Application Report
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TLC555-Q1 Used as a Positive and Negative Charge Pump

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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.

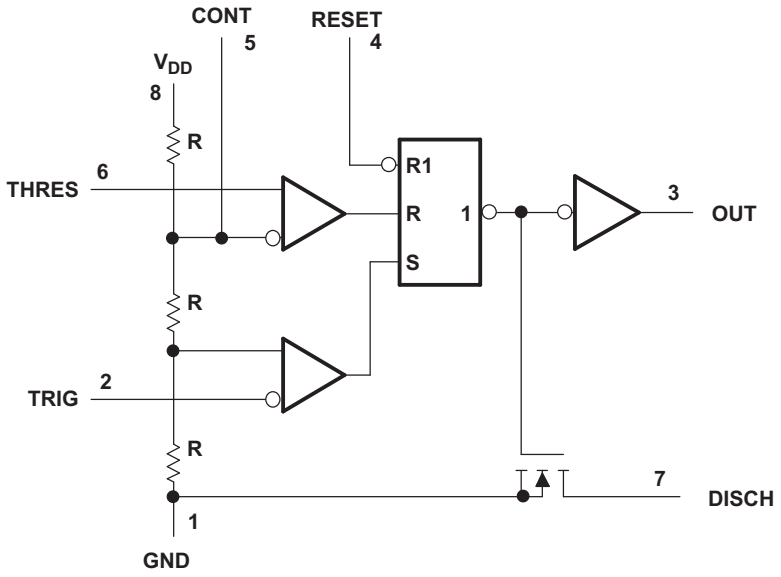

Figure 1. Functional Block Diagram

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).

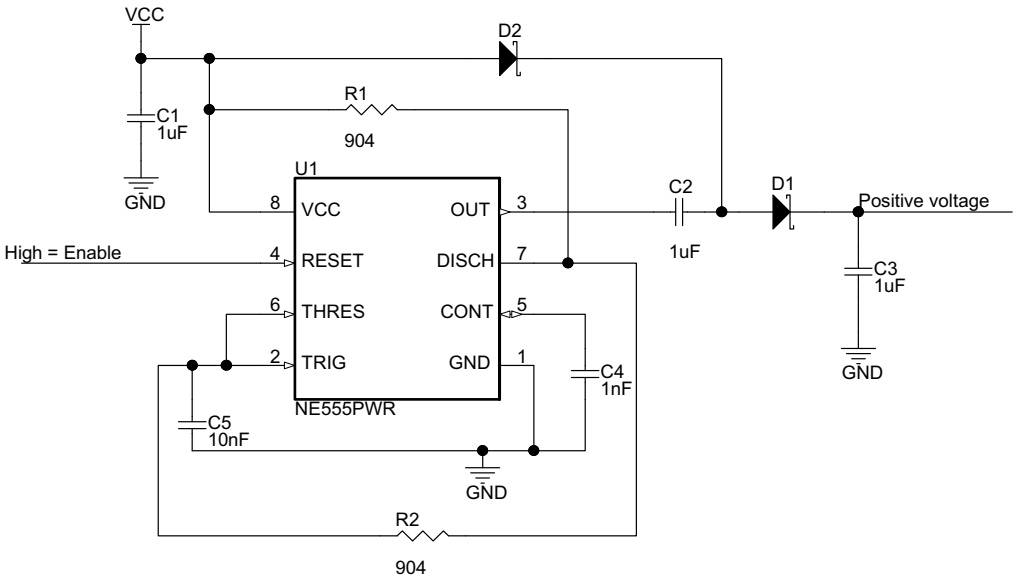

Figure 2. Positive Charge-Pump Circuit

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 1. Operation of Positive Charge Pump

RESET	OUT pin 3	Charge Pump	Doubler Level
High	Switching	ON	$2V_{CC} – 2V_f$
Low	Low	OFF	$V_{CC} – 2V_f$

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.

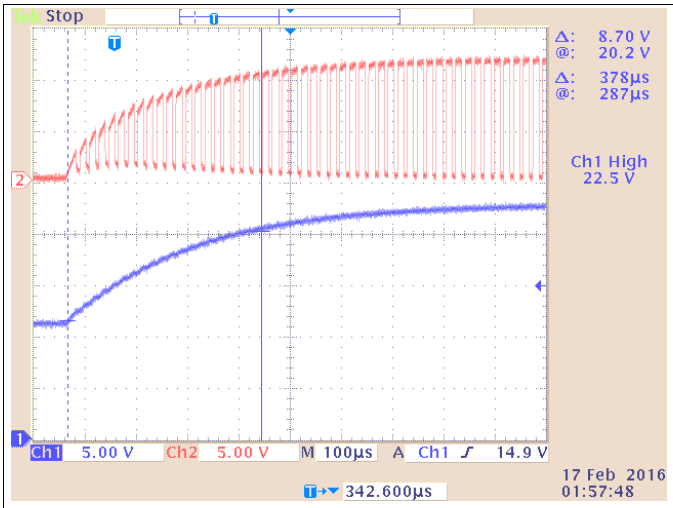

Figure 3. Power-Up Timing—RESET Switching from Low to High

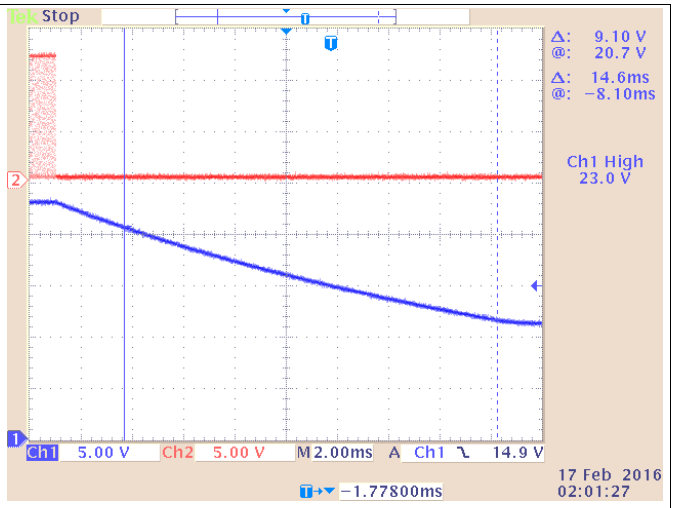

Figure 4. Power-Down Timing—RESET Switching from High to Low

2.2 Characterization

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

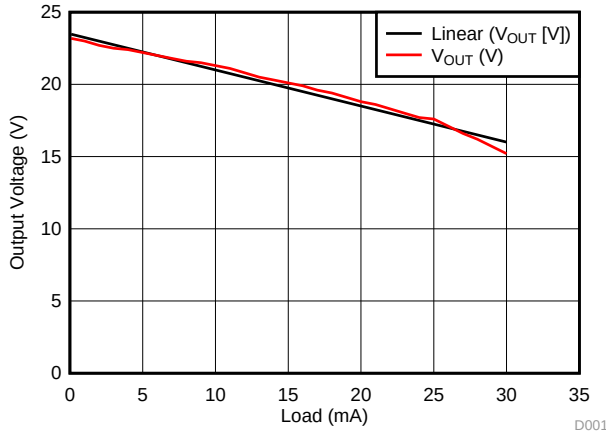

Figure 5. Charge-Pump Output Voltage versus Load Current

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.

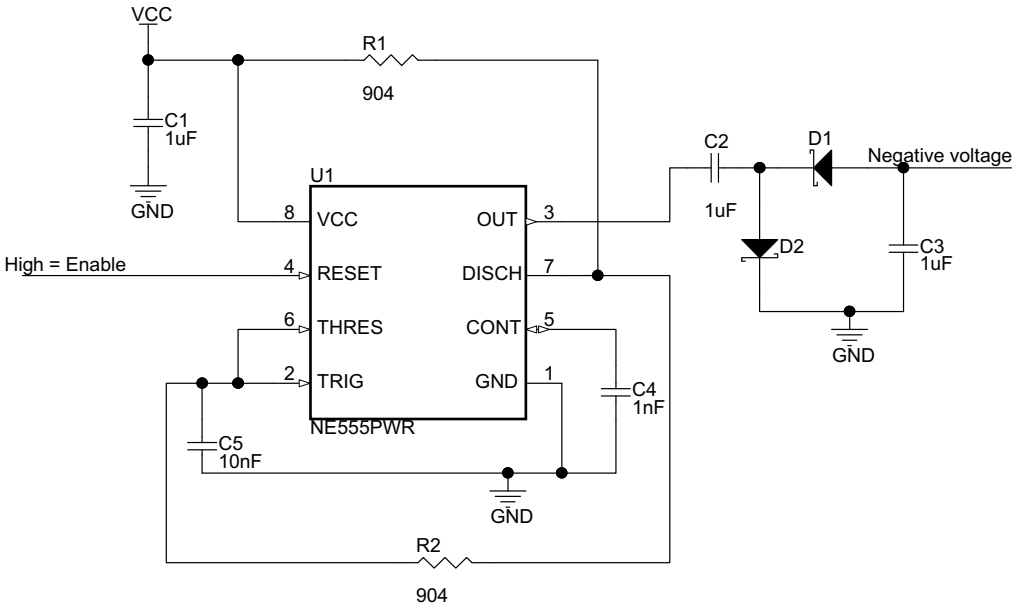

Figure 6. Negative Charge Pump Circuit

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 2. Operation of Negative Charge Pump

RESET	OUT pin 3	Charge pump	Inverting level
High	Switching	ON	$-V_{CC} + 2V_f$
Low	Low	OFF	0

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.

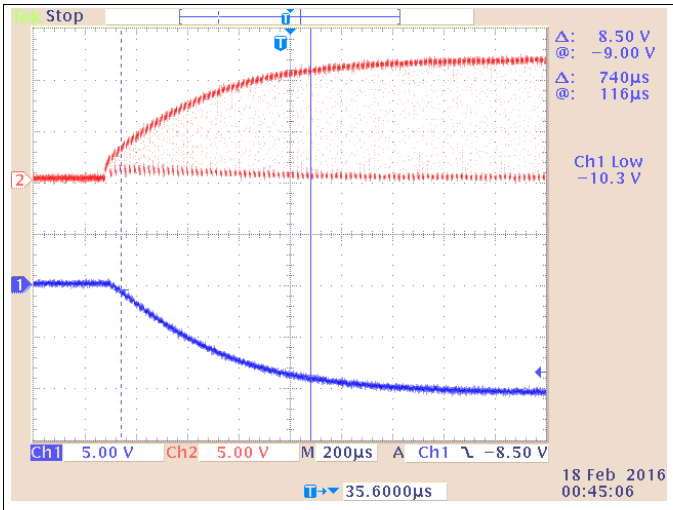

Figure 7. Power-Up Timing—RESET Switching from Low to High

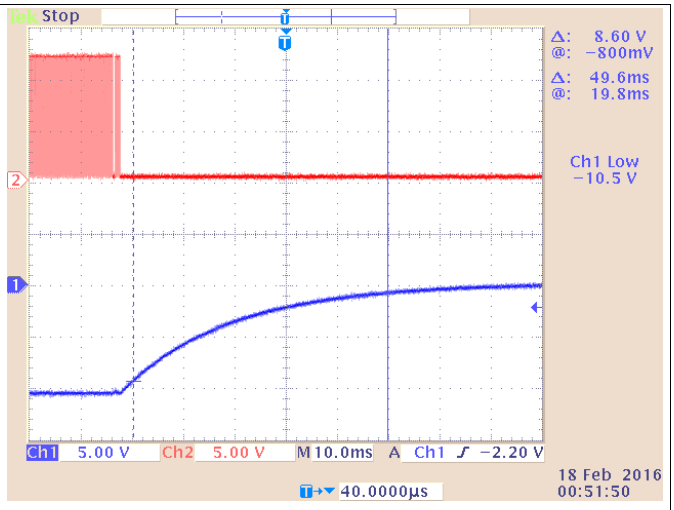

Figure 8. Power-Down Timing—RESET Switching from High to Low

3.2 Characterization

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

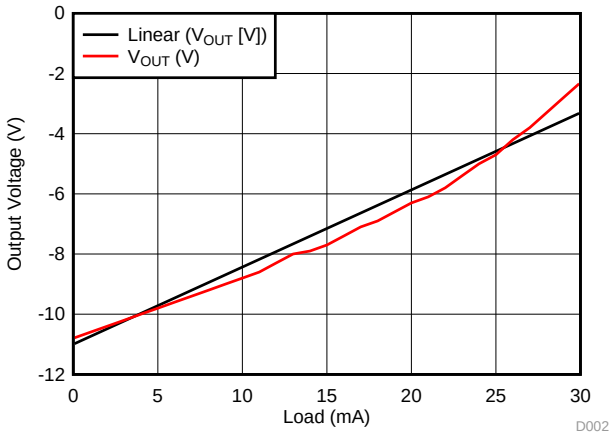

Figure 9. Charge Pump Output Voltage versus Load Current

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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