This application note describes the way, how to easily design the simple, non isolated AC/DC converter for powering low voltage control part of mains applications with triac, or SCR power switch. Some examples are: dishwashers, microwave ovens, coffee machines, night illumination and so on. In comparison with resistive, or capacitive dropper is this solution more comfortable and features some advantages such as:

- Wide Input Voltage Range 85 VAC – 265 VAC
- Smaller Size, Lower Weight, Lower Total Cost
- Good Line and Load Regulation, No Need of Additional Linear Regulators
- Efficient Design with Up to 80% Efficiency
- Overload, Short–Circuit and Thermal Protected
- Simple for Low Cost Mass Production
- Universal Design for Wide Range of Output Currents and Voltages

Schematic diagram

Figure 1. Complete Schematic Diagram of the 12 V/0.2 A Converter


**Inductor selection**

For the selected output power need to be selected certain minimum value of the inductance. This value is dependent on the mode of operation. Reduced value results in Discontinuous Conduction Mode of operation (DCM).

Practically was found that the borderline between Continuous Conduction Mode of operation (CCM) and DCM is commonly set slightly below maximum output power. The result is low cost of the inductor, freewheeling diode (trr > 35 ns), higher efficiency and lower cost. The negative result is in lower output power and higher cost of the NCP101x Power Switcher.

The current ripple in the inductor during the Ton time may be expressed by Equation 1.

\[
\Delta \text{ripple}(\text{Ton}) = \text{Ton} \cdot \left( \frac{(V_{\text{min}} - V_{ds} - V_{O})}{L_{\text{min}}} \right) \quad \text{(eq. 1)}
\]

Where:
- T\text{on} = ON Time, Internal Power Switch in ON,
- V_{\text{min}} = Minimum Rectified Input Voltage,
- V_{ds} = Drain–to–Source Voltage Drop,
- V_{O} = Output Voltage,
- L_{\text{min}} = Minimum Inductor Value.

The current ripple in the inductor during the Toff time may be expressed by Equation 2.

\[
\Delta \text{ripple}(\text{Toff}) = \text{Toff} \cdot \left( \frac{V_{O}}{L_{\text{min}}} \right) \quad \text{(eq. 2)}
\]

T\text{off} = OFF Time, Internal Power Switch in OFF.

The current through the inductor at the beginning of the Ton time is shown by Equation 3.

\[
\text{I}_{\text{init}} = \text{I}_{\text{set}} - \Delta \text{ripple} \quad \text{(eq. 3)}
\]

I_{\text{set}} = Peak Switching Current Set by the FB Loop.

**Table of Preselected Inductors** \((V_{\text{min}} = 120 \, \text{V}, \, V_{ds} = 9 \, \text{V}, \, V_{O} = 12 \, \text{V}, \, I_{\text{set}} = 0.405 \, \text{A}, \, f_{\text{op min}} = 59 \, \text{kHz})\)

<table>
<thead>
<tr>
<th>Inductance (\muH)</th>
<th>Coilcraft Part Number (see appendix for address)</th>
<th>\Delta \text{ripple} (\text{A})</th>
<th>Output Current (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>470</td>
<td>RFB0810–471</td>
<td>0.39</td>
<td>0.25</td>
</tr>
<tr>
<td>680</td>
<td>RFB0810–681</td>
<td>0.27</td>
<td>0.32</td>
</tr>
<tr>
<td>820</td>
<td>RFB0810–821</td>
<td>0.22</td>
<td>0.34</td>
</tr>
<tr>
<td>1000</td>
<td>RFB0810–102</td>
<td>0.18</td>
<td>0.36</td>
</tr>
<tr>
<td>1500</td>
<td>RFB0810–152</td>
<td>0.12</td>
<td>0.40</td>
</tr>
</tbody>
</table>

NOTE: The output current is the theoretical value and need to be multiplied by the efficiency (~0.7).
Freewheeling diode selection
The freewheeling diode needs to be selected accordingly to the mode of operation. For the CCM operation needs to be used the ultra fast diode with $t_{rr} < 35$ ns. For the DCM operation the standard ultra fast diode with $t_{rr} < 75$ ns is enough.

<table>
<thead>
<tr>
<th>Part number</th>
<th>$V_{RRM}$ (V)</th>
<th>$I_{F(AV)}$ (A)</th>
<th>$t_{rr}$ (ns)</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>MUR160</td>
<td>600</td>
<td>1.0</td>
<td>75</td>
<td>Axial Lead</td>
</tr>
<tr>
<td>MURA160T3</td>
<td>600</td>
<td>1.0</td>
<td>75</td>
<td>SMD SMA</td>
</tr>
<tr>
<td>MURS160T3</td>
<td>600</td>
<td>1.0</td>
<td>75</td>
<td>SMD SMB</td>
</tr>
<tr>
<td>MURS260T3</td>
<td>600</td>
<td>2.0</td>
<td>75</td>
<td>SMD SMB</td>
</tr>
</tbody>
</table>

Electrical specification of the example at Figure 1:
Input: 85 V AC – 265 V AC
Output: + 12 V / 200 mA

NOTE: The polarity is proportional to common line.

COMPONENT LAYOUT

Figure 2. Component Layout – Top Side

Figure 3. Component Layout – Bottom Side

PCB LAYOUT

Figure 4. PCB Layout
EMI TEST RESULTS

Test Conditions:
Input: 230 V AC
Output: 11.7 VDC
Load: Resistive 68 R

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Figure 5. Conducted EMI