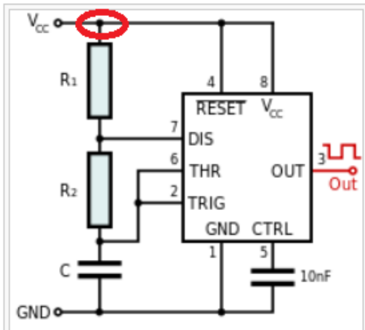
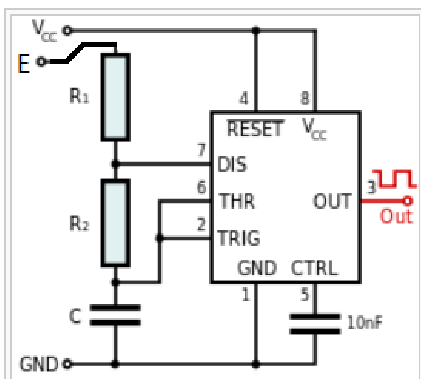
ADC w/Propeller & 555 timer

If we take the standard *555 a-stable circuit* and modify it by removing R_1 from V_{cc} (red circle in figure)



Standard 555 astable circuit

You end up with this circuit (see figure below) able to detect voltages greater the V_{cc} when connect to the terminal labeled *E*.

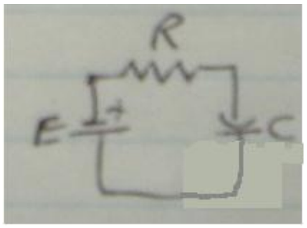


VCO using 555

When constructed with R_1*=470K-ohm* and R_2*=10K-ohm* and *C=.1 uF* you should get similar results, if V_{cc} = *5v*. Connect *output pin 3* through a *10K-ohm* resistor to any pin on your *propeller*, should you decide to follow along.

Proving the ‘change’ of behavior takes a little bit of math, and I hope I got it right. I use to have a book named *555 timer cook book* (don’t recall authors name), that gave a great break down of the timer operation and its math. And now, I don’t. It was tossed out by accident as a relative was ‘doing a charitable deed’.

So, this was a good excuse for me to dig out my physics book and stretch that area of the brain again. Given a circuit such as shown here:



RC circuit

$$E = IR + V_c$$

Eq-1

But when rewritten with 'charge' *q* instead:

$$I = \frac{dq}{dt}$$

and

$$V_c = \frac{q}{C}$$

This yields the following expression:

$$E = \frac{dq}{dt} R + \frac{q}{C}$$

$$\frac{dq}{dt} = \frac{E - \frac{q}{C}}{R}$$

or

$$\frac{dq}{dt} = \frac{EC - q}{RC}$$

And finally

$$\frac{dq}{EC - q} = \frac{dt}{RC}$$

(eq-2)

And this last step I hadn't done in a while! Now the expression in *eq-2* can be integrated.

$$\int_{q_1}^{q_2} \frac{1}{EC - q} dq = \frac{1}{RC} \int_0^t dt$$

Here, because of the *555* and a V_{cc} of *5v*, we have two *fixed* charges for q_1 and q_2.

$q_1 = \frac{5C}{3}$ & $q_2 = \frac{10C}{3}$ and will not vary with *E*.

This leads us two definite integrals:

$$-\ln(EC - q_2) - (-\ln(EC - q_1) = \frac{t}{RC}$$

Combining log's, yields:

$$\ln\left(\frac{EC - \frac{5C}{3}}{EC - \frac{10C}{3}}\right) = \frac{t}{RC}$$

After simplifying:

$$\ln\left(\frac{3E - 5)}{3E - 10}\right) = \frac{t}{RC}$$

Which leads to this expression:

$$t = \ln\left(\frac{3E - 5)}{3E - 10}\right) RC$$

Now, I should point out that this expression is just the 'charge' time and not the discharge time. In fact, the software I use (and may be attached) reads only the charge time. Before we get too far ahead of ourselves, let's test this last expression with *E = 5v*. And see what it yields?

$$t = \ln\left(\frac{15 - 5)}{15 - 10}\right) RC = \ln(2)\, RC$$

This last part *ln(2)RC* you can look up as the charge time *t* of an astable timer using the 555.

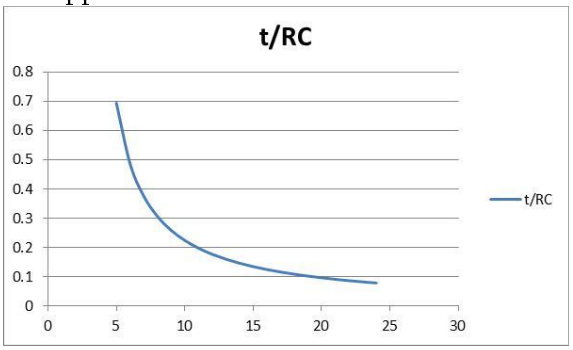
So the expression:

$$t = \ln\left(\frac{3E - 5)}{3E - 10}\right) RC$$

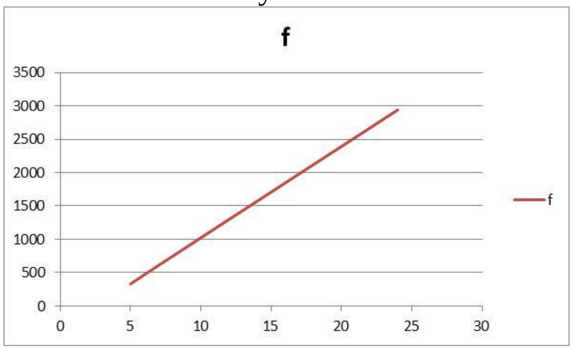
Can be used to predict behavior for *E>5* in a table:

E	t/RC	E	t/RC
5	0.693147	15	0.133531
6	0.485508	16	0.123614
7	0.374693	17	0.115069
8	0.305382	18	0.107631
9	0.257829	19	0.101096
10	0.223144	20	0.09531
11	0.19671	21	0.090151
12	0.175891	22	0.085522
13	0.159065	23	0.081346
14	0.145182	24	0.077558

In graph form this appears as:



When plotting f=1/t we have for my circuit RC combo:



My RC circuit yields *f=320 Hz @ E=5v*. But you should get a linear response exactly as I observed in my circuit.