# Keeping things in focus
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Focusing can be a chore at times and if you are one of the practitioners of the arcane art of astro-photography achieving the best focus possible is critical. Any tool that helps an imager get to that point is worth more than gold and to my mind no focusing aid is as useful as a motorized focuser. The ability to focus while looking at a computer image is priceless and even for visual observing the ability to adjust focus without any wobbles and jitters makes life a lot simpler.

A motorized focuser is comprised of a motor, a method to control the motor and some way of connecting the motor to the telescope. Together they should be able to do three things well: focus in either direction, start focusing on command and when done, stop focusing on command. This might sound quite simple but it does take a bit of thought.

To turn a DC motor bi-directionally simply requires that the polarity of the voltage going to the motor is able to be reversed as needed. This can be done simply with two reversing switches. A reversing push button switch known as an 'on/momentary on' switch will reverse the polarity when pressed and return to it's original state when released. To focus both directions two switches are needed each of which have three terminals. One of these is common and goes to one of the motor's terminals. One of the other two terminals on each switch will be connected to ground (negative) and the other to the battery positive.

Stopping the motor accurately takes some thought as DC motors tend to 'free-wheel' for a bit after the power is removed which, if not taken into account, has an effect on the accuracy of the focuser. The simplest way to stop a motor immediately is to short the motor's two leads together; a method known as dynamic braking. Using the switches described above both motor terminals are shorted together when neither button is pressed which provides the braking effect.

For this project I'm using DPDT switches each of which is, in effect, two complete switches in a single unit. One circuit of each switch controls the motor voltage polarity as described and the other (both switches wired in parallel) turns the power on to the electronics when either button is pressed.
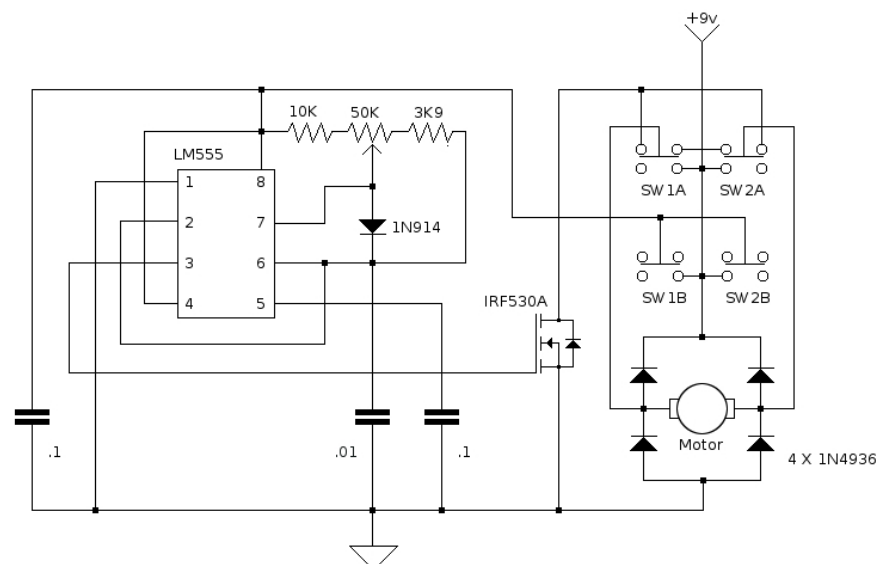
Speed control is achieved using a method called 'pulse width modulation' which simply means that the motor circuit is pulsed (turned on and off) very rapidly. As long as the switching frequency is high enough the motor will see the source as DC with a varying voltage which is perfect for a DC motor where the voltage relates to speed. For fast speeds the circuit is on longer than it is off and *vice-versa* for slow speeds. The ratio of on time to off time is known as the 'duty cycle'. PWM is easy with a small and inexpensive IC chip known as a 555 timer. This chip generates an adjustable duty cycle square wave at various frequencies.
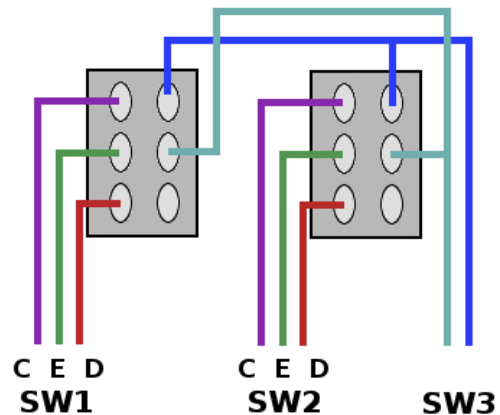
I want the focus controller to be as simple to use as possible so I'm adding complexity inside the box in order to simplify the controls outside the box. The entire user-interface is the potentiometer to adjust the speed and the two buttons. As mentioned above each button will also serve to connect the power to the timer circuit. This saves battery power as nothing in the box is powered until a focusing button is pressed.

The timer circuit generates a square wave which turns on and off a MOSFET (in this case at about 2.3KHz) to complete the motor's connection to ground. When the transistor is on the current flows through the motor and when it is off the the circuit is broken. The potentiometer serves to adjust the duty cycle between 14% and 94%.
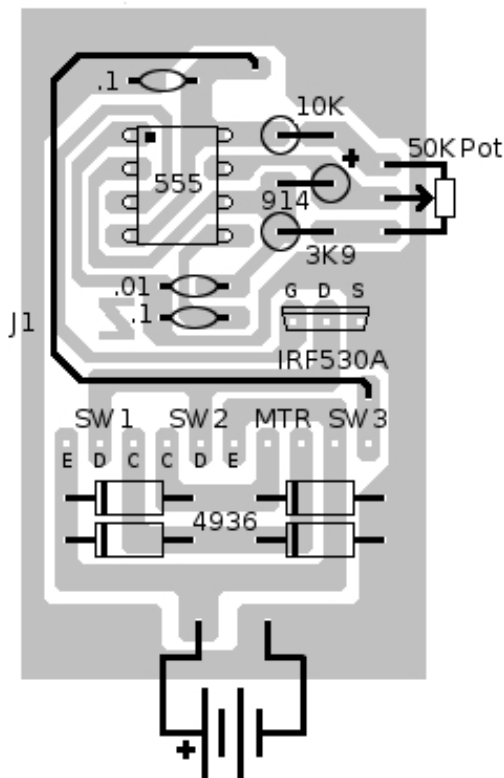
The schematic diagram shows how this all works. Note the four diodes around the motor which are used to protect the transistor from stray voltages. When power to a DC motor is cut the magnetic field in it's coils collapses and a large voltage can be generated. The diodes serve to steer this into the positive side of the power supply (battery) to keep it from damaging the transistor. The circuit can run on any voltage from 5 to 16 volts and would be a perfect match for a 9v battery or a 12v connection from a mount.

At left is the part layout for this project. SW1, SW2 and SW3 are for the switch connections as per the wiring diagram shown above. Male headers with .1" spacing can be used unplugging the connections from the board is needed but with the box I used just soldering the wires onto the board works fine.

The board itself, which is very small, can fit in any plastic enclosure that will hold the buttons and connectors but I would purchase the Hammond box specified in the parts list. It has card-guides molded into the sides which, if the board is carefully trimmed, will hold the board upright in

the case with no screws needed. There is enough room behind the board for the battery and potentiometer and enough ahead of the board for the switches. As you can see from the picture at the top of the article I've mounted the potentiometer on the bottom side of the case but you can layout your box as you see fit. With this case layout I had to trim away the two corners that protrude from the body of the case to allow the battery and potentiometer wires to pass over the board.

The simplest method of connecting a motor to a focuser is to use a belt which allows for a great latitude in motor placement. A plastic pulley on the motor's output shaft can turn a belt (or an asparagus elastic.. great things those) that is wrapped around one of your focusing knobs (Crayfords work better than rack-and-pinion). If it is to be used on a Schmidt-Cass or Mak-Cass with a moving primary it can be done as I did it by adding a pulley to the focus knob. With a refractor an over-long dovetail bar that reaches back to near the focuser would be a great place to mount a motor.

On my old C8 (shown above right), there were suitable tapped holes in the rear casing after I removed it from the forks to allow me to mount a hand-cut and bent sheet metal bracket for my motor. If your scope doesn't have anywhere to mount a bracket and you have to drill and tap some holes take precautions against metal flakes flying around inside your tube. If you don't want to drill and tap then you'll have to get creative. My bracket is cut out of thin sheet aluminum and is in three pieces; two arms down the sides to provide stiffness and a bent plate that holds the gear-head motor. The belt (here just an elastic band) runs from a brass pulley on the motor to the pulley fixed to the focusing knob.

Using a long wire between the motor and the controller can also be useful. This can actually be quite long as voltage drop won't be an issue unless extremely fine wire is used. Enough length means one can be sitting at a laptop several feet from the telescope and still use the powered focuser while analyzing images on the computer screen.

All-in-all a handy little project and fairly simple to build.

You can find the PhotoShop file containing the board mask, layout *etc.* at:

 http://ozastro.dyndns.org/variable_focuser_board1.psd

Happy focusing!

Parts list

Part	DigiKey #	Price
1 x 555 CMOS timer chip	LM555CNNS-ND	$1.46
1 x IRF530A n-channel PowerFET (or suitable equivalent)	IRF530PBF-ND	$1.62
4 x 1N4936 1A fast-recovery diodes	1N4936DICT-ND	$2.04
1 x 1/4W 10K resistor (min quantity 5)	10KQBK-ND	$0.32 (pack)
1 x 1/4W 3K9 resistor (min quantity 5)	3.9KQBK-ND	$0.32 (pack)
1 x 1N914B fast recovery diode	1N914BCT-ND	$0.05
1 x 50K potentiometer with knob	See below	
2 x .1uF ceramic disk capacitors (min quantity 10)	BC1101CT-ND	$0.81 (pack)
1 x .01uF ceramic disk capacitor (min quantity 10)	1103PHCT-ND	$0.72 (pack)
2 x On-(mom on) DPDT push button switches	360-2152-ND	$15.00
2 x Red caps for switches	360-2164-ND	$1.38
1 x Hammond 1591LBK project box	HM113-ND	$6.46
A connector for the motor	See below	
A connector for power (or 9v pigtail)	See below	

The switches are by far the most expensive parts in this build. From Digikey they cost $7.50 each but they are VERY good parts and well worth the expense. The rest of the parts came to about $15.00 not counting the potentiometer which can be had for about $4.00 from somewhere like Radio Shack (part number 271-002 with switch which is not needed) or cheaper at an electronics outlet. A knob for it will cost about another $1.00. Get your connectors and wire from RS also.