captures the error signal and amplifies it through the internal Error Amplifier (EA). The output of EA is sent to the Primary Side Constant Voltage Modulator (PS-CVM) for CV control. The internal reference voltage for EA is trimmed to 2V with high accuracy.

During the CV sampling process, an internal variable current source is flowing to FB pin for Cable Drop Compensation (CDC). Thus, there is a step at FB pin in the transformer demagnetization process, as shown in Fig.2. Fig.2 also illustrates the equation for “demagnetization plateau”， where Vo and VF is the output voltage and diode forward voltage; R1 and R2 is the resistor divider connected from the auxiliary winding to FB Pin, Ns and Na are secondary winding and auxiliary winding respectively.

When system enters over load condition, the output voltage falls down and the FB sampled voltage should be lower than 2V internal reference which makes system enter CC Mode automatically.

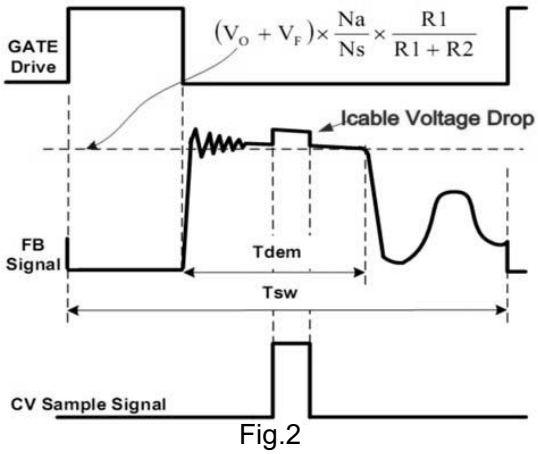



Fig.2

## PSR Constant Current Modulation (PSR-CCM)

Timing information at the FB pin and current information at the OS pin allow accurate regulation of the secondary average current. The control law dictates that as power is increased in CV regulation and approaching CC regulation the primary peak In U6116, current is at Ipp(max), as shown in Fig.3.

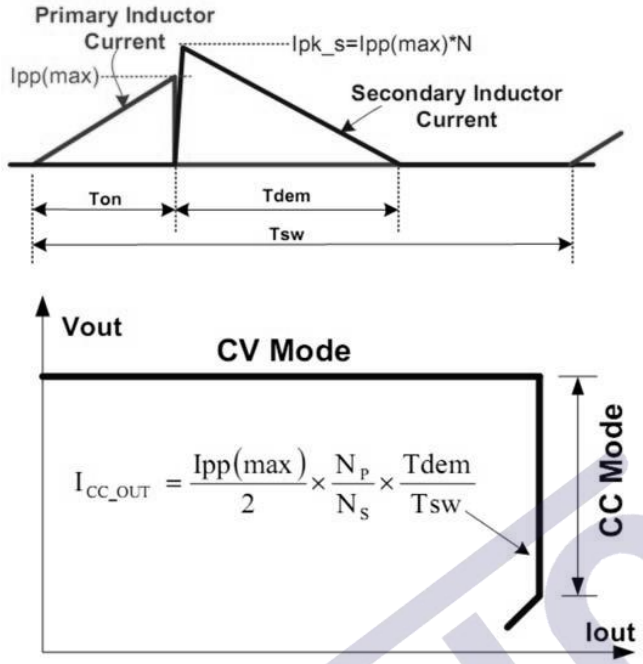



Fig.3

Referring to Fig.3 above, the primary peak current, transformer turns ratio, secondary demagnetization time (Tdem), and switching period (Tsw) determines the secondary average output current Iout. Ignoring leakage inductance effects, the equation for average output current is shown in Fig.3. When the average output current Iout reaches the regulation reference in the Primary Side Constant Current Modulator (PS-CCM) block, the IC operates in pulse frequency modulation (PFM) mode to control the output current at any output voltage at or below the voltage regulation target as long as the auxiliary winding can keep VDD above the IIVLO turn-off threshold.

In U6116, the ratio between Tdem and Tsw in CC mode is 1/2. Therefore, the average output current can be expressed as:

$$I_{PSR\_CC\_OUT}(\mathrm{m}A) \cong \frac{1}{4} \times N \times \frac{500\mathrm{m}V}{Rcs\ (\Omega)}$$

In the equation above，

N--The turn ratio of primary side winding to secondary side winding.

Res-- the sensing resistor connected between the power MOSFET source to GND.

## Quasi Resonant Buck (QR-Buck) Constant Current Control for LED Lighting

If SEL pin is short to GND, U6116 will works in Quasi-Resonant Buck mode. In QR-Buck mode, the IC keeps CS peak current constant and starts new PWM cycle with valley switching. Therefore, high precision CC and high conversion efficiency can be achieved simultaneously. The average output current is given by:

$$I_{BUCK\_CC\_OUT}(\mathrm{m}A) \cong \frac{1}{2} \times \frac{500\mathrm{m}A}{Rcs\ (\Omega)}$$

## Multi Mode Control in CV Mode

To meet the tight requirement of averaged system efficiency and no load power consumption, a hybrid of frequency modulation (FM) and amplitude modulation (AM) is adopted in U6116 which is shown in the Fig 4.

Around the full load, the system operates in FM mode. When normal to light load conditions, the IC operates in FM+AM mode to achieve excellent regulation and high efficiency. When the system is near zero loading, the IC operates in FM again for standby power reduction. In this way, the no-load consumption can be less than 70mW.

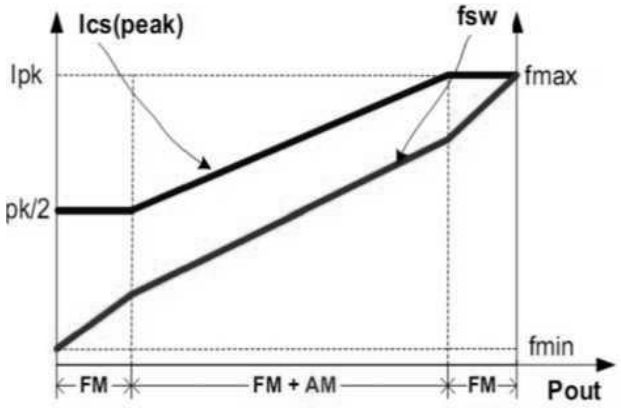



Fig.4

## Programmable Cable Drop Compensation (CDC) in CV Mode

In smart phone charger application, the battery is always connected to the adapter with a cable wire which can cause several percentages of voltage drop on the actual battery voltage. In U6116, an offset voltage is generated at FB pin by an internal current source (modulated by CDC block, as shown in Fig.5) flowing into the resistor divider. The current is proportional to the switching period, thus, it is inversely proportional to the output power Pout. Therefore, the drop due the cable loss can be compensated. As the load decreases from full loading to zero loading, the offset voltage at FB pin will increase. By adjusting the resistance of R1 and R2 (as shown in Fig.), the cable loss compensation can be programmed. The percentage of maximum compensation is given by:

$$\frac{\Delta V(\text{cable})}{V\text{out}} \approx \frac{I\text{cable\_max} \times (R1 // R2)}{V_{FB\_REF}} \times 100\%$$

For example, R1=3 KΩ , R2=18KΩ , The percentage of maximum compensation is given by:

$$\frac{\Delta V(\text{cable})}{V\text{out}} \approx \frac{63\mu A \times (3K // 18K)}{2V} \times 100\% = 8.1\%$$

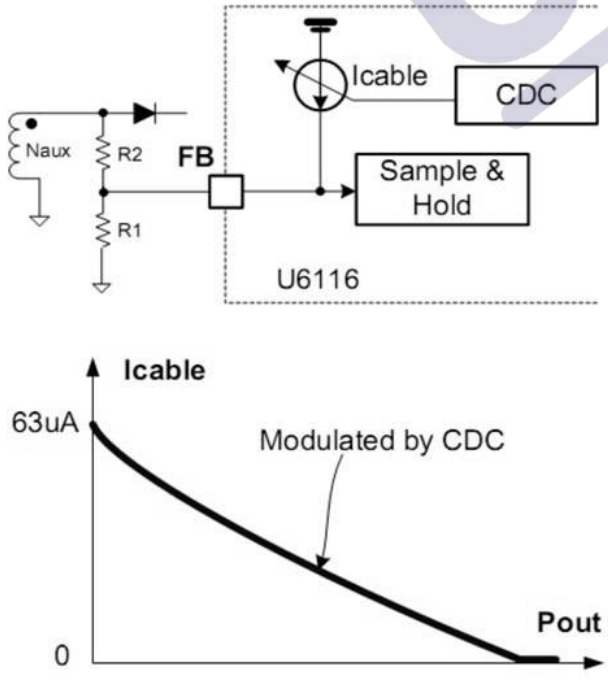



Fig.5

## Optimized Dynamic Response for PSR

In U6116, the dynamic response performance is optimized to meet USB charge requirements.

## Audio Noise Free Operation for PSR

As mentioned above, the multi-mode CV control with a hybrid of FM and AM provides frequency modulation. An internal current source flowing to CS pin realizes CS peak voltage modulation. In U6116, the optimized combination of frequency modulation and CS peak voltage modulation algorithm can provide audio noise free operation from full loading to zero loading.

## Short Load Protection (SLP)

In U6116, the output is sampled on FB pin and then compared with a threshold of IIVP (0.7V typically) after an internal blanking time (10ms typical).

In U6116, when sensed FB voltage is below 0.7V, the IC will enter into Short Load Protection (SLP) mode, in which the IC will enter into auto recovery protection mode.

## VDD Over Voltage Protection (OVP) and Zener Clamp

When VDD voltage is higher than 30V (typical), the IC will stop switching. This will cause VDD fall down to be lower than VDD_OFF (typical 9V) and then the system will restart up again. An internal 34.5V (typical) zener clamp is integrated to prevent the IC from damage.

## On Chip Thermal Shutdown (OTP)

When the IC temperature is over 165 °C, the IC shuts down. Only when the IC temperature drops to 135 °C, IC will restart.

## Pin Floating Protection

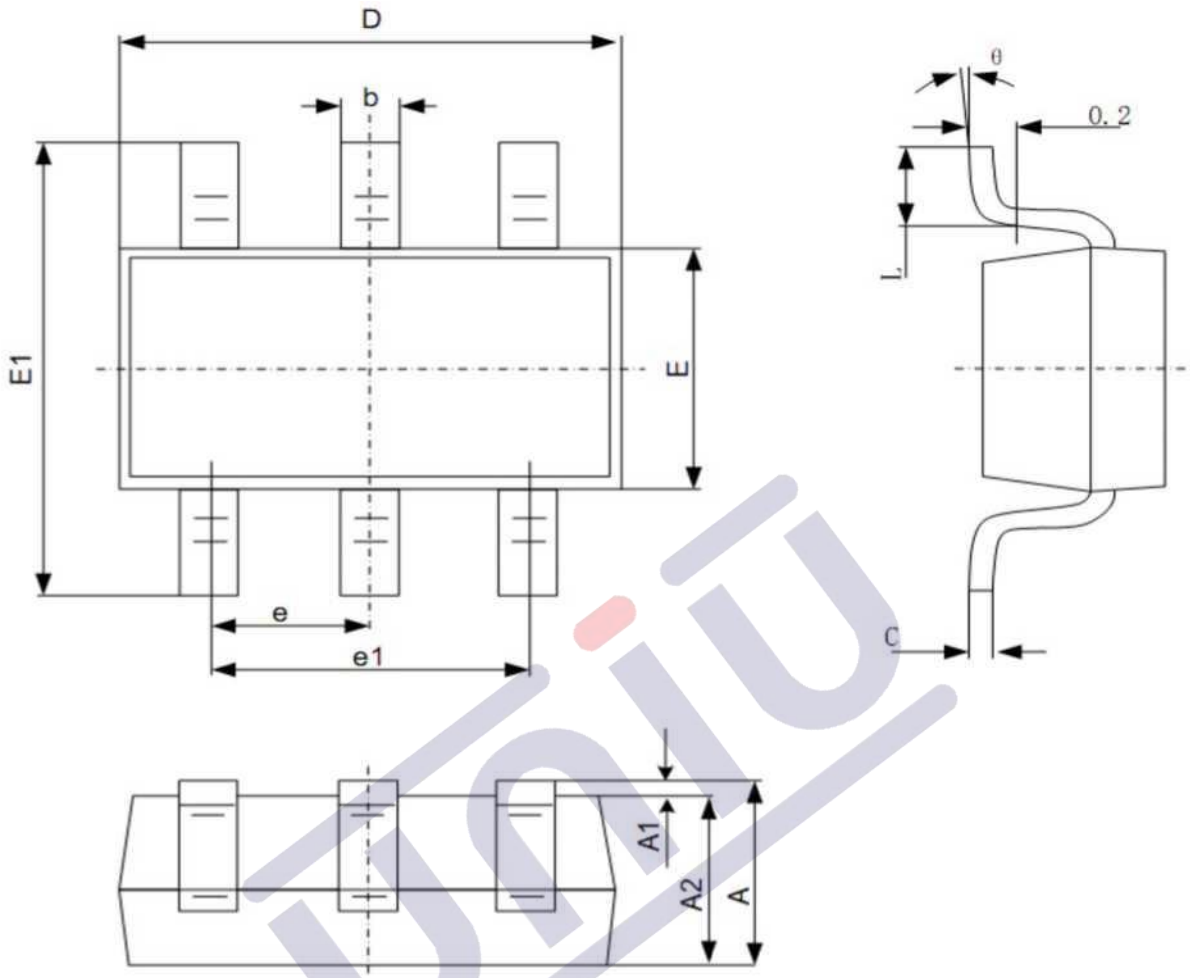
In U6116, if pin floating situation occurs, the IC is designed to have no damage to system.

## Soft Totem-Pole Gate Driver

U6116 has a soft totem-pole gate driver with optimized EMI performance.

## Package Dimension

SOT23-6




| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | Min | Max | Min | Max |
| A | 0.900 | 1.200 | 0.035 | 0.047 |
| A1 | 0.000 | 0.150 | 0.000 | 0.006 |
| A2 | 0.900 | 1.100 | 0.035 | 0.043 |
| b | 0.300 | 0.500 | 0.012 | 0.020 |
| c | 0.100 | 0.200 | 0.004 | 0.008 |
| D | 2.800 | 3.020 | 0.110 | 0.119 |
| E | 1.500 | 1.700 | 0.059 | 0.067 |
| 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 |
| e | 0° | 8° | 0° | 8° |

## 1.版本记录

| DATE | REV. | DESCRIPTION |
|---|---|---|
| 2018/04/19 | 1.0 | First Release |
| 2021/11/10 | 1.1 | Layout adjustment |
| | | |
| | | |

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