LM555 Duty Cycle Expansion

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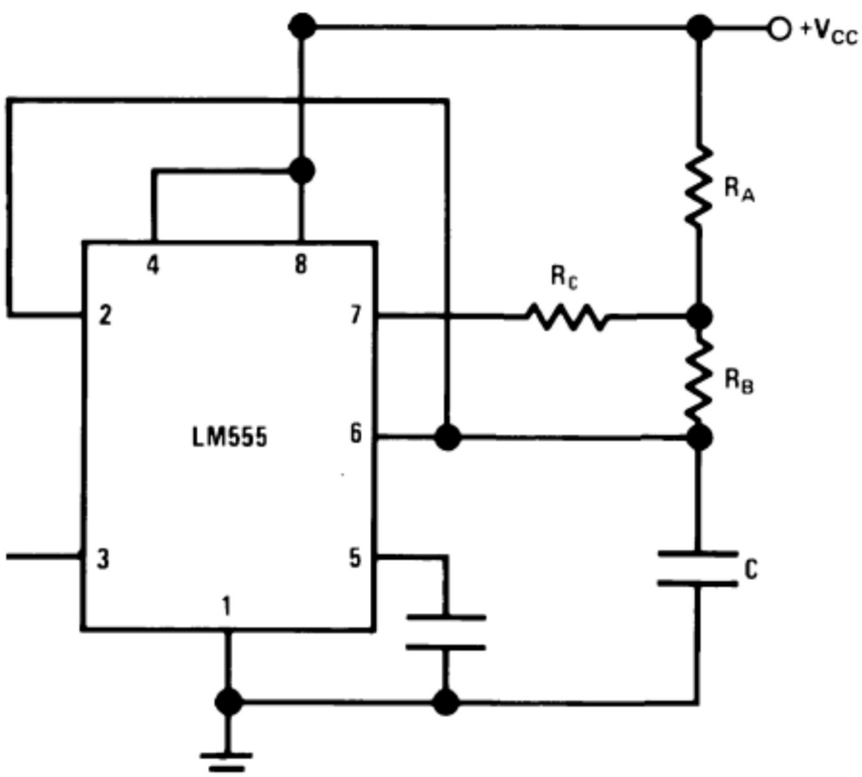
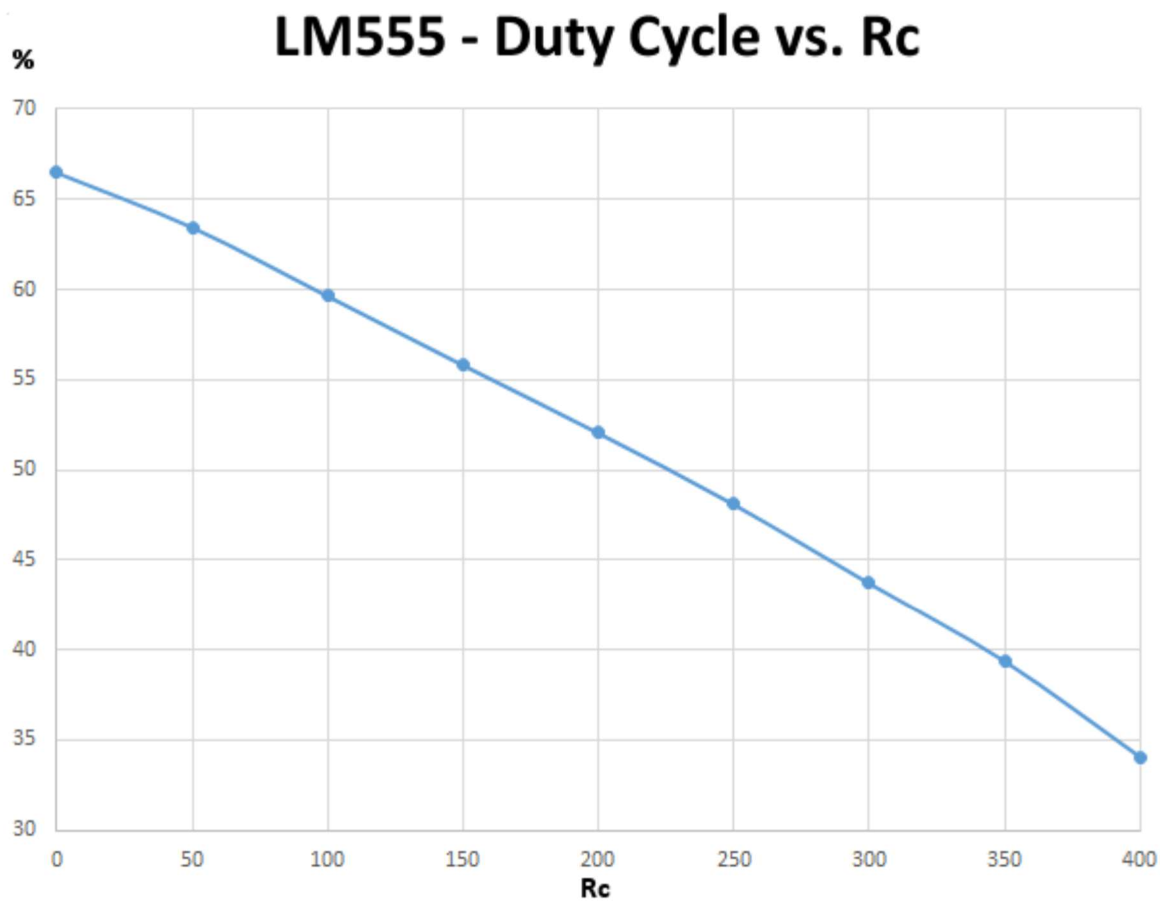
First introduced in 1972, the ubiquitous LM555 timer IC has proven to be perhaps the most popular integrated circuit of all time. One notable drawback with the design is that is it not possible to achieve an output duty cycle under 50%. Of course, an output inverter chip could be added, but there is another way! About ten years ago I came up with a brilliant (in my opinion), simple modification that resolves the problem by adding one additional resistor to the basic astable multivibrator circuit, R_C.



By placing R_C in the discharge path, “off” time is increased without affecting “on” time. Note however, if R_C is too large then the discharge voltage on pin 6 never reaches the $V_{CC}/3$ threshold and circuit stops oscillating.

Although there are an infinite number of solutions, let's simplify everything and apply the very useful case of $R_A = R_B$. The result is that output duty cycle can range from 2/3 down to 1/3 just by changing R_C! The following plot shows duty cycle in percent versus R_C when $R_A = R_B = 1k$.



In more generic terms, setting:

$$x = \frac{R_C}{R_A}$$

We can calculate duty cycle directly using the polynomial:

$$D = 67 - 69 \cdot x - 26 \cdot x^2$$

For 50% duty cycle, $x = 0.225$ and frequency reduces to:

$$f = \frac{0.36}{R_A C}$$