

## Description

The AP39811 is a high performance power switcher integrated with a primary side regulation controller and an integrated N-channel power MOSFET for the application of shaver charger. It is easy to achieve a targeted slant IV curve without an opto-coupler and secondary control circuitry. A resistor connected between FB pin and CPR pin is introduced to adjust the slew rate of the slant IV curve.

The AP39811 operates in Pulse Frequency Modulation (PFM) mode and peak current Amplitude Modulation (AM) mode to form a fine tune frequency curve within the whole power range. Therefore, AP39811 can achieve high average efficiency and avoid audible noise.

The AP39811 provides comprehensive protections without additional circuitry. It contains  $V_{CC}$  over voltage protection, output over voltage protection, XFMR anti-saturation protection, bulk-cap open protection, open loop protection, over temperature protection, etc.

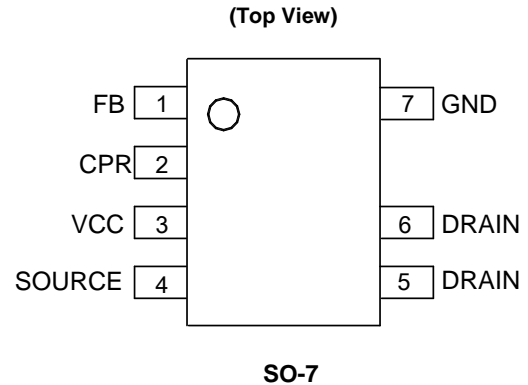
The AP39811 is available in SO-7 package.

## Features

- Primary Side Control for Eliminating Opto-Coupler
- Built-In 650V Power MOSFET
- Slant IV Curve Control
- 75mW No-Load Input Power
- Flyback Topology in DCM Operation
- External Adjustable Line Compensation for CC
- Multiple AM/PFM Control Mode to Improve Audio Noise and Efficiency
- Frequency Jitter to Improve System EMI
- Valley-On for the Higher Efficiency and Better EMI Behavior
- Multiple Protections:
  - Over Voltage Protection (OVP)
  - Bulk-Cap Open Protection
  - Transformer Saturation Protection (TSP) via Primary Peak Current Limitation
  - Internal Over Temperature Protection (OTP)
- SO-7 Package
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**

Notes: 1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.  
 2. See <https://www.diodes.com/quality/lead-free/> for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.  
 3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

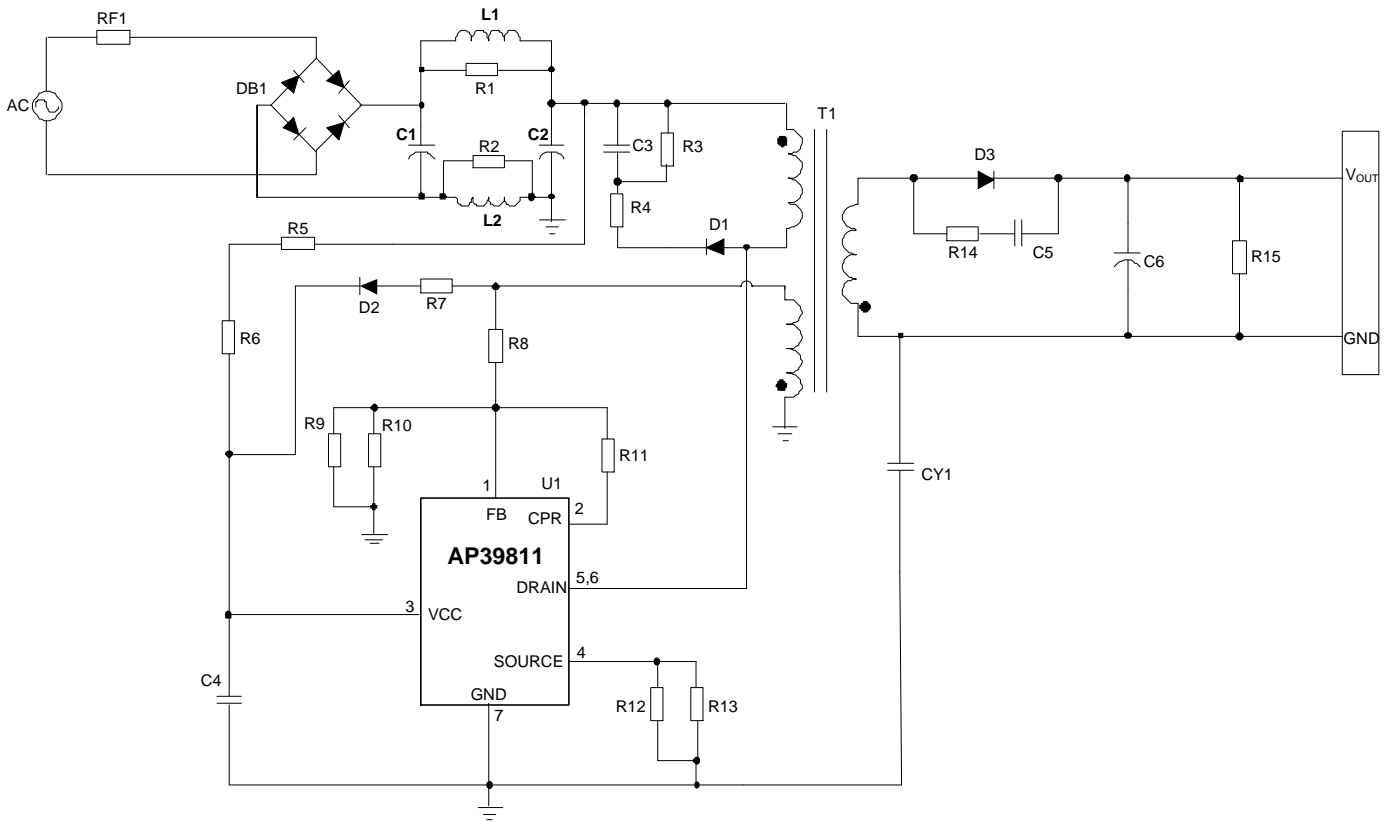
## Pin Assignments



## Applications

- Shaver Charger

**Typical Applications Circuit**



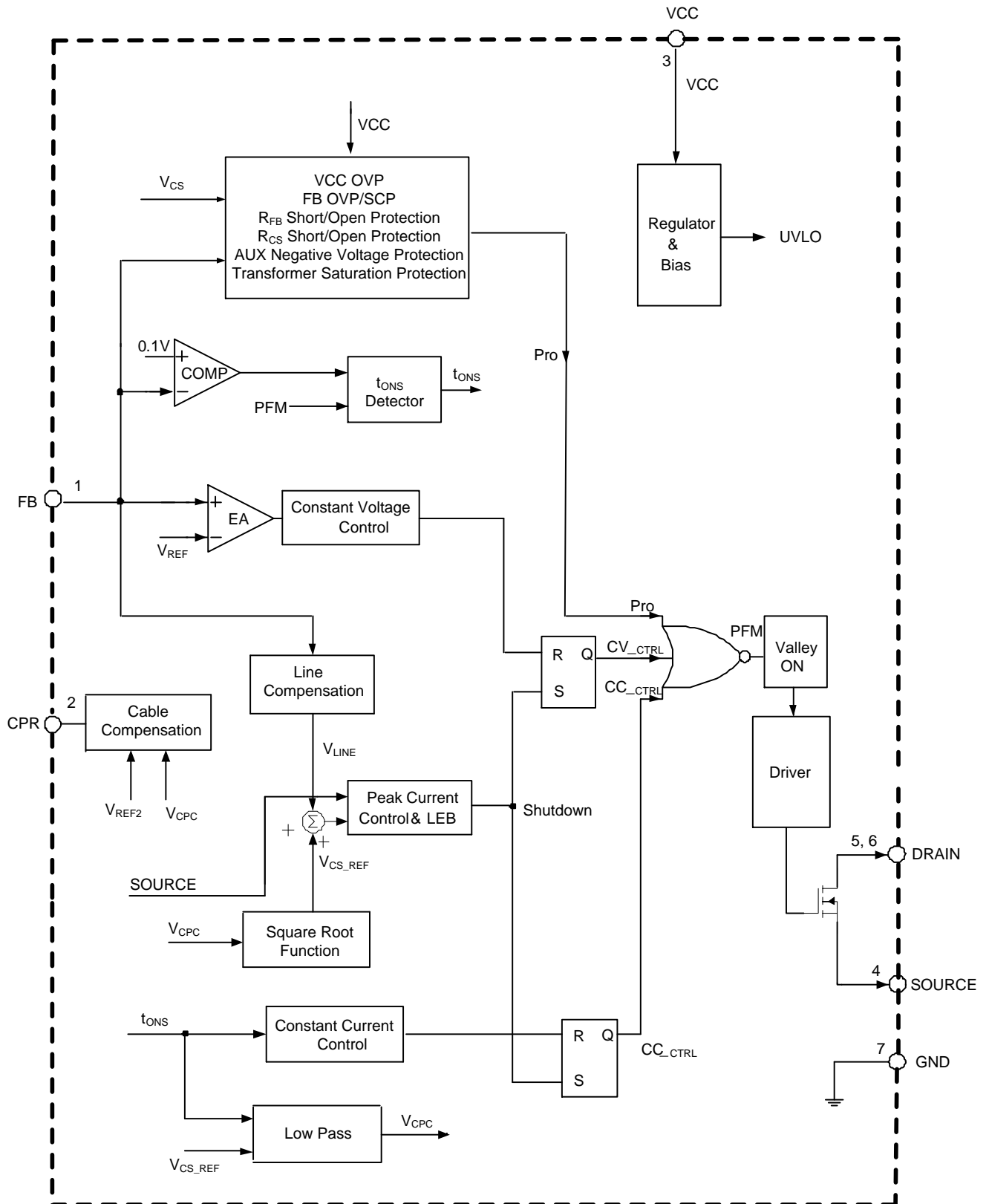
**Pin Descriptions**

| Pin Number | Pin Name | Function  |
|------------|----------|---|
| 1          | FB       | Connect to the auxiliary winding through a resistor divider network, used as a multi-function pin to realize output voltage detection for CV control, $t_{ONS}$ detection for CC control, line voltage sense for line compensation, and cable compensation as well. |
| 2          | CPR      | A resistor is connected between FB pin and CPR pin to adjust slant-IV curve.  |
| 3          | VCC      | The power supply for the IC.  |
| 4          | SOURCE   | SOURCE terminal of the integrated MOSFET. The primary side current is sensed through this pin.  |
| 5, 6       | DRAIN    | DRAIN terminal of the integrated MOSFET.  |
| 7          | GND      | Signal ground. Current return for driver and control circuits.  |

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**Functional Block Diagram**

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## Absolute Maximum Ratings (Note 4)

| Symbol        | Parameter   | Rating      | Unit          |
|---------------|---|-------------|---------------|
| $V_{CC}$      | Supply Voltage                                    | -0.3 to 35  | V             |
| $V_{SOURCE}$  | SOURCE Input Voltage                              | -0.3 to 8   | V             |
| $V_{CPR}$     | CPR Input Voltage                                 | -0.3 to 8   | V             |
| $V_{FB}$      | FB Input Voltage                                  | -0.3 to 8   | V             |
| $V_{DS}$      | Drain-Source Voltage ( $T_J=+25^{\circ}C$ )       | 650         | V             |
| $T_J$         | Operating Junction Temperature                    | -40 to +150 | $^{\circ}C$   |
| $T_{STG}$     | Storage Temperature                               | -65 to +150 | $^{\circ}C$   |
| $T_{LEAD}$    | Lead Temperature (Soldering, 10s)                 | +300        | $^{\circ}C$   |
| $\theta_{JC}$ | Thermal Resistance (Junction to Case) (Note 5)    | 2           | $^{\circ}C/W$ |
| $\theta_{JA}$ | Thermal Resistance (Junction to Ambient) (Note 5) | 78          | $^{\circ}C/W$ |
| —             | ESD (Human Body Model)                            | 2000        | V             |
| —             | ESD (Charged Device Model)                        | 1000        | V             |

Notes: 4. Stresses greater than those listed under *Absolute Maximum Ratings* can cause permanent damage to the device. These are stress ratings only, and 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 Ratings* for extended periods can affect device reliability.

5. Test condition: Device mounted on FR-4 substrate PC board, 2oz copper, with 1inch<sup>2</sup> cooling area.

## Recommended Operating Conditions

| Symbol   | Parameter           | Min | Max | Unit        |
|----------|---------------------|-----|-----|-------------|
| $V_{CC}$ | Supply Voltage      | 10  | 28  | V           |
| $T_A$    | Ambient Temperature | -40 | +85 | $^{\circ}C$ |

**Electrical Characteristics** (@ $T_A = +25^\circ\text{C}$ ,  $V_{CC} = 15\text{V}$ , unless otherwise specified.)

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| Symbol                             | Parameter  | Condition  | Min  | Typ  | Max  | Unit          |
|------------------------------------|--|--|------|------|------|---------------|
| <b>STARTUP AND UVLO SECTION</b>    |  |  |      |      |      |               |
| $V_{TH\_ST}$                       | Startup Threshold  | —  | 14.5 | 16   | 17.5 | V             |
| $V_{OPR(MIN)}$                     | Minimum Operating Voltage  | —  | 6.1  | 6.8  | 7.5  | V             |
| <b>STANDBY CURRENT SECTION</b>     |  |  |      |      |      |               |
| $I_{ST}$                           | Startup Current  | $V_{CC} = V_{TH\_ST} - 1\text{V}$ Before Startup | —    | 1    | 3    | $\mu\text{A}$ |
| $I_{CC\_OPR}$                      | Minimum Operating Current  | Static Current                                   | 450  | 550  | 650  | $\mu\text{A}$ |
| <b>CURRENT SENSE SECTION</b>       |  |  |      |      |      |               |
| $V_{CS\_H}$                        | Peak Current Sense Threshold Voltage   | 33% to 100% CC Load                              | 540  | 600  | 660  | mV            |
| $V_{CS\_L}$                        |  | No Load to 3% CC Load                            | 180  | 200  | 220  | mV            |
| $R_{LINE}$                         | Built-In Line Compensation Resistance  | —  | 48   | 60   | 72   | $\Omega$      |
| $t_{LEB}$                          | Leading Edge Blanking  | —  | 250  | 300  | 350  | ns            |
| <b>CONSTANT VOLTAGE SECTION</b>    |  |  |      |      |      |               |
| $V_{FB}$                           | Feedback Threshold Voltage   | Closed Loop Test of $V_{OUT}$                    | 2.3  | 2.35 | 2.4  | V             |
| Ratio $SAMPLE\_L$                  | Sample Ratio   | No Load to 3% CC Load                            | 50   | 55   | 60   | %             |
| Ratio $SAMPLE\_H$                  | Sample Ratio   | 33% to 100% CC Load                              | 55   | 60   | 65   | %             |
| $t_{SAMPLE\_H}$                    | Sample Time When $t_{ONS} > 15\mu\text{s}$                                   | —  | 6.4  | 8    | 9.6  | $\mu\text{s}$ |
| <b>CONSTANT CURRENT SECTION</b>    |  |  |      |      |      |               |
| $t_{ONS}/t_{SW}$                   | Secondary Winding Conduction Duty  | Tested @ $V_{FB} = 1\text{V}$                    | 0.7  | 0.75 | 0.8  | —             |
| <b>FREQUENCY JITTER</b>            |  |  |      |      |      |               |
| $\Delta V_{CS}/V_{CS}$             | $V_{CS}$ Modulation  | No Load to Full Load                             | 2.5  | 3    | 3.5  | %             |
| <b>CABLE COMPENSATION</b>          |  |  |      |      |      |               |
| $V_{CPR\_CABLE\_MIN}$              | Minimum Cable Compensation   | AP39811A   | 1.33 | 1.4  | 1.47 | V             |
|                                    |  | AP39811B   | 2.04 | 2.14 | 2.24 | V             |
| <b>VALLEY-ON SECTION</b>           |  |  |      |      |      |               |
| $t_{VAL-ON}$                       | Valid Off Time of Valley-On  | From the End of $t_{ONS}$                        | 26   | 32   | 38   | $\mu\text{s}$ |
| <b>DYNAMIC SECTION</b>             |  |  |      |      |      |               |
| $t_{OFF(MAX)}$                     | Maximum Off Time   | AP39811A   | 0.9  | 1    | 1.1  | ms            |
|                                    |  | AP39811B   | 700  | 768  | 836  | $\mu\text{s}$ |
| <b>PROTECTION FUNCTION SECTION</b> |  |  |      |      |      |               |
| $V_{FB(OVP)}$                      | Over Voltage Protection at FB Pin  | —  | 3.3  | 3.6  | 3.9  | V             |
| $V_{CC(OVP)}$                      | Over Voltage Protection at VCC Pin   | —  | 29.5 | 32   | 34.5 | V             |
| $t_{ONP(MAX)}$                     | Maximum Turn-On Time   | —  | 12.8 | 16   | 19.2 | $\mu\text{s}$ |
| $V_{CS(MIN)}$                      | Minimum Peak Current Sense Voltage at $t_{ONP} = 4\mu\text{s}$ (First Cycle) | —  | 80   | 100  | 130  | mV            |
| $V_{CS(MAX)}$                      | Maximum CS Voltage   | —  | 675  | 750  | 825  | mV            |
| $V_{FB\_NEG\_L}$                   | Low Threshold for FB Negative Voltage Protection                             | —  | 8.4  | 14   | 19.6 | mV            |
| $V_{FB\_NEG\_H}$                   | High Threshold for FB Negative Voltage Protection                            | —  | 25.2 | 42   | 58.8 | mV            |

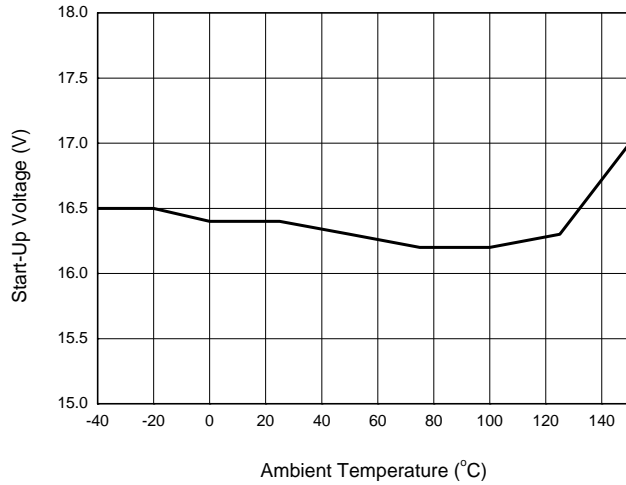
**Electrical Characteristics** (continued) (@ $T_A = +25^\circ\text{C}$ ,  $V_{CC} = 15\text{V}$ , unless otherwise specified.)

| Symbol                      | Parameter  | Condition | Min  | Typ. | Max  | Unit             |
|-----------------------------|--|-----------|------|------|------|------------------|
| $T_{OTP}$                   | Shutdown Temperature                                       | —         | +115 | +130 | +145 | $^\circ\text{C}$ |
| $T_{HYS}$                   | Temperature Hysteresis                                     | —         | +27  | +30  | +33  | $^\circ\text{C}$ |
| <b>Power MOSFET Section</b> |  |           |      |      |      |                  |
| $BV_{DSS}$                  | Integrated MOSFET Drain-Source Break-Down Voltage (Note 6) | —         | 650  | —    | —    | V                |
| $R_{DS(ON)}$                | Static Drain-Source On-Resistance                          | —         | —    | 9    | —    | $\Omega$         |
| $I_D$                       | Continuous Drain Current                                   | —         | —    | —    | 1    | A                |

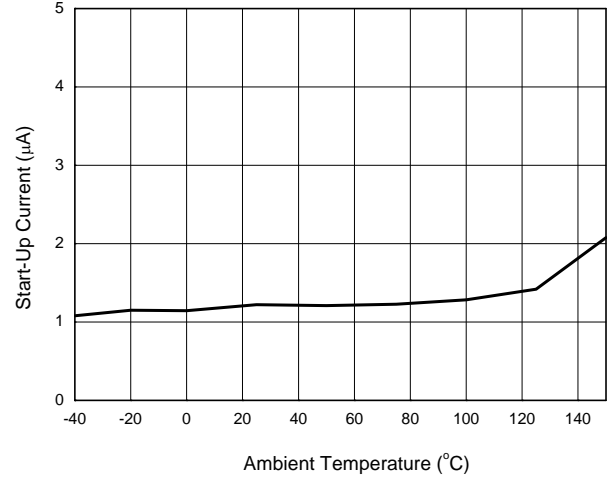
Note: 6. The aging condition of drain-source voltage is 80% of  $BV_{DSS}$ .

**Performance Characteristics**

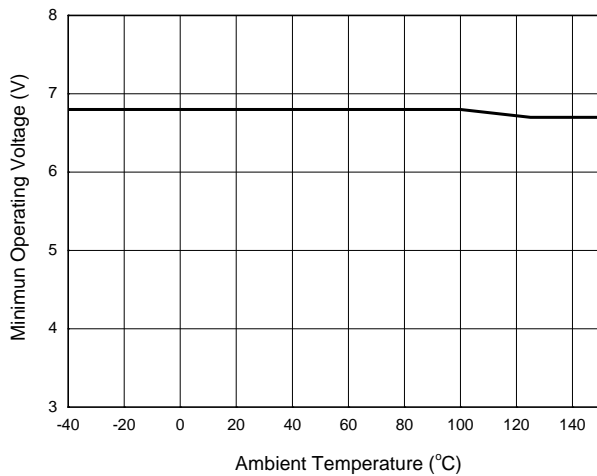
**Start-Up Voltage vs. Ambient Temperature**



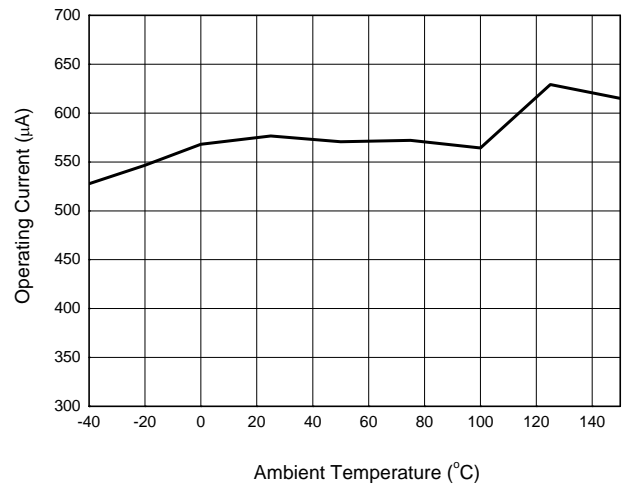
**Start-Up Current vs. Ambient Temperature**



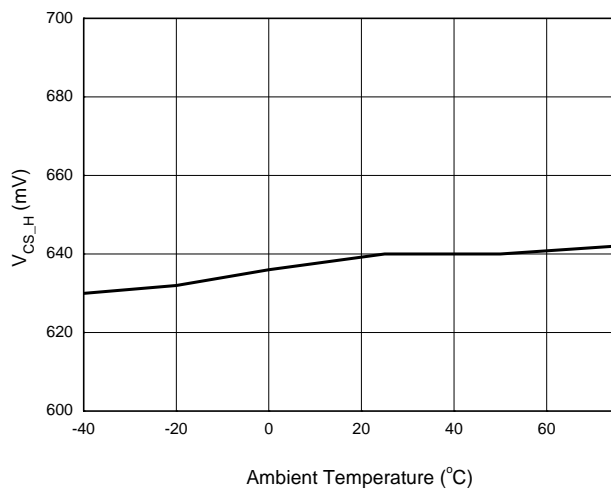
**Minimal Operating Voltage vs. Ambient Temperature**



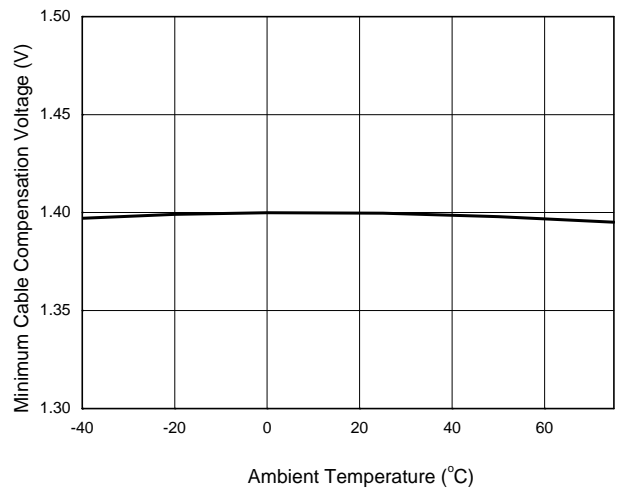
**Operating Current vs. Ambient Temperature**



**V<sub>CS\_H</sub> vs. Ambient Temperature**

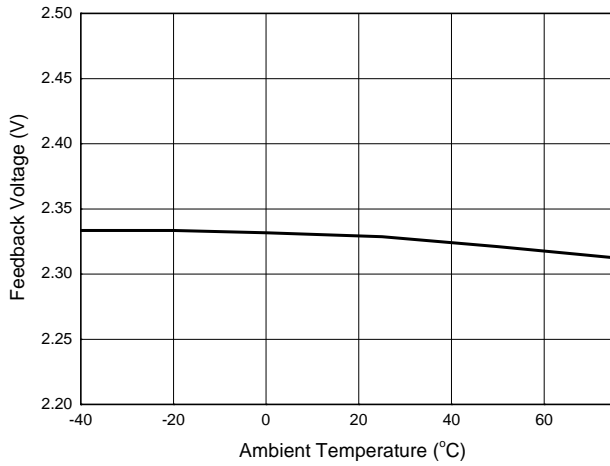


**Minimum Cable Compensation Voltage vs. Ambient Temperature**

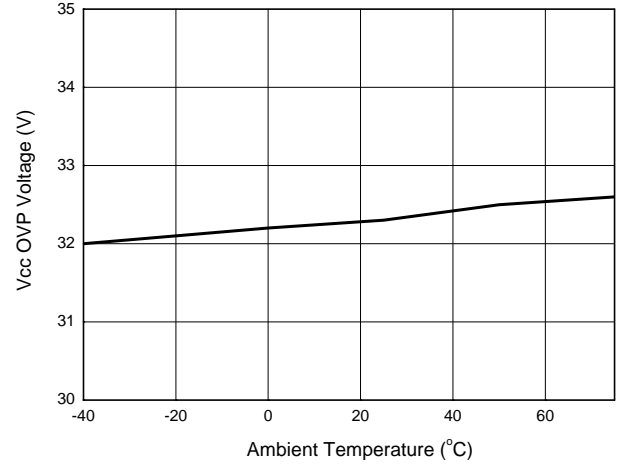


**Performance Characteristics** (continued)

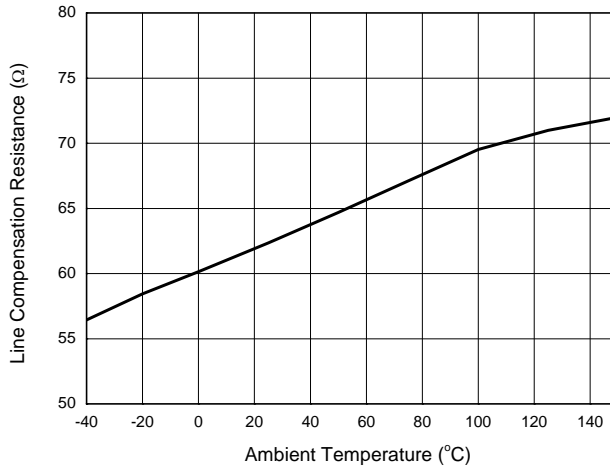
**Feedback Voltage vs. Ambient Temperature**



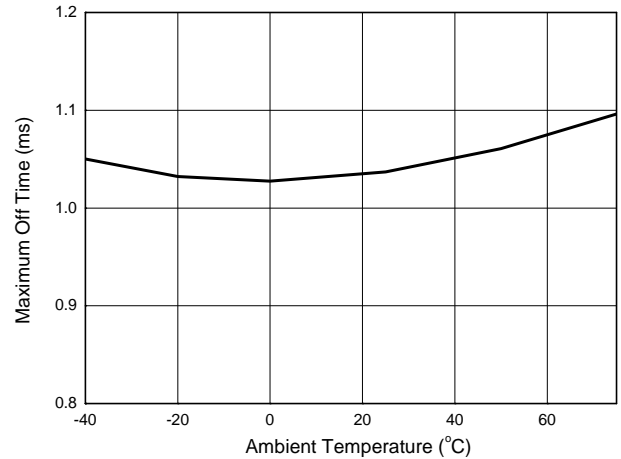
**V<sub>CC</sub> OVP Voltage vs. Ambient Temperature**



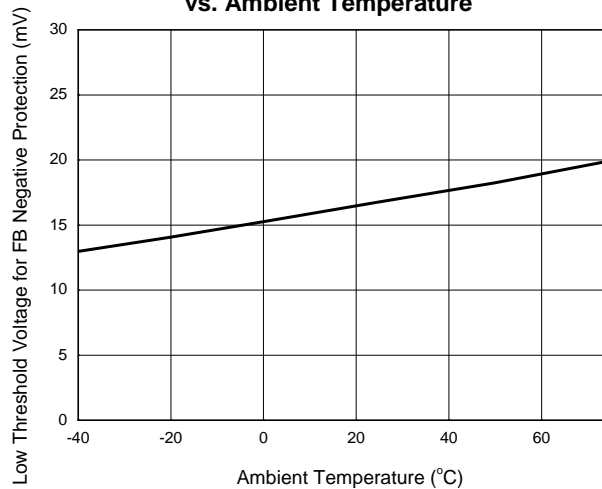
**Line Compensation Resistance vs. Ambient Temperature**



**(AP39811A) Maximum Off Time vs. Ambient Temperature**



**Low Threshold Voltage for FB Negative Protection vs. Ambient Temperature**





## Operation Description

### 1. The Conventional PSR Operating Waveforms

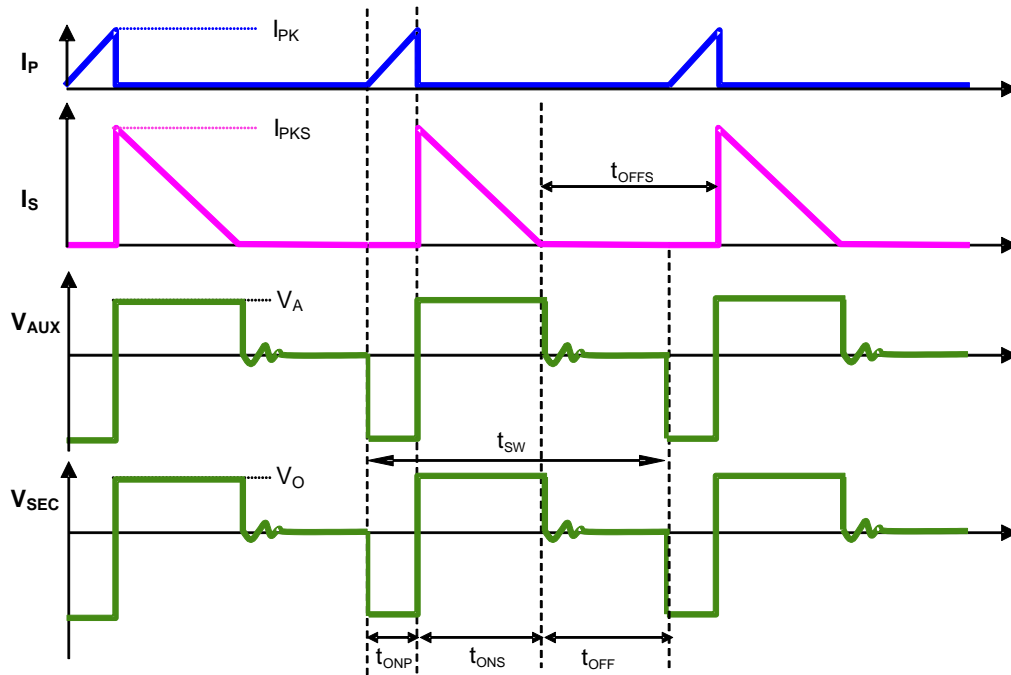


Figure 1. The Operation Waveform of Flyback PSR System

Figure 1 shows the typical waveforms which demonstrate the basic operating principle of AP39811 application. And the parameters are defined as following.

$I_P$ ---The primary-side current

$I_S$  ---The secondary-side current

$I_{PK}$ ---Peak value of primary-side current

$I_{PKS}$ ---Peak value of secondary-side current

$V_{SEC}$ ---The transient voltage at secondary winding

$V_O$ ---The output voltage

$V_{AUX}$ ---The transient voltage at auxiliary winding

$V_A$ --- The stable voltage at auxiliary winding when rectification diode is in conducting status, which equals the sum of voltage VCC and the forward voltage drop of auxiliary diode

$t_{SW}$  ---The period of switching frequency

$t_{ONP}$  ---The conduction time when primary-side switch is "ON"

$t_{ONS}$  ---The conduction time when secondary-side diode is "ON"

$t_{OFF}$  ---The dead time when neither primary-side switch nor secondary side diode is "ON"

$t_{OFFS}$  --- The time when secondary-side diode is "OFF"

For primary-side regulation, the primary current  $i_p(t)$  is sensed by a current sense resistor  $R_{CS}$  connected to pin SOURCE. The current rises up linearly at a rate of:

$$\frac{di_p(t)}{dt} = \frac{V_{IN}(t)}{L_M} \quad (1)$$

As illustrated in Figure 1, when the current  $i_p(t)$  rises up to  $I_{PK}$ , the primary MOSFET would turn off. The constant peak current is given by:

$$I_{PK} = \frac{V_{CS}}{R_{CS}} \quad (2)$$

**Operation Description** (continued)

The energy stored in the magnetizing inductance  $L_M$  each cycle is therefore:

$$E_g = \frac{1}{2} \times L_M \cdot I_{PK}^2 \quad (3)$$

So the power transferring from the input to the output is given by:

$$P = \frac{1}{2} \times L_M \times I_{PK}^2 \times f_{SW} \quad (4)$$

Where, the  $f_{SW}$  is the switching frequency. When the peak current  $I_{PK}$  is constant, the output power would depend on the switching frequency  $f_{SW}$ .

**2. A Special IV Curve for Shaver Charger**

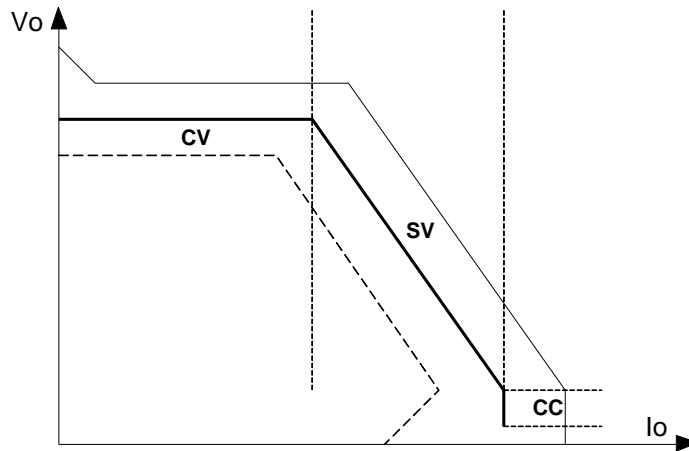


Figure 2. A Special IV Curve

Figure 2 is a typical IV curve special for shaver charger, comparing to a conventional charger. In addition to usual Constant Voltage (CV) part and Constant Current (CC) part, shaver charger requires a unique Slanted Voltage (SV) part. To achieve this special IV curve, the AP39811 creatively adopts a new control method, called Enhanced Cable Compensation method.

**3. Constant Voltage Control**

The output voltage is proportional to the auxiliary winding voltage during  $t_{ONS}$  period indicated by Formula 5. This auxiliary winding voltage is divided by resistors  $R_{FB1}$  and  $R_{FB2}$  before inputting to the FB pin. As Figure 3 illustrated, the AP39811 detects the FB voltage at the end of  $t_{SAMPLE}$  during  $t_{ONS}$  period, the detected voltage which reflects the output voltage is regulated to  $V_{FB}$  of 2.4V with the help of the constant voltage control block. To be compatible with different system designs and avoid the turn-off spike impact, the  $t_{SAMPLE}$  is designed to be part of  $t_{ONS}$ , usually 55% of  $t_{ONS}$  at light load and 60% of  $t_{ONS}$  at heavy load. For system design, adjusting the ratio of  $R_{FB1}$  and  $R_{FB2}$  can get the target output voltage value.

$$V_{AUX} = \frac{N_{AUX}}{N_S} \times (V_o + V_d) \quad (5)$$

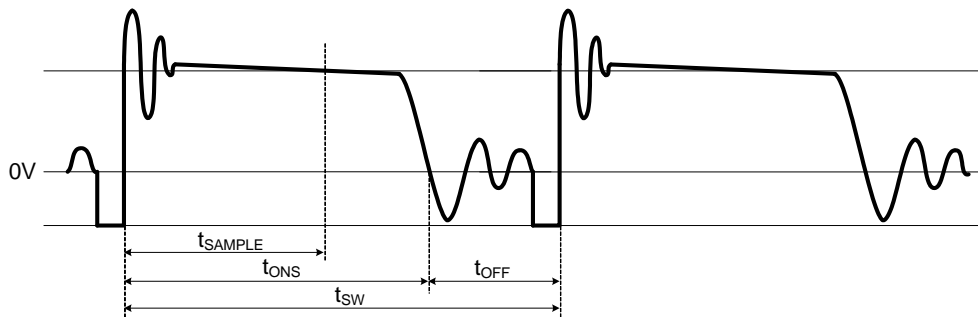


Figure 3. Auxiliary Voltage Waveform

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**Operation Description** (continued)

**4. Slanted Voltage Control**

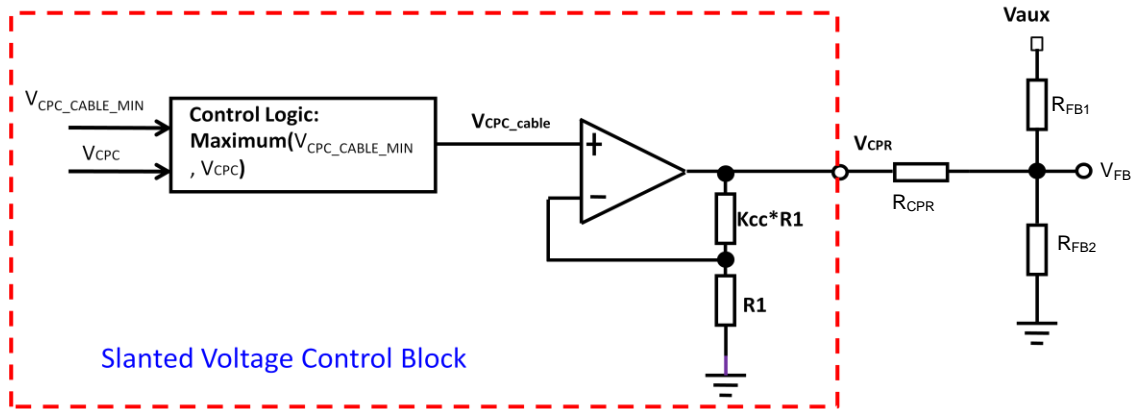


Figure 4. Slanted Voltage Control Block

In AP39811, an enhanced cable compensation method is introduced to achieve the slanted IV curve. As shown in Figure 4, the voltage on CPR pin represents the cable compensation voltage which is changed according to the load condition. The resistance  $R_{CPR}$  connected between CPR pin and FB pin is used to adjust the cable compensation value.

$$V_O = \frac{(V_{FB} - V_{CPR}) * R_{FB1} + \left(1 + \frac{R_{FB1}}{R_{FB2}}\right) * V_{FB}}{N_{as}} - V_d \tag{6}$$

Formula 6 indicates the mathematical relationship within all  $V_{OUT}$ -related parameters.  $V_{FB}$  is 2.4V regulated by constant voltage control block,  $N_{as}$  is the turns ratio of auxiliary winding turns to secondary winding turns,  $V_{CPR}$  is the CPR pin voltage,  $V_d$  is the forward voltage of secondary rectify diode,  $R_{FB1}$  and  $R_{FB2}$  are used as the voltage divider net. As it shows, the  $V_{CPR}$  will affect the  $V_{OUT}$  greatly and it is controlled by AP39811.

Figure 4 illustrates the control principle of slanted voltage control block, as it can be seen,  $V_{CPR}$  is proportional to  $V_{CPC\_CABLE}$ , refer to Formula 7

$$V_{CPR} = V_{CPC\_CABLE} * (1 + K_{CC}) \tag{7}$$

$K_{CC}$  is an inner factor, for AP39811A, it is 1.5, while for AP39811B, it is 1.2. The  $V_{CPC\_CABLE}$  is derived by comparing the  $V_{CPC\_CABLE\_MIN}$  and  $V_{CPC}$ , the higher value is assigned to  $V_{CPC\_CABLE}$ .  $V_{CPC}$  is an inner factor that is proportional to the output current and it directly indicates the load condition.  $V_{CPC\_CABLE\_MIN}$  is a constant value, so  $V_{CPC\_CABLE\_MIN}$  is constant, for AP39811A it is 1.4V and 2.14V for AP39811B, this parameter is fixed within AP39811, so the ratio of the inflection point of CV and SV to CC point is fixed. The higher the  $V_{CPC\_CABLE\_MIN}$ , the larger the ratio is. Figure 5 shows the relationship of  $V_{CPR}$ ,  $V_{FB}$  and  $I_O$ . Before the inflection point, the  $V_{FB}$  and  $V_{CPR}$  are both constant and the constant output voltage is achieved. After the inflection point, the  $V_{CPR}$  increases along with the load current, which leads to a decreasing output voltage and the slanted output voltage part is formed. Note that when the  $V_{CPR}$  is lower than  $V_{FB}$  in range A, AP39811 has positive cable compensation and the compensation voltage is added to the  $V_{FB}$ -regulated voltage. In range B, the cable compensation is reversed and the compensation voltage is subtracted from the  $V_{FB}$ -regulated voltage.

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**Operation Description** (continued)

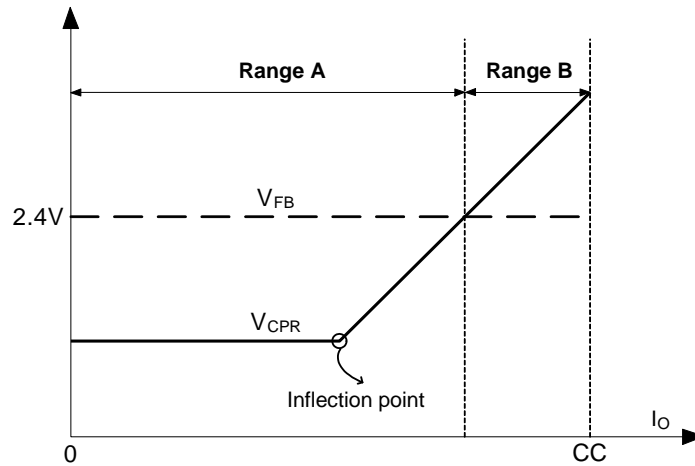


Figure 5:  $V_{CPR}$  and  $V_{FB}$  Versus  $I_o$

**5. Constant Current Control**

In AP39811, Formula 8 shows the related parameters that determine the output current. To get a constant output current, the  $V_{CS}$  and  $t_{ONS}/t_{SW}$  is fixed in AP39811 during CC mode. Meanwhile, reliable control logic is integrated within AP39811 to ensure the system swift smoothly between CC mode and CV/SV mode.

$$I_{OUT} = \frac{1}{2} * \frac{N_p}{N_s} * I_{pk} * \frac{t_{ONS}}{t_{SW}} = \frac{1}{2} * \frac{N_p}{N_s} * \frac{V_{CS}}{R_{CS}} * \frac{t_{ONS}}{t_{SW}} \quad (8)$$

**6. Multiple Segment Peak Current**

In the original PFM PSR system, the switching frequency decreases with the decreasing output current, which will encounter audible noise issue when switching frequency decreases below 20kHz.

In order to avoid audible noise issue, the AP39811 uses 3-segment primary peak current control method at CV and SV mode, the current sense threshold voltage is piecewise defined. As shown in Figure 6, the low threshold  $V_{CS\_L}$  is set under 3% CC load, the high threshold  $V_{CS\_H}$  is set above 33% CC load. Within the range from 3% to 33%, the threshold  $V_{CS\_M}$  increases basing on the load condition, the  $V_{CS\_M}$  is carefully calculated inside the AP39811 to make the system operate at a constant switching frequency which is higher than 20kHz.

As for the special IV curve, the maximum switching frequency occurs at the slanted voltage mode. During this mode, the  $V_{CS}$  reaches its maximum threshold  $V_{CS\_H}$ , so the frequency varies only with the input power, carefully select the primary inductance to get a reasonable frequency feature.

**Operation Description** (continued)

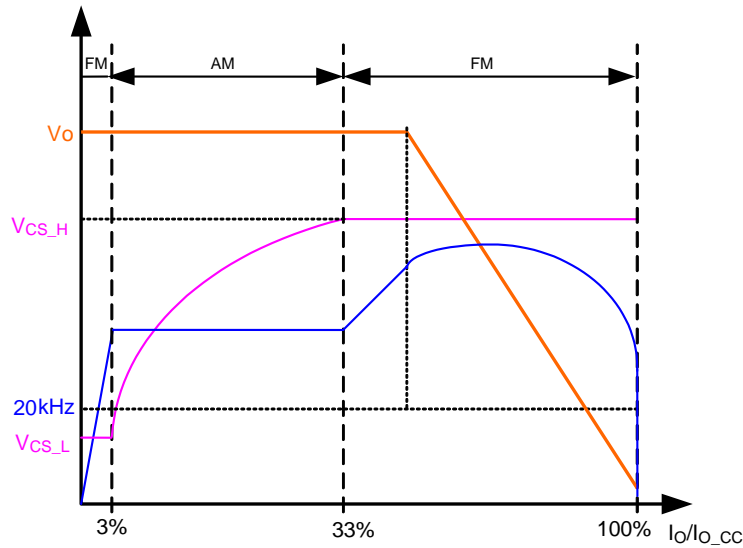


Figure 6:  $V_{CS}$  and  $f_S$  Versus  $I_o$

**7. Leading Edge Blanking**

When the power switch is turned on, a turn-on spike will occur on the  $V_{CS}$  sense resistance. To avoid false-termination of the switching pulse, a 300ns leading-edge blanking is built in. During this blanking period, the current sense comparator is disabled and the primary MOSFET cannot be turned off.

**8. Valley Turn-on**

When the off time ( $t_{OFF}$ ) is shorter than  $t_{VAL-ON}$ , the AP39811 power system can work with valley turn-on. It can reduce the switching-on power losses and achieve high overall efficiency. At the same time, because of valley turn-on the switching frequency has the random jitter feature, which will be beneficial to conductive EMI performance. And valley turn-on can also reduce the power switch turn-on spike current and then achieve the better radioactive EMI performance.

**9.  $V_{CS}$  Jitter**

Even though the valley turn-on function produces the random frequency jitter feature, an active frequency jitter function is added in the AP39811. The active frequency dithering is realized by applying variation on  $V_{CS}$  reference ( $V_{CS\_REF}$ ). The  $V_{CS\_REF}$  is changed every 2 cycles and the period of variation is 12 cycles, which is shown as Figure 7. The variation between  $V_{CS4}$  and  $V_{CS1}$  is  $\pm 3\%$  using the mean level as a reference.

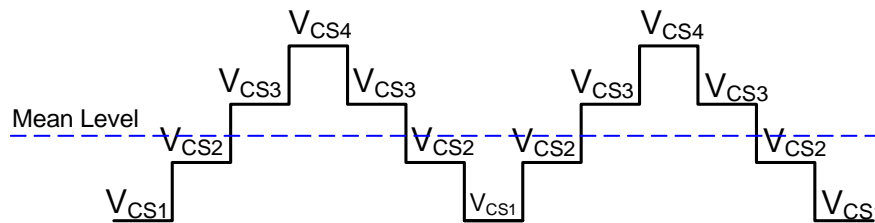


Figure 7:  $V_{CS}$  Jitter

**10. Adjustable Line Compensation**

In real system, there exists a delay time, from the  $V_{SOURCE}$  reach the inner  $V_{CS}$  threshold to the actual switch turn-off point. The delay time contains the propagation time of the inner comparator and the driver delay, and it does not change with line voltage. The delay time leads to different primary peak current under different line voltage, which results in different output current in CC mode.

**Operation Description** (continued)

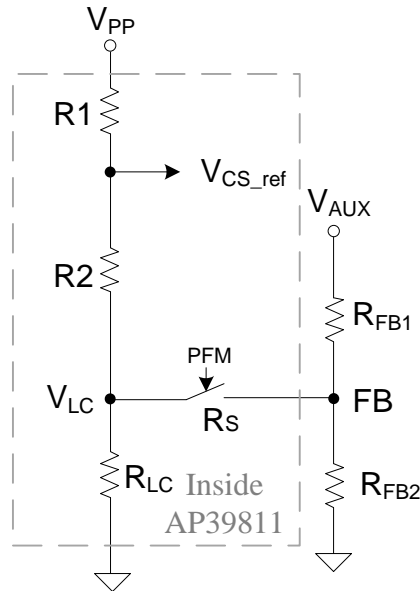


Figure 8: Line Compensation Control Circuit

In order to alleviate the difference under the universal input voltage, the AP39811 integrates the line compensation control circuit shown as Figure 8. During the primary on stage, an inner switcher  $R_S$  switches on, the  $R_{LC}$  is much smaller compared with  $R_{FB2}$ , so the  $R_{FB2}$ 's effect on line compensation can be neglected, the proportional line voltage is detected through  $R_{FB1}$  and  $R_{LC}$ , and is added to the  $V_{CS}$  threshold ( $V_{CS\_REF}$ ). The  $V_{LC}$  can be derived from the Formula 9:

$$V_{LC} = \frac{\frac{R_{FB1}}{3 * R2} * V_{PP} - V_{AUX}}{1 + \frac{R_{FB1}}{3 * R2} + \frac{R_{FB1}}{R_{LC}}} \quad (9)$$

The final compensated  $V_{CS}$  is :

$$V_{CS\_REF} = \frac{1}{3} * V_{PP} + \frac{2}{3} * V_{LC} \quad (10)$$

In the above formulas,  $V_{PP}$  is 1.8V at CC mode,  $R_{LC}$  is 60Ω,  $R2$  is 60kΩ,  $R1$  is two times of  $R2$ ,  $V_{AUX}$  is the auxiliary winding voltage during primary-on period, which is proportional to bus voltage. Based on the formula, we can make a conclusion that a smaller  $R_{FB1}$  results in deeper line compensation. If we know the delay time,  $t_{DELAY}$ , typically 150ns in AP39811, we can calculate the  $R_{FB1}$  as a reference for the system design.

**11. Protection**

The AP39811 provides versatile protections to prevent the system from damage under various fault conditions. Most protections will trigger auto-recovery mode in which the system will restart as soon as the  $V_{CC}$  drops to  $V_{OPR(MIN)}$ , when the fault conditions are removed, the system will recover to normal operation automatically.

**V<sub>CC</sub> OVP**

A  $V_{CC}$  OVP threshold is set to protect the IC from damage. When the  $V_{CC}$  OVP protection is triggered, the IC will stop output drive signal immediately and the system will enter auto-recovery mode.

**Output Over Voltage Protection (SOVP)**

As it described above that the FB pin voltage during  $t_{ONS}$  reflects the output voltage proportionally, this voltage can be used to realize SOVP. The AP39811 set a higher threshold,  $V_{FB(OVP)}$ , to shut down the system if the sampled voltage reached the threshold continuously for 3 switching cycles, the SOVP will be triggered and the system will enter auto-recovery mode.

## Operation Description (continued)

### Transformer Anti-Saturation Protection

Under some fault conditions or bad system design, the transformer may approach saturation and the current increases dramatically. To avoid power device damage since of transformer saturation, AP39811 integrated a maximum  $V_{CS}$  threshold  $V_{CS(MAX)}$  to protect the system, If there are 3 consecutive pulses where  $V_{CS}$  exceeds the threshold, the controller will shut down and enter auto-recovery mode.

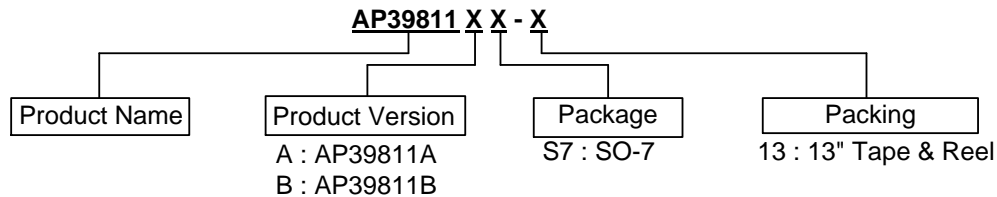
### Over Temperature Protection (OTP)

If the IC junction temperature exceeds the threshold of +130°C, the AP39811 will shut down immediately and enter auto-recovery mode. Note that even when the  $V_{CC}$  reaches  $V_{TH\_ST}$ , the IC will not output any drive pulse until the junction temperature falls of a hysteresis temperature of +30°C.

### Bulk Capacitor Open Protection

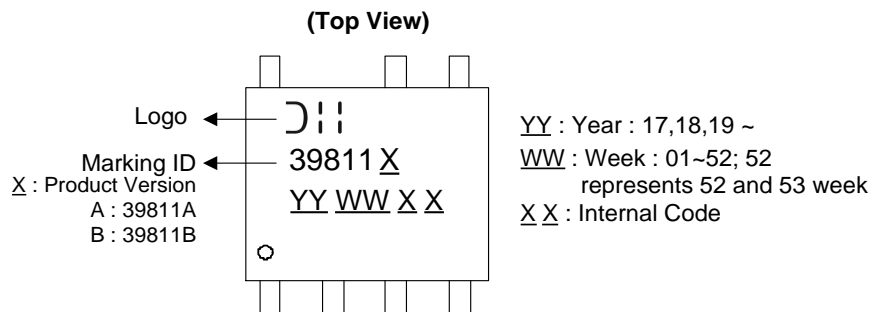
When the bulk capacitor opens, the bus voltage becomes a rectified half sine wave with large line frequency ripple. The IC can identify this fault by detecting bus voltage valley value. The AP39811 detects the bus voltage at each switching cycle through FB pin. If the detected voltage is lower than  $V_{FB\_NEG\_L}$  for 3 consecutive switching cycles, the IC will shut down and enter auto-recovery mode. During the auto recovery mode, when the  $V_{CC}$  reaches the  $V_{TH\_ST}$ , the controller will output one drive pulse to detect the bus voltage. If the detected signal is higher than  $V_{FB\_NEG\_H}$ , the IC will output subsequent pulses and the system will operate normally, otherwise the IC will shut down again and enter next restart cycle.

## Ordering Information



| Package | Part Number   | Marking ID | Packing          |
|---------|---------------|------------|------------------|
| SO-7    | AP39811AS7-13 | 39811A     | 4000/Tape & Reel |
| SO-7    | AP39811BS7-13 | 39811B     | 4000/Tape & Reel |

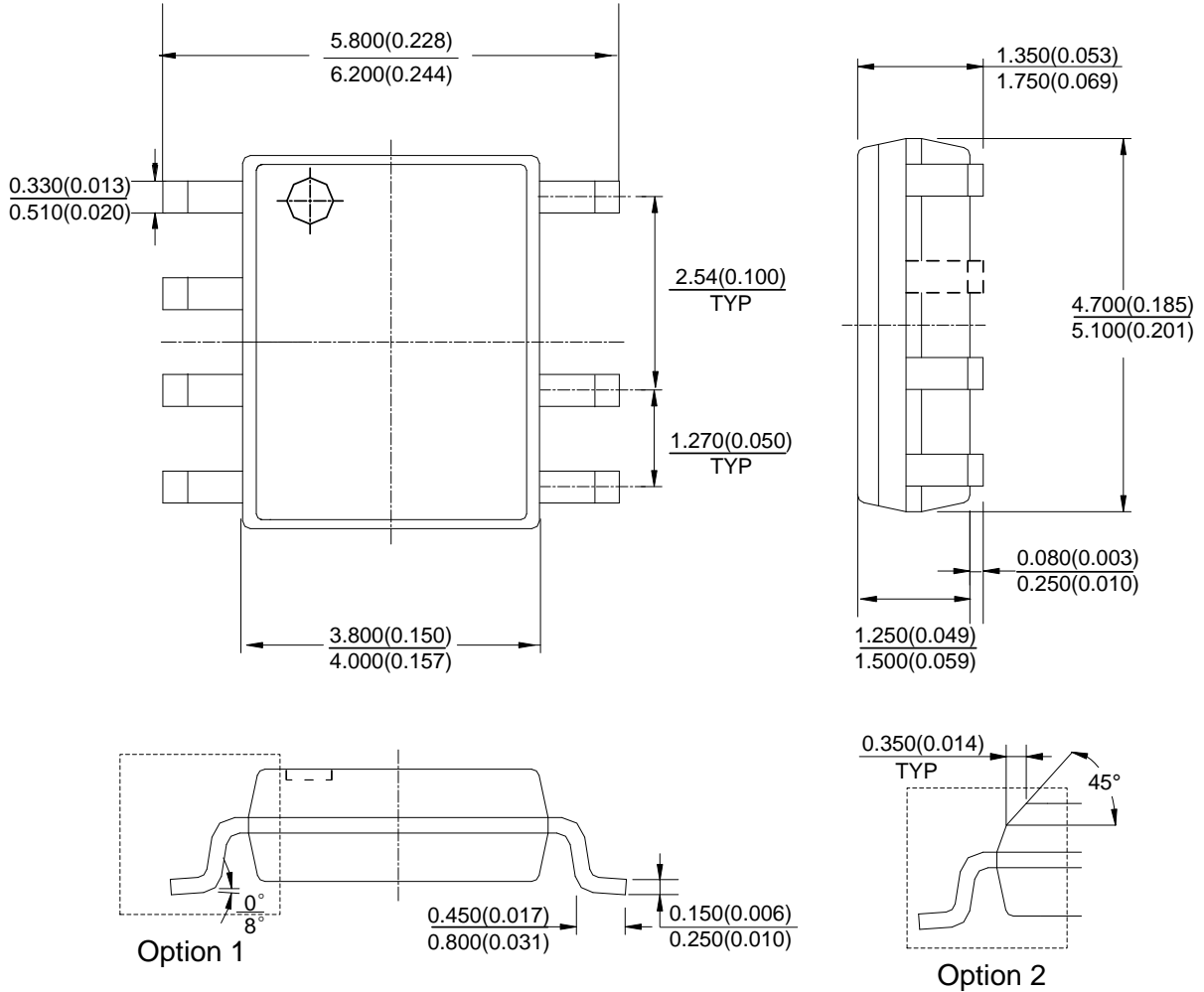
## Marking Information



**Package Outline Dimensions** (All dimensions in mm (inch).)

Please see <http://www.diodes.com/package-outlines.html> for the latest version.

(1) Package Type: SO-7



Note: Eject hole, oriented hole and mold mark is optional.

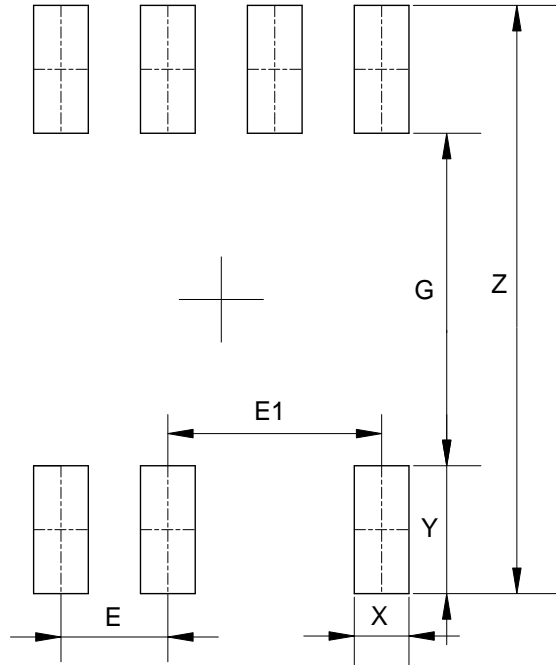
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**Suggested Pad Layout**

Please see <http://www.diodes.com/package-outlines.html> for the latest version.

(1) Package Type: SO-7



| Dimensions | Z<br>(mm)/(inch) | G<br>(mm)/(inch) | X<br>(mm)/(inch) | Y<br>(mm)/(inch) | E<br>(mm)/(inch) | E1<br>(mm)/(inch) |
|------------|------------------|------------------|------------------|------------------|------------------|-------------------|
| Value      | 6.900/0.272      | 3.900/0.154      | 0.650/0.026      | 1.500/0.059      | 1.270/0.050      | 2.540/0.100       |

NEW PRODUCT

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