RTT TECHNOLOGY TOPIC
August/September 2007

Radio in Cellular Phones

A developing need for radio in cellular phones
Figures announced in August by RAJAR (Radio Joint Audience Research in the UK) highlight the rapid growth in radio listening both via fixed and mobile devices.

Radio listening has increased quarter on quarter to 45.6 million people, or 91% of the UK population, up by almost 600,000 listeners since the first quarter of 2007.

12.8% of listening is now via a digital platform (DAB, DTV, Internet) with digital listening hours now totaling 136 million hours per week. Overall listening to digital only services is growing quickly, from 905,000 listeners in the second quarter of 2003 to 6.09 million in the second quarter o f2007. During an average week 26.2% of the population (adults 15+) now listen to radio via a digital platform.

The number of mobile phone owners (aged 15+) who claim to have listened to the radio via a mobile phone has risen 27% year on year. Over a quarter of 15-24-year-old mobile phone owners (1.8 million) say they have listened to the radio on a mobile phone in this way, a year on year rise of 25%.

The fact that there is a growth in 'linear listening', listening to particular programmes at particular times should not be a surprise. Choice and the quality of programming have improved in parallel with significant improvements in radio receiver performance. In the UK at least DAB radios now work really rather well.

However DAB radios in cellular handsets are a rarity and hybrid TV and radio services such as Movio have failed to achieve the economies of scale needed to sustain a viable business.

And yet there is money to be made out of traditional radio broadcasting. It is relatively easy to deliver good quality community radio. It is relatively hard to deliver good quality community TV. It is relatively easy to deliver good quality national radio. It is relatively hard to deliver good quality national TV.

There is a natural affinity between local and national radio and local and national radio that translates directly into business advantage. The Guardian Newspaper Group in the UK own 37 radio stations. The mix of media and journalistic cross over value delivers a revenue and profit stability that is intrinsically hard to match in the tabloid and TV sector.

The relatively robust value chain in local and national radio particularly digital local and national radio would suggest an underlying rationale to replace the FM radio functionality presently integrated into many cellular phones with digital radio.

From a mobile user perspective it is easier when walking to listen to radio than to watch TV.

It is of course technically feasible to access digital radio via the internet via a cellular phone using a cellular downlink.

We would however argue that this is neither power nor spectrally efficient.

A separate but integrated broadcast receiver if well implemented has the potential to deliver a better user experience both in terms of power drain and audio quality.

Broadcast receiver technology and spectral options
The problem globally is to decide which of the many available flavours of digital radio to include and which bands to support in a small form factor device.

Digital radio can also include TV. Until recently BT were using DAB to deliver IP TV in the VHF band in the UK. Crown Castle had a similar trial in the US at L Band.

Similarly digital radio can be delivered over digital TV channels.

Traditional distinctions between radio and TV are therefore no longer valid. Decisions on which delivery option to use for a particular service should therefore be a function of available bandwidth and the 'cost' of that bandwidth both in terms of dollar cost and transmission and receiver efficiency.

Table 1 shows the range of broadcast system and spectral options available between long wave and L band

Table 1 **System options and Frequency allocations - Long Wave to L Band**

Radio Band	Frequency	Operational bandwidth	Digital broadcast system options
Long Wave	3 kHz-300 kHz	<300 KHz	DRM (DRM- digital AM)
Medium Wave	300 kHz-3000 kHz (3 MHz)	<3000 KHz	DRM
Short Wave	3 MHz - 30 MHz	<30 MHz	DRM
VHF Band I	47-68 MHz	21MHz	DRM+
VHF OIRT (Russia)	65.8-74 MHz	10 MHz	DRM+
VHF Japan	76-90 MHz	14 MHz	DRM+
VHF (Band 2)	87.5-107.9 MHz	20 MHz	DRM+
VHF (Band 3)	174 - 233 MHz	12 MHz	DAB (218-230 MHz)
UHF (Band 4)	470-790 MHz	320 MHz	DVB/DVBH/ATSC/ISDBT/ MediaFlo
UHF (Band 5)	790-862	70 MHz	DVB/DVB-H ATSC/ISDBT/ MediaFlo
L Band	1452-1492	40 MHz	DAB/DMB World space (1453-1490)
	1670-1675	5 MHz	DVB-H

Long wave, medium wave and short wave USB DRM receiver modules are already available for use with lap tops. DRM+ is presently being finalized as a standard for VHF.

The number of digital channels in the VHF band is however likely to be limited at least over the next 5 to seven years due to the present global dominance of FM and an understandable regulatory hesitance to enforce a more rapid transition.

There are additional allocations for broadcasting in S band, mainly satellite services, for example SDARS used in the US by XM Radio and Sirius. These satellite based systems work well when accessed via an optimised antenna installed with a ground plane for example on a car or truck roof. They are less optimum for small form factor hand held devices.

There are substantial commonalities between Digital Radio Mondiale, DAB, DVB, DVB H and ISDB-T in that they all use OFDM as of course do Wi Fi , WiMax and LTE.

Thus it is reasonably easy to produce a tuner that can handle most if not all of the terrestrial broadcast technology options.

This is not the same as producing a tuner that can work effectively across all spectral options.

UHF as an option for digital radio delivery

The form factors of present cellular handsets are rather small for long wave and medium wave and VHF but it is possible to design compact antennas that work at these frequencies quite adequately.

FM radios at VHF work perfectly well in small form factor devices and suffer minimal interference from the cellular functions in the phone which are typically 700 or 800 MHz away.

Thus a combination of DRM and DRM+ would seem to be more or less ideal apart from the fact that digital VHF will not be available for some time.

This suggests that it might be better to deliver digital radio to cellular handsets via the UHF band. There are already substantial numbers of TV broadcast channels implemented in the band across the better part of 400 MHz of available bandwidth between 470 and 862 MHz.

In the UK the BBC make national radio services available as part of the UHF digital TV DVB multiplex though not local radio due to present capacity constraints.

Digital radio could be an important part of an integrated UHF broadcast and cellular service

AMPS/UMTS850 handsets already transmit at the top end of the UHF band between 824 and 849 MHz and plans are well in hand to auction up to 112 MHz of additional UHF bandwidth which could be available to the cellular operator community on a global basis.

This introduces some useful potential benefits, for example being able to design an integrated tuner transceiver that can handle cellular and simultaneous digital radio and or digital TV reception.

However there are some practical tuner and transceiver design issues that need addressing.

Practical UHF Design considerations

Locally generated cellular transmission power within a cellular handset can be of the order of between 20 and 23 dBm. This signal will be literally side by side with a wanted radio/TV broadcast signal of around -90 dBm.

This is not a problem provided the signals can be kept apart. Keeping signals apart implies filtering and dynamic range. Filtering implies a transition bandwidth or guard band that accommodates the roll off characteristics of the filters. Increasing dynamic range increases DC power drain.

In a cellular phone operating at 800 or 900 MHz the transition bandwidth needed to keep the cellular transmit energy out of the cellular receive path is 45 MHz. This is known as the duplex spacing. A broadcast signal would need a similar amount of protection.

There are other alternatives. For example a GSM phone is time division duplexed which means that it does not transmit and receive at the same time. A duplex filter and duplex spacing is therefore no longer needed though the duplex spacing is retained both for legacy reasons and to provide system sensitivity benefits.

The same principle can be applied to a broadcast receive signal.

The DVB standard includes DVB H. In DVB H the broadcast signal is time sliced. The original rationale for time slicing was and still is to reduce the DC power drain in the tuner - the tuner wakes up for a short period of time, recovers and decodes a transmission burst, moves the contents of the transmission burst into a buffer and goes back to sleep again. The time between receive bursts can be as long as 6 seconds but would typically be much shorter, of the order of tens of milliseconds.

Conveniently and not entirely coincidentally this fits neatly with the frame structures used in present and future cellular systems, allowing for the three signals in the handset (broadcast receive, cellular receive and cellular transmit) to be time division multiplexed together.

There are other incidental advantages. Spare time space in the multiplex can be used to process received signal strengths and error rates which can be used to drive handover algorithms for DVB H and handover and admission control for the cellular network.

This does not mean it would not be possible to receive a non time sliced broadcast signal, for example DVB rather than DVB H, in a cellular handset in the same band, for example UHF at the same time, but in this case a transition bandwidth would be needed which would need to be similar to existing cellular duplex spacing ratios.

However there are other differences that need to be addressed.

A DVB or DVB H tuner for UHF will generally be designed to tune across the band. It has to do this because digital broadcast channels could be anywhere in the band depending on the country in which the device is being used.

The alternative is to produce country or region specific variants which can just work on the locally available channels.

The disadvantage of tuning across the band is that it is hard/ impossible to deliver good sensitivity from the device and the device is vulnerable to interference from other in band transmissions, for example from other mobile cellular handsets.

The disadvantage of producing country specific or regionally specific variants is that it is difficult/ impossible to achieve economies of scale because addressable markets are too small.

The difference is significant. For example a digital broadcast tuner working across the whole UHF band would typically have a sensitivity of between -92 and -98 dBm.

A UMTS handset working across a much narrower band, for example 25 MHz rather than 400 MHz could have a sensitivity of better than -120 dBm.

Admittedly this is not a like for like comparison as the UMTS handset is working in a 5 MHz channel and the digital broadcast channel is 6, 7 or 8 MHz but the difference is any case substantial.

And the difference is important. One of the lessons learnt from the BT Movio experience in the UK and Modeo experience in New York is that users with an integrated cellular/mobile TV and radio receiver expect to listen to digital radio and for that matter to listen and watch digital TV wherever and when ever they have cellular coverage.

The present sensitivities available from digital TV and radio tuners are not sufficient to meet that experience expectation.

One option is to increase broadcast transmission power levels. To an extent this is happening as digital switch over proceeds. In the UK for example digital TV signals are being increased by 7 dB as and when analogue signals are turned off in a particular area.

The second option is to retransmit digital TV and digital radio signals from cellular transmitters. The objective with options 1 and 2 is to ensure that received signal strengths as seen by portable and mobile devices are similar irrespective of whether the received signals are cellular or digital broadcast.

The third option is to improve the sensitivity of the broadcast receiver.

UHF DVB tuners typically though not universally employ a notch filter to take out GSM 900 mobile transmit energy.

UHF tuners integrated with UHF cellular handsets essentially have to extend this principal and use band pass filtering to separate out each of the three signal paths, broadcast receive, cellular receive and cellular transmit.

This is possible provided there is sufficient transition bandwidth between the transmit path and two receive paths and sufficient dynamic range in the receiver to handle the largest received in band signal. The transition bandwidth can either be in the frequency domain (RF duplex spacing) and/or time domain (time division duplexing) or a mixture of both.

If time domain duplexing is used there are useful potential commonalities between DVB H and present and possible future cellular TDD and TDD/FDD frame structures.

The end result of combining options 1, 2 and 3 would be an integrated user device that could work as a cellular phone and receive digital radio and/or digital TV with equal efficiency both in terms of the link budget requirement and DC power drain.

Summary

Analogue radio is now something of an anomaly in an increasingly digital world.

It is reasonable to assume that users will come to expect digital radio functionality in their cellular handsets as a right rather than a privilege. This is particularly true given the present promotion of mobile TV functionality in present devices.

It has to be recognised that implementing digital radio in the VHF band will be a slow process.

Similarly digital radio spectral allocations in L band and S band are not sufficiently universal to achieve sufficient economies of scale.

This leaves UHF as the most obvious option though possibly with long wave and medium wave as an additional part of the mix.

From a technology perspective this suggests that Digital Radio Mondiale and DVB would be useful partners.

From a handset design perspective adding digital radio and or digital TV into a UHF cellular phone and making them work together implies a need for some reasonably innovative filter and switching functions.

The scale economies that would be achieved form such a universal device would more than outweigh any associated component or performance cost penalties.

From a system planning perspective there is a strong imperative to balance out received strengths in mobile portable devices irrespective of whether the signals are broadband cellular or digital radio or digital TV.

This would need to be combined with a significant increase in present UHF DVB tuner sensitivity in order to meet future user expectations.

This would form the basis for a UHF integrated radio and cellular proposition- a universal UHF handset.

Such a device would offer positive cross over value opportunities both for traditional radio and TV broadcasters and cellular broadband operators and suggests a closer coupling between these traditionally separate entities would be beneficial to all parties concerned.

ENDS
Broadcast receiver design and performance trends represent just one area of present RTT research on the impact of technology and engineering change on spectral and corporate value.

If you would like more details of other study work presently under way or are interested in commissioning bespoke research or advice on technology, engineering, market or business issues then please contact;

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