

PFM/PWM Step-Up DC/DC Controller

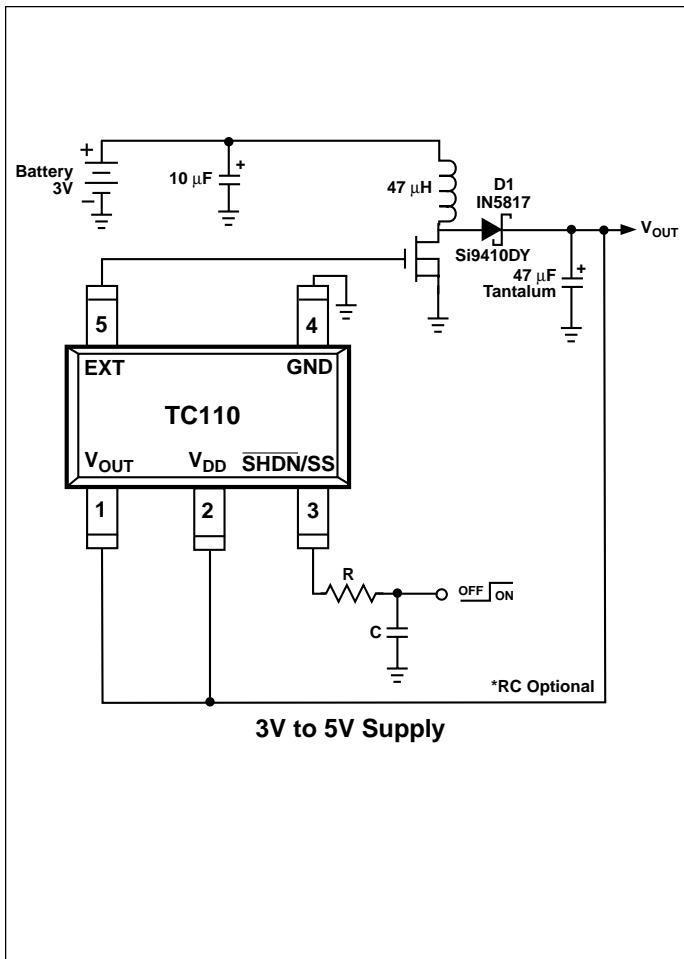
FEATURES

- Space-Saving 5-Pin SOT-23A Package
- Guaranteed Start-Up at 0.9V
- 50 μ A (Typ) Supply Current ($f_{OSC} = 100$ KHz)
- 300 mA Output Current @ $V_{IN} \geq 2.7V$
- 0.5 μ A Shutdown Mode
- 100 KHz and 300 KHz Switching Frequency Options
- Programmable Soft-Start
- 84% Efficiency

TYPICAL APPLICATIONS

- Palmtops
- Battery Powered Systems
- Positive LCD Bias Generators
- Portable Communicators

TYPICAL OPERATING CIRCUIT



GENERAL DESCRIPTION

The TC110 is a step-up (Boost) switching controller that furnishes output currents as high as 300 mA while delivering a typical efficiency of 84%. The TC110 normally operates in pulse width modulation mode (PWM), but automatically switches to pulse frequency modulation (PFM) at low output loads for greater efficiency. Supply current draw for the 100 KHz version is typically only 50 μ A, and is reduced to less than 0.5 μ A when the SHDN input is brought low. Regulator operation is suspended during shutdown.

Housed in a tiny 5-pin SOT-23A package, the TC110 occupies minimum board space, and uses tiny external components (the 300 KHz version allows for less than 5 mm surface-mount magnetics).

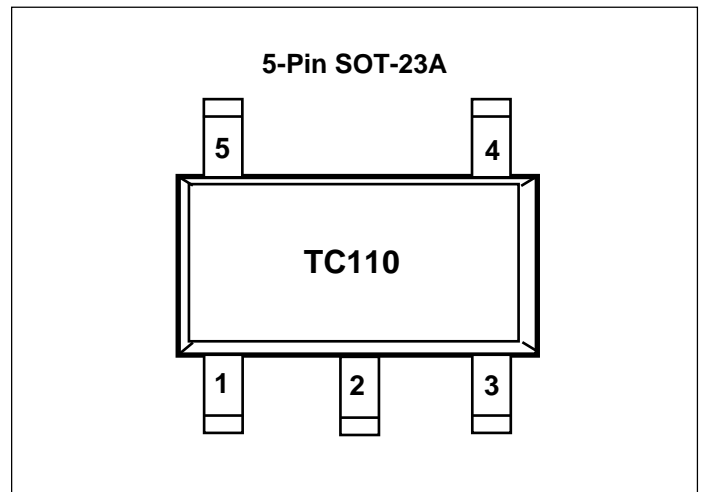
The TC110 accepts input voltages from 2.0V to 10.0V, with a guaranteed start-up voltage of 0.9V.

ORDERING INFORMATION

Part Number	Output Voltage* (V)	Package	Osc. Freq. (KHz)	Operating Temp. Range
TC110501ECT	5.0	5-Pin SOT-23A	100	-40 to +85°C
TC110331ECT	3.3	5-Pin SOT-23A	100	-40 to +85°C
TC110301ECT	3.0	5-Pin SOT-23A	100	-40 to +85°C
TC110503ECT	5.0	5-Pin SOT-23A	300	-40 to +85°C
TC110333ECT	3.3	5-Pin SOT-23A	300	-40 to +85°C
TC110303ECT	3.0	5-Pin SOT-23A	300	-40 to +85°C

NOTE: *Other output voltages available. Please contact Microchip Technology for details.

PIN CONFIGURATION



TC110

ABSOLUTE MAXIMUM RATINGS*

Voltage on V _{DD} , V _{OUT} , $\overline{\text{SHDN}}$ Pins	-0.3V to +12V
EXT Output Current	±100 mA
Voltage on EXT Pin	-0.3V to V _{DD} +0.3V
Power Dissipation	150 mW
Operating Temperature	-40°C to +85°C
Storage Temperature	-40°C to +125°C

*Static-sensitive device. Unused devices must be stored in conductive material. Protect devices from static discharge and static fields. Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions above those indicated in the operational sections of the specifications is not implied. Exposure to Absolute Maximum Rating Conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS: Note 1, T_A = 25°C, V_{IN} = 0.6V X V_R, V_{DD} = V_{OUT}, unless otherwise noted.

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V _{DD}	Supply Voltage	Note 2	2.0	—	10.0	V
V _{START}	Start-Up Supply Voltage	I _{OUT} = 1 mA	—	—	0.9	V
V _{HOLD-UP}	Oscillator Hold-Up Voltage	I _{OUT} = 1 mA	—	—	0.7	V
I _{DD}	Boost Mode Supply Current	V _{OUT} = $\overline{\text{SHDN}}$ = (0.95 x V _R); f _{OSC} = 300 KHz; V _R = 3.0V	—	120	190	μA
		V _R = 3.3V	—	130	200	μA
		V _R = 5.0V	—	180	280	μA
		f _{OSC} = 100 KHz; V _R = 3.0V	—	50	90	μA
		V _R = 3.3V	—	50	100	μA
		V _R = 5.0V	—	70	120	μA
I _{STBY}	Standby Supply Current	V _{OUT} = $\overline{\text{SHDN}}$ = (V _R + 0.5V); f _{OSC} = 300 KHz; V _R = 3.0V	—	20	34	μA
		V _R = 3.3V	—	20	35	μA
		V _R = 5.0V	—	22	38	μA
		f _{OSC} = 100 KHz; V _R = 3.0V	—	11	20	μA
		V _R = 3.3V	—	11	20	μA
		V _R = 5.0V	—	11	22	μA
I _{SHDN}	Shutdown Supply Current	$\overline{\text{SHDN}}$ = GND, V _O = (V _R x 0.95)	—	0.05	0.5	μA
f _{OSC}	Oscillator Frequency	V _{OUT} = $\overline{\text{SHDN}}$ = (0.95 x V _R); f _{OSC} = 300 KHz	255	300	345	KHz
		f _{OSC} = 100 KHz	85	100	115	KHz
V _{OUT}	Output Voltage	Note 3	V _R x 0.975	V _R	V _R x 1.025	V
DTYMAX	Maximum Duty Cycle (PWM Mode)	V _{OUT} = $\overline{\text{SHDN}}$ = 0.95 x V _R	—	—	92	%
DTYPFM	Duty Cycle (PFM Mode)	I _{OUT} = 0 mA	15	25	35	%
V _{IH}	SHDN Input Logic High	V _{OUT} = (V _R x 0.95)	0.65	—	—	V
V _{IL}	SHDN Input Logic Low	V _{OUT} = (V _R x 0.95)	—	—	0.20	V
REXTH	EXT ON Resistance to V _{DD}	V _{OUT} = $\overline{\text{SHDN}}$ = (V _R x 0.95); V _R = 3.0V	—	32	47	Ω
		V _R = 3.3V	—	29	43	Ω
		V _R = 5.0V	—	20	29	Ω
REXTL	EXT ON Resistance to GND	V _{OUT} = $\overline{\text{SHDN}}$ = (V _R x 0.95); V _R = 3.0V	—	20	30	Ω
		V _R = 3.3V	—	19	27	Ω
		V _R = 5.0V	—	13	19	Ω
η	Efficiency	V _{EXT} = 0.4V	—	84	—	%

Notes: 1. For V_R = 3.0V, I_{OUT} = 120mA; For V_R = 3.3V, I_{OUT} = 130mA; For V_R = 5.0V I_{OUT} = 200 mA.

2. See Application Notes "Operating Mode" description for clarification.

3. V_R is the factory output voltage setting.

PIN DESCRIPTION

Pin Number	Name	Description
1	V _{OUT}	Power and Voltage Sense Input. This dual function input provides both feedback voltage sensing and internal chip power. It should be connected to the regulator output. (See <i>Applications</i> section).
2	V _{DD}	Power Supply Voltage Input.
3	$\overline{\text{SHDN}}/\text{SS}$	Shutdown Input. A logic low on this input suspends device operation and reduces supply current to less than 0.5 μA . Device operation resumes when $\overline{\text{SHDN}}$ is brought high. An RC circuit connected to this input also determines the soft-start time.
4	GND	Ground Terminal.
5	EXT	External Switch Transistor Drive Complimentary Output. This pin drives the external switching transistor. It may be connected to the base of the external bipolar transistor or gate of the external N-channel MOSFET. (See <i>Applications</i> section).

TC110

DETAILED DESCRIPTION

TC110 is a PFM/PWM step-up DC/DC controller for use in systems operating from two or more cells, or in low voltage, line-powered applications. It uses PWM as the primary modulation scheme, but automatically converts to PFM at output duty cycles less than approximately 10%. The conversion to PFM provides reduced supply current, and therefore higher operating efficiency at low loads. The TC110 uses an external switching transistor, allowing construction of switching regulators with maximum output currents of 300 mA.

The TC110 consumes only 70 μA , typical, of supply current and can be placed in a 0.5 μA shutdown mode by bringing SHDN low. The regulator is disabled during shutdown, and resumes normal operation when SHDN is brought high. Other features include start-up at $V_{\text{IN}} = 0.9\text{V}$, an externally-programmable soft start time and tiny 5-pin SOT-23A packaging.

Operating Mode

The TC110 is powered by the voltage present on the V_{DD} input. The applications circuits of Figures 1a and 1b show operation in the bootstrapped and non-bootstrapped modes. In bootstrapped mode, the TC110 is powered from the output (start-up voltage is supplied by V_{IN} through the inductor and Schottky diode while Q1 is off). In bootstrapped mode, the switching transistor is turned on harder because its gate voltage is higher (due to the boost action of the regulator), resulting in higher output current capacity.

The TC110 is powered from the input supply in the non-bootstrapped mode. In this mode, the supply current to the TC110 is minimized. However, the drive applied to the gate of the switching transistor swings from the input supply level to ground, so the transistor's ON resistance increases at low input voltages. Overall efficiency is increased since supply current is reduced, and less energy is consumed charging and discharging the gate of the MOSFET. While the TC110 is guaranteed to start up at 0.9V the device performs to specifications at 2.0V and higher.

Low Power Shutdown Mode

The TC110 enters a low power shutdown mode when SHDN is brought low. While in shutdown, the oscillator is disabled and the output switch (internal or external) is shut off. Normal regulator operation resumes when SHDN is brought high. SHDN may be tied to the input supply if not used. *Note:* Because the TC110 uses an external diode, a leakage path between the input voltage and the output node (through the inductor and diode) exists while the regulator is in shutdown. Care must be taken in system design to assure the input supply is isolated from the load during shutdown.

Soft Start

Soft start allows the output voltage to gradually ramp from 0V to rated output value during start-up. This action minimizes (or eliminates) overshoot, and in general, reduces stress on circuit components. Figure 2 shows the circuit required to implement soft start. Values of 470K and 0.1 μF for R_{SS} and C_{SS} are adequate for most applications.

Input Bypass Capacitors

Using an input bypass capacitor reduces peak current transients drawn from the input supply, and reduces the switching noise generated by the regulator. The source impedance of the input supply determines the size of the capacitor that should be used.

Output Capacitor

The effective series resistance of the output capacitor directly affects the amplitude of the output voltage ripple. (The product of the peak inductor current and the ESR determines output ripple amplitude.) Therefore, a capacitor with the lowest possible ESR should be selected. Smaller capacitors are acceptable for light loads or in applications where ripple is not a concern. The Sprague 595D series of tantalum capacitors are amongst the smallest of all low ESR surface mount capacitors available. Table 1 lists suggested component numbers and manufacturers.

Inductor Selection

Selecting the proper inductor value is a trade-off between physical size and power conversion requirements. Lower value inductors cost less, but result in higher ripple current and core losses. They are also more prone to saturate since the coil current ramps to a higher value. Larger inductor values reduce both ripple current and core losses, but are larger in physical size and tend to increase the start-up time slightly.

A 22 μH inductor, therefore, is recommended for the 300 KHz versions and a 47 μH inductor is recommended for the 100KHz versions. Inductors with a ferrite core (or equivalent) also are recommended. For highest efficiency, use an inductor with a series resistance less than 20m Ω .

The inductor value directly affects the output ripple voltage. Equation 3 is derived as shown below, and can be used to calculate an inductor value, given the required output ripple voltage and output capacitor series resistance:

$$V_{\text{RIPPLE}} \approx \text{ESR}(di)$$

Equation 1.

where ESR is the equivalent series resistance of the output filter capacitor, and V_{RIPPLE} is in volts.

Expressing di in terms of switch ON resistance and time:

$$V_{\text{RIPPLE}} \approx \frac{\text{ESR} [(V_{\text{IN}} - V_{\text{SW}})t_{\text{ON}}]}{L}$$

Equation 2.

Solving for L:

$$L \approx \frac{\text{ESR} [(V_{\text{IN}} - V_{\text{SW}})t_{\text{ON}}]}{V_{\text{RIPPLE}}}$$

Equation 3.

Care must be taken to ensure the inductor can handle peak switching currents, which can be several times load currents. Exceeding rated peak current will result in core saturation and loss of inductance. The inductor should be selected to withstand currents greater than I_{PK} (Equation 10) without saturating.

Calculating the peak inductor current is straightforward. Inductor current consists of an AC (sawtooth) current centered on an average DC current (i.e. input current). Equation 6 calculates the average DC current. Note that minimum input voltage and maximum load current values should be used:

$$\text{Input Power} = \frac{\text{Output Power}}{\text{Efficiency}}$$

Equation 4.

Re-writing in terms of input and output currents and voltages:

$$(V_{\text{IN(MIN)}}) (I_{\text{IN(MAX)}}) = \frac{(V_{\text{OUT(MAX)}})(I_{\text{OUT(MAX)}})}{\text{Efficiency}}$$

Equation 5.

Solving for input current:

$$I_{\text{IN(MAX)}} = \frac{(V_{\text{OUT(MAX)}})(I_{\text{OUT(MAX)}})}{(\text{Efficiency})(V_{\text{IN(MAX)}})}$$

Equation 6.

The sawtooth current is centered on the DC current level; swinging equally above and below the DC current calculated in Equation 6. The peak inductor current is the sum of the DC current plus half the AC current. Note that

minimum input voltage should be used when calculating the AC inductor current (Equation 9).

$$V = \frac{L(di)}{dt}$$

Equation 7.

$$di = \frac{V(dt)}{L}$$

Equation 8.

$$di = \frac{[(V_{\text{IN(MIN)}}) - V_{\text{SW}}]t_{\text{ON}}}{L}$$

Equation 9.

where: $V_{\text{SW}} = V_{\text{CESAT}}$ of the switch (note if a CMOS switch is used substitute V_{CESAT} for $R_{\text{DS(ON)}} \times I_{\text{IN}}$)

Combining the DC current calculated in Equation 6, with half the peak AC current calculated in Equation 9, the peak inductor current is given by:

$$I_{\text{PK}} = I_{\text{IN(MAX)}} + 0.5(di)$$

Equation 10.

Output Capacitor

The effective series resistance of the output capacitor directly affects the amplitude of the output voltage ripple. (The product of the peak inductor current and the ESR determines output ripple amplitude.) Therefore, a capacitor with the lowest possible ESR should be selected. Smaller capacitors are acceptable for light loads or in applications where ripple is not a concern. The Sprague 959D series of tantalum capacitors are amongst the smallest of all low ESR surface mount capacitors available. Table 1 lists suggested component numbers and manufacturers.

TC110

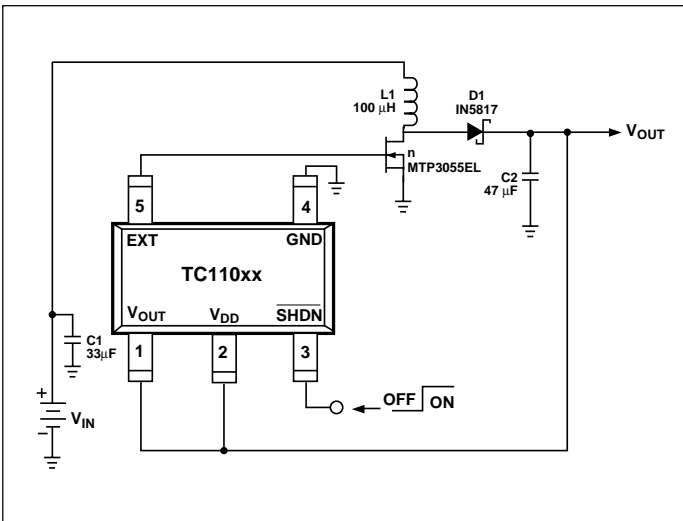


Figure 1a. Bootstrapped Operation

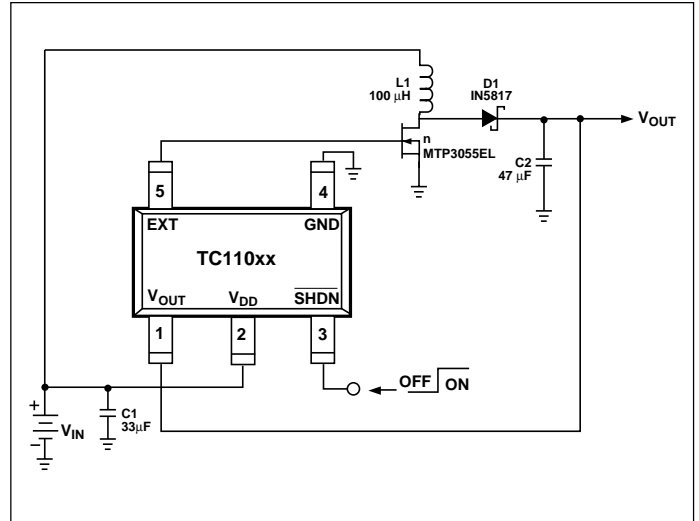


Figure 1b. Non-Bootstrapped Operation

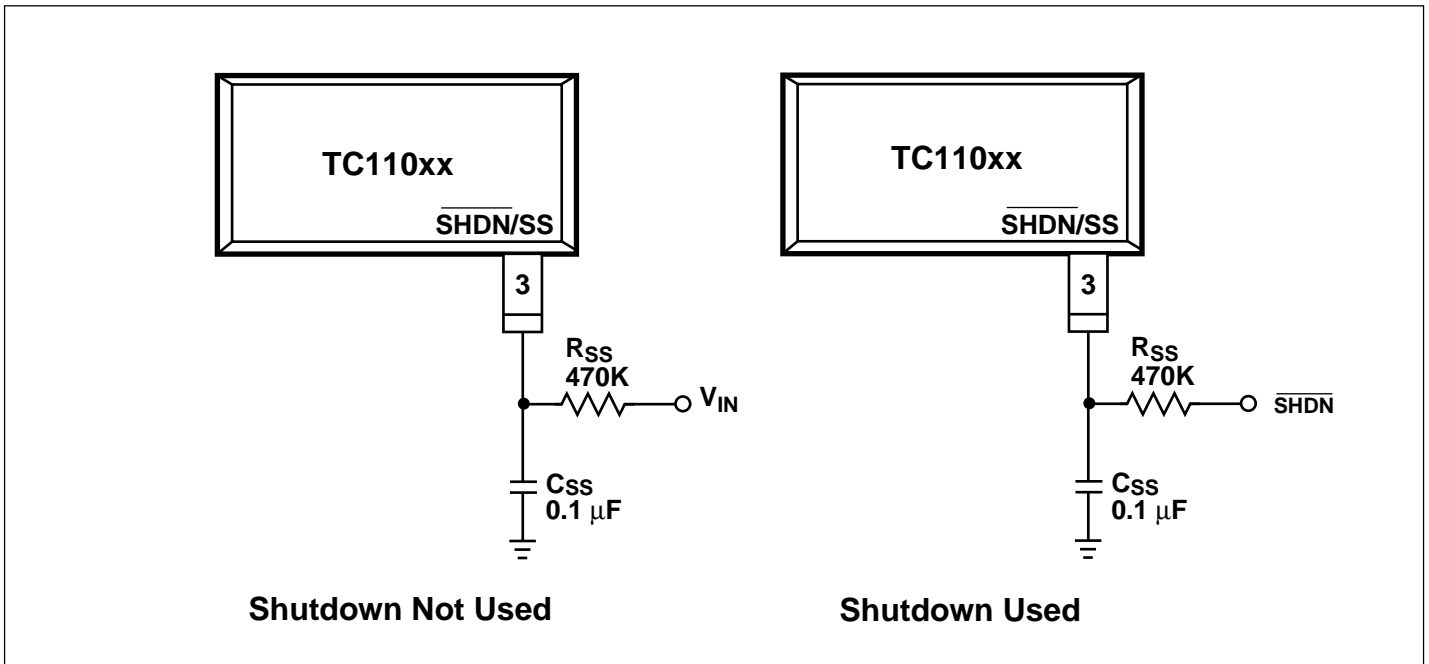


Figure 2. Soft Start/Shutdown Circuit

Board Layout Guidelines

As with all inductive switching regulators, the TC110 generates fast switching waveforms which radiate noise. Interconnecting lead lengths should be minimized to keep stray capacitance, trace resistance and radiated noise as low as possible. In addition, the GND pin, input bypass capacitor and output filter capacitor ground leads should be connected to a single point. The input capacitor should be placed as close to power and ground pins of the TC110 as possible.

Output Diode

For best results, use a Schottky diode such as the MA735, 1N5817, MBR0520L or equivalent. Connect the diode between the FB (or SENSE) input as close to the IC as possible. Do not use ordinary rectifier diodes since the higher threshold voltages reduce efficiency.

External Switching Transistor Selection

The EXT output is designed to directly drive an N-channel MOSFET or NPN bipolar transistor. N-channel MOSFETs afford the highest efficiency because they do not draw any gate drive current, but are typically more expensive than bipolar transistors. If using an N-Channel MOSFET, the gate should be connected directly to the EXT output as shown in Figure 1. EXT is a complimentary output with a maximum ON resistances of 43Ω to V_{DD} when high and 27Ω to ground when low. Peak currents should be kept below 10 mA.

When selecting an N-channel MOSFET, there are three important parameters to consider: total gate charge (Qg); ON resistance ($r_{DS(on)}$) and reverse transfer capacitance (CRSS). Qg is a measure of the total gate capacitance that will ultimately load the EXT output. Too high a Qg can reduce the slew rate of the EXT output sufficiently to grossly lower operating efficiency. Transistors with typical Qg data sheet values of 50 nC or less can be used. For example, the Si9410DY has a Qg(typ) of 17nC @ $V_{GS} = 5V$. This equates to a gate current of:

$$I_{GATE(max)} = f_{MAX} \times Qg = 115 \text{ KHZ} \times 17 \text{ nC} = 2 \text{ mA}$$

The two most significant losses in the N-Channel MOSFET are switching loss and I^2R loss. To minimize these, a transistor with low $r_{DS(on)}$ and low CRSS should be used.

Bipolar NPN transistors can be used, but care must be taken when determining base current drive. Too little current will not fully turn the transistor on, and result in unstable regulator operation and low efficiency. Too high a base drive causes excessive power dissipation in the transistor and

increase switching time due to over-saturation. For peak efficiency, make RB as large as possible, but still guaranteeing the switching transistor is completely saturated when the minimum value of h_{FE} is used.

APPLICATIONS

Circuit Design

Figure 3 shows a TC110 operating as a 100 KHz bootstrapped regulator with soft start. This circuit uses an NPN switching transistor (Zetex FZT690B) that has an h_{FE} of 400 and V_{CESAT} of 100 mV at $I_C = 1A$. Other high beta transistors can be used, but the values of RB and CB may need adjustment if h_{FE} is significantly different from that of the FZT690B.

Figure 4 and 5 both utilize an N-Channel switching transistor (Silconix Si9410DY). This transistor is a member of the Littlefoot™ family of small outline MOSFETs. The circuit of Figure 4 operates in bootstrapped mode, while the circuit of Figure 5 operates in non-bootstrapped mode.

TC110

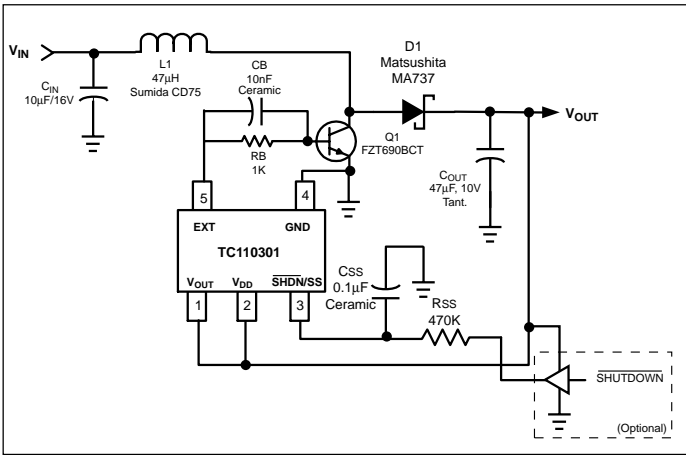


Figure 3. 100 KHz Bootstrapped Regulator with Soft Start Using a Bipolar Transistor

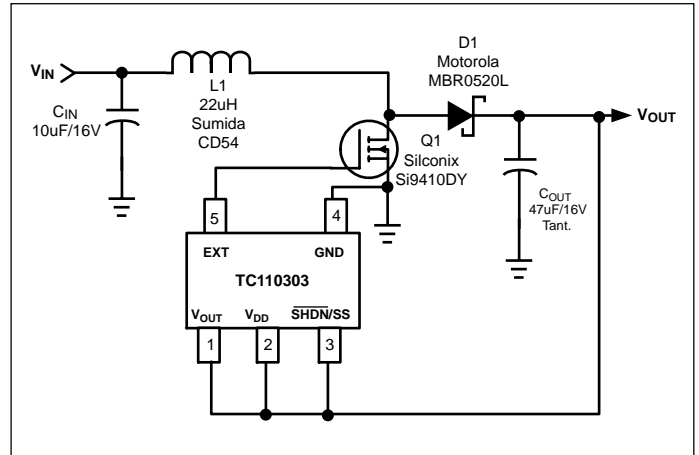


Figure 4. 300 KHz Bootstrapped, N-Channel Transistor

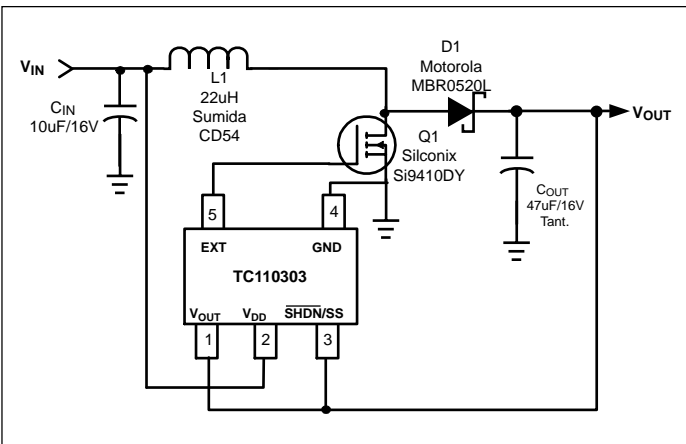


Figure 5. 300 KHz Non-Bootstrapped, N-Channel Transistor

TC110 DEMO CARD

The TC110DEMO allows the user to quickly prototype TC110-based circuits. The TC110DEMO consists of a printed circuit board (with TC110 installed on the foil side of the board); with separate Schottky diode, output capacitor and 100 μ H Coiltronics inductor. The circuit schematic appears in Figure 7.

The board is designed to accept either a 100 μ H or 20 μ H torroidal inductor. The remaining components install in

accordance with the component side layout diagram of Figure 6. Jumper blocks J1 and J2 control shutdown and operating mode selection respectively. Shorting J1, terminal X to OFF, places the TC110 in shutdown; normal operation is enabled when J1 terminal X is shorted to ON. Shorting J2, terminal Y to BS, selects bootstrapped operating mode; shorting J2 terminal Y to NB, selects non-bootstrapped operation.

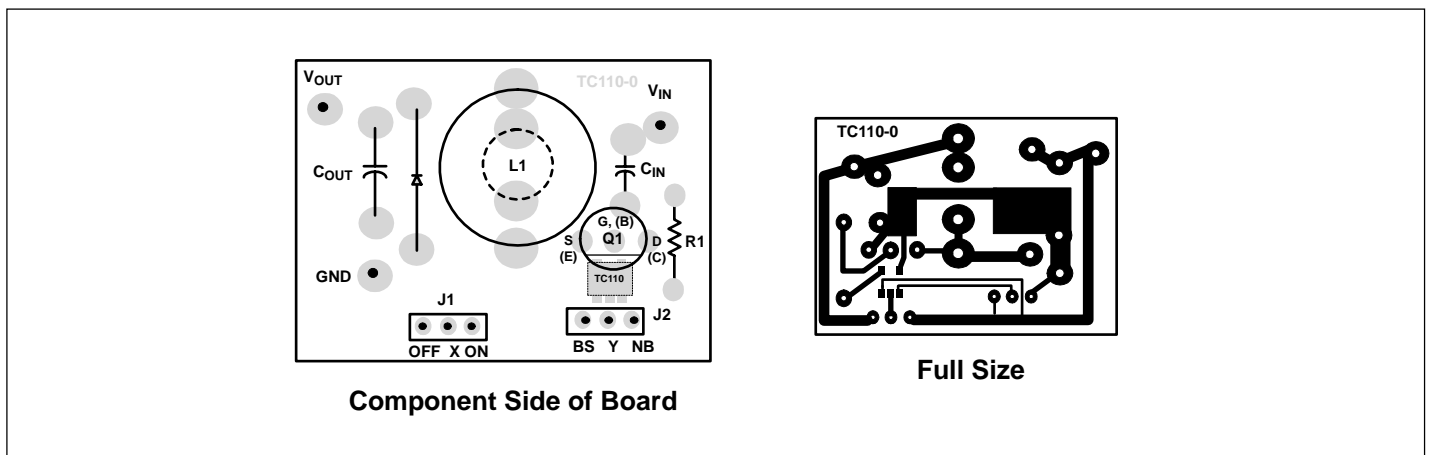


Figure 6. TC110 Demo Board Layout

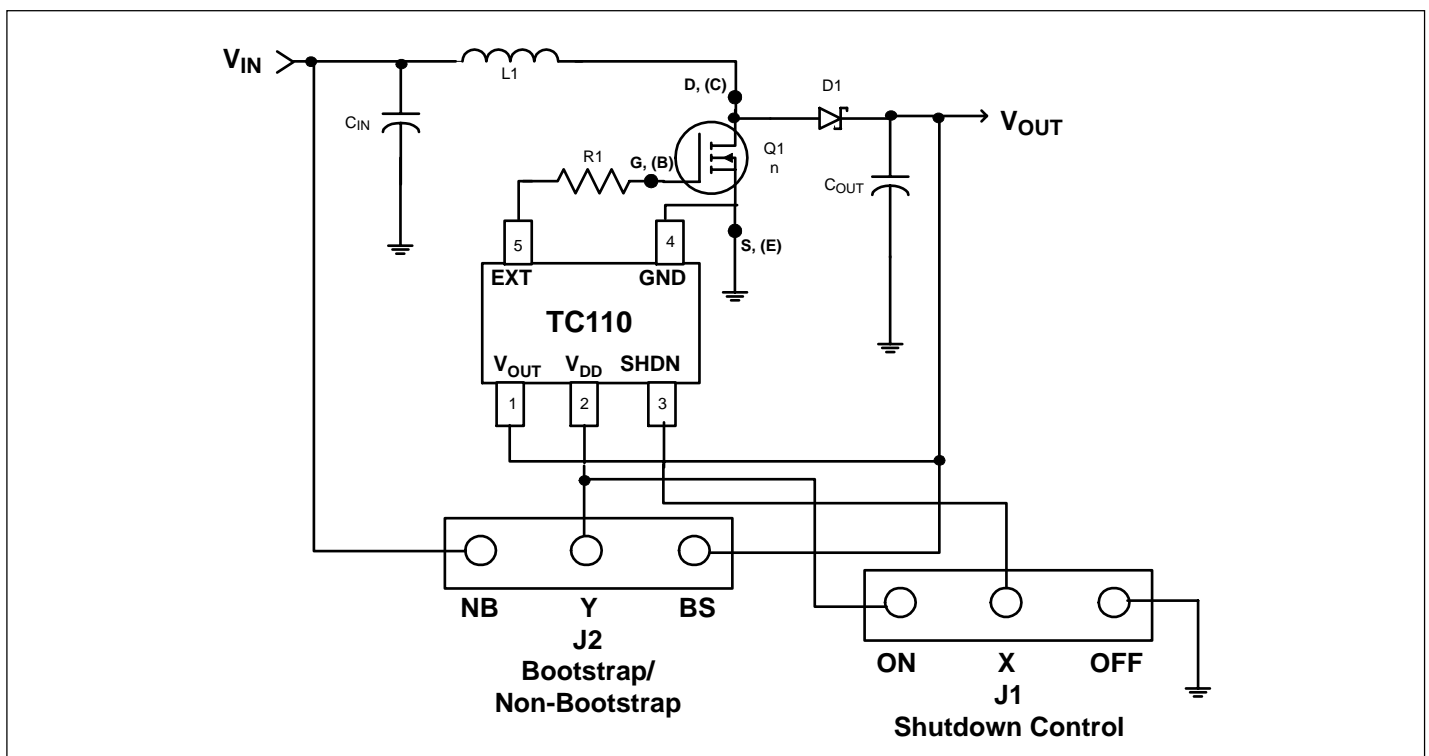


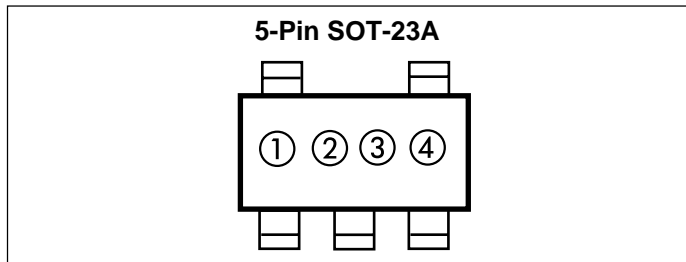
Figure 7. TC110 Demo Schematic

TC110

Table 1. Suggested Components and Manufacturers

Type	Inductors	Capacitors	Transistors	Diodes
Surface Mount	Sumida CD54 Series (300 KHz) CD75 (100 KHz) Coiltronics CTX Series	Matsuo 267 Series Sprague 595D Series Nichicon F93 Series	N-channel Silconix Si9410DY Motorola MTP3055EL MTD20N03	Nihon EC10 Series Matshushita MA735 Series
Through Hole	Sumida RCH855 Series RCH110 Series Renco RL1284-12	Sanyo OS-CON Series Nichicon PL Series	NPN Zetex ZTX694B	Motorola 1N5817 – 1N5822

MARKINGS



① represents product classification; TC110 = M

② represents 1st integer of voltage and frequency

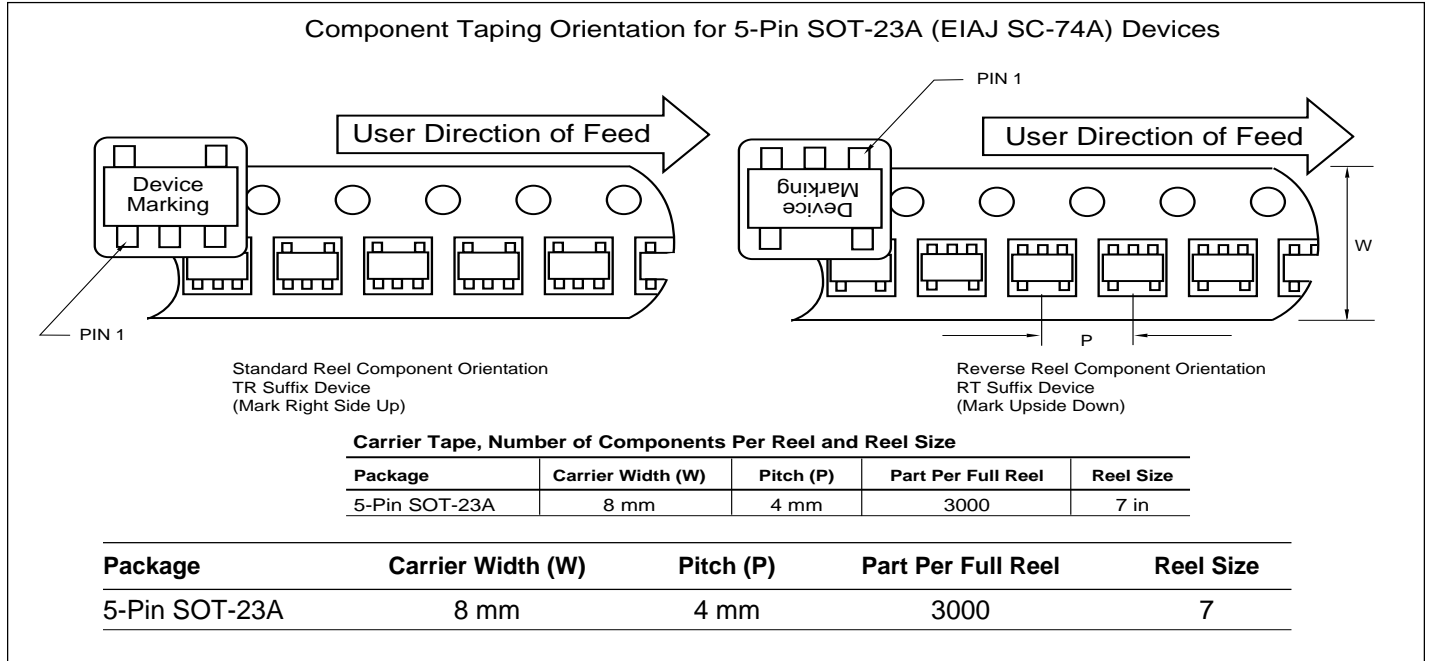
Symbol		
100KHz	300KHz	Output Voltage
B	1	1.
C	2	2.
D	3	3.
E	4	4.
F	5	5.
H	6	6.

③ represents 1st decimal of voltage and frequency

Symbol		
100KHz	300KHz	Output Voltage
0	A	.0
1	B	.1
2	C	.2
3	D	.3
4	E	.4
5	F	.5
6	H	.6
7	K	.7
8	L	.8
9	M	.9

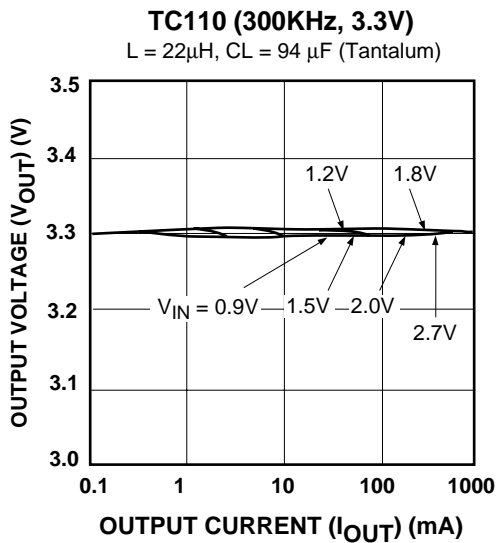
④ represents lot ID number

TAPING FORMS

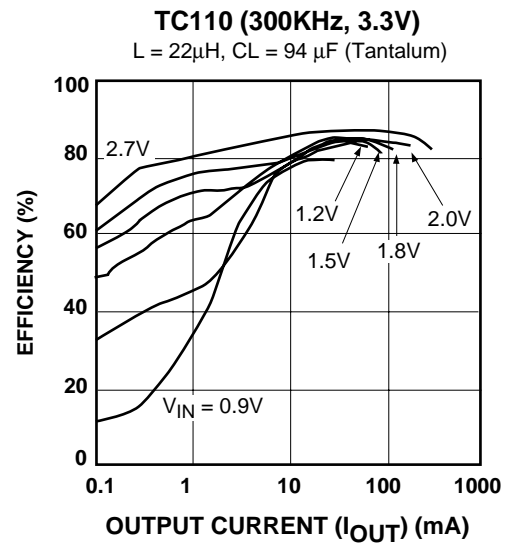


TYPICAL CHARACTERISTICS CURVES

OUTPUT VOLTAGE vs. OUTPUT CURRENT

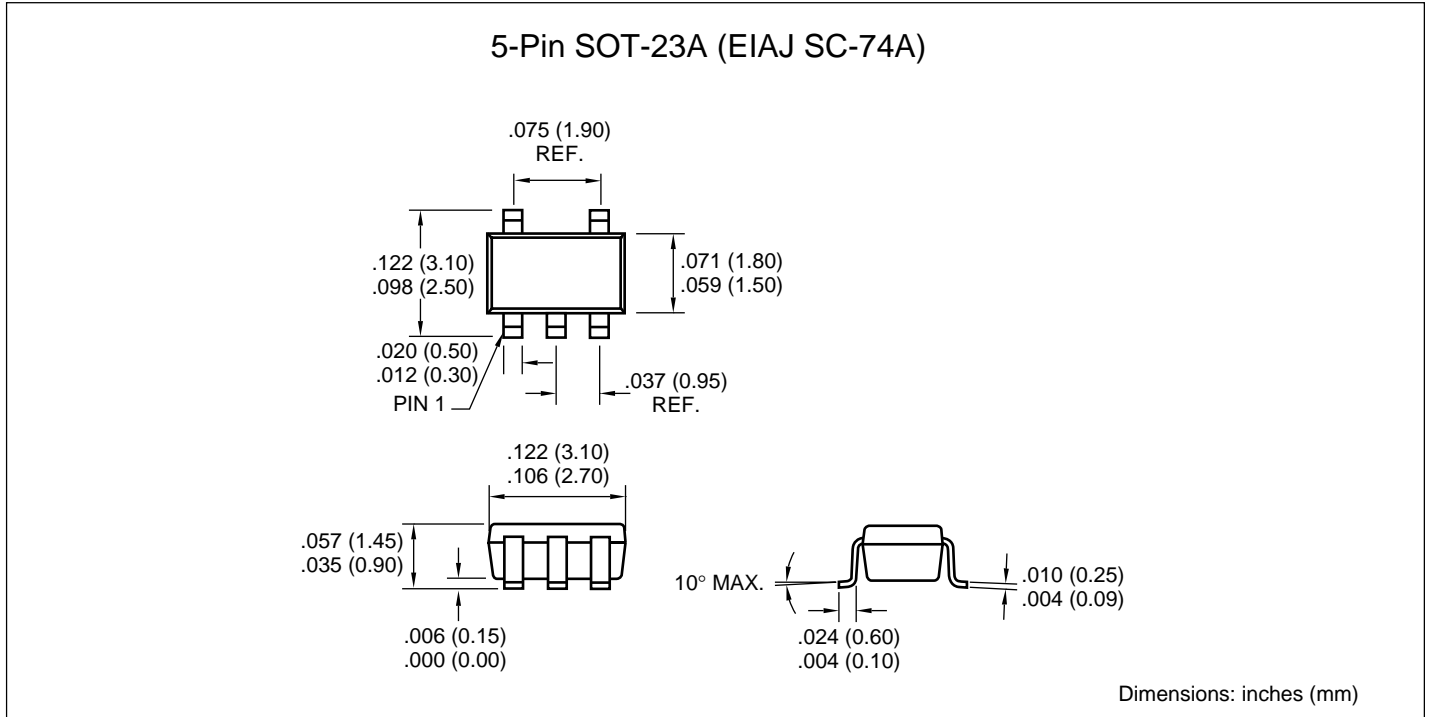


EFFICIENCY vs. OUTPUT CURRENT



TC110

PACKAGE DIMENSIONS





WORLDWIDE SALES AND SERVICE

AMERICAS

Corporate Office

2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200 Fax: 480-792-7277
Technical Support: 480-792-7627
Web Address: <http://www.microchip.com>

Rocky Mountain

2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7966 Fax: 480-792-7456

Atlanta

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

Austin

Analog Product Sales
8303 MoPac Expressway North
Suite A-201
Austin, TX 78759
Tel: 512-345-2030 Fax: 512-345-6085

Boston

2 Lan Drive, Suite 120
Westford, MA 01886
Tel: 978-692-3848 Fax: 978-692-3821

Boston

Analog Product Sales
Unit A-8-1 Millbrook Tarry Condominium
97 Lowell Road
Concord, MA 01742
Tel: 978-371-6400 Fax: 978-371-0050

Chicago

333 Pierce Road, Suite 180
Itasca, IL 60143
Tel: 630-285-0071 Fax: 630-285-0075

Dallas

4570 Westgrove Drive, Suite 160
Addison, TX 75001
Tel: 972-818-7423 Fax: 972-818-2924

Dayton

Two Prestige Place, Suite 130
Miamisburg, OH 45342
Tel: 937-291-1654 Fax: 937-291-9175

Detroit

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

Los Angeles

18201 Von Karman, Suite 1090
Irvine, CA 92612
Tel: 949-263-1888 Fax: 949-263-1338

Mountain View

Analog Product Sales
1300 Terra Bella Avenue
Mountain View, CA 94043-1836
Tel: 650-968-9241 Fax: 650-967-1590

New York

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

Toronto

6285 Northam Drive, Suite 108
Mississauga, Ontario L4V 1X5, Canada
Tel: 905-673-0699 Fax: 905-673-6509

ASIA/PACIFIC

China - Beijing

Microchip Technology Beijing Office
Unit 915
New China Hong Kong Manhattan Bldg.
No. 6 Chaoyangmen Beidajie
Beijing, 100027, No. China
Tel: 86-10-85282100 Fax: 86-10-85282104

China - Shanghai

Microchip Technology Shanghai Office
Room 701, Bldg. B
Far East International Plaza
No. 317 Xian Xia Road
Shanghai, 200051
Tel: 86-21-6275-5700 Fax: 86-21-6275-5060

Hong Kong

Microchip Asia Pacific
RM 2101, Tower 2, Metroplaza
223 Hing Fong Road
Kwai Fong, N.T., Hong Kong
Tel: 852-2401-1200 Fax: 852-2401-3431

India

Microchip Technology Inc.
India Liaison Office
Divyasree Chambers
1 Floor, Wing A (A3/A4)
No. 11, OIShaughnessey Road
Bangalore, 560 025, India
Tel: 91-80-2290061 Fax: 91-80-2290062

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

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

Microchip Technology Taiwan
11F-3, No. 207
Tung Hua North Road
Taipei, 105, Taiwan
Tel: 886-2-2717-7175 Fax: 886-2-2545-0139

EUROPE

Australia

Microchip Technology Australia Pty Ltd
Suite 22, 41 Rawson Street
Epping 2121, NSW
Australia
Tel: 61-2-9868-6733 Fax: 61-2-9868-6755

Denmark

Microchip Technology Denmark ApS
Regus Business Centre
Lautrup høj 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 - 1er 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 Munich, Germany
Tel: 49-89-627-144 0 Fax: 49-89-627-144-44

Germany

Analog Product Sales
Lochamer Strasse 13
D-82152 Martinsried, Germany
Tel: 49-89-895650-0 Fax: 49-89-895650-22

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 5869 Fax: 44-118 921-5820

All rights reserved. © 2001 Microchip Technology Incorporated. Printed in the USA. 1/01  Printed on recycled paper.

01/09/01

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.