# AMATEUR RADIO ANTENNA MASTS

Information for NSW Planning & Infrastructure

from the Wireless Institute of Australia

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## Frequency Bands

Amateur radio operators are licensed by the Australian Communications and Media Authority (ACMA) under the *Radiocommunications Act 1992*, after passing stringent examinations in prescribed technical and regulatory subjects. Regulations under the Act provide radio amateurs access to narrow frequency bands throughout the radio frequency spectrum so that they can pursue their particular interests. In Australia, these are as follows:

| Spectrum Sector | Amateur Bands | Nominal Wavelength |
|---|---|---|
| Low Frequency - **LF** | 135.7 – 137.8 kHz | 2200 metres |
| Medium Frequency - **MF** | 472 – 479 kHz | 600 metres |
| | 1.800–1.875 MHz | 160 metres |
| High Frequency - **HF** | 3.500 – 3.700 MHz<br>3.776 – 3.800 MHz | 80 metres |
| | 7.000 – 7.300 MHz | 40 metres |
| | 10.100 – 10.150 MHz | 30 metres |
| | 14.000 – 14.350 MHz | 20 metres |
| | 18.068 – 18.168 MHz | 17 metres |
| | 21.000 – 21.450 MHz | 15 metres |
| | 24.890 – 24.990 MHz | 12 metres |
| | 28.000 – 29.700 MHz | 10 metres |
| Very High Frequency - **VHF** | 50.000 – 54.000 MHz | 6 metres |
| | 144.000 – 148.000 MHz | 2 metres |
| Ultra High Frequency - **UHF** | 430.000 – 450.000 MHz | 70 centimetres |
| | 1240 – 1300 MHz | 23 centimetres |
| | 2300 – 2302 MHz<br>2400 – 2450 MHz | 13 centimetres |
| Super High Frequency - **SHF** | 3.3 – 3.6 GHz (‘slices’ of) | 9 centimetres |
| | 5.65 – 5.85 GHz | 5 centimetres |
| | 10.0 – 10.5 GHz | 3 centimetres |
| | 24.0 – 24.25 GHz | 1.25 centimetres |
| Extremely High Frequency - **EHF** | 47.0 – 47.2 GHz | Millimetre-wave bands |
| | 76.0 – 81 GHz | |
| | 122.25 – 123.0 GHz | |
| | 134.0 – 141.0 GHz | |
| | 241.0 – 250 GHz | |

These frequency bands are generally congruent with those allocated by other countries’ administrations throughout the world. The allocations are determined by the International Telecommunications Union (ITU) at regular World Radio Conferences and adopted by countries through international treaties.

New frequency allocations for radio amateurs have become available world-wide over the past decade. The MF band at 472 – 479 kHz was released to Australian radio amateurs in December 2012; the LF band at 135.7 – 137.8 kHz became available only a few years ago, as well as millimetre-wave bands in the EHF spectrum. New technologies such as software defined radio, digital communication modes and computer-aided design applications are changing the way radio amateurs pursue their hobby.

The principal span of radio amateurs' "on-air" activities includes:

Terrestrial communications, point-to-point:

- between amateurs across the State, across Australia and around the world; and
- via high altitude balloon borne repeaters;

Space communications

- via Earth-orbiting amateur radio satellites;
- using the Moon as a passive reflector, known as "moonbounce"; and
- with astronauts aboard manned space vehicles (eg. the International Space Station).

## Scope of This Submission

As the issue of radiocommunications antennas and masts is a highly complex subject, coverage of the issues relevant to the *Statewide streamlined approvals code* has been confined to primary areas of amateur radio application and practice at present, and those likely to be relevant into the foreseeable future.

A framework for exempt and complying development is sought so that the activities, applications and practices available to radio amateurs are not unnecessarily or inadvertently fettered in the future as the range of technologies, applications and activities available to radio amateurs continues to develop and diversify.

## Antenna Masts – Fundamental Considerations

The design, construction, siting and performance of a radiocommunications antenna system are dependent on the **wavelength** of the operating frequency.

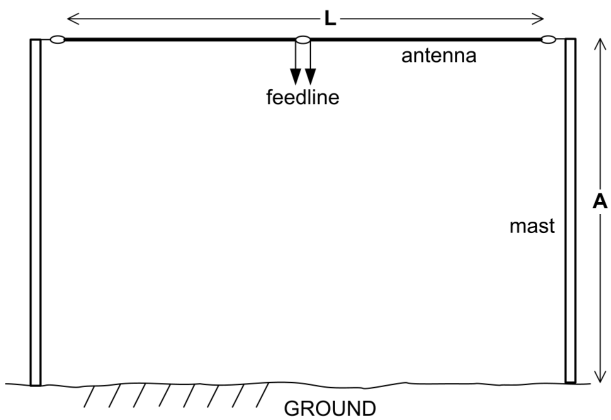
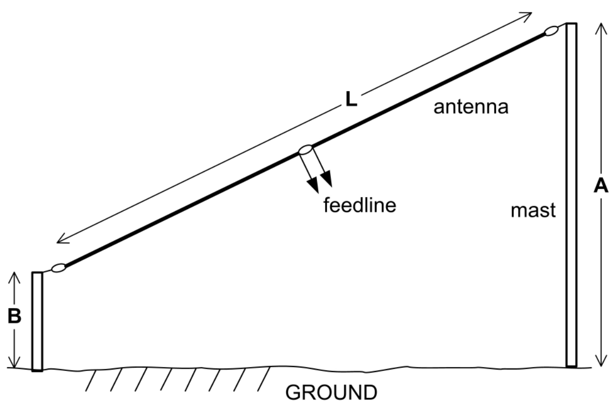
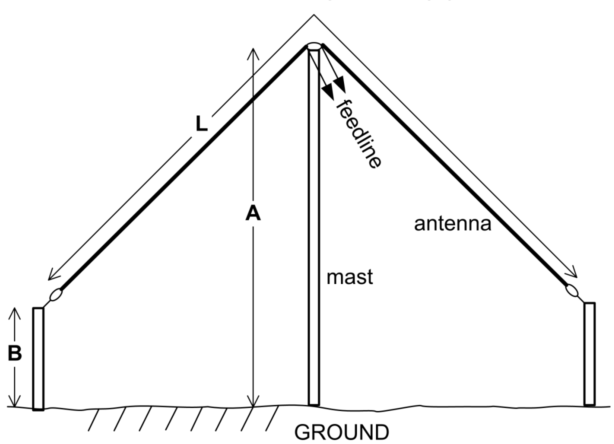
The physical parameters of siting an antenna are inevitably determined by a host of influencing factors – but particularly, the wavelength-related size of objects in the antenna's immediate surroundings and, similarly, those of intermediate surroundings (the neighbourhood).

The "clutter" of these spaces will have considerable influence on an antenna's behaviour and thus a station's communications abilities and performance, because the clutter distorts an antenna's signal response and increases radio path loss through shadowing and diffraction ("*Hata Model for Urban Areas*", http://en.wikipedia.org/wiki/Hata_Model_for_Urban_Areas).

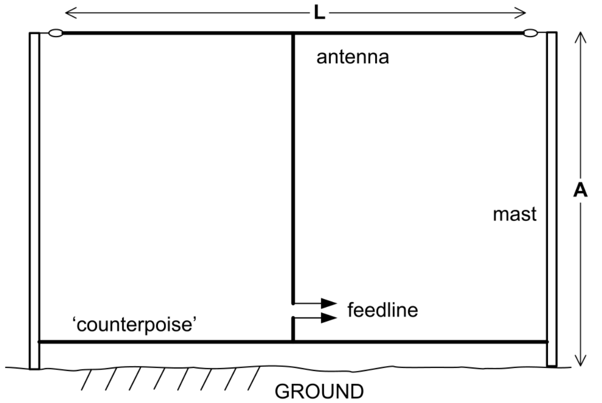
The physical size of residential blocks (urban or rural) will also dictate antenna siting and the size of antenna configurations.

An antenna mast may serve to support wire-type antennas or to support self-contained antenna types atop, or attached to, the mast. For reasons of economy, a mast or masts will often be used to support multiple antennas.

Basic antenna and mast configurations, and their general applications, are illustrated in Table 1, which provides a guide to the dimensions of various common physical configurations. As would be appreciated, this is not an exhaustive list; there are many combinations and permutations possible, generally dictated by the particular circumstances, ingenuity and creativity of individual radio amateurs.

| TABLE 1 | |
|---|---|
| **Antenna Type** | **Applications & Configuration** |
| **DIPOLE / DOUBLET**<br> | **Application: HF bands**<br><br>**L**: ranges from half wavelength to as long as practicable.<br><br>**A**: minimum preferred height of half wavelength. eg. for the 20 metre band, A ≈ 10 – 11 metres. One wavelength or greater achieves appreciable improvement, eg. 14 – 15m height for 21 MHz and bands above that; such heights also improves performance for 40m and 80m band applications. |
| **SLOPER DIPOLE / DOUBLET**<br> | **Application: HF bands**<br><br>**L**: ranges from half wavelength to as long as practicable.<br><br>**A**: minimum preferred height of half wavelength. eg. for the 20 metre band, A ≈ 10 – 11 metres. Other comments as for dipole above.<br><br>**B**: above head height, or whatever's practicable. |
| **INVERTED–V DIPOLE / DOUBLET**<br> | **Application: HF bands**<br><br>**L**: ranges from half wavelength to as long as practicable.<br><br>**A**: minimum preferred height of half wavelength. eg. for the 20 metre band, A ≈ 10 – 11 metres. Other comments as for dipole above.<br><br>**B**: above head height, or whatever's practicable. |

## MARCONI

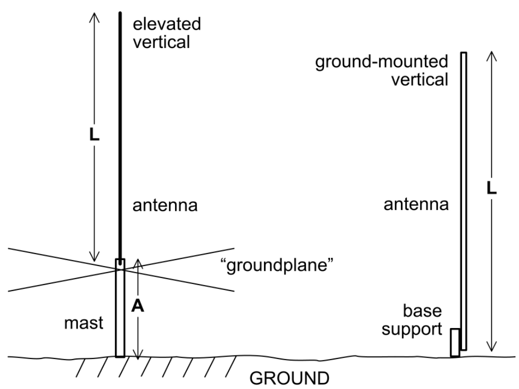



**Application: LF & MF bands**

**L**: as long as practicable.

**A**: as high as practicable. The greater the height, the greater the achievable efficiency and performance.

## VERTICALS

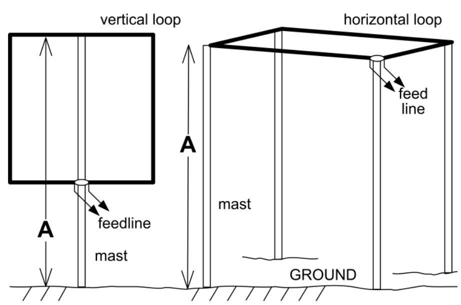



**Applications: LF-MF-HF-VHF bands**

**L**: typically, a quarter wavelength on HF bands, eg. for the 40m band, <u>L ≈ 10 - 11 metres</u>. For the lower frequency bands (80m, 160m, 600m, 2200m), as long as practicable. On these bands, the greater the height, the greater the achievable efficiency.

**A**: above head height, or as high as practicable. On VHF-UHF, this means raising the antenna above the urban clutter (eg. 10m to 15m height).

## LOOPS



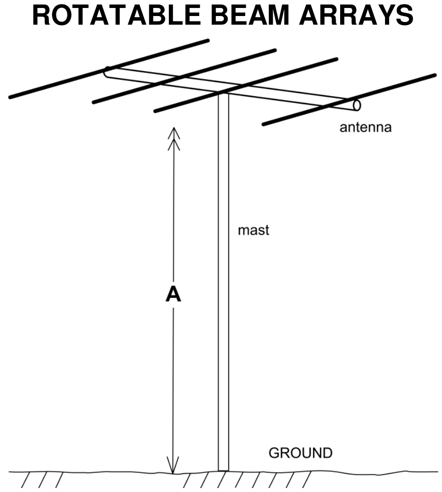

**Applications: LF-MF-HF bands**

**A**: as high as practicable. The greater the height, the greater the achievable efficiency and performance.

Other loop geometries are also used, eg. triangular, circular.

Loop lengths may be equal to or less than one wavelength.

## ROTATABLE BEAM ARRAYS




**Applications: HF-VHF-UHF-SHF bands**

**<u>HF</u>**

**A**: <u>minimum preferred</u> height of half wavelength. eg. for the 20 metre band, A ≈ 10 – 11 metres. Other comments as for dipole above.

**<u>VHF-UHF</u>**

**A**: as high as practicable; raising the antenna above the adjacent urban clutter (eg. 10m to 15m height).

'Stacking' beams one above the other or side-by-side is sometimes used.

Loop arrays and dishes are included.

Antenna masts for radio applications, free-standing or guyed, may be of the following common styles:

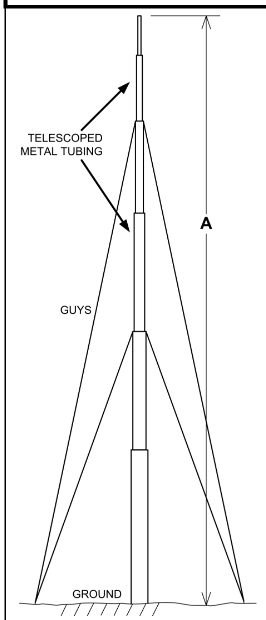
- **a)** metal tubing (eg. Hills Telomast [1], NBS [2]);
- **b)** fibreglass tubing (eg. Haverford telescopic poles [3]);
- **c)** bolted metal-lattice (eg. Southern Cross [4]);
- **d)** welded metal-lattice construction (eg. NBS [2] and Nally [5]); or
- **e)** wood.

[1] www.hillsantenna.com.au [2] www.nbsantennas.com.au
[3] www.haverford.com.au/telescopic-poles.html [4] www.ellistanks.com.au/towers.htm
[5] www.nallyradiotowers.com.au

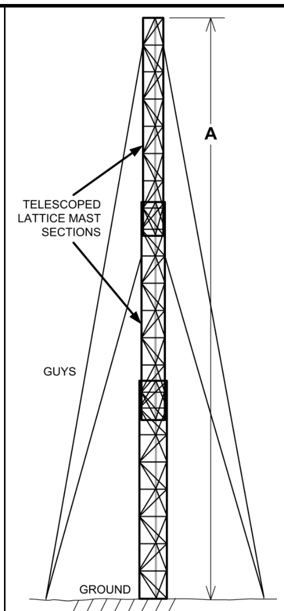
All these mast styles are acceptable under exempt development regulations for licensed amateur radio operators in South Australia and Victoria, which list height as the only parameter.

Metal construction masts are illustrated in Table 2. The dimension '**A**' refers '**A**' in Table 1.

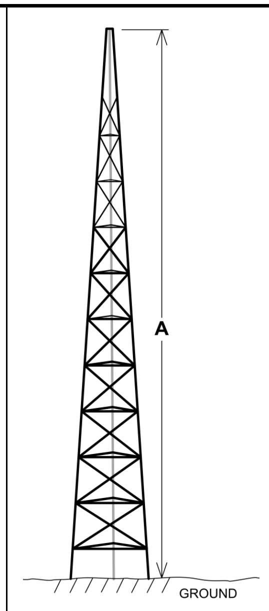
**TABLE 2**



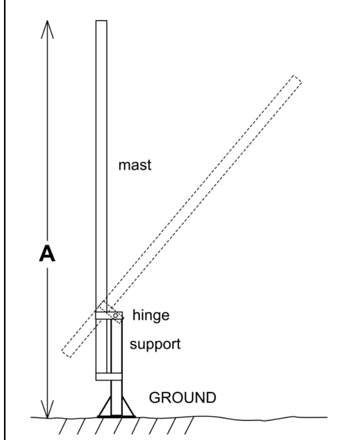

**Guyed telescoping tubing mast.**




**Guyed telescoping lattice mast.**




**Free-standing lattice mast.**




**Tilt-over tubing mast.**

Commercial manufacturers and suppliers offer radio masts at a variety of standard heights, which are manufactured to meet Australian Standard AS 1170. For example:

- Hills Telomasts for 6, 9, 12 and 15 metre heights;
- Nally free-standing, guyed and tilt-over masts to 10.8 metres, and guyed masts for 8, 10.8, 15 and 30 metre heights; and
- NBS free-standing, tilt-over and guyed masts for 5.5 to 13.8 metre heights.

In some applications, a metal mast is the antenna itself, as illustrated in Table 1, *Verticals*. (eg. TET-Emtron, telescopic 8.5 metre vertical, model TEV-1, www.tet-emtron.com; Benelec 5.05 metre vertical, model - Station Master MK2, www.benelec.com.au).

**Mast Guying**

Commercially-made guyed masts are designed and manufactured to meet Australian Standard AS 1170. Hence, the guy rope or wire employed is appropriately selected to meet the load specifications under the Australian Standard. Commercial mast suppliers also provide guy rope and wire as separate components, and other guying components. Colours to reduce the "visibility" of guys can be selected.

## Siting Issues

Sheet metal roofing or aluminium foil sarking beneath roof tiles will affect the performance of an antenna mounted to (or adjacent to) a dwelling, especially in the HF range where the metal roofing or sarking behave as an "elevated ground". Hence, it is advantageous to site the antenna in such instances as far as practicable above the roof in terms of wavelength.

Where residential properties are sited on sloping ground, an antenna mast is best mounted as high as practicable on the site, otherwise, in a lower place on the block, a mast of greater height would be necessary to achieve an advantageous clearance in terms of wavelength.

The ACMA requires radio amateurs to ensure that electromagnetic energy (EME) levels from their facilities do not exceed mandatory health exposure limits at places accessible to the general public (www.acma.gov.au/WEB/STANDARD/pc=PC_1826). This requirement is a regulatory condition of their licence to operate radiocommunications transmitters. In practical terms, it comes down to maintaining minimum or greater distances between antennas and neighbouring properties or other adjacent public areas. Hence, the mounting heights of antennas are an important factor in EME compliance.

Issues relating to boundary proximity of antennas, or overhang of rotatable antennas, are addressable by radio amateurs under EME compliance.

## Picture Gallery of Various Amateur Radio Mast and Antenna Installations

Ground-mounted multi-band antenna of a type standing 5.5 to 8 metres tall.

Wideband HF vertical antenna mounted on a guyed pipe mast.

Telescopic metal-lattice mast with stacked rotatable HF Yagi beams.

Rotatable HF Yagi beam with VHF vertical above and a wire dipole attached to the free-standing metal-lattice mast.

Tilt-over metal pipe mast with stacked rotatable Yagi beams and a VHF vertical.

Free-standing hydraulic tilt-over metal pipe mast with rotatable “Hex beam”.