

## Re: 555 – Adjustable duty cycle circuit questions

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**From:** John Popelish ([jpopelish\\_at\\_rica.net](mailto:jpopelish_at_rica.net))

**Date:** 07/26/04

Date: Mon, 26 Jul 2004 11:08:07 -0400

Rubicon wrote:

>

> *John,*

>

> *I have a circuit consuming 3.8mA controlling another circuit consuming  
> up to 500mA both from a 9V battery and I thought that the 555 (P.D.M)  
> circuit could increase the batteries "life" by having the first  
> circuit on only a part of the time – half a second on/half a second  
> off. As it consumes 3.8mA I hoped that a CMOS 555 with its 10mA output  
> current source could switch it directly.*

It certainly will not provide 10 milliamps with zero voltage drop. but the drop may be acceptable. This data sheet:

<http://cache.national.com/ds/LM/LMC555.pdf>

specifies no more than a .6 volt drop for pull up with a 5 volt supply and a 2 mA load for a pull up resistance of 300 ohms. But with a 12 volt supply, the pull up voltage drop is no more than 1.5 volts with a 10 mA load for a pull up resistance of 150 ohms. With a 9 volt supply, I would expect a value between these two. Something on the order of 200 ohms, perhaps. So a 3.8 mA load would drop about .7 or .8 volts across the LMC555 pull up output.

If you could operate your 3.8 mA load during the pull down part of the cycle, the LMC555 output resistance would be between 75 and 40 ohms.

> *Another problem I have is that the first circuit triggers a CMOS 555  
> to switch on a 3VDC/500mA geared motor for about 15 seconds via a  
> BD139 NPN transistor. The transistor controls a LM317 regulator set to  
> 3VDC out which powers the motor (Motors V+ to LM317 3V+out, Motors V–  
> to transistors collector with LM317 V–). The motor has the required  
> diode and caps and a cap from the LM317 V+out to the transistors  
> emitter. The whole thing works from a 9VDC regulated power supply  
> (wall wart) but not well from a 9V battery. The startup surge of the  
> motor is 500mA then settles to approx 290mA and the geared motor  
> rotates but with less torque. I could adjust the LM317 for more  
> voltage out I suppose.*

>

> *In a previous post when I first started using a 555 and asked*

- > regarding the running of a 3VDC motor from a 9V battery and triggered
- > by a 555 John Popelish wrote:
- > \*\*\*\*\*
- > Simplest and most efficient are two different solutions. A series
- > resistor that sets the speed to about what you need is probably the
- > simplest. The most efficient would be a something like a second 555
- > timer set to mid or high kilohertz frequency, gated on by the slow
- > 555 described, above, to act as a pulse duty modulator to lower the
- > average voltage applied to the motor. If it puts out a pulse width
- > that is about 1/3 of the total cycle time, the average voltage to the
- > motor will be about 1/3 of the supply voltage, with no intentional
- > losses. And the battery current will average a little more than 1/3
- > of the motor current, extending the battery life, considerably. But
- > you will have to pay more attention to transistor turn on and turn off
- > times and use a fast diode (Schottky) across the motor to keep the
- > switching losses low.
- > \*\*\*\*\*
- >
- > Not yet figured out the values for the 555 pulse duty modulators or
- > the transistor. I think that the output of one 555 should be
- > capacitively coupled to the trigger of the next but not sure.
- > Not even sure that the LM317 will like being switched by the 555 and
- > the transistor and what exactly is mid to high kHz frequency? 30kHz+?
- >
- > As always any help is appreciated.
- >
- > Andrew.

If you use a 1/3 duty cycle pulse to drive the 3 volt motor from a 9 volt source, the average voltage is 3 volts (9 volts 1/3 of the time, 0 volts 2/3 of the time) so there is no use for the voltage regulator at all. The duty cycle replaces the regulator. The difference as far as the battery is concerned is that with the regulator, the battery current equals the motor current at all times, but with the duty cycle version, the battery current equals the motor current only during the 1/3 on time. During 2/3 of the time, the motor current coasts through a flyback diode, and the battery current is zero. So the average battery current (over the pulse cycle) is about 1/3 of the motor current. A 500 mA motor current is produced with an average battery current of about 167 mA.

When the motor gets going and its current falls to 290 mA, the battery current will approach 100 mA. The only reason the battery current will not be exactly 1/3 of the motor current is the small power loss in the switch and flyback diode.

And there is no reason to do this switching at 30 kHz, except to make the process quiet. 5 to 10 kHz is probably plenty fast to allow the motor inductance to hold the current roughly constant during a cycle (though you should verify the current ripple before finalizing the design). Remember that each switching process adds a bit of loss to the operation.

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John Popelish