Review

The Ciro-Mazzoni 'Baby' Loop

I think it's fair to say that we would all like an antenna system that is efficient, low noise, and which does not require a large amount of real estate.

Sadly, at least for most of us, 20m towers with multi-element Yagis are out of the question and therefore we must content ourselves with somewhat more modest objectives. So, after trying a number of 'compact' antenna systems I finally settled on the Ciro-Mazzoni 'Baby' magnetic loop.

This design offers continuous coverage from 6,600kHz to 29,800kHz, neatly covering 40m through 10m. Its power rating is 400W up to 15m and then 1kW on 12m and 10m. Note however that the controller is limited to 200W, so a linear amplifier has to be placed *after* the controller. Equally, if you are using a linear then it must be straight through in the receive mode so as not to disturb the automatic tuning algorithm. This also means that any ATU must also be in the bypass mode in receive.

Although only 1m in diameter, it weighs 16kg and will require two people to mount it. It arrived fully assembled and well packed in a large substantial cardboard box weighing 26kg, complete with its controller and 24V power supply. This was in July of 2015, and since then the controller has been replaced with the Mk-II unit, which is a significant improvement over its predecessor. I subsequently purchased this new controller, along with, at that time, the optional RS-232/485 interface. There also appears to be provision for an Ethernet port, although this option has yet to be made available.

The beauty of this controller is that it has its own tuning signal generator. In operation, one enters the desired frequency on the keypad, press the ENTER key, and the controller will disconnect the transceiver and connect the antenna to the internal tuning signal amplifier.

As with the 'Stealth' antenna reviewed in the July 2019 *RadCom*, if the new frequency is far removed from the existing frequency the actuator is driven at high speed in the required direction, with the SWR being continuously monitored. As soon as the controller detects the SWR reducing, then it switches to the fine tune mode where the motor is pulsed. Eventually a minimum is found, the tuning ceases, and the antenna relay re-connects the transceiver to the loop.

For further details, including RS-232 pinouts, setup, and Auto/Semi-Auto frequency tracking with Icom, Yaesu, Kenwood, Flex, Elecraft and Elad transceivers, see **[1]**. The controller works with *all* the Ciro-Mazzoni loops and the firmware is easily upgraded.

Mounting

One of the beauties of a mag loop is that height is of no advantage. For optimum SWR, Ciro-Mazzoni recommend mounting so that the bottom of the loop is between 1.5m and 2.5m above the ground, as shown in **Photo 1**. Any higher and the SWR suffers. Bearing in mind that there are extremely high RF currents and voltages present when transmitting, you will need to take precautions to ensure animals, children and adults cannot come into contact with any part of the loop. It is also prudent to ensure that no-one is in the immediate vicinity of the antenna, as some people are peculiarly sensitive to the very strong magnetic field. *[See also Safety Distances for Small HF Loop Antennas, Dr P de Neef, AE7PD,* RadCom *June 2016 – Ed].*

As the loop comes completely assembled it only needs mounting onto a pole. The maximum diameter is 60mm. In my case I used a 400mm length of 38mm x 2mm wall tubing and mounted this on a Yaesu G450C rotator. A rotator is by no means essential, but it does allow you to take advantage for interference rejection of the very deep null that occurs at right-angles to the plane of the loop. Whereas with a beam antenna you invariably rotate it such as to maximise the received signal, in the case of a loop it is more advantageous to rotate it so as to maximise the received signal to noise ratio.

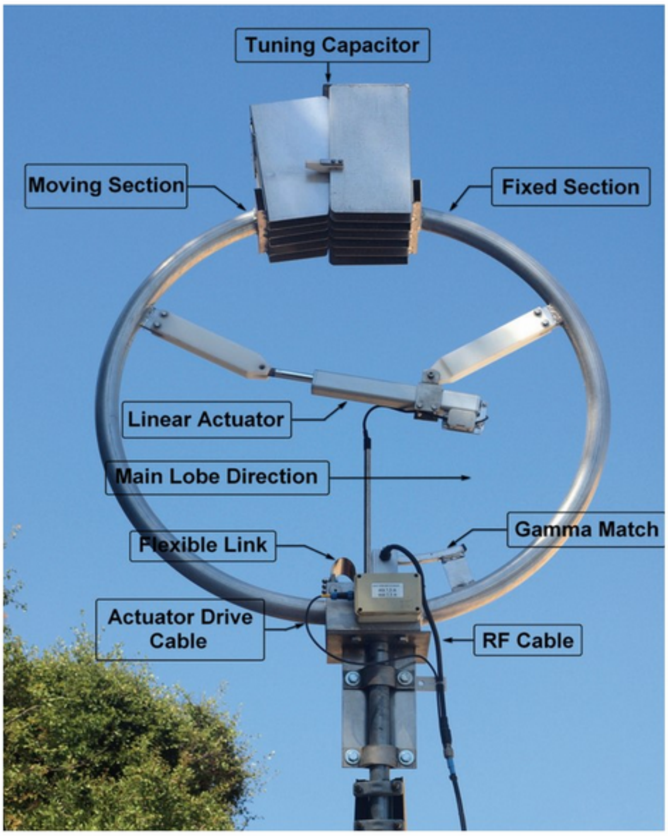

PHOTO 1: When mounting the loop, height above ground is no advantage.

The controller is connected to the loop by means of a 2-core cable for the motor, and the usual PL-259 terminated coaxial cable for the RF feed. The motor cable is fed through a compression gland and is connected to a 'choc-block' connector. The 'sense' of the connection is unimportant, as this is 'discovered' by the controller during the setup procedure.

In my case, I modified the connection and replaced the compression gland with a SP-13/IP-68 waterproof 2-pin plug and socket as shown in **Photo 2**. This was so that, if necessary, the same control cable and controller as used for my 'Stealth' loop could be used.

I also ensured that the 'sense' of the motor connection was identical, and this modification meant that testing and adjusting the antenna in the garden could be accomplished quite easily. I found that the cables tended to chafe against the antenna mounting plate as the rotator was turned, so I made a cable support arm using a piece of a domestic cutting board to hold the cable away from the support plate. *[We understand the manufacturer is looking into this – Ed].*

Importance of a flat feedline

The controller's algorithm relies on the fact that far from resonance the SWR is both high and constant. If there are discontinuities in the

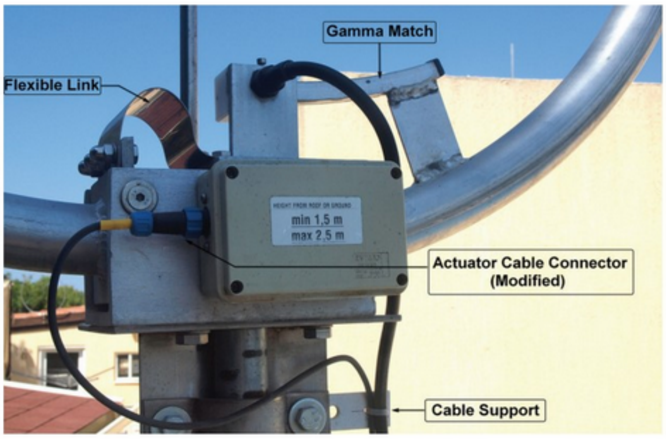

PHOTO 2: The modified connection that replaced the compression gland.

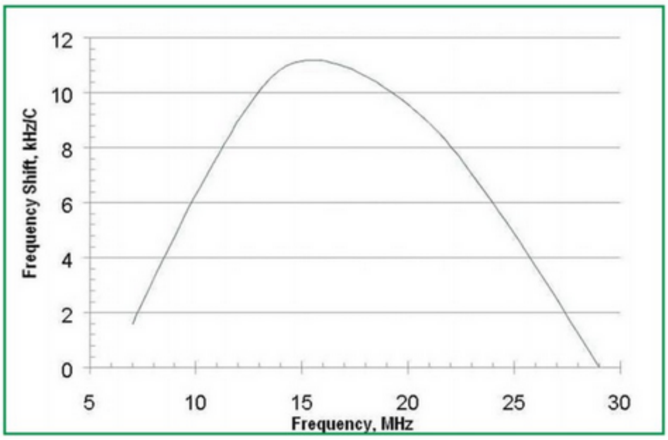

FIGURE 1: The correlation between frequency shift and temperature.

transmission line, this introduces false nulls, which seriously confuses the controller. I discovered this when I moved to my new QTH. When the antenna was mounted, the original RF cable was too short, so I extended it with a 5m length using a SO-239 bullet. This worked for a while, and then one day I found that the antenna would no longer tune. After some head scratching I put my spectrum analyser and tracking generator to work and swept the whole thing from 6 to 30MHz and discovered a number of odd peaks and troughs. Using my network analyser in its Time Domain Reflectometer mode quickly established that there was a discontinuity some 20m away from the shack – the SO-239 bullet! The moral is to only use a continuous length of coaxial cable!

Temperature sensitivity

Whilst operating JT-65 one day in the summer I was somewhat puzzled to find that throughout the day the SWR was constantly changing. This caused me to investigate the temperature sensitivity of the antenna. I set the antenna to the centre of an amateur band very early in the morning, and then measured the resonant frequency and temperature throughout the day. As expected there was a strong correlation between frequency shift and temperature, as shown in **Figure 1**.

On reflection, this is hardly surprising; the antenna is made from aluminium, which has a high coefficient of expansion, along with the actuator motor's nylon mounting bars. The net result is that as the temperature increases the antenna expands, opening the tuning capacitor and increasing the resonant frequency. This effect is greatest on the 20m and 17m bands, as can be seen from Figure 1. Whether this is of concern depends upon your operating habits. In general, it would only really be significant if you are operating on a relatively fixed frequency using a mode such as FT-8 in a contest. It is easily corrected simply by pressing the ENTER key on the key pad to force a re-tune operation.

A secondary effect of this temperature sensitivity was an inability to tune to 6,600kHz when the temperature was higher than 38°C. This was easily corrected by slightly moving the position of the clamp on the actuator body. Be aware however that as little as 2mm of movement will change the resonant frequency at the low frequency end by 50kHz.

Power supply

The controller requires a power supply of 24V and draws approximately 70mA in the idle state, 430mA when driving the actuator at full speed, and about 130mA in the fine tune mode when stepping the motor. The PSU supplied with my unit in 2015 was a switch-mode 'wall wart' plug-in supply, and sadly it proved to be something of a hash generator. Bear in mind that my QTH is extremely quiet, with the noise floor on 20m during the day time at about S2/S3, so *any* additional noise is audible. I made a simple unregulated 24V linear power supply that completely eliminated the noise. The supply does not need to be regulated, as a little 'reverse engineering' confirmed that the 24V is only used directly by a L298N 'H'-Bridge motor controller that drives the actuator's motor. The controller contains a LM2594 switching converter that reduces the incoming voltage down to the necessary logic voltages. Tests have shown that the actuator's motor will operate even down to 6V quite reliably, so a regulated 24V supply really is unnecessary.

How does it work?

I was somewhat taken to task by one correspondent with my Stealth loop review for failing to explain how the antenna works, so, suitably chastened, here is a brief review. Are you sitting comfortably? Good, then I'll begin. Once upon a time, in a land far, far away…

The problem with electrically shortening an antenna is that its radiation resistance drops dramatically, leading to poor efficiency and difficulty with matching. The usual 'cure' is to add inductance to compensate for the inherent capacitive reactance of a short antenna, but these inductors have their own losses. To try and minimise this, capacity 'hats' are added to the ends of the antenna to reduce the amount of inductance required, but even so, efficiency still suffers.

Vertical antennas are a possible solution, but they too have their difficulties. To obtain a reasonable efficiency you need at least 32 radials of ¼ wavelength, which can be difficult to accommodate.

Enter the magnetic loop. Loop antennas have been around in one form or another almost from the beginning of radio, but were mostly used for reception. Many of you will doubtless remember the attaché case portable radios popular in the 60s with a frame aerial in the lid that, in fact, was a multi-turn tuned loop. Direction finding antennas were also tuned loops, so it was quite well known that loops could make reasonably good receiving antennas, but little was done to investigate their utility as a transmitting antenna. Nevertheless, a tuned, single-turn loop can be made into a reasonably efficient transmitting antenna if certain principles are followed.

The earliest reference I could find describing a practical transmitting loop is **[2]**, and since then a number of commercial and amateur loops have appeared. **[3]** is a reference to this same antenna used for amateur purposes, but apparently not very successfully.

The essential feature of a small transmitting loop is that its circumference should be short,

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around 1/8 λ to 1/10 λ, and, if this is met, then the current distribution around the loop at resonance is essentially uniform. Unfortunately the radiation resistance of such a short loop is extremely low, of the order of 0.01Ω to 0.02Ω. This being so, in order for the loop to be efficient the loss resistances must be of the order of 0.001Ω, which is hard to achieve.

To achieve a low loss, the loop must be constructed of large diameter low resistivity tubing to minimise skin effect losses. Either aluminium or copper is usually used. In the case of the Baby Loop, it is 50mm x 2mm aluminium tubing. The next problem is that of tuning the antenna. Here a variety of methods exist, but for high powers either an air-spaced or a vacuum dielectric variable capacitor is used. This latter component is not ideally suited, however, as the contact resistance of the mounting clamps, as well as the maximum RF current rating tend to restrict its use (as well as the mechanical difficulties of rotating it). The C-M loop uses an air-spaced capacitor that is integral with the loop and is TIG welded to minimise resistance.

In operation, as can be seen in Photo 1, one half of the loop is fixed, and the other half can open and close, moved by the linear actuator, and in order to minimise the resistance and avoid RF currents flowing through the pivot, a substantial flexible link is bolted with six screws joining both halves of the loop.

Since the loss resistance is very low, the Q of the tuned loop is very high – it has to be, otherwise your expensively generated RF simply warms up the resistances. If that was your intent, then there are certainly cheaper ways of doing it!

This high Q tuned circuit – 1,100 at 7MHz – inherently has a narrow bandwidth that means that any frequency change will require re-tuning. On the other hand, it acts as a good harmonic filter as well as a narrow-band front-end pre-selector, both of which are desirable characteristics.

The next problem is that of coupling power into the loop. There are a number of methods, but the two main contenders are the auxiliary loop, as used by MFJ, and the gamma match, as used by Ciro-Mazzoni. Recall that for a small loop at resonance the current distribution around the loop is essentially uniform. The voltage distribution however is a maximum at the capacitor, and tapers off as you move away, until at a point diametrically opposite it is zero. This is the neutral point. Therefore, at some point around the loop from the neutral point the V/I relationship will be 50Ω. Consequently, if the screen of the feeder is attached to the neutral point and the centre conductor to the 50Ω point, a good match into the loop will exist and it will be easy to inject power. The only drawback is that this leads to some asymmetry in the radiation pattern with the main lobe in the direction of the gamma match and about a 6dB front to back ratio.

Unfortunately, this nominal 50Ω point varies with frequency but in practice the loop coupling is optimised at the lowest frequency because as the frequency increases so does the radiation resistance, and, all other things being equal, so does the efficiency, so that even at the highest frequency the match is still reasonable despite not necessarily being optimum.

Local interference rejection

Most local interference is electrostatic in nature, and since a magnetic loop responds primarily to the H-field component and not the E-field, this local source of noise tends to be rejected, leading to an antenna system that is remarkably quieter than dipoles, verticals, or beams.

Performance

All this is well and good, but, how well does it perform? Most reviewers at this point tend to relate the QSOs they have had and use this as an indication of antenna performance. Unfortunately this does not take into account the vagaries of propagation, location and other factors. After all, if one can couple power into it, almost anything will radiate – the question is, how well?

To answer this I use a WSPRLite transmitter and run tests over a 24 hour period to establish just how far the 200mW signal can be received. This at least gives a baseline performance of the antenna, and from the received signal strength reports some inferences can be made as to the likely performance for other modes. **Table 1** lists the 10 most distant contacts on 40m over a 24 hour period. Where there were multiple hits, the average signal-to-noise ratio is used. **Table 2** lists a similar record of the 10 most distant contacts on 30m also over a 24 hour time frame. **Table 3** lists a similar record of the 10 most distant contacts on 20m also over a 24 hour time frame.

Final Comments

Whilst this antenna is never going to compete with a 3-element Yagi on a 40' tower, as can be seen, the C-M Baby loop can give a very good account of itself and, for someone looking for a compact antenna, this should certainly be on your short list. The main drawback is that, being a very high-Q antenna, it is necessary to re-tune for even a small change in frequency, however, this can be done automatically by linking the RS-232 port of the controller with your transceiver, see [1] for details. Offsetting this however, is the fact that local interference is rejected, and this might well be the deciding factor given the amount of signal pollution on the HF bands today in both city and urban areas.

The manufacturer claims that the gain compared to a λ/2 dipole is -4dB at 7MHz, and -0.3dB at 28MHz. Note this is with respect to an optimally mounted dipole, and few of us can actually manage to erect one at the optimum height, and thus in practice the loop is likely to be somewhat better than these figures might suggest.

TABLE 1: The 10 most distant contacts on 40m over a 24 hour period.

Callsign	Distance, km	SNR, dB	Count
KD2OM	8,822	−23	16
N2HQI	8,755	−25	2
KB1MH	8,496	−30	1
WA9WTK	8,469	−25	3
TF3GZ	5,020	−25	1
EA8BFK	4,398	−24	1
EI7HZB	3,787	−25	8
SA3LLL	3,545	−26	2
MOUNI	3,397	−26	2
G8ORM	3,392	−28	1

TABLE 2: The 10 most distant contacts on 30m over a 24 hour time frame.

Callsign	Distance, km	SNR	Count
WD4AH	10,114	−23	3
K9AN	9,697	−27	3
KD2OM	8,822	−24	6
N2HQI	8,755	−27	3
TF4M	4,979	−17	4
TF1VHF	4,881	−25	15
EA8BVP	4,568	−25	11
EA8BFK	4,398	−23	5
SA2LLL	3,545	−22	24
SM2KOT	3,523	−22	2

TABLE 3: The 10 most distant contacts on 20m also over a 24 hour time frame.

Callsign	Distance, km	SNR	Count
VK3WHO	14,086	−18	10
PI9ESA	2,969	−13	15
PA3ANG	2,898	−26	1
OH2BT	2,895	−17	1
PI4THT	2,833	−19	15
OZ2BRN	2,808	−21	4
DK8JP	2,805	−23	8
DLOHT	2,781	−21	3
DB4YP	2,722	−26	3
DF5FH	2,695	−19	11

Suffice to say that I have been very pleased with both the quality of construction as well as the results I've obtained, in addition to the support I've received from both Martin Lynch & Sons and Ciro-Mazzoni, and, if this antenna were to be destroyed, then I would *have* to replace it with another Baby Loop. The loop currently costs £1229.95 from www.hamradio.co.uk.

References

[1] Adrian Ryan, Ciro-Mazzoni 'Stealth' Antenna Review, *RadCom,* July 2019, pp 30 – 32.

[2] K. Patterson, Down To Earth Army Antenna, *Electronics,* August 1967.

[3] L. McCoy, The Army Loop In Ham Communications, *QST*, March 1968, pp 17 – 18.