

LM2682

Switched Capacitor Voltage Doubling Inverter

General Description

The LM2682 is a CMOS charge-pump voltage inverter capable of converting positive voltage in the range of +2.0V to +5.5V to the corresponding doubled negative voltage of -4.0V to -11.0V respectively. The LM2682 uses three low cost capacitors to provide 10 mA of output current without the cost, size, and EMI related to inductor based circuits. With an operating current of only 150 μA and an operating efficiency greater than 90% with most loads, the LM2682 provides ideal performance for battery powered systems. The LM2682 offers a switching frequency of 6 kHz.

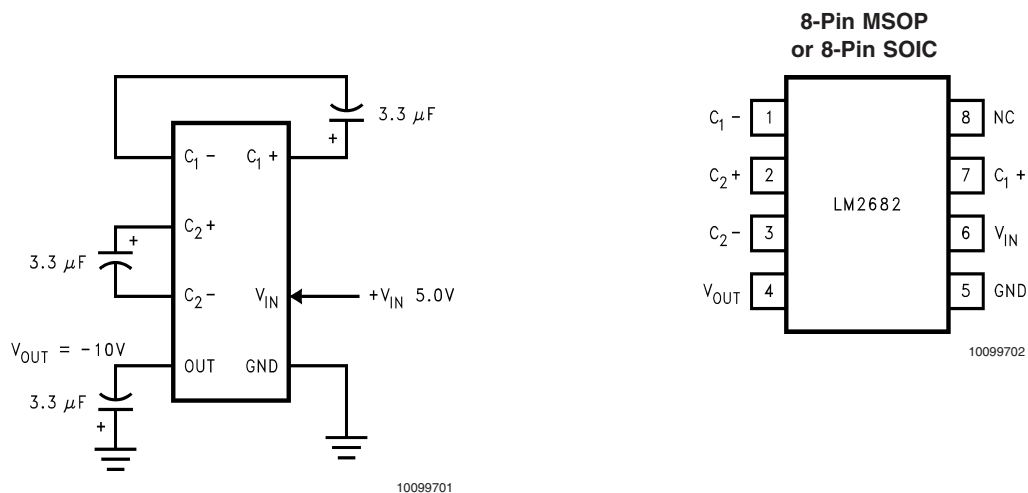
Features

- Inverts then doubles input supply voltage
- Small MSOP-8 package (mini SO-8) and SO-8 package
- 90 Ω typical output impedance
- 94% typical power efficiency at 10 mA

Applications

- LCD contrast biasing
- GaAs power amplifier biasing
- Interface power supplies
- Handheld instrumentation
- Laptop computers and PDAs

Typical Operating Circuit and Pin Configuration



Ordering Information

Order Number	Package	Package Number	Package Marking	Supplied As
LM2682MM	MSOP-8	MUA08A	S11A	Tape and Reel (1000 units/reel)
LM2682MMX	MSOP-8	MUA08A	S11A	Tape and Reel (3500 units/reel)
LM2682M	SO-8	M08A	LM2682M	Rail (95 units/rail)
LM2682MX	SO-8	M08A	LM2682M	Tape and Reel (2500 units/reel)

Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Input Voltage (V_{IN})	+5.8V
V_{IN} dV/dT	1V/ μ sec
V_{OUT}	-11.6V
V_{OUT} Short-Circuit Duration	Continuous
Storage Temperature	-65°C to +150°C
Lead Temperature Soldering	+300°C

Power Dissipation (Note 2)

MSOP-8	300 mW
SO-8	470 mW
T_{JMAX}	+150°C

Operating Ratings

ESD Susceptibility (Note 3)

Human Body Model	2 kV
Machine Model	200V
Ambient Temp. Range	-40°C to +85°C
Junction Temp. Range	-40°C to +125°C

LM2682**Electrical Characteristics**

$V_{IN} = 5V$ and $C_1 = C_2 = C_3 = 3.3\mu F$ unless otherwise specified. Limits with **bold typeface** apply over the full operating ambient temperature range, -40°C to +85°C, limits with standard typeface apply for $T_A = 25^\circ C$.

Symbol	Parameter	Conditions	Min	Typical (Note 4)	Max	Units
V_{IN}	Supply Voltage Range	$R_L = 2\text{ k}\Omega$	2.0		5.5	V
I_{IN}	Supply Current	Open Circuit, No Load		150	300 400	μA
R_{OUT}	V_{OUT} Source Resistance	$I_L = 10\text{ mA}$		90	150 200	Ω
		$I_L = 5\text{ mA}, V_{IN} = 2\text{ V}$		110	250	Ω
f_{OSC}	Oscillator Frequency	(Note 5)		12	30	kHz
f_{SW}	Switching Frequency	(Note 5)		6	15	kHz
η_{POWER}	Power Efficiency	$R_L = 2\text{ k}\Omega$ (Note 6)	90	93		%
$\eta_{VOLTAGE}$	Voltage Conversion Efficiency			99.9		%

Note 1: Absolute Maximum Ratings are those values beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics.

Note 2: The maximum power dissipation must be de-rated at elevated temperatures (only needed for $T_A > 85^\circ C$) and is limited by T_{JMAX} (maximum junction temperature), θ_{J-A} (junction to ambient thermal resistance) and T_A (ambient temperature). θ_{J-A} is 140°C/W for the SO-8 package and 220°C/W for the MSOP-8 package. The maximum power dissipation at any temperature is:

$$P_{DissMAX} = (T_{JMAX} - T_A) / \theta_{J-A} \text{ up to the value listed in the Absolute Maximum Ratings.}$$

Note 3: The human body model is a 100 pF capacitor discharged through a 1.5 k Ω resistor into each pin. The machine model is a 200pF capacitor discharged directly into each pin.

Note 4: Typical numbers are at 25°C and represent the most likely norm.

Note 5: The output switches operate at one half of the oscillator frequency, $f_{OSC} = 2f_{SW}$.

Note 6: The minimum specification is guaranteed by design and is not tested.

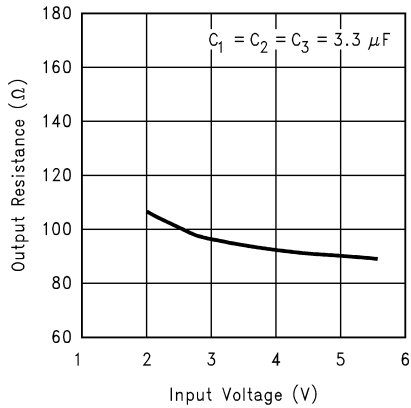
Pin Description

Pin Number	Symbol	Description
1	C_{1-}	Capacitor C_1 negative terminal
2	C_{2+}	Capacitor C_2 positive terminal
3	C_{2-}	Capacitor C_2 negative terminal
4	V_{OUT}	Negative output voltage ($-2V_{IN}$)
5	GND	Device ground
6	V_{IN}	Power supply voltage
7	C_{1+}	Capacitor C_1 positive terminal
8	NC	No Connection

Typical Performance Characteristics

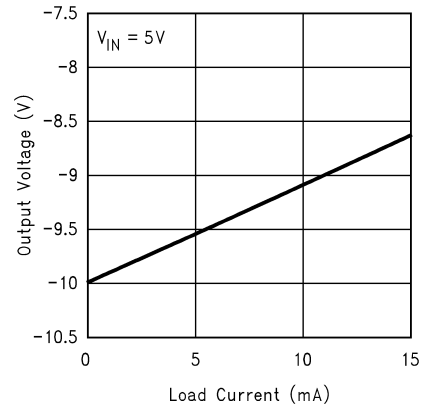
$V_{IN} = 5V$ and $T_A = 25^\circ C$ unless otherwise noted.

Output Resistance vs Input Voltage



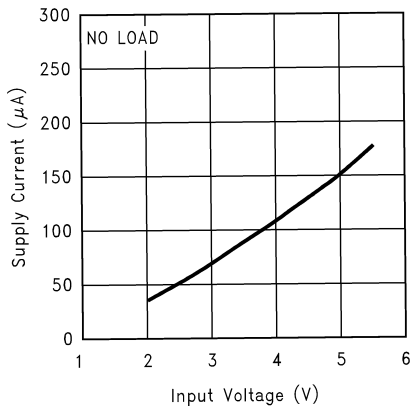
10099706

Output Voltage vs Load Current



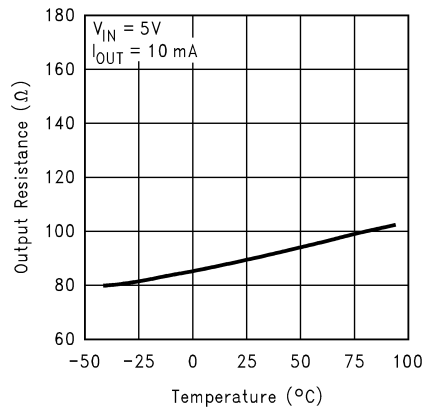
10099707

Supply Current vs Input Voltage



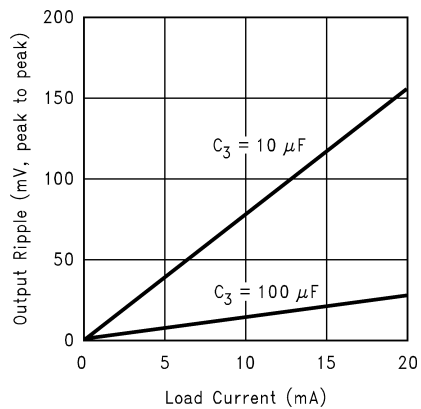
10099708

Output Resistance vs Temperature



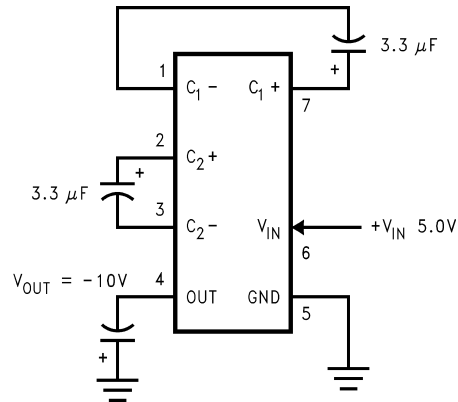
10099709

Output Voltage Ripple vs Load Current



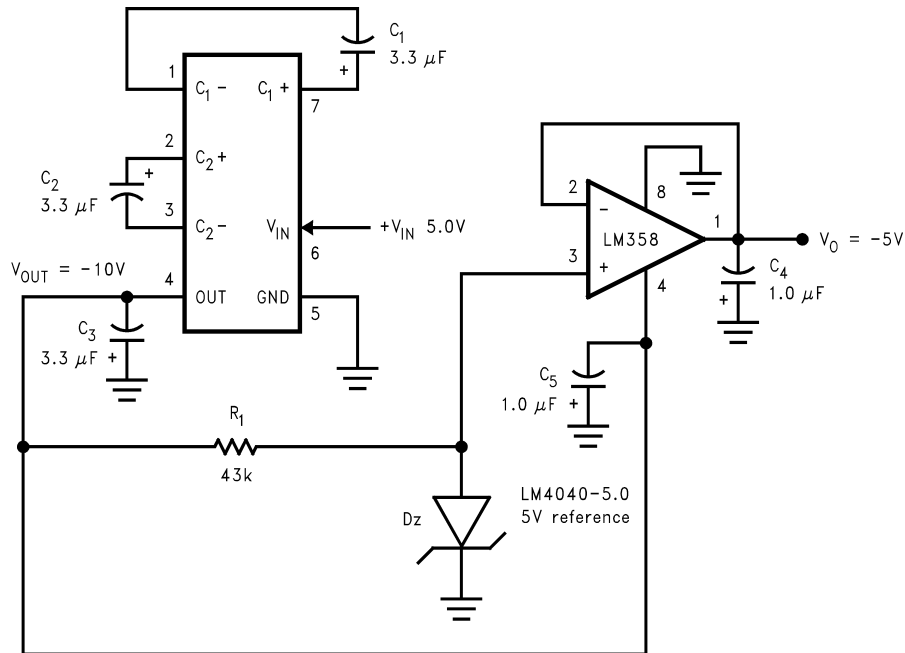
10099710

Basic Application Circuits



10099703

FIGURE 1. Doubling Voltage Inverter



10099704

FIGURE 2. +5V to -5V Regulated Voltage Converter

Application Information

VOLTAGE DOUBLING INVERTER

The main application of the LM2682 is to generate a negative voltage that is twice the positive input voltage. This circuit requires only three external capacitors and is connected as shown in *Figure 1*. It is important to keep in mind that the efficiency of the circuit is determined by the output resistance. A derivation of the output resistance is shown below:

$$R_{OUT} = 2(R_{SW1} + R_{SW2} + ESR_{C1} + R_{SW3} + R_{SW4} + ESR_{C2}) + 2(R_{SW1} + R_{SW2} + ESR_{C1} + R_{SW3} + R_{SW4} + ESR_{C2}) + 1/(f_{OSC} \times C1) + 1/(f_{OSC} \times C2) + ESR_{C3}$$

Using the assumption that all four switches have the same ON resistance our equation becomes:

$$R_{OUT} = 16R_{SW} + 4ESR_{C1} + 4ESR_{C2} + ESR_{C3} + 1/(f_{OSC} \times C1) + 1/(f_{OSC} \times C2)$$

Output resistance is typically 90Ω with an input voltage of +5V, an operating temperature of 25°C, and using low ESR 3.3 μF capacitors. This equation shows the importance of capacitor selection. Large value, low ESR capacitors will reduce the output resistance significantly but will also require a larger overall circuit. Smaller capacitors will take up less space but can lower efficiency greatly if the ESR is large. Also to be considered is that C1 must be rated at 6 VDC or greater while C2 and C3 must be rated at 12 VDC or greater.

Application Information (Continued)

The amount of output voltage ripple is determined by the output capacitor C3 and the output current as shown in this equation:

$$V_{\text{RIPPLE P-P}} = I_{\text{OUT}} \times (2 \times \text{ESR}_{C3} + 1/[2 \times (f_{\text{OSC}} \times C3)])$$

Once again a larger capacitor with smaller ESR will give better results.

+5V TO -5V REGULATED VOLTAGE CONVERTER

Another application in which the LM2682 can be used is for generating a -5V regulated supply from a +5V unregulated supply. This involves using an op-amp and a reference and is connected as shown in *Figure 2*. The LM358 op-amp was chosen for its low cost and versatility and the LM4040-5.0 reference was chosen for its low bias current requirement. Of course other combinations may be used at the designer's discretion to fit accuracy, efficiency, and cost requirements. With this configuration the circuit is well regulated and is still capable of providing nearly 10 mA of output current. With a 9 mA load the circuit can typically maintain 5% regulation on

the output voltage with the input varying anywhere from 4.5V to the maximum of 5.5V. With less load the results are even better. Voltage ripple concerns are reduced in this case since the ripple at the output of the LM2682 is reduced at the output by the PSRR of the op-amp used.

PARALLELING DEVICES

Any number of devices can be paralleled to reduce the output resistance. As shown in *Figure 3*, each device must have its own output pumping capacitors, C1 and C2, but only one shared output capacitor is required. The effective output resistance is the output resistance of one device divided by the number of devices used in parallel. Paralleling devices also gives the capability of increasing the maximum output current. The maximum output current now becomes the maximum output current for one device multiplied by the number of devices used in parallel. For example, if you parallel two devices you can get 20 mA of output current and have half the output resistance of one device supplying 10 mA.

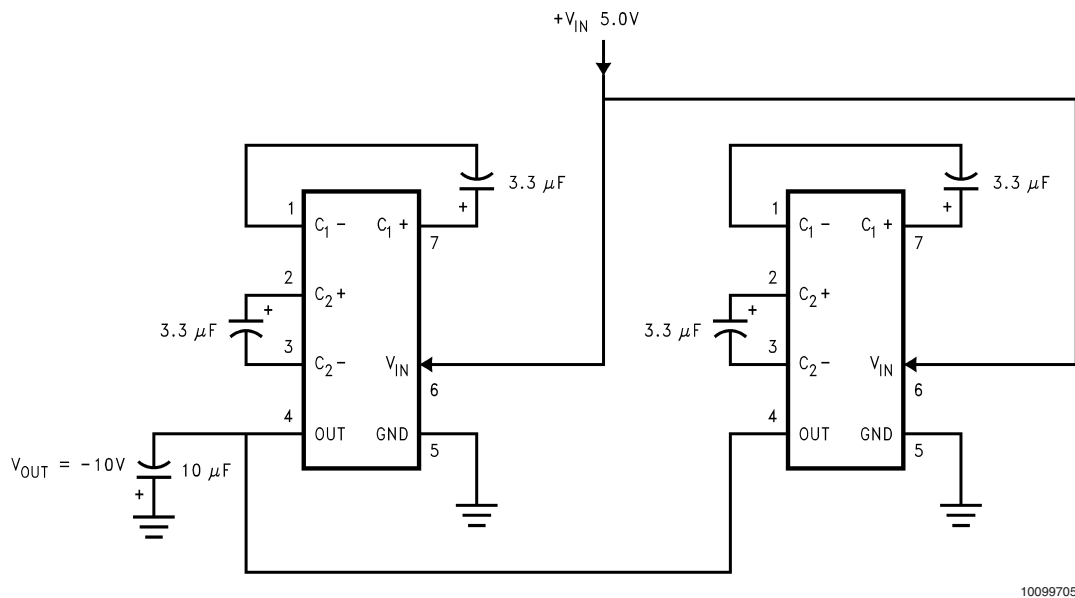
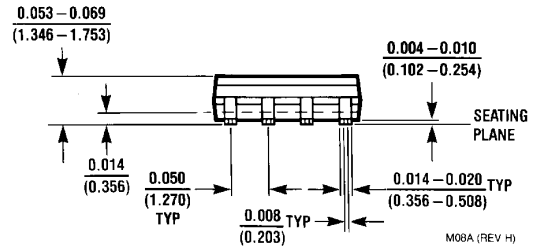
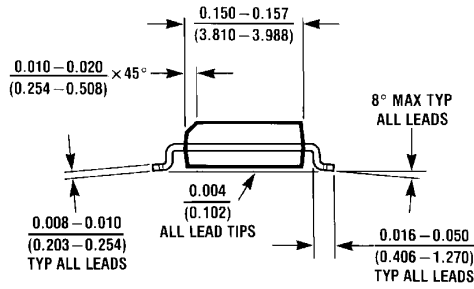
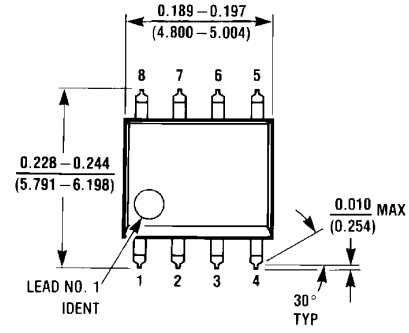
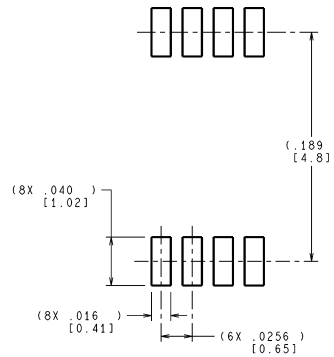
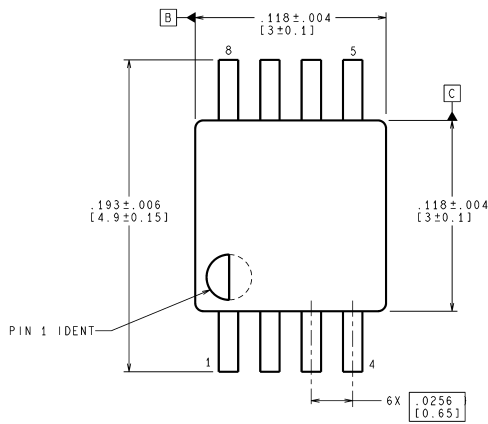


FIGURE 3. Paralleling Devices

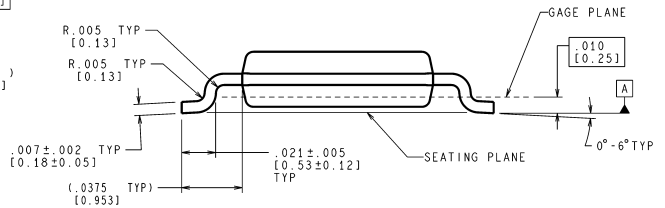
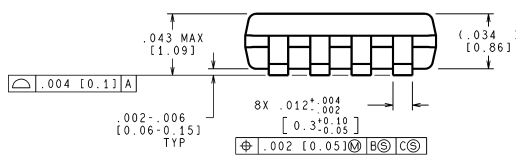
Physical Dimensions inches (millimeters) unless otherwise noted



8 Lead (0.150" Wide) Molded Small Outline Package, JEDEC NS Package Number M08A



LAND PATTERN RECOMMENDATION



CONTROLLING DIMENSION IS INCH
VALUES IN [] ARE MILLIMETERS

MUA08A (Rev E)

Surface Mount Mini SO-8 Package NS Package Number MUA08A

Notes

National does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied and National reserves the right at any time without notice to change said circuitry and specifications.

For the most current product information visit us at www.national.com.

LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

BANNED SUBSTANCE COMPLIANCE

National Semiconductor certifies that the products and packing materials meet the provisions of the Customer Products Stewardship Specification (CSP-9-111C2) and the Banned Substances and Materials of Interest Specification (CSP-9-111S2) and contain no "Banned Substances" as defined in CSP-9-111S2.



National Semiconductor
Americas Customer
Support Center
Email: new.feedback@nsc.com
Tel: 1-800-272-9959

National Semiconductor
Europe Customer Support Center
Fax: +49 (0) 180-530 85 86
Email: europa.support@nsc.com
Deutsch Tel: +49 (0) 69 9508 6208
English Tel: +44 (0) 870 24 0 2171
Français Tel: +33 (0) 1 41 91 8790

National Semiconductor
Asia Pacific Customer
Support Center
Email: ap.support@nsc.com

National Semiconductor
Japan Customer Support Center
Fax: 81-3-5639-7507
Email: jpn.feedback@nsc.com
Tel: 81-3-5639-7560

www.national.com