ABSTRACT

This application report describes an alternative use of the TLC555-Q1 device as a charge pump. The square-wave output switching between the supply voltage and GND with few additional capacitors and diodes makes the device suitable for generating a positive or negative voltage multiplier. Using the TLC555-Q1 device as a charge pump is a cheap and easy solution for doubling, tripling, or inverting the supply voltage.

A charge pump can be used in automotive applications requiring reverse battery protection. A diode can also be used for battery protection; however, it causes a voltage drop and lowers efficiency. The charge pump is also capable of driving a MOSFET transistor with low drain-to-source on resistance.

Charge pumps can be used in a nonsynchronous rectifier when in low dropout mode to cause a high output ripple with light load. The charge-pump output can be connected to the BOOT pin for providing the necessary voltage to drive the upper-pass transistor.

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1 Block Diagram Description

This device uses two window comparators, an RS flip-flop, an open-drain MOSFET, and a totem-pole output stage. The device also has a RESET pin for enabling and disabling the output. The supply voltage range of 2 V to 15 V enables the devices to work in an automotive environment with a fully-charged 12-V battery and during cold cranking.

2 Setup for Positive Charge Pump

The TLC555-Q1 device is configured as typical timer. The switching frequency and duty cycle is determined by the timing components R1, R2, and C5. The two diodes (D1, D2) and two ceramic capacitors (C3, C4) generate the positive charge pump $2V_{CC} - 2V_{f}$. The D2 anode connected to $V_{CC}$ makes the charge pump voltage at $V_{CC} - 2V_{f}$ when the TLC555-Q1 device is disabled. The charge pump can be at 0 V if the TLC555-Q1 device is disabled by connecting the D2 anode to the OUT pin (pin 3).
2.1 Power Up and Power Down

The device RESET pin can be used to enable and disable the charge pump according to Table 1.

<table>
<thead>
<tr>
<th>RESET</th>
<th>OUT pin 3</th>
<th>Charge Pump</th>
<th>Doubler Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Switching</td>
<td>ON</td>
<td>$2V_{CC} - 2V_i$</td>
</tr>
<tr>
<td>Low</td>
<td>Low</td>
<td>OFF</td>
<td>$V_{CC} - 2V_i$</td>
</tr>
</tbody>
</table>

Figure 3 shows the power up timing by switching the RESET pin from low to high. Figure 4 shows the power down timing by switching the RESET pin from high to low.

2.2 Characterization

The characterization of the doubler charge-pump circuit is at $V_{CC} = 12$ V. The output is $2V_{CC} - 2V_i$, where $V_i$ is the drop across a diode. Figure 5 shows the doubler charge pump versus the load current.

![Figure 5. Charge-Pump Output Voltage versus Load Current](image-url)
3 Setup for Negative Charge Pump

The TLC555-Q1 device is configured as typical timer. The switching frequency and duty cycle is determined by the timing components R1, R2 and C5. The 2 diodes (D1, D2) and 2 ceramic capacitors (C3, C4) generate the negative charge-pump inverter. The charge pump is at 0 V when the TLC555-Q1 device is disabled.

![Negative Charge Pump Circuit](image)

Figure 6. Negative Charge Pump Circuit

3.1 Power Up and Power Down

The device RESET pin can be used to enable and disable the charge pump according to Table 2.

<table>
<thead>
<tr>
<th>RESET</th>
<th>OUT pin 3</th>
<th>Charge pump</th>
<th>Inverting level</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Switching</td>
<td>ON</td>
<td>$-V_{CC} + 2V_{T}$</td>
</tr>
<tr>
<td>Low</td>
<td>Low</td>
<td>OFF</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 2. Operation of Negative Charge Pump
Figure 7 shows the power up timing by switching the RESET pin from low to high. Figure 8 shows the power down timing by switching the RESET pin from high to low.

3.2 Characterization

The characterization of the doubler charge-pump circuit is at \( V_{CC} = 12 \) V. The output is \( -2V_{CC} + 2V_i \), where \( V_i \) is the drop across a diode. Figure 9 shows the negative doubler charge pump versus the load current.

4 Summary

The TLC555-Q1 device can be configured in multiple charge-pump configurations with few external components. The device can be used as a cost-saving measure in many applications.
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