



# THE DATASHEET OF MP6910DZ-LF



### DESCRIPTION

The MP6910 is a fast turn-off intelligent rectifier for Flyback converters that combines a 100V power switch that replaces diode rectifiers for high efficiency. The chip regulates the forward voltage drop of the internal power switch to about 70mV and turns it off before the voltage goes negative.

### FEATURES

- Supports DCM and Quasi-Resonant Flyback converter
- Integrated 10mΩ 100V Power Switch
- Compatible with Energy Star, 1W Standby Requirements
- $V_{DD}$  Range From 8V to 24V
- 70mV  $V_{DS}$  Regulation Function <sup>(1)</sup>
- Max 400kHz Switching Frequency
- Light Load Mode Function <sup>(1)</sup> with <300uA Quiescent Current
- Supports High-side and Low-side Rectification
- Power Savings of Up to 1.5W in a Typical Notebook Adapter

### APPLICATIONS

- Industrial Power Systems
- Distributed Power Systems
- Battery Powered Systems
- Flyback Converters

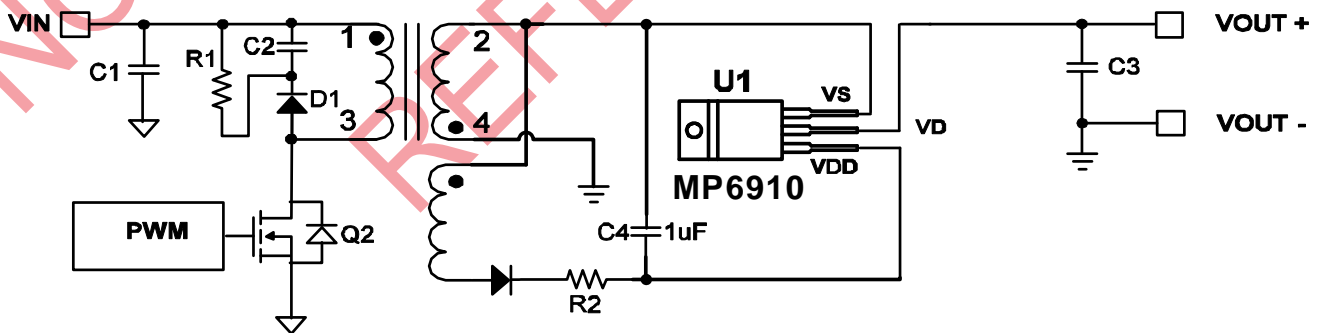
All MPS parts are lead-free and adhere to the RoHS directive. For MPS green status, please visit MPS website under Products, Quality Assurance page.

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#### Notes:

- 1) Related issued patent: US Patent US8,067,973; US8,400,790. CN Patent ZL201010504140.4; ZL200910059751.X. Other patents pending

### TYPICAL APPLICATION

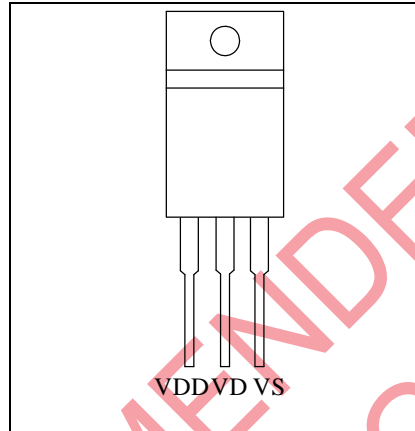


### ORDERING INFORMATION

| Part Number* | Package | Top Marking |
|--------------|---------|-------------|
| MP6910DZ     | TO220-3 | MP6910DZ    |

\* For RoHS Compliant Packaging, add suffix -LF; (e.g. MP6910DZ-LF)

### PACKAGE REFERENCE



### ABSOLUTE MAXIMUM RATINGS <sup>(2)</sup>

|  |                 |
|--|-----------------|
| $V_{DD}$ to $V_S$ .....                                    | -0.3V to +27V   |
| $V_D$ to $V_S$ .....                                       | -0.7V to +100V  |
| Maximum Operating Frequency.....                           | 400kHz          |
| Continuous Drain Current ( $T_C=25^\circ\text{C}$ ) .....  | 40A             |
| Continuous Drain Current ( $T_C=100^\circ\text{C}$ ) ..... | 15A             |
| Maximum Power Dissipation <sup>(3)</sup> .....             | 2.7W            |
| Junction Temperature .....                                 | 150°C           |
| Lead Temperature (Solder).....                             | 260°C           |
| Storage Temperature .....                                  | -55°C to +150°C |

### Recommended Operation Conditions <sup>(4)</sup>

|  |                 |
|--|-----------------|
| $V_{DD}$ to $V_S$ .....                  | 8V to 24V       |
| Operating Junction Temp. ( $T_J$ ) ..... | -40°C to +125°C |

### Thermal Resistance <sup>(5)</sup>

|              | $\theta_{JA}$ | $\theta_{JC}$ |
|--------------|---------------|---------------|
| TO220-3..... | 45            | 3             |

#### Notes:

- 2) Exceeding these ratings may damage the device.
- 3)  $T_A=+25^\circ\text{C}$ . The maximum allowable power dissipation is a function of the maximum junction temperature  $T_J(\text{MAX})$ , the junction-to-ambient thermal resistance  $\theta_{JA}$ , and the ambient temperature  $T_A$ . The maximum allowable continuous power dissipation at any ambient temperature is calculated by  $P_D(\text{MAX}) = (T_J(\text{MAX})-T_A)/\theta_{JA}$ . Exceeding the maximum allowable power dissipation will cause excessive die temperature, and the regulator will go into thermal shutdown. Internal thermal shutdown circuitry protects the device from permanent damage.
- 4) The device is not guaranteed to function outside of its operating conditions.
- 5) Measured on JESD51-7, 4-layer PCB.

**ELECTRICAL CHARACTERISTICS** $V_{DD} = 12V$ ,  $T_A = +25^\circ C$ , unless otherwise noted.

| Parameter   | Symbol         | Conditions            | Min  | Typ  | Max  | Units      |
|---|----------------|-----------------------|------|------|------|------------|
| Drain-to-Source Breakdown Voltage                       | $V_{(BR)DSS}$  |                       | 100  | 110  |      | V          |
| $V_{DD}$ Voltage Range                                  |                |                       | 8    |      | 24   | V          |
| $V_{DD}$ UVLO Rising                                    |                |                       | 5.0  | 6.0  | 7.0  | V          |
| $V_{DD}$ UVLO Hysteresis                                |                |                       | 0.8  | 1.2  | 1.5  | V          |
| Operating Current                                       | $I_{CC}$       | $F_{SW}=100kHz$       |      | 4.5  | 8    | mA         |
| Light-Load Mode Current                                 |                |                       |      | 260  | 360  | $\mu A$    |
| <b>CONTROL CIRCUITRY SECTION</b>                        |                |                       |      |      |      |            |
| $V_{SS} - V_D$ Forward Voltage                          | $V_{fwd}$      |                       | 55   | 70   | 85   | mV         |
| Turn-on Delay <sup>(6)</sup>                            | $T_{Don}$      |                       |      | 200  |      | ns         |
| Turn off Threshold ( $V_{SS}-V_D$ ) <sup>(6)</sup>      |                |                       |      | 30   |      | mV         |
| Turn-off Delay <sup>(6)</sup>                           | $T_{Doff}$     | $V_D = V_{SS}$        |      | 30   | 45   | ns         |
| Minimum On-time <sup>(6)</sup>                          | $T_{MIN}$      |                       |      | 1.6  |      | $\mu s$    |
| Light-load-enter Delay                                  | $T_{LL-Delay}$ |                       |      | 120  |      | $\mu s$    |
| Light-load-enter Pulse Width                            | $T_{LL}$       |                       |      | 2.2  |      | $\mu s$    |
| Light-load-enter Pulse Width Hysteresis                 | $T_{LL-H}$     |                       |      | 0.2  |      | $\mu s$    |
| Light-load Mode Exit Pulse Width Threshold ( $V_{DS}$ ) | $V_{LL-DS}$    |                       | -400 | -250 | -150 | mV         |
| <b>POWER SWITCH SECTION</b>                             |                |                       |      |      |      |            |
| Single Pulse Avalanche Current <sup>(7)</sup>           | $I_{AS}$       |                       |      | 66   |      | A          |
| Single Pulse Avalanche Energy <sup>(7)</sup>            | $E_{AS}$       |                       |      | 597  |      | mJ         |
| Drain-Source On-State Resistance                        | $R_{DS(ON)}$   | $V_{GS}=10V, I_D=20A$ |      | 10.2 |      | m $\Omega$ |
| Input Capacitance                                       | $C_{iss}$      | $V_{DS}=40V, f=1MHz$  |      | 5110 |      | pF         |
| Output Capacitance                                      | $C_{oss}$      |                       |      | 334  |      | pF         |
| Reverse Transfer Capacitance                            | $C_{rss}$      |                       |      | 150  |      | pF         |
| <b>DRAIN-SOURCE DIODE CHARACTERISTICS</b>               |                |                       |      |      |      |            |
| Reverse Recovery Time                                   | $t_{rr}$       |                       |      | 81   |      | ns         |
| Diode Reverse Charge                                    | $Q_{rr}$       |                       |      | 190  |      | nC         |

**Notes:**

6) Guaranteed by Design and Characterization.

7) Starting  $T_J=25^\circ C$ ,  $L=0.3mH$ **PIN FUNCTIONS**

| Pin # | Name | Description                                |
|-------|------|--|
| 1     | VDD  | Supply Voltage                             |
| 2     | VD   | FET Drain                                  |
| 3     | VS   | FET Source, also used as reference for VDD |

## BLOCK DIAGRAM

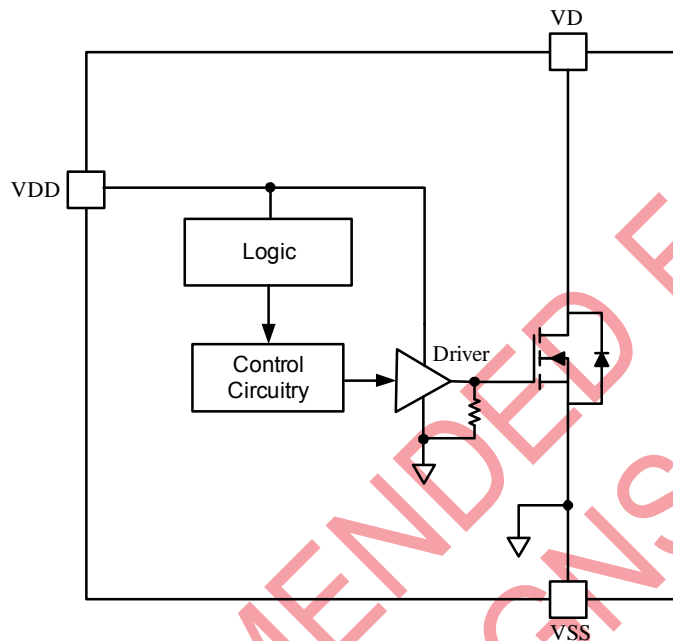


Figure 1—Function Block Diagram

## OPERATION

The MP6910 supports operation in DCM and Quasi-Resonant Flyback converters. The control circuitry controls the gate in forward mode and will turn the gate off when the MOSFET current is fairly low.

### Blanking

The control circuitry contains a blanking function. When it pulls the integrate Mosfet on/off, it makes sure that the on/off state at least lasts for some time. The turn on blanking time is  $\sim 1.6\mu\text{s}$ , which determines the minimum on-time. During the turn on blanking period, the turn off threshold is not totally blanked, but changes the threshold voltage to  $\sim +50\text{mV}$  (instead of  $-30\text{mV}$ ). This assures that the part can always be turned off even during the turn on blanking period. (Albeit slower)

### Under-Voltage Lockout (UVLO)

When the VDD is below UVLO threshold, the part is in sleep mode and the integrated Mosfet is never turned on.

### Basic Operation

The basic operations of flyback converter with MP6910 are:

- **Turn On Phase**

The switch current will first flow through the body diode of the integrate Mosfet, which generates a negative  $V_{ds}$  across it ( $< -500\text{mV}$ ). The voltage is much smaller than the turn on threshold of the control circuitry ( $-70\text{mV}$ ), which turns on the integrate Mosfet after 200ns turn on delay (defined in Fig.2).

- **Conducting Phase**

When the integrated Mosfet is turned on,  $V_{ds}$  becomes to rise according to its on resistance, as soon as  $V_{ds}$  rises above the turn on threshold ( $-70\text{mV}$ ), the control circuitry stops pulling up the gate driver, which leads the driver voltage of the integrate Mosfet dropped to larger the on resistance to ease the rise of  $V_{ds}$ . By doing that,  $V_{ds}$  is adjusted to be around  $-70\text{mV}$  even when the current through the switch is

fairly small, this function can make the internal driver voltage fairly low when the mosfet is turned off to fast the turn off speed (this function is still active during turn on blanking period which means the integrate mosfet could still be turned off even with very small duty).

Fig.3 shows synchronous rectification operation at heavy load condition. Due to the high current, the internal driver voltage will be saturated at first. After  $V_{ds}$  goes to above  $-70\text{mV}$ , driver voltage decreases to adjust the  $V_{ds}$  to typical  $-70\text{mV}$ .

Fig.4 shows synchronous rectification operation at light load condition. Due to the low current, the driver voltage never saturates but begins to decrease as soon as the integrated mosfet is turned on and adjust the  $V_{ds}$ .

- **Turn Off Phase**

When  $V_{ds}$  rises to trigger the turn off threshold ( $-30\text{mV}$ ), the driver voltage of the switch is pulled to low after about  $20\text{ns}$  turn off delay (defined in Fig.2) by the control circuitry. Similar with turn-on phase, a  $200\text{ns}$  blanking time is added after the switch is turned off to avoid error trigger.

### Light-load Latch-off Function

The gate driver of integrate Mosfet in MP6910 is latched to save the driver loss at light-load condition to improve efficiency. The light-load-enter pulse width  $T_{LL}$  is internal fixed ( $\sim 2.2\mu\text{s}$ ). When synchronous power switch conducting period keeps lower than  $T_{LL}$  for longer than the light-load-enter delay ( $T_{LL\text{-Delay}}$ ), MP6910 enters light-load mode and latches off the integrate Mosfet (Fig.5 for detail).

During light-load mode, MP6910 monitors the integrate Mosfet body diode conducting period by sensing  $V_{DS}$  (when  $V_{DS}$  exceeds the light-load mode exit pulse width threshold  $V_{LL\text{-}DS}$ , MP6910 considers the integrate Mosfet body diode conducting time finishes). If the Mosfet body diode conduction time is longer than  $T_{LL}+T_{LL\text{-}H}$  ( $T_{LL\text{-}H}$ , light-load-enter pulse width hysteresis), the light-load mode is finished and the integrate

Mosfet of MP6910 is unlatched to restart the synchronous rectification (Fig.6 for detail).

### Typical System Implementations

Fig.7 shows the typical system implementation for the IC supply derived from output voltage, which is available in low-side rectification and the output voltage is recommended to be in the  $V_{DD}$  range of MP6910 (from  $8\text{V}$  to  $24\text{V}$ ).

If output voltage is out of the  $V_{DD}$  range of MP6910 or high-side rectification is used, it is recommended to use an auxiliary winding from the power transformer for the IC supply, which is shown in Fig.8 and Fig.9.

There is another non-auxiliary winding solution for the IC supply, which uses an external LDO circuit from the secondary transformer winding. See fig.10 and fig.11, compared with using auxiliary winding for IC supply, this solution has a bit higher power loss which is dissipate on the LDO circuit especially when the secondary winding voltage is high.

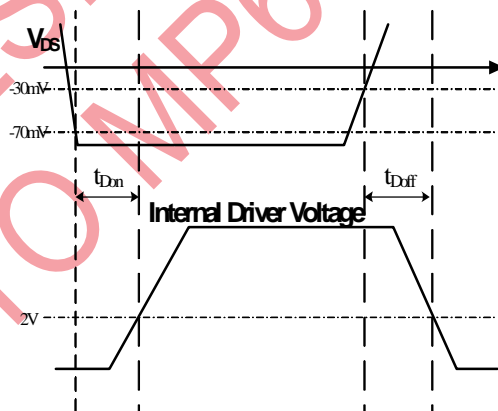


Figure 2—Turn on and Turn off delay

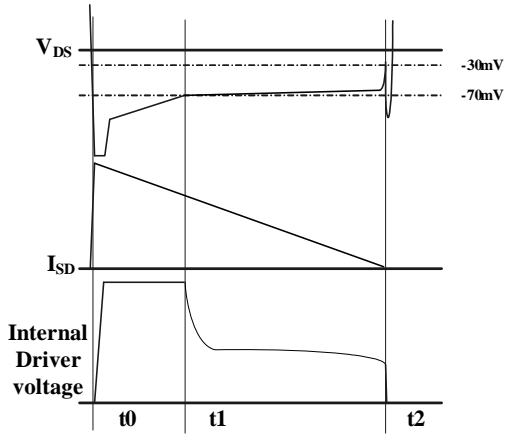


Figure 3—Synchronous Rectification Operation at heavy load

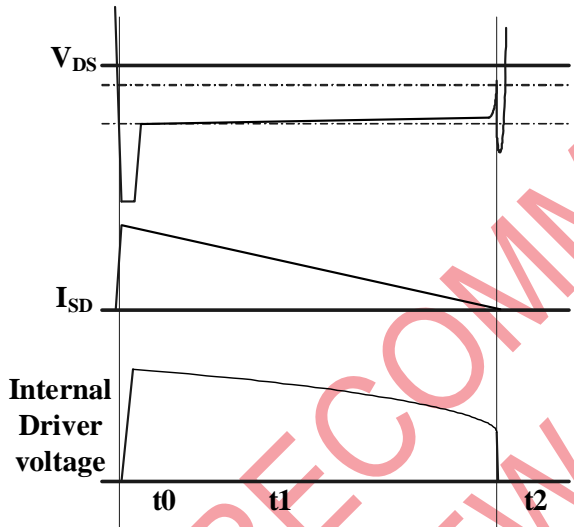


Figure 4—Synchronous Rectification Operation at light load

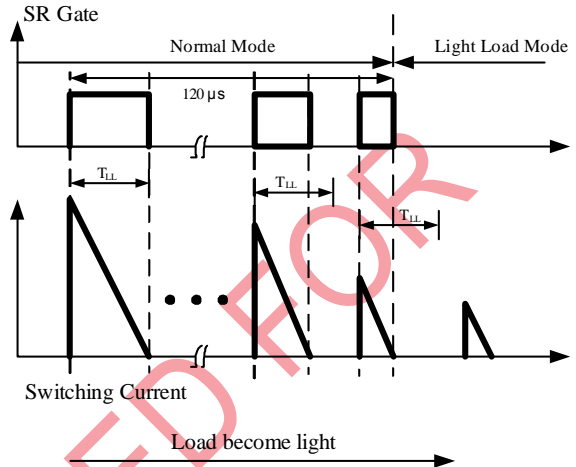


Figure 5—Enter Light Load Mode

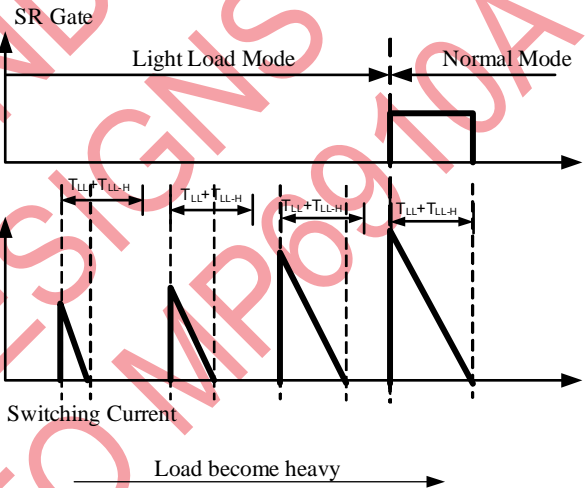


Figure 6—Exit Light Load Mode

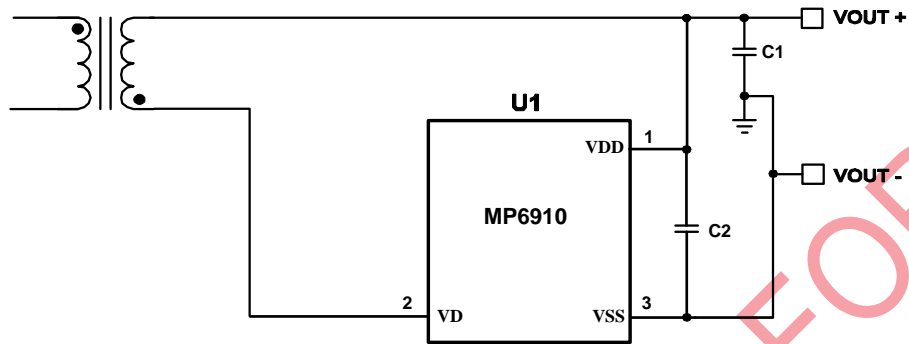


Figure 7—IC supply derived directly from output voltage

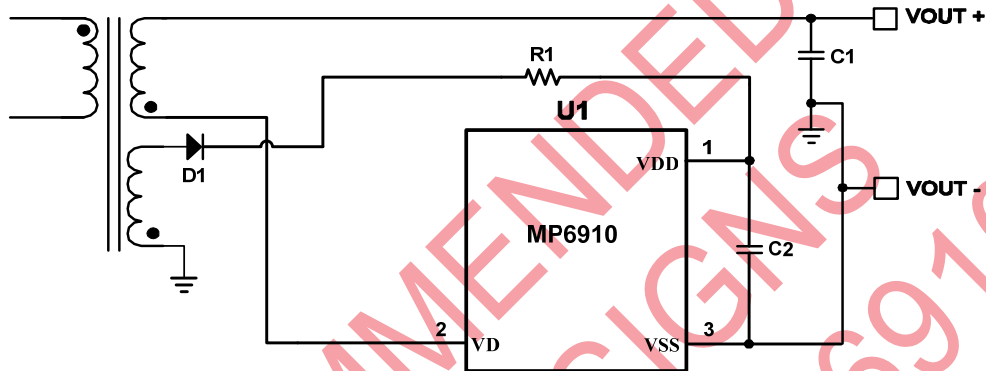


Figure 8—IC supply derived from auxiliary winding in low-side rectification

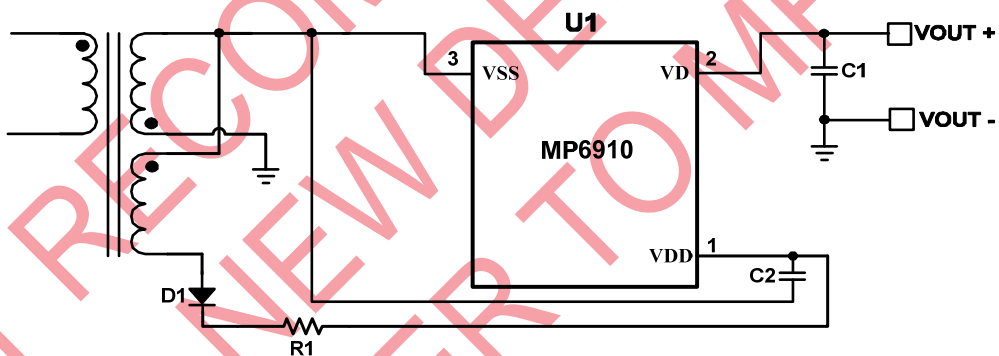


Figure 9—IC supply derived from auxiliary winding in high-side rectification

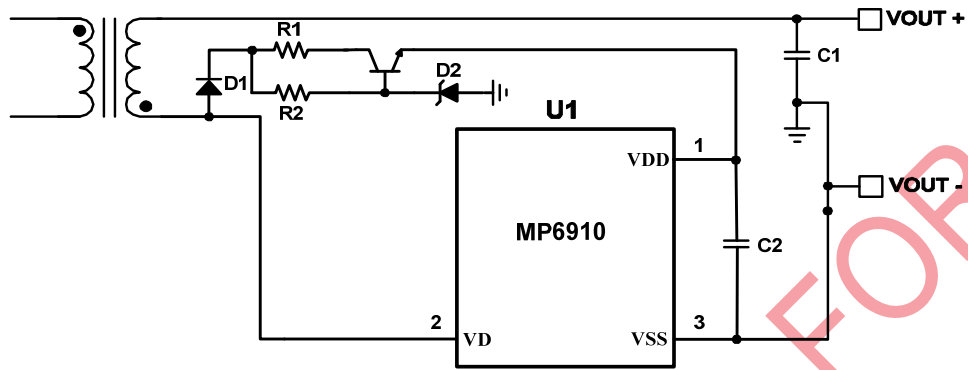


Figure 10—IC supply derived from secondary winding in low-side rectification

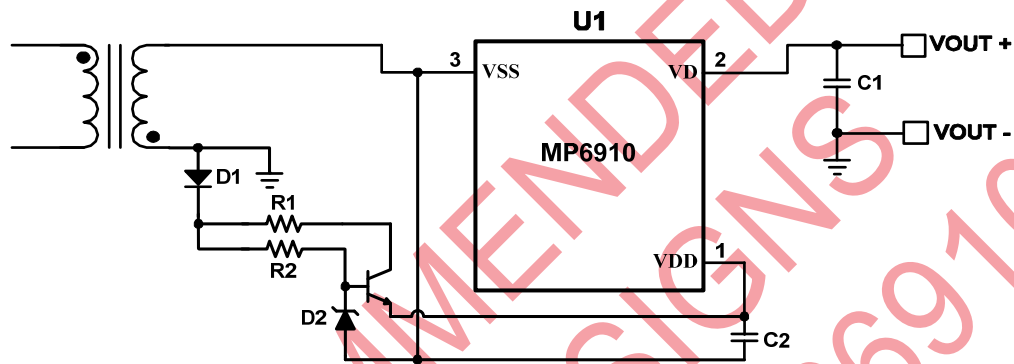
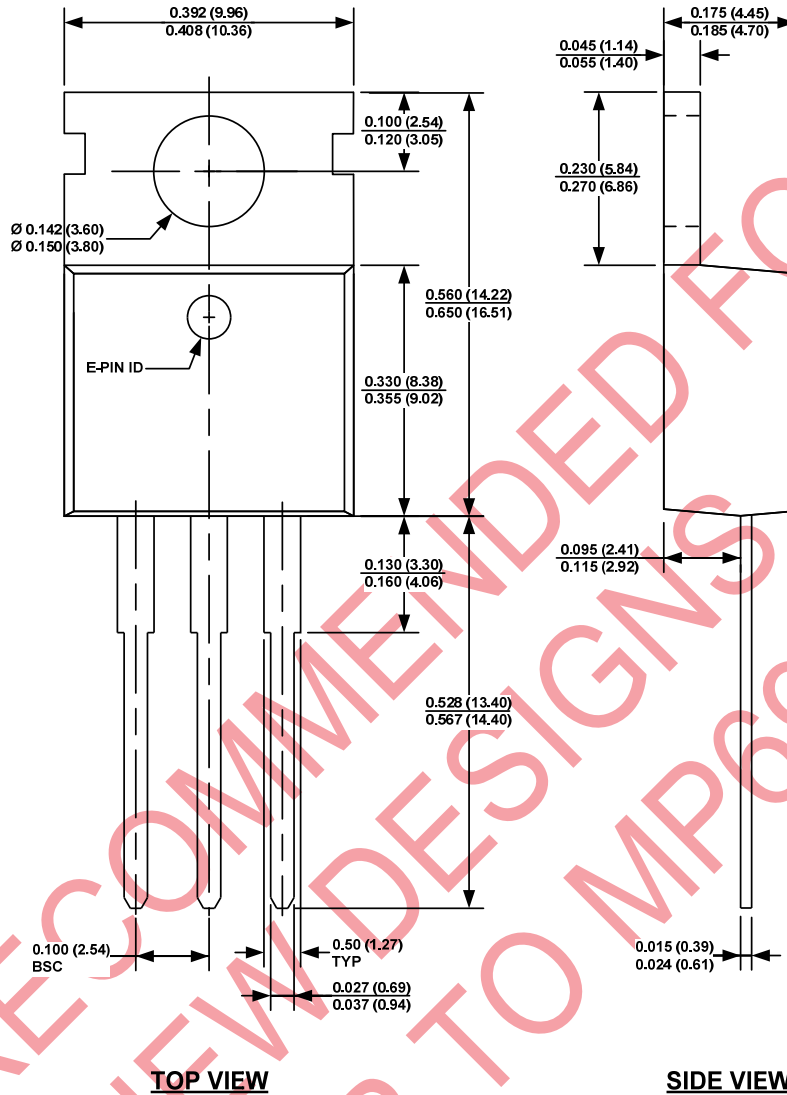


Figure 11—IC supply derived from secondary winding in high-side rectification







**NOTE:**

- 1) CONTROL DIMENSION IS IN INCHES. DIMENSION IN BRACKET IS IN MILLIMETERS.
- 2) PACKAGE LENGTH DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.
- 3) PACKAGE WIDTH DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSIONS.
- 4) DRAWING CONFORMS TO JEDEC TO-220
- 6) DRAWING IS NOT TO SCALE.

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