

CHARGE PUMP DC-TO-DC CONVERTER

FEATURES

- Wide Operating Range 3V to 18V
- Increased Output Current 40mA
- Pin Compatible with ICL7662/SI7661/TC7660/LTC1044
- No External Diodes Required
- Low Output Impedance @ $I_L = 20\text{mA}$ 40Ω Typ.
- No Low-Voltage Terminal Required
- CMOS Construction

ORDERING INFORMATION

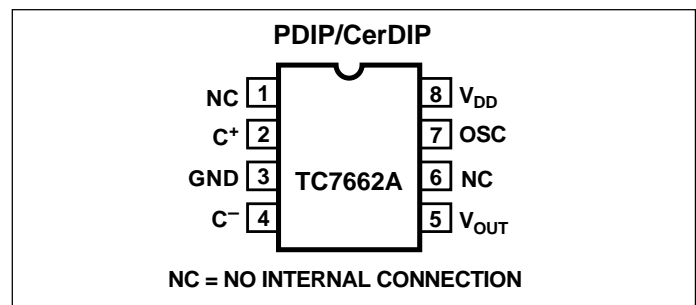
Part No.	Package	Temperature Range
TC7662ACPA	8-Pin Plastic DIP	0°C to +70°C
TC7662AEPA	8-Pin Plastic DIP	-40°C to +85°C
TC7662AIJA	8-Pin CerDIP	-25°C to +85°C
TC7662AMJA	8-Pin CerDIP	-55°C to +125°C

GENERAL DESCRIPTION

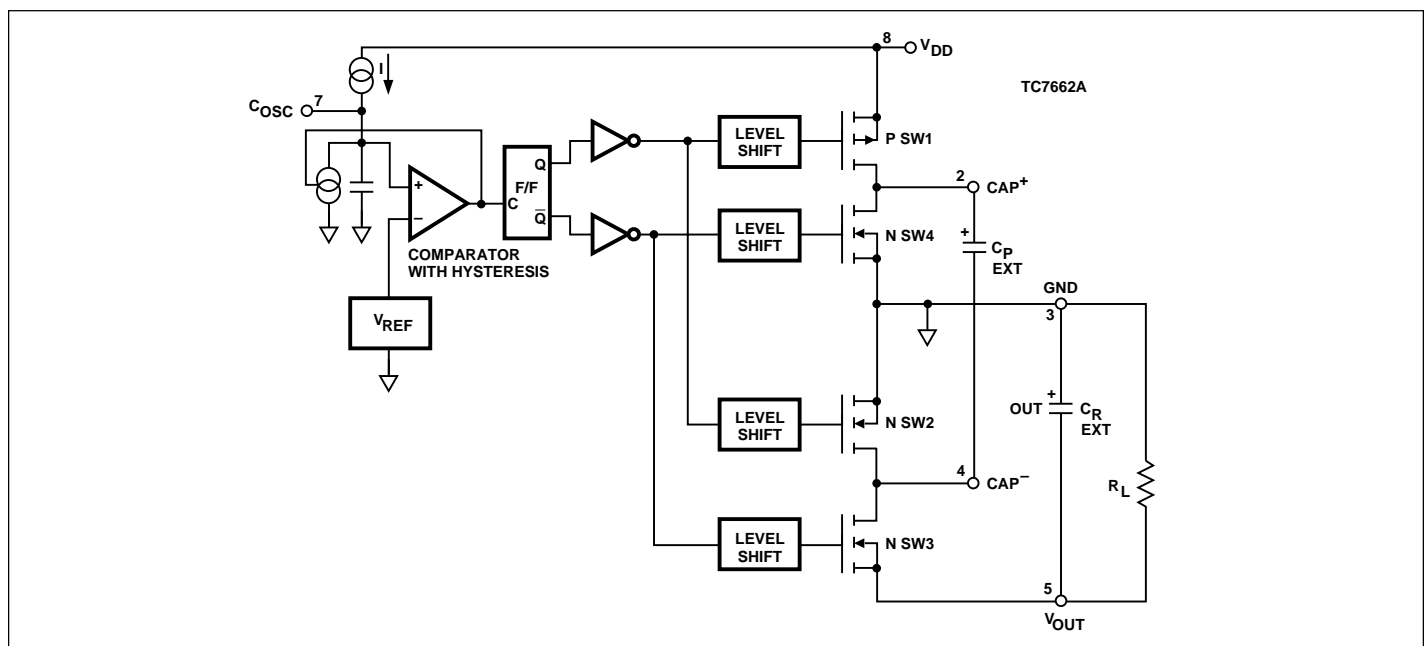
The TC7662A is a pin-compatible upgrade to the industry standard TC7660 charge pump voltage converter. It converts a +3V to +18V input to a corresponding -3V to -18V output using only two low-cost capacitors, eliminating inductors and their associated cost, size and EMI. In addition to a wider power supply input range (3V to 18V versus 1.5V to 10V for the TC7660), the TC7662A can source output currents as high as 40mA. The on-board oscillator operates at a nominal frequency of 12kHz. Operation below 10kHz (for lower supply current applications) is also possible by connecting an external capacitor from OSC to ground.

The TC7662A directly is recommended for designs requiring greater output current and/or lower input/output voltage drop. It is available in 8-pin PDIP, and CerDIP packages in commercial and extended temperature ranges.

PIN CONFIGURATION



FUNCTIONAL BLOCK DIAGRAM



CHARGE PUMP DC-TO-DC CONVERTER

TC7662A

ABSOLUTE MAXIMUM RATINGS*

Supply Voltage V_{DD} to GND	+18V
Input Voltage (Any Pin)	$(V_{DD} + 0.3)$ to $(V_{SS} - 0.3)$
Current Into Any Pin	10mA
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
Power Dissipation ($T_A \leq 70^\circ\text{C}$)	
Plastic DIP	730mW
CerDIP	800mW
SOIC	

Package Thermal Resistance

CPA, EPA θ_{JA}	140°C/W
IJA, MJA θ_{JA}	90°C/W

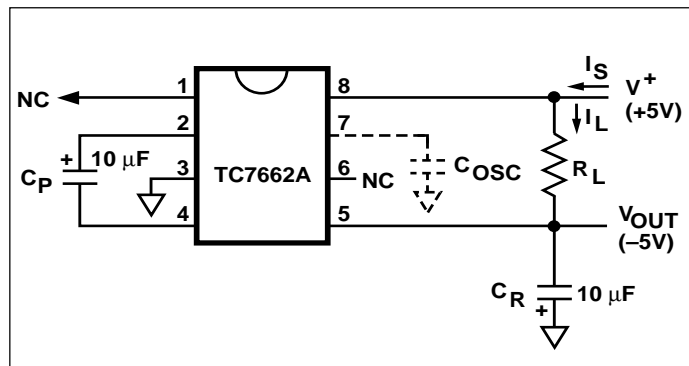
Storage Temperature Range	- 65°C to +150°C
Lead Temperature (Soldering, 10 sec)	+300°C
ESD Protection	$\pm 2000\text{V}$
Output Short Circuit	Continuous (at 5.5V Input)

* 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: $V_{DD} = 15\text{V}$, $T_A = +25^\circ\text{C}$ (See Test Circuit), unless otherwise specified.

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_{DD}	Supply Voltage		3	—	18	V
I_S	Supply Current	$R_L = \infty$ $V_{DD} = +15\text{V}$ $0^\circ\text{C} \leq T_A \leq +70^\circ\text{C}$ $- 55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$ $V_{DD} = +5\text{V}$ $0^\circ\text{C} \leq T_A \leq +70^\circ\text{C}$ $- 55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$	—	510 560 650 190 210 210	700 — — — — —	μA
R_O	Output Source Resistance	$I_L = 20\text{mA}$, $V_{DD} = +15\text{V}$ $I_L = 40\text{mA}$, $V_{DD} = +15\text{V}$ $I_L = 3\text{mA}$, $V_{DD} = +5\text{V}$	—	40 50 100	50 60 125	Ω
C_{OSC}	Oscillator Frequency		—	12	—	kHz
P_{EFF}	Power Efficiency	$V_{DD} = +15\text{V}$ $R_L = 2\text{ k}\Omega$	93	97	—	%
V_{EFF}	Voltage Efficiency	$V_{DD} = +15\text{V}$ $R_L = \infty$ Over Operating Temperature Range	99 96	99.9 —	— —	%

TEST CIRCUIT



APPLICATIONS INFORMATION

Theory of Operation

The TC7662A is a capacitive charge pump (sometimes called a switched-capacitor circuit), where four MOSFET switches control the charge and discharge of a capacitor.

The functional diagram (page 1) shows how the switching action works. SW1 and SW2 are turned on simultaneously, charging C1 to the supply voltage, V_{DD} . This assumes that the ON resistance of the MOSFETs in series with the capacitor produce a charging time (3 time constants) less than the ON time provided by the oscillator frequency, as shown:

$$3 (R_{DS(ON)} C_1) < C_1 / (0.5 f_{OSC})$$

In the next cycle, SW1 and SW2 are turned OFF and, after a very short interval with all switches OFF (preventing large currents from occurring due to cross conduction), SW3 and SW4 are turned ON. The charge in C1 is then transferred to C_{OUT} , BUT WITH THE POLARITY INVERTED. In this way, a negative voltage is derived.

An oscillator supplies pulses to a flip-flop that is fed to a set of level shifters. These level shifters then drive each set of switches at one-half the oscillator frequency.

The oscillator has a pin that controls the frequency of oscillation. Pin 7 can have a capacitor added that is connected to ground. This will lower the frequency of the oscillator by adding capacitance to the internal timing capacitor of the TC7662A. (See Oscillator Frequency vs. C_{EXT} , page 5.)

Capacitors

In early charge pump converters, capacitors were not considered critical due to the high $R_{DS(ON)}$ of the MOSFET switches. In order to understand this, let's look at a model of a typical electrolytic capacitor (Figure 1).

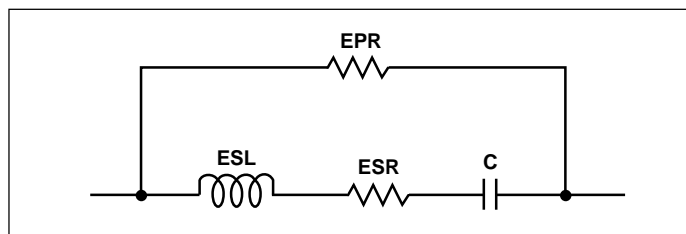


Figure 1. Capacitor Equivalent Circuit

Note one of its characteristics is ESR (equivalent series resistance). This parasitic resistance winds up in series with the load. Thus, both voltage and power conversion efficiency are compromised if a low ESR capacitor is not used.

For example, in the "Test Circuit", changing C_P and C_R capacitors from typical ESR to low ESR types, the effective converter output impedance changed from 45Ω to 40Ω , an improvement of 12%.

This applies to all types of capacitors, including film types (polyester, polycarbonate etc.).

Some applications information suggests that the capacitor is not critical and attributes the limiting factor to the capacitor's reactance value. Let's examine this:

$$X_C = \frac{1}{2\pi f C} \text{ and } Z_C = \frac{X_C}{DS}$$

where DS (duty cycle) = 50%.

Thus, $Z_C \approx 1.33\Omega$ at $f = 12\text{kHz}$, where $C = 10\mu\text{F}$.

For the TC7662A, $f = 12,000\text{Hz}$, and a typical value of C would be $10\mu\text{F}$. This is a reactive impedance of $\approx 1.33\Omega$. If the ESR is as great as 5Ω , the reactive value is not as critical as it would first appear, since the ESR would dominate. The 5Ω value is typical of a general-purpose electrolytic capacitor.

Synchronizing

The TC7662A may be synchronized by connecting pin 7 of the TC7662A through a 100k resistor in series with a diode to a negative-going pulse source. The negative pulse voltage can be +5V with a 5 microsecond duration going negative to 0V.

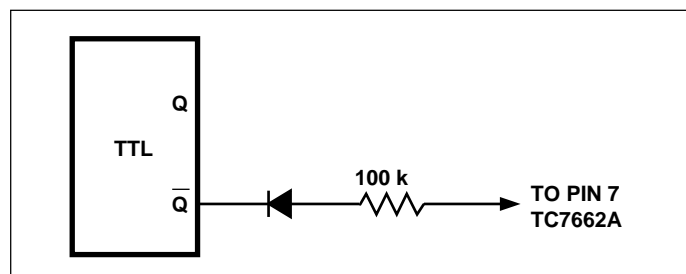


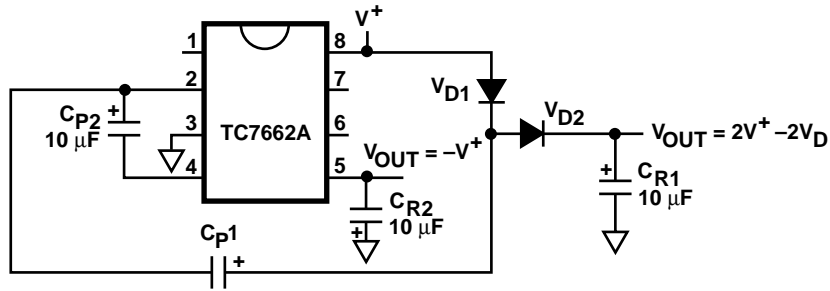
Figure 2. Synchronization

CHARGE PUMP DC-TO-DC CONVERTER

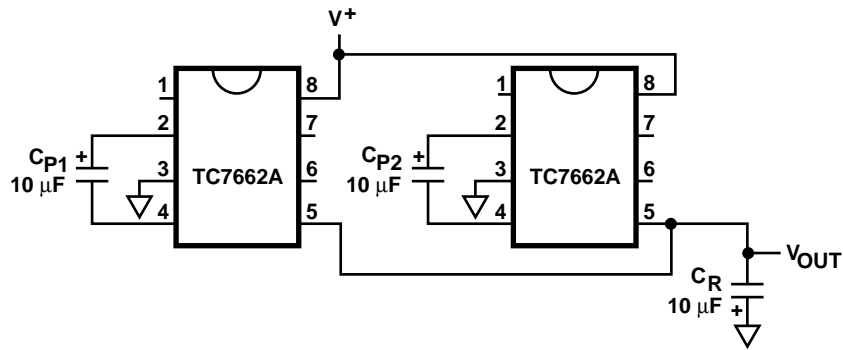
TC7662A

TYPICAL APPLICATIONS

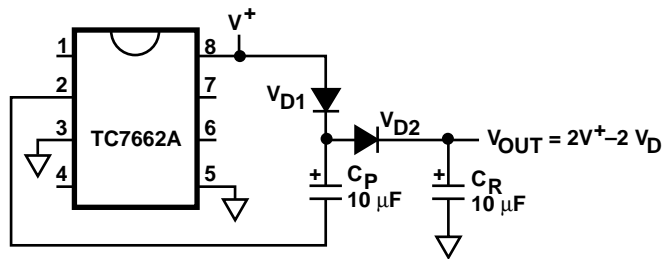
Combined Negative Converter and Positive Multiplier



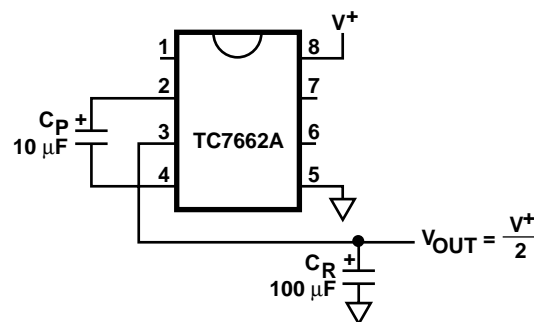
Lowering Output Resistance by Paralleling Devices



Positive Voltage Multiplier



Split V^+ In Half

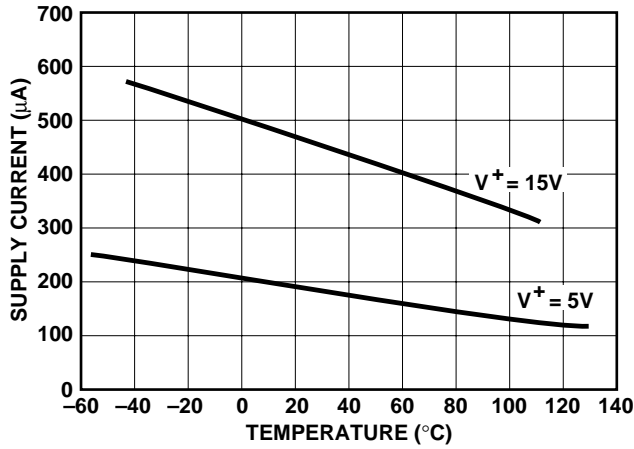


CHARGE PUMP DC-TO-DC CONVERTER

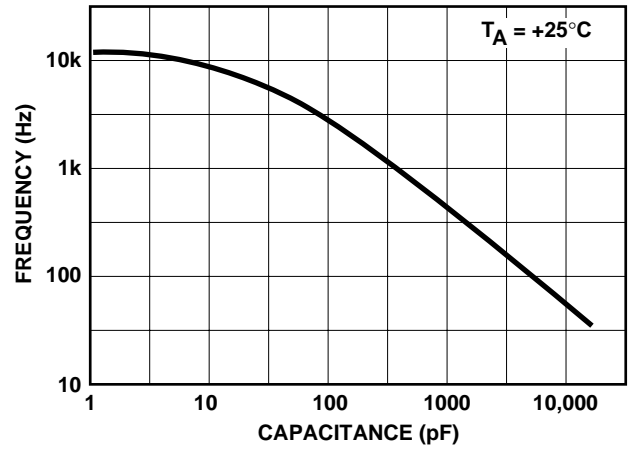
TC7662A

TYPICAL CHARACTERISTICS CURVES

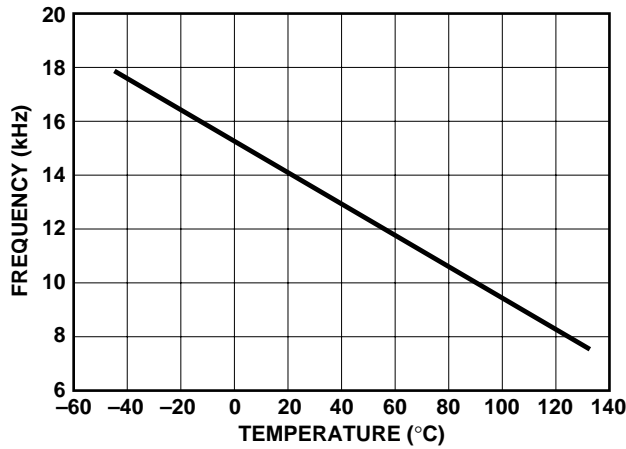
Supply Current vs Temperature



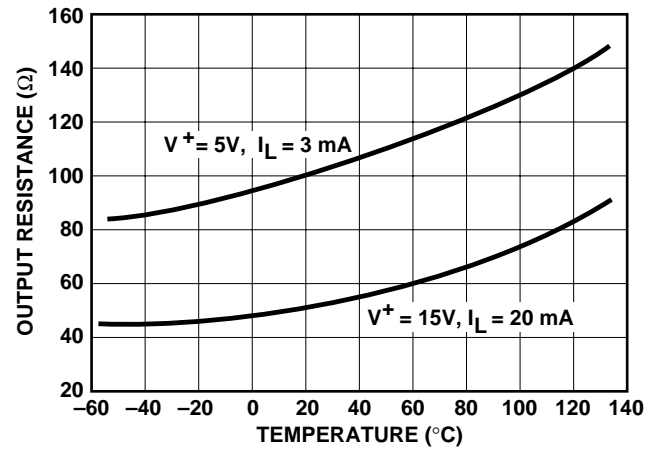
Oscillator Frequency vs C_{EXT}



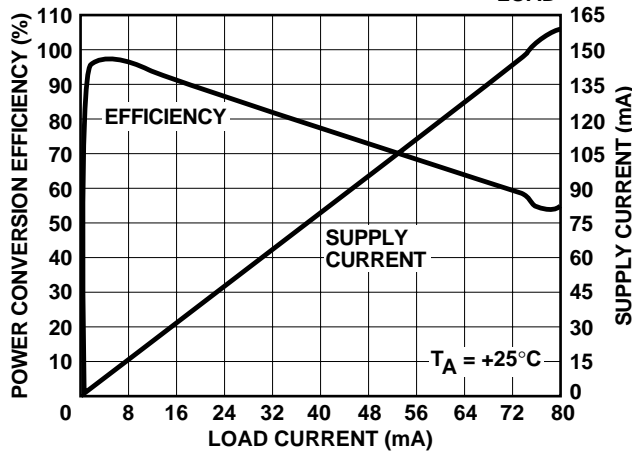
Frequency vs Temperature



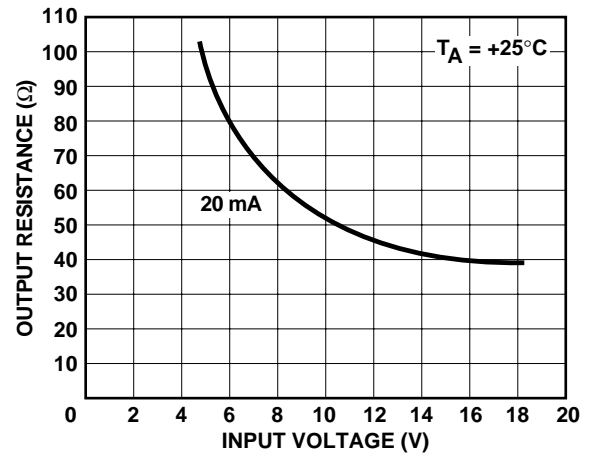
Output Resistance vs Temperature



Power Conversion Efficiency vs I_{LOAD}



Output Resistance vs Input Voltage

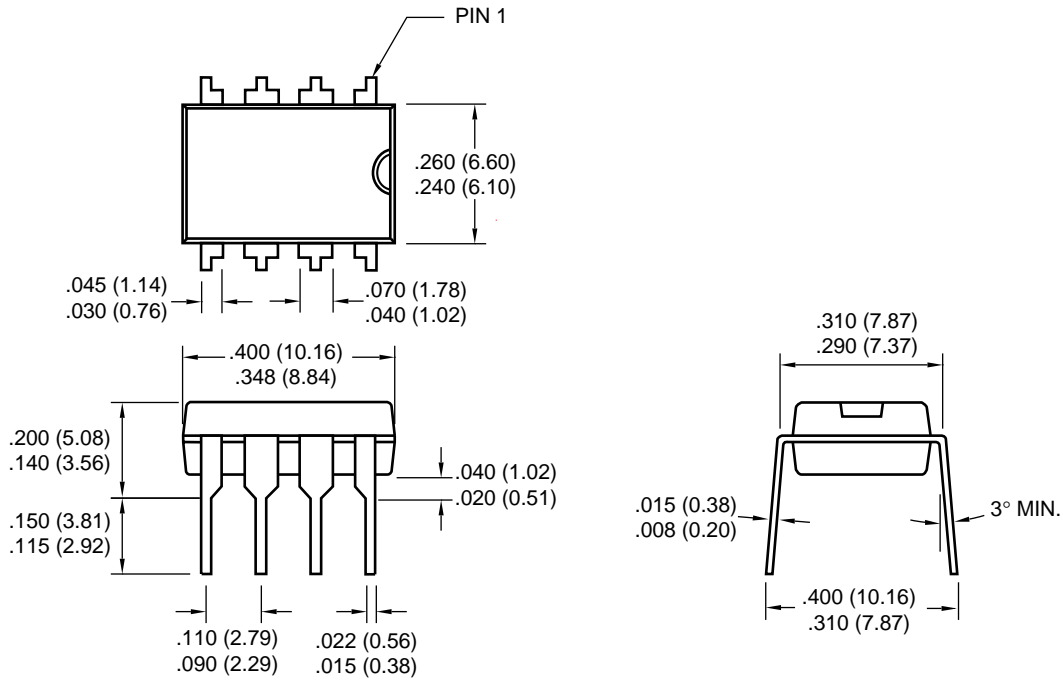


CHARGE PUMP DC-TO-DC CONVERTER

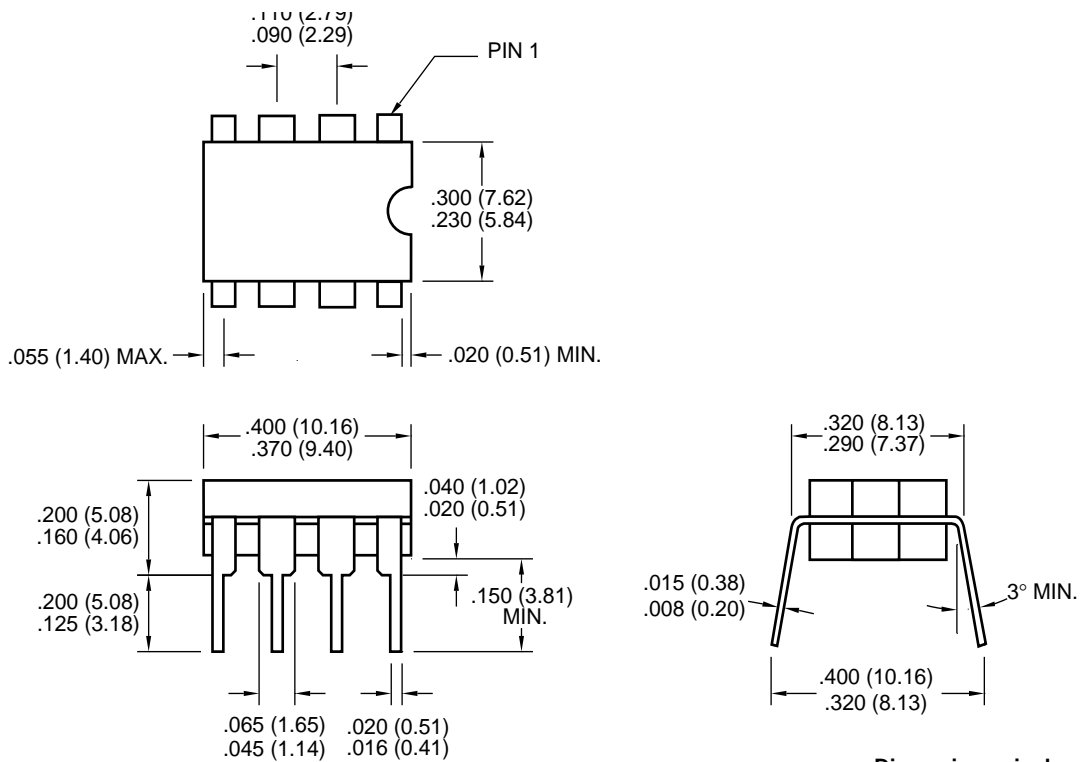
TC7662A

PACKAGE DIMENSIONS

8-Pin Plastic DIP



8-Pin CerDIP



Dimensions: inches (mm)



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, O'Shaughnessy 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 SARM
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.