Portable Magnetic Loop Antennas

Ham Radio’s Best Kept Secret

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“Small loops have a poor efficiency and are mainly used as receiving antennas at low frequencies”

- BALONEY
- LOOPS Like
  - Verticals are Shrouded
  - In Myth
Topics

- Why a Small Magnetic Loop?
- What is a Small Magnetic Loop?
- Build or Buy?
- Design Considerations
- Building Tips
- Operating Tips
Why a Portable Magnetic Loop?

- Extremely Fast Setup (<3min)
- Best Designs High Efficiency (>80%)
- Very Easy Experimentation
- Very Easy Design (using online calculators)
- Very Easy to Buy (PY1AHD)
- Excellent Noise Null
- High-Q good for Multi-TX Environment
- Need Only 1 Loop Diameter Above Ground
- Resonant—No Tuner Needed
- No Radials or Trees Necessary
- Chicks Dig Them
What is a Small Magnetic Loop?

- A magnetic loop behaves electrically as a coil (inductor) with a small but non-negligible radiation resistance due to its finite size. It can be analyzed as coupling directly to the magnetic field (opposite to the principle of a Hertzian dipole which couples directly to the electric field) in the near field, which itself is coupled to an electromagnetic wave in the far field through the application of Maxwell's equations.
Build or Buy?

- **Buying**
  - Loops Made Commercially by Alex PY1AHD and MFJ, maybe others
    - Alex makes SML 7-30 KIT (on display) and WalkHam
    - SML 7-30 Well Built, Well Designed, prettier than most all homebuilt loops!
    - Alex’s Website a MUST for Loop Fans
      - [http://www.alexloop.com/](http://www.alexloop.com/)
PY1AHD SML 7-30
PY1AHD WALKHAM
Building a Loop

- Don’t be Afraid to Experiment!
- But SAFETY FIRST! HIGH VOLTAGES!
- I mean REALLY HIGH
Design Considerations

- Use Online Mag Loop Calculators for Rough Design
- Others—Google “Magnetic Loop Calculator”
Design Considerations—Loop Circumference

- Loop Circumference Must be Less than $\frac{1}{4}$ Wave at Highest Frequency (or things get squirrelly)
- Best Efficiency for Loop is its Highest Usable Frequency
  - Loops Get Increasingly Inefficient the Lower in Frequency they are Tuned—Just Like a Mobile Whip EXAMPLE:
    - AlexLoop More Efficient at 10m than 40m
Design Considerations—Loop Thickness

- Thicker Loop Material More Efficient

- Practical Considerations:
  - Minimum 3/8” Copper Refrigerator Tubing
  - ¾” Copper Tubing, Rigid or Flexible, Excellent Size
Design Considerations—Loop Shape

- Maximum Area for Given Circumference Most Efficient
  - This Means a Circle!
  - But Octagonal, Square, other Shapes Will Work

- Perfect Circle not Required
Design Considerations—Loop Height

- Vertical Loops Needs Only 1 Loop Diameter Above Ground
  - No apparent gain from increased height

- Horizontal Loop Considerations Same as Dipole
Many Ways to Feed a Small Magnetic Loop

- Delta Match
- Gamma Match
- Feed Loop Transformer
  - Hands Down Winner
  - Easiest to Build
  - Easiest to Fiddle
  - PY1AHD Alex uses it!
Design Considerations—Feed Loop Transformer

- Make Feed Loop 1/5 size of Main Loop
- Can Use Large Diameter Solid Copper Wire (8 gauge or larger)
- 3/8” Copper Refrigerator Tubing Excellent
Design Considerations—Feed Loop Transformer

- Solder Coax Braid to One Side of Feed Loop, Center Conductor to Other Side

- Feed Loop Must Not Touch Main Loop—Space According to Voltage
Design Considerations—Loop Capacitor

WARNING!! VERY HIGH VOLTAGES!!!

- Even QRP Radios Can Generate 1000 Volts or More Across Capacitor
- 100-watt Radio Can Generate 10,000 Volts or More
- RF BURNS ARE NOT FUN
Design Considerations—Loop Capacitor

- Low Loss Capacitor Means Higher Loop Efficiency
  - Butterfly Capacitors Good
  - Vacuum Variables Good
    - Expensive with High Voltage Rating
    - Many Turns Means Finer Tuning -- Wider Range
- Welded Plates Better
- Contrary to Conventional Wisdom, Conventional Capacitor Will Work
Design Considerations—Loop Capacitor

Butterfly Capacitor
Design Considerations—Loop Capacitor

Vacuum Variable
Design Considerations—Loop Capacitor

- Can be Motorized with Small 1-2 rpm DC Motor and Control Box
  - More Difficult to Motorize Vacuum Variable
  - Allows Remote Tuning

- Use Ganged Capacitor as Split Stator to Eliminate Wiper Losses
Design Considerations—Loop to Capacitor Connection

- Connections Must be as Low Loss as Possible
- Use Copper Braid, such as Grounding Strap Material
- Squash Main Loop Tube on Braid and Solder—Vice Grips or C-Clamp to Squish
Design Considerations—Who’s On Top?

- Feed Loop or Variable Capacitor can go at Top of Loop
- Other Component at Other End
- For Big Loops, Easier if Capacitor on Bottom
Design Considerations—Capacitor Value and Voltage Rating

- Depending on Band, Size of Loop, other Variables, Capacitor will be in the 12pf to 350pf Range.

- Voltage Rating should be as High as Possible! Use loop calculator to determine what is required. Some Vacuum Variables under-rated for Voltage.
Construction Tips

- If Building “Loop Up” Can Cheaply Simulate Capacitors with Coaxial Stubs
  - Build Long, then Trim to Work and Either Measure with Capacitance Meter or Use Published Tables

- Better to Build “Capacitor Up” (starting with capacitor and designing loop to work at proper frequency)
Construction Tips

- Can Increase Capacitance with Stubs or Doorknob or Mica Capacitors in Parallel with Variable but WATCH VOLTAGE RATING!
Construction Tips

- Radiation Resistance Around 1 Ohm, so Solder Wherever Possible and Use Large Mechanical Joints
- Grounding Strap Braid from HRO Works Well, But Solder Lug Connectors!
Using A Mag Loop in the Field

- MAG LOOPS are Onlooker Magnets!

- WARN Visitors of High Voltage!
  - THEY WILL TRY TO TOUCH IT!

- Onlookers will also Detune Loop by Capacitive Coupling
Using A Mag Loop in the Field

- For Small Loops, Use Cheap Photo Tripod
- For Larger Loops, Purpose-Built Mast
- Non-Conductive Mast Better, MUST be Insulated from Loop
- Elevate 1 Loop Diameter
  - No Advantage to Higher Loop Height
- Keep Away from Large Metal Objects like Cars, UFOs, T-72 Tanks, etc
Using A Mag Loop in the Field

- **TUNING:**
  - High-Q Makes Tuning by Receiver Noise Easy and Fairly Accurate
    - ALWAYS check SWR before APPLYING Full POWER
  - Can Use MFJ-249/269 or other Antenna Analyzer, but Stand as Far from Loop as Possible
    - Step in, Step out Dance Dance Revolution!
Using A Mag Loop in the Field

- Using Mag Loop Horizontally:
Using A Mag Loop in the Field

- **AXIS of Loop is Pattern Direction**
  - Pattern Figure-8 Shaped
    - Peak Direction somewhat Broad
    - Noise Direction Narrow

- I Have Worked JA, KH6, and UA0 Portable with Alex Loop with 5-10 Watts. EVEN SSB! First KH6 repeatedly said he didn’t believe me since I was 57 on 5W
Using a Mag Loop in the Field

- LOCATION, LOCATION, LOCATION
  - Salt-Water Amplifier
  - Hilltops

- Alex Loop Weighs Same as Length of Coax -- 2 lbs

- Doomsday Loop Weighs 30 lbs
Sample Project—Doomsday Loop

High Power Loop
15 and 20 Meter Coverage
Doomsday Loop

- Butterfly Capacitor: Found on Ebay with no Specs
  - Turned out to be about 30-60pf
  - 15,000 volt plate spacing
  - Excellent Bread Slicer
Doomsday Loop

- Loop: 3/4” Rigid Copper Pipe Cut into Octagon Shape
  - Pre-soldered 45 deg. Elbows
  - Circumference about 11 feet
  - Soldered with Propane Torch on Concrete while XYL out of House
Doomsday Loop

- Feed Loop: 3/8” Copper Refrigerator Tubing
  - Much easier to cut with tubing cutter
  - Solder center and braid of coax direct to loop
  - Fed with RG58
Doomsday Loop

- Capacitor Fit into RubberMaid Storage Bin
- But only tuned 15 meters
  - Built RG-8 Coax Stub and trimmed until 20 meters tuned, measured value
- Placed two 15KV Doorknob Capacitors in Series, in Parallel with Variable
Doomsday Loop
Doomsday Loop
Questions?
THANKS TO ALL WHO HELPED

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- Hiroki AH6CY
- And Everybody Else!