PM-1 : DAB Radio

by Paul Messenger

A limited digital radio service has actually been available in the UK since 1995 from the BBC, though the equipment to receive it has only quite recently become available, and the full complement of public service and commercial stations and proper nationwide coverage have yet to be achieved. Nevertheless, DAB (digital audio broadcasting) is now a commercial reality, and even at this very early stage some dealers are reporting healthy interest and sales.

DAB originally began life in 1981, at the Institut fur Rundfunktechnik (RIT), and in 1987 it fell under the European project banner of Eureka 147, which brought together broadcasters and radio manufacturers from a number of European countries. Although DAB is by no means the only conceivable format for digital radio, it does have the full backing of many governments and broadcast organisations around the world, especially in Europe, and the 'chip reduction' engineering needed to make affordable domestic receivers is well advanced.

While this support should ensure that DAB is the European radio format of the future, it's still much too early to predict how quickly it will take off, as the classic 'chicken and egg' scenario still has to be overcome. Broadcasters are reluctant to invest in services for which there's very little receiving equipment, while radio manufacturers are working to reduce manufacturing costs and hence hardware prices in order to attract a broad mass market audience.

This will inevitably take time, because DAB receiving equipment is complex and therefore, at least initially, expensive. It involves a new radio receiving 'front end', a high speed processor which extracts the wanted station, a digital-to-analogue converter, an analogue pre-amplifier output, plus a potentially elaborate display.

Although DAB isn't going to take off overnight, it does have some very real and unique advantages over existing analogue AM and FM radio services. The most important of these is the increase in capacity: the British DAB frequency allocation has room for many more stations than the existing FM band. Because DAB is digital there are all sorts of possibilities for transmitting other data besides audio, such as text or graphics, and the signal will be entirely free from the background noise and various distortions (especially multi-path) which beset the analogue services.

According to BBC-sponsored research, one in seven home radio listeners suffer problems with FM radio, and as many as a third experience difficulties with in-car reception. The DAB signal has a potential ruggedness which FM analogue can never match, equally well suited to home or mobile reception, and specifically addressing the difficulties which undermine traditional analogue radio.

HOW IT WORKS

It is of course theoretically possible to transmit digital radio using the full CD-type 16-bit PCM code. Indeed, such signals were available for some years in Germany, but have now

been switched off. Although the service appealed to domestic hi-fi listeners, radio's prime constituency today is mobile reception, which is fundamentally incompatible with the satellite-to-dish approach the Germans adopted.

However, such a PCM/CD-type is incompatible with the lower frequencies used for terrestrial radio broadcasts in the UK (analogue or DAB), because CD's stereo audio code runs at around 1.4Mbits/s, and there would literally be room for only a handful of stations within the whole spectrum allocation.

The solution to this limitation came with the development of data reduction and compression techniques, which use psychoacoustic principles to discard 'unnecessary' data. When the DAB specification was being finalised, it was decided to use the MPEG-1 Layer II digital audio format (often referred to as MPEG-2), which offers a wide selection of degrees of data compression (from around 6:1 to 20:1 compared to PCM), and this in turn allows a sensible number of stations to be broadcast.

In Britain, monochrome TV transmissions on VHF Band III were finally closed down in the late-1980s. Part of the newly vacated spectrum was allocated to PMR (private mobile radio services, as used by utility companies and the like). The other part was reserved for Digital Radio. Rooftop aerials are readily available, as some continental countries still use Band III for TV. Such aerials should be linked to domestic receivers using a 50 ohm downlead.

Improving mobile reception was a major priority when DAB was being conceived, so the format incorporates certain features to tackle the problems which plague mobile FM reception in particular. One criterion was to devise an approach which is essentially free from multi-path distortion, while the national broadcasters wanted to adopt a 'single frequency network' approach, to avoid the FM requirement to re-tune when moving from the region served by one transmitter to the next.

TACKLING MULTI-PATH

Multi-path distortion results when a radio antenna receives the same broadcast signal from more than one source. The time delay between the arrivals results in phase cancellation which can distort the signal.

In order to avoid one mechanism which would create multi-path effects when a receiver picks up both transmitters, adjacent FM transmitters deliberately carry the same signal on different frequencies, necessitating re-tuning when travelling around. However, FM radio signals are also reflected from hills and buildings, and these reflections also provide a major source of multi-path distortion. Although a domestic radio tuner can minimise multi-path effects by using a roof-mounted directional antenna, that is obviously not an option for mobile or portable reception.

The DAB system has been expressly designed to eliminate multi-path effects. Indeed DAB receivers take advantage of multi-path reception to strengthen rather than scramble the signal. The DAB receiver locks onto the complete datastream being broadcast by the

transmitter multiplex, and picks out the segments relevant to the wanted station. Because of the way the datastream signal is organised and 'flagged', it doesn't matter whether the signal arrives directly or after reflection - or, for that matter, whether it comes from a nearby or a more distant transmitter.

And because DAB has been engineered to be essentially immune from the problems of multi-path reception, adjacent transmitters can operate on the same frequency right across the country, and the same station will occupy the same 'spot on the dial' wherever it is being received.

STATIONS BECOME MULTIPLEXES

A major difference between DAB radio and previous analogue systems lies in the way the separate signals from a group of different stations and services are bundled together and transmitted as a complete interleaved datastream known as a 'multiplex' or 'ensemble'.

In Britain there will be seven of these multiplexes within Band III: one for BBC national radio; one for commercial national radio stations; four for local independent and BBC services; and one as yet unallocated. The BBC national multiplex, for example, is transmitted in a 1.5MHz wide chunk of spectrum on channel 12B (225.648MHz), and simulcasts the five national networks (Radios 1-5) plus extra live sports and the World Service. Also planned are a live Parliament station, a rolling news service, and a popular music station based on archive live material.

Happily, listeners will remain entirely unaware of this fundamental organisational distinction between DAB and traditional radio services. All available stations will be tuned in automatically, and accessed by specific pre-set or scanning arrangements.

However, the idea of having to share transmission arrangements with close commercial rivals has been difficult for some broadcasters to accept. What might be very suitable indeed for a large public service network provider with a number of stations to distribute, such as the BBC in Britain, doesn't sit so well with the independent regional infrastructure which exists in the US, for example. This is one reason why some countries (notably Japan and the US) have so far shown little interest in Eureka 147 DAB.

Why adopt the 'multiplex' approach? In order to create a more rugged signal. Isolated single-station digital transmissions in Band III would be much more susceptible to degradation from 'spike' interference. Grouping a number of stations together, interleaving the data and integrating powerful error correction creates a much broader bandwidth transmission signal with effective immunity from 'spike' depradations.

At the time of writing only the BBC multiplex is formally and officially broadcasting. An estimated 60 per cent of the UK population is currently able to receive DAB, and this is scheduled to rise to 85 per cent by 2002. The national commercial network stations have also started trial transmissions in the London area, and hope to reach 66 per cent of the

population by the end of 1999. Local DAB broadcasting could follow soon afterwards. The UK is also looking at using the much higher frequency L-band (as used by Canada and parts of Europe) for local DAB services over the next decade. This is unlikely to be a 'single frequency network', and will operate more like FM frequency mapping, allowing smaller, local stations access to DAB.

The exact number of stations each multiplex can carry will depend on how much data each uses. The bit-rate required to give acceptable quality stereo music is much higher than that needed for a mono speech service, for example.

The BBC expects to use a mixture of full or half-rate audio signal sampling (48,000 and 24,000 samples per second respectively), and transmit at anything between 32 kbits/s and 256 kbits/s. At the time of writing the three stereo music networks, Radios 1, 2 and 3, are all using 192kbits/s - somewhat less than the 256kbits/s that the BBC is using for the sound channels of its digital TV broadcasts.

Theoretically, stereo signals can range between 64kbits/s and 384kbits/s, though it seems unlikely that broadcasters will use more than 192kbits/s; mono bit rates go from 32-192kbits/s.

DATA SERVICES

Over the years, radio has become synonymous with audio, but digital audio data is essentially no different from other types of data. Some data (codenamed PAD, for Programme Associated Data) will be associated with the audio channels, providing such features as dynamic range control (receiver end compression) and Radiotext information, including the potential for quite advanced graphics.

Other data services will be independent from the audio channels, and capable of various functions. Detailed 'real time' traffic information, for example, could be integrated with car navigation systems, providing routes expressly customised and updated to minimise journey times. The BBC is already piloting such a service, called TPEG.

The various data services will appeal to different types of user. The hi-fi radio tuner will probably feature a relatively large display which will not only give details of the station identity, but also information on the programme content and perhaps individual song titles - or even rolling lyrics (for karaoke fans!). World Service broadcasts already carry quite comprehensive rolling text headlines.

A personal computer fitted with a DAB card would be well equipped to handle any complex graphics being carried on the data-only services, as well as a useful source of 'personal radio'. Clearly, traffic information is aimed exclusively at the mobile user, for whom graphics might be inappropriate. Most hi-fi DAB tuners will feature the RDI (Receiver Data Interface) port, and this could be linked to a PC, which could decode the data only services (eg the BBC's web site) and display this on its large screen without needing an on-board DAB card.

Since the transmission network is still only partly complete, it would be unwise to judge DAB reception at this early stage. Feedback from different dealerships around the home counties region suggest that in-home reception is at present somewhat patchy and unpredictable, but will presumably improve with time. Unlike FM, where background noise steadily becomes louder as the signal weakens, with DAB you either get it or you don't get it, for any given site and antenna. There's no intermediate situation.

Like any new technology, DAB digital radio has its protagonists and its critics, and will serve some interests better than others. The 'single frequency network' and immunity from multi-path distortions should ultimately give consistently high quality reception for mobile users. Although audiophiles may remain unimpressed by MPEG-2's (MPEG-1 Layer II's) data-reduced digital audio signals, the complete absence of background hiss regularly excites comment from people hearing DAB for the first time. The banishment of multi-path distortions is a major advantage for all, and those who suffer from poor FM reception may find salvation at last. Even those who generally enjoy good FM will at least have the bonus of extra stations and features.

CHART

LIST OF CURRENT DAB BROADCASTS
(logged at 5pm, 15/9/99, Arcam DAB tuner)

MULTIPLEX (MHz)	STATION	BIT RATE (kbits/s)
225.648	BBC Radio 1	192
225.648	BBC Radio 2	192
225.648	BBC Radio 3	192
225.648	BBC Radio 4	192
225.648	BBC Radio 5 Live	96
225.648	BBC Radio 5 Live Sports+	64
225.648	BBC World Service	80
225.648	BBC Test	128
227.360	Capital FM	160
227.360	Capital Gold	160
227.360	Kiss 100	160
227.360	LBC	64
227.360	Magic	160
227.360	N.Direct	64
227.360	XFM	160
227.360	Sunrise	64
222.064	Classic	192
222.064	D1 Test 1	192
222.064	D1 Test 2	160
222.064	D1 Test 3	160

222.064	D1 Test 4		128
222.064	Talk Radio		80
220.352	Heart 106.2	160	
220.352	Sunrise Radio	64	
220.352	Sunrise Audio	64	
220.352	Virgin Radio (L)		160
220.352	Virgin Audio	160	
220.352	WRN1	64	
220.352	WRN Audio		64
220.352	GLR 94.9		128
220.352	GLR Audio		128

(there are many more stations since this author date of 1999)

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