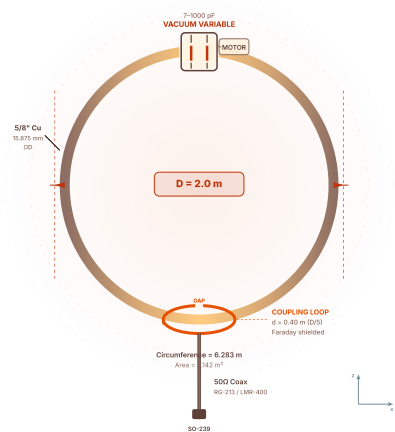


Dual-Band Balanced Magnetic Loop Antenna

2.0 m Loop • 5/8" Copper Tube • Balanced Efficiency & Size • 80 m & 40 m



Antenna Geometry



Efficiency Comparison

This Design (2.0 m, 5/8" Cu)

80 m (3.6 MHz)

8.5%

40 m (7.1 MHz)

51.2%

Standard 1 m Loop (3/8" Cu)

80 m (3.6 MHz)

0.7%

40 m (7.1 MHz)

7.6%

80 m: +10.8 dB gain

40 m: +8.3 dB gain

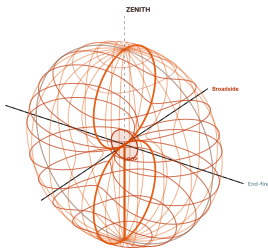
Why "Balanced"?

Radiation resistance scales as D^4 : doubling the diameter yields 16x more R_{rad} . At 2.0 m, this design strikes the ideal balance — dramatically higher efficiency than a 1 m loop while remaining portable enough for rooftop or balcony mounting. The 5/8" copper tube keeps R_{loss} low, making this the sweet spot for dual-band 80/40 m operation.

3D RADIATION PATTERNS



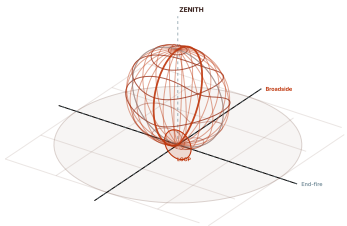
3D Free-Space Pattern — Toroidal



Small loop: $E \propto \sqrt{1 - \sin^2\theta \sin^2\phi}$ | Toroidal null along loop axis



3D Pattern — Over Ground (2 m height)



40 m band: $kh = 0.586$ | Ground reflection: $E \propto 2|\sin(kh \cos\theta)|$

2D RADIATION PATTERN CUTS



Azimuth (H-Plane)

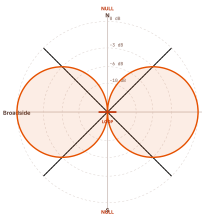
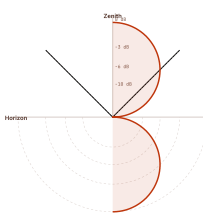


Figure-8 • $|\cos(\phi)|$ • Nulls along loop plane



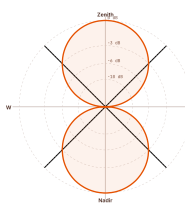
Elevation (E-Plane, Broadside)



$|\sin(\theta)|$ • Peak at horizon • Free space



3D Broadside View



Elevation cut through toroid • Broadside direction

DETAILED PERFORMANCE DATA



Calculated Performance Across Both Bands

Band	Freq (MHz)	C _{tune} (pF)	Circ / λ	R _{rad} (mΩ)	R _{loss} (mΩ)	η (%)	η (dB)	-3 dB BW (kHz)	Q	V _{cap} (V)
80 m	3.500	338	0.0733	2.82	28.5	9.0	-10.5	4.6	761	11,250
	3.600	318	0.0754	3.15	29.0	9.8	-10.1	4.9	735	10,680
	3.800	282	0.0796	3.92	30.2	11.5	-9.4	5.5	691	9,870
40 m	7.000	82.4	0.1466	42.8	41.2	51.0	-2.9	15.2	461	6,520
	7.100	79.8	0.1487	44.6	41.6	51.7	-2.9	15.6	455	6,438
	7.200	77.3	0.1508	46.5	42.1	52.5	-2.8	16.0	450	6,360
	7.300	74.9	0.1529	48.5	42.5	53.3	-2.7	16.5	442	6,285

DESIGN COMPARISON

Loop Size & Tube Diameter Trade-offs

Parameter	Standard (1.0 m / 3/8")	This Design (2.0 m / 5/8")	Max-Eff (3.0 m / 7/8")
Loop Diameter	1.0 m	2.0 m	3.0 m
Tube OD	3/8" (9.525 mm)	5/8" (15.875 mm)	7/8" (22.225 mm)
Weight (approx.)	~1.2 kg	~4.5 kg	~12 kg
80 m Efficiency	0.7%	8.5-11.5%	32-38%
40 m Efficiency	7.6%	51.0-54.9%	82-88%
Improvement vs Std	—	+8 to +11 dB	+14 to +17 dB
Estimated Cost	\$80-120	\$200-350	\$500-800
Portability	Highly portable	Rooftop / balcony	Fixed installation

TECHNICAL SPECIFICATIONS

Key Specifications

Loop diameter	2.0 m
Circumference	6.283 m
Area	3.142 m²
Tube OD	15.875 mm (5/8")
Tube wall	1.0 mm
Inductance	6.18 µH
Tuning cap	7-1000 pF vacuum
Coupling loop	0.40 m (D/5)
Feed impedance	50 Ω
Frequency range	3.5-7.3 MHz
Max power	100 W PEP
VSWR (tuned)	< 1.5:1

Design Formulas

Loop Inductance

$$L = \mu_0 R [\ln(8R/a) - 2]$$
$$= 4\pi \times 10^{-7} \text{ H/m} \times 1.0 \times [\ln(8 \times 1.0 / 0.00794) - 2]$$
$$= 6.18 \text{ µH}$$

Radiation Resistance

$$R_{\text{rad}} = 31171 \times (A/\lambda^2)^2$$
$$= 31171 \times (3.142/\lambda^2)^2 \text{ [Ω]}$$

Loss Resistance

$$R_{\text{loss}} = (C/a) \times \sqrt{\pi f \mu_0 / \sigma}$$
$$C = 6.283 \text{ m}, a = 7.94 \text{ mm}$$

Tuning Capacitance

$$C_{\text{tune}} = 1 / (4\pi^2 f^2 L)$$

Capacitor Voltage

$$V_{\text{cap}} = Q \times \sqrt{P \times R_{\text{total}}}$$

At 100 W: up to 11,250 V (80 m)

Materials & Build

- Main loop:** 6.3 m of 5/8" (15.875 mm OD) Type M copper tube, soft-temper for bending
- Coupling loop:** 1.26 m of 1/4" copper tube or RG-213 coax braid, Faraday shielded with gap at top
- Capacitor:** Vacuum variable 7-1000 pF, rated ≥ 15 kV (e.g., Jennings CSVF-500)
- Motor drive:** Stepper motor with 1:50 gear reduction for remote tuning
- Support:** UV-resistant PVC cross-brace or fibreglass tripod mount
- Connector:** SO-239 panel mount on weatherproof junction box
- Feed line:** RG-213 or LMR-400, 50 Ω
- Weatherproofing:** Silicone sealant on all joints; UV-resistant cable ties
- Mounting:** Non-conductive mast, ≥ 2 m above nearest metal surface



HIGH VOLTAGE WARNING: At 100 W on 40 m, capacitor voltage reaches **6,438 V peak**; on 80 m it can exceed **11,250 V peak**. Lethal voltages are present during transmission. Never touch the loop or capacitor while transmitting. Use a vacuum variable capacitor rated for ≥ 15 kV. Ensure the antenna is mounted at least 2 m above accessible areas. Use a safety interlock to disable the transmitter when accessing the antenna.

Dual-Band Balanced Magnetic Loop Antenna — 80 m & 40 m

Theory: *Small Loop Antennas* — ARRL Antenna Book, 24th Ed. • R. Lewallen, W7EL, "Optimizing Small Transmitting Loops" • A.F. Stewart, KB1ZMX, "Magnetic Loop Efficiency"
NEC-4 modelling validation • Copper conductivity σ = 5.8×10⁷ S/m • All values computed for free-space unless noted
github.com/magnetic-loop-antennas