Introduction
The LTC6900 is a precision low power oscillator that is extremely easy to use and occupies very little PC board space. It is a lower power version of the LTC1799, which was featured in the February 2001 issue of this magazine.

The output frequency, \( f_{OSC} \), of the LTC6900 can range from 1kHz to 20MHz—programmed via an external resistor, \( R_{SET} \), and a 3-state frequency divider pin, as shown in Figure 1.

\[
R_k \text{ MHz} = \left\lfloor \frac{10\text{MHz}}{N \cdot f_{OSC}} \right\rfloor, N = \left\{ \frac{100}{10}, 1 \right\}
\] (1)

A proprietary feedback loop linearizes the relationship between \( R_{SET} \) and the output frequency so the frequency accuracy is already included in the expression above. Unlike other discrete RC oscillators, the LTC6900 does not need correction tables to adjust the formula for determining the output frequency.

Figure 2 shows a simplified block diagram of the LTC6900. The LTC6900 master oscillator is controlled by the ratio of the voltage between \( V^+ \) and the \( V_{SET} \) pin and the current, \( I_{RES} \), entering the \( V_{SET} \) pin. As long as \( I_{RES} \) is precisely the current through resistor \( R_{SET} \), the ratio of \( (V^+ - V_{SET}) / I_{RES} \) equals \( R_{SET} \) and the frequency of the LTC6900 depends solely on the value of \( R_{SET} \). This technique ensures accuracy, typically \( \pm 0.5\% \) at ambient temperature.

As shown in Figure 2, the voltage of the \( V_{SET} \) pin is controlled by an internal bias, and by the gate to source voltage of a PMOS transistor. The voltage of the \( V_{SET} \) pin \( (V_{SET}) \) is typically 1.1V below \( V^+ \).

Programming the Output Frequency
The output frequency of the LTC6900 can be programmed by altering the value of \( R_{SET} \) as shown in Figure 1 and the accuracy of the oscillator will not be affected. The frequency can also be programmed by steering current in or out of the \( V_{SET} \) pin, as conceptually shown in Figure 3. This technique can degrade accuracy as the ratio \( (V^+ - V_{SET}) / I_{RES} \) is no longer uniquely dependent on the value of \( R_{SET} \) as shown in Figure 2. This loss of accuracy will become noticeable when the magnitude of \( I_{PROG} \) is comparable to \( I_{RES} \). The frequency variation of the LTC6900 is still monotonic.

Figure 4 shows how to implement the concept shown in Figure 3 by connecting a second resistor, \( R_{IN} \), between the \( V_{SET} \) pin and a ground referenced voltage source \( V_{IN} \).

For a given power supply voltage in Figure 4, the output frequency of the LTC6900 is a function of \( V_{IN} \), \( R_{IN} \), \( R_{SET} \), and \( (V^+ - V_{SET}) = V_{RES} \):

\[
f_{OSC} = \frac{10\text{MHz}}{N} \cdot \frac{20k}{R_{IN} \parallel R_{SET}} \cdot \left[ 1 + \frac{(V_{IN} - V^+)}{V_{RES}} \cdot \frac{1}{1 + \frac{R_{IN}}{R_{SET}}} \right]
\]

When \( V_{IN} = V^+ \) the output frequency of the LTC6900 assumes the highest value and it is set by the parallel combination of \( R_{IN} \) and \( R_{SET} \). Also note, the output frequency, \( f_{OSC} \), is independent of the value of \( V_{RES} = (V^+ - V_{SET}) \) so, the accuracy of \( f_{OSC} \) is within the datasheet limits.
When $V_{\text{IN}}$ is less than $V^+$, and especially when $V_{\text{IN}}$ approaches the ground potential, the oscillator frequency, $f_{\text{OSC}}$, assumes its lowest value and its accuracy is affected by the change of $V_{\text{RES}} = (V^+ - V_{\text{SET}})$. At 25°C $V_{\text{RES}}$ varies by ±8%, assuming the variation of $V^+$ is ±5%. The temperature coefficient of $V_{\text{RES}}$ is 0.02%/°C.

By manipulating the algebraic relation for $f_{\text{OSC}}$ above, a simple algorithm can be derived to set the values of external resistors $R_{\text{SET}}$ and $R_{\text{IN}}$, as shown in Figure 4:

1. Choose the desired value of the maximum oscillator frequency, $f_{\text{OSC(MAX)}}$, occurring at maximum input voltage $V_{\text{IN(MAX)}} \leq V^+$.

2. Set the desired value of the minimum oscillator frequency, $f_{\text{OSC(MIN)}}$, occurring at minimum input voltage $V_{\text{IN(MIN)}} \geq 0$.

3. Choose $V_{\text{RES}} = 1.1$ and calculate the ratio of $R_{\text{IN}}/R_{\text{SET}}$ from the following:

$$R_{\text{IN}} = \frac{R_{\text{IN}}}{R_{\text{SET}}} = \frac{(V_{\text{IN(MAX)}} - V^+ - f_{\text{OSC(MAX)}} + f_{\text{OSC(MIN)}})}{V_{\text{RES}} + f_{\text{OSC(MAX)}} - f_{\text{OSC(MIN)}}}$$

Once $R_{\text{IN}}/R_{\text{SET}}$ is known, calculate $R_{\text{SET}}$ from:

$$R_{\text{SET}} = \frac{100M}{N} - \frac{20k}{f_{\text{OSC(MAX)}}}$$

Example 1: In this example, the oscillator output frequency has small excursions. This is useful where the frequency of a system should be tuned around some nominal value.

Let $V^+ = 3V$, $f_{\text{OSC(MAX)}} = 2MHz$ for $V_{\text{IN(MAX)}} = 3V$ and $f_{\text{OSC(MIN)}} = 1.5MHz$ for $V_{\text{IN}} = 0V$. Solve for $R_{\text{IN}}/R_{\text{SET}}$ by equation (3), yielding $R_{\text{IN}}/R_{\text{SET}} = 9.9/1$. $R_{\text{SET}} = 110.1k\Omega$ by equation (4). $R_{\text{IN}} = 9.9R_{\text{SET}} = 1.089M\Omega$. For standard resistor values, use $R_{\text{SET}} = 110k\Omega$ (1%) and $R_{\text{IN}} = 1.1M\Omega$ (1%)

Table 1: Variation of $V_{\text{RES}}$ for various values of $R_{\text{IN}}/R_{\text{SET}}$

<table>
<thead>
<tr>
<th>$R_{\text{IN}}$</th>
<th>$R_{\text{SET}}$ ($V_{\text{IN}} = V^+$)</th>
<th>$V_{\text{RES}}$, $V^+ = 3V$</th>
<th>$V_{\text{RES}}$, $V^+ = 5V$</th>
</tr>
</thead>
<tbody>
<tr>
<td>20k</td>
<td>0.98V</td>
<td>1.03V</td>
<td>1.08V</td>
</tr>
<tr>
<td>40k</td>
<td>1.03V</td>
<td>1.08V</td>
<td>1.12V</td>
</tr>
<tr>
<td>80k</td>
<td>1.07V</td>
<td>1.12V</td>
<td>1.15V</td>
</tr>
<tr>
<td>160k</td>
<td>1.1V</td>
<td>1.15V</td>
<td>1.17V</td>
</tr>
<tr>
<td>320k</td>
<td>1.12V</td>
<td>1.17V</td>
<td>N/A</td>
</tr>
</tbody>
</table>

$V_{\text{RES}} =$ Voltage across $R_{\text{SET}}$