Advanced Monolithic Systems

AMS682

INVERTING VOLTAGE DOUBLER

FEATURES
- **99.9% Voltage Conversion Efficiency**
- **92% Power Conversion Efficiency**
- **Wide Input Voltage Range +2.4V to 5.5V**
- **185µA Supply Current**
- **Available in SO-8 and PDIP Packages**
- **Only 3 external Capacitors Required**

APPLICATIONS
- **Portable Handheld Instrumentation**
- **Cellular Phones**
- **Panel Meters**
- **-10V from +5V logic Supply**
- **-6V from a Single 3V Lithium Cell**
- **LCD Display Bias Generator**
- **Operational Amplifiers Power Supplies**

GENERAL DESCRIPTION

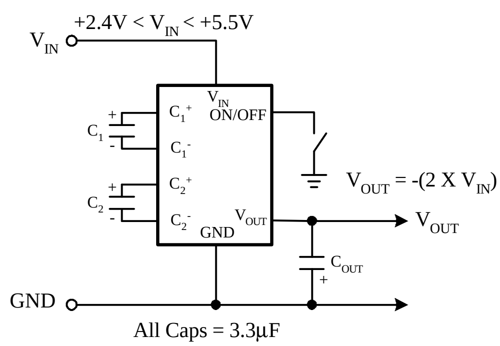
The AMS682 is a CMOS charge pump converter that provides an inverted doubled output from a single positive supply. Requiring only three external capacitors for full circuit implementation the device has an on -board 12kHz (typical) oscillator which provides the clock.
Low output source impedance (typically 140Ω), provides output current up to 10mA. The AMS682 features low quiescent current and high efficiency, making it the ideal choice for a wide variety of applications that require a negative voltage derived from a single positive supply. The compact size and minimum external parts count of the AMS682 makes it useful in many medium current, dual voltage analog power supplies.

The AMS682E is operational in the full industrial temperature range of -40°C to 85°C while AMS682C is operating over a 0°C to 70°C temperature range. The AMS682E/AMS682C are available in surface mount 8-Pin SOIC (SO-8) and 8-Pin Plastic DIP (PDIP) packages.

ORDERING INFORMATION:

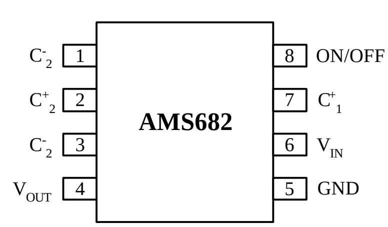
PACKAGE TYPE		OPERATING TEMPERATURE RANGE
8 LEAD SOIC	8 LEAD PDIP	
AMS682ES	AMS682EP	-40 to 85° C
AMS682CS	AMS682CP	0 to 70° C

TYPICAL OPERATING CIRCUIT



PIN CONFIGURATIONS

8-LEAD DIP/ 8-LEAD SOIC



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ABSOLUTE MAXIMUM RATINGS

V_{IN}	+5.8V
V_{IN} $\Delta V/\Delta T$	1V/µsec
V_{OUT}	-11.6V
V_{OUT} Short Circuit Duration	Continuous
Power Dissipation (T_A 70°C)	
Plastic DIP	730mW
SOIC	470mW

Operating Temperature Range	
AMS682E	-40°C to 85°C
AMS682C	0°C to 70°C
Storage temperature	-85°C to +150°C
Soldering information	
Lead Temperature (Soldering 10sec)	+300°C

ELECTRICAL CHARACTERISTICS

Electrical Characteristics at V_{IN} =+5V and T_A = +25°C test circuit figure 1, unless otherwise specified.

Parameter		Conditions	AMS682 Min	Typ	Max	Units
Supply Voltage Range	V_{IN}	R_L=2kΩ	2.4	—	5.5	V
Supply Current	I_{IN}	$R_L = \infty$	—	185	300	µA
		$R_L = \infty$	—	—	**400**	
V_{OUT} Source Resistance	R_{OUT}	I^-_L = 10mA	—	140	180	Ω
Source Resistance		I^-_L =10mA	—	170	**230**	
		I^-_L = 5mA , V_{IN} = 2.8V	—		320	
Oscillator Frequency	F_{OSC}		—	12	—	kHz
Power Efficiency	P_{EFF}	R_L = 2kΩ	90	92	—	%
Voltage Conversion Efficiency	$V_{OUT}E_{FF}$	V_{OUT} $R_L = \infty$	99	99.9	—	%

PIN DESCRIPTION

PIN NO 8-PIN DIP/SOIC	SYMBOL	DESCRIPTION
1	C_1^-	Input. Capacitor C_1 negative terminal.
2	C_2^+	Input. Capacitor C_2 positive terminal.
3	C_2^-	Input. Capacitor C_2 negative terminal
4	V_{OUT}	Output. Negative output voltage (-2V_{IN})
5	GND	Input. Device ground.
6	V_{IN}	Input. Power supply voltage.
7	C_1^+	Input. Capacitor C_1 positive terminal.
8	ON/OFF	ON/OFF Oscilator.

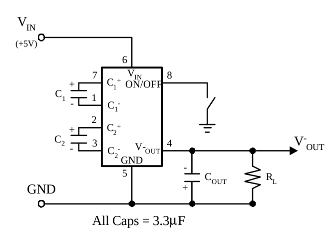


Figure 1. AMS682 Test Circuit

DETAILED DESCRIPTION

Phase 1

V_{SS} charge storage- before this phase of the clock cycle, capacitor C_1 is already charged to +5V. C_1^+ is then switched to ground and the charge in C_1^- is transferred to C_2^-.
Since C_2^+ is at +5V, the voltage potential across capacitor C_2 is now -10V.

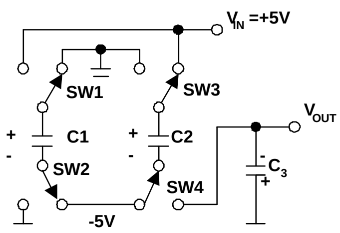


Figure 2. Charge Pump - Phase 1

Phase 2

V_{SS} transfer- phase two of the clock connects the negative terminal of C_2 to the negative side of reservoir capacitor C_3 and the positive terminal of C_2 to the ground, transferring the generated -10V to C_3. Simultaneously, the positive side of capacitor C_1 is switched to +5V and the negative side is connected to ground. C_2 is then switched to V_{CC} and GND and Phase 1 begins again.

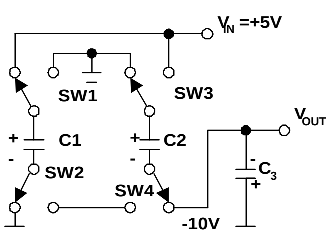


Figure 3. Charge Pump - Phase 2

MAXIMUM OPERATING LIMITS

The AMS682 has on-chip zener diodes that clamp VIN to approximately 5.8V, and V^-_{OUT} to -11.6V. Exceeding the maximum supply voltage will potentially damage the chip. With an input voltage of 2V to 5.5V the AMS682 will operate over the entire operating temperature range.

EFFICIENCY CONSIDERATIONS

Theoretically a charge pump voltage multiplier can approach 100% efficiency under the following conditions:

- The charge pump switches have virtually no offset and are extremely low on resistance.
- Minimal power is consumed by the drive circuitry.
- The Impedances of the reservoir and pump capacitors are negligible.

For the AMS682, efficiency is as shown below:

Voltage Efficiency = $V_{OUT} / (-2V_{IN})$

$V_{OUT} = -2V_{IN} + V_{DROP}$

$V_{DROP} = (I_{OUT})(R_{OUT})$

Power Loss = $I_{OUT} (V_{DROP})$

There will be a substantial voltage difference between V_{OUT} and $2V_{IN}$ if the impedances of the pump capacitors C_1 and C_2 are high with respect to their respective output loads.
If the values of the reservoir capacitor C_3 are larger the output ripple will be reduced. The efficiency will be improved if both pump and reservoir capacitors have larger values. (See "Capacitor Selection" in Application Section.)

APPLICATIONS

Negative Doubling Converter

The AMS682 is most commonly used as a charge pump voltage converter which provides a negative output of two times a positive input voltage (Fig.4)

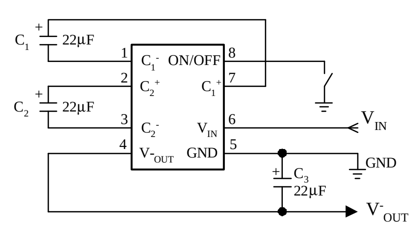


Figure 4. Inverting Voltage Doubler

APPLICATIONS (Continued)

Capacitor Selection

The output resistance of the AMS682 is determined in part by the ESR of the capacitors used. An expression for R_{OUT} is derived as shown below:

$R_{OUT} = 2(R_{SW1}+R_{SW2}+ESR_{C1}+R_{SW3}+R_{SW4}+ESR_{C2})$

$+2(R_{SW1}+R_{SW2}+ESR_{C1}+R_{SW3}+R_{SW4}+ESR_{C2})$

$+1/(f_{PUMP} \times C1) + 1/(f_{PUMP} \times C2) + ESR_{C3}$

Assuming all switch resistances are approximately equal:

$R_{OUT} = 16 R_{SW}+ 4ESR_{C1}+ 4ESR_{C2}+ ESR_{C3}$

$+1/(f_{PUMP} \times C1) + 1/(f_{PUMP} \times C2)$

R_{OUT} is typically 140Ω at +25°C with VIN =+5V and 3.3µF low ESR capacitors. The fixed term (16RSW) is about 80-90Ω. Increasing or decreasing values of C1 and C2 will affect efficiency by changing R_{OUT}.
Table 1 shows R_{OUT} for various values of C1 and C2 (assume 0.5Ω ESR). C1 must be rated at 6VDC or greater while C2 and C3 must be rated at 12VDC or greater.
Output voltage ripple is affected by C3. Typically the larger the value of C3 the less the ripple for a given load current. The formula for p-p V_{RIPPLE} is :

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

For a 10µF (0.5Ω ESR), f_{PUMP} = 10kHz and I_{OUT}=10mA the peak -to-peak ripple voltage at the output will be less than 60mV. In most applications ($I_{OUT} \leq$ 10mA) a 10-20µF capacitor and 1-5µF pump capacitors will be sufficient. Table 2 shows V_{RIPPLE} for different values of C3 (assume 1Ω ESR).

Paralleling devices

Paralleling multiple AMS682 reduces the output resistance of the converter. The effective output resistance is the output resistance of one device divided by the number of devices. Figure 5 illustrates how each device requires separate pump capacitors C_1 and C_2, but all can share a single reservoir capacitor.

-5V Regulated Supply From A Single 3V Battery

Figure 6 shows a -5V power supply using one 3V battery.
The AMS682 provides -6V at V^{-}_{OUT}, which is regulated to -5V by the negative LDO. The AMS682 input can vary from 3V to 5.5V without affecting regulation significantly. A voltage detector is connected to the battery to detect undervoltage. This unit is set to detect at 2.7V. With higher input voltage, more current can be drawn from the outputs of the AMS682.
With 5V at V_{IN} , 10mA can be drawn from the regulated output. Assuming 150Ω source resistance for the converter, with I_L=10mA, the charge pump will drop 1.5V.

Table 1. R_{OUT} vs. C1, C2

C1, C2 (µF)	R_{OUT} (Ω)
0.05	4085
0.10	2084
0.47	510
1.00	285
3.30	145
5.00	125
10.00	105
22.00	94
100.00	87

Table 2. V_{RIPPLE} Peak-to-Peak vs. C3 (I_{OUT} =10mA)

C3(µF)	V_{RIPPLE} (mV)
0.50	1020
1.00	520
3.30	172
5.00	120
10.00	70
22.00	43
100.00	25

APPLICATIONS (Continued)

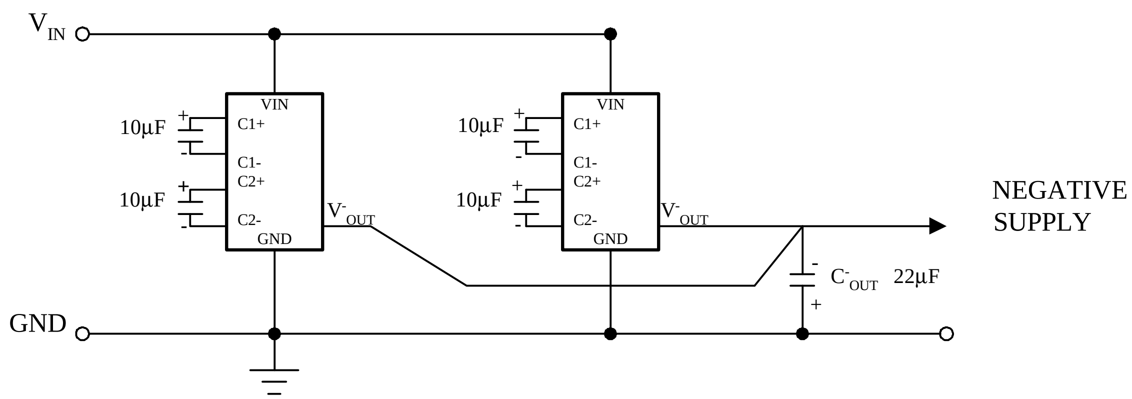


Figure 5. Paralleling AMS682 for Lower Output Source Resistance

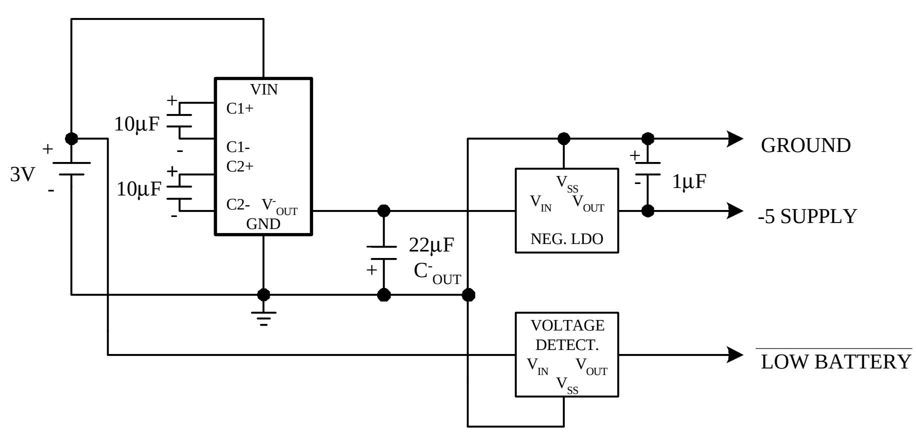
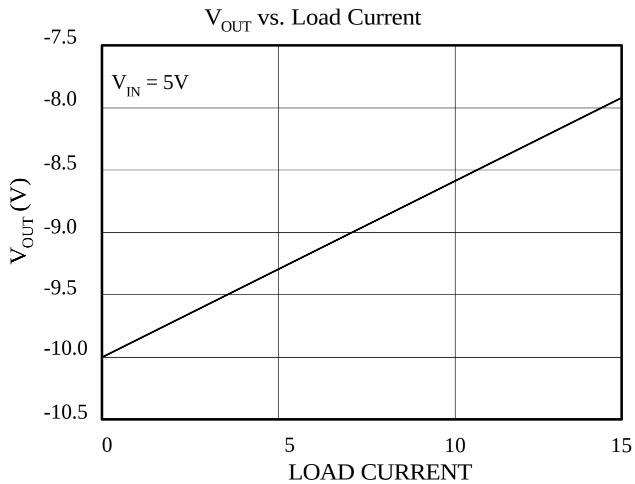
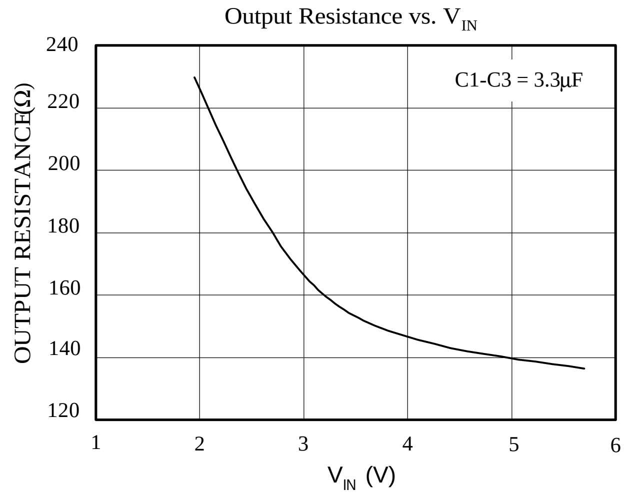
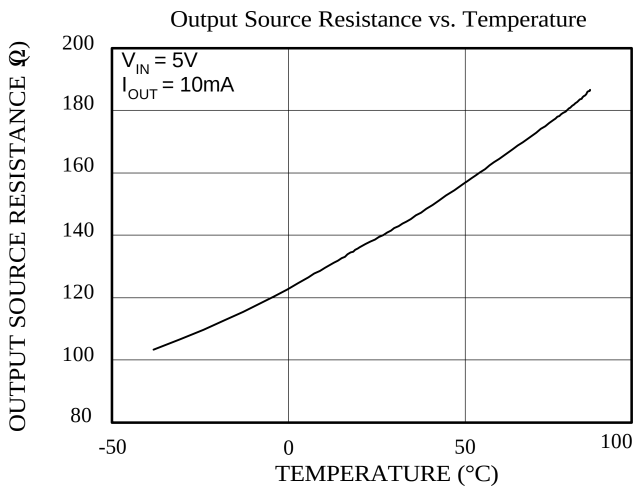


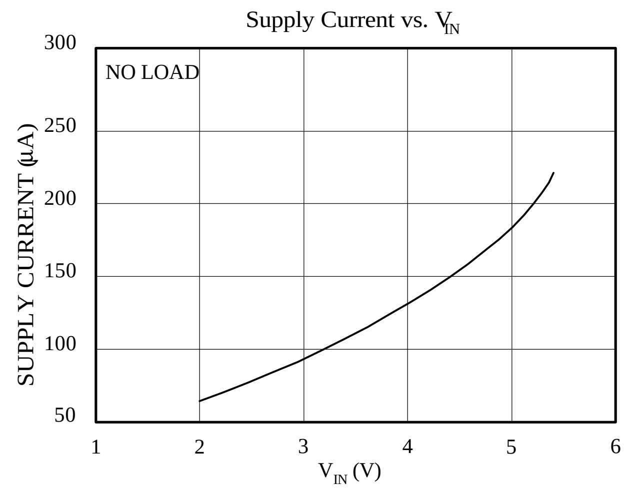
Figure 6. Negative Supply Derived from 3V Battery

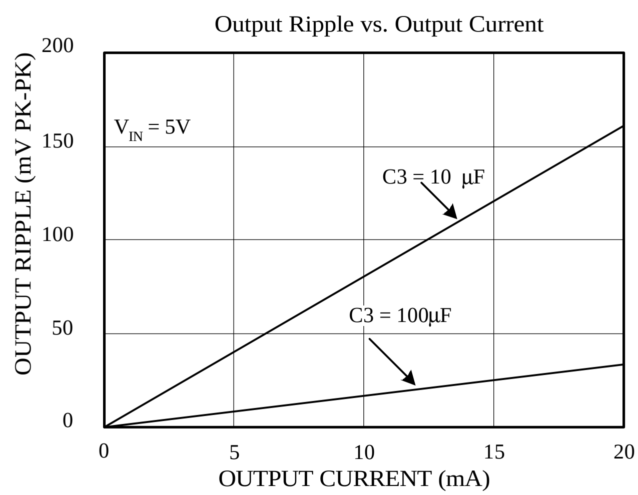
TYPICAL PERFORMANCE CHARACTERISTICS (F_{OSC} = 12kHz)





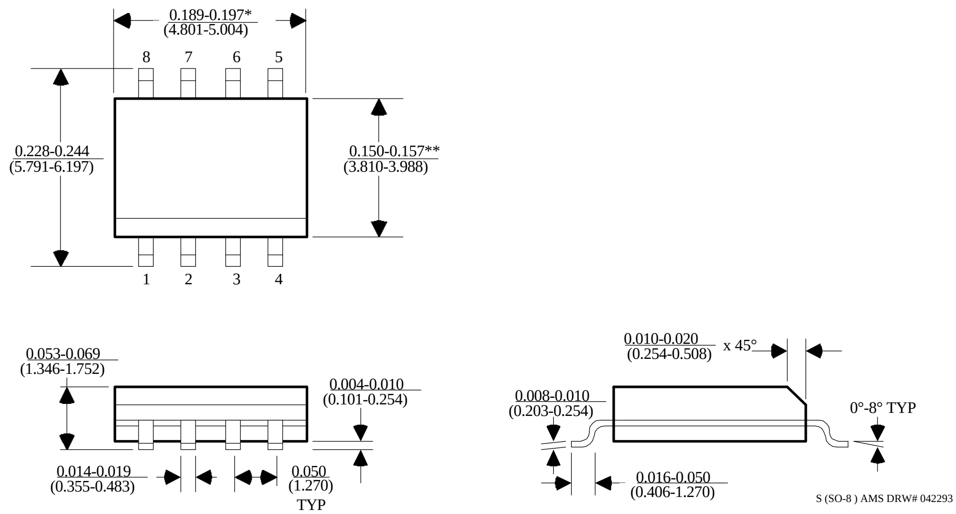






PACKAGE DIMENSIONS inches (millimeters) unless otherwise noted.

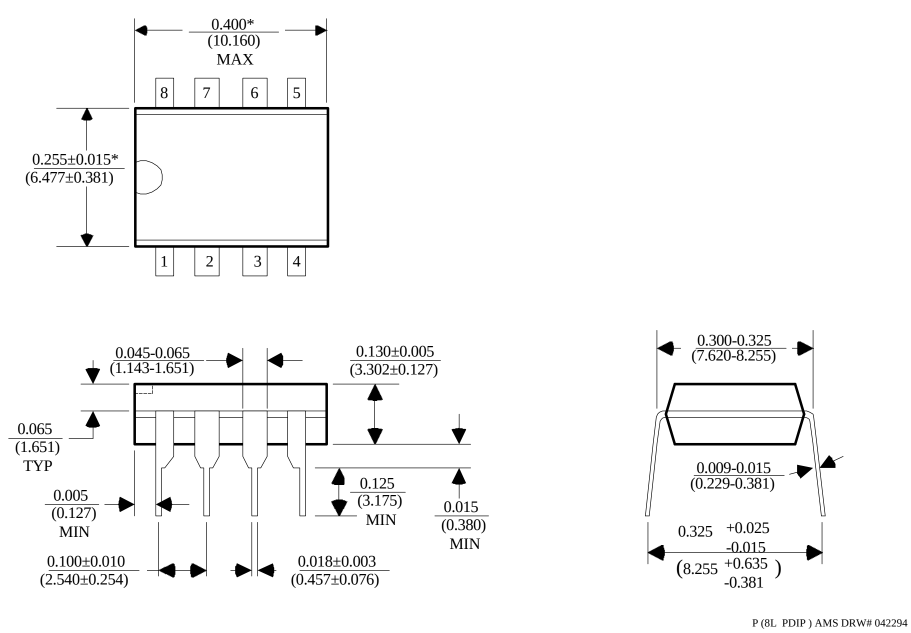
8 LEAD SOIC PLASTIC PACKAGE (S)



*DIMENSION DOES NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.006" (0.152mm) PER SIDE

**DIMENSION DOES NOT INCLUDE INTERLEAD FLASH. INTERLEAD FLASH SHALL NOT EXCEED 0.010" (0.254mm) PER SIDE

8 LEAD PLASTIC DIP PACKAGE (P)



*DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTUSIONS.
MOLD FLASH OR PROTUSIONS SHALL NOT EXCEED 0.010" (0.254mm)