Antennas

Loop antennas again

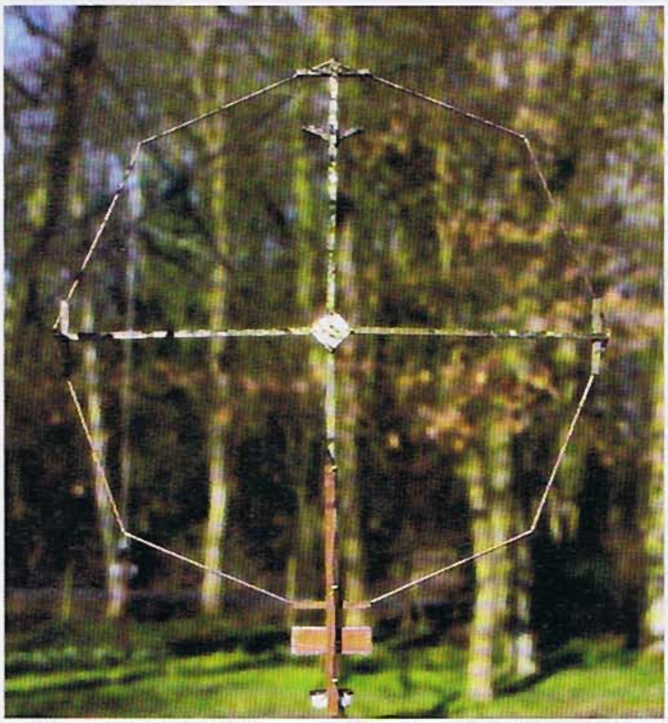


PHOTO 1: The G0UVR 11.70m diameter loop for 40 and 80m, almost perfectly camouflaged against the woody background.

BETTER THAN EXPECTED. Small transmitting loop antennas (sometimes referred to as magnetic loops) have been discussed in considerable detail, to such an extent that I felt reluctant to air this subject further. Additionally, some of this very detailed literature has been at the centre of controversy regarding the efficiency and effectiveness of these antennas. As a result I had avoided getting involved with them, that is until last year when I constructed one using a novel tuning capacitor design by G8JNJ and found that the antenna performed better than been I had been led to believe.

LOOP DESIGN PROGRAM. Ger Akse, G0UVR (PA0AXE), e-mailed me to say, "When we came to live at our present address in 1994, it became clear that I had to erect my aerials in a small wooded area, full with mature high trees. As the many branches and the canopies of these trees make it practically impossible to put up a dipole for the lower bands at a reasonable height, I decided with some reluctance to try a magnetic loop. Our move from using tank-gas to natural gas in 1996 had left me with a nice supply of 22mm diameter copper pipe.

"Before I decided to build a loop, I read whatever I could find about this type of antenna. I collected the formulae ruling the properties of magnetic loops and wrote a program in Turbo Pascal (under MS-DOS) to analyse the properties of magnetic loops".

The formulae used by the program are shown in **Figure 1**. **Figure 2** shows of the properties of the loop made by Harry Brash, GM3RVL, described in December 2010 Antennas. Assuming that the formulae are right and that the joints of the loop to the capacitor plates are loss-free, the efficiency figures should be reasonably reliable. Figure 2 shows that the efficiency on 30m drops to 36%, requiring tuning capacitor of 100pF. The bandwidth narrows to 8kHz.

GM3RVL suggested that his loop would cover 40m but on that band the efficiency drops to a mere 14%, the values for the tuning capacitor have to be increased to 203-216pF and the bandwidth narrows to 5kHz. I personally think that 30m is the lowest band that can used with his loop design."

G0UVR goes on to say: "In your article the importance of keeping the loss resistance as low as possible is stressed and rightfully so. However, getting the radiation resistance of the loop as high as possible is likely equally important. To do so the area of the loop needs to be increased. As bending a 3m length of 22mm diameter copper tubing into a circle was already described as hard work, increasing that length will make bending almost impossible. A circle, for a given circumference, has the greatest area (and thus the greatest radiation resistance) and can be constructed using 7/8in diameter hard-line coax.

"If that is not available there is the alternative of abandoning the circle and going instead for an octagonal or a square shape, using straight sections of 22mm tubing soldered together with angle joints. For an octagon seven angle joints of 45° are required; for a square we need only four right angle (90°) joints. From this point of view the square is to be preferred, however the octagon has a bigger area than the square. As I do not know how much RF losses the joints cause, it is impossible to say which shape would be better."

LOOP DESIGN FOR THE LOWER BANDS. G0UVR wanted a loop for 40 and 80m and chose the optimum size for 40m, being about 11.70m diameter. The loop is shown in **Photo 1**. This arrangement is upside down (compared with most loop designs) to allow access to the tuning capacitor for maintenance purposes.

The loop was constructed from six 1.50m and two 1.35m lengths of 22mm tube, arranged to leave enough space for the box containing the tuning capacitors. Two 500pF wide spaced capacitors in series (each good for 7.5kV) are used to tune the loop. The method of connecting the capacitors to the loop is best described by referring to **Photo 2**. Two flat pieces of tubing are bolted thoroughly on the stators of the two capacitors. They protrude through the Plexiglas top of the tuning box and their top-ends are again thoroughly bolted to the two bottom tubes of the loop.

The properties of this loop, calculated by the program, are shown in **Figure 3**. As the formula for loss-resistance does not take into account the losses in tube-joints, the losses in connecting the tube-ends to the capacitors and the losses in the capacitors, the efficiency figures may be slightly inflated.

COUPLING ARRANGEMENT. The coupling loop is a half Faraday loop, with the coax inner and braid at the apex connected. The loop is not made of standard coaxial cable such as RG213 and is described by G0UVR as follows:

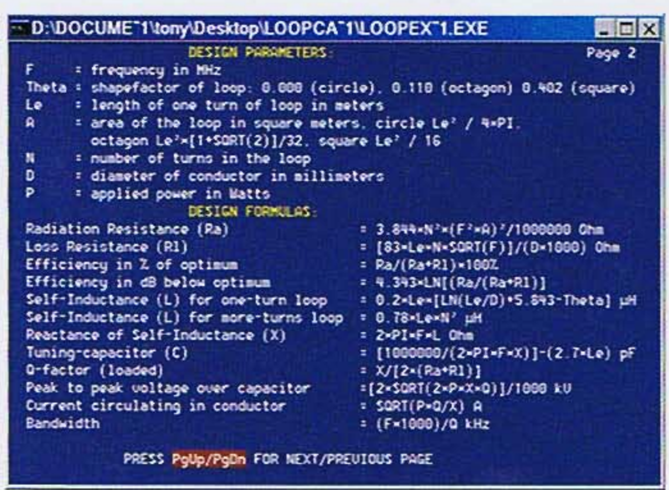
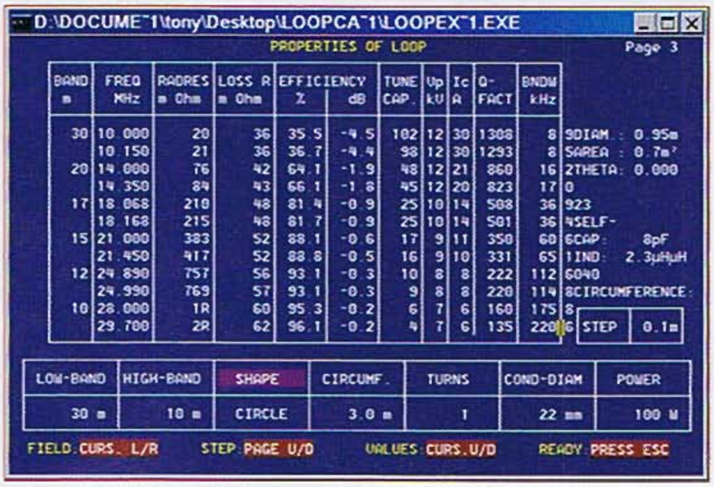


FIGURE 1: The formulae on which G0UVR's loop calculation program is based.


D:\DOCUME~1\tony\Desktop\LOOPCA~1\LOOPEX~1.EXE

PROPERTIES OF LOOP Page 3

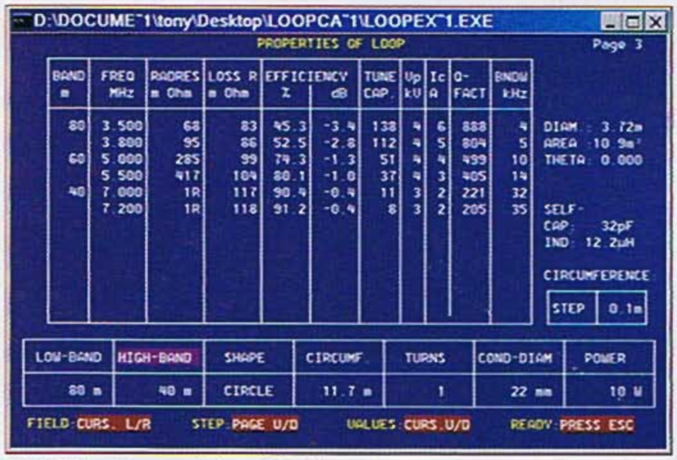
BAND m	FREQ MHz	RADRES m Ohm	LOSS R m Ohm	EFFICIENCY %	dB	TUNE CAP.	Up kV	Ic A	Q-FACT	BNDW kHz
30	10.000	20	36	35.5	-4.5	102	12	30	1308	8
	10.150	21	36	36.7	-4.4	98	12	30	1293	8
20	14.000	76	42	64.1	-1.9	48	12	21	860	16
	14.350	84	43	66.1	-1.8	45	12	20	823	17
17	18.068	210	48	81.4	-0.9	25	10	14	508	36
	18.168	215	48	81.7	-0.9	25	10	14	501	36
15	21.000	383	52	88.1	-0.6	17	9	11	350	60
	21.450	417	52	88.8	-0.5	16	9	10	331	65
12	24.890	757	56	93.1	-0.3	10	8	8	222	112
	24.990	769	57	93.1	-0.3	9	8	8	220	114
10	28.000	1R	60	95.3	-0.2	6	7	6	160	175
	29.700	2R	62	96.1	-0.2	4	7	6	135	220

9DIAM. : 0.95m
SAREA : 0.7m²
2THETA: 0.000
0
923
4SELF-
6CAP: 8pF
1IND: 2.3µHµH
6040
8CIRCUMFERENCE:
8
6 STEP 0.1m

LOW-BAND	HIGH-BAND	SHAPE	CIRCUMF.	TURNS	COND-DIAM	POWER
30 m	10 m	CIRCLE	3.0 m	1	22 mm	100 W

FIELD: CURS. L/R STEP: PAGE U/D VALUES: CURS.U/D READY: PRESS ESC

FIGURE 2: Characteristics of the GM3RVL loop on the bands 10 to 30m.


D:\DOCUME~1\tony\Desktop\LOOPCA~1\LOOPEX~1.EXE

PROPERTIES OF LOOP Page 3

BAND m	FREQ MHz	RADRES m Ohm	LOSS R m Ohm	EFFICIENCY %	dB	TUNE CAP.	Up kV	Ic A	Q-FACT	BNDW kHz
80	3.500	68	83	45.3	-3.4	138	4	6	888	4
	3.800	95	86	52.5	-2.8	112	4	5	804	5
60	5.000	285	99	74.3	-1.3	51	4	4	499	10
	5.500	417	104	80.1	-1.0	37	4	3	405	14
40	7.000	1R	117	90.4	-0.4	11	3	2	221	32
	7.200	1R	118	91.2	-0.4	8	3	2	205	35

DIAM.: 3.72m
AREA :10.9m²
THETA: 0.000
SELF-
CAP: 32pF
IND: 12.2µH
CIRCUMFERENCE:
STEP 0.1m

LOW-BAND	HIGH-BAND	SHAPE	CIRCUMF.	TURNS	COND-DIAM	POWER
80 m	40 m	CIRCLE	11.7 m	1	22 mm	10 W

FIELD: CURS. L/R STEP: PAGE U/D VALUES: CURS.U/D READY: PRESS ESC

FIGURE 3: Characteristics of his G0UVR's enlarged loop (see Photo 1) on the 40, 60 and 80m bands.

"The inner conductor is made from 5 or 6mm diameter brass or copper tubing. This is then covered with heat-shrink. The outer conductor is made from the braid of coax, which is then for weatherproofing covered with vinyl tape. In January 1997 I read an article in *PW* written by Des Heath, G3ABS, under the title 'Postage Stamp Loops'. He claimed that a coupling loop made this way provided better coupling than could be achieved using standard coax. Whether that is true or not, I do not know, but I made my coupling loop (which is 2.40m long) that way. For aesthetic reasons I shaped it the same as the main loop (ie octagonal) and clamped it on two sides to the main loop using PVC pipe clamps.

"Although the term 'small' may not strictly be applicable for a loop of this size, it is still very small in terms of wavelength. The bottom of the loop sits about 1m above the ground as shown in Photo 1 and the plane of the loop is in the East-West direction.

"As shown in Photo 2, the capacitors are driven by a small 1.5-3V electric motor via a multi-ratio gearbox (available from Maplin), set for 1 to 2 rpm.

"The loop worked from scratch and its performance exceeded my expectations. The antenna puts out a good signal all over Europe and, with good luck, I managed a QSO on 80m with Canada (Prince Edward Islands) and even with New Zealand on 40m. It has been in use since 1997 and so far the tuning motor has only been replaced once."

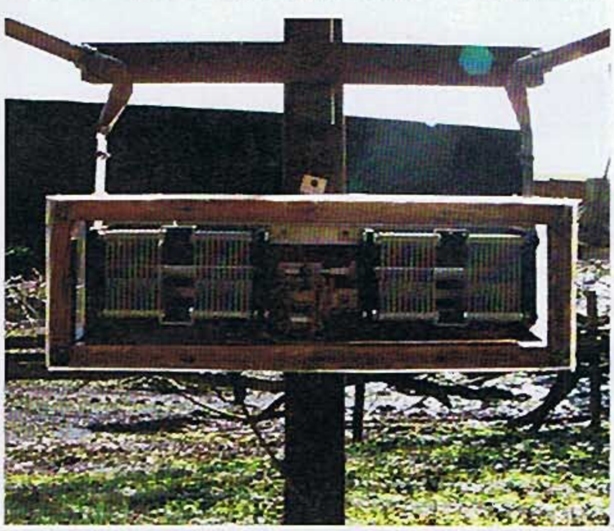


PHOTO 2: Detail of the tuning capacitance mechanism.

COMPARISONS. I made a model of the GM3RVL loop using *EZNEC*. This program uses a totally different method of calculating antenna performance to the method so far described, so a comparison seemed to be in order.

The gain of the GM3RVL loop on the 10m and 30m bands using the G0UVR's program (Figure 2) is -0.2dB and -4.4dB respectively, while the tuning capacitors required are 6pF and 98pF respectively. The same antenna, analysed using *EZNEC* on the same bands, resulted in a gain of 0.5dBi and –2.01dBi respectively, while the tuning capacitors required are 8pF and 88pF respectively. The gain reference for the G0UVR program is dB down from a 100% efficient antenna, while the *EZNEC* reference is an isotropic source.

In addition I used the loop calculation program from 66pacific calculators [1], described in September 2010 Antennas, to model this same loop on 30m. It predicts a gain -4.6dB below 100%. It also makes comments regarding the loop length relative to frequency, in particular that the conductor length for a small transmitting loop antenna should be greater than 1/8 wavelength.

The efficiency of a loop antenna falls dramatically as the loop size is reduced (or the operating frequency of a given loop is reduced). For example, the efficiency of the GM3RVL loop drops to a mere 14% when tuned down to 40m using a 210pF tuning capacitor.

CONTROVERSY. There is nothing more likely to put one off an antenna type than the label 'controversial'. It implies unproven performance. As I mentioned at the beginning of this column, these transmitting loop antennas have been discussed in considerable detail by eminent antenna experts, often with differing views regarding the antenna's efficacy, hence the controversy. [2] [3] and [4] represent a small sample of this discussion. However, note the variation in antenna efficiencies over the frequency range 10 to 28MHz shown in Figure 2.

If you have a restricted QTH and conventional antennas are a problem then the loop antenna could well be the one for you. Provided that you make the loop the appropriate size for the frequency bands of interest, keep the losses low using appropriate construction practices and don't position it close to electromagnetic obstacles then you could be pleasantly surprised by its performance.

Finally I leave the last word to G0UVR. "Encouraged by the success of the 80/40m loop I decided to make another two magnetic loops to take with me on camping holidays on the continent. The larger of the two has the maximum size for 20m and works on 40m also when I parallel the two tuning capacitors with a fixed capacitor made of double-sided PCB. In the late nineties I tried this loop when on holiday near Florence. It appeared to work fine on 20 and 40 and I even managed to work Japan on these two bands on 20m with good reports, albeit on 40 with some difficulty. The smaller one that I made a few years later has the maximum size for 10m and thus works down to 17m but not fully tested as yet because of the poor propagation on these bands."

REFERENCES

[1] www.66pacific.com/calculators.

[2] *Loop Antennas – Facts not Fiction*, Tony Henk, G4XVF, *Radio Communication* September/October, 1991.

[3] *Electrically-small transmitting loops*, Dr Jack Belrose, VE2CV, *RadCom* June/July 2004.

[4] *New truths about small tuned loops in a real environment*, Professor Mike Underhill, G3LHZ, *RadCom* August/Sept 2004.