Base station antennas for 3G networks

Brian Collins

Many 3G networks will be rolled out by operators who already have a mature 2G Network. Other networks will be rolled out by a new 3G operators, either alone or in co-operation with other networks. All operators will be faced with the challenge of obtaining sufficient coverage at acceptable cost, and the methods employed will have to take account of the increasing environmental pressure on network infrastructure. This article describes antennas solutions which are available from CSA Wireless.

Experience in the USA doing the roll-out of IS-95 networks has led to a number of refinements in the specification of W-CDMA as it will be used for 3G networks. The achievement of full channel capacity will remain dependent on good management of the various soft hand-off modes; this in turn depends on effective management of the coverage overlap provided between different base stations and different sectors. The use of the correct antennas at every base station is a vital tool in this management.

Antenna parameters for 3G

Azimuth radiation pattern

The extent of overlap between the sectors of a single base station strongly determines the number of users who will find themselves in a soft hand-off mode, with consequent reduction in the number of users supported. IS-95 examples exist in which a single user is simultaneously in soft hand-off with all three sectors at a base station. To reduce this possibility, the use of antennas with 65-degree azimuth beamwidth has become normal, even in rural environments; in addition, increasing attention is paid to the rate of roll-off of the main beam beyond ±60 degrees, and the achievement of a high front-to-back ratio over a substantial sector at the rear of the antenna.

Elevation radiation pattern

With GSM systems it has been noticeable that while a number of operators look for antennas with a high degree of upper sidelobe suppression and null-fill, other operators feel that these parameters are of little importance and are unwilling to concede any loss of gain in order to achieve them. Current experience suggests that this division of opinion is continuing into 3G networks.

Elevation beam tilt

Base station antennas for GSM1800 networks are typically down-tilted until the upper -3 dB point falls in the horizontal plane. Current specifications for 3G antennas typically call for the same electrical downtilt.

An increasing number of 3G networks now require antennas with adjustable electrical beam tilt, a feature referred to in more detail later in this article.

Polarisation

The use of polarisation diversity in 2G networks is now well accepted, especially in urban areas. The change from space diversity to polarisation diversity has incurred some loss in diversity gain but the change has been accepted on the basis of reduced cost and a much lower visual profile for the antenna system. Most 3G networks will use polarisation diversity for initial roll-out, although some space diversity systems will also be used.

A dual-polar antenna has two ports for reception, and both are usually used for transmission. This technique reduces the use of lossy combining hardware and provides sufficient isolation between transmitters to avoid IMP generation. The technique is often referred to as 'air combining'.

Bandwidth

The frequency band allocated to 3G systems (1920 MHz to 2170 MHz) is slightly wider than that used for GSM1800 (11.3% compared with 9.9%). The further development of antenna techniques allows coverage of this wider band with no significant reduction in antenna performance. Wideband antennas allowing operation on the GSM1800 and UMTS bands are becoming available, but the ordinary constraints of physics mean that some performance trade-offs are needed over such a large bandwidth (27%).

Multi-band antennas

Dual-band antennas have become an accepted feature of 2G networks where a single operator has licences in the 900MHz band and the 1800MHz band. This use of multi-band antennas is now being extended to the UMTS band where antennas for various frequency combinations are now available. These include 900/2100MHz, 1800/ 2100MHz, and 900/1800/2100MHz.

Multi-band antennas often include integral diplexers, usually for the 900/1800MHz bands, allowing a single pair of feeders to provide dual-polar operation in both bands.

There are various options for the combination of antenna parameters in two bands. Some operators prefer to match the elevation beamwidths, while other operators seek more gain in the upper band to compensate for higher transmission losses.

Wide band antennas

While antenna designs can be extended to cover 1710MHz – 2170MHz, the use of a single antenna for both frequency bands has some disadvantages. Some power will inevitably be lost when signals on the two bands are combined, and a single antenna will have the same elevation beam tilt on both frequency bands. In this respect operators will not wish to disturb their 2G antennas, but at the same time they will want to optimise their 3G networks.

For similar reasons the application of single broadband antennas covering the 900MHz, 1800MHz and 2100MHz is very unlikely except in special applications.

Masthead amplifiers

Many networks have adopted the use of masthead amplifiers in the 1800MHz band. It appears that the majority of UMTS operators will adopt the same practice. Because MHAs contribute to the increasingly cluttered appearance of base station antennas systems, operators are likely to look for improved integration of MHAs with antennas. Full integration is probably unacceptable because of the relatively lower reliability of MHAs, but a variety of integrated mounting solutions is now available from CSA.

Antennas with adjustable electrical downtilt

When additional base stations are introduced in a network, the elevation beam tilt of adjacent cells is increased to control the overlap between the new cell and existing cells. This adjustment has traditionally been achieved by adjusting antenna mountings to provide additional mechanical beam tilt, or by exchanging a complete antenna for a version with the larger electrical beam tilt. Both these operations incur the cost of a site visit. They require access to the antennas structure and the use of antenna riggers, so the operation is prone to delay when the weather is inclement. Changing antennas represents a significant cost in network budgets.

An antenna with beam tilt that can be remotely adjusted provides the simple and effective way in which antenna performance can be optimised. The additional cost of adjustable antennas and their associated control systems is recovered in a much lower cost of system optimisation.

Multi-band antennas have introduced new requirements for remotely-adjustable electrical tilt (RET). As operators move from optimised single-band systems to dual-band operation they need the ability to optimise the 'new' system. A good solution is to use an antenna with a downtilt matching the previous antenna, while providing adjustable tilt for the new system. This provides both the previously optimised performance and the flexibility to optimise the new system in the field.

Environmental planning pressures create further requirements for adjustable tilt. Antennas must often be flush-mounted and mechanical downtilt may not be allowed. In this case, system optimisation can be provided by adjustable electrical tilt

The logistics costs associated with using a large variety of antennas with fixed tilt are increasing as the number of varieties grows. A much smaller range of products with RET allows a much smaller number of antennas to be used, with reduced costs of inventory management.

Some operators expect that it will prove possible to make frequent changes in the antenna downtilts to dynamically manage and optimise the capacity of their networks. Other operators have found it necessary to change the downtilt of their 2G network antennas very infrequently and are currently uncertain as to the cost/benefit offered by remotely adjustable downtilt. A number of operators are currently installing adjustable antennas, but are not installing the remote control facilities until they see whether they are necessary.

Design options

The widespread use of antennas with AET will depend on four factors:

1. The achievement of the same performance as a standard fixed antenna
2. Reliability comparable with the best fixed antennas
3. The cost premium of an adjustable antenna with its control system
4. Adoption of an open industry standard control interface

Performance

Antennas are now available with adjustable electrical tilt which are in every respect equal in performance to standard fixed antennas. This performance has been achieved by applying quasi-linear phase shift across the antenna and by insuring accurate impedance matching of all antenna components.

Reliability

CSA pioneered the use of microstrip techniques for base station antennas and has been manufacturing them in large quantities for more than a decade. During this time they have demonstrated an exceptional level of product reliability in the field. CSA has always paid special attention to design details which avoid the generation of passive intermodulation products (IMPs) during an extended operating life.

To achieve the low IMP levels which are necessary for duplex transmit/receive operation, all base station antenna manufacturers have adopted the use of mechanical phase shifters, together with conventional mechanical servo drives (usually using stepper motors). The reliability of the antenna will depend heavily on that of the drive system, in particular on the care with which it is protected against lightning and EMC .

CSA uses contactless phase shifters, made from high-precision injection mouldings to ensure very high long-term reliability and very low IMP levels. The components are suitable for use in dynamic real time control, but even if left in a fixed position for several years they will operate reliably when required.

The reliability of the AET antenna will largely be determined by the reliability of its associated control system, as the phase shifters have been designed to have very high reliability. The control system can provide BITE and other self-test features, to allow the status of the system to be monitored at any time.

Cost premium

For the foreseeable future the main cost premium associated with adjustable tilt antennas will be the cost of the control system and its thorough protection against lightning/EMC threats, together with its interfacing to other network control elements. These costs will fall as the market for adjustable antennas increases in volume.

At most base stations a number of antennas are mounted on a common structure. A control system will shortly be available from CSA allowing all the antennas on the structure to be addressed and controlled individually.

Open control interface

Agreement on an open interface is needed by the industry, allowing products from various antenna manufacturers to interface transparently with network equipment from different vendors. An open standard will also encourage manufacturers to provide integrated control systems for antennas, MHAs and other antenna-related accessories.

Extension to other frequency bands

The incentive for the implementation of adjustable tilt is currently the need to provide more optimisation tools for 3G networks. At the same time it is to be expected that adjustable tilt antennas will become available in the 2G bands, especially for multi-frequency antennas.

A practical example

The following example details a typical UMTS antenna with adjustable downtilt, together with comparable data on a standard fixed antenna. Both antennas have nine radiating elements.

Parameter	*AET antenna*	*Fixed tilt antenna*
Operating bandwidth	1900 - 2170MHz	1900 - 2170MHz
Gain	18dBi	18dBi
Azimuth beamwidth	65° ± 5°	65° ± 5°
Elevation beamwidth	7.5°	7.5°
Electrical beamtilt	0° to -10° (continuously and remotely adjustable)	0°, 2° or 5°
Tilt stability over the band	± 0.25°	± 0.25°
Upper sidelobes	-18dB	-18dB
Gain	18dBi	18dBi
Front/back ratio	30dB	30dB
Maximum VSWR	1.4:1	1.5:1
Intermodulation (2 carriers at +43dBm)	-153dBc	-153dBc
Input power	2 x 150W	2 x 150W
Weight	6.5kg	6kg
Dimensions (mm)	1230 x 170 x 100	1300 x 170 x 100

Brian Collins, BSC Associates Ltd,
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