Features:
• 99.9% Voltage Conversion Efficiency
• 92% Power Conversion Efficiency
• Wide Input Voltage Range:
  - +2.4V to +5.5V
• Only 3 External Capacitors Required
• 185 μA Supply Current
• Space-Saving 8-Pin SOIC and 8-Pin PDIP Packages

Applications:
• -10V from +5V Logic Supply
• -6V from a Single 3V Lithium Cell
• Portable Handheld Instruments
• Cellular Phones
• LCD Display Bias Generator
• Panel Meters
• Operational Amplifier Power Supplies

General Description:
The TC682 is a CMOS charge pump converter that provides an inverted doubled output from a single positive supply. An on-board 12 kHz (typical) oscillator provides the clock and only 3 external capacitors are required for full circuit implementation.

Low output source impedance (typically 140Ω), provides output current up to 10 mA. The TC682 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 (for example: generation of -6V from a 3V lithium cell or -10V generated from a +5V logic supply).

The minimum external parts count and small physical size of the TC682 make it useful in many medium-current, dual voltage analog power supplies.

Device Selection Table

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package</th>
<th>Operating Temp. Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC682COA</td>
<td>8-Pin SOIC</td>
<td>0°C to +70°C</td>
</tr>
<tr>
<td>TC682CPA</td>
<td>8-Pin PDIP</td>
<td>0°C to +70°C</td>
</tr>
<tr>
<td>TC682EOA</td>
<td>8-Pin SOIC</td>
<td>-40°C to +85°C</td>
</tr>
<tr>
<td>TC682EPA</td>
<td>8-Pin PDIP</td>
<td>-40°C to +85°C</td>
</tr>
</tbody>
</table>

Functional Block Diagram

Package Type

8-Pin PDIP

8-Pin SOIC
1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings*

\[ V_{IN} \] ................................................................. +5.8V  
\[ V_{IN} \frac{dV}{dT} \] ....................................................... 1V/\mu sec  
\[ V_{OUT} \] ....................................................................... -11.6V  
Short-Circuit Duration - \[ V_{OUT} \] ..................... Continuous  
Power Dissipation (\( T_A \leq 70^\circ C \))  
8-Pin PDIP ....................................................................... 730 mW  
8-Pin SOIC ....................................................................... 470 mW  
Operating Temperature Range......................-40°C to +85°C  
Storage Temperature (Unbiased)..............-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.

TC682 ELECTRICAL SPECIFICATIONS

Electrical Characteristics: Over operating temperature range, \( V_{IN} = +5V \), test circuit Figure 3-1 unless otherwise noted.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
<th>Test Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_{IN} )</td>
<td>Supply Voltage Range</td>
<td>2.4</td>
<td></td>
<td>5.5</td>
<td>V</td>
<td>( R_L = 2 , k\Omega )</td>
</tr>
<tr>
<td>( I_{IN} )</td>
<td>Supply Current</td>
<td></td>
<td></td>
<td>185</td>
<td>300</td>
<td>400</td>
</tr>
<tr>
<td>( R_{OUT} )</td>
<td>( V_{OUT} ) Source Resistance</td>
<td></td>
<td></td>
<td>140</td>
<td>180</td>
<td></td>
</tr>
<tr>
<td>( F_{OSC} )</td>
<td>Oscillator Frequency</td>
<td></td>
<td>12</td>
<td></td>
<td></td>
<td>kHz</td>
</tr>
<tr>
<td>( P_{EFF} )</td>
<td>Power Efficiency</td>
<td>90</td>
<td>92</td>
<td></td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>( V_{OUT, EFF} )</td>
<td>Voltage Conversion Efficiency</td>
<td>99</td>
<td>99.9</td>
<td></td>
<td></td>
<td>%</td>
</tr>
</tbody>
</table>
### 2.0 PIN DESCRIPTION

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

**TABLE 2-1: PIN FUNCTION TABLE**

<table>
<thead>
<tr>
<th>Pin No. (8-Pin PDIP, SOIC)</th>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>C1−</td>
<td>Input. Capacitor C1 negative terminal.</td>
</tr>
<tr>
<td>2</td>
<td>C2+</td>
<td>Input. Capacitor C2 positive terminal.</td>
</tr>
<tr>
<td>3</td>
<td>C2−</td>
<td>Input. Capacitor C2 negative terminal.</td>
</tr>
<tr>
<td>4</td>
<td>VOUT</td>
<td>Output. Negative output voltage (-2V\textsubscript{IN}).</td>
</tr>
<tr>
<td>5</td>
<td>GND</td>
<td>Input. Ground.</td>
</tr>
<tr>
<td>6</td>
<td>V\textsubscript{IN}</td>
<td>Input. Power supply voltage.</td>
</tr>
<tr>
<td>7</td>
<td>C1+</td>
<td>Input. Capacitor C1 positive terminal.</td>
</tr>
<tr>
<td>8</td>
<td>NC</td>
<td>No connection.</td>
</tr>
</tbody>
</table>
3.0 DETAILED DESCRIPTION

3.1 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.

3.2 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 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.

3.3 Maximum Operating Limits

The TC682 has on-chip Zener diodes that clamp V_{IN} to approximately 5.8V, and V_{OUT} to -11.6V. Never exceed the maximum supply voltage or excessive current will be shunted by these diodes, potentially damaging the chip. The TC682 will operate over the entire operating temperature range with an input voltage of 2V to 5.5V.

3.4 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 TC682, efficiency is as shown below:

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

\[ V_{DROP} = (I_{OUT}) (R_{OUT}) \]

\[ \text{Power Loss} = I_{OUT} (V_{DROP}) \]

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.

Larger values of reservoir capacitor C_3 will reduce output ripple. Larger values of both pump and reservoir capacitors improve the efficiency. See Section 4.2 “Capacitor Selection” “Capacitor Selection”.
4.0  TYPICAL APPLICATIONS

4.1  Negative Doubling Converter

The most common application of the TC682 is as a charge pump voltage converter which provides a negative output of two times a positive input voltage (Figure 4-1).

\[ R_{OUT} = 2(R_{SW1} + R_{SW2} + E_{SR}C_1 + R_{SW3} + R_{SW4} + E_{SR}C_2) + 2(R_{SW1} + R_{SW2} + E_{SR}C_1 + R_{SW3} + R_{SW4} + E_{SR}C_2) + \frac{1}{(f_{PUMP} \times C_1)} + \frac{1}{(f_{PUMP} \times C_2)} + E_{SR}C_3 \]

Assuming all switch resistances are approximately equal:

\[ R_{OUT} = 16R_{SW} + 4E_{SR}C_1 + 4E_{SR}C_2 + E_{SR}C_3 + \frac{1}{(f_{PUMP} \times C_1)} + \frac{1}{(f_{PUMP} \times C_2)} \]

\[ R_{OUT} \text{ is typically } 140\Omega \text{ at } +25^\circ \text{C with } V_{IN} = +5V \text{ and } 3.3 \mu F \text{ low ESR capacitors. The fixed term (16R_{SW}) is about 80-90}\Omega \text{. It can be seen easily that increasing or decreasing values of C1 and C2 will affect efficiency by changing } R_{OUT}. \text{ However, be careful about ESR. This term can quickly become dominant with large electrolytic capacitors. Table 4-1 shows } R_{OUT} \text{ for various values of C1 and C2 (assume } 0.5\Omega \text{ ESR). C1 must be rated at 6VDC or greater while C2 and C3 must be rated at 12VDC or greater.} \]

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 \[ V_{RIPPLE} \] is given below:

\[ V_{RIPPLE} = \frac{1}{2(f_{PUMP} \times C_3)} + 2(E_{SR}C_3)(I_{OUT}) \]

For a 10 \mu F (0.5\Omega ESR) capacitor for C3, \[ f_{PUMP} = 10 \text{ kHz and } I_{OUT} = 10 \text{ mA the peak-to-peak ripple voltage at the output will be less than 60 mV. In most applications } I_{OUT} < = 10 \text{ mA a 10-20} \mu \text{F capacitor and 1-5} \mu \text{F pump capacitors will suffice. Table 4-2 shows } V_{RIPPLE} \text{ for different values of C3 (assume } 1\Omega \text{ ESR).} \]

### TABLE 4-1: OUTPUT RESISTANCE VS. C1, C2

<table>
<thead>
<tr>
<th>C1, C2 (\mu F)</th>
<th>R_{OUT}(\Omega)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05</td>
<td>4085</td>
</tr>
<tr>
<td>0.10</td>
<td>2084</td>
</tr>
<tr>
<td>0.47</td>
<td>510</td>
</tr>
<tr>
<td>1.00</td>
<td>285</td>
</tr>
<tr>
<td>3.30</td>
<td>145</td>
</tr>
<tr>
<td>5.00</td>
<td>125</td>
</tr>
<tr>
<td>10.00</td>
<td>105</td>
</tr>
<tr>
<td>22.00</td>
<td>94</td>
</tr>
<tr>
<td>100.00</td>
<td>87</td>
</tr>
</tbody>
</table>

### TABLE 4-2: V_{RIPPLE} PEAK-TO-PEAK VS. C3 (I_{OUT} 10mA)

<table>
<thead>
<tr>
<th>C3 (\mu F)</th>
<th>V_{RIPPLE} (mV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.50</td>
<td>1020</td>
</tr>
<tr>
<td>1.00</td>
<td>520</td>
</tr>
<tr>
<td>3.30</td>
<td>172</td>
</tr>
<tr>
<td>5.00</td>
<td>120</td>
</tr>
<tr>
<td>10.00</td>
<td>70</td>
</tr>
<tr>
<td>22.00</td>
<td>43</td>
</tr>
<tr>
<td>100.00</td>
<td>25</td>
</tr>
</tbody>
</table>
4.3 Paralleling Devices

Paralleling multiple TC682s reduces the output resistance of the converter. The effective output resistance is the output resistance of a single device divided by the number of devices. As illustrated in Figure 4-2, each requires separate pump capacitors C1 and C2, but all can share a single reservoir capacitor.

4.4 -5V Regulated Supply From A Single 3V Battery

Figure 4-3 shows a -5V power supply using one 3V battery. The TC682 provides -6V at VOUT, which is regulated to -5V by the negative LDO. The input to the TC682 can vary from 3V to 5.5V without affecting regulation appreciably. A TC54 device 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 TC682. With 5V at VIN, 10 mA can be drawn from the regulated output. Assuming 150Ω source resistance for the converter, with IL = 10 mA, the charge pump will droop 1.5V.

**FIGURE 4-2:** Paralleling TC682 for Lower Output Source Resistance

**FIGURE 4-3:** Negative Supply Derived from 3V Battery
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, $C_1 = C_2 = C_{OUT} = 3.3 \mu F$, $T_A = 25^\circ C$ unless otherwise noted.
6.0 PACKAGING INFORMATION

6.1 Package Marking Information
Package marking data not available at this time.

6.2 Taping Form

Component Taping Orientation for 8-Pin SOIC (Narrow) Devices

<table>
<thead>
<tr>
<th>Package</th>
<th>Carrier Width (W)</th>
<th>Pitch (P)</th>
<th>Part Per Full Reel</th>
<th>Reel Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-Pin SOIC (N)</td>
<td>12 mm</td>
<td>8 mm</td>
<td>2500</td>
<td>13 in</td>
</tr>
</tbody>
</table>
6.3 Package Dimensions

**Note:** For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging

**8-Pin Plastic DIP**

![8-Pin Plastic DIP Diagram]

**8-Pin SOIC**

![8-Pin SOIC Diagram]

**Note:** For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging
7.0 REVISION HISTORY

Revision D
Added a note to each package outline drawing.
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