RADIO FREQUENCY SYSTEMS

HF & DEFENCE ANTENNA SYSTEMS

Applications Guide

A world of solutions in HF Antenna Systems

INTRODUCING RADIO FREQUENCY SYSTEMS

RFS is a global designer and manufacturer of cable and antenna systems plus active and passive RF conditioning modules, providing total-package solutions for wireless infrastructure.

RFS serves the defence, telecommunications and broadcast industries. Our products and systems can be found in every corner of the globe.

The RFS customer base includes defence and government organisations, telecommunications companies, cellular and mobile service providers, telecommunications systems suppliers and radio, television and microwave networks.

Today, with production facilities on 5 continents and sales and support offices in 24 countries, RFS is ideally positioned to service the rapid development of modern wireless communications infrastructures anywhere in the world.

A leading global RF supplier

PRODUCTS AND SERVICES

RFS is a world leader in the innovative design, manufacture and installation of HF antennas, feeder systems, combiners, baluns and associated sub-systems. RFS also excels in the design, development and manufacture of leading-edge tactical and transportable antenna systems.

As RFS designs are broadband, our antennas suit a wide range of applications ranging from simple low cost SSB installations to complex large scale military installations and electronic warfare countermeasure systems.

The RFS product range includes tactical manpack, transportable and fixed antennas for omnidirectional, directional and beam steering applications and field conditions. These antenna systems are used for short, medium and long-distance broad area coverage to ionospheric propagation and shore-ship/ship-shore/ground-air communications.

HF Over The Horizon Radar Transmit Array - Vertical log periodic arrays, each 1km long and 1MW input power.

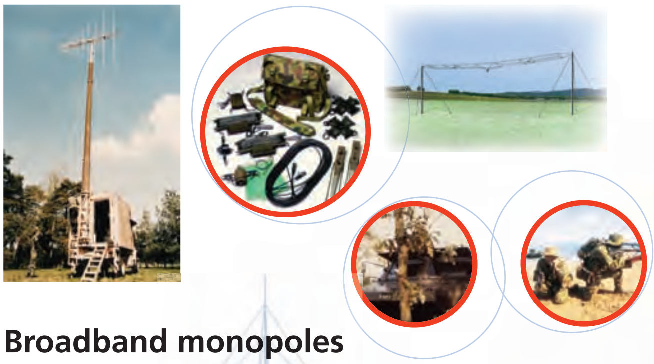
Strategic and tactical HF antenna systems

PRODUCT OVERVIEW

The RFS range of strategic and tactical HF Antenna Systems provide economical and innovative solutions that can be fully tailored to suit particular system requirements and applications.

Tactical antennas

RFS' wide range of tactical man-pack and transportable antennas are available in standard designs, or can be customised to meet specific customer requirements.



Broadband monopoles

Designed for medium to long distance omni-directional operation, these antennas exhibit low angle radiation patterns - an economical solution for general HF communication applications.

Horizontal and vertical log periodics

Suitable for short to long distance applications, RFS' horizontal log periodic antenna performance is virtually ground independent, with take-off angles able to be tailored to suit particular requirements. Alternatively, the RFS vertical log periodic antenna series provides ground-dependant vertical beam-widths and is characterised by a low angle radiation that is essentially constant at all frequencies.

Rotatable log periodics

High performance directional antennas designed to provide short, medium and long range coverage. These units exhibit high gain characteristics coupled with excellent rotational speed and accuracy, making these multipurpose antennas the ideal solution for multi-link applications.

Biconical dipoles

This omnidirectional broadband series is designed for short and medium range coverage. As neither terminating resistors nor antenna tuning hardware is required, essentially all input power is radiated.

Standard and tandem deltas

Omnidirectional high angle radiators designed for ionospheric propagation over short to medium distances. Radiation results from a wave travelling upward to a resistive termination at the antenna's apex. Similar in form to the standard delta, the tandem delta does not have a terminating resistor - as a result, all input power is radiated, achieving gains of 3-4dB over the standard delta.

Antenna switching matrices

Antenna switching matrices facilitate multiple transmitter/receiver to multiple antenna inter-connections, providing a compact system with low VSWR and high isolation characteristics.

HF Shortwave broadcast antennas

High performance omni- and directional antennas are available to suit shortwave HF broadcasting applications. These antennas are capable of handling high input powers and have a wide frequency bandwidth.

ENGINEERING CAPABILITY

In the creation of both standard and custom HF and tactical antennas, RFS' design capabilities are among the most advanced in the world.

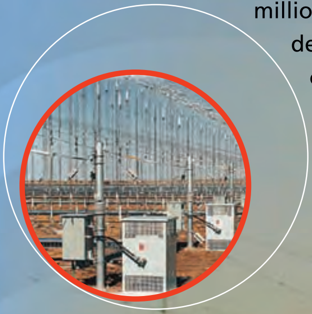
Our highly-qualified team of scientists and engineers work to a continuous program of research and design, developing and adapting HF products at the cutting edge of modern technology. HF antenna systems are developed with the use of world leading modelling capabilities developed over 3 decades.

HF RADAR – SKYWAVE AND SURFACEWAVE SYSTEMS, PROJECT EXAMPLES

JINDALEE OVER THE HORIZON RADAR NETWORK (JORN)

The Jindalee 'Over the Horizon' radar network (JORN) is an HF skywave radar system providing surveillance over an area of approximately 20 million square kilometres (8 million square miles). The largest project of its kind in the world, the JORN installation provides a powerful surveillance facility using advanced Over The Horizon Radar (OTHR) technology – a technique which extends conventional radar range some thousands of kilometres beyond line-of-sight.

RFS' involvement in the project has been pivotal to the successful development, design and installation of the world's largest, high precision HF transmit and receive antenna arrays. The massive US$24 million antenna arrays have been entirely designed, built, installed and commissioned by RFS. It represents a major technological leap forward for global antenna development.



Total design excellence

Circular horizontal log period array to provide sector coverage.

JORN STATISTICS

Transmit antennas

Three vertical log periodic antenna arrays, each 1000m long. 42,000 metres of three inch coaxial feed cable. Two million metres of galvanised earth mat wire. A total of three megawatts of input power.

Receive antennas

Three doublet monopole arrays, each three kilometres in length. 500,000 metres of half inch coaxial feed cable. 700,000 square metres of galvanised earth mat mesh.

JORN INSTALLATION

Antenna installation also proved to be an enormous practical and logistical challenge. During the four year construction period, 250 semi-trailer loads were dispatched from RFS' southern city bases, carrying millions of antenna components over long hauls into the deep outback.

The antennas were installed in some of the country's most extreme climactic conditions – from -5 to 60°C; in humid, dusty and sometimes torrential monsoon conditions. The installation of the hundreds of guyed antenna masts (often to tolerances measured in millimetres), plus the seemingly endless array of coaxial cabling, cable trays and earth mats represents a very real human success.

HF MODERNISATION PROJECT

This project integrated the Australia wide Army / Navy / Airforce HF communications into a single 4 site system. RFS provided the antenna site design, antenna system design, the antenna manufacture, earth works, installation and commissioning.

Each site comprised a horizontal log periodic rosette array with an outer diameter of 500m as well as other HF antennas which had to be placed to provide optimum system performance.

HF Over The Horizon Radar Receive Array. Doublet monopole arrays, each 3km in length.

SYSTEM DESIGN, INTEGRATION AND COMMISSIONING

RFS is able to offer complete HF and tactical turnkey project services, with specific resources and skills in the key areas of:

- Installation
- Field supervision
- Commissioning
- Sub-system design
- Training
- Project management

With over 30 years of in-field experience, RFS has specific capability in the design, construction and commissioning of all major HF communication systems and sub-systems including foundation/civil work, towers, antenna systems, transmission line and accessories.

total project
solutions - anywhere

GLOBAL PROJECT KNOW-HOW

In over 30 years, RFS has developed a wealth of global HF and tactical project experience for a wide range of international military, government and telecommunication organisations.

EXAMPLES OF KEY RFS HF AND TACTICAL PROJECTS INCLUDE:

UN Peace-keeping Forces – Supply of tactical antennas.

French army – Various tactical/transportable antenna design and supply projects.

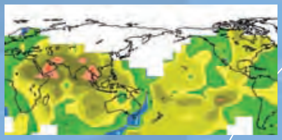
French military – Trans horizon radar station ‘Nostrodamus’.

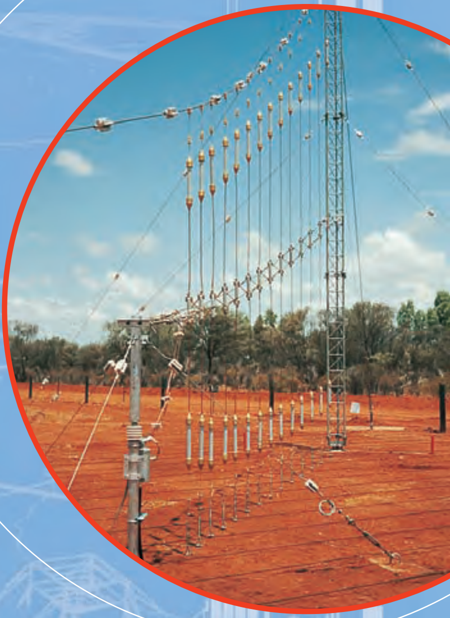
Middle East – Supply and installation of numerous HF antennas throughout the Middle East.

Asian defence projects – Extensive HF antenna installations developed throughout Indonesia, Malaysia, Thailand and Singapore.

Australian Defence Force – A wide range of HF projects, including the world-leading JORN installation and the HF Modernization Project.

Australian Army – Development and supply of tactical/ transportable antennas for the Raven, Wagtail and Hiport/Medport projects.





Introduction

HF communication systems offer an independence that makes them unique compared to other types of communication. This has led to continued use by military forces, no matter what other means they have for communication. Personnel in embassies and consulates have also found that HF can be advantageous during times of civil disturbance. There are also many civilian applications, where the cost-effectiveness of HF provides a useful solution, particularly in remote areas.

HF communication systems operating in the range of 2 to 30MHz primarily use sky waves reflected and refracted by the ionosphere. Successful propagation depends greatly on ionospheric conditions, and changes within the ionosphere may require a change of operating frequency. Wide band antennas are therefore, preferred for HF communication systems, and will be discussed in detail later in this guide.

Expectations of HF operation can cause early challenges, particularly if the user has been involved with satellite, VHF or UHF communications. High quality communication can be affected by sunspots, bad choice of frequencies, low power and an inefficient antenna.

The usefulness of an HF system depends on:
- power output
- selection of frequency
- ionospheric variations
- the antenna system.

Power is important, but only if it can be radiated. An increase in power must be considerable if it is to have a significant effect. An increase from 100 to 400W is only 6dB, which at HF may, or may not, be noticeable. A change from an inefficient to an efficient antenna can be far more significant. It is the antenna that ultimately determines the efficiency of an HF system. The modern HF antenna has radiation pattern characteristics that are matched to the required transmission distance, so that the maximum amount of power is received at the receiving location.

The choice of frequencies is also extremely important. Since the radio spectrum is a valuable resource and is finite, the allocation of frequencies is usually the function of a government authority. Propagation characteristics of HF radio waves are such that the lower frequencies are more suitable for short distance communications, whereas higher frequencies are suitable for long distance communications. The choice of frequencies is based on the distances to be covered and variations in the ionosphere. The ionosphere directly affects radio signal reflection or absorption and, therefore, the distance of communication.

Ionosphere

These effects are due to the various ionised layers of the ionosphere that are caused by radiation from the sun (Fig. 1). Therefore any change in solar radiation will affect these layers. Variations in the ionosphere and the nature of radio waves mean that no radio system will give 100% communications all the time.

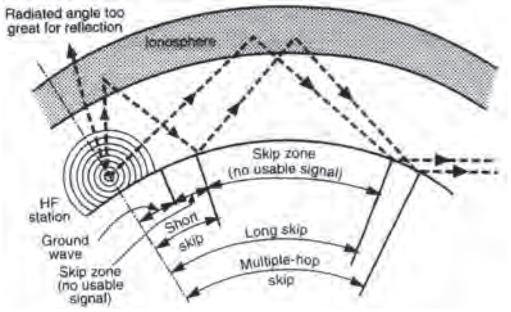


Fig. 1 Ionospheric propagation

The predictable variations occur with the time of day, seasons of the year and the regular ll-year sunspot cycle (Fig. 2). Solar flares and solar storms may also affect HF communications.

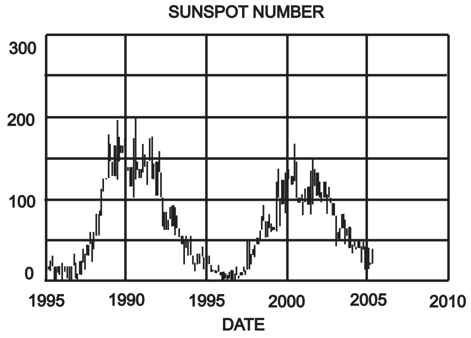


Fig. 2 Picture of 11 year sunspot cycle

Take-off Angle

The take-off angle is the elevation angle, measured from the ground, at which the maximum radiation takes place, or is desired to take place. Whether the antenna is directional or omni-directional there are three basic needs for take-off angle corresponding to the following transmission distances.

Groundwave propagation.
For very short distance communication: 0-100km. Effectively, the desired take-off angle is zero degrees and only vertical polarization can be used.

High angle radiation.
Using a single reflection or refraction from the ionosphere to achieve short distance communication over the distance 0-1000km. For this requirement, an antenna with maximum radiation at high elevation angles is most suitable.

Low angle radiation.
Using a single refraction from the ionosphere, or multiple refractions combined with reflections from the earth's surface, to achieve medium to long distance communication over the distance 1000km or more. An antenna with maximum radiation at low elevation angles is most suitable.

The angle of take off appropriate for the range to be covered can be selected by varying the height above ground, as shown for a simple half wave dipole (Fig. 3). For short distances a high angle of radiation is required, e.g. H = λ/4. For longer distances a lower angle, where H= λ or higher, will produce better results. For more complicated broadband antennas, the principle is the same, except that it is the effective height of the antenna that is optimized over the frequency band.

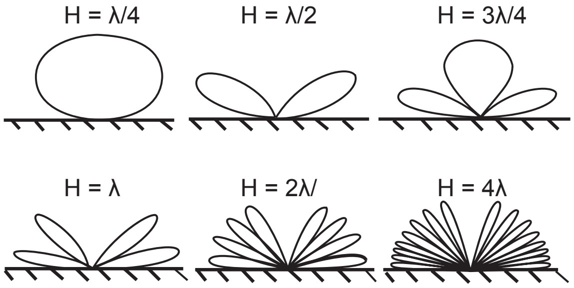


Fig 3. Dipole Take-off Angle Variation with Mounting Height

Horizontal & Vertical Polarisation

What is the meaning of polarization in HF communication systems? Many publications present radiation patterns for horizontal as well as vertical polarization. However, the polarization of waves refracted and reflected from the ionosphere is in many cases different from the polarization of the wave radiated from a transmitting antenna. It is, therefore, most important and more practical to consider the total radiated power intensity than the field strength of one or two components.
However, there is one area where the polarization has a great impact. The interaction of an HF antenna with real or "lossy" ground is very dependant on the polarization. The reflection of a horizontally polarized wave is almost perfect from real ground, regardless of the incident angle. However, a vertically polarized wave is substantially absorbed by real ground, and at a certain angle of incidence, known as the Brewster angle, may be almost completely absorbed. A vertically polarized antenna may therefore have much less gain over real ground, than is predicted on the basis of a perfectly conducting or "ideal" ground model. The use of ground screens to recover this gain will be discussed later.

Transmitting or Receiving

When considering an antenna to do a specific task at frequencies below 30MHz, some of the essential differences between transmitting and receiving requirements can be overlooked, frequently to the detriment of overall cost-effectiveness. Often the same transmitting antenna type is also specified for reception, without consideration of the differing roles - a good transmitting antenna is not always a good receiving antenna.

Requirements For Transmitting
The main requirement is to obtain the highest possible field intensity in the desired area of coverage at the appropriate take-off angle. For this, we need to:

- maximize the realized gain of the antenna
- ensure that antenna efficiency is as high as possible
- optimize the impedance match to the source to be as close as possible..

Gain and Radiation Pattern
The gain, or more exactly, directive gain of an antenna when used for transmitting, may be regarded as the sensitivity of that antenna when receiving a plane wave of the same polarization. The three-dimensional geometrical surface representing the directive gain, or sensitivity as a function of direction, is called the radiation pattern, which describes equally the performance of either a transmitting, or a receiving antenna.
Directive gain for HF antennas is usually specified with reference to a radiator that radiates uniformly in all directions, the so-called isotropic radiator. Gain specified in this way is designated as X dBi. An alternative method of specifying gain is with reference to a resonant half-wave dipole under the same conditions, in which case, the gain is stated as Y dBd. The dipole has a directive pattern, having a directive gain of 2.13dBi, therefore the gain expressed in dBi is 2.13dB more than the Fig expressed in dBd.

Input impedance and VSWR
Another antenna characteristic, which is the same when connected to either a transmitter or receiver, is its input or feed point impedance. When driven from a transmitter, this represents the load impedance appearing across the feed point terminals of the antenna. When connected to a receiver it represents the internal impedance of the antenna, acting in series with the voltage induced by an incident wave.
A quantity that describes the effect of the antenna on connected equipment, and vice versa, is the voltage standing wave ratio (VSWR). The meaning and the limitations of this quantity will be investigated later.
It will be shown that there is a marked difference between the transmitting and receiving operation of an antenna, and that the VSWR assumes different significance, when considered for transmit or receive antennas.

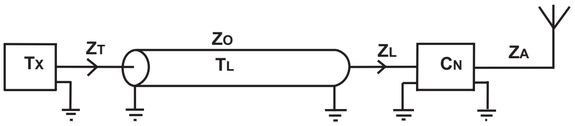


Fig. 4 Radio Transmission System

Fig. 4 shows a schematic circuit diagram of a typical radio transmission system. The power of a transmitter is usually delivered to an antenna by means of a transmission line, in the frequency bands under consideration. T_X designates the transmitter operating into a load impedance Z_T. T_L is the transmission line of characteristic impedance Z_0, feeding the output power of the transmitter to the transmit antenna via the coupling network C_N, which transforms the antenna input impedance Z_0 into Z_L, the terminating or load impedance of the transmission line.

Some antennas have been developed to match directly to suitable transmission lines. The coupling network CN, Fig. 4, is then unnecessary, and the antenna terminals are directly connected to the transmission line. Examples include:

- Wideband HF conical vertical monopoles with a typical unbalanced input impedance of 50 ohms.
- Wideband HF biconical horizontal dipoles, with a typical balanced input impedance of 300 ohms allowing direct connection to 300 ohm balanced line.
- Wideband HF vertical or horizontal HF log-periodic dipole antennas, also designed for 300 ohm balanced line.

The wide-band properties of these antennas make them very useful for transmitting stations. Although it is practically not possible to obtain a constant resistive antenna input impedance over the wanted wide frequency band, the designer keeps the fluctuations of the antenna input impedance Z_A with respect to Z_0, the characteristic impedance of the line, within specified limits. A departure of Z_A from Z_0 produces a partial reflection of the electromagnetic power from the antenna feed point thus producing standing waves along the feeder line T_L.

The standing waves are characterized by the “voltage standing-wave-ratio (VSWR), which is the ratio of the maximum voltage on the line to the minimum voltage. The transmitter is adjusted for optimum operation when the line, T_L in Fig. 4, is terminated in a resistive load equal to Z_0. The power delivered to this load is the practically obtainable maximum. If the line feeds the antenna and Z_A differs from Z_0, a part of the power will be reflected back towards the transmitter and the antenna radiated power is reduced correspondingly loss on the transmission line increases when VSWR rises. In a high power transmitting system corona effects can occur on the line due to high VSWR.

A practical characteristic of a transmit antenna is the maximum permissible VSWR, which may be designated by S_A. A frequently specified maximum VSWR, for antennas in the HF and MF bands is 2:1 (i.e. $S_A = 2$). This means that the mis-match between antenna impedance Z_A and characteristic impedance Z_0 of the line reflects $\{(S_A-1) / (S_A+1)\}^2$ x 100% = 11% of the power and the signal strength is reduced by 0.5dB.

Coupling Networks

A more general problem is encountered when an antenna is used which has a nominal impedance Z_C different from the characteristic impedance Z_0 of the selected transmission line. A coupling network C_N will then be inserted between antenna and line, as in Fig. 4. The maximum VSWR of the antenna in the operating frequency range, with respect to a line of characteristic impedance Z_C, may be designated by S_C. The coupling network, designed for transfer of a terminating impedance Z_C, into an input impedance $Z_L = Z_0$, will exhibit some fluctuations of the input Impedance Z_L due to variations in its frequency response. The maximum VSWR appearing on the Z_0 line when the network C_N is terminated by a resistive impedance Z_C, may be designated by S_C.

If a coupling network is used with the antenna, as shown in Fig. 4, the standing waves produced on the transmission line T_L will depend on the frequency response of the antenna and the coupling network. The corresponding VSWR on the line T_L may be designated by S_0. Its value will be between limits given by the inequality:
$S_AS_C \ge S_0 \ge S_A/S_C$, when $S_A > S_C$ (If $S_A < S_C$, the last term has to be inverted)

Antenna Efficiency

The output power of the transmitter, reduced by the loss on the transmission line and in networks inserted between transmitter and antenna, represents the input power P_A to the antenna. A part of this input power may be dissipated in conductors and dielectric components of the antenna and in the environment. e.g. in a ground system. The remaining power
$P = \eta P_A \quad (\eta \le 1)$ is radiated

The antenna efficiency η depends on the frequency, the type of the antenna and on the environment. The efficiency can be improved in certain cases, e.g. by improving the ground system to reduce losses. Many antennas, at HF and higher frequencies experience a negligible loss with respect to the radiated power; i.e. the efficiency is practically unity.

Radio Noise

At frequencies below 30 MHz, radio noise is a significant factor in Signal to Noise Ratio S/N. The graph,

Fig. 5, adapted from C.I.R. Report 322-3: “World Distribution and Characteristics of Atmospheric Radio Noise”, Geneva, 1963, page 345, indicates for 2.5 KHz bandwidth, average noise values for midnight in summer.

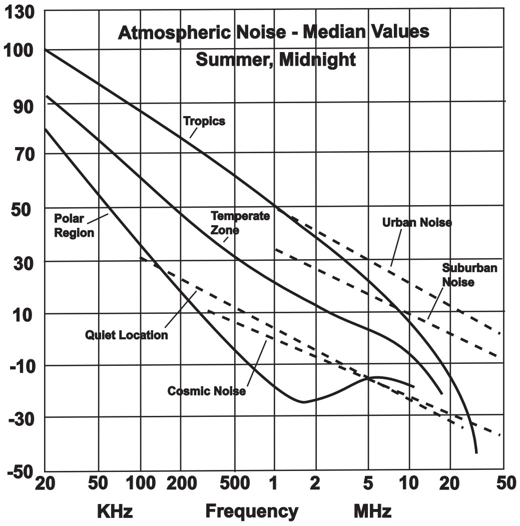


Fig. 5 Radio Noise Levels

The radio noise level is dependent upon geographical position, the operating frequency band, the time of day, season, etc. The noise power N is therefore a given design parameter, and the antenna must be designed or selected so that the operating S/N satisfies the condition S/N >S_0/N where S_0 is the minimum signal power required at the receiver input.

There are two ways available to increase the signal power if required - either by increasing the radiation of the transmit antenna as described earlier, or by increasing the directivity of the receive antenna.

The resulting S/N ratio, which affects the quality of the signal on demodulation, depends on the cumulative effect of all noise sources, i.e. the external radio noise mentioned above, plus thermal noise due to the resistance of antenna elements and transmission line, and also due to active elements – transistors in the receiving system, particularly in the input stages.

Requirements For Receiving

- main requirement is to obtain the largest possible signal to noise ratio.
- high efficiency and a good match may not be essential to maximize the signal to noise ratio.

External Factors Affecting Signal to Noise Ratio:

- *Interfering Signal*

Where a strong interfering signal is present, a radiation pattern null in that direction is main requirement.

- *High External Noise Environment*

At frequencies below 10MHz, the external atmospheric noise produced by distant thunderstorms is of such a level that a resonant dipole antenna may receive 20 to 30dB more external noise than that generated by the receiver stages, the feeder, or the antenna itself. An appreciable mismatch between antenna and the receiver system reduces the signal level to the receiver, but since the noise level is also reduced in proportion. S/N remains unchanged. Under these conditions a loss of 10dB or more due to antenna efficiency or poor impedance match to the receiver has virtually no effect on signal to noise ratio.

This situation can often be used to advantage since it allows the use of resistively loaded broadband travelling wave antennas, which have a low efficiency at low frequencies. It also allows the use of compromise matched short antennas, e.g. whips, which are a poor impedance match to the receiver, but offer great advantages in terms of cost and portability.

In some applications, antennas of reduced efficiency may actually improve the receiving system performance. By offering lower signal levels of the same S/N to the receiver, the receiver operates at a more favourable point in its dynamic range, reducing the likelihood of overload conditions, so reducing intermodulation products and improving spurious signal rejection capability of the receiving system.

The frequency range 10 to 30MHz represents a transition stage from predominantly external noise. which is reducing (see graph. Fig. 5) as the equipment noise component is increasing with frequency. In practice, therefore in this band system VSWR limits should be generally less than 3:1, if degradation of S/N by the antenna system is to be avoided.

Receiving Antennas

A receive antenna responds to waves incident to the antenna, from all directions if the antenna is omnidirectional, or from specified directions if the antenna has directional properties. The sensitivity as a function of direction follows the same law as the radiation of the same antenna when transmitting. The radiation pattern of the antenna therefore also describes its directional response as a receive antenna.

At any one time, a receiving system is usually required to receive information carried on a wave originating from one transmitting station of a complete communication system. All other waves in the operating frequency band of the antenna are either interfering transmissions, or random radiation from space and environment, described as radio noise. Satisfactory communication is possible, only if the power extracted by the antenna system from the wanted wave, (the signal S) is sufficiently higher than the power received from interfering waves so that, after processing in the receiver, the demodulated signal is reasonably clear and undistorted.

Assuming that interference received by the antenna is only radio noise, the noise power N in the ratio S/N refers to the radio noise received by the antenna and the thermal noise in the receiving system. S/N is the most important design parameter of any receiving antenna installation since it is of primary importance in the complete receiving system. A secondary design parameter is the signal level, the signal power S delivered to the receiver input. Modern receivers are highly sensitive, so that the choice of the antenna is not usually affected by the required minimum signal level, but by a specified S/N.

S/N Ratio of a Receiving Antenna System
It can be shown, under the assumption that radio noise is received equally from all directions (not always the case in practice) that:

- noise power N received by the antenna is independent of its directivity.
- the S/N ratio can be increased by increasing the directivity.

In practice, since noise levels received from different directions can vary e.g. man-made noise from an adjacent city, or electric power lines, it is important to try to select the best site available. The directional receiving antenna's advantages are enhanced, whenever its directional pattern discriminates against unwanted interference, in favour of the desired radio wave.

Broadband vs. Narrowband Antennas

HF antennas can be separated into broadband and narrowband groups according to their frequency response.

Narrow Band Antennas

Monopoles

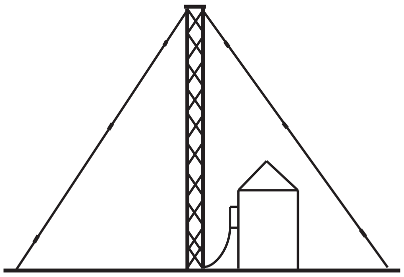


Fig. 6 Vertical Radiator (Monopole)

The vertical radiator or monopole (Fig. 6) often has an insulated mast as the antenna. It can be resonant at a quarter wavelength (half the length of a dipole) or non-resonant and tuned with an antenna tuning unit, but that introduces inefficiencies. The guy wires must be interrupted with insulators at regular intervals, although part of the top guy wire may be a component of the antenna circuit.
A good ground is required, and, since top soil often has low conductivity, an artificial ground mat is used. This consists of 60 or more radials of heavy copper wire laid on, or just below, the soil surface and connected to a central copper ring. The length of the radials should be at least a quarter wavelength at the lowest operating frequency. Sometimes metallic spikes are driven into the ground at regular intervals and soldered to the radials to improve contact with the surrounding soil.
A good ground wave makes communication with mobiles over short ranges more reliable. However, high angle radiation is poor, so that performance may be unsatisfactory at intermediate distances. Receiver noise level is generally high, since man-made noise is predominately vertically polarized.

Dipoles
The simple dipole (Fig. 7) is efficient and inexpensive, but will only operate on one frequency.

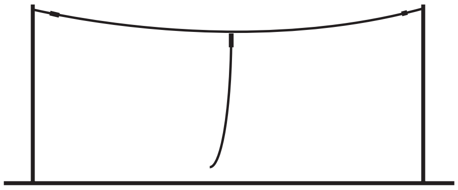


Fig 7 Dipole

A variation is the inverted vee dipole (Fig. 8). This has basically the same characteristics as the horizontal dipole, but requires only one mast.

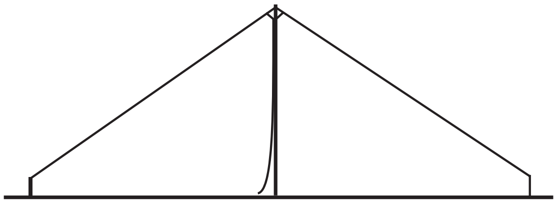


Fig 8 Inverted V Dipole

Broadband Antennas

The clever way to go, when more than one frequency is involved, is to use a broadband antenna that will operate on all the required frequencies without adjustment. RFS broadband antennas operate on either the travelling wave principle or the log-periodic principle. The pictures in this guide illustrate the great variety of broadband antennas available for a multitude of operational needs.

Travelling Wave Antennas
Travelling wave antennas are very successful. With these the input impedance remains within reasonable limits and so does the radiation pattern. Two techniques are available to obtain travelling waves in antennas- to avoid reflections leading to standing waves:

- antennas having a conical shape of the radiators, which increases the energy radiated along

the antenna conductors so that very little energy is reflected back to the input.
- insertion of resistive components into more simple wire radiators to avoid reflections and standing waves.

Conical Antennas
Fig 9 is a horizontal dipole based on the geometrical principle. With this the conical or biconical shape of each dipole arm causes waves starting at the feed point to become disengaged, i.e. to be radiated. Biconical dipole antennas are designed for short to long range communication with power ratings in excess of 40kW PEP and are available in 2-30MHz or 3-30MHz frequency ranges.

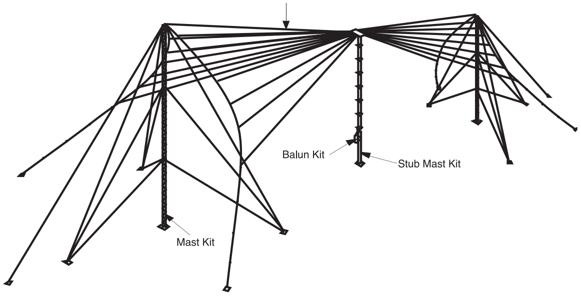


Fig 9 Broadband Dipole (BDH Series)

The monopole (Fig. 10) is designed for medium to long range omni-directional coverage, and covers the standard bands of 2-30MHz or 3-30MHz. Power ratings are usually up to 80kW PEP.

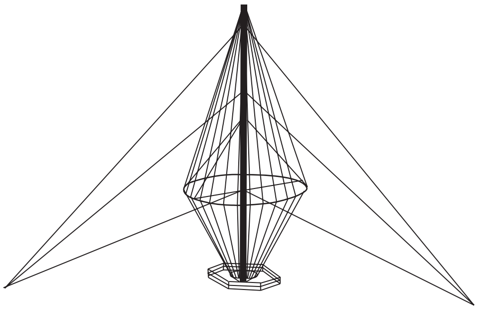


Fig 10 Broadband Monopole (WM Series)

Resistively Loaded Antennas
Fig 11 shows a horizontal travelling-wave dipole based on the principle of inserting resistive components to avoid reflections. In each dipole arm is a resistor inserted at about two-thirds of an arms length from the feed point. There are several models of broadband travelling wave dipole covering 2-30MHz, 3-30MHz and 5-30MHz. Standard power rating is 1kW Av or 4kW PEP. These antennas are ideal for short to medium range communication up to 3000km.

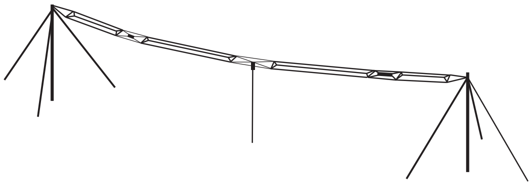


Fig 11 Travelling Wave Dipole (TWD Series)

If one mast and one half of the dipole are removed, and the remaining arm is tilted, the semi-delta antenna of Fig 12 is obtained, i.e. a tilted travelling-wave monopole. Between the lower longer section of the monopole and the upper section, a resistor with a parallel inductor is inserted to avoid standing waves. Operation is from 2-30MHz with a power rating of 250W Av, 1000W PEP. Where soil is poor and operation below 3.5MHz is essential, a low frequency kit is available.

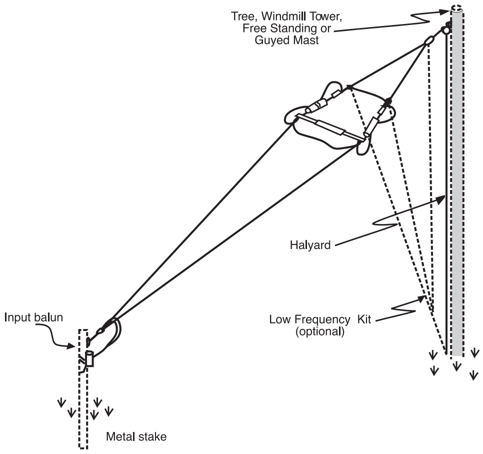


Fig 12 Semi-Delta Antenna (SD Series)

Another popular HF antenna, the Sloping Vee illustrated in Fig 13 has been used for decades for directional transmitting and receiving. This antenna consists of two wires assembled as a Vee with the apex at the top of a mast. Each wire slopes down and is terminated in a grounded resistor R_E. A balanced feeder transmission line is used to drive the Vee at the apex. Experience has shown that VSWR with these antennas is affected by ground conditions. This is because ground existing between the earth terminals of the terminating resistors acts like a resistive/capacitive component and VSWR usually exceeds acceptable values at some frequencies.

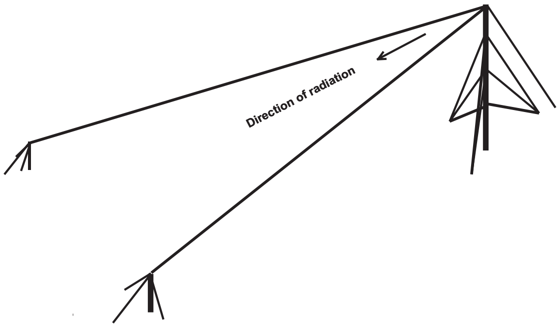


Fig 13 Sloping Vee

To improve the VSWR performance of the historical Sloping-Vee antenna, RFS developed the Sloping-Triangle Antenna shown in Fig 14. VSWR does not exceed 2:1, because antenna current does not pass through the soil. It is designed for medium to long distance communication over 3-30MHz or 5-30MHz. Power ratings are up to 1kW Av, 4kW PEP.

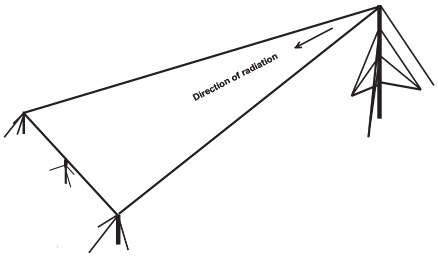


Fig 14 Sloping Triangle (ST Series)

Broadband delta antennas (Figs 15 - 18) are possibly the most used series of broadband antennas in the world. These antennas are designed for high-angle ionospheric propagation over short to medium distances from 0-1000km or more. Radiation results from a wave travelling upward to a resistive termination of the apex of the antenna.
The dual wing delta in Fig. 15 is omni-directional. There are two versions: 2-30MHz and 3-30MHz. Power ratings available are up to 1kW Av, 4kW PEP. The radiating wings are fed via open wire line, or by coaxial cable using a balanced/unbalanced impedance transformer (balun).

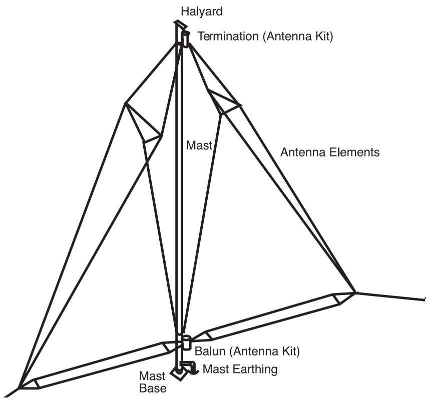
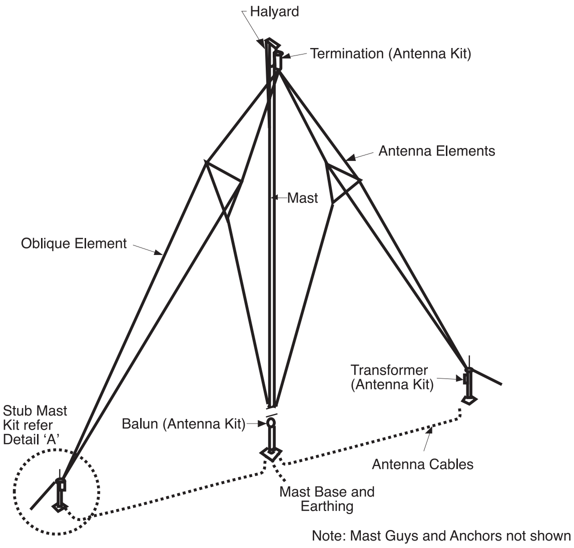


Fig 15 Delta Antenna (D Series)

The antenna in Fig. 16 is similar to that in Fig. 15 but the radiating elements are fed by co-axial cable that can be buried instead of above-ground open wire line. This enhancement can be useful where personnel have access - on parade grounds, etc.

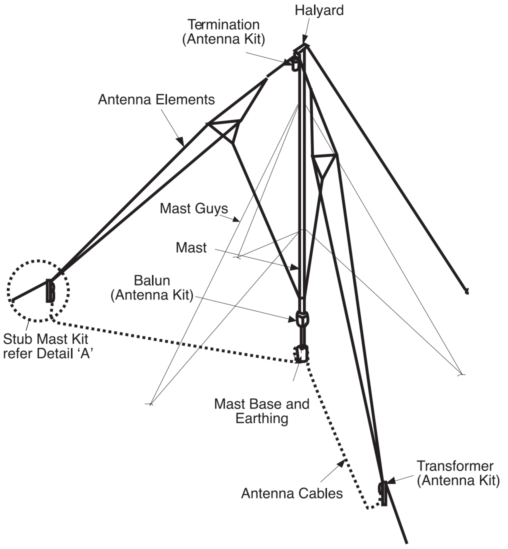


Note: Mast Guys and Anchors not shown

Fig 16 Cable-Fed Delta Antenna (DC Series)

Two dual wing deltas can be mounted on one mast to enable two transmitters to operate simultaneously and independently. The isolation between the two antennas is greater than 30dB.

To enhance the radiation in a particular direction, the two arms of a delta antenna can be moved around the mast as shown in Fig. 17. This model is known as a directional delta and extends the range of communication to up to 1600km or more. It is available to cover 2-30MHz and 3-30MHz and power ratings are from 1kW Av. to 4kW PEP.



Note: Mast Guys and Anchors not shown

Fig 17 Directional Delta Antenna (DDC Series)

The tandem delta (Fig. 18) is specifically designed for high grade short to medium distance circuits for communications and HF broadcasting. The tandem delta does not have a resistive termination at its apex. It is actually two delta antennas. One delta is terminated in another and so nearly 100% of the energy is radiated, giving the tandem delta a 2dB to 4dB gain over the standard delta. Power ratings are up to 80kW PEP.

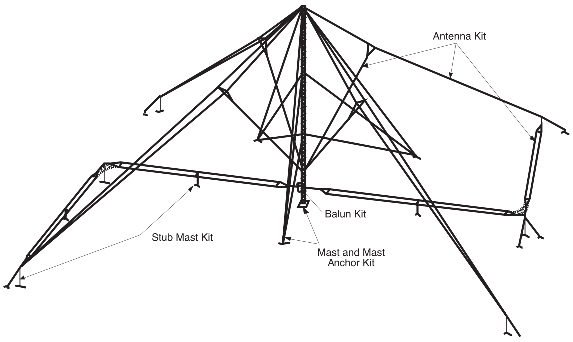


Fig 18 Tandem Delta Antenna (TDG Series)

Log-periodic Antennas

Wide-band antennas incorporating another principle are log-periodic antennas. These are of particular interest for high performance HF communication systems. They comprise an array of tapered dipoles with tapered spacing between adjacent dipoles where the tapering is constant (i.e. the ratio of adjacent dipole length and adjacent spacing is constant) in each model. The log-periodic dipole antenna is a resonant antenna. However, due to the tapered configuration, it is resonant at any operating frequency. Actually only three, four or five dipoles (the so called “active region”), which are close to resonance, operate at the incidental frequency.

The horizontal log periodic dipole array (Fig. 19) is for medium to long distance communication. It is available with a wide range of take off angles and gains. Power ratings are from 1 to 20kW Av. and frequency ranges are from 2-30MHz. No ground screen is required.

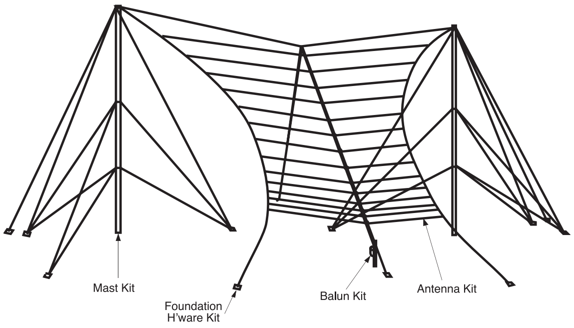


Fig 19 Horizontal Log Periodic Dipole Antenna (HLP Series)

A rotatable version of the horizontally polarized log periodic antenna is shown in Fig 20. This antenna can be used to achieve high quality transmission with some flexibility in selection of the transmission direction. The antenna is available in 4-30 MHz and 6-30 MHz versions with power ratings up to 10kW Av, 40KW PEP.

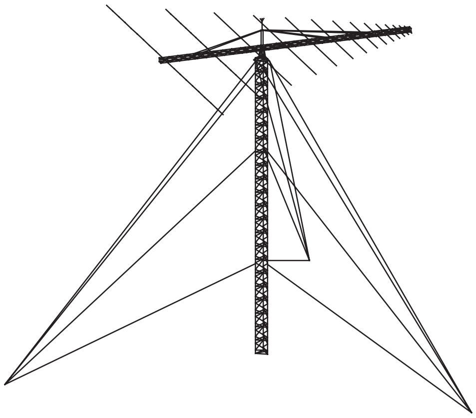


Fig 20 Rotatable Log Periodic Dipole Antenna (HLO Series)

The vertically polarized version shown in Fig 21 provides a very low take-off angle for radiation that is ideal for long distance communication. Power ratings are from 1 to 20kW AV, 40kW PEP and frequency ranges are from 3.5-30MHz. For optimum performance, the low angle radiation can be enhanced by extending a ground screen for several wavelengths in front of the antenna.

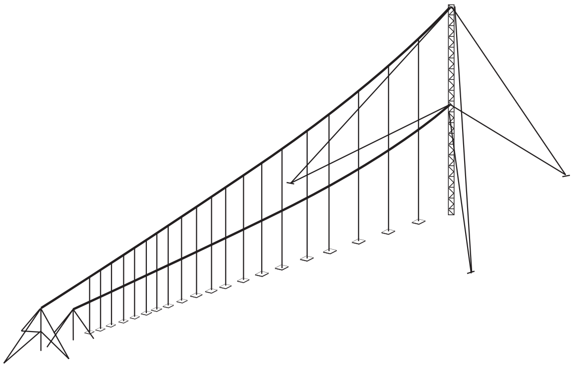


Fig 21 Vertical Log Periodic Dipole Antenna (VLP Series)

The electronically steerable log periodic dipole rosette (Fig. 22) is designed for shore-ship or ground-air communications. Four separate antennas share a common mast and operators can achieve full 360 degree coverage by switching power to the appropriate antenna. These antennas provide maximum opportunity to optimize circuit performance in the selected directions.

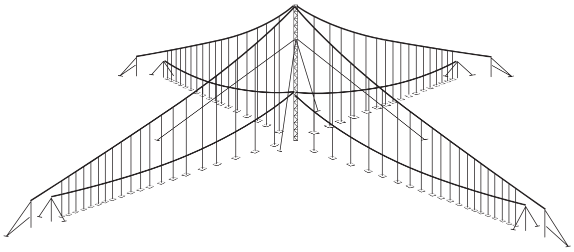


Fig 22 Vertical Log Periodic Dipole Rosette Antenna (VLPR Series)

Ground Screens

Ground screens have two main purposes:

- They form an essential part of vertically polarised monopole antenna systems (WM series, for example) by providing a return path for the current being fed to the monopole. In this application they are referred to as impedance stabilization ground screens, and typically extend radially for one-quarter wavelength at the lowest frequency of operation. They can be placed on the surface of the ground, or buried slightly below the surface, for convenience. Although not strictly required to stabilize impedance for other antenna types, they can improve the efficiency of vertical dipoles, and certain other antennas, by reducing ground losses.
- They can enhance the low angle radiation of vertically polarised antennas. Unfortunately, to be effective for this purpose, very large ground screens are required. These usually consist of grids or mesh of wires and typically extend 10 to 20 wavelengths in the required transmission direction. It usually requires a performance / cost trade-off analysis to determine if there is a need for such a screen. Note that the impedance stabilization ground screens are usually much too small to perform this function.

Conclusion

As can be seen, RFS manufactures a wide range of broadband antennas. Selecting the right antenna is crucial if the operational objectives of the system are to be realized. RFS can offer advice to ensure that the antenna selection is tailored to suit your individual requirements.