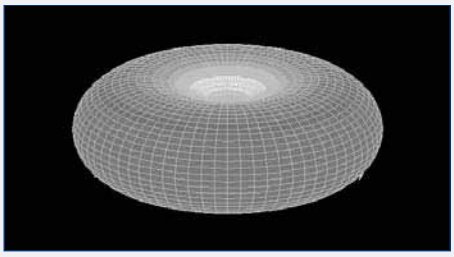
Antenna Gain

WHAT IS GAIN?

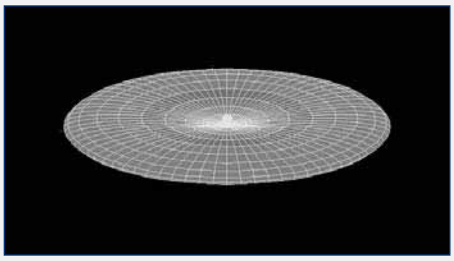
The gain of an antenna is a measure of the improvement in transmitted or received signal strength when its performance is measured against the theoretical standard isotropic radiator, whose radiation pattern represents a perfect sphere. Gain can only be achieved by focussing the radiation pattern in the direction in which it is needed by the addition of more radiating elements and/or directors and reflectors (such as in the case of yagis).



Typical unity gain radiation pattern

Some antennas can produce a "spotlight" radiation beam (or main lobe), focussing on a narrow target but covering large distances. Others produce a broad coverage area like a lantern. Generally, the higher the amount of gain the better the range, but this depends entirely on the application.

A well-designed high gain antenna will ensure the main radiation lobe is focussed on the horizon rather than up to the sky. That's great for rural areas, but for city use where base stations are located atop tall buildings, too much gain may not always be the best solution.



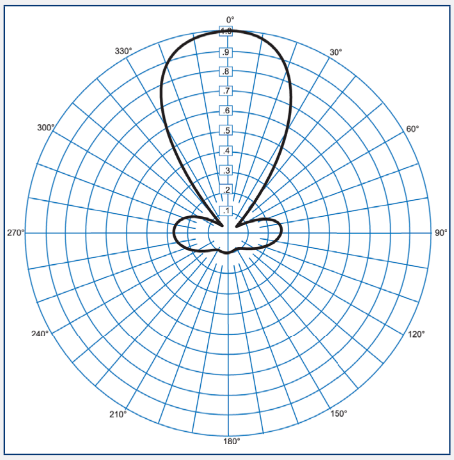
Typical high gain radiation pattern

HOW IS GAIN DEFINED?

Various antenna manufacturers use different references when declaring their gain figures. Some use a dipole reference, some the theoretical isotropic radiator and some use a figure that in fact has no claimed reference.

Most readers of this catalogue know roughly how long an antenna must physically be to deliver it's claimed gain in a particular frequency band. The laws of physics cannot be defeated and without "capture area" there is simply no way to increase antenna gain.

Unfortunately, in the absence of a defined reference, some claims made in catalogues and on retail packaging by some manufacturers, are, well, wrong. Whilst this is "understood" by experienced dealers, who make their own informed judgments, publishing these oftenexaggerated claims is very much an attempt to entice customers to purchase one product (with superior ratings) over another.



Typical yagi directional antenna pattern

It is important to remember that the gain of an antenna MUST be related to a reference of some description, which in most cases will be either the isotropic radiator or a lossless half wave dipole. Gain statements that are made without an indication of a suitable reference are meaningless and misleading. The most commonly used and accepted gain measures are dB¼λ, dBi and dBd.

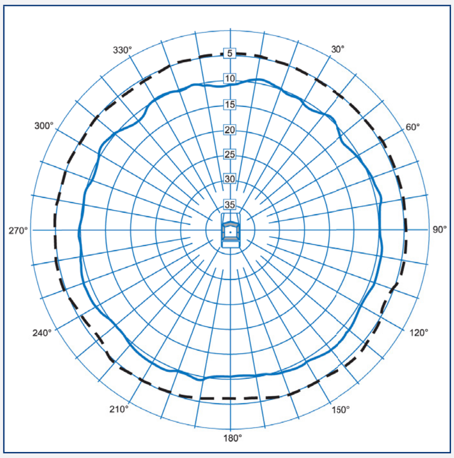
The gain specifications listed in our catalogue for our range of base station antennas are all referenced to an isotropic radiator, and are thus expressed in dBi. Also listed is the gain referenced to a lossless half wave dipole in dBd, which is simply 2.15dB below the dBi rating.

Antenna Gain

WHY ARE MOBILE ANTENNAS TREATED DIFFERENTLY?

Whilst the isotropic radiator and half wave dipole are appropriate gain references for base station antennas, a more meaningful and practical reference has been used for our range of mobile antenna gain specifications. This is the ¼ wave centre roof mounted whip (dB¼λ). Why? Because we can measure it, and we DO measure it. It is not a theoretical reference, but a practical one, and we believe it serves our customers best.

As a matter of almost pure coincidence, should you measure a roof mounted ¼ wave antenna on the horizon, it is a close approximation to the theoretical isotropic radiator. We have tested this in the field, comparing the ¼ wave whip to the ½ wave dipole, since we could not find an isotropic radiator in our toolbox. (Well perhaps it was there, but being infinitely small we just couldn't see it!).



Typical mobile antenna pattern

CONSISTENT WITH THEORY

Theoretically, a ¼ wave whip mounted on an infinite ground plane will exhibit the gain of a half wave dipole, or 2.15dBi, in a direction perpendicular to the axis of the whip. As the ground plane diminishes, the main lobe of the whip's radiation pattern will tilt upwards, away from the ground plane. Our pattern tests have shown that when mounted in the centre of a standard vehicle roof, a ¼ wave whip exhibits a gain of approximately 0dBi in the direction perpendicular to the whip, that is, at the horizon, and that the gain peak is at a point some 25-30 degrees above the horizon, due to the effect of the limited ground plane.

Therefore, when referencing the gain of a mobile antenna against a ¼ wave centre roof mounted whip, the gain can be considered as being referenced to an isotropic radiator at a plane perpendicular to the whip (that is, at the horizon or 0 degree elevation).

BUT THEN THERE'S MOUNTING

All antenna radiation patterns are affected by their mounting environment.

The gain exhibited by certain mobile antennas when mounted on a vehicle gutter or roof bar can be better than their specifications would suggest.

This is especially true for the ground independent Mopoles and high gain Mopoles offered by RFI. These antennas, being ground independent, are usually range tested and rated against a standard dipole reference. When a Mopole is placed on a vehicle gutter or roof bar, the vehicle's roof, again being a less than infinite ground plane, causes a slight uptilting AND compression of the major lobe, increasing the effective gain of the antenna.

Thus, an end fed dipole antenna, range tested at 0dBd in controlled field tests (2.15dBi gain at the horizon) will, when gutter or roof bar mounted, perform significantly better than a roof mounted quarter wave due to this additional gain contribution.

The brief statements made on our Mopole antenna pages characterize this additional gain as "improved performance" rather than textbook gain, as the additional performance claimed is dependent on the mounting position for the antenna. RFI have collated and published extensive information on the performance of mobile antennas in various mounting locations to help illustrate the resulting compromises of antenna mounting and operational performance in mobile antennas.

Similarly, base station antennas are dramatically affected by antenna mounting positions. The side mounting of base station antennas is a point of particular interest and this can be characterized, and even quite accurately modelled. Each application however tends to be individual and mounting arrangements are rarely precisely controlled enough to allow system planners to take this into account.

The RFI engineering team is happy to advise on individual antenna selection and regularly prepares papers and presentations on the optimal antenna choices in typical applications.

CATALOGUED GAIN FIGURES

In general, stated gain specifications are nominal, and taken at the centre of the tuned bandwidth of the antenna, but slight variations can be expected. Where comprehensive data is required for use in coverage analysis software packages, RFI can provide digitised antenna pattern data in accordance with industry standard TIA-804-B formats for most of our base station antennas. For more specific gain information please contact your local RFI representative.

WIND RATINGS

The listed wind ratings for base station antennas are defined as follows:

- **Projected Area (no ice)** - A statement of the equivalent flat plate surface area of the antenna. This has been calculated in accordance with AS1170.2:2002, the Australian Wind Loading standard, which is based on ISO4354, an international standard covering wind actions on structures.
- **Projected Area (with ice) -** A uniform radial build-up of 12.7mm of ice is applied to all surfaces of the antenna, in accordance with TIA329C. The projected area is then re-calculated in accordance with AS1170.2:2002.
- **Wind Load (thrust) -** The effective force applied perpendicular to the plane of the antenna presenting the greatest projected area, as a result of the pressure applied due to a constant 160km/h wind velocity.
- **Wind Gust Rating -** A structural engineering calculation in accordance with AS1170.2:2002, giving consideration to the yield strength of the materials used in the construction of the antenna. This figure determines the maximum wind velocity at which the mechanical stresses in the antenna components are just below the allowable yield strength of the boom and/or other elements.
- **Torque -** The bending or turning moment resulting from the Wind Load (thrust) calculated above, acting at the uppermost clamping point. For Corner Reflectors, the torque figure represents a rotational torque.

These important engineering specifications have been published in metric units. The following conversion factors may be used to convert these and other listed mechanical units to imperial units:

Length	1 ft = 0.305 m
	1 in = 25.4 mm
Weight	1 lbs = 0.454 kg
Projected Area	1 ft2 = 929 cm2
Wind Load	1 lbs (f) = 4.448 N
Wind Gust Rating	1 mph = 1.609 km/h
Torque	1 ft-lbs = 1.356 Nm