Portable remote tunable magnetic loop antenna

Version 1.0

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With a very small investment (maybe even less than \$50) and some components which can be easily found at any HAM you can have a very compact and efficient antenna for portable use with the following features :

- Covered HF bands: 40m to 10m (5.5MHz-29.8MHz);
- Max. power: 10W (tested with an Yaesu FT-450AT);
- Remote tunable through the coax (battery operated tuner, low power consumption);
- Takes very little space when folded (~ 600mm x 200mm x 100mm, including the support);
- Extremely fast tuning (around 5s from 7 to 30MHz).

The final product will look like in the following pictures.

a. Folded



b. In operation

See the YouTube movie by clicking on the following picture:



c. The remote tuner (I don't have yet a case for it). This is a preliminary version which was modified by removing the buzzer. It provides a much more reliable operation mounted at the antenna (see schematic). Considering the speed of the tuning, the buzzer is not really useful and can be eliminated, especially if you intend to operate the antenna from a larger distance.



The components

First let's see where we can find the main components at the cheap price. For the prototype I've found some of the components at cheaper prices on the local (RO) market (ex. the relay).

 2 GANG VARIABLE AIR CAPACITOR ALPS HQ! WITH BRACKET, BESTSELLER OVER THE GLOBE! (~ \$12) at: http://www.ebay.co.uk/itm/2-GANG-VARIABLE-AIR-CAPACITOR-ALPS-HQ-BRACKET-BESTSELLER-OVER-GLOBE-/160776906586?pt=UK_ConsumerElectronics_SpecialistRadioEquipment_SM&hash=item256f0ce75a#ht_500wt _1413



 S3003 Standard Servo for RC Futaba Car Boat Airplane (~ \$2/pcs.) at: <u>http://www.ebay.co.uk/itm/S3003-Standard-Servo-RC-Futaba-Car-Boat-Airplane-</u> /330587246821?pt=UK_ToysGames_RadioControlled_JN&hash=item4cf88910e5#ht_2919wt_1163



3. **Z-66 Power Supply plastic box 132.2x78x656mm** (~ \$3) at: http://www.adelaida.ro/product_info.php?products_id=17767



 4. 10, Laser Machine Micro Limit Sensor Auto Switch, KW11i (~ \$0.3\$/pcs. X 2) at: <u>http://www.ebay.co.uk/itm/10-Laser-Machine-Micro-Limit-Sensor-Auto-Switch-KW11i-</u> /320743450998?pt=UK BOI Industrial Automation Control ET&hash=item4aadcca976#ht 1656wt 1163



5. 10x Axial Magnetic Cored RF Choke Inductor Coil (~ \$0.2\$/pcs. X 2) at: <u>http://www.ebay.co.uk/itm/10x-Axial-Magnetic-Cored-RF-Choke-Inductor-Coil-</u>/260977490201?pt=UK_BOI_Electrical_Components_Supplies_ET&var=&hash=item82686c6fb6#ht_500wt_1180



6. 5 pcs L7805CV L7805 7805 IC ICs Voltage Regulator IC 5V 1.5A Integrated Circuit (~ \$0.3/pcs.) at: <u>http://www.ebay.co.uk/itm/5-pcs-L7805CV-L7805-7805-IC-ICs-Voltage-Regulator-IC-5V-1-5A-Integrated-Circuit-</u>/330694797626?pt=UK_BOI_Electrical_Components_Supplies_ET&hash=item4cfef2293a#ht_2512wt_1163



7. 10pcs,Tone Alarm Ringer Active Buzzer 1.5V - 12V (~ \$0.2/pcs.) at: <u>http://www.ebay.co.uk/itm/10pcs-Tone-Alarm-Ringer-Active-Buzzer-1-5V-12V-12B-</u>/390338766471?pt=UK_BOI_Electrical_Components_Supplies_ET&hash=item5ae200e687#ht_1195wt_1163



 Subminiature 2A Relay DPDT 12V Coil (~ \$2.5) at: <u>http://www.ebay.co.uk/itm/Subminiature-2A-Relay-DPDT-12V-Coil-</u> /300546945553?pt=UK_BOI_Electrical_Components_Supplies_ET&hash=item45f9fe7211#ht_1749wt_905



9. **5 pcs NE555P NE555 IC Low Power DIP-8 pin High Reliability Integrated Circuit** (~ \$0.4/pcs.) at: <u>http://www.ebay.co.uk/itm/5-pcs-NE555P-NE555-IC-Low-Power-DIP-8-pin-High-Reliability-Integrated-Circuit-</u> /330694795743?pt=UK_BOI_Electrical_Components_Supplies_ET&hash=item4cfef221df#ht_2404wt_1163



10. **10pcs precision 0.1W 100K Ohm MR065-104 Variable Resistor** (~ \$0.25/pcs.) at: <u>http://www.ebay.co.uk/itm/10pcs-precision-0-1W-100K-Ohm-MR065-104-Variable-Resistor-</u> /320851051417?pt=UK BOI Electrical Components Supplies ET&hash=item4ab4368399#ht 2791wt 1163



11. Carbon Film Variable Potentiometer 47K pack of 5 (~ \$0.4\$/pcs.) at: <u>http://www.ebay.co.uk/itm/Carbon-Film-Variable-Potentiometer-47K-pack-5-</u> /160710976429?pt=UK BOI Electrical Components Supplies ET&hash=item256b1ee3ad#ht 1457wt 1163



12. **10** Pcs **12** x **12** x **20mm** Red Momentary Push Button Tact Switches (~ \$0.2/pcs.) at: <u>http://www.ebay.co.uk/itm/10-Pcs-12-x-20mm-Red-Momentary-Push-Button-Tact-Switches-</u> <u>/140736737222?pt=UK_BOI_Electrical_Components_Supplies_ET&hash=item20c4902fc6#ht_2004wt_1396</u>



13. BP 9V 9 Volt Ni-MH Rechargeable Battery 300mAh (~ \$4) at:

http://www.ebay.co.uk/itm/BP-9V-9-Volt-Ni-MH-Rechargeable-Battery-300mAh-/120642915230?pt=UK_ConsumerElectronics_Batteries_SM&hash=item1c16e0cb9e#ht_2716wt_1265



14. BNC female with 4 holes flange solder connector adapter (~ \$2\$/pcs. X2) at:

http://www.ebay.co.uk/itm/BNC-female-4-holes-flange-solder-connector-adapter-/320698006057?pt=UK_ConsumerElectronics_SpecialistRadioEquipment_SM&hash=item4aab173a29#ht_4175wt_1 396

Then we will need some small components for the tuning part:

- R1, R3, R11 1K SMD type 1206
- C1, C2, C3, C4, C5, C9, C10, C11 0.1uF/50V SMD type 1206
- C6 2.2nF / 1.5KV, ceramic
- C7 10uF/16V Tantalum SMD TAJC106K016R
- D2, D3, D4, D8, D9, D10, D11 1N4004 (or any other small rectifier diode)
- D1, D5 1N4148
- T2 BC338 (or any other NPN transistor in plastic case able to drive the relay)
- L1, L4 25T (0.1mm) on FT50-43 (with space between turns for smaller parasite capacity

The schematic



How to build

You have to follow the below main steps. Further details will be added based on the feedback from the readers of this document.

Antenna side

1. Build the mechanical part of the antenna

Looking at the following pictures you will understand the concept and adapt it to your available materials. The main loop is made from 3m of CNT400 coax (with PL259 connectors at both ends and braid soldered together with the central pin. The coupling loop is made from 60cm of RG58/U cable. Again, the braid and central wire are soldered together at both ends and connected to another piece of RG58 which is connected at the other end to the main PCB.

The vertical tube is made from 2 pieces of 25mm diameter PPR tube in order to be able to dismount it.



Because the RG58 cable is passed through the tube, you need to let a piece of around 10cm to pass out from the tube in the back of the variable capacitor case in order to be able to extend the tube without forcing the cable. Both loops and the case are fixed to the tube using the standard clamps for the PPR tubes.



To couple the two parts, use a 32mm diameter PP black tube.



NOTE: In the following pictures you will see a smaller servo (micro type). This was not powerful enough to securely drive the capacitor and was changed with the 3003 model. The micro switches are missing too. Concentrate only on the mechanical part.





2. Modify the servo for continuous rotation and no motor controller

In order to use the RC servomotor for variable capacitor control you need to modify it. By default it can rotate only around 120 deg and must be controlled through 3 wires using impulse wide modulation. You need to:

- a) Remove the angle limit
- Follow the procedure presented in the following YouTube video ONLY TILL THE MINUTE 3:37

http://www.youtube.com/watch?v=SK8mhnEzcvY

- b) Remove the electronic control board unsolder the PCB from the motor pins;
- c) Remove the integrated potentiometer mechanically connected to the servo shaft. This can easily be done without any effort, just extracting it together with the PCB.
- d) Add the filter composed from C9, C10, L2 and L3 directly in the servo case. Solder the SMC capacitors directly on the chokes pins and cover the components with a thermo contractible tube. The back of the servo will look like in the following picture;



- e) Follow the procedure in a) in reverse order to mount the servo back .
- 3. Draw and etch the PCB which will hold the variable capacitor and the rest of the components

The traces are not critical. The PCB will look like in the following pictures. Solder the SO239 connectors directly on the PCB.

NOTE: Solder together the ground and the central pin of the connector and then reinforce everything using epoxy glue (ex. POXIPOL).



- 4. Mount the two micro switches on a small PCB and solder this perpendicular to the main one
- 5. Fix the capacitor on the main PCB using 4 x 3mm screws

The two sections of the capacitor will be used in series, so the two stators will be soldered on the main PCB, to the two lateral SO239 connectors

- 6. Build the coupler between the motor and the capacitor from plastic or Teflon
- 7. Mount the rest of the components on the PCB, except the buzzer and the 4 diodes (D8, D9, D10, D11). This part is not yet built and uses a separate PCB. The document will be updated when finished. The whole module will look like in the following picture.





At the end the tubing part was painted in black for a nicer look... $\textcircled{\baselinetwidth}$

Tuner side

1. Draw and etch the double side PCB

This is the top side of the PCB.



This is the bottom side of the PCB



My prototype PCB was drawn by hand using a waterproof pink pen.

2. Solder all the components on the PCB

Use the following picture to place the components on both sides. Because no metalized vias were used, a very thin copper wire was used to link the top and bottom pads where they are under a big component (ex. the relay or the switches).



This is a picture of the back of the PCB with the SMD components mounted



Operating the antenna

You need to proceed as follows:

- Connect the antenna to the Tuner using RG58 (or any other type of 50ohm cable);
- Connect the tuner to the 9V NiMH Akk;
- Connect the tuner to the transceiver.
 NOTE: Do not use more than 10W (better 5W) with this antenna as you risk to blow the variable capacitor!!!
- Switch on the transceiver and select the desired frequency. For better tuning select AM mode.
- Use UP /DOWN buttons till you hear the highest level of noise. For faster tune press FAST (central) button in the same time
- Press PTT (in AM mode, in order to transmit a continuous signal and then again UP/DOWN buttons till you obtain the minimum SWR. In my case, with FT817 this mean no segment on the SWR display. This is possible for all bands between 40 and 10m.

You are now ready to use the antenna. Please be aware that if you change the frequency even in the same band, you need to follow again the tuning steps.

Document History

Initial version of the document (v1.0). It will be updated from time to time based on your feedback

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