AERIAL OVERVIEW

PART TWO

MF ANTENNA PRACTICALITIES

Modern antenna design must satisfy the broadcaster's twin requirements of technical and cost efficiency. Faced with the task of resolving these sometimes contradictory demands, the designer of antenna systems has a number of options. In part two of this two-part series, **Brian S. Collins,** *Technical Director of C&S Antennas, discusses practical aspects of MF antenna specification and design.*

THE achievement of a fully cost effective MF antenna system requires careful judgment in the balancing of the costs of:

Capital equipment,
Civil works,
Installation,
Maintenance,
Lost service due to faults.

The costs of power, maintenance and loss of service vary widely for different installations. Thus some installations must operate in countries with a humid coastal climate and poor local facilities: others operate in countries with dry climates and adequate trained manpower with good facilities for maintenance. The costs of lost service time are more easily quantified in money terms for stations whose income depends on advertising revenue, but must also be considered for any government or public service radio station.

1. Masts and stays

The choice between the use of stayed masts and self supporting towers should reflect both the difference in initial installed cost and the costs which will be incurred over the service life of the structure in maintenance. In the case of a stayed mast the cost of maintenance of the stays and insulators are particularly significant. Unless the location of a station presents unusual difficulties of available ground area, a stayed mast will generally be cheaper than a mast of the same height. The exception is if very high powers are involved, when the cost of stay insulation may make a tower economically attractive. Unfortunately, as noted in the earlier article, towers cannot provide equivalent anti-fade performance to that obtained from tall masts (unless loaded or provided with dressing wires). The cost of self supporting towers also rises more quickly with increasing height than that of stayed masts.

Materials

Steel is universally used for the construction of tall structures. The use of aluminium, an apparently attractive material, is very much limited by its poor fatigue characteristics. At the present time structural steel is almost always hot dip galvanised to provide basic protection against corrosion. A well coated galvanised surface has a very long life expectancy when exposed to a rural, non-contaminated atmosphere, even in a tropical climate. The zinc coating is attacked by industrial pollutants, so in an industrial area structures will require a full protective paint treatment. The paint system required for maximum corrosion prevention is entirely different from that required to provide the usual ICAO red and white banding whose purpose is to make the structure more visible to low-flying aircraft. When necessary an ICAO colour scheme can be applied as a top coat in a full protective system. Particular care must be taken in specifying the pre-treatment of newly galvanised surfaces before paint is applied, or extensive peeling may take place after only a few months in service. Painting before shipment has proved satisfactory if the pre-treatment and the paint system are correct and the paint has been properly applied.

Stays

The basic stayrope material for large structures is galvanised high tensile steel wire. This material is particularly subject to corrosion, mainly because of water retention in the structure of the rope and the many crevices in which electrolytic action can begin. The lower ends of stays are also exposed to erosion by blowing dust and sand in arid locations. Unfortunately stayropes require very specialised labour and equipment for their maintenance. Thermoplastic-impregnated galvanised steel wire ropes are available and these may certainly be expected to require very little maintenance, off-setting their higher initial cost. Various greases and special paints are available to increase the life of stayropes and should certainly be used at industrial or coastal locations.

Several synthetic fibre or composite stayrope materials are now available and have found some acceptance for use on smaller structures operating at lower powers. Not all the experience of users has been satisfactory and the wider application of these comparatively new ropes will follow the accumulation of more user experience and the evolutionary development of the materials themselves.

The design of stay insulators has seen the advent of high voltage/high strength oil-filled fibre core types. These, together with the 'fail safe' versions of related design, provide suitable high voltage insulation for the upper ends of stays. The design of medium voltage insulators for stay 'break-up' use is less satisfactory. Traditional egg insulators

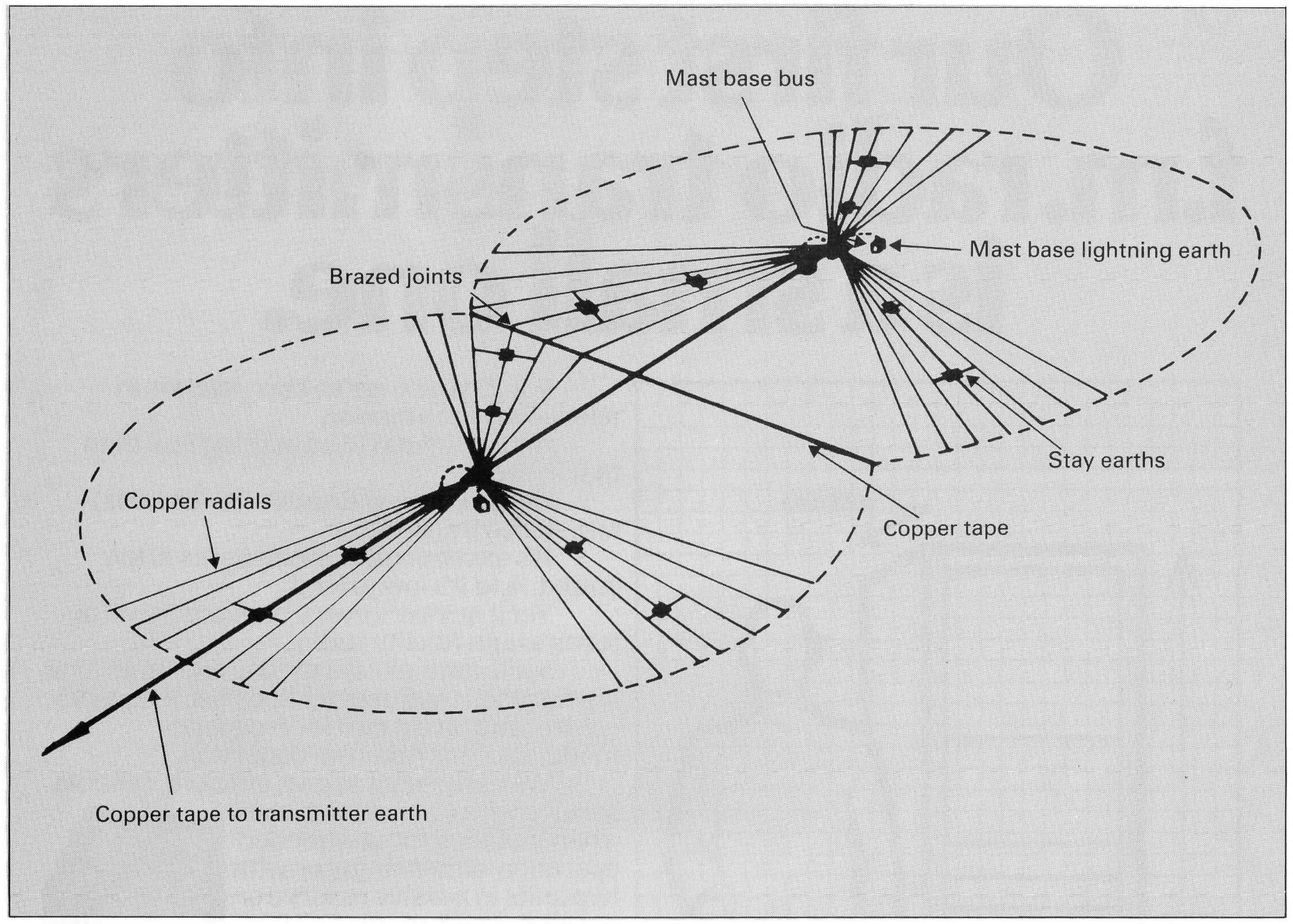


Figure 1: Configuration of a typical earth system.

have poor voltage breakdown characteristics, particularly when wet, and arcing damage is often to be seen on the stay rope ends looped around the insulators. Alternative designs are often very expensive and are too heavy for use with modern lightweight masts.

As the cost of stay insulation is very large for high power radiators, it is often more economical to adopt a wider and more rigid mast section with the object of reducing the number of stay levels needed.

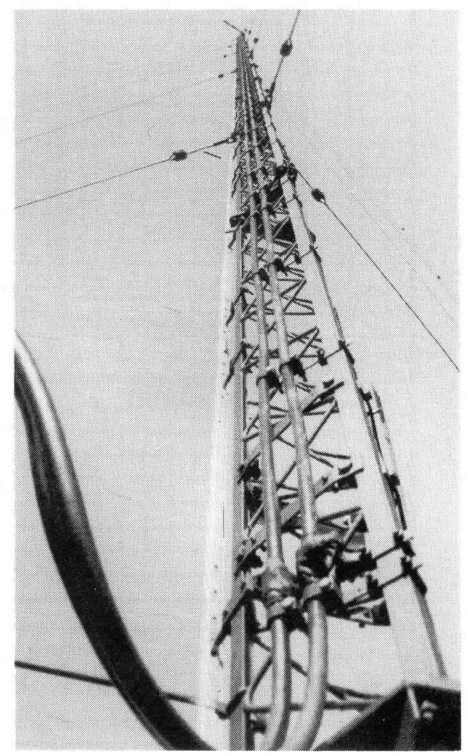
Wind

The specification of maximum wind speed has a very important effect on the design and cost of a mast. The engineer specifying the windspeed to the antenna supplier must try to obtain the most accurate available data for the location where the antenna is to be erected. When using modern design codes (for example BS CP3) the designer must begin by knowing an accurate and reliable 'basic wind speed' for the antenna location. Overdesign is expensive and underdesign is a danger to life.

The terms 'maximum', 'design', 'working' and 'survival' applied to windspeed often appear in specifications without any really clear, quantifiable and unambiguous meaning. National design codes differ and may be specifically intended for application to the particular conditions of the country concerned. The comparison of structures each offered as compliant with a different national code is difficult, especially when the structures may be destined for erection on another continent.

2. Ground systems

The ground around the antenna at any radio station has a relatively poor conductivity compared with the perfectly conducting ground which the antenna engineer would like. As a result of the imperfect ground the input impedance of the antenna is modified, the ground wave field intensity is diminished and the nulls in the vertical radiation pattern of the antenna are filled in. These effects can be reduced by the use of a suitable ground mat, usually in the form of a system of radial wires converging at a point below the mast base. Ground systems have been extensively studied and a large literature is available. Despite this, a



MF Mast Radiator supporting MF Passive Reflector and VHF Transmitting antennas.

large number of non-optional systems are still specified, often by using the misleading rule of thumb that the radial length should be equal to the mast height: this leads to small lossy systems for use with short masts, and excessively large and expensive systems for use with tall anti-fade masts. A site with high ground conductivity should be found if at all possible. Radial wires may be buried to allow the land to be grazed by animals or even ploughed with modern equipment, so the cost of using productive agricultural land can be minimised.

Figure 1 shows a typical ground system for a 2-mast antenna. The two radial systems are truncated where they intersect and the wires are brazed to a copper tape. A lightning conductor earth arrangement is also shown, comprising buried plates or spikes. The number of radial wires at each mast base is usually 120, but often it is economic to use fewer than this. The wire thickness is largely determined by the strength needed for handling and burying, and by the rate of corrosion expected given the chemical nature of the ground at the site concerned. At the mast bases the radial wires are clamped and brazed to a copper sheet covering the mast base block, or to a copper busbar surrounding it and solidly bonded to the lower fittings on the mast base insulator (or the mast base if the mast is shunt fed). Any parts of the ground system which are above the ground surface should be painted with black bitumastic paint to protect them from corrosion and from theft.

Lightning protection

The antenna ground system is usually solidly bonded to the transmitter station ground, avoiding any danger from different ground potentials during a lightning strike. Mast lighting circuits are protected by a finial projecting above the top lantern on the mast. A typical lightning protection system for an antenna tuning unit (ATU) comprises an arcing horn at the mast base, a feed conductor formed into a single turn loop and a further arcing horn connected across the bowl insulator on the ATU input. Arcing horns are preferable to ball gaps as they are self-extinguishing and the chance of an arc being sustained by the transmitter is reduced.

The lowest section of each mast stay is bonded to ground to avoid the risk of lightning damage to a concrete stay anchor block.

Static charges accumulate on the mast body and on insulated stay sections. The charge on the mast body should be discharged to earth by a suitable indicator which may be a separate RF choke or part of the ATU circuit.

The charges on the stay sections are often ignored, but should be discharged by providing a high resistance DC path across the stay breakup insulators: this is particularly necessary on high power installations where a damaging RF arc may follow an ionised path provided by a static discharge.

The damaging effects of RF arcs which may be established by lightning or static discharges may be alleviated by providing sensitive VSWR trips or optical arc detectors wired into transmitter trip circuits. RF power is removed at the onset of a fault and is restored after a brief delay to allow transient effects to disperse.

3. Antenna tuning units

The RF network required to feed the antenna may be as simple as a single inductor or capacitor, or may be a complex system costing more than any other single item of equipment on the transmitting station.

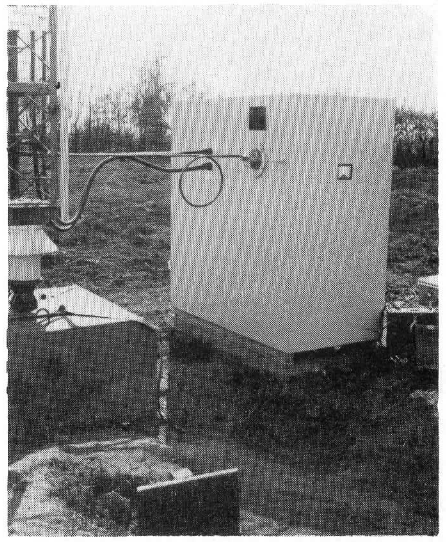
Simple low power ATU's are housed in small weatherproof cabinets placed alongside the antenna base. They may be provided with sun shields or anti-condensation heaters as required by the local climate. Simple devices of this type are used up to powers of around 50 kW, but they do not provide convenient access for large or complex networks, especially in bad weather conditions.

An antenna tuning house (ATH) to contain and protect the tuning networks need only be a small building of local materials. CSA prefer to use non-combustible materials for ATH's when the power to be fed to the antenna exceeds 100 kW, owing to the risk of fire caused by an RF arc following a lightning strike.

Traditional ATH's for medium and high power installations were screened by copper sheets on the floor, walls and roof: the RF equipment was mounted on the floor. Modern CSA equipment is constructed in completely screened cubicles and requires no screening of the ATH. This is a very safe arrangement as maintenance staff can enter the ATH and examine the equipment under operating conditions without any risk. Equipment panels and switches may be fully interlocked to the transmitter if required: safety facilities usually specified include feeder and antenna isolation and earthing switches.

4. Transmission Lines

Both flexible and semi-flexible coaxial cable and various configurations of open wire feeder are in current use. Coaxial cables with foam dielectric are an obvious choice for low and medium power stations (up to 50 kW). Air dielectric coaxial cables are convenient



Base of MF Mast Radiator showing earth and feeding arrangements.

and produce a very tidy installation, but they are very expensive, require a constant supply of dry pressurised gas and are prone to damage by accidental over-voltage. A substantial factor of safety is needed, especially as the system must work for brief periods into fault conditions, for example when the arcing horn is acting during a lightning strike. No irreparable damage must occur at such times.

Unbalanced open wire feeders are generally used for MF installations: they have the advantages over cables of low initial cost and of easy transport, installation and maintenance. However they suffer the disadvantages of loss by radiation, uncertain high voltage performance in bad weather or polluted atmospheres, and proneness to damage by vehicles, falling ice or by deliberate sabotage or vandalism. They need regular inspection and maintenance, but can be repaired fairly easily whatever problems may arise. All these considerations, as well as the basic parameters of power rating, attenuation and achievable VSWR must be taken into account before the feeder type is chosen for any installation.

5. Conclusion

The design of a modern antenna installation for an MF transmitting station requires careful judgment of a host of technical, economic and environmental factors. Sound decisions at the planning stage will continue to pay dividends over the whole working life of the station.

The subject has been necessarily much simplified to condense it into two articles and must be somewhat generalised, since decisions often depend on specific factors: CSA can advise on these and further aspects of specification, planning and maintenace, based on a sound history of successful project completion.