

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
- Available in 8-Pin PDIP and 8-Pin Cerdip Packages

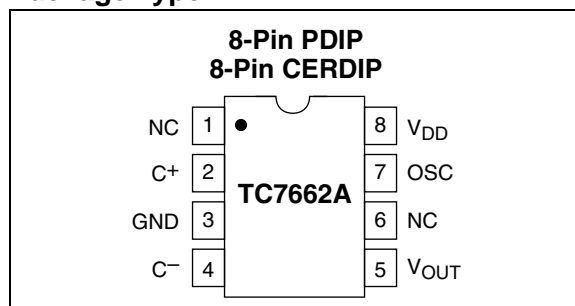
Applications

- Laptop Computers
- Disk Drives
- Process Instrumentation
- μP -based Controllers

Device Selection Table

Part Number	Package	Operating Temp. Range
TC7662ACPA	8-Pin PDIP	0°C to +70°C
TC7662AEPA	8-Pin PDIP	-40°C to +85°C
TC7662AIJA	8-Pin Cerdip	-25°C to +85°C
TC7662AMJA	8-Pin Cerdip	-55°C to +125°C

Package Type



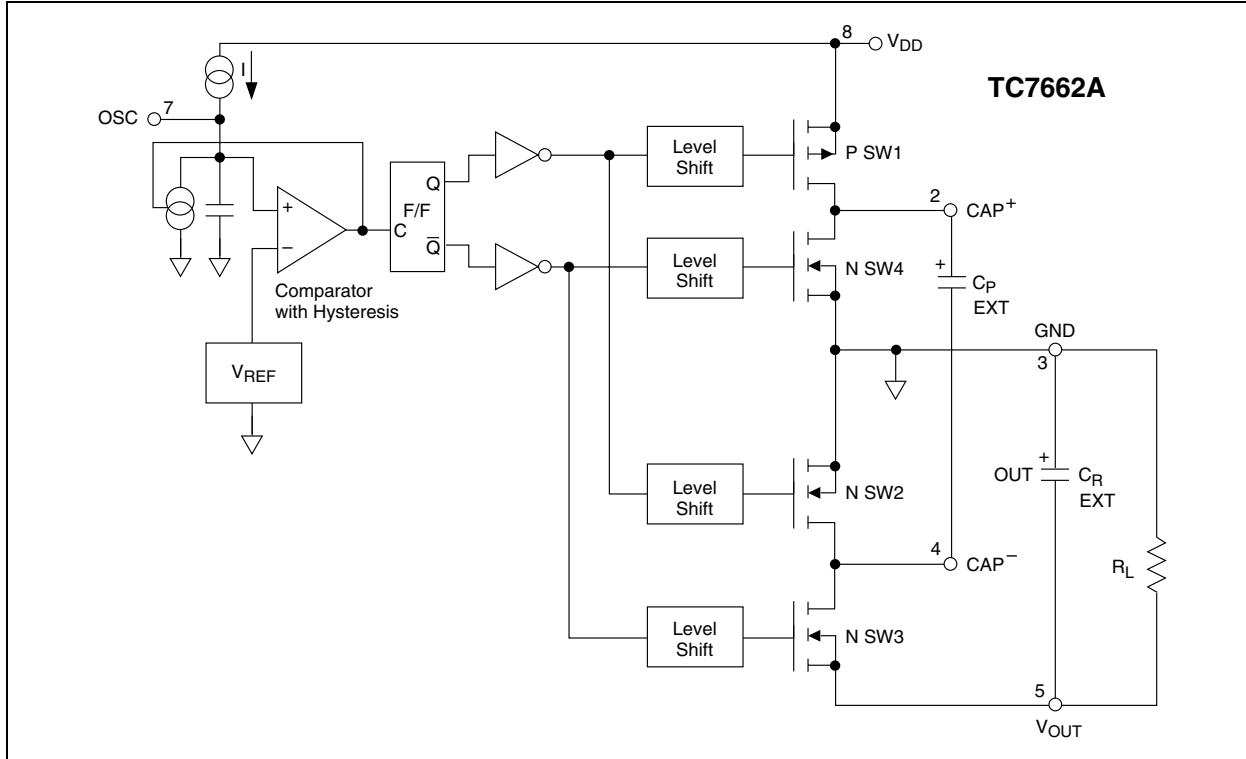
General Description

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 12kHz (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.

TC7662A

Functional Block Diagram



1.0 ELECTRICAL CHARACTERISTICS

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
Output Short Circuit	Continuous (at 5.5V Input)
ESD Protection	$\pm 2000V$
Package Power Dissipation ($T_A \leq 70^\circ C$)	
8-Pin Cerdip	800mW
8-Pin PDIP	730mW
Package Thermal Resistance	
CPA, EPA θ_{JA}	140°C/W
IJA, MJA θ_{JA}	90°C/W
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 +150°C

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 operation sections of the specifications is not implied. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability.

TC7662A ELECTRICAL SPECIFICATIONS

Electrical Characteristics: $V_{DD} = 15V$, $T_A = +25^\circ C$, Test circuit (Figure 3-1) unless otherwise noted.						
Symbol	Parameter	Min	Typ	Max	Units	Test Conditions
V_{DD}	Supply Voltage	3	—	18	V	
I_S	Supply Current	—	—	—	μA	$R_L = \infty$ $V_{DD} = +15V$ $0^\circ C \leq T_A \leq +70^\circ C$ $-55^\circ C \leq T_A \leq +125^\circ C$
		—	510	700		
		—	560	—		
		—	650	—		$V_{DD} = +5V$
		—	190	—		$0^\circ C \leq T_A \leq +70^\circ C$
		—	210	—		$-55^\circ C \leq T_A \leq +125^\circ C$
		—	210	—		
R_O	Output Source Resistance	—	40	50	Ω	$I_L = 20mA$, $V_{DD} = +15V$ $I_L = 40mA$, $V_{DD} = +15V$ $I_L = 3mA$, $V_{DD} = +5V$
		—	50	60		
		—	100	125		
F_{OSC}	Oscillator Frequency	—	12	—	kHz	
P_{EFF}	Power Efficiency	93	97	—	%	$V_{DD} = +15V$ $R_L = 2k\Omega$
		—	—	—		
V_{EFF}	Voltage Efficiency	99	99.9	—	%	$V_{DD} = +15V$ $R_L = \infty$
		—	—	—		Over operating temperature range.
		96	—	—		

TC7662A

2.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in Table 2-1.

TABLE 2-1: PIN FUNCTION TABLE

Pin No. (8-Pin PDIP, CERDIP)	Symbol	Description
1	NC	No connection.
2	C ⁺	Charge pump capacitor positive terminal.
3	GND	Ground terminal.
4	C ⁻	Charge pump capacitor negative terminal.
5	V _{OUT}	Output voltage.
6	NC	No connection.
7	OSC	Oscillator control input. Bypass with an external capacitor to slow the oscillator.
8	V _{DD}	Power supply positive voltage input.

3.0 DETAILED DESCRIPTION

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 block diagram shows how the switching action works. SW1 and SW2 are turned on simultaneously, charging C_P 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:

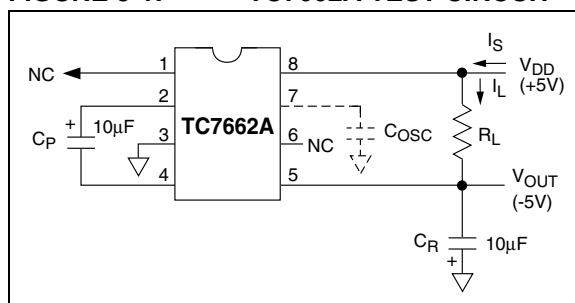
$$3 (R_{DS(ON)} C_P) < C_P / (0.5 f_{OSC}).$$

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 C_P is then transferred to C_R , 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 Typical Characteristics – Oscillator Frequency vs. C_{OSC} .)

FIGURE 3-1: TC7662A TEST CIRCUIT



3.1 Theoretical Power Efficiency Considerations

In theory, a voltage converter can approach 100% efficiency if certain conditions are met:

1. The drive circuitry consumes minimal power.
2. The output switches have extremely low ON resistance and virtually no offset.
3. The impedances of the pump and reservoir capacitors are negligible at the pump frequency.

The TC7662A approaches these conditions for negative voltage conversion if large values of C_P and C_R are used.

Note: Energy is lost only in the transfer of charge between capacitors if a change in voltage occurs.

The energy lost is defined by:

$$E = 1/2 C_P (V_1^2 - V_2^2)$$

V_1 and V_2 are the voltages on C_P during the pump and transfer cycles. If the impedances of C_P and C_R are relatively high at the pump frequency (refer to Figure 3-1), compared to the value of R_L , there will be a substantial difference in voltages V_1 and V_2 . Therefore, it is desirable not only to make C_R as large as possible to eliminate output voltage ripple, but also to employ a correspondingly large value for C_P in order to achieve maximum efficiency of operation.

3.2 Dos and Don'ts

- Do not exceed maximum supply voltages.
- Do not short circuit the output to V^+ supply for voltages above 5.5V for extended periods; however, transient conditions including start-up are okay.
- When using polarized capacitors in the inverting mode, the + terminal of C_P must be connected to pin 2 of the TC7662A and the + terminal of C_R must be connected to GND (pin 3).
- If the voltage supply driving the TC7662A has a large source impedance (25-30 ohms), then a 2.2µF capacitor from pin 8 to ground may be required to limit the rate of rise of the input voltage to less than 2V/µsec.

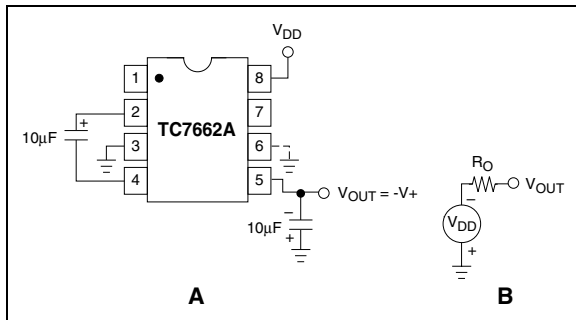
TC7662A

4.0 TYPICAL APPLICATIONS

4.1 Simple Negative Voltage Converter

The majority of applications will undoubtedly utilize the TC7662A for generation of negative supply voltages. Figure 4-1 shows typical connections to provide a negative supply where a positive supply of +3V to +18V is available.

FIGURE 4-1: SIMPLE NEGATIVE CONVERTER AND ITS OUTPUT EQUIVALENT



The output characteristics of the circuit in Figure 4-1 are those of a nearly ideal voltage source in series with a resistance as shown in Figure 4-1b. The voltage source has a value of $-(V_{DD})$. The output impedance (R_O) is a function of the ON resistance of the internal MOS switches (shown in the Functional Block Diagram), the switching frequency, the value of C_P and C_R , and the ESR (equivalent series resistance) of C_P and C_R . A good first order approximation for R_O is:

$$R_O \cong 2(R_{SW1} + R_{SW2} + ESR_{CP}) + 2(R_{SW3} + R_{SW4} + ESR_{CP}) + \frac{1}{f_{PUMP} \times C_P} + ESR_{CR}$$

($f_{PUMP} = \frac{f_{OSC}}{2}$, R_{SWX} = MOSFET switch resistance)

Combining the four R_{SWX} terms as R_{SW} , we see that:

$$R_O \cong 2 \times R_{SW} + \frac{1}{f_{PUMP} \times C_P} + 4 \times ESR_{CP} + ESR_{CR}$$

R_{SW} , the total switch resistance, is a function of supply voltage and temperature (See Section 5.0, Typical Characteristics "Output Source Resistance" graphs), typically 23Ω at $+25^\circ\text{C}$ and 5V. Careful selection of C_P and C_R will reduce the remaining terms, minimizing the output impedance. High value capacitors will reduce the $1/(f_{PUMP} \times C_P)$ component, and low ESR capacitors will lower the ESR term. Increasing the oscillator frequency will reduce the $1/(f_{PUMP} \times C_P)$ term, but may have the side effect of a net increase in output impedance when $C_P > 10\mu\text{F}$ and there is not enough time to fully charge the capacitors every cycle. In a typical application when $f_{OSC} = 12\text{kHz}$ and $C = C_P = C_R = 10\mu\text{F}$:

$$R_O \cong 2 \times 23 + \frac{1}{(5 \times 12^3 \times 10 \times 10^{-6})} + 4 \times ESR_{CP} + ESR_{CR}$$

$$R_O \cong (46 + 20 + 5 \times ESR_C)\Omega$$

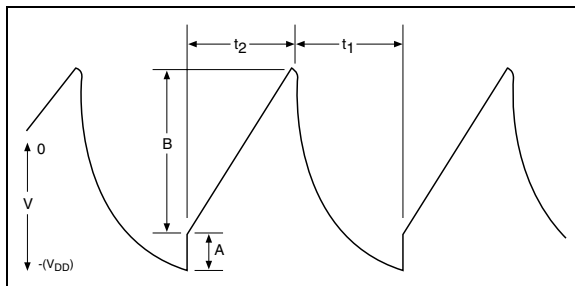
Since the ESRs of the capacitors are reflected in the output impedance multiplied by a factor of 5, a high value could potentially swamp out a low $1/(f_{PUMP} \times C_P)$ term, rendering an increase in switching frequency or filter capacitance ineffective. Typical electrolytic capacitors may have ESRs as high as 10Ω .

4.2 Output Ripple

ESR also affects the ripple voltage seen at the output. The total ripple is determined by 2 voltages, A and B, as shown in Figure 4-2. Segment A is the voltage drop across the ESR of C_R at the instant it goes from being charged by C_P (current flowing into C_R) to being discharged through the load (current flowing out of C_R). The magnitude of this current change is $2 \times I_{OUT}$, hence the total drop is $2 \times I_{OUT} \times ESR_{C_R}$ volts. Segment B is the voltage change across C_R during time t_2 , the half of the cycle when C_R supplies current to the load. The drop at B is $I_{OUT} \times t_2 / C_R$ volts. The peak-to-peak ripple voltage is the sum of these voltage drops:

$$V_{RIPPLE} \cong \left(\frac{1}{2 \times f_{PUMP} \times C_R} + 2 \times ESR_{C_R} \times I_{OUT} \right)$$

FIGURE 4-2: OUTPUT RIPPLE



4.3 Paralleling Devices

Any number of TC7662A voltage converters may be paralleled to reduce output resistance (Figure 4-3). The reservoir capacitor, C_R , serves all devices, while each device requires its own pump capacitor, C_P . The resultant output resistance would be approximately:

$$R_{OUT} = \frac{R_{OUT} \text{ (of TC7662A)}}{n \text{ (number of devices)}}$$

4.4 Cascading Devices

The TC7662A may be cascaded as shown (Figure 4-4) to produce larger negative multiplication of the initial supply voltage. However, due to the finite efficiency of each device, the practical limit is 10 devices for light loads. The output voltage is defined by:

$$V_{OUT} = -n (V_{IN})$$

where n is an integer representing the number of devices cascaded. The resulting output resistance would be approximately the weighted sum of the individual TC7662A R_{OUT} values.

FIGURE 4-3: PARALLELING DEVICES LOWERS OUTPUT IMPEDANCE

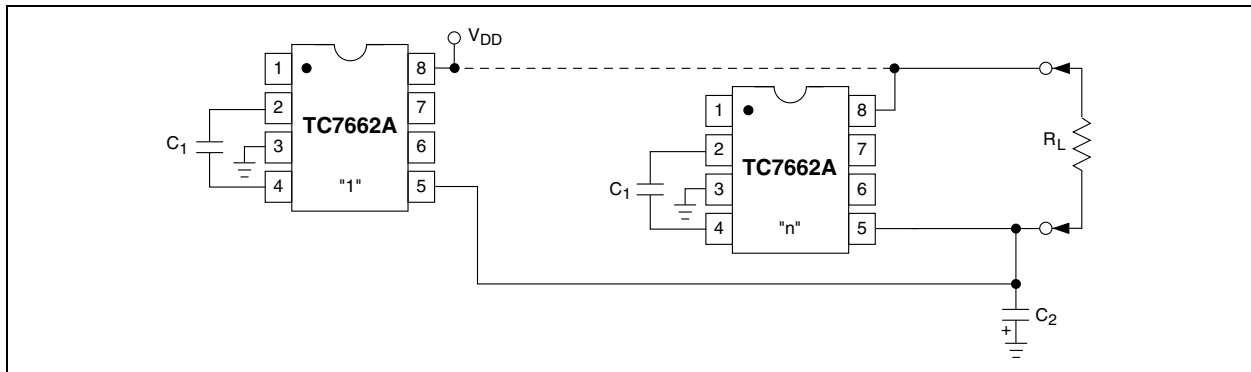
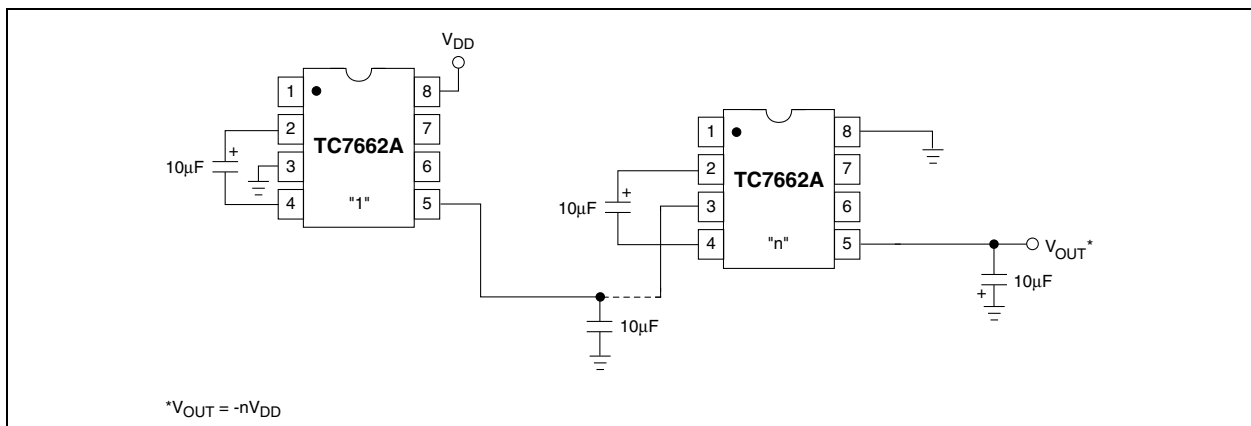


FIGURE 4-4: INCREASED OUTPUT VOLTAGE BY CASCADING DEVICES

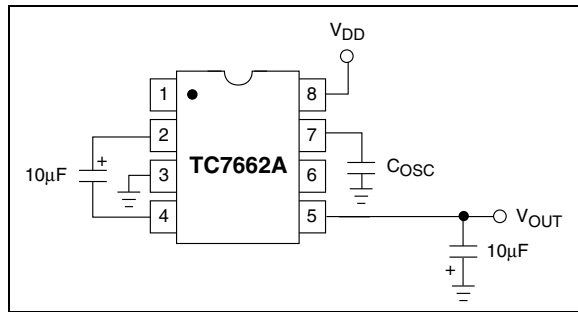


TC7662A

4.5 Changing the TC7662A Oscillator Frequency

It is possible to increase the conversion efficiency of the TC7662A at low load levels by lowering the oscillator frequency. This reduces the switching losses, and is shown in Figure 4-5. However, lowering the oscillator frequency will cause an undesirable increase in the impedance of the pump (C_P) and reservoir (C_R) capacitors; this is overcome by increasing the values of C_P and C_R by the same factor that the frequency has been reduced. For example, the addition of a 100pF capacitor between pin 7 (OSC) and V_{DD} will lower the oscillator frequency to 2kHz from its nominal frequency of 12kHz (multiple of 6), and thereby necessitate a corresponding increase in the value of C_P and C_R (from 10 μ F to 68 μ F).

FIGURE 4-5: LOWERING OSCILLATOR FREQUENCY

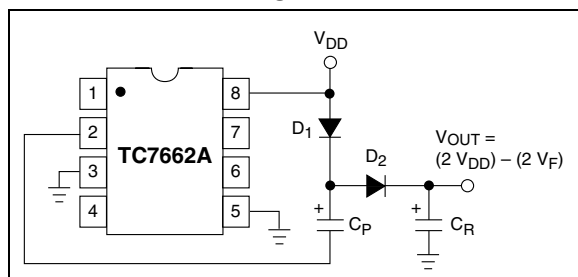


4.6 Positive Voltage Doubling

The TC7662A may be employed to achieve positive voltage doubling using the circuit shown in Figure 4-6. In this application, the pump inverter switches of the TC7662A are used to charge C_P to a voltage level of $V_{DD} - V_F$ (where V_{DD} is the supply voltage and V_F is the forward voltage on C_P plus the supply voltage (V_{DD}) applied through diode D_2 to capacitor C_R). The voltage thus created on C_R becomes $(2 V_{DD}) - (2 V_F)$, or twice the supply voltage minus the combined forward voltage drops of diodes D_1 and D_2 .

The source impedance of the output (V_{OUT}) will depend on the output current, but for $V_{DD} = 5V$ and an output current of 10 mA, it will be approximately 60 Ω .

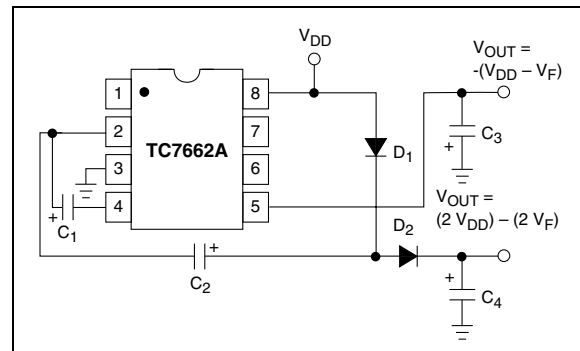
FIGURE 4-6: POSITIVE VOLTAGE MULTIPLIER



4.7 Combined Negative Voltage Conversion and Positive Supply Multiplication

Figure 4-7 combines the functions shown in Figure 4-1 and Figure 4-6 to provide negative voltage conversion and positive voltage doubling simultaneously. This approach would be, for example, suitable for generating +9V and -5V from an existing +5V supply. In this instance, capacitors C_1 and C_3 perform the pump and reservoir functions, respectively, for the generation of the negative voltage, while capacitors C_2 and C_4 are pump and reservoir, respectively, for the doubled positive voltage. There is a penalty in this configuration which combines both functions, however, in that the source impedances of the generated supplies will be somewhat higher due to the finite impedance of the common charge pump driver at pin 2 of the device.

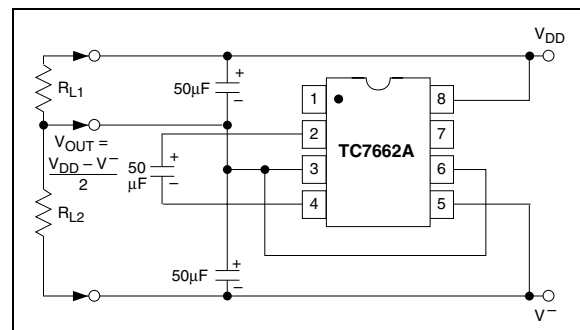
FIGURE 4-7: COMBINED NEGATIVE CONVERTER AND POSITIVE DOUBLER



4.8 Voltage Splitting

The same bidirectional characteristics can be used to split a higher supply in half, as shown in Figure 4-8. The combined load will be evenly shared between the two sides. Because the switches share the load in parallel, the output impedance is much lower than in the standard circuits, and higher currents can be drawn from the device. By using this circuit, and then the circuit of Figure 4-4, +15V can be converted (via +7.5V and -7.5V) to a nominal -15V, though with rather high series resistance (~250 Ω).

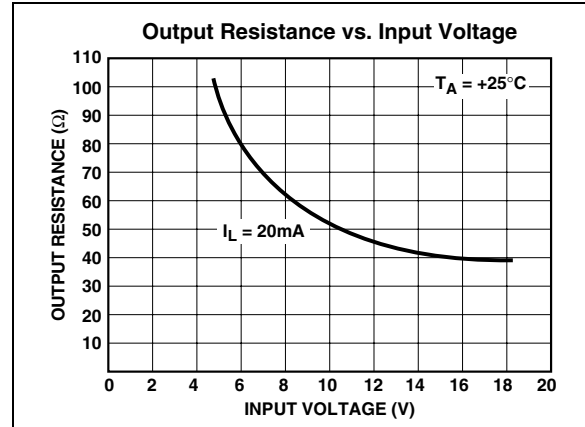
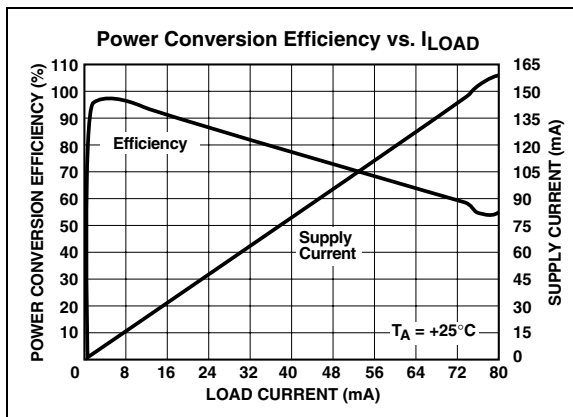
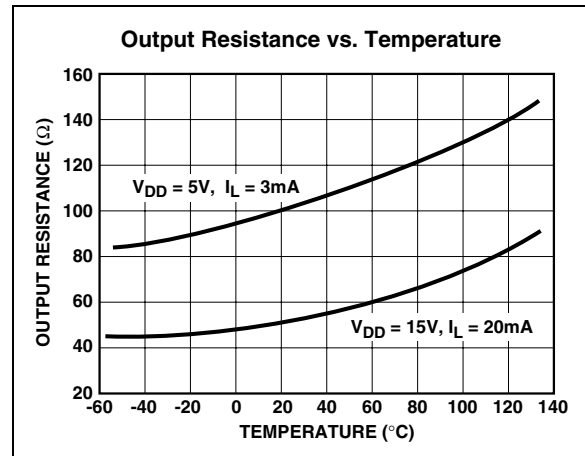
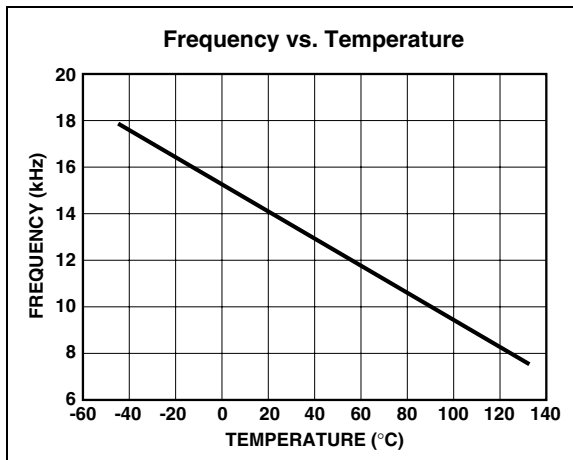
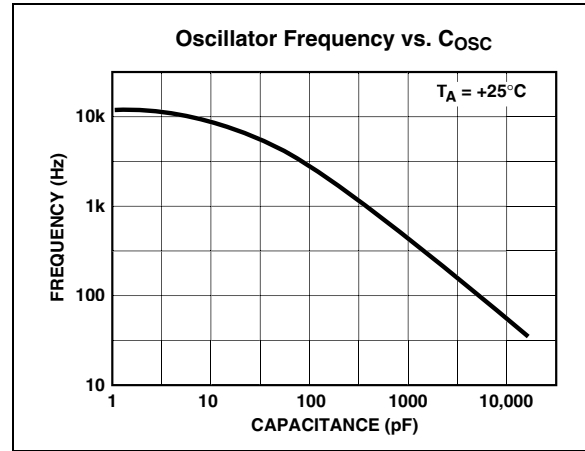
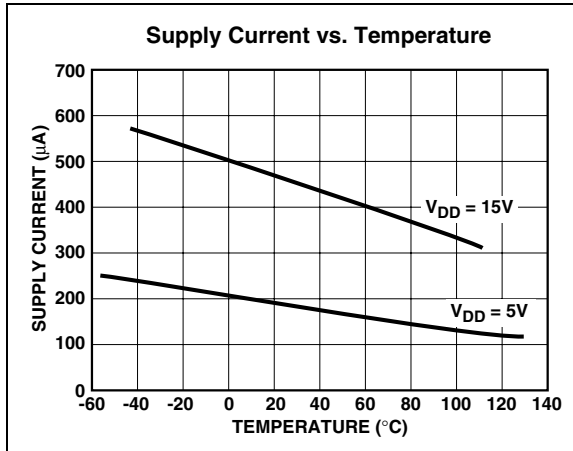
FIGURE 4-8: SPLITTING A SUPPLY IN HALF



5.0 TYPICAL CHARACTERISTICS

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.

Circuit of Figure 3-1, $C_P = C_R = 10\mu\text{F}$, $C_{ESRCP} \approx C_{ESRCR} \approx 1\Omega$, $T_A = 25^\circ\text{C}$ unless otherwise noted.



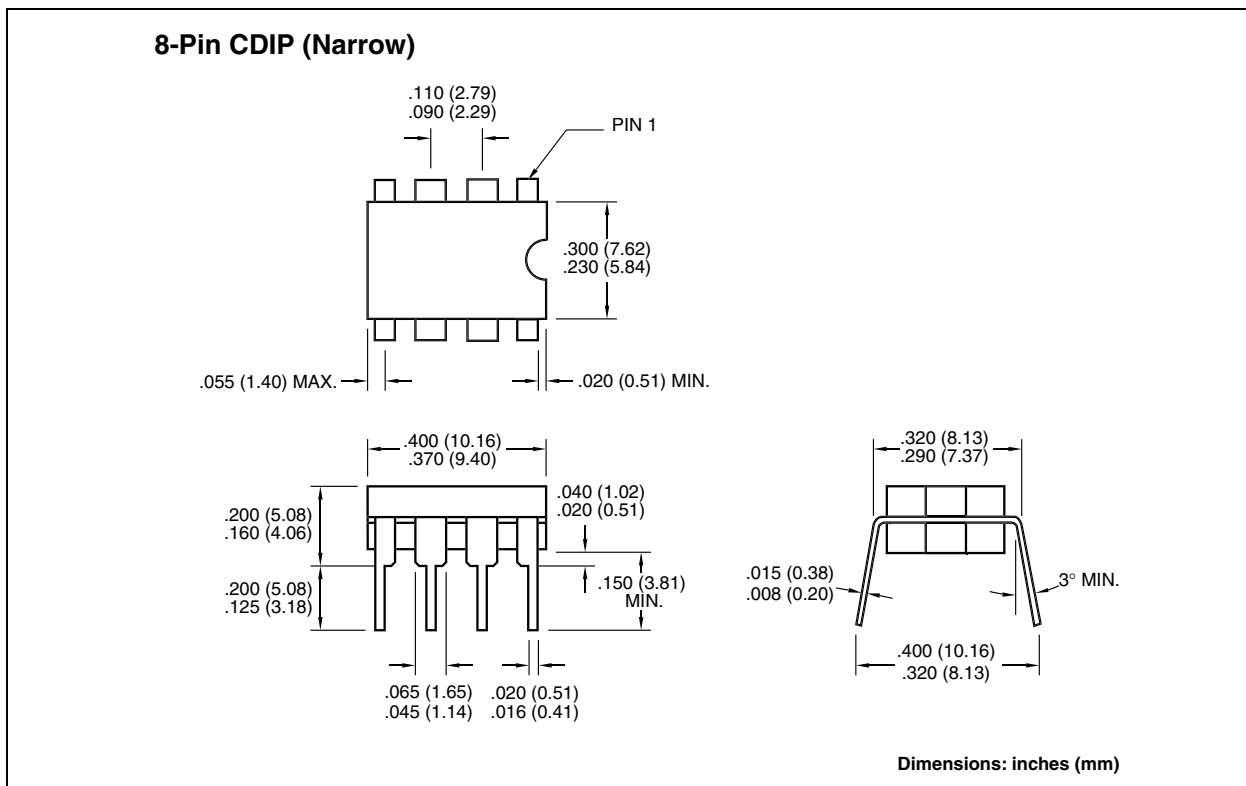
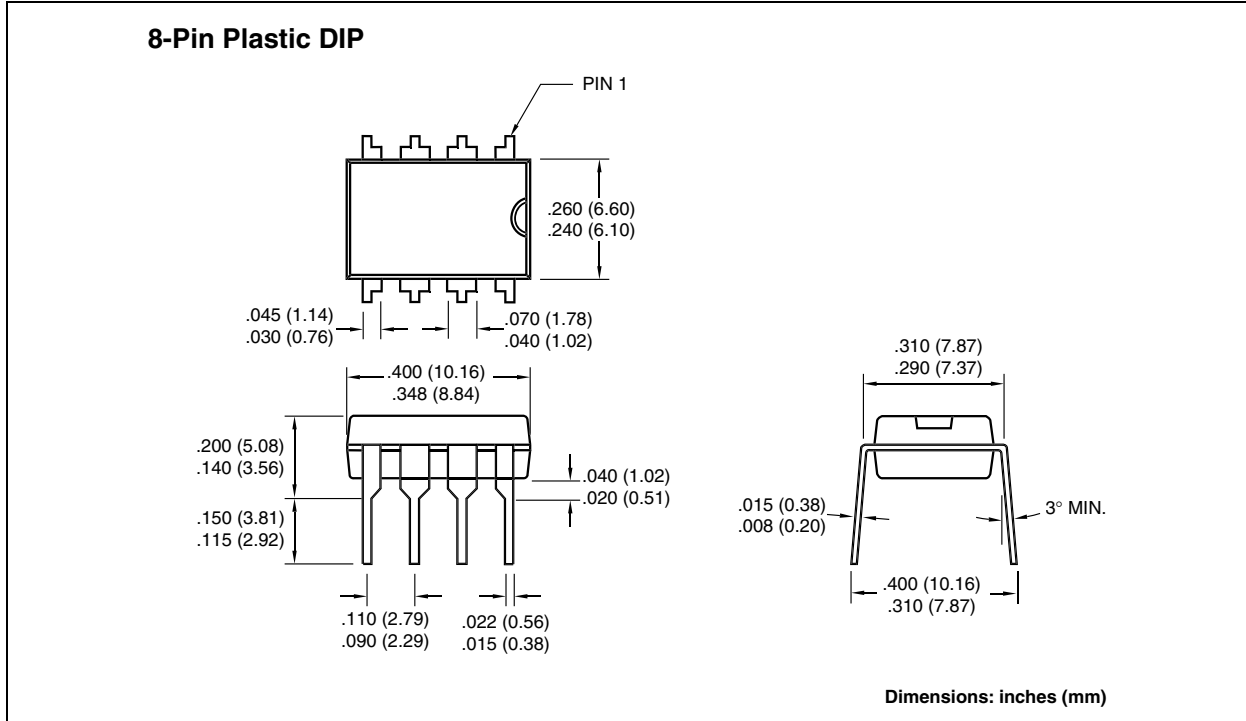
TC7662A

6.0 PACKAGING INFORMATION

6.1 Package Marking Information

Package marking data not available at this time.

6.2 Package Dimensions



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)

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) to receive the most current information on our products.

TC7662A

NOTES:

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, FilterLab, KEELOQ, microID, MPLAB, PIC, PICmicro, PICMASTER, PICSTART, PRO MATE, SEEVAL and The Embedded Control Solutions Company are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

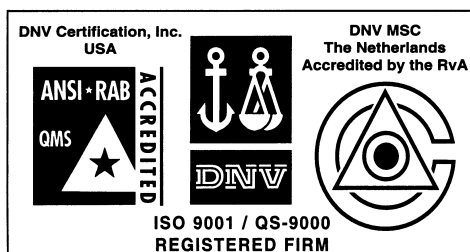
dsPIC, ECONOMONITOR, FanSense, FlexROM, fuzzyLAB, In-Circuit Serial Programming, ICSP, ICEPIC, microPort, Migratable Memory, MPASM, MPLIB, MPLINK, MPSIM, MXDEV, PICC, PICDEM, PICDEM.net, rfPIC, Select Mode and Total Endurance are trademarks of Microchip Technology Incorporated in the U.S.A.

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: 480-792-7456

Atlanta

500 Sugar Mill Road, Suite 200B
Atlanta, GA 30350
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

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

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, 24th Floor,
Ming Xing Financial Tower
No. 88 TIDU Street
Chengdu 610016, China
Tel: 86-28-6766200 Fax: 86-28-6766599

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. 1315, 13/F, Shenzhen Kerry Centre,
Renminnan Lu
Shenzhen 518001, China
Tel: 86-755-2350361 Fax: 86-755-2366086

Hong Kong

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

EUROPE

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
Gustav-Heinemann Ring 125
D-81739 Munich, 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

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

03/01/02

