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Q-MAC ELECTRONICS

HF TRANSCEIVERS & ANTENNA SYSTEMS

Mobile and Base Station Antenna Systems

HF HELP FILES

Q-MAC Electronics Pty Ltd

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Mobile and Base Station Antenna Systems

HEAD OFFICE 142 Hasler Road, Osborne Park WA 6017. Australia
Telephone: +618 9242 2900, Facsimile: +618 9242 3900
Email: info@qmac.com
Web: www.qmac.com

1 Introduction

Within Australia and in developing countries, communication using HF radio represents a highly cost effective method of spanning large distances. In order to obtain optimum performance, an appropriate choice and installation of antenna system is necessary.

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2 Base Station

Where space permits at a base station and where only a few fixed operating frequencies are required, a half wave wire dipole suspended between two masts is an effective choice. This consists of two wire elements of length l = (71/freq in MHz) metres for each channel required. The dipoles for each channel can be fed in parallel at the centre point by a BALUN transformer which allows 50 ohm coaxial feed cable to be used. (see figure 1)

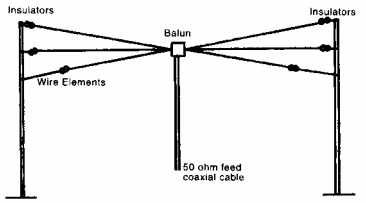

Figure 1: Multi Frequency dipole

The dipole exhibits a directional characteristic with maximum radiation perpendicular to the wire axis (see figure 2).

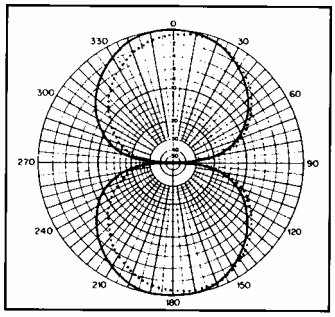

Figure 2: Polar Diagram for Half Wave Dipole

If the required service area extends beyond 700km, then elevating the antenna up to one quarter wavelength L = (75/freq in MHz) metres will achieve better low angle radiation (hence longer distance) however if communication in the range 100km-700km is required then a lower elevation is acceptable.

A space saving version of the multiple dipole antenna is available in the form of a multiple helical dipole. Here the elements are rendered shorter by continuously loading in a spiral around a tapering fibreglass former. This can mount on a single pole with a central balun hub from which the “cats whiskers” emerge. There is some decrease in efficiency relative to the wire dipole however it is a very useful antenna where space is limited and has the advantage that it can be easily rotated, allowing signal peaking or nulling out of interference.

Where wide frequency operation is desired along with operational flexibility a broadband wire antenna is useful. These come in a variety of designs. The three wire Travelling Wave Dipole is often used in fixed locations and performs well over most of the HF band (see figure 3).

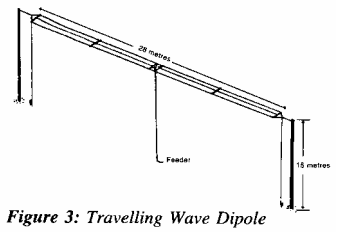

Figure 3: Travelling Wave Dipole

The same advice on mounting height applies to this antenna as to the half-wave dipole. However the polar diagram is somewhat different. At frequencies below 7MHz the main radiation is perpendicular to the wire axis but the nulls are less deep. Above 7MHz the pattern becomes more complex with more radiation appearing down the

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axis of the antenna. The antenna requires supports up to 45 metres apart dependent on model. This three wire antenna is 1.8metres in width and incorporates a step-up balun and a termination box.

A simpler single wire broadband dipole antenna is also available. This is similar in length an again has a 600 ohm step up balun but has two load boxes of approximately 900 ohm about 2/3 of the way along each arm.

Half size unbalanced monopole versions of the above antenna are available for portable use in the bush and these rely upon an earth connection to function. This may be as simple as a wire fence or a vehicle chassis.

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3 Mobile Antennas

At HF it simply is not possible to obtain an antenna which is anywhere approaching one quarter wavelength mounted on a vehicle. For example at 5MHz one quarter wavelength is 15 metres. A reasonable size for a vehicle antenna is 1.8 metres, less than one eighth of the optimum length. The task of the antenna system designer is to deliver the maximum amount of radiated power to the antenna. The radiation resistance of an antenna is the load to which the power must be delivered. For an electrically short antenna (a 1.8metre whip antenna at 5 MHz) the radiation resistance is approximately 0.28 ohm. For a vehicle mounted antenna, RF loss resistance is typically 5ohm so it can be seen that this sort of antenna is less than 5% efficient.

This problem is overcome to a degree by using a continuously loaded whip antenna which has a spiral of insulated wire on a tapered fibreglass former. The length of the wire is arranged to be resonant at the operating frequency obtaining a tune and match simultaneously. Taps may be added to allow frequency selection by means of a turns bypassing lead fitted with wander plugs. A robust and relatively efficient antenna results from this arrangement. Its drawback lies in the necessity for manual intervention.

Automatic tuning HF antenna systems are available in a number of forms usually designed specifically for the manufacturers own HF transceiver.

The electrical equivalent circuit of the short 1.8metre whip typically used on a vehicle is as in figure 4.

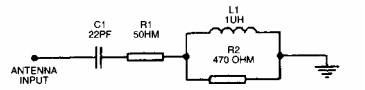

Figure 4: *Electrical equivalent circuit for 1.8 metre HF mobile whip*

Below 8 MHz the effect of the 1uH inductor and 470R resistor is not significant and the effect of the 22pF capacitor and 5R resistor dominates. This is a highly reactive load. Between 8 and 24 MHz the resistive component climbs and the reactive component diminishes. At around 25 MHz the LC elements are close to resonance and the reactive component is close to zero and resistance around 40ohms.

In order to transfer maximum power to this network, the antenna tuner must cancel the capacitive reactance and transform the resistive part to 50 ohms. The reactance cancellation is invariably done by adding series inductance. The impedance transformation is obtained either by using a transformer or by using an LC network with series inductance and shunt capacitance.

Physical implementations of the above are quite different between manufacturers. The Codan 9358 autotuner is a one piece unit with whip mounted above a continuous inductor which is varied in value by a capacitive coupling piston driven by a stepper motor. Impedance transformation is effected using a variable ratio transformer. The Barrett 910 autotuner is a one piece unit which selects the correct reactance cancelling inductance by relay switched, binary weighted inductances. A relay switched impedance transformer is used. The Q-MAC TA-90 is a two-piece unit with a continuously loaded whip fed from a separately mounted tuner box (see photo). Relay switched binary weighted inductors are used however these are the more compact toroidal type. A relay switched impedance transformer is used.

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With any mobile whip the integrity of the ground connection to the vehicle body is critical. Also the antenna whip should be as clear of the body as possible to ensure efficient radiation. At the lower frequencies the voltage at the base of the whip on transmit can exceed 2000volts so keeping the base insulator clean is important.

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4 Other Information

4.1 Author

Mr Rod Macduff BSc, BA, MIEEE, MIEE, FIEAust

Rod Macduff is Managing Director of Q-MAC Electronics which is a specialist supplier of HF Communications to the Humanitarian, Aid & Relief and Military organisations. Rod Macduff worked with Racal BCC for 10 years on the Jaguar V tactical hopping radio and travelled extensively consulting with armies on their secure communication issues. The Q-MAC HF-90 hopping radio is in service in 75 nations and has been adopted by Humanitarian, Aid & Relief, Army, Police and Intelligence organisations.

4.2 About Q-MAC Electronics

Q-MAC Electronics is specialist designer and manufacturer of HF Transceivers. The flagship product the HF-90 is the world's smallest high performance HF SSB Transceiver. The HF-90 and Q-MAC Electronics have been awarded many accolades and is currently used by thousands of users in over 80 countries worldwide. The HF-90 is one of the most versatile HF transceivers available and is suited to military, paramilitary and humanitarian aid and relief applications.

Q-MAC offers the HF-90 in a variety of configurations suited to manpack, vehicle and base station applications. A full complement of accessories is also offered for use with the HF-90; including antennas, field battery charging accessories, carry packs/cases and more. All Q-MAC products are backed by the company's strong commitment to after sales service, support and certified ISO9001 quality standards.

4.3 Contact Details

For Further Information Contact;

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