TB008

Transformerless Power Supply

Author: Stan D'Souza
Microchip Technology Inc.

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:

© 2000 Microchip Technology Inc.

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

(1) All prices based on 100 qty. price from Digikey Catalog.

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.

© 2000 Microchip Technology Inc.

NOTES:

WORLDWIDE SALES AND SERVICE

AMERICAS

Corporate Office
Microchip Technology Inc.
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-786-7200 Fax: 480-786-7277
Technical Support: 480-786-7627
Web Address: http://www.microchip.com

Atlanta
Microchip Technology Inc.
500 Sugar Mill Road, Suite 200B
Atlanta, GA 30350
Tel: 770-640-0034 Fax: 770-640-0307

Boston
Microchip Technology Inc.
5 Mount Royal Avenue
Marlborough, MA 01752
Tel: 508-480-9990 Fax: 508-480-8575

Chicago
Microchip Technology Inc.
333 Pierce Road, Suite 180
Itasca, IL 60143
Tel: 630-285-0071 Fax: 630-285-0075

Dallas
Microchip Technology Inc.
4570 Westgrove Drive, Suite 160
Addison, TX 75248
Tel: 972-818-7423 Fax: 972-818-2924

Dayton
Microchip Technology Inc.
Two Prestige Place, Suite 150
Miamisburg, OH 45342
Tel: 937-291-1654 Fax: 937-291-9175

Detroit
Microchip Technology Inc.
Tri-Atria Office Building
32255 Northwestern Highway, Suite 190
Farmington Hills, MI 48334
Tel: 248-538-2250 Fax: 248-538-2260

Los Angeles
Microchip Technology Inc.
18201 Von Karman, Suite 1090
Irvine, CA 92612
Tel: 949-263-1888 Fax: 949-263-1338

New York
Microchip Technology Inc.
150 Motor Parkway, Suite 202
Hauppauge, NY 11788
Tel: 631-273-5305 Fax: 631-273-5335

San Jose
Microchip Technology Inc.
2107 North First Street, Suite 590
San Jose, CA 95131
Tel: 408-436-7950 Fax: 408-436-7955

AMERICAS (continued)

Toronto
Microchip Technology Inc.
5925 Airport Road, Suite 200
Mississauga, Ontario L4V 1W1, Canada
Tel: 905-405-6279 Fax: 905-405-6253

ASIA/PACIFIC

Beijing
Microchip Technology, Beijing
Unit 915, 6 Chaoyangmen Bei Dajie
Dong Erhuan Road, Dongcheng District
New China Hong Kong Manhattan Building
Beijing 100027 PRC
Tel: 86-10-85282100 Fax: 86-10-85282104

Hong Kong
Microchip Asia Pacific
Unit 2101, Tower 2
Metroplaza
223 Hing Fong Road
Kwai Fong, N.T., Hong Kong
Tel: 852-2-401-1200 Fax: 852-2-401-3431

India
Microchip Technology Inc.
India Liaison Office
No. 6, Legacy, Convent Road
Bangalore 560 025, India
Tel: 91-80-229-0061 Fax: 91-80-229-0062

Japan
Microchip Technology Intl. Inc.
Benex S-1 6F
3-18-20, Shinyokohama
Kohoku-Ku, Yokohama-shi
Kanagawa 222-0033 Japan
Tel: 81-45-471- 6166 Fax: 81-45-471-6122

Korea
Microchip Technology Korea
168-1, Youngbo Bldg. 3 Floor
Samsung-Dong, Kangnam-Ku
Seoul, Korea
Tel: 82-2-554-7200 Fax: 82-2-558-5934

Shanghai
Microchip Technology
Unit B701, Far East International Plaza,
No. 317, Xianxia Road
Shanghai, 200051 P.R.C
Tel: 86-21-6275-5700 Fax: 86-21-6275-5060

ASIA/PACIFIC (continued)

Singapore
Microchip Technology Singapore Pte Ltd.
200 Middle Road
#07-02 Prime Centre
Singapore 188980
Tel: 65-334-8870 Fax: 65-334-8850

Taiwan, R.O.C
Microchip Technology Taiwan
10F-1C 207
Tung Hua North Road
Taipei, Taiwan, ROC
Tel: 886-2-2717-7175 Fax: 886-2-2545-0139

EUROPE

Denmark
Microchip Technology Denmark ApS
Regus Business Centre
Lautrup hoj 1-3
Ballerup DK-2750 Denmark
Tel: 45 4420 9895 Fax: 45 4420 9910

France
Arizona Microchip Technology SARL
Parc d'Activite du Moulin de Massy
43 Rue du Saule Trapu
Batiment A - ler Etage
91300 Massy, France
Tel: 33-1-69-53-63-20 Fax: 33-1-69-30-90-79

Germany
Arizona Microchip Technology GmbH
Gustav-Heinemann-Ring 125
D-81739 München, Germany
Tel: 49-89-627-144 0 Fax: 49-89-627-144-44

Italy
Arizona Microchip Technology SRL
Centro Direzionale Colleoni
Palazzo Taurus 1 V. Le Colleoni 1
20041 Agrate Brianza
Milan, Italy
Tel: 39-039-65791-1 Fax: 39-039-6899883

United Kingdom
Arizona Microchip Technology Ltd.
505 Eskdale Road
Winnersh Triangle
Wokingham
Berkshire, England RG41 5TU
Tel: 44 118 921 5858 Fax: 44-118 921-5835

01/21/00

DNV Certification, Inc. USA
ANSI-RAB QMS ACCREDITED
DNV
DNV MSC The Netherlands Accredited by the RvA
ISO 9001 / QS-9000 REGISTERED FIRM

Microchip received QS-9000 quality system certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona in July 1999. The Company's quality system processes and procedures are QS-9000 compliant for its PICmicro® 8-bit MCUs, KEELOQ® code hopping devices, Serial EEPROMs and microperipheral products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001 certified.

All rights reserved. © 2000 Microchip Technology Incorporated. Printed in the USA. 1/00 Printed on recycled paper.

Information contained in this publication regarding device applications and the like is intended through suggestion only and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. No representation or warranty is given and no liability is assumed by Microchip Technology Incorporated with respect to the accuracy or use of such information, or infringement of patents or other intellectual property rights arising from such use or otherwise. Use of Microchip's products as critical components in life support systems is not authorized except with express written approval by Microchip. No licenses are conveyed, implicitly or otherwise, except as maybe explicitly expressed herein, under any intellectual property rights. The Microchip logo and name are registered trademarks of Microchip Technology Inc. in the U.S.A. and other countries. All rights reserved. All other trademarks mentioned herein are the property of their respective companies.