

## 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  $\mu$ A 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.

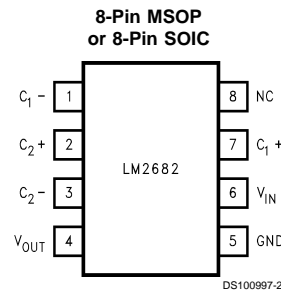
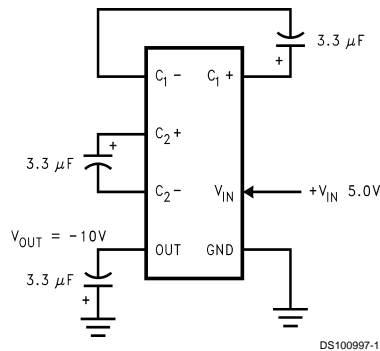
#### Features

- Inverts then doubles input supply voltage
- Small MSOP-8 package (mini SO-8) and SO-8 package
- 90 $\Omega$  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/ $\mu$ 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	$R_L = 2\text{ k}\Omega$	<b>2.0</b>		<b>5.5</b>	V
$I_{IN}$	Supply Current	Open Circuit, No Load		150	300 <b>400</b>	$\mu A$
$R_{OUT}$	$V_{OUT}$ Source Resistance	$I_L = 10\text{ mA}$		90	150 <b>200</b>	$\Omega$
		$I_L = 5\text{ mA}, V_{IN} = 2\text{ V}$		110	<b>250</b>	$\Omega$
$f_{OSC}$	Oscillator Frequency	(Note 5)		12	<b>30</b>	kHz
$f_{SW}$	Switching Frequency	(Note 5)		6	<b>15</b>	kHz
$\eta_{POWER}$	Power Efficiency	$R_L = 2\text{ k}$ (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),  $\theta_{JA}$  (junction to ambient thermal resistance) and  $T_A$  (ambient temperature).  $\theta_{JA}$  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:

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

**Note 3:** The human body model is a 100 pF capacitor discharged through a 1.5 k $\Omega$  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,  $f_{OSC} = 2f_{SW}$ .

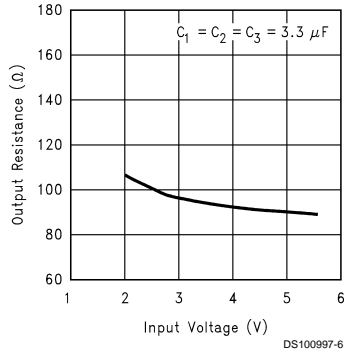
**Note 6:** The minimum specification is guaranteed by design and is not tested.

**Pin Description**

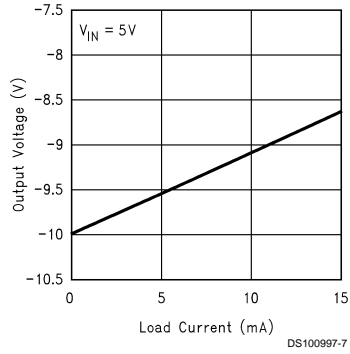
Pin Number	Symbol	Description
1	$C_{1-}$	Capacitor $C_1$ negative terminal
2	$C_{2+}$	Capacitor $C_2$ positive terminal
3	$C_{2-}$	Capacitor $C_2$ negative terminal
4	$V_{OUT}$	Negative output voltage ( $-2V_{IN}$ )
5	GND	Device ground
6	$V_{IN}$	Power supply voltage
7	$C_{1+}$	Capacitor $C_1$ positive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

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

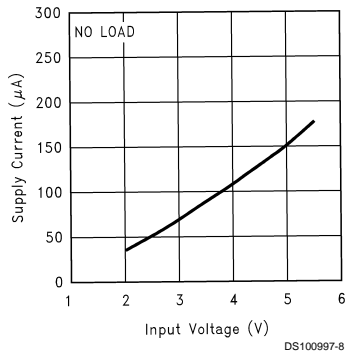
**Output Resistance vs Input Voltage**



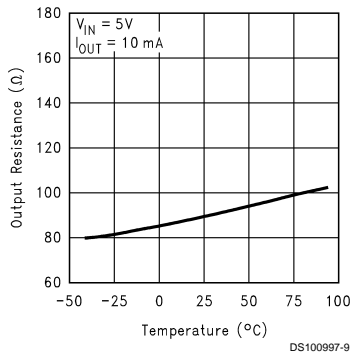
**Output Voltage vs Load Current**



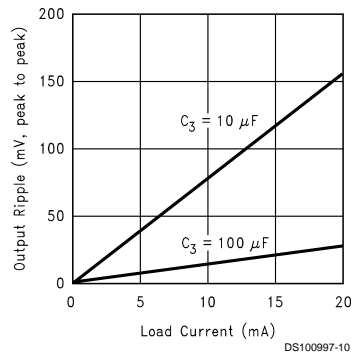
**Supply Current vs Input Voltage**



**Output Resistance vs Temperature**



**Output Voltage Ripple vs Load Current**



## Basic Application Circuits

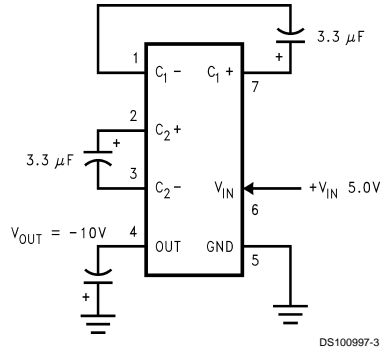


FIGURE 1. Doubling Voltage Inverter

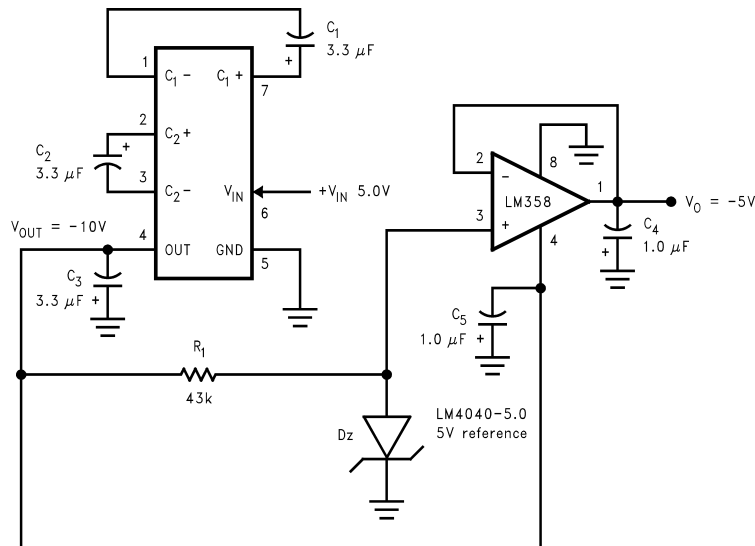


FIGURE 2. +5V to -5V Regulated Voltage Converter

## 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:

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

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

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

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.

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

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

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

## Application Information (Continued)

### +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 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.

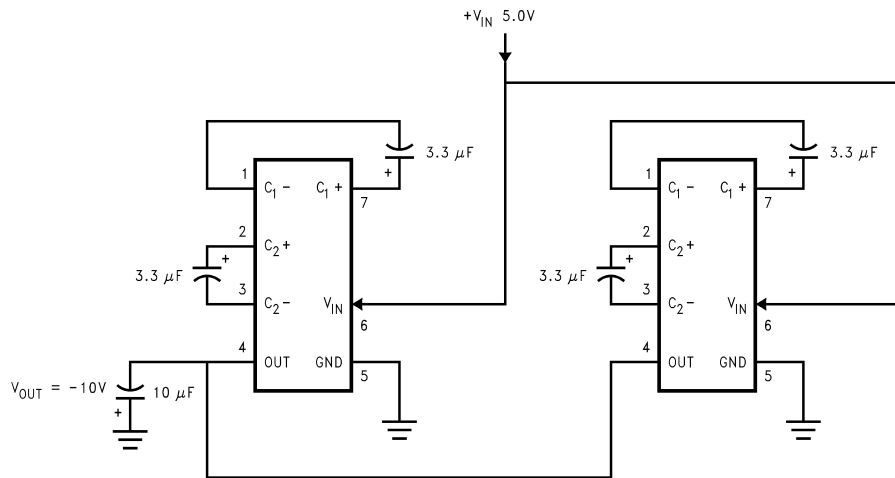
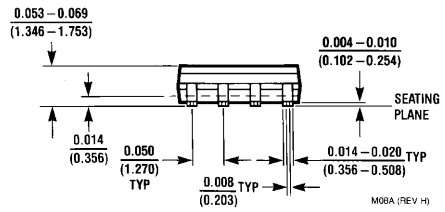
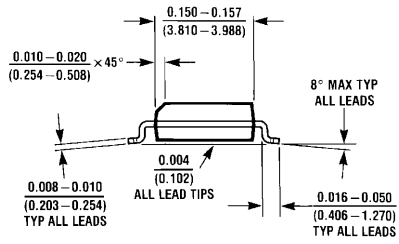
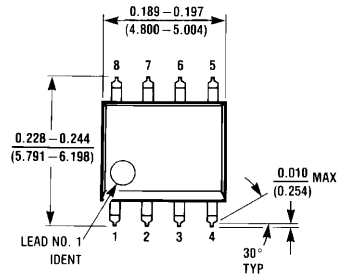


FIGURE 3. Paralleling Devices

DS100997-5

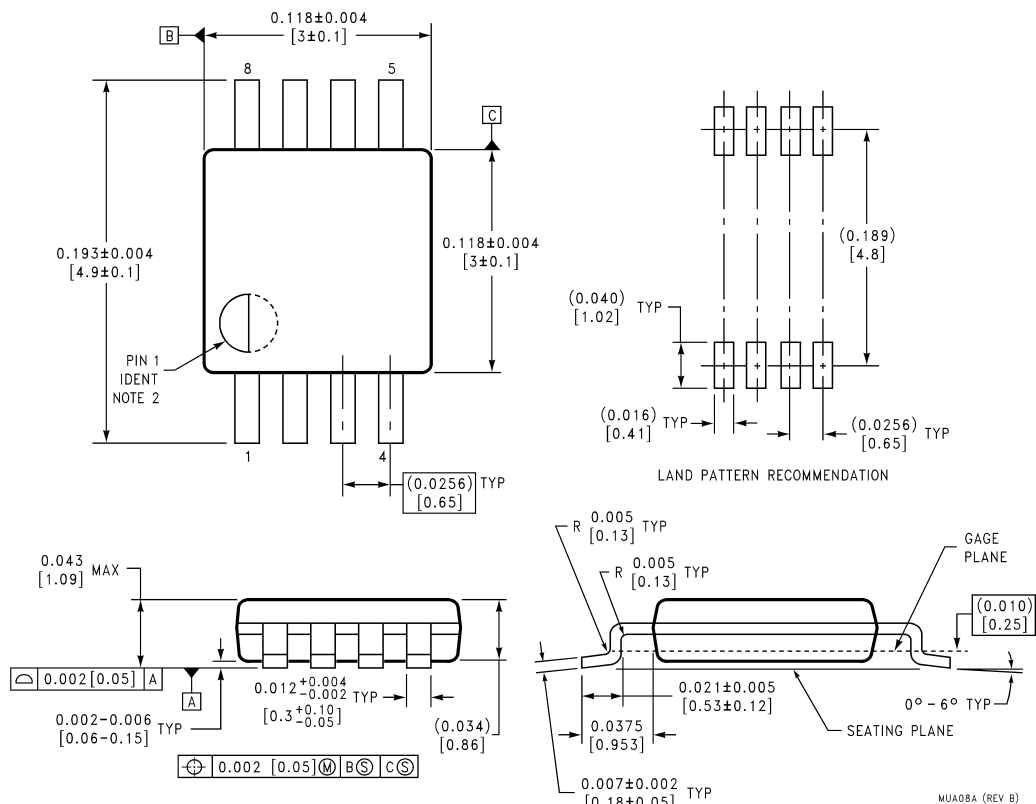
**Physical Dimensions** inches (millimeters) unless otherwise noted



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

M08A (REV. H)

**Physical Dimensions** inches (millimeters) unless otherwise noted (Continued)



**Surface Mount Mini SO-8 Package  
NS Package Number MUA08A**

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