BASE STATION earth STATION

PRODUCT FEATURE

Antenna Options For 3G Systems In the 2GHz Band

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Summary
The further expansion of network infrastructure, stimulated by the advent of UMTS, will create further pressure to reduce the visual profile of base station towers and antennas. The article examines antenna system options for the addition of 3G operation in the frequency band 1920 – 2170 MHz to networks using the existing 900 and 1800 MHz bands, and indicates possible technical solutions. The situation in the US is different, as there is no immediate prospect of the availability of new frequency bands, and government policy has restricted the use of multiple frequency bands by the same operator.

Introduction

The first major tranche of licenses for 3rd Generation mobile systems operating in the frequency band 1920 - 2170 MHz are scheduled for issue in mid-2000, with public service commencing around 18 months later. Licenses will be granted to some existing 2G network operators, as well as to new entrants to the market, and many administrations will encourage the development of 'soft' networks, where a newly-branded service is carried by a physical network belonging to a third party (which may already operate a 2G network).

Operators in many countries are already encountering strong resistance to the erection of more base stations from planning (zoning) authorities and local residents. The advent of new base stations for 3G operation - or the erection of even more antennas on existing structures - will be resisted. Re-using existing sites is financially attractive to operators, as rental costs for new sites and antennas are reduced, and it will be more economic to upgrade the existing supporting communications infrastructure rather than starting from scratch.

This article examines the possibilities for new multi-band antenna systems which will be needed to support the expansion of 3G systems. It concentrates on the situation in Europe and Asia, as the availability of new spectrum is less imminent in the US.

Basic requirements

An operator's basic requirement will be to add facilities for the 1920 - 2170 MHz band to the installations already in place for existing services. A mixture of 900 MHz and 1800 MHz operators is already established - together with a rapidly increasing number of 900/1800 MHz dual-band operators. The basic requirements will be for antenna systems covering the following bands:

The use of GSM-based systems on the present bands will be combined with W-CDMA operation at 2100 MHz. As the two services will have different coverage, capacity, hand-off and interference characteristics, it is currently unclear as to how the antenna performance at 2100 MHz should be optimally related to that in the existing GSM bands. If 2100 MHz facilities are added by changing the existing antenna, the characteristics in the existing service band must be affected as little as possible, or present network optimization will be disrupted.

Future options

Existing networks use space diversity, with increasing application of polarization diversity. One relatively easy upgrade would be to replace a pair of vertically polarized antennas (in either 900 or 1800 MHz) with a separate dual-polar antenna for the new and existing bands. This would result in some loss of diversity gain in the 2G service, but allows a completely independent choice of parameters for the 2G and 3G services.

Existing dual-polar base stations will require dual-band, dual polar antennas. It has already been shown to be possible to design effective wideband 1800/2100 MHz antennas, but this option assumes that generally similar characteristics (for example azimuth beamwidth and gain) are needed for both bands. Separate antennas can be enclosed in a single radome, but a two-band in-line configuration has less gain for a given envelope length and a lateral arrangement may have problems with squint and isolation.

The interleaving techniques already in use for 900/1800 MHz dual-band antennas can be adapted to a 900/2100 MHz combination, although the design compromises may be slightly more significant because the present octave frequency relationship is lost. Most parameters, for example azimuth beamwidth, gain and beamtilt can be specified independently for each band.

Tri-band antennas can be realized by extending existing techniques, and could provide independent parameters on all three bands.

The increasing user capacity and physical density of 2G networks has been accompanied by a slow move towards antennas with narrower azimuth beamwidths and correspondingly improved frequency re-use. The US experience of CDMA (IS54) has shown the importance of controlling the extent of soft-handoff which can seriously erode system capacity, and the problems encountered when pilot channels overlap. These considerations suggest that W-CDMA systems will be engineered with relatively narrow sectors, perhaps with more than 3 at each base station.

How many ports?

Most existing 1800 MHz operators use low-noise masthead amplifiers (MHAs) in order to increase the base station receiver sensitivity and balance the performance of the up- and down-links. It appears likely that 3G W-CDMA systems may also employ MHAs. As both the 1800 MHz and 2100 MHz bands are planned with the base station receive band at the lower frequency end of the band, and systems generally operate in duplex mode, it is not possible to use a simple broadband amplifier and single set of filters. The options using a pair of single-band antennas and a single dual-band antenna are shown in **Figure 1a**. The number of filters needed is the same for both arrangements, so the choice of arrangements will probably depend on whether the same antenna characteristics can be used on both bands. Interleaving 1800 MHz and 2100 MHz antennas is probably not possible, so if independent antennas are needed, they will have to be accommodated in-line or alongside one another. Antennas with stable wideband characteristics over both bands have already been demonstrated, so the arrangement of **Figure 1b** is certainly practical.

Either one or two feed cables can be used with both arrangements, but the use of a single feeder requires close co-location of the amplifiers, so the system of Figure 1b is probably the right choice, eliminating a number of jumpers and having an overall lower cost.

The integration of MHAs with antennas is again under general discussion, but from Figure 1 it will be appreciated that the dimensions of the required high-Q filters largely determine the size of the MHA module, and so the practical usefulness of an integrated product.

A dual-polar tri-band antenna could have 2, 4 or 6 ports, according to requirements for MHAs and feeders. (2 ports: all bands combined, 4 ports: 900 + 1800/2100 MHz, 6 ports: all bands separate.)

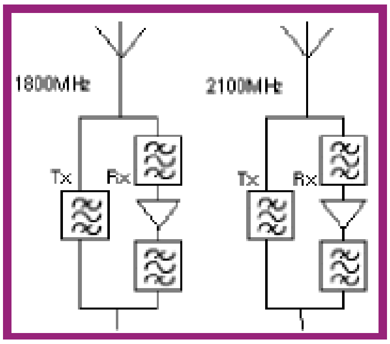

Figure 1a. Two single-band antennas.

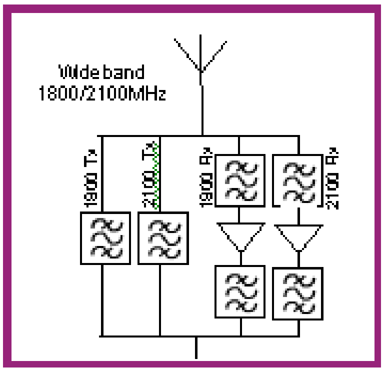

Figure 1b. Dual-band antenna.

Smart antennas

The operation of the UMTS system envisages and facilitates the possible use of 'smart' antennas. These can provide a number of facilities such as beam steering and null management so the C/I ratio is maximized at all times. Smart antennas will operate under the direct control of the base station software and can be regarded as a system in which most of the base station RF hardware is moved up the tower. Such systems are sometimes described as providing space division multiple access (SDMA), and their use can extend the range and/or capacity of a base station. The scale of adoption of these systems is unclear at the present time for reasons of both cost and visual profile; they will probably appear first at hot spots where capacity and coverage problems are most severe. With the continuing fall in the cost of electronics and its ever-increasing scale of integration and reliability, it is likely that some measure of 'smart' functionality will be progressively applied to every base station. At present, it is the cost of suitable hardware for the transmit function that limits application, as there is no point in providing more capacity in the up-link than the down-link and the problems of linearity and power efficiency in CDMA power amplifiers continue to pose practical problems when designing masthead equipment.

Shrinking the base station antenna

Experience with present systems shows that antenna towers are disliked as features of both townscape and rural landscape. Both new and existing operators will come under more and more pressure to use the smallest and least conspicuous antennas possible. This pressure will increasingly dominate purely technical and economic considerations in determining the external shape of future base stations. **Figures 2** and **3** show the progress of the past few years in reducing the size of the antenna installation for a complete 3-sector base station with diversity provision on the receive antennas.

Figure 2. Comparison between a conventional 2G space diversity base station and a CSA Wireless polarization-diversity system potentially providing operation for dual-band 1800/2100 MHz operation.

Figure 3. A new compact CSA Wireless 3-sector dual-polar antenna, providing facilities for a complete base station in a tube only 5 inches (130mm) in diameter.

Conclusion

This article has shown some of the possibilities for new antenna systems for 3rd Generation systems in the 2 GHz UMTS frequency band. The alternatives which are adopted for practical systems will depend on the variety of equipment provided by the infrastructure manufacturers and choices made by new licensees in response to technical, economic and environmental pressures.