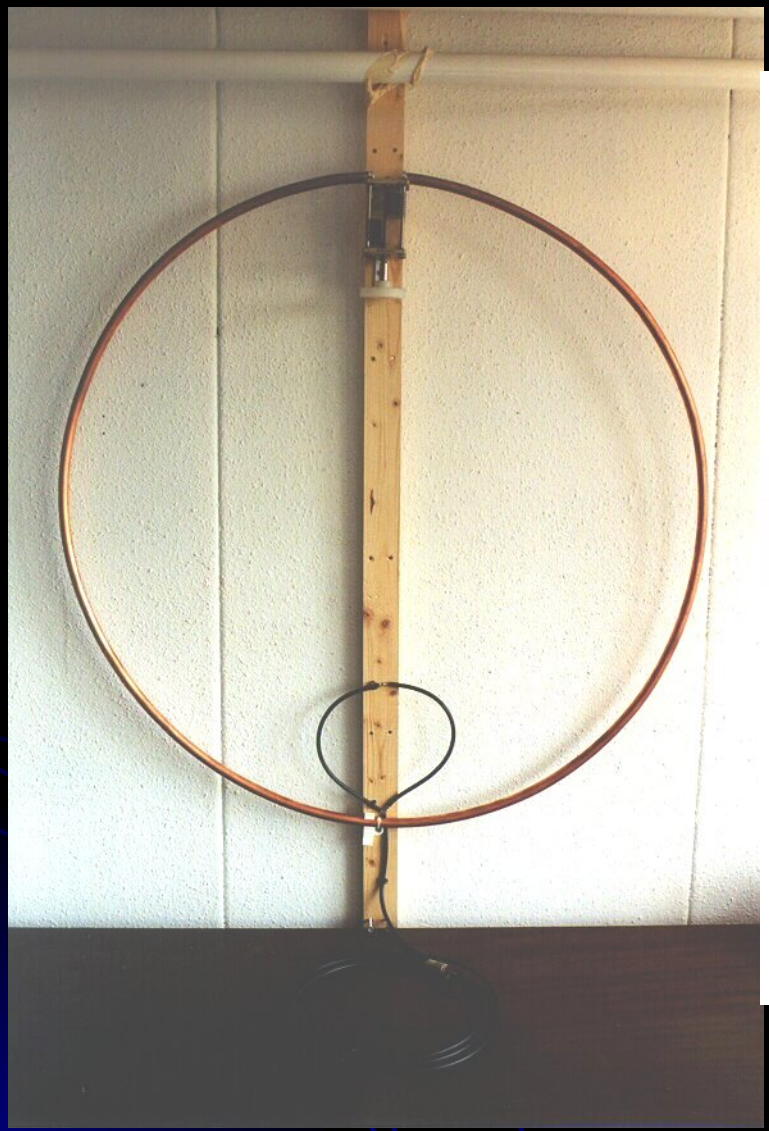
Portable Magnetic Loop Antennas

Ham Radio's Best Kept Secret

Eric Norris WD6DBM v2.00




MFJ
Super Hi-Q Loop

WIKIPEDIA, The Last Word on Antenna Design

- "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

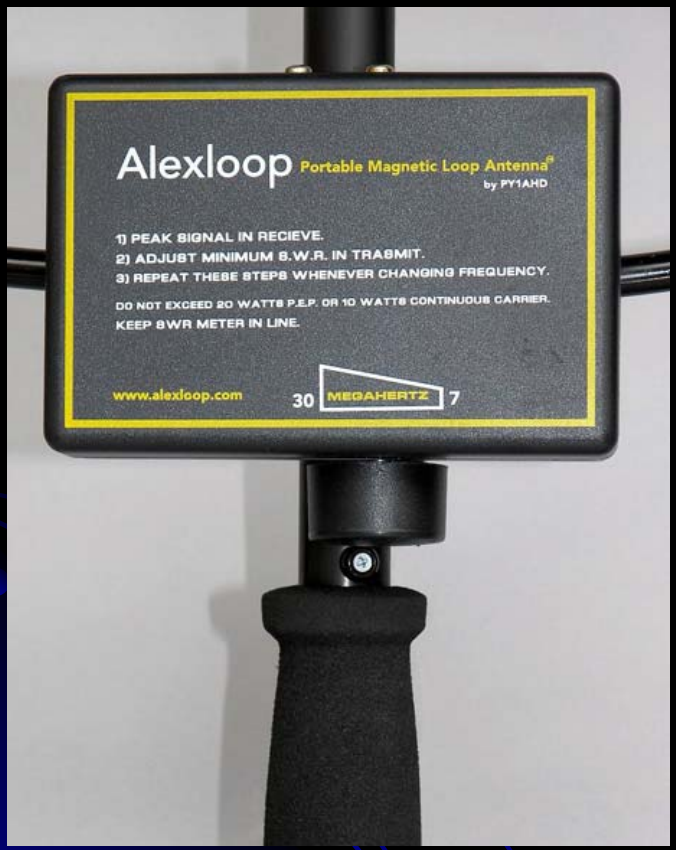
What is a Small Magnetic Loop?

- *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/

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

- http://www.66pacific.com/calculators/small_tx_loop_calc.aspx

- Others—Google “Magnetic Loop Calculator”

Design Considerations—Loop Circumference

- Loop Circumference Must be Less than ¼ 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

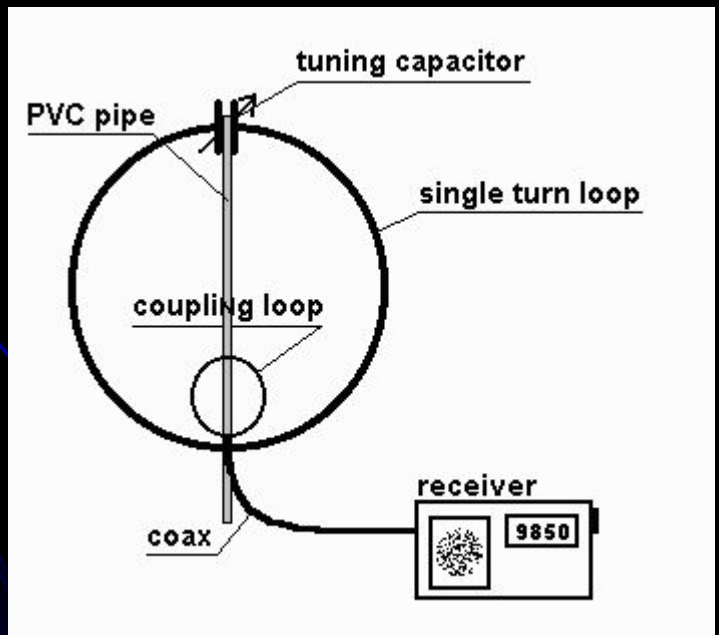
- Vertical Loops Needs Only 1 Loop Diameter Above Ground
  - No apparent gain from increased height
- Horizontal Loop Considerations Same as Dipole

Design Considerations—Loop Feed

- 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!!!

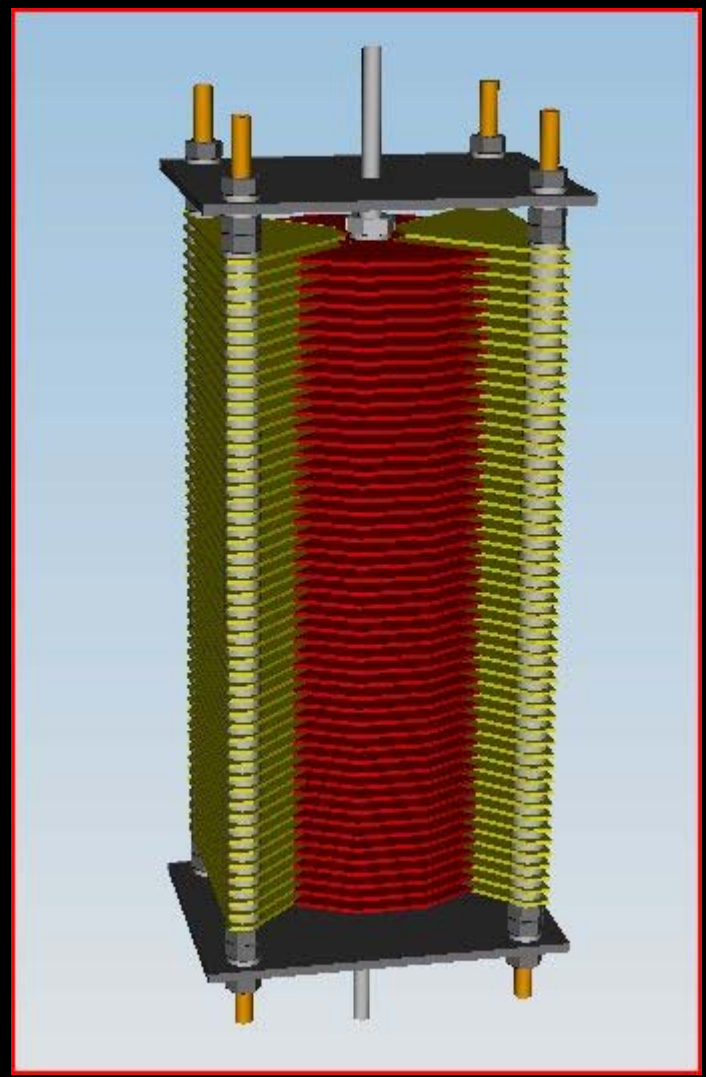
- Even QRP Radios Can Generate 1000 Volts or More Across Capacitor
- 100-watt Radio Can Generate 10,000 Volts or More
- RF BURNS ARE NOT FUN

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

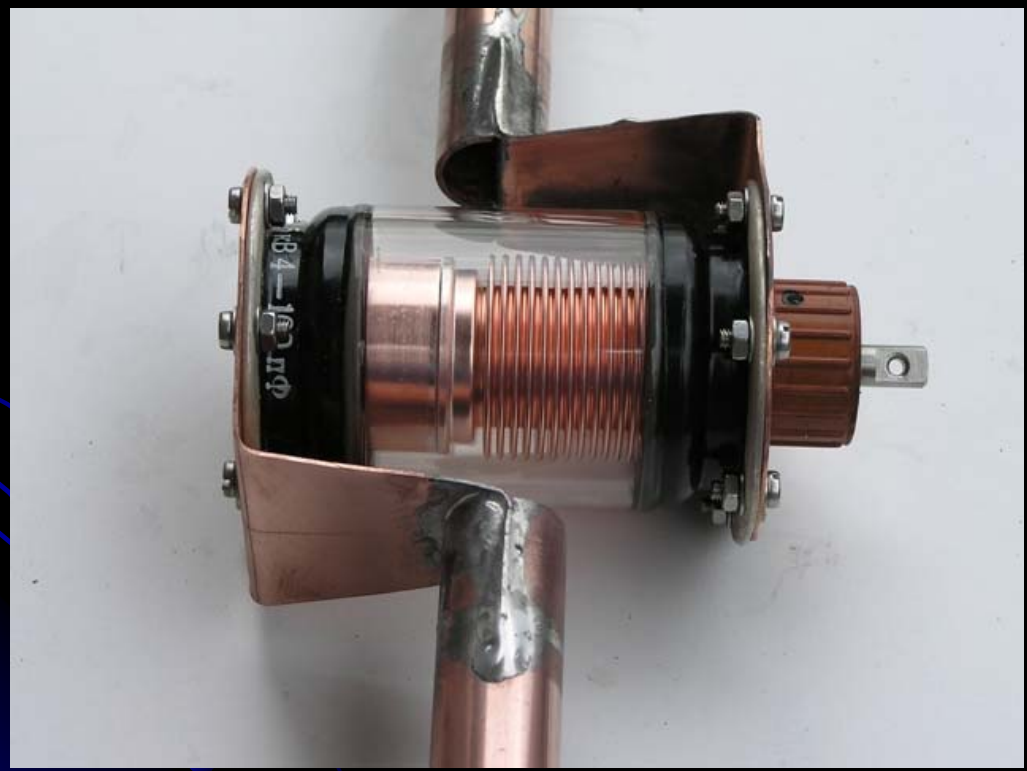
Design Considerations—Loop Capacitor

- 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

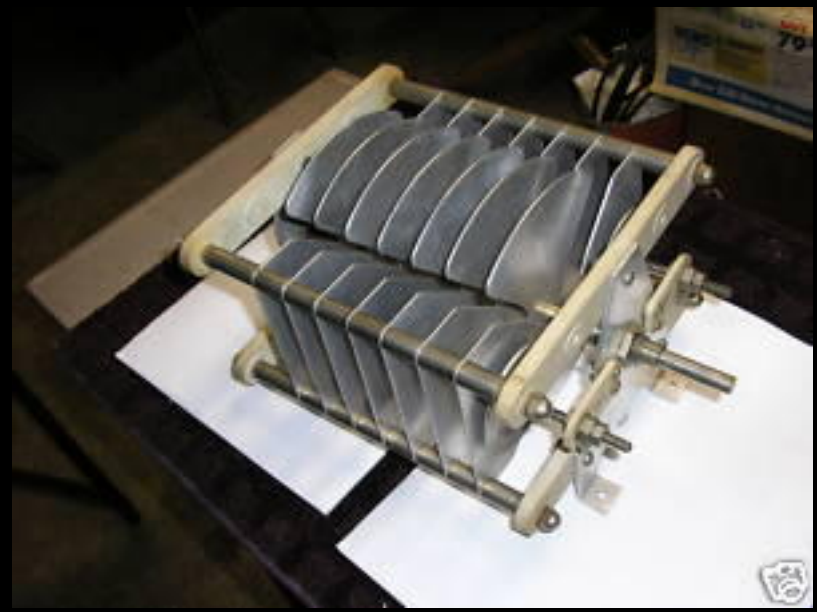
Sample Project—Doomsday Loop

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

- Alex PY1AHD
- Hiroki AH6CY
- And Everybody Else!