

## Charge Pump DC-to-DC Voltage Converter

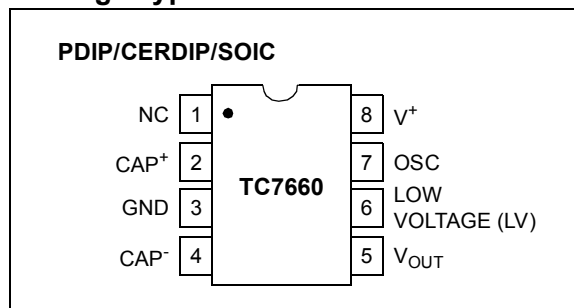
### Features

- Wide Input Voltage Range: +1.5V to +10V
- Efficient Voltage Conversion (99.9%, typ)
- Excellent Power Efficiency (98%, typ)
- Low Power Consumption: 80  $\mu$ A (typ) @  $V_{IN} = 5V$
- Low Cost and Easy to Use
  - Only Two External Capacitors Required
- Available in 8-Pin Small Outline (SOIC), 8-Pin PDIP and 8-Pin Cerdip Packages
- Improved ESD Protection (3 kV HBM)
- No External Diode Required for High-Voltage Operation

### Applications

- RS-232 Negative Power Supply
- Simple Conversion of +5V to  $\pm 5V$  Supplies
- Voltage Multiplication  $V_{OUT} = \pm n V^+$
- Negative Supplies for Data Acquisition Systems and Instrumentation

### Package Types



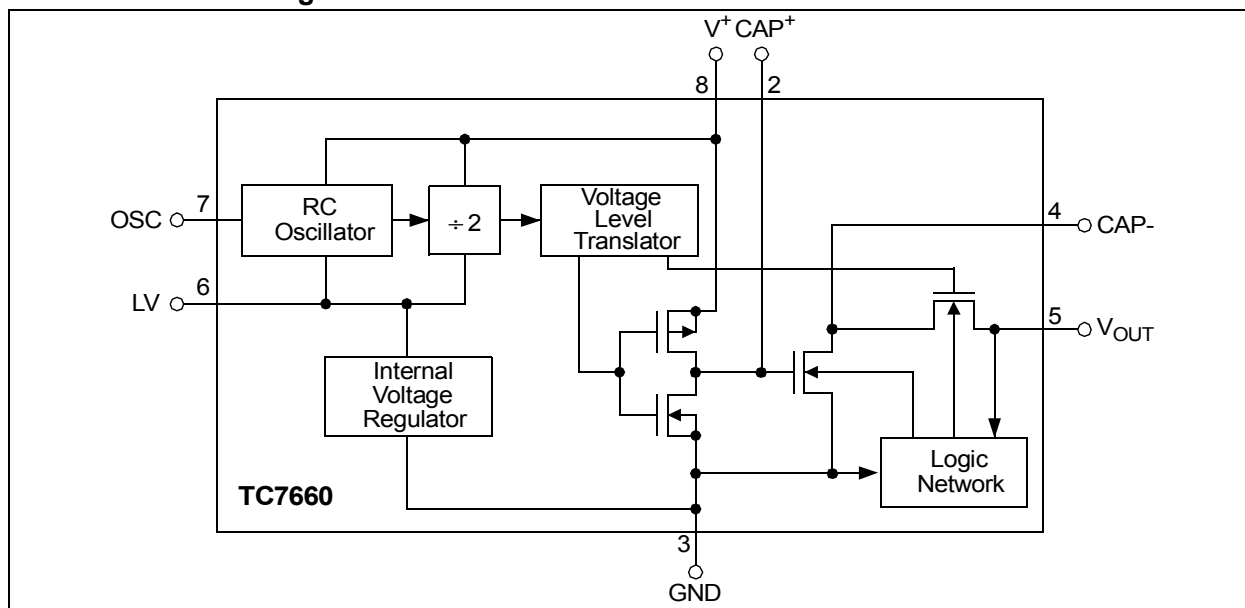
### General Description

The TC7660 is a pin-compatible replacement for the industry standard 7660 charge pump voltage converter. It converts a +1.5V to +10V input to a corresponding -1.5V to -10V output using only two low cost capacitors, eliminating inductors and their associated cost, size and electromagnetic interference (EMI).

The on-board oscillator operates at a nominal frequency of 10 kHz. Operation below 10 kHz (for lower supply current applications) is possible by connecting an external capacitor from OSC to ground.

The TC7660 is available in 8-Pin PDIP, 8-Pin Small Outline (SOIC) and 8-Pin Cerdip packages in commercial and extended temperature ranges.

### Functional Block Diagram



# TC7660

## 1.0 ELECTRICAL CHARACTERISTICS

### Absolute Maximum Ratings\*

Supply Voltage .....	+10.5V
LV and OSC Inputs Voltage: <b>(Note 1)</b>	
.....	-0.3V to $V_{SS}$ for $V^+ < 5.5V$
.....	$(V^+ - 5.5V)$ to $(V^+)$ for $V^+ > 5.5V$
Current into LV .....	20 $\mu A$ for $V^+ > 3.5V$
Output Short Duration ( $V_{SUPPLY} \leq 5.5V$ ).....	Continuous
Package Power Dissipation: ( $T_A \leq 70^\circ C$ )	
8-Pin CERDIP .....	800 mW
8-Pin PDIP .....	730 mW
8-Pin SOIC .....	470 mW
Operating Temperature Range:	
C Suffix .....	0°C to +70°C
I Suffix .....	-25°C to +85°C
E Suffix .....	-40°C to +85°C
M Suffix .....	-55°C to +125°C
Storage Temperature Range .....	-65°C to +160°C
ESD protection on all pins (HBM) .....	$\geq 3$ kV
Maximum Junction Temperature .....	150°C

\* **Notice:** Stresses above those listed under "Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational sections of this specification is not intended. Exposure to maximum rating conditions for extended periods may affect device reliability.

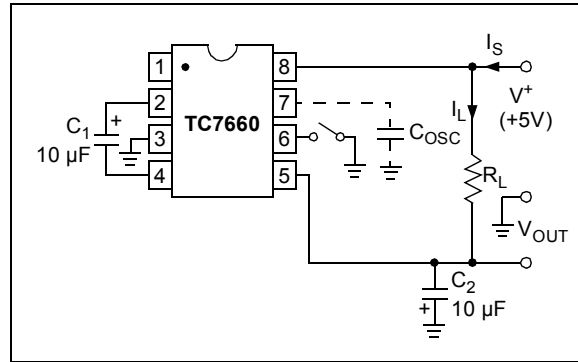


FIGURE 1-1: TC7660 Test Circuit.

## ELECTRICAL SPECIFICATIONS

**Electrical Characteristics:** Unless otherwise noted, specifications measured over operating temperature range with  $V^+ = 5V$ ,  $C_{OSC} = 0$ , refer to test circuit in Figure 1-1.

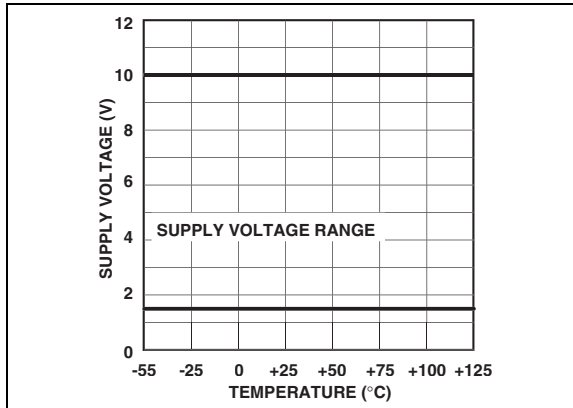
Parameters	Sym	Min	Typ	Max	Units	Conditions
Supply Current	$I^+$	—	80	180	$\mu A$	$R_L = \infty$
Supply Voltage Range, High	$V^+_H$	3.0	—	10	V	$\text{Min} \leq T_A \leq \text{Max}$ , $R_L = 10$ k $\Omega$ , LV Open
Supply Voltage Range, Low	$V^+_L$	1.5	—	3.5	V	$\text{Min} \leq T_A \leq \text{Max}$ , $R_L = 10$ k $\Omega$ , LV to GND
Output Source Resistance	$R_{OUT}$	—	70	100	$\Omega$	$I_{OUT}=20$ mA, $T_A = +25^\circ C$
		—	—	120		$I_{OUT}=20$ mA, $T_A \leq +70^\circ C$ (C Device)
		—	—	130		$I_{OUT}=20$ mA, $T_A \leq +85^\circ C$ (E and I Device)
		—	104	150		$I_{OUT}=20$ mA, $T_A \leq +125^\circ C$ (M Device)
		—	150	300		$V^+ = 2V$ , $I_{OUT} = 3$ mA, LV to GND $0^\circ C \leq T_A \leq +70^\circ C$
		—	160	600		$V^+ = 2V$ , $I_{OUT} = 3$ mA, LV to GND $-55^\circ C \leq T_A \leq +125^\circ C$ (M Device)
Oscillator Frequency	$f_{OSC}$	—	10	—	kHz	Pin 7 open
Power Efficiency	$P_{EFF}$	95	98	—	%	$R_L = 5$ k $\Omega$
Voltage Conversion Efficiency	$V_{OUTEFF}$	97	99.9	—	%	$R_L = \infty$
Oscillator Impedance	$Z_{OSC}$	—	1.0	—	M $\Omega$	$V^+ = 2V$
		—	100	—	k $\Omega$	$V^+ = 5V$

**Note 1:** Destructive latch-up may occur if voltages greater than  $V^+$  or less than GND are supplied to any input pin.

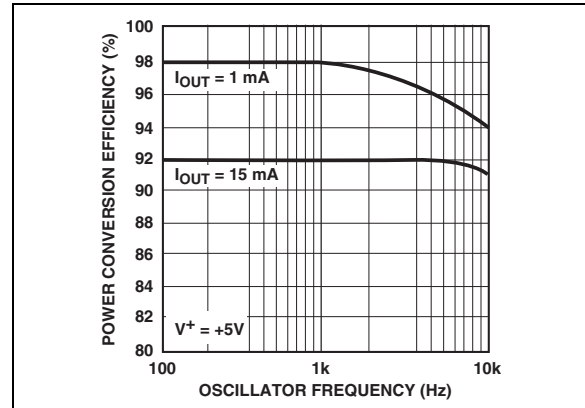
## 2.0 TYPICAL PERFORMANCE CURVES

**Note:** The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

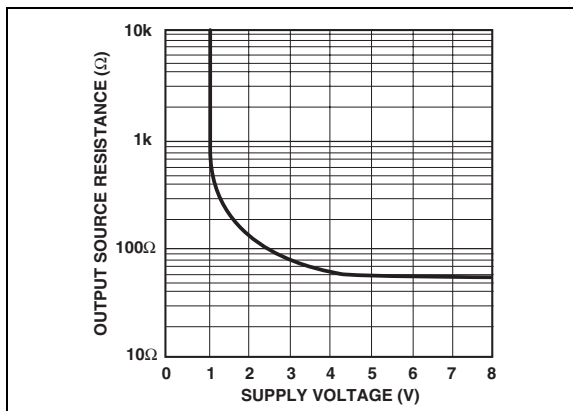
**Note:** Unless otherwise indicated,  $C_1 = C_2 = 10 \mu\text{F}$ ,  $\text{ESR}_{C1} = \text{ESR}_{C2} = 1 \Omega$ ,  $T_A = 25^\circ\text{C}$ . See Figure 1-1.



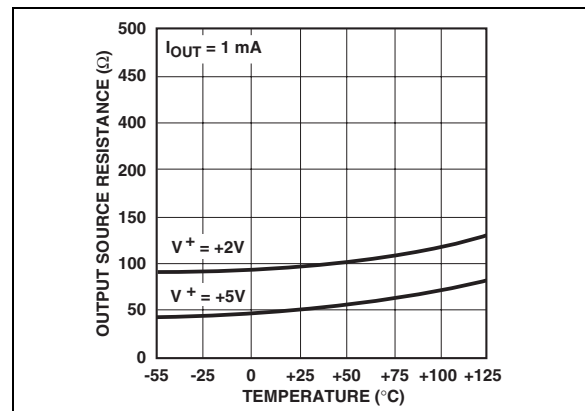
**FIGURE 2-1:** Operating Voltage vs. Temperature.



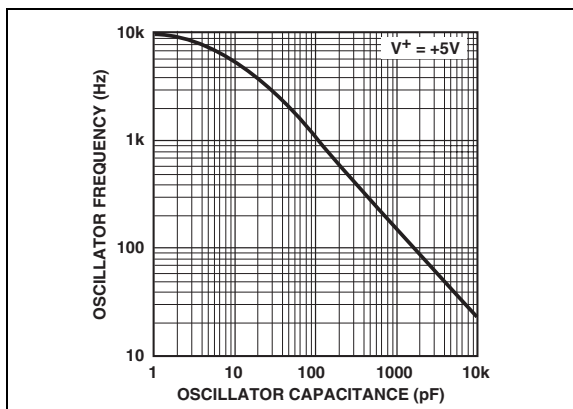
**FIGURE 2-4:** Power Conversion Efficiency vs. Oscillator Frequency.



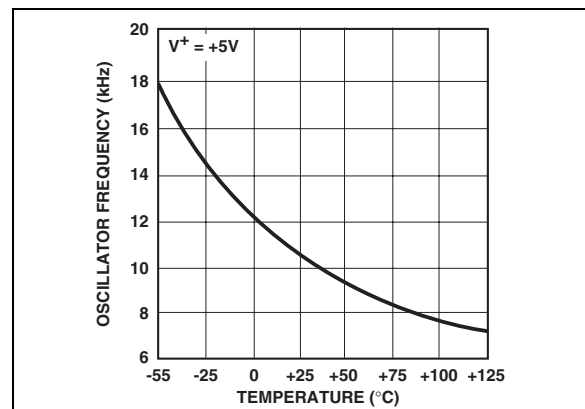
**FIGURE 2-2:** Output Source Resistance vs. Supply Voltage.



**FIGURE 2-5:** Output Source Resistance vs. Temperature.



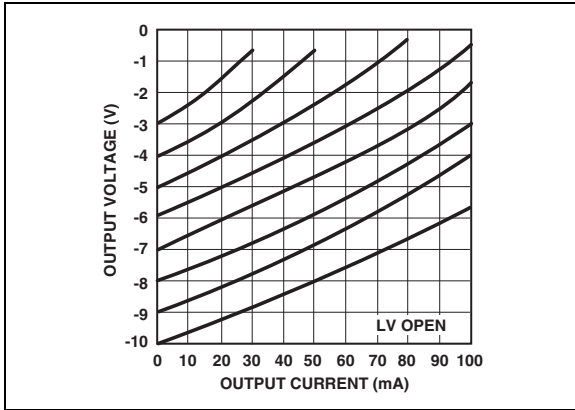
**FIGURE 2-3:** Frequency of Oscillation vs. Oscillator Capacitance.



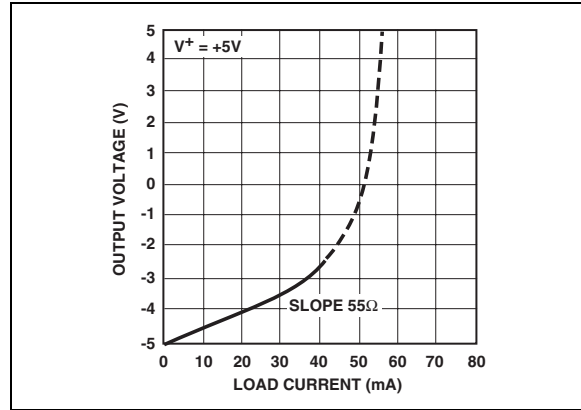
**FIGURE 2-6:** Unloaded Oscillator Frequency vs. Temperature.

# TC7660

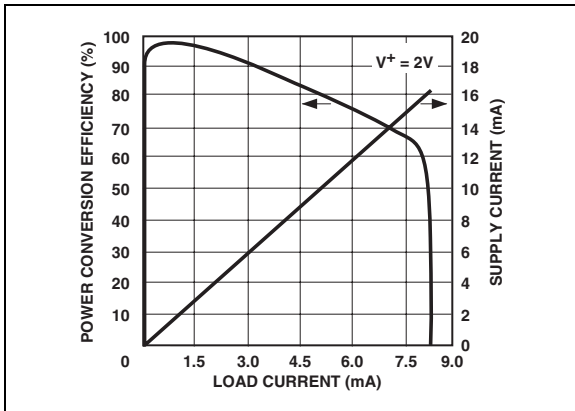
Note: Unless otherwise indicated,  $C_1 = C_2 = 10 \mu\text{F}$ ,  $\text{ESR}_{C1} = \text{ESR}_{C2} = 1 \Omega$ ,  $T_A = 25^\circ\text{C}$ . See Figure 1-1.



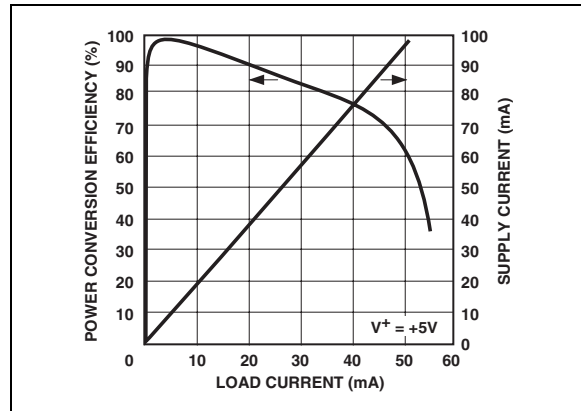
**FIGURE 2-7:** Output Voltage vs. Output Current.



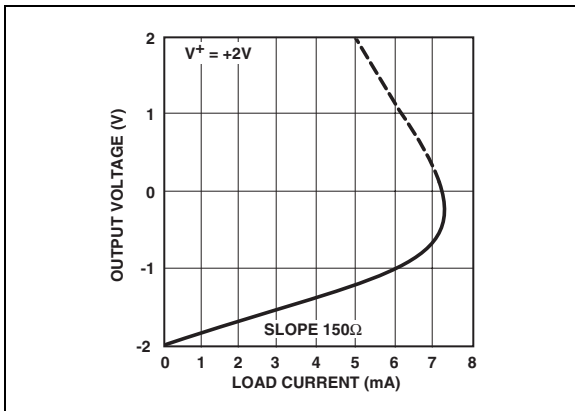
**FIGURE 2-10:** Output Voltage vs. Load Current.



**FIGURE 2-8:** Supply Current and Power Conversion Efficiency vs. Load Current.



**FIGURE 2-11:** Supply Current and Power Conversion Efficiency vs. Load Current.



**FIGURE 2-9:** Output Voltage vs. Load Current.

## 3.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in Table 3-1.

**TABLE 3-1: PIN FUNCTION TABLE**

Pin No.	Symbol	Description
1	NC	No connection
2	CAP <sup>+</sup>	Charge pump capacitor positive terminal
3	GND	Ground terminal
4	CAP <sup>-</sup>	Charge pump capacitor negative terminal
5	V <sub>OUT</sub>	Output voltage
6	LV	Low voltage pin. Connect to GND for V <sub>+</sub> < 3.5V
7	OSC	Oscillator control input. Bypass with an external capacitor to slow the oscillator
8	V <sup>+</sup>	Power supply positive voltage input

### 3.1 Charge Pump Capacitor (CAP<sup>+</sup>)

Positive connection for the charge pump capacitor, or flying capacitor, used to transfer charge from the input source to the output. In the voltage-inverting configuration, the charge pump capacitor is charged to the input voltage during the first half of the switching cycle. During the second half of the switching cycle, the charge pump capacitor is inverted and charge is transferred to the output capacitor and load.

It is recommended that a low ESR (equivalent series resistance) capacitor be used. Additionally, larger values will lower the output resistance.

### 3.2 Ground (GND)

Input and output zero volt reference.

### 3.3 Charge Pump Capacitor (CAP<sup>-</sup>)

Negative connection for the charge pump capacitor, or flying capacitor, used to transfer charge from the input to the output. Proper orientation is imperative when using a polarized capacitor.

### 3.4 Output Voltage (V<sub>OUT</sub>)

Negative connection for the charge pump output capacitor. In the voltage-inverting configuration, the charge pump output capacitor supplies the output load during the first half of the switching cycle. During the second half of the switching cycle, charge is restored to the charge pump output capacitor.

It is recommended that a low ESR (equivalent series resistance) capacitor be used. Additionally, larger values will lower the output ripple.

### 3.5 Low Voltage Pin (LV)

The low voltage pin ensures proper operation of the internal oscillator for input voltages below 3.5V. The low voltage pin should be connected to ground (GND) for input voltages below 3.5V. Otherwise, the low voltage pin should be allowed to float.

### 3.6 Oscillator Control Input (OSC)

The oscillator control input can be utilized to slow down or speed up the operation of the TC7660. Refer to Section 5.4, "Changing the TC7660 Oscillator Frequency", for details on altering the oscillator frequency.

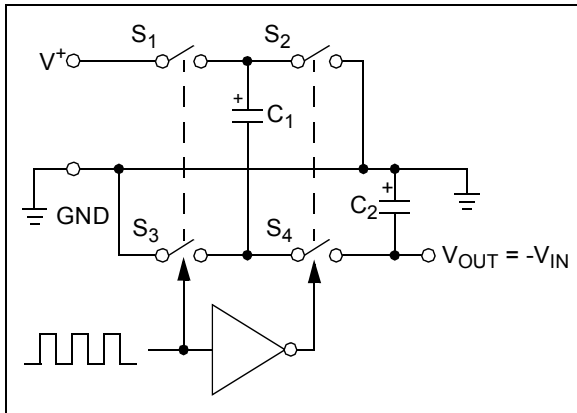
### 3.7 Power Supply (V<sup>+</sup>)

Positive power supply input voltage connection. It is recommended that a low ESR (equivalent series resistance) capacitor be used to bypass the power supply input to ground (GND).

## 4.0 DETAILED DESCRIPTION

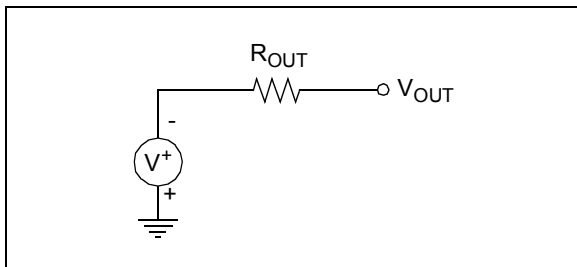
### 4.1 Theory of Operation

The TC7660 charge pump converter inverts the voltage applied to the  $V^+$  pin. The conversion consists of a two-phase operation (Figure 4-1). During the first phase, switches  $S_2$  and  $S_4$  are open and switches  $S_1$  and  $S_3$  are closed.  $C_1$  charges to the voltage applied to the  $V^+$  pin, with the load current being supplied from  $C_2$ . During the second phase, switches  $S_2$  and  $S_4$  are closed and switches  $S_1$  and  $S_3$  are open. Charge is transferred from  $C_1$  to  $C_2$ , with the load current being supplied from  $C_1$ .



**FIGURE 4-1:** Ideal Switched Capacitor Inverter.

In this manner, the TC7660 performs a voltage inversion, but does not provide regulation. The average output voltage will drop in a linear manner with respect to load current. The equivalent circuit of the charge pump inverter can be modeled as an ideal voltage source in series with a resistor, as shown in Figure 4-2.



**FIGURE 4-2:** Switched Capacitor Inverter Equivalent Circuit Model.

The value of the series resistor ( $R_{OUT}$ ) is a function of the switching frequency, capacitance and equivalent series resistance (ESR) of  $C_1$  and  $C_2$  and the on-resistance of switches  $S_1$ ,  $S_2$ ,  $S_3$  and  $S_4$ . A close approximation for  $R_{OUT}$  is given in the following equation:

### EQUATION

$$R_{OUT} = \left[ \frac{I}{f_{PUMP} \times C I} + 8R_{SW} + 4ESR_{C1} + ESR_{C2} \right]$$

Where:

$$f_{PUMP} = \frac{f_{OSC}}{2}$$

$R_{SW}$  = on-resistance of the switches

$ESR_{C1}$  = equivalent series resistance of  $C_1$

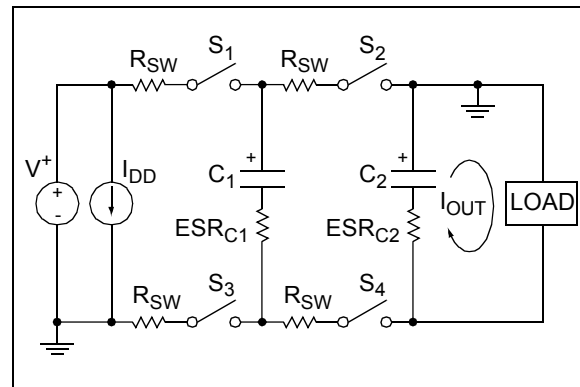
$ESR_{C2}$  = equivalent series resistance of  $C_2$

### 4.2 Switched Capacitor Inverter Power Losses

The overall power loss of a switched capacitor inverter is affected by four factors:

1. Losses from power consumed by the internal oscillator, switch drive, etc. These losses will vary with input voltage, temperature and oscillator frequency.
2. Conduction losses in the non-ideal switches.
3. Losses due to the non-ideal nature of the external capacitors.
4. Losses that occur during charge transfer from  $C_1$  to  $C_2$  when a voltage difference between the capacitors exists.

Figure 4-3 depicts the non-ideal elements associated with the switched capacitor inverter power loss.



**FIGURE 4-3:** Non-Ideal Switched Capacitor Inverter.

The power loss is calculated using the following equation:

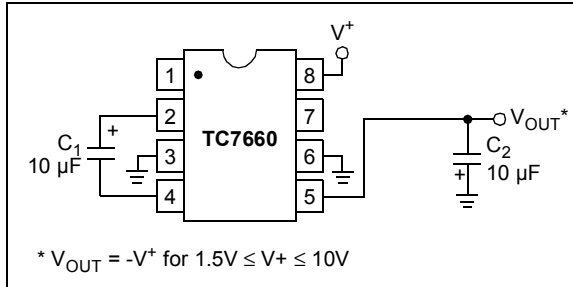
### EQUATION

$$P_{LOSS} = I_{OUT}^2 \times R_{OUT} + I_{DD} \times V^+$$

## 5.0 APPLICATIONS INFORMATION

### 5.1 Simple Negative Voltage Converter

Figure 5-1 shows typical connections to provide a negative supply where a positive supply is available. A similar scheme may be employed for supply voltages anywhere in the operating range of +1.5V to +10V, keeping in mind that pin 6 (LV) is tied to the supply negative (GND) only for supply voltages below 3.5V.



**FIGURE 5-1:** Simple Negative Converter.

The output characteristics of the circuit in Figure 5-1 are those of a nearly ideal voltage source in series with a 70Ω resistor. Thus, for a load current of -10 mA and a supply voltage of +5V, the output voltage would be -4.3V.

### 5.2 Paralleling Devices

To reduce the value of  $R_{OUT}$ , multiple TC7660 voltage converters can be connected in parallel (Figure 5-2). The output resistance will be reduced by approximately a factor of  $n$ , where  $n$  is the number of devices connected in parallel.

#### EQUATION

$$R_{OUT} = \frac{R_{OUT}(of\ TC7660)}{n\ (number\ of\ devices)}$$

While each device requires its own pump capacitor ( $C_1$ ), all devices may share one reservoir capacitor ( $C_2$ ). To preserve ripple performance, the value of  $C_2$  should be scaled according to the number of devices connected in parallel.

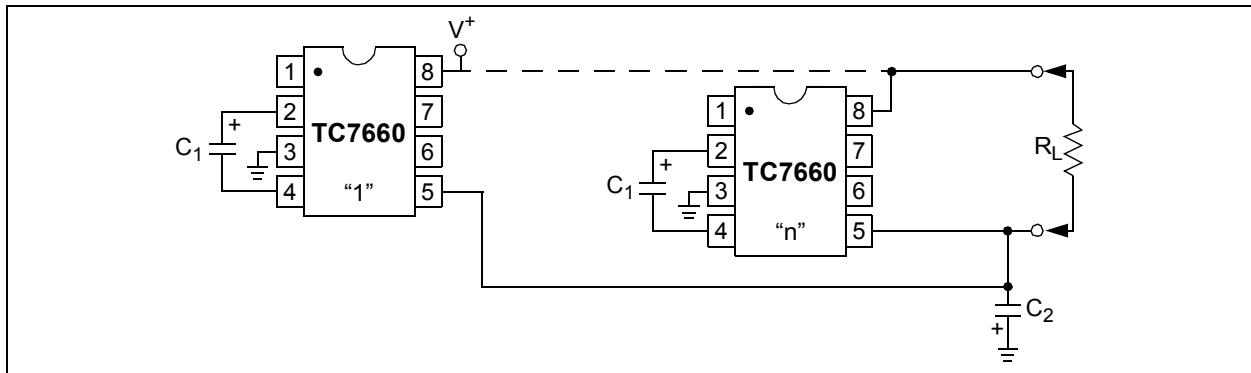
### 5.3 Cascading Devices

A larger negative multiplication of the initial supply voltage can be obtained by cascading multiple TC7660 devices. The output voltage and the output resistance will both increase by approximately a factor of  $n$ , where  $n$  is the number of devices cascaded.

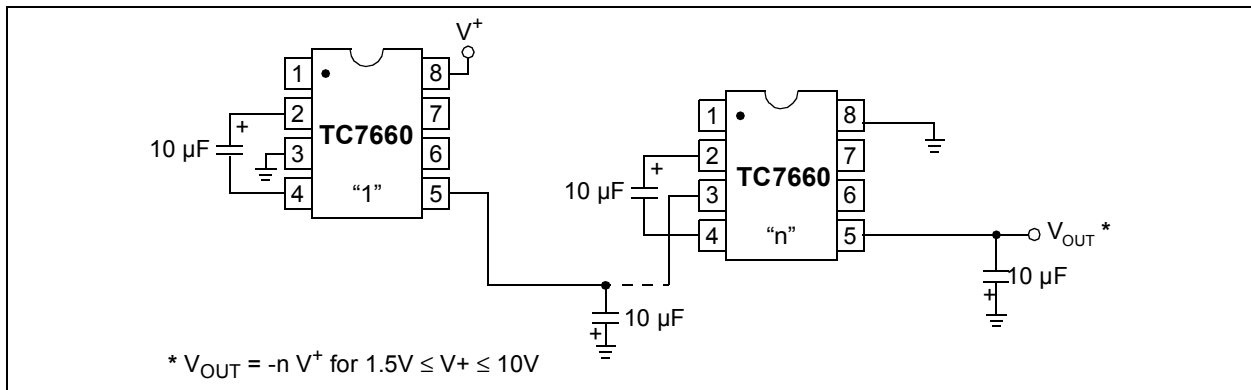
#### EQUATION

$$V_{OUT} = -n(V^+)$$

$$R_{OUT} = n \times R_{OUT}(of\ TC7660)$$



**FIGURE 5-2:** Paralleling Devices Lowers Output Impedance.



**FIGURE 5-3:** Increased Output Voltage By Cascading Devices.

## 5.4 Changing the TC7660 Oscillator Frequency

The operating frequency of the TC7660 can be changed in order to optimize the system performance. The frequency can be increased by over-driving the OSC input (Figure 5-4). Any CMOS logic gate can be utilized in conjunction with a 1 kΩ series resistor. The resistor is required to prevent device latch-up. While TTL level signals can be utilized, an additional 10 kΩ pull-up resistor to V<sup>+</sup> is required. Transitions occur on the rising edge of the clock input. The resultant output voltage ripple frequency is one half the clock input. Higher clock frequencies allow for the use of smaller pump and reservoir capacitors for a given output voltage ripple and droop. Additionally, this allows the TC7660 to be synchronized to an external clock, eliminating undesirable beat frequencies.

At light loads, lowering the oscillator frequency can increase the efficiency of the TC7660 (Figure 5-5). By lowering the oscillator frequency, the switching losses are reduced. Refer to Figure 2-3 to determine the typical operating frequency based on the value of the external capacitor. At lower operating frequencies, it may be necessary to increase the values of the pump and reservoir capacitors in order to maintain the desired output voltage ripple and output impedance.

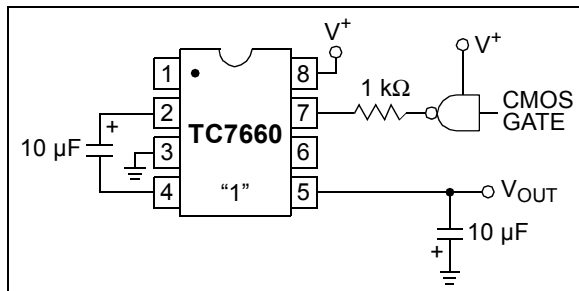


FIGURE 5-4: External Clocking.

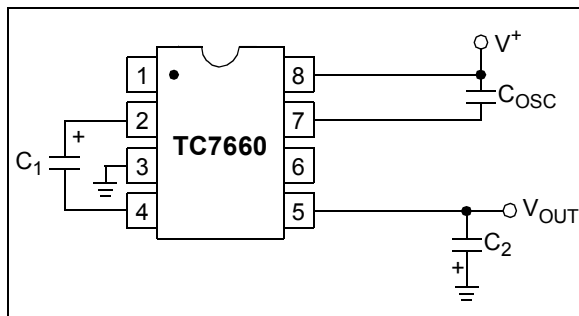


FIGURE 5-5: Lowering Oscillator Frequency.

## 5.5 Positive Voltage Multiplication

Positive voltage multiplication can be obtained by employing two external diodes (Figure 5-6). Refer to the theory of operation of the TC7660 (Section 4.1). During the half cycle when switch S<sub>2</sub> is closed, capacitor C<sub>1</sub> of Figure 5-6 is charged up to a voltage of V<sup>+</sup> - V<sub>F1</sub>, where V<sub>F1</sub> is the forward voltage drop of diode D<sub>1</sub>. During the next half cycle, switch S<sub>1</sub> is closed, shifting the reference of capacitor C<sub>1</sub> from GND to V<sup>+</sup>. The energy in capacitor C<sub>1</sub> is transferred to capacitor C<sub>2</sub> through diode D<sub>2</sub>, producing an output voltage of approximately:

### EQUATION

$$V_{OUT} = 2 \times V^+ - (V_{F1} + V_{F2})$$

where:

V<sub>F1</sub> is the forward voltage drop of diode D<sub>1</sub>  
and  
V<sub>F2</sub> is the forward voltage drop of diode D<sub>2</sub>.

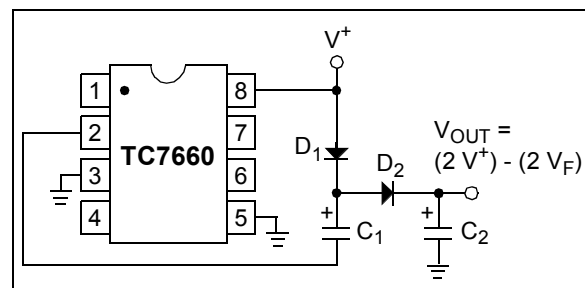
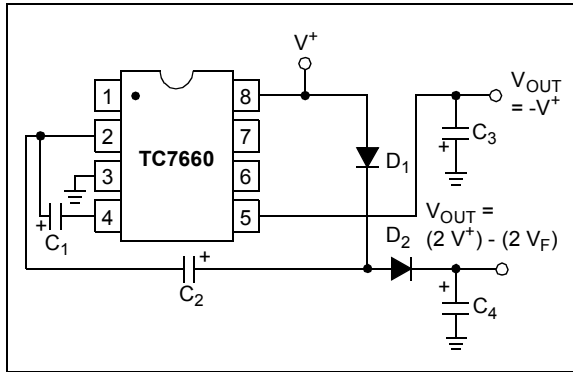


FIGURE 5-6: Positive Voltage Multiplier.

## 5.6 Combined Negative Voltage Conversion and Positive Supply Multiplication

Simultaneous voltage inversion and positive voltage multiplication can be obtained (Figure 5-7). Capacitors C<sub>1</sub> and C<sub>3</sub> perform the voltage inversion, while capacitors C<sub>2</sub> and C<sub>4</sub>, plus the two diodes, perform the positive voltage multiplication. Capacitors C<sub>1</sub> and C<sub>2</sub> are the pump capacitors, while capacitors C<sub>3</sub> and C<sub>4</sub> are the reservoir capacitors for their respective functions. Both functions utilize the same switches of the TC7660. As a result, if either output is loaded, both outputs will drop towards GND.

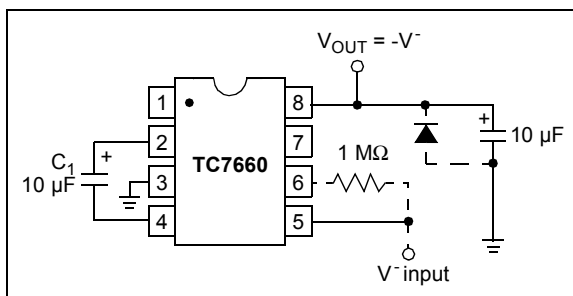




**FIGURE 5-7:** Combined Negative Converter And Positive Multiplier.

## 5.7 Efficient Positive Voltage Multiplication/Conversion

Since the switches that allow the charge pumping operation are bidirectional, the charge transfer can be performed backwards as easily as forwards. Figure 5-8 shows a TC7660 transforming  $-5V$  to  $+5V$  (or  $+5V$  to  $+10V$ , etc.). The only problem here is that the internal clock and switch-drive section will not operate until some positive voltage has been generated. An initial inefficient pump, as shown in Figure 5-7, could be used to start this circuit up, after which it will bypass the other ( $D_1$  and  $D_2$  in Figure 5-7 would never turn on), or else the diode and resistor shown dotted in Figure 5-8 can be used to "force" the internal regulator on.



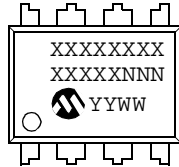
**FIGURE 5-8:** Positive Voltage Conversion.

# TC7660

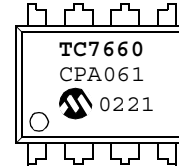
## 6.0 PACKAGING INFORMATION

### 6.1 Package Marking Information

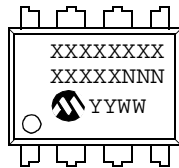
8-Lead PDIP (300 mil)



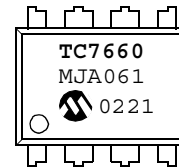
Example:



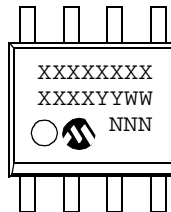
8-Lead CERDIP (300 mil)



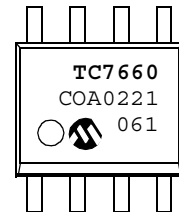
Example:



8-Lead SOIC (150 mil)



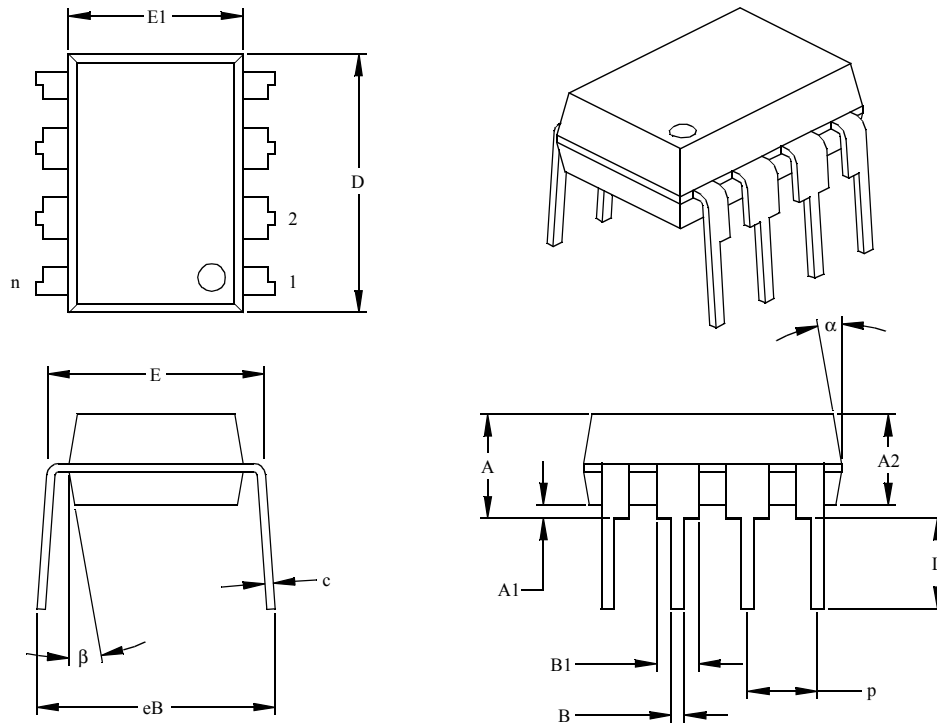
Example:



Legend:	XX...X	Customer specific information*
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week '01')
	NNN	Alphanumeric traceability code
<b>Note:</b>	In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line thus limiting the number of available characters for customer specific information.	

\* Standard marking consists of Microchip part number, year code, week code, traceability code (facility code, mask rev#, and assembly code). For marking beyond this, certain price adders apply. Please check with your Microchip Sales Office.

## 8-Lead Plastic Dual In-line (P) – 300 mil (PDIP)



Units		INCHES*			MILLIMETERS		
Dimension Limits		MIN	NOM	MAX	MIN	NOM	MAX
Number of Pins	n		8			8	
Pitch	p		.100			2.54	
Top to Seating Plane	A	.140	.155	.170	3.56	3.94	4.32
Molded Package Thickness	A2	.115	.130	.145	2.92	3.30	3.68
Base to Seating Plane	A1	.015			0.38		
Shoulder to Shoulder Width	E	.300	.313	.325	7.62	7.94	8.26
Molded Package Width	E1	.240	.250	.260	6.10	6.35	6.60
Overall Length	D	.360	.373	.385	9.14	9.46	9.78
Tip to Seating Plane	L	.125	.130	.135	3.18	3.30	3.43
Lead Thickness	c	.008	.012	.015	0.20	0.29	0.38
Upper Lead Width	B1	.045	.058	.070	1.14	1.46	1.78
Lower Lead Width	B	.014	.018	.022	0.36	0.46	0.56
Overall Row Spacing	§ eB	.310	.370	.430	7.87	9.40	10.92
Mold Draft Angle Top	α	5	10	15	5	10	15
Mold Draft Angle Bottom	β	5	10	15	5	10	15

\* Controlling Parameter  
 § Significant Characteristic

Notes:  
 Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010" (0.254mm) per side.  
 JEDEC Equivalent: MS-001  
 Drawing No. C04-018

# TC7660

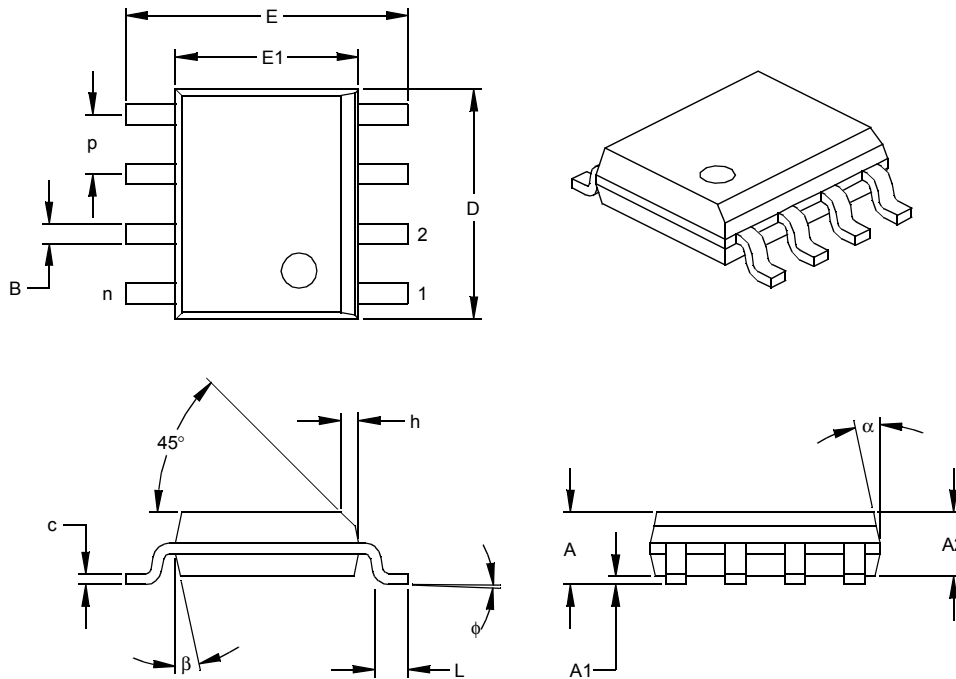
---

---

## 8-Lead Ceramic Dual In-line – 300 mil (CERDIP)

Packaging diagram not available at this time.

## 8-Lead Plastic Small Outline (SN) – Narrow, 150 mil (SOIC)



Dimension Limits	Units	INCHES*			MILLIMETERS		
		MIN	NOM	MAX	MIN	NOM	MAX
Number of Pins	n		8			8	
Pitch	p		.050			1.27	
Overall Height	A	.053	.061	.069	1.35	1.55	1.75
Molded Package Thickness	A2	.052	.056	.061	1.32	1.42	1.55
Standoff §	A1	.004	.007	.010	0.10	0.18	0.25
Overall Width	E	.228	.237	.244	5.79	6.02	6.20
Molded Package Width	E1	.146	.154	.157	3.71	3.91	3.99
Overall Length	D	.189	.193	.197	4.80	4.90	5.00
Chamfer Distance	h	.010	.015	.020	0.25	0.38	0.51
Foot Length	L	.019	.025	.030	0.48	0.62	0.76
Foot Angle	φ	0	4	8	0	4	8
Lead Thickness	c	.008	.009	.010	0.20	0.23	0.25
Lead Width	B	.013	.017	.020	0.33	0.42	0.51
Mold Draft Angle Top	α	0	12	15	0	12	15
Mold Draft Angle Bottom	β	0	12	15	0	12	15

\* Controlling Parameter  
 § Significant Characteristic

**Notes:**

Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010" (0.254mm) per side.

JEDEC Equivalent: MS-012

Drawing No. C04-057

# TC7660

---

---

NOTES:

## PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office.

<u>PART NO.</u>	<u>X</u>	<u>/XX</u>
Device	Temperature Range	Package
Device:	TC7660:	DC-to-DC Voltage Converter
Temperature Range:	C =	0°C to +70°C
	E =	-40°C to +85°C
	I =	-25°C to +85°C (CERDIP only)
	M =	-55°C to +125°C (CERDIP only)
Package:	PA =	Plastic DIP, (300 mil body), 8-lead
	JA =	Ceramic DIP, (300 mil body), 8-lead
	OA =	SOIC (Narrow), 8-lead
	OA713 =	SOIC (Narrow), 8-lead (Tape and Reel)

**Examples:**

- a) TC7660COA: Commercial Temp., SOIC package.
- b) TC7660COA713: Tape and Reel, Commercial Temp., SOIC package.
- c) TC7660CPA: Commercial Temp., PDIP package.
- d) TC7660EOA: Extended Temp., SOIC package.
- e) TC7660EOA713: Tape and Reel, Extended Temp., SOIC package.
- f) TC7660EPA: Extended Temp., PDIP package.
- g) TC7660JA: Industrial Temp., CERDIP package
- h) TC7660MJA: Military Temp., CERDIP package.

## Sales and Support

### Data Sheets

Products supported by a preliminary Data Sheet may have an errata sheet describing minor operational differences and recommended workarounds. To determine if an errata sheet exists for a particular device, please contact one of the following:

1. Your local Microchip sales office
2. The Microchip Corporate Literature Center U.S. FAX: (480) 792-7277
3. The Microchip Worldwide Site ([www.microchip.com](http://www.microchip.com))

Please specify which device, revision of silicon and Data Sheet (include Literature #) you are using.

### New Customer Notification System

Register on our web site ([www.microchip.com/cn](http://www.microchip.com/cn)) to receive the most current information on our products.

# TC7660

---

NOTES:



---

**Note the following details of the code protection feature on Microchip devices:**

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products.

---

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, under any intellectual property rights.

**Trademarks**

The Microchip name and logo, the Microchip logo, KEELOQ, MPLAB, PIC, PICmicro, PICSTART and PRO MATE are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.


FilterLab, microID, MXDEV, MXLAB, PICMASTER, SEEVAL and The Embedded Control Solutions Company are registered trademarks of Microchip Technology Incorporated in the U.S.A.

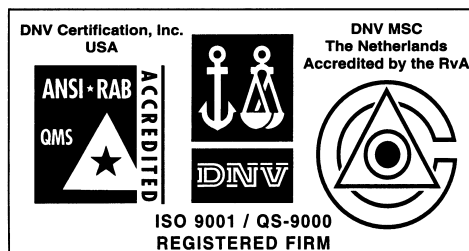
dsPIC, dsPICDEM.net, ECONOMONITOR, FanSense, FlexROM, fuzzyLAB, In-Circuit Serial Programming, ICSP, ICEPIC, microPort, Migratable Memory, MPASM, MPLIB, MPLINK, MPSIM, PICC, PICDEM, PICDEM.net, rPIC, Select Mode and Total Endurance are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

Serialized Quick Turn Programming (SQTP) is a service mark of Microchip Technology Incorporated in the U.S.A.

All other trademarks mentioned herein are property of their respective companies.

© 2002, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.

 Printed on recycled paper.



*Microchip received QS-9000 quality system certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona in July 1999 and Mountain View, California in March 2002. The Company's quality system processes and procedures are QS-9000 compliant for its PICmicro® 8-bit MCUs, KEELOQ® code hopping devices, Serial EEPROMs, microperipherals, non-volatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001 certified.*



# MICROCHIP

## 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: 480-792-4338

#### Atlanta

3780 Mansell Road, Suite 130  
Alpharetta, GA 30022  
Tel: 770-640-0034 Fax: 770-640-0307

#### Boston

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

#### 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

#### Detroit

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

#### Kokomo

2767 S. Albright Road  
Kokomo, Indiana 46902  
Tel: 765-864-8360 Fax: 765-864-8387

#### Los Angeles

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

#### 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

#### 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

#### China - Beijing

Microchip Technology Consulting (Shanghai)  
Co., Ltd., Beijing Liaison Office  
Unit 915  
Bei Hai Wan Tai Bldg.  
No. 6 Chaoyangmen Beidajie  
Beijing, 100027, No. China  
Tel: 86-10-85282100 Fax: 86-10-85282104

#### China - Chengdu

Microchip Technology Consulting (Shanghai)  
Co., Ltd., Chengdu Liaison Office  
Rm. 2401-2402, 24th Floor,  
Ming Xing Financial Tower  
No. 88 TIDU Street  
Chengdu 610016, China  
Tel: 86-28-86766200 Fax: 86-28-86766599

#### China - Fuzhou

Microchip Technology Consulting (Shanghai)  
Co., Ltd., Fuzhou Liaison Office  
Unit 28F, World Trade Plaza  
No. 71 Wusi Road  
Fuzhou 350001, China  
Tel: 86-591-7503506 Fax: 86-591-7503521

#### China - Shanghai

Microchip Technology Consulting (Shanghai)  
Co., Ltd.  
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

#### China - Shenzhen

Microchip Technology Consulting (Shanghai)  
Co., Ltd., Shenzhen Liaison Office  
Rm. 15-16, 13/F, Shenzhen Kerry Centre,  
Renminnan Lu  
Shenzhen 518001, China  
Tel: 86-755-82350361 Fax: 86-755-82366086

#### China - Hong Kong SAR

Microchip Technology Hongkong Ltd.  
Unit 901-6, 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, O'Shaughnessy Road  
Bangalore, 560 025, India  
Tel: 91-80-2290061 Fax: 91-80-2290062

### Japan

Microchip Technology Japan K.K.  
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 135-882  
Tel: 82-2-554-7200 Fax: 82-2-558-5934

### Singapore

Microchip Technology Singapore Pte Ltd.  
200 Middle Road  
#07-02 Prime Centre  
Singapore, 188980  
Tel: 65-6334-8870 Fax: 65-6334-8850

### Taiwan

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

### EUROPE

#### Austria

Microchip Technology Austria GmbH  
Durisolstrasse 2  
A-4600 Wels  
Austria  
Tel: 43-7242-2244-399  
Fax: 43-7242-2244-393

#### Denmark

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

#### France

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

Microchip Technology GmbH  
Steinheilstrasse 10  
D-85737 Ismaning, Germany  
Tel: 49-89-627-144 0 Fax: 49-89-627-144-44

#### Italy

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

Microchip Ltd.  
505 Eskdale Road  
Winkersley Triangle  
Wokingham  
Berkshire, England RG41 5TU  
Tel: 44 118 921 5869 Fax: 44-118 921-5820

11/15/02