

MF Antennas for the Eighties

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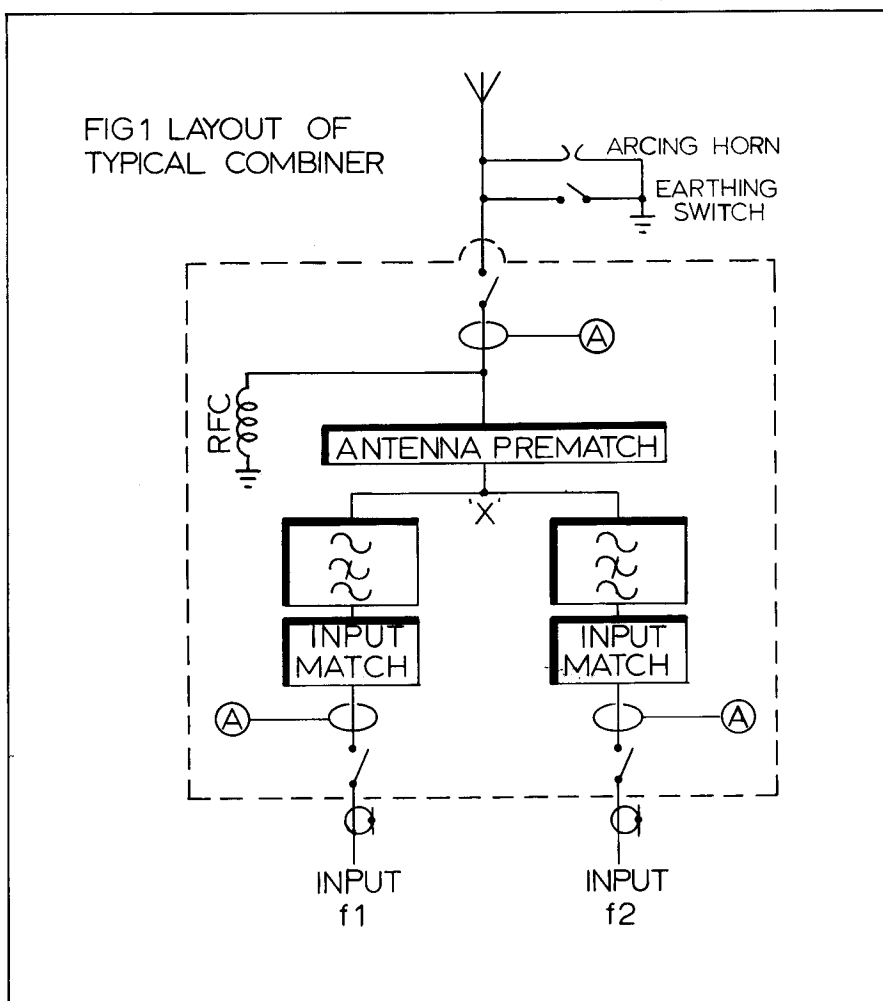
In most parts of the world MF radio remains the medium with the largest mass audience. The service planner is confronted by an ever more crowded spectrum and consequent restrictions; the broadcaster must accommodate more services on his transmitting stations. The antenna engineer has responded to the present situation by producing reliable high power multi-frequency antennas, often with stringently defined directional characteristics.

C & S Antennas (CSA) have developed a design philosophy which provides a wide variety of antennas using a consistent design method and proven range of components. The types of radiating structure used in the MF band has not shown any fundamental change over a number of years but by using modern network techniques much greater flexibility is obtained in their use in both directional and non-directional systems.

Multiplexers

To conserve space on transmitting stations and also to save the cost of further large masts and towers, increasing use is being made of multiplexers to combine the outputs of several transmitters into a single antenna. A typical 2-input combiner is shown in figure 1. Each transmitter is joined to a common point ('X') through a bandstop filter tuned to the frequency of the other transmitter. The common point is connected to the antenna by a matching network whose function is to transform the antenna impedance to the value which will allow the circulating currents and operating voltages in the filters to be minimised. The choice of common point impedance depends on the antenna characteristics, the spacing between the input frequencies and the available network components. If input powers are low and the antenna impedances are favourable the prematch circuit is not required. An input matching network is provided to match the input impedance presented by the filter to the incoming transmission line.

The diagram also shows typical measurement and safety facilities. Switches on inputs and output allow isolation of the circuit for access and also provide convenient points for impedance measurements. An arcing horn, earthing switch and static leak provide lightning and static protection. Current transformers are used to drive meters to indicate input and output currents.



Similar design methods are used for combiners for three or four frequencies. The complexity of a combiner rises quickly as the number of inputs is increased but separate co-sited antennas often require an even larger number of filters if intermodulation and crossmodulation effects are to be kept acceptably low.

Directional Antennas

The use of multi-element directional antennas on the MF band is now well established. The advent of computers has increased analysis of stability and adjustment tolerances much easier. Owing to the high cost of multi-element antennas the incentive for multiplexing more than one service onto the same antenna is very large. The technical problems posed are generally less severe than those presented by single element antennas where the whole power of each transmitter is fed into a single element. The requirement for isolation between transmitter inputs to ensure low IP's is more stringent than that required to ensure proper independent adjustment of the

antenna drive currents at each frequency. A separate phase and amplitude control network is provided for each frequency so quite different and independent radiation patterns may be obtained at each channel. Because the changing electrical spacing between antenna elements provides changing constraints on the available radiation patterns on each channel, different drive amplitudes and phases will be required at each channel to obtain similar radiation patterns.

The instruments used to monitor the phases and amplitudes of the element currents are not usually frequency selective so a system of filters is required to allow the currents at each frequency to be monitored independently while the system is on the air.

To provide widely different radiation patterns from a single array, it is sometimes arranged to vary the number of driven elements between one channel and another, or to vary the excitation at a single frequency to provide night/daytime service or service to different target zones.

Constraints

There are a number of interacting constraints which must be considered when the multifrequency operation of an antenna is being proposed.

- Relative frequency separation between channels.
- Input power at each channel.
- Antenna impedance at each channel.

The circulating current in parallel LC bandstop filters is a direct function of the ratio between the stop frequency and the applied frequency. It becomes very difficult to design combiners for frequencies spaced by less than 10 per cent ($f/f_0 < 1.10$). In general it is only possible to cope with such small spacings at low powers or when the antenna impedance at both frequencies is particularly favourable. Very wide frequency separations are not a problem.

It is obvious that the size and therefore the cost of network components rises as higher voltage and current ratings are needed. It is necessary to remember that the peak voltages at different frequencies add directly, so the peak voltage obtained from 3 x 50kW transmitters will be the same as would be obtained from a single 450 kW transmitter. Isolations of around 40dB are usually required between transmitters, but when trans-



150kW ATH with additional rejectors, covers removed.

(Photo : courtesy of the BBC)

mitters with very different output powers are multiplexed, higher isolations will be needed to protect the lower power transmitters.

When high power transmitters are being combined, the antenna prematching circuit needs very careful design. The impedance presented by the antenna will be very different at the different input frequencies. It is often desirable to reduce this variation to minimise the ratings, and therefore the cost, of the combiner components. In some instances the antenna can be physically modified to

achieve a more satisfactory combination of input impedances at different channels. The height of vertical radiators must normally not exceed 0.65 wavelengths at the highest operating frequency if acceptable vertical radiation patterns and ground wave field strength are to be achieved.

The techniques described in this article have been applied successfully to a wide variety of antennas including mast radiators, Tee antennas and sloping wire radiators. Similar methods have been used to permit a Tee antenna to be used simultaneously with each of the two mast supporting it.

Turning Theory Into Hardware

As we have seen there is wide scope for the antenna engineer to design economically attractive systems for the broadcaster, helping to squeeze the best possible operational flexibility from given resources of money and land. These designs must be turned into hardware which is easy for the non-specialist to assemble, predictable in performance, easy to adjust under site conditions and which is stable and reliable in service over a long period.

CSA have realised these objectives by:

1. Use of first class circuit components.
2. Attention to mechanical design.
3. Adoption of cubicle construction.

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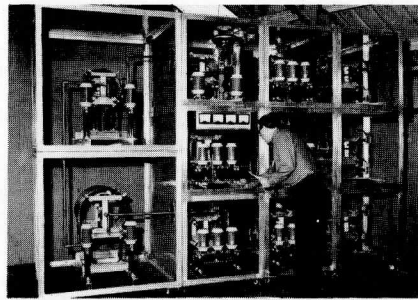
4. Use of computer aided electrical circuit optimisation.
5. Provision of good access, metering and switching.

Components

To achieve consistent and reliable results the designer must be able to call on a range of first class components with known characteristics and factors of safety. For high power applications only a limited range of components is available and their ratings must be known with complete certainty. Inductors must be stable in service but must be designed to allow easy, accurate and continuous adjustment to any required inductance. Capacitors require ample kVAR ratings and low temperature coefficients to ensure proper stability under working conditions.

Mechanical Design

To maintain accurate tuning of resonant circuits and stability of array currents, mechanical design must be stable and rigid. Conductor joints and coil taps must maintain reliable contact over a period of many years. All materials must be corrosion resistant and must be plated where necessary to avoid electrolytic corrosion at joints, particularly when the equipment must operate in tropical conditions.



3 x 10kW triplexer with additional filters for other on-site transmissions, covers removed.

(Photo : courtesy of the BBC)

Cubicle Construction

CSA construct all networks in closed cubicles of standard design. In general each circuit function is contained in a separate cubicle. This construction provides a number of important advantages:

1. **Full electrical screening of networks.** It is normally not necessary to provide full screening for the antenna tuning house (ATH).
2. **Complete independence of electrical adjustments.** Unexpected coupling effects between different circuits are completely avoided
3. **Good access for assembly and**

maintenance. Every circuit has sufficient space around it to allow easy assembly, adjustment or cleaning. The risk of accidental disturbance of other parts of the circuit is avoided.

4. **Compact installation.** Components do not need to be spread out to reduce unwanted coupling and efficient use is made of the height available in the ATH.
5. **Easy identification of circuit function.** Each cubicle contains parts with a unique and identified function.
6. **Easy inspection under working conditions.** It is safe for personnel to enter the ATH while the network is powered as no live parts are exposed or un-screened.

Prefabrication

All parts of the networks are prefabricated, assembled and tested at works. This reduces the possibility of problems, delays and unforeseen malfunctions at site.

Computer Optimised Design

The use of computerised design methods allows optimisation of component values. This allows components to be used economically whilst maintaining assured factors of safety. Inductor dimensions have been chosen to provide optimum Q factors when inductors are mounted in standard cubicles.

Crucial to the design of antenna feed networks and insulation schemes is a knowledge of the characteristics of the antenna elements which it is required to feed. A suite of antenna programmes is available to predict antenna array performance and element impedances and operating voltages.

Test Facilities

Large networks are designed with the commissioning and maintenance engineers in mind. As well as good access and visibility the networks provide switch links at inputs and outputs for easy connection of test-gear. Thermoammeters are driven from large toroidal current transformers : their failure cannot disable an antenna and they are largely secure from premature failure due to lightning strike. Extended indication can be provided to an operating position, or on more complex arrays a full monitoring system is provided.

Service Proved

CSA MF networks are setting new standards in performance and reliability based on a thorough understanding of the electrical and mechanical engineering skills needed to create them and of the needs of the broadcasters who use them. □

