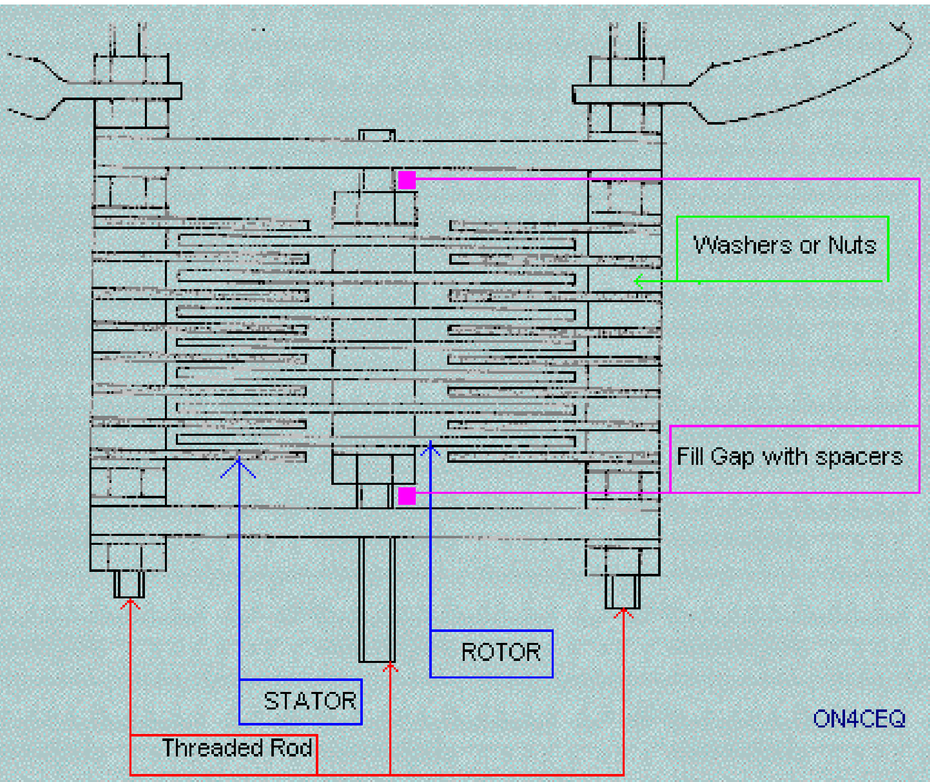
Magnetic Loop Antenna for 20/15m with Remote Tuning

by George Szymanski, DU1GM

part 1.....

Having recently become interested in JT65A working on 20m, I had a QSO with a station in Hawaii who was using a loop antenna mounted on the balcony of his 28th floor hotel room. The loop was just 80cm in diameter and could be tuned to any band from 20m to 10m. His signal was very strong considering he was only running a few watts from a Yaesu FT817. One advantage of magnetic loop antennas is that they tend to reject much of the electrical signal and therefore any local electrical interference will be greatly reduced. I use a vertical antenna for HF work because I have no space for any other type of antenna and it is really very good at picking up power line noise and various other electrical noises! A loop would be very small and could fit into my limited space. I resolved to make a loop of around 1m in diameter with the 20m band in mind. The calculations gave an efficiency of 45% on 20m and 73% on 15m. To give more efficiency on 20m would entail making a bigger loop which would not tune to higher bands due to stray capacitances. A larger loop would be required with a diameter of 2m in order to maximize the efficiency on 20m only.

I found an interesting web page giving construction details and I set about making the necessary parts to construct a high voltage variable capacitor needed to tune the loop. While transmitting with 100W a voltage of 5,000V would be generated across the capacitor, therefore a high voltage type is required.

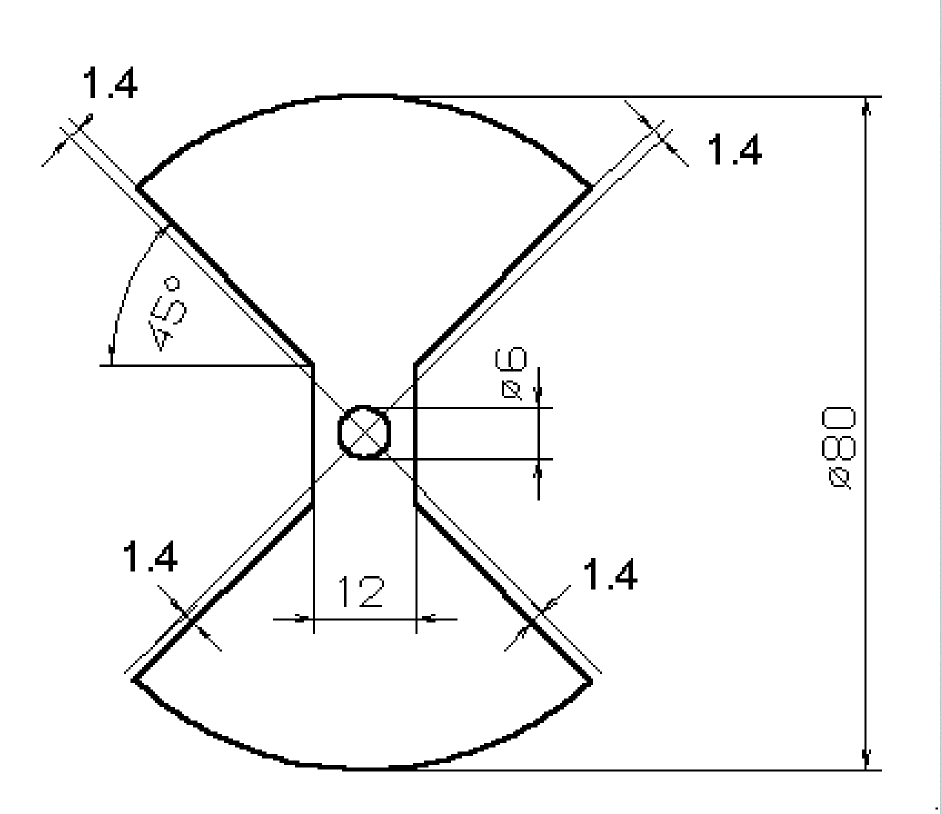


The capacitor end parts were made from some 6mm thick Perspex scrap bought from a shop in Santa Cruz, Manila, for P80. The rotor and stator plates were made from 1mm thick aluminum sheet and were quite easy to cut out with shears but this does need some strength in the fingers! Do watch out for blisters! The Perspex can be difficult to cut with simple tools due to the possibility of splintering, but I used a junior hacksaw without too much difficulty. Thinner Perspex could be used but not so thin that the end plates can be flexed. The capacitor plates need to be kept firmly in place so as not to short together. Also be careful when drilling the Perspex as it can shatter and throw out small shards. Eye protection is essential.

A butterfly type capacitor has lower losses than the standard type of variable so this would be most suitable for a small loop antenna where losses need to be kept to a minimum.

The plates were held together with 6mm threaded stainless steel rod, with spacers of washers and nuts. Threaded brass rod can also be used but is more difficult to obtain here. One should not use ferrous materials as these would introduce high losses. It is important when using stainless steel parts that it is all tightened as far as possible to reduce the resistance. Ideally solderable metals like brass and copper should be used.

A vacuum variable capacitor would be the best choice for this project if it were not for the high cost and lack of availability in this country. Anyway, in the spirit of amateur radio it is best to make your own as far as possible and there will then be a lot more pride in the finished product. It is not too difficult to make your own butterfly variable capacitor of the required voltage rating.



This is the rotor plate. The number of rotor and stator plates required depends on the capacitance you will need to tune a given diameter of loop for a particular frequency.

For the spacing of the vanes you can use 2 M6 washers (6kV) or an M6 nut (12 kV) if you use aluminum plate 1 mm thick.

If you use a nut then the best thing to do is remove the thread by drilling with a 6.2 mm drill.
The effective area for the vanes is 11.7 cm² and with the formula for 2 washers = (0.0885 x 11.7 cm²)/ 0.1 cm = 10.35 pF for 1 air gap.

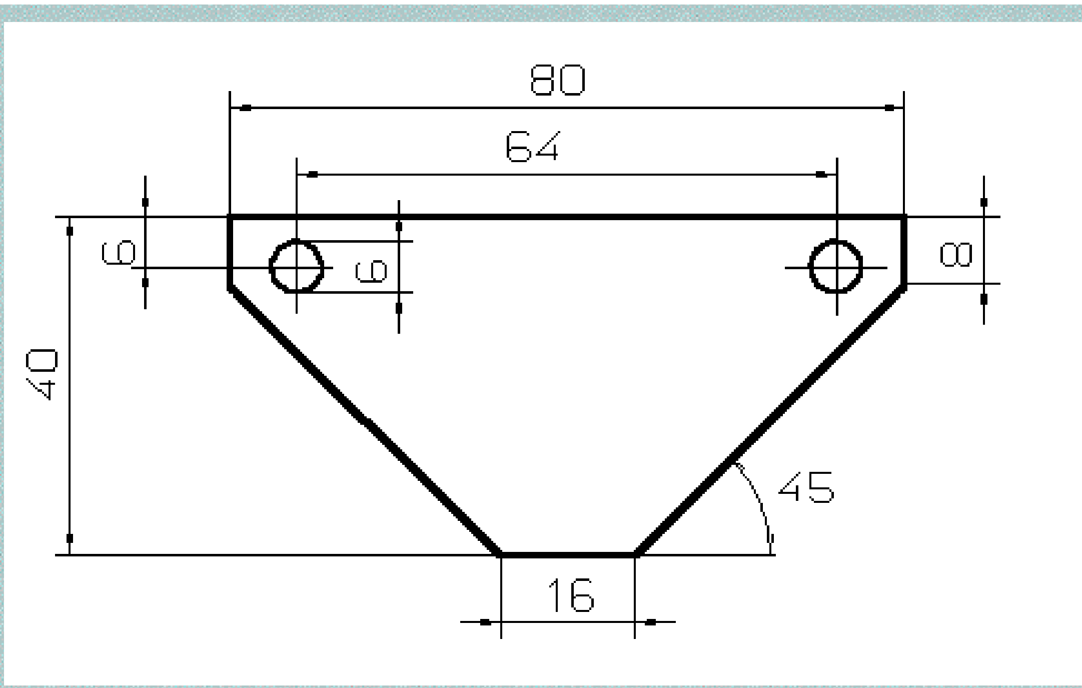
for 1 nut = (0.0885 x 11.7 cm²)/0.2 cm = 5.17 pF for 1 air gap.

Example:

If you you make a capacitor with 2 washers as spacing and you make 5 rotor vanes and 6 stator vanes then you have 10 air gaps.

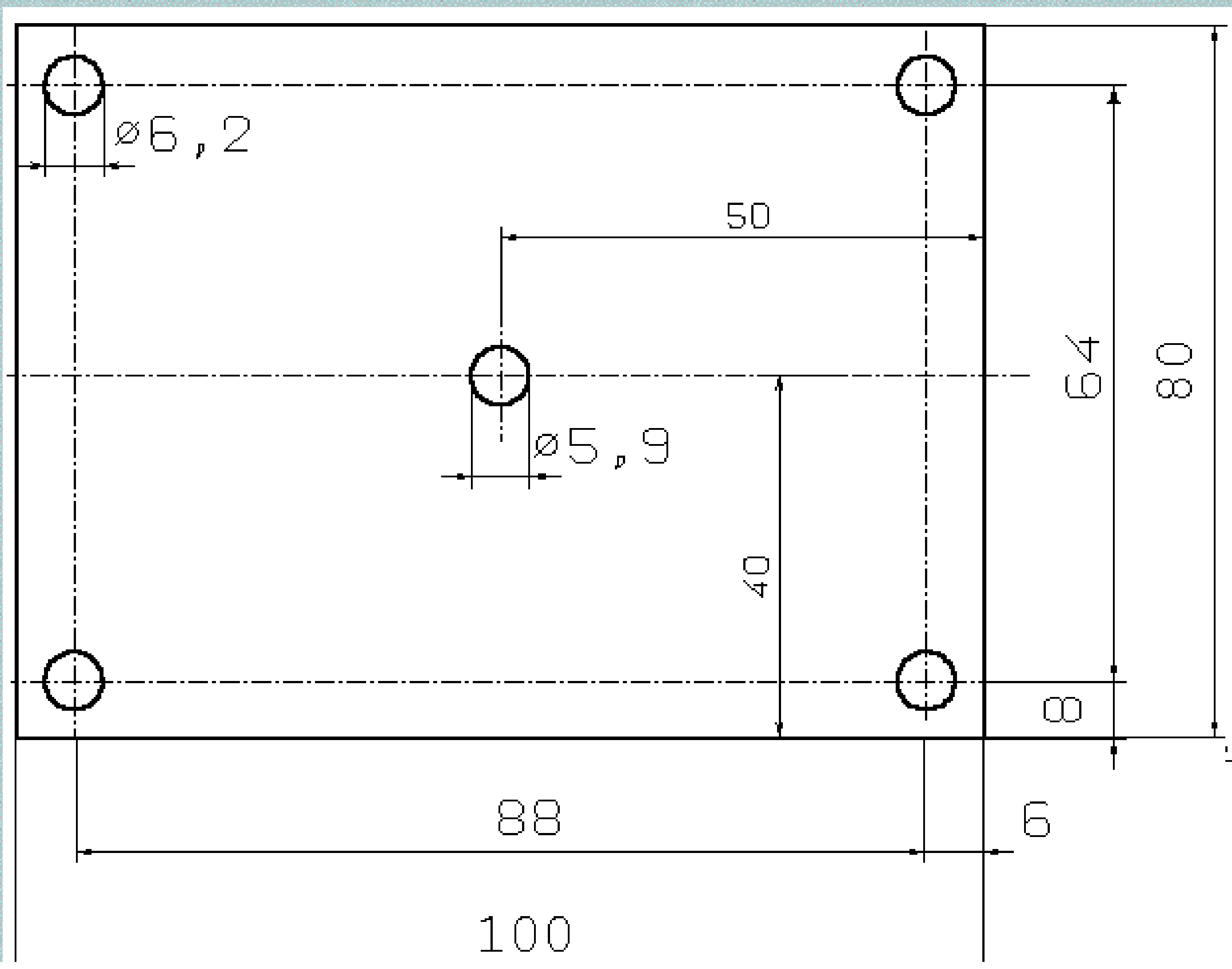
10.35 pF x 10 = 103 pF + 10 pF stray capacitance = 113 pF / 2 = 56 pF

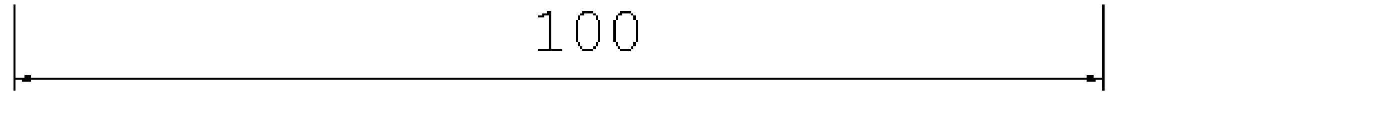
The final result is a capacitor with a value from 5 - 56 pF.



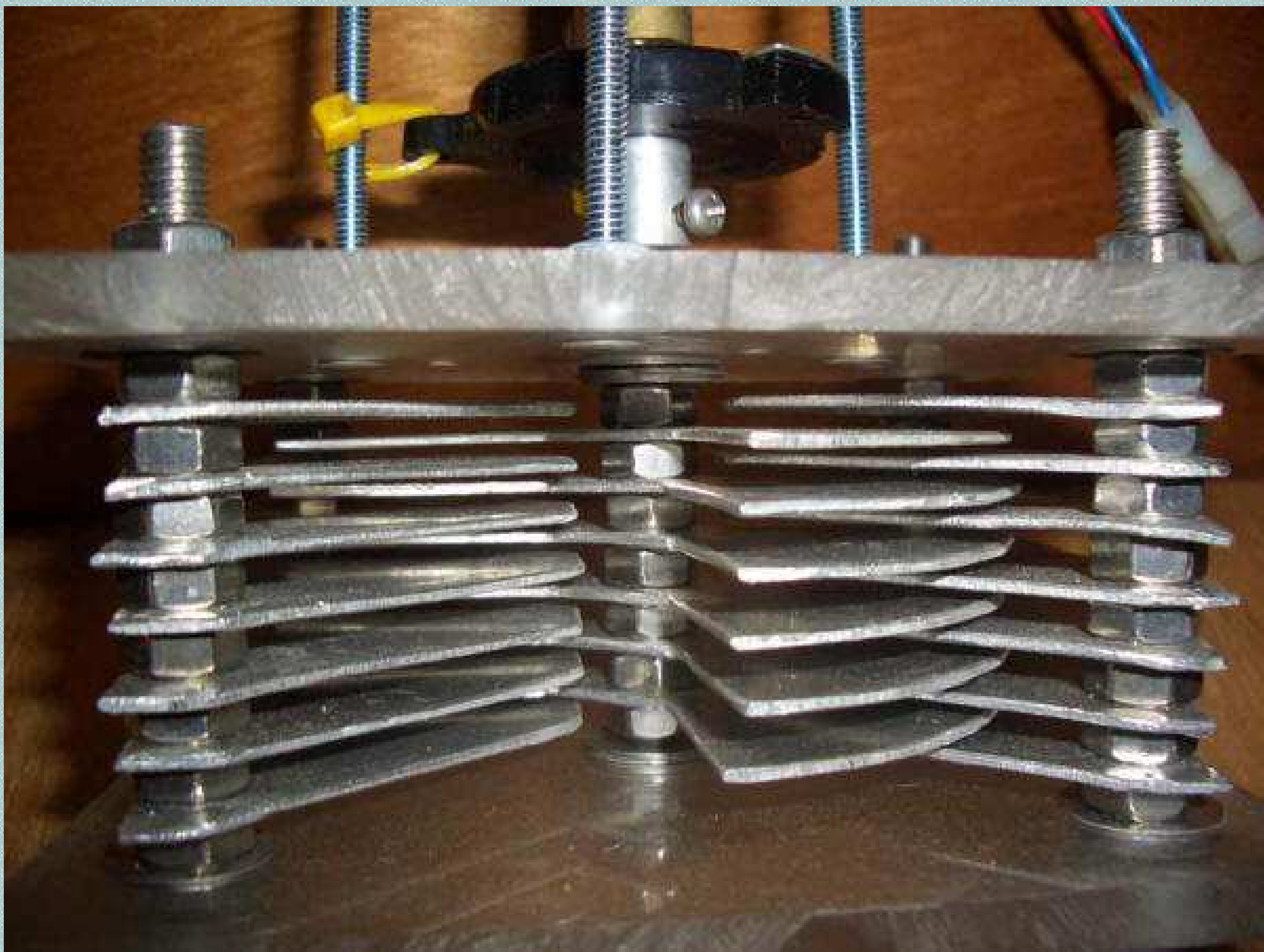
The stator plate is shown above. All dimensions are mm.

For the rotor and stator plates I made thin card templates so I could mark the aluminum sheet more easily.



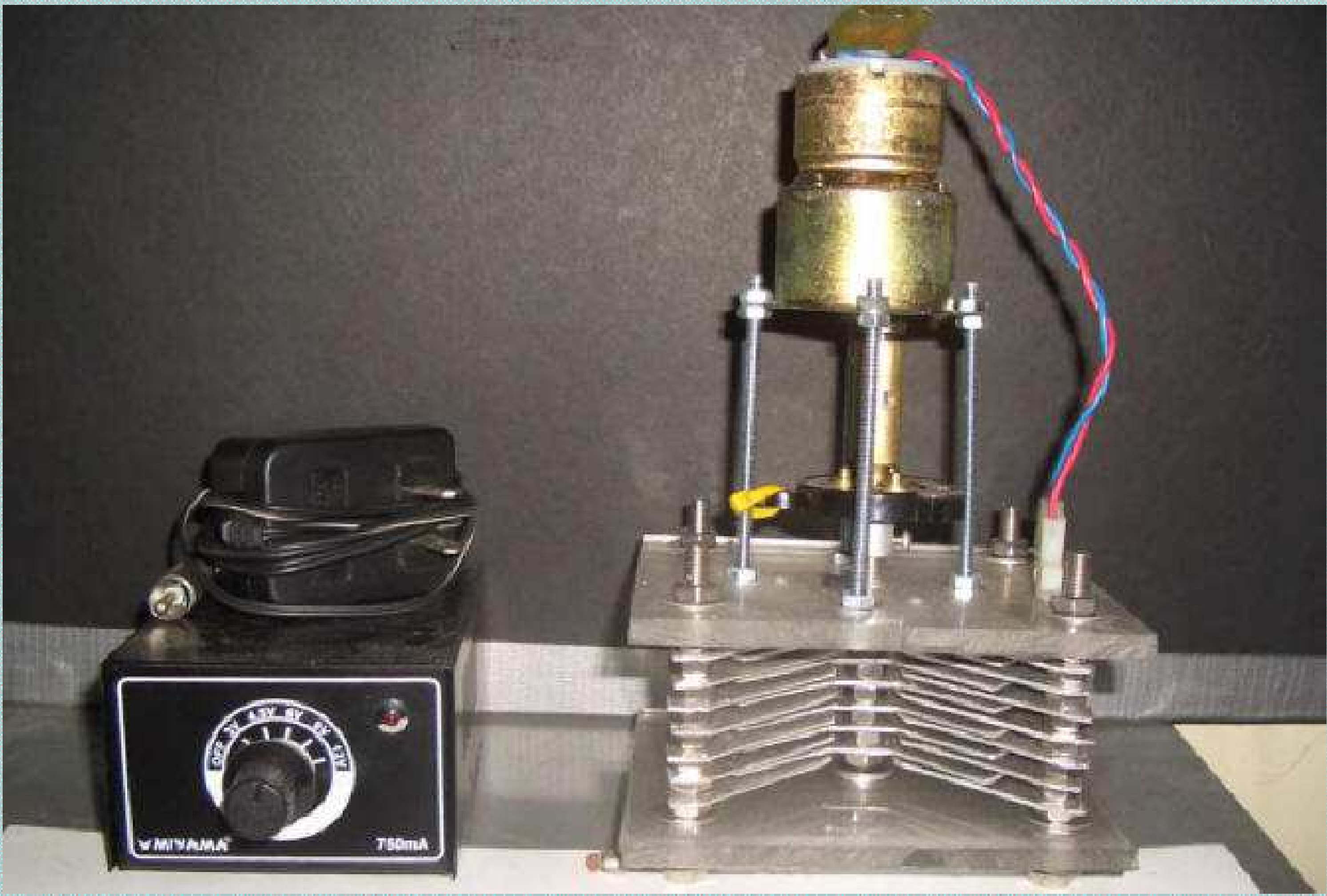


The two end plates, made from Perspex are made to the dimensions shown above.



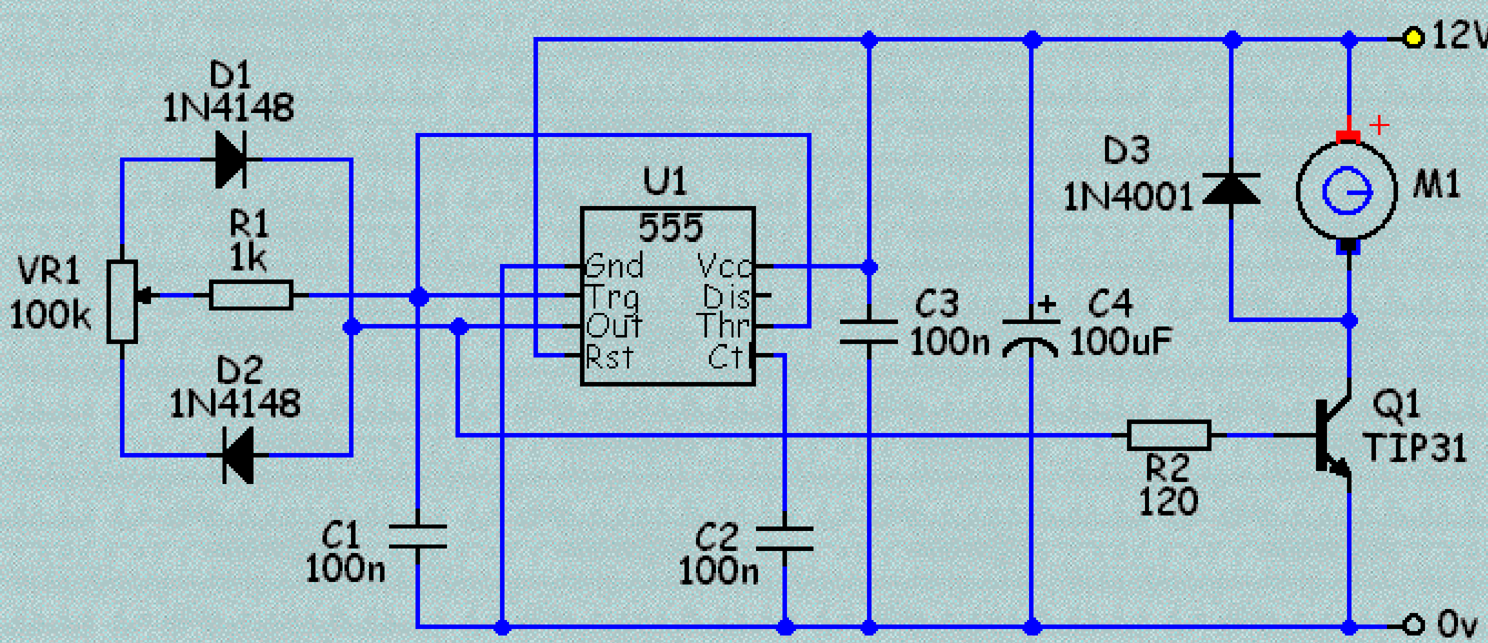
picture of completed capacitor

To turn the tuning capacitor remotely, I built a tuning motor unit using a scrap 12v reversible motor purchased in Raon, Quiapo for P300, complete with a fitted gearbox. The motor runs quite slowly on 9V and this is almost slow enough for coarse tuning. To slow down the motor further for fine tuning I made a small pulse-width-modulated supply set to a lower voltage and there was still sufficient torque to turn the capacitor at a nice slow rate. Even at this slow rate however, the fine tuning was a little critical so I inserted a 7:1 reduction drive. the tuning is now super slow on fine and good on coarse tuning. The coarse tuning gave around 50 seconds between meshed and unmeshed capacitor plates and the fine tuning now takes 2 minutes. The motor supply was built into a small box together with a forward and reverse control to turn the capacitor. The control enables fine adjustment of SWR by rocking back and forth on the switch for the final tweak.

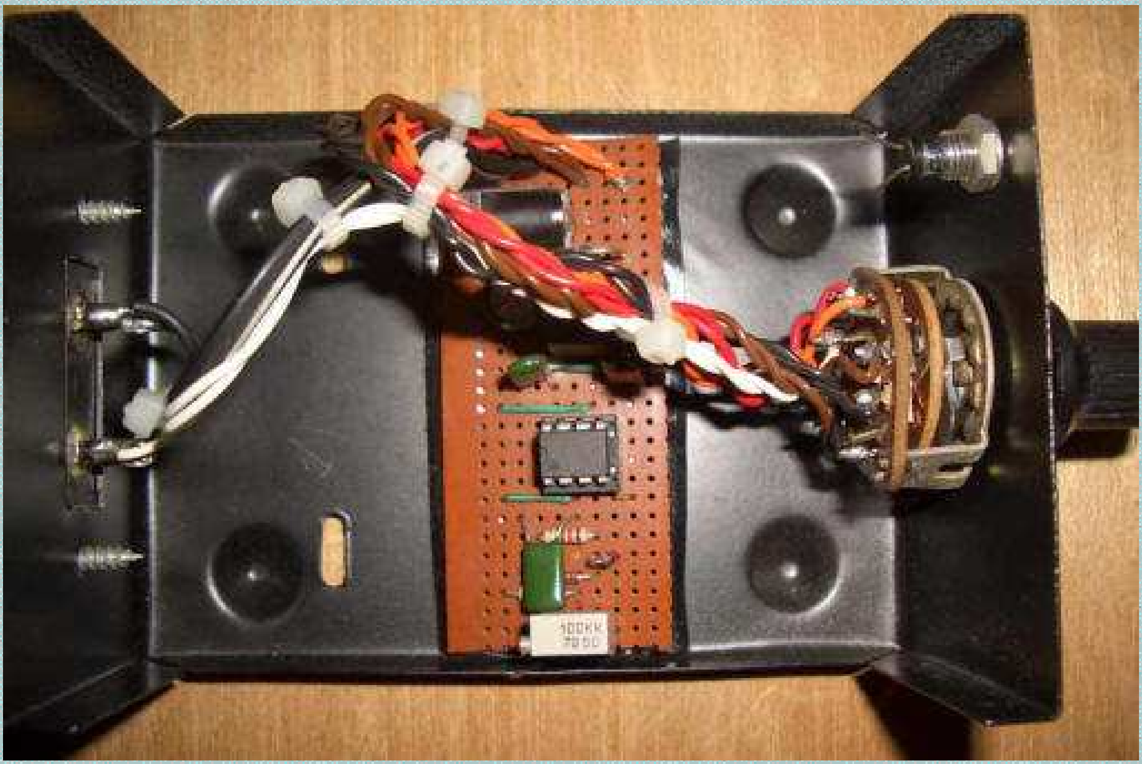


showing the control unit and the motor/gearbox arrangement

The control unit was housed in a small power supply box, bought in Deeco in Raon. It has 4 positions, reverse fast and slow, and forward slow and fast. The circuit is shown below and I initially thought the voltage control would be good enough for the fine tuning. In fact I had to raise the voltage somewhat from the minimum that would provide enough torque from the motor and therefore I had to add the extra reduction drive between the motor and the capacitor.



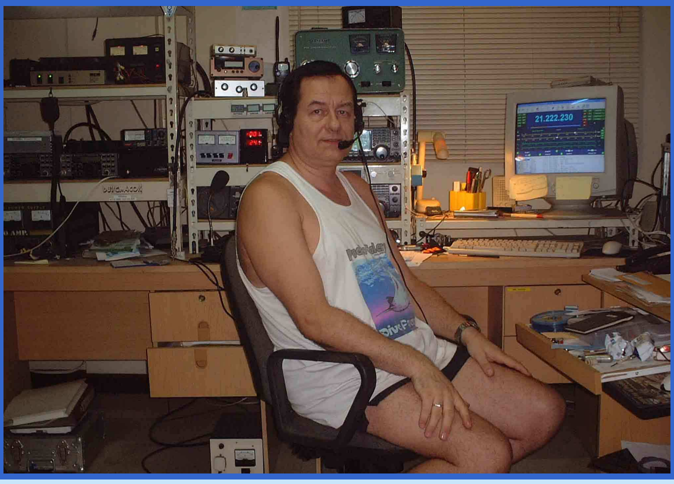
Schematic of the pwm speed controller.



A look inside the control box showing its simplicity. You can see the switching which is not shown on the schematic above. This simply sends the motor voltage out in either forward or reverse mode, at full or reduced voltage, to give the four speeds.

I tested the capacitor with a 1m loop of RG8 coax, using the braid as the conductor. A small coupling loop was fabricated from smaller diameter RG58 coax. The whole assembly was hung up temporarily and tested with an MFJ Antenna Analyzer to determine the frequency range for maximum and minimum capacitance. At this point I noticed that the highest frequency possible was just short of 21MHz so I removed two plates from the capacitor assembly to compensate. Fortunately the 20m band still tuned in nicely. Of course the 18MHz band also comes into the range of tuning. As the assembly was indoors I did not make any attempt to contact other stations although the loop was receiving quite well on 20m and 15m. As a final step I transmitted 50W into the loop and the unit tuned up very nicely with 1:1 SWR and no problems from the capacitor. The capacitor plate distances will be able to handle the voltages produced by transmitting at 100W with no problems and this will be tested in the final product.

The next step is to construct the loop from copper tube, build a loop support frame and make a more robust coupling loop, as well as finishing off the control box with a custom labeled front panel. I plan to mount the loop outdoors on a rotator so I can see the effect of nulling out local noise or peaking signals in a particular direction. All this will be the subject of the 2nd part of this article, coming soon as they say!



D U 1 G M

Send comments or questions....
Antenna Patch Panel
Refurbishing the A3S
Compact Fluorescent Lights
JT65a on HF
HRD Review
Soldering
Disaster Preparedness
Yesteryear

Main Page | Back to Articles | News Page