Small HF Antennas

- The Small Space and Big Antenna Dilemma
- Constraints
  ✦ Covenants
  ✦ Restricted lot size
  ✦ City Bylaws
  ✦ Boards of Variance
  ✦ Strata Rules
  ✦ Neighbor complaints of unsightly “structures”
  ✦ What else if that’s not enough?

12/2/2006 NSARC HF Operators
The Challenge

- How to make HF antennas perform in small spaces
- Small antennas
  - Small means shorter antennas that fit available space
- How to make Stealth antennas
  - Ant’s that are visible but don’t look like antennas
- How to Hide antennas
  - Out of sight but somewhere in/on the housing structure
Operating Issues

- Performance issues using short antennas
  - Lower gain – less “wire in the sky”
  - Narrower bandwidths – tuning required
  - Non-50 ohm feed point impedances – tuner needed

- Interference more likely
  - Proximity to audio, video, AM, FM, PC, Tel, etc equipment
  - QRP to 100 watts probable max

- Safety issue
  - You and the antenna may share the same space
  - RF biological exposure limits to be checked
  - Structural integrity of mounted antennas – make secure
Building RF Transparency

- Conducting materials at 1/2 wavelength spacing

- Wooden frame structures
  - RF transparency - good
  - Internal conductors – “antennas”
    - Power, telephone, cable, alarm etc wiring
    - Copper plumbing

- Concrete structures
  - RF shielded at HF
    - Rebar and metal framed windows – small aperture
    - Metal 2 x 4 framing inside building
    - Internal conductors
Which Floor? Apt / Condo

- Top floor
  - access to roof top antennas
  - short feeder runs
  - best separation from tenants, none above
- Bottom
  - access to ground mounted antennas
  - grounding systems possible
  - feeder runs OK
  - tenant spacing, top & 2 sides
- Mid floors
  - interior or balcony mounted antennas
  - tenants all around
Some Antenna Theory

- Basic antenna forms – only 2!
  - Hertzian form
  - Marconi form

- Understanding Short antennas
  - Properties
  - Behavior
  - Performance

- What type might be best depends on circumstances
Antenna Circuit

- Generator – the transmitter
- Feedline – two conductors
- Antenna – two wires
- Antenna as $R =$ radiation resistance at resonance

- Complete the circuit - current must flow entirely around the loop
Hertzian Antenna

- No earth connection required for Antenna – good!
- Antenna radiates independent of ground

- Rig grounded by green wire in power cord - SAFETY
- This ground is not part of the antenna system.
Marconi Antenna

- Antenna operates “against” ground.
- Ground circuit is required – real earth or artificial
- Ground is the other half of the antenna circuit
- Ground consists of a conductive surface to mirror the top half of the antenna

- Rig grounded by green wire in power cord - SAFETY
- Safety ground could become part of antenna system
- Not desirable
Standard Antenna

to which most other antennas are compared

- Resonant Half Wave dipole

- At resonance, feed point ~ 50 ohms (radiation resistance)
  - Good match to 50 ohm coax
  - Low VSWR
  - Maximum power transfer from rig to antenna

- Short antenna performance measured against this
  - gain, impedance, bandwidth,
Short Antenna Properties

- Antenna no longer resonant at desired frequency
- Antenna gain is reduced due to shortness
- Feed point impedance changes
  - radiation resistance drops significantly
  - capacitive reactance appears at the feed point
  - feedline matching becomes poor and & high VSWR results
- Efficiency drops
  - ohmic losses become a significant part of the feed point $Z$
Solutions

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- Dipoles
- Loops
- Verticals
- Long (actually short) wires
- Other?
Restore Resonance

- Short antenna “looks” capacitive

- Restore feed point impedance to look resistive

- Add an inductor somewhere “in” the antenna
  - nulls out the capacitance – creates resonant circuit
  - used with both dipoles & verticals

- Add a capacitor to the end of antenna
  - make antenna look longer (electrically) than it is
  - used most often with verticals
Use an External Tuner

- Antenna is not brought back to resonance
  - no inductive or capacitive loading added
- Tuner matches complex antenna feed point impedance to 50 ohm output of transmitter
- Useful for multi-band operation
- Tuning limitations may be evident if tuner cannot match the antenna / feed line impedance.
- Rig tuners not well suited to off–resonant antennas
Loading Coils

- Loading Coils are inserted in series with antenna
  - “makes up for shortness”

- Spi-Ro Manufacturing offers “Shortners”
  - [http://www.spiromfg.com/](http://www.spiromfg.com/)

- Cancels the Capacitive component

- Resonates the antenna

- Coil placement
  - Dipoles – one in each leg
  - Verticals – one towards or at the bottom
Coil Loaded Dipole

- Balanced system
- Single band
- No ground issues
- Reduce lengths
  - 80m dipole from 132 ft to 69 ft
  - 40m dipole from 66 ft to 38 ft
  - most likely an outdoor application
- Radio tuner ought to be OK

Balun

http://www.spiromfg.com/
Wire Antennas

- Shortened, loaded balanced multi-band dipoles
  - No ground issues
  - Multi band
  - Outdoor
- Alpha Delta  [http://www.alphadeltacom.com/]
  - DX-EE  40 ft / 40 thru 10
  - Radio tuner probably OK
- B & W  [http://www.bwantennas.com/]
  - BWD series  20 ft / 20 thru 10m
  - Radio tuner OK
- Radio Works  [http://radioworks.com/]
  - G5RV all band
  - External tuner needed
Compact Dipoles

- Ventenna
  - 20 to 10m
  - 80 & 40m options
  - length unknown

- Buddipole
  - 40 to 2m
  - coil loaded
  - collapsible
  - 16 feet extended
  - http://www.buddipole.com/
Compact Vertical

- Ventenna
  - 40 to 10m
  - 80m option
  - length 10’ 6” (3.2m)
MFJ Loop Antenna

- Small and very suitable for apartments
- 36 inch diameter
- No ground system required
- MFJ-1786 20 thru 10m
- MFJ-1788 40 thru 15 m
- Good performance reviews on eHam
- Low noise advantage
- Self tuning – no external tuner needed
- Inside or outside dwelling
Wire Loop Antenna

- Home made - construct wire loop
- Could reside inside dwelling
- Hang horizontal or vertical
- Requires external tuner & balun
  - LDG Z-100 tuner + RBA balun
  - http://www.ldgelectronics.com
- No ground required
- Random length loop – big as possible
Compact Yagi's

- Hybrid Quad
  - Model MQ-1
  - 20 thru 6m
  - 11 ft elements / <5 ft boom
  - http://www3.sympatico.ca/
- G4MH Mini Beam
  - 10 /15/ 20m 3 element
  - 2m boom / 5m elements
- ZX Mini-2000 Beam
  - 10/15/20m  3 element
  - 3m boom / 3.4m elements
- Both at http://www.dxzone.com/cgi-bin/dir/jump2.cgi?ID=4044
Vertical Antennas

- Verticals are unbalanced antennas
- Require a ground plane or counterpoise
- Copper plumbing and Safety ground wiring NOT a good choice for RF ground / counterpoise.
- Mounting possible off balconies, rooftops or at ground level
- Inside a dwelling, maybe not so practical
Radial System
Multiwire

- A system of wires at base of vertical
  - minimum 2 per band if using multi band vertical
  - single band, try for 8 as long as possible, up to ¼ wave

- Lay radials out symmetrically as possible

- Bend ends to fit, no bends at base

- Lay radials on surfaces
  - roof, hold in place with bricks
  - lawns - trench and bury (staples avail. from DX Engineering)
Counterpoise
Single Wire

- A conductor(s) used as a substitute for earth or ground in an antenna system.
- Usually just one or two wires
- Counterpoise will have RF on it and will radiate
- Undefined operation if using building copper pipe or safety ground wiring as counterpoise.
- MFJ-931 Artificial Ground – loads a short counterpoise
Coil Loaded Vertical

- Coil at base = feed point
- Intended for mobile applications
- Uses car body as counterpoise
- Use as base with a radial or counterpoise system

~ 5 feet high
Change bands by Moving tap on coil

http://www.mfjenterprises.com/
Capacity “Hats”

- Capacity “Hat” placed at end (top) of antenna
- Resonates the antenna
- Removes the Capacitive component
- Placement most effective at end of antenna
Capacity “Hats”

40 thru 2m
No Radials
Feed line balun
12 feet high
24” footprint

80/40m
Needs, guys & radials
33 feet high

MFJ-1796

http://www.mfjenterprises.com/

MFJ-1792
Current Baluns

- Coax feedline to vertical – use a current choke / balun
- Keep RF from flowing on coax & entering shack
- Isolates rig / ant from safety ground
- Coax coil choke
  - CQ magazine Oct 2006 pg 44

- Snap On chokes
  - RF Parts or DX Engineering
  - http://www.dxengineering.com/

- Ferrite Beads
  - Palomar Engineering model BA-8
  - http://www.palomar-engineers.com/
Some Vertical Antennas

- Trap
  - Good for ground mount or flat roof
  - to 30 ft high
  - Requires ground system
  - Multi-band 80 thru 10m
  - MFJ http://www.mfjenterprises.com/
  - Hygain http://www.wb0w.com/hygain/hygain.htm

- Screwdriver
  - Motorized, tuneable
  - Multiband, fully resonant 80 – 10m
  - Extends to ~ 9 ft, some shorter
  - Requires ground system
  - High Sierra http://www.cq73.com/
  - Tarheel http://www.tarheelantennas.com/home
More Vertical Antennas

- Mobile Whip
  - Require ground system
  - Ham Sticks, monoband, ~ 6 ft
  - Outbacker multiband ~ 7.5 ft
    - Use Outpost tripod for ground mounting

- Balcony Verticals
  - Designed for balcony mount
  - Require ground system
  - ~ 6 ft
  - Multiband 40 – 10m
  - MFJ 1622

Radials / counterpoises generally required.
Balcony Mounted

- Short verticals mounted on railings
  - Metal railings as counterpoise
  - Wooden railings, run counterpoise wires on wood or on floor; cover with mat

- Longer verticals
  - Painter pole, retractable, telescoping “mast”
  - Mobile whips
  - June 2006 TCA
More Balcony Mounts

- http://www.eham.net/forums/AntennaRestrictions
- Pigeon “preventors”
- Ideas, reviews, comments ….
Long Wire Antennas

- Random lengths of wire – long as possible
  - easy to build – string outdoors, #22 insulated black
  - need to support two ends

- Typically non resonant

- Usually end fed – high Z point

- Must have a tuner (other than rig)

- Tuner must have a “ground” or counterpoise connection
Stealth

- ARRL Book
- Flagpole Verticals – ground mounted
- Wires lying on roof tops
  - Black insulation, small dia, #22
- Wires on Gable ends
  - No good under AL eaves with AL gutters
- Wires on Fences - Loops
- Attics for yagi’s
- VHF/UHF on short mast looks like TV antennas
- Vent pipe VHF/UHF verticals, roof mounted
  - Ventnna
Subsurface Dipole

Really ??

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- If on ground floor and able to trench the yard
  - Buried ~ 8 inches

- Reported 16dB less gain
  - ~ 3 S points less than a comparable, low dipole
- Rather “experimental”
Safety

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- Exposure to RF fields
  - Biological heating
  - Safety Code 6 – Canadian Standard
  - Exposure Factor - closeness to antenna
  - Exposure Factor - transmitter power levels

- Antenna Voltages
  - RF burns from ends of antennas
  - “Hot” grounds at unknown locations if safety ground or plumbing used as counterpoise

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Exposure Calculation

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- Approaches Safety Code 6 – uncontrolled environment
- Calculate safe field strength

http://n5xu.ae.utexas.edu/cgi-bin/rfsafety.cgi

Calculate Radio Frequency Power Density

What is the average power at the antenna:
In watts

What is the antenna gain in dBi:
Enter 2.2 for dipoles; add 2.2 for antennas rated in dBd

What is the distance to the area of interest:
From the center of the antenna, in feet

What is the frequency of operation:
In MHz

Do you wish to include effects of ground reflections?  Yes  No

Calculation Results

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Controlled Environment</th>
<th>Uncontrolled Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Power at the Antenna</td>
<td>20.000 watts</td>
<td></td>
</tr>
<tr>
<td>Antenna Gain in dBi</td>
<td>0.00 dBi</td>
<td></td>
</tr>
<tr>
<td>Distance to the Area of Interest</td>
<td>5.00 feet</td>
<td></td>
</tr>
<tr>
<td>Frequency of Operation</td>
<td>20.000 MHz</td>
<td></td>
</tr>
<tr>
<td>Are Ground Reflections Calculated?</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Estimated RF Power Density</td>
<td>0.0686 mw/cm²</td>
<td></td>
</tr>
<tr>
<td>Maximum Permissible Exposure (MPE)</td>
<td>2.25 mw/cm²</td>
<td>0.46 mw/cm²</td>
</tr>
<tr>
<td>Distance to Compliance From Center of Antenna</td>
<td>0.92 feet</td>
<td>2.00 feet</td>
</tr>
<tr>
<td>Does the Area of Interest Appear to be in Compliance?</td>
<td>yes</td>
<td>yes</td>
</tr>
</tbody>
</table>
Summary

- Consider balanced antenna systems first
- Verticals work will work but require radials or counterpoise
- Long wires will work but require counterpoise
- Try and get the antenna outside somewhere
- Do not create a "special" station RF ground – the radial or counterpoise is your RF ground
- Keep antenna away from metallic objects
  - Aluminum window frames
  - Service entrance
- If moving, choose antenna friendly site