Build a Multi-Band Mono Delta Loop

For 40, 30, 20 and 15 Meters.

Jose I. Calderon (DU1ANV)
Makiling Amateur Radio Society (MARS)

[This article is dedicated to our fellow MARS’…ian, Louie/4F1AAZ, who passed away many years ago. He squeezed-in all possible efforts into his retiring years to dedicate his time in amateur radio. His legacy as a true home brewer is an indelible mark in the history of our Radio Society. We will remember him for his top quality craftsmanship on his home brewed projects. Many of the equipment and amateur radio accessories used by the MARS’…ians today bears the quality mark of Louie.]

Field Days and other outdoor Ham Radio activities are always exciting. As soon as the set-up is completed, everybody scampers like a pack of wolves to grab the microphone to announce that DX1MK/MARS is on the air and ready for operation. Added to this, the first operator will definitely would like to operate in his own preferred band. The next operator will then grab the microphone and switches the transceiver immediately to another band. Pandemonium breaks loose in a short-while. One will shout Hey OL’man! We can't operate in that band. The antenna system is not for that band! Then someone would shout, What??? The excitement will then dwindle and the poor Chairman is blamed for the disarray.

As usual, this problem crops up during club meetings at MARS whenever field days are planned. One day, a special meeting was called to discuss the participation of the Society to the up-coming Asia Pacific Boy Scout Jamboree to be held at the Mt. Makiling Scout Reservation in Los Baños, Laguna. Also, the next JOTA activity is fast approaching. We had exactly one month to spare before the JOTA activity. Planning and scheduling was always perfect except for one perennial problem... the HF antenna. It was always a “finger pointing scenario” to see who is going to give-in and dismantle his home QTH antenna to be used in the coming field day activity. It was at this point of that special meeting that the majority of the members unanimously tabled and voted to assist the chairman of the “Field Day Committee” to produce a portable HF antenna for Club use. At this meeting, the group finally decided to solve this problem once and for all! .... Find and construct a practical but simple antenna that can be carried by anyone, with or without a transport. It must be easy to set-up. And, the antenna must be capable of operating in several favorite amateur bands at a moment's notice. The club meeting was adjourned and soon enough, the members polarized themselves to ponder with the executive resolution.

Immediately after that raucous meeting, I went to work in my ham shack's library. I dug through my aging file of references. Then I remembered vividly a magazine which I bought some years before in a nearby magazine stand while visiting the British Museum in London. Digging through the magazine files, I finally found it. It was an old British "Radio communication" (January 1987) magazine, a publication geared for the consumption of European Hams. A compact multi-band antenna by GM3AXX with interesting features that fits our MARS needs. In addition, the antenna described was a delta loop configuration, which adds a plus due to its known performance to have a directional gain over a dipole. It can be erected anywhere and easy to install. The
substance of the article was exactly what we needed. By the sheer need of the Club, I constructed one unit based on the general specifications given. The antenna detail is shown in Fig 1.

![The Multi Band Delta Loop](image)

**Fig 1.** Construction and setup of the multi band mono delta loop. See text for the band switching detail.

So! .... One early morning at the beginning of the JOTA activity, a weird looking wire loop appeared tethered in one branch of the big acacia tree at the Boy Scout camp. I was making the tune-up adjustments while the curious boy scouts were gathered around. I finally cautioned the boy scouts by ordering them to back off from the antenna. A few meters near the acacia trunk, the operating table was surrounded by the MARS'ians. Each wanted to grab the only microphone and make the first contact. The first call instantaneously caused a Pile-up Hi Hi! Chairman Louie/4F1AAZ, (now Silent Key) was highly excited and responding to individual calls. In the late afternoon, it was time to demonstrate to the boy scouts the exciting world of amateur radio. We switched the band to 20 meters. Louie initiated the first call and got an immediate response. I remember one station in Vancouver, Canada was frantically requesting for an RST report and his turn to QSO with other JOTA participants. I watched the whole procedure as each scout scrambled to get a chance to talk to the Canadian station. The exciting atmosphere led me to open a bottle of cold beer. As I made the first gulp, a happy feeling crept around me and then said to myself ... that mono delta loop is doing fine. MARS's frustrations is now a thing of the past, I mused.

This antenna served in many more JOTA activities in the years that followed. It also saw service during the famous Asia Pacific Boy Scout Jamboree held at Mt. Makiling in Los Baños, Laguna where it transmitted RF energy around the Southeast Asia Region and Oceania under its callsign, DX1APJ. The local Boy Scouts and those representing these regions in the camp were happy. And most of all, our chairman Louie/4F1AAZ
was so filled with great satisfaction that he went to the extent of sequestering the antenna for keeps. Thereafter, the antenna materializes only during field days!

**Construction of the multi-Band Delta Loop**

GM3AXX described briefly the construction and adjustment but I have translated it according to my own style of writing to clarify some salient points. The following steps were adopted while constructing the MARS multi-band mono delta loop:

1. Make up a 14 MHz. delta loop using two separate lengths of 10 meter plus 10 centimeters each of No. 12 or No. 14 stranded copper wire and connect them in series with an insulator as shown at the bottom of Fig 1. The 10 cm extra wire is passed through the end hole of the insulator then looped back to the wire element to form a splice for later soldering. Do the same to the other wire but at the opposite end of the insulator. Now, cut two pieces of extra antenna wire, about 90 centimeters each. Splice one end of each wire separately at each terminal junction of the loop antenna and insulator and solder the splice. These wires will form the pigtailis (marked X and Y in Fig 1.) and they will be trimmed later during tune-up.

2. Feed the loop at its apex (marked as F, F in Fig 1) with RG-8 or RG-58 coax cable (any length) through a PL-259 connector. The coax feed detail used in the MARS antenna is shown Fig 2 below:

![Diagram of MARS antenna](image)

**Fig 2.** Mounting detail of the wire elements to the SO-239 coax connector. Use a plate of appropriate size made of phenolic, Plexiglas or acrylic plastic for mounting the SO 239 (see illustration).

In the MARS antenna, I used a Plexiglas plate. This is the kind used by bus companies for bus windowpanes. Thanks to Allen (now DV1AIR). He retrieved this chunk from the Kapalaran Bus line’s junk yard in Santa Cruz Laguna. Nevertheless, you can use any kind of insulator including phenolic boards, PVC and or acrylic.
plastic. This plate has a dimension of 15 cm X 6 cm and about 5 mm thick (or thicker). The size depends on your preference but strength of the plate is required as the same plate will hold the SO-239 and whole antenna when suspended. Six (6) equidistant small holes must be drilled along a center line in this plate, 3 to the left and 3 to the right side of the SO-239 mounting hole to accommodate the feed-through wire elements (to serve as anchors) and nylon string (see drawing in Fig. 2). Of course, solder the end of the wire elements (marked F, F) to the SO-239 terminals as shown in the drawing.

3. Suspend the loop at its apex about 30-35 feet above ground (a pole or a tree). When the antenna is mounted, the base corners are held taut via insulators with nylon ropes and tied to any support so that the bottom’s section is about 4 feet above ground. Warning: It needs to be higher if there is risk of people especially children touching the wire ends (wires marked “X” and “Y” and the associated switching circuit).

4. Make up a ground post high enough to reach the middle bottom of the loop. Use this to support the switch board insulator. This insulated board is where the terminal lugs are to be installed and to which the pigtail wires (X and Y) are to be connected when changing band. Form a phenolic board, or whatever is available that is an RF insulator (Caution: these are high voltage points. Be careful! Do not try anything else. Otherwise you will turn your switch box into a “Smokey box”). Here is the portion that needs your amateur ingenuity. You can drill holes in the phenolic board and install brass bolts with nuts to serve as the terminal lugs. This is the system of switching in the MARS antenna. Sturdy alligator clips were soldered at the end of each pigtail so that switching is done manually to change bands by clipping these alligator clips to each respective pair of terminal lugs. The distance between each terminal lug is not critical but for easier transfer of the alligator clips when changing bands, a minimum distance between brass bolts of 5-6 cm is adequate. Otherwise, you can install a high voltage rated ganged switch if you prefer. These ceramic switches are usually found in radio electronic surplus stores selling used broadcast station spare parts. I think GM3AXX used this type. Make sure those terminals “A” hold the loading coil for the 10 MHz band. Terminals “B” are "open" for the 7 and 21 MHz band and terminals “C” is a "shorting stub/wire" of adequate wire size for the 14 MHz band. These are shown in Fig. 3 below:

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**Fig 3.** Construction of the band switch. L1 = 25 turns of # 14 enamel solid copper wire wound in a 2 inch Ø PVC tube. L2 = Shorting wire stub. The B terminals are open.

**Switch Positions:**
- A = 10 MHz
- B = 7 MHz & 21 MHz
- C = 14 MHz
The principle of the Multi-band Mono Delta Loop

This ingeniously designed single wire loop antenna works in 4 amateur bands in a delta shaped configuration (hence I called it a multi-band mono delta loop). It occupies a small space yet it works like a gem. Thanks to the designer, GM3AXX. I have drawn the illustrations to analyze the electrical characteristics of the completed loop antenna. This is shown in Fig 4 below.

![Illustration of multi-band mono delta loop antennas](image)

**Fig 4.** The Four electrical properties of the multi-band delta loop. The principle is shown in 1, 2, 3 and 4 illustrations for each operating band.

The loop's physical properties and the respective bands where it will resonate are explained below:

1. When the pair of pigtails is connected to terminals “C”, the loop is completed via \( L_2 \) (a shorting stub wire). This brings the whole loop to assume a full wave delta loop which will resonate at 14 MHz (20 meters). See drawing “1” in Fig 4.

2. When the pair of pigtails is transferred to terminals “B”, the B terminals are open and the loop assumes an inverted V-dipole in delta loop configuration. By virtue of the physical length of the wires, this delta shaped dipole will resonate at 7 MHz (40 Meters). The same configuration is \( 3 \times \frac{\lambda}{2} \) of 21 MHz, which is the odd harmonic of 7 MHz (its 3\(^{rd}\) harmonic). Hence, the same antenna will resonate in the 21 MHz band (15 meters). See drawing “3” and “4” respectively, in Fig 4.

3. When the pair of pigtails is transferred to terminals “A”, the loop is completed via \( L_1 \) (an inductor coil). This inductance will serve as a series loading coil to
bring the loop to appear as if it is a full-wave antenna at 10 MHz (30 meters). See drawing “2” in Fig 4.

The physical lengths of the antenna components are calculated following a similar method for estimating wire lengths of full wave loops. The example of the loop’s electro-physical size calculation at various bands is shown in Table 1 below:

**Table 1.** The relationship of calculated physical lengths and resonant frequency of the loop when operated at various selected bands.

<table>
<thead>
<tr>
<th>Meter Band</th>
<th>MHz</th>
<th>Electro-physical Wavelength (E-P)</th>
<th>1(\lambda)</th>
<th>½(\lambda)</th>
<th>¼(\lambda)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Meters</td>
<td>Feet</td>
<td>Meters</td>
</tr>
<tr>
<td>40</td>
<td>7.050</td>
<td></td>
<td>43.404</td>
<td>142.365</td>
<td>21.702</td>
</tr>
<tr>
<td>30</td>
<td>10.000</td>
<td>Loaded full wave</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>14.100</td>
<td></td>
<td>21.702</td>
<td>71.182</td>
<td>10.851</td>
</tr>
<tr>
<td>15</td>
<td>21.150</td>
<td>The 40 meter dipole is operated at its 3(^{rd}) harmonic ((= 7.234 \times 3 = 21.702 \text{ M}))</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Where \(\lambda_{E-P}\) (Linear meter) = \[
\frac{306}{\text{Freq. (MHz)}}
\] 1 linear meter \(= 3.28\) Feet

Hence, the mono delta loop will operate in 4 separate amateur bands by merely transferring the pair of pigtails in the respective terminal lugs (see Fig 1).

**Tuning the antenna**

From the analysis of the principle of this antenna as earlier discussed above, the builder should take note of the relationships of the various operating frequencies selected. Particularly, the 40 meter band (must be ½\(\lambda\)) and the 20 meter band (must be \(1\lambda\)). Therefore, it is mandatory to follow a step by step procedure dictated by the logic of the data shown in Table 1.

Below is the procedure I developed for tuning the MARS mono delta loop:

1. **This is the first step and foremost** –
   1.1 Select your operating frequency in the 40 meter band (example – 7.050 MHz)
   1.2 Connect the pair of pigtails \((X\ and\ Y)\) to terminals “B” and check VSWR.
   1.3 If the lowest VSWR reading is far below 7.050 MHZ, this means that the pigtails are long. Trim (cut and shorten) the pigtails equally by removing 1cm at a time until the lowest VSWR is at 7.050 MHz. If the lowest VSWR occurs...
above 7.050 MHz, this means that the pigtails are too short (you must add length). This scenario however is unlikely because the length of the pigtails have been pre-cut longer than calculated.

1.4 Once everything is OK, then proceed to step 2.

2. Now, Transfer the pair of pigtails to position "C", and check VSWR at 14.100 MHz. Lowest VSWR should occur in this frequency.

   2.1 If the lowest VSWR occurs far above 14.100 MHz, the antenna is short. You must lengthen the shorting stub (marked L₂) to form a long legged “U”. Adjust (trim) the length of this stub until you attain the lowest VSWR at 14.100 MHz. Or, to whatever frequency you prefer but must be above 14.100 MHz and within the 20 meter amateur band.

In the MARS antenna, it was tuned to 14.250 MHz. The stub was about 20 centimeters long when stretched and then folded to form a “U”.

(Note: DO NOT and NEVER again disturb the lengths of the pigtail wires during this tune-up step)

3. The final step - Then, and only then, that you switch to position "A". It is necessary to tune position "B and C" first, in that order, before attempting to tune position "A".

Transfer the pair of pigtails to switch position "A". Adjust loading coil (marked as L₁) until loop resonates at 10.125 MHz. GM3AXX’s coil was 20 turns on a 2-inch coil former but I suggest that you start with 25 turns, then remove one turn at a time until the loop resonates.

This frequency band is optional. The builder can opt to disregard this feature but if you are a CW and FSK nerd, then construct the coil which is very easy to make. Louie/4F1AAZ made one and added this feature so we can also monitor clearly the UTC time signals of the atomic clock of WWVH (Hawaii) at 10.000 MHz. We also monitor this frequency to serve as time and frequency standards to synchronize wrist watches, ham shack clocks and calibrate radio receivers and transceivers.

This completes the tune-up! You can now enjoy multi-band operation with the 4 in 1 delta loop.

Installation and Tune-up Notes

Similar to other antenna home brewing projects, careful tune-up is essential once the antenna is installed in the selected area. The frequency of resonance is affected by physical objects that exist within the vicinity of the high voltage RF points of the loop. Another critical factor is the height of the antenna above earth ground. These factors will affect the wire element lengths. This is the reason why all calculated physical lengths must be cut with extra lengths added (the pigtails) so they can be trimmed during tune-up. Tuning the 20 meter band to your desired frequency is a little tricky. If your resonant frequency is still too low in this band, the only remedy is to compromise by shortening further the pigtail lengths (X and Y) to bring the frequency selected in the 40 meter band higher by a few hundred cycles up until the antenna resonates at the
selected frequency in the 20 meter band, when the pigtailed are transferred to Position 
"C". In the MARS antenna, these were trimmed also.

The antenna should be installed somewhere and as far as possible from solid objects 
such as plants and leafy branches of trees. Whenever the antenna is transferred to 
another location, it is mandatory to re-check the resonant frequency of each band 
before firing the transceiver.

As usual, the loop will perform at its top efficiency when installed in the clear. Loops can 
be made to radiate RF energy more efficiently when the wire elements are well spread 
apart. This means that the proper placement of the two insulators at the lower corners 
of the base of the triangle (Delta) is critical. A practical guide is to draw an imaginary 
circle with the widest diameter that when placed inside the triangle, the 3 inner sides of 
the delta loop are barely touching the outside circumference of that imaginary circle. In 
the MARS antenna, these two insulators were made movable to adjust the sides of the 
triangle formed when these were held taut by the anchor nylon ropes.

If the antenna is installed permanently at the home QTH, it can be installed in the 
garden or any other open space where people especially children cannot reach the 
band switch. If installed this way but can be reached by hand, then you can change 
bands manually. You can stop transmitting. Run downstairs and on to the garden, 
switch band and back to the ham shack. Remember however the caution. Do not run 
down the stairs if you did not switch OFF your VOX. If you forgot to switch OFF your 
VOX, and your dog barks or your cat is in heat, any barking or meowing will fry you 
right there in the garden in the middle of the night while tinkering with the terminals. 
This happened to me. Luckily however, my fingers were not fried but my expensive 
Palomar Engineers R-X Noise Bridge was cooked while doing the preliminary tune-up 
of the loop.

**Performance of the completed antenna**

The antenna has a gain that is broadside to the plane (front and back) of the loop. The 
radiation pattern looks like a figure "8". It is up to you to decide how you are going to 
orient it. This will depend on your favorite azimuth coverage. In particular, the 
performance of the loop in the 15 and 20 meter bands were very satisfying. When the 
40 meter band is cooperative, we observed no appreciable difference between a true 
inverted-V dipole antenna and this delta configuration on local QSO contacts. There 
was enough latitude for frequency excursions above and below the resonant 
frequencies, typical to a full wave delta loop.

The completed antenna can be installed and dismantled easily but the most gratifying 
feature of this mono delta loop is its capability to work on different bands. This is 
especially useful when the antenna is used during field days and when setting up 
Amateur Radio communications in response to emergency situations.

The Amateur is Patriotic ... His knowledge and his station 
are always ready for the service of his country and his 
community — Paul M. Segal