TB008

Transformerless Power Supply

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INTRODUCTION

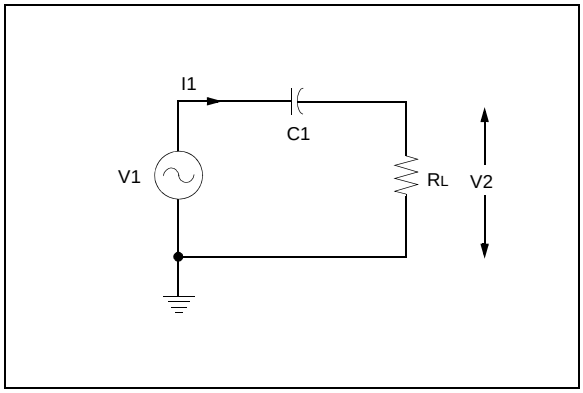
In most non-battery applications, the power to the microcontroller is normally supplied using a wall mounted transformer, which is then rectified, filtered and regulated. In most applications, this method of generating the regulated voltage is cost effective and can be justified. However, there are applications where the PIC12/16/17 is the main controller and low voltage is not required by other components except the PIC12/16/17. In these instances, the cost of the transformer becomes the sizable cost factor in the system. Transformerless power supplies, thus, have a distinct advantage in cost as well as in size. The disadvantages of using a transformerless power supply are: (1) low current supply and (2) no isolation from the AC line voltage. The PIC12/16/17 microcontrollers draw a maximum of 10 mA, even at the highest frequency and voltage of operation, therefore low current availability is not an issue. AC line voltage isolation can be addressed by using MOVs or transient suppressors on the PIC12/16/17.

IMPLEMENTATION

When a capacitor and resistor are connected in series to an AC source, as in Figure 1, a constant current can be maintained through the resistor, so long as the reactance of the capacitors is much greater than the resistance. The current flow is dependent upon the value of the capacito,r and assuming that V_1 is much greater than V_2, the value of the current can be assumed to be:

$I_{RMS} = V_1/X_C$ where X_C is the reactance of the capacitor.

FIGURE 1:

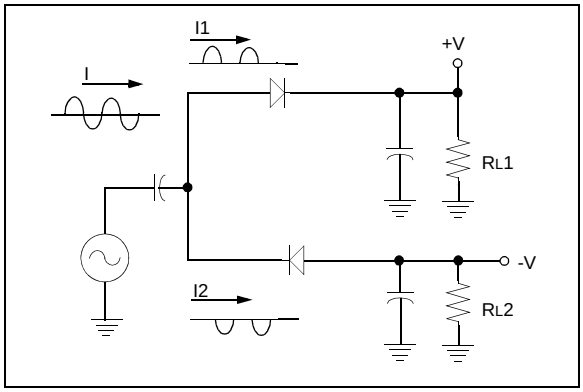


Assuming a line voltage of $V_1 = 115V$ and line frequency = 60 Hz,

$I_{RMS} = 115(2\pi 60C) = 4300C$ or $I_{RMS} \approx 40$ mA/μF.

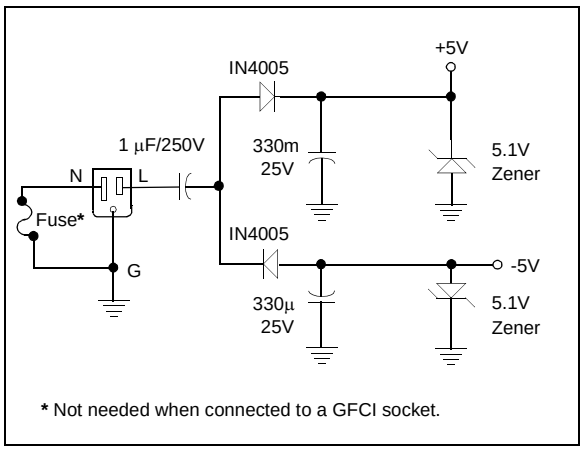
In order to get a DC voltage using this system, a pair of rectifiers and filter caps can be added as shown in Figure 2. This would give us a capability of driving one half of the current through the positive part and the other half through the negative part. The max current on each side would be = 20 mA/μF.

FIGURE 2:



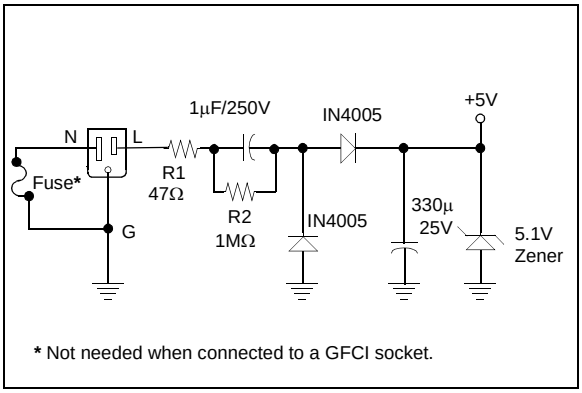
In most applications, the output voltage should be regulated. Figure 3 shows a diagram for a practical circuit where a +/- 5V regulated output is generated. Note that the neutral is connected to ground through a fuse. This would guard against improper AC wiring.

FIGURE 3:



In most PIC12/16/17 applications, the negative voltage is not required. Figure 3 has been thus modified for a single ended supply as in Figure 4. Note that R1 and R2 are required for UL approval.

FIGURE 4:



Precautions:

1. As mentioned earlier, the neutral should be connected to earth ground through a fuse. This would insure protection in case of improper wiring.
2. The AC coupling capacitors and rectifier diodes should be able to withstand the peak voltage in the system. Remember $V_{RMS} = V_{PG}/2$, where $V_{PG} = V_{PEAK}$ to earth ground voltage. Hence for a 120V system, the max voltage = 170V. For a 240V system, the max voltage = 340V.

TABLE 1: COST ANALYSIS OF A +5V POWER SUPPLY WITH/WITHOUT A TRANSFORMER

Components	Unit Price(1)	Qty	Transformer P.S.	Qty.	Transformerless P.S.
1.1 VA transformer	5.65	1	5.65	0	—
1N4005 diode	0.05	2	0.10	2	0.10
1 µF/250V cap	0.57	0	—	1	0.57
5.1V Zener	0.11	1	0.11	1	0.11
330 µF/25V filter cap	0.17	1	0.17	1	0.17
Total			6.03		0.95

Note 1: All prices are based on 100 quantity pricing from the 2000 Digikey Catalog and are listed here for comparison purposes only.

As can be seen, the cost of the transformer power supply is 6 times that of the transformerless power supply. In quantities of 100, the cost of a transformerless power supply is less than a dollar.

CONCLUSION

A transformerless power supply is a low cost, small footprint alternative by which a PIC12/16/17 can be powered.

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