RTT TECHNOLOGY TOPIC
May 2010

Multi Band Switching

This month's technology topic leads on from last months topic on UHF Broadband and Multi Band RF design and looks at the particular challenges of implementing low loss high isolation linear switch paths in multi band handsets.

An additional level of detail on this topic can be accessed via the Resources section of our new web site **www.makingtelecomswork.com**

www.makingtelecomswork.com provides a cost and time efficient way in which telecommunication engineers, product managers and policy makers can access **technical information and advice not readily available elsewhere in the public domain.**

The web site also provides information on RTT workshops, **Making Telecoms Work in Europe**, **Making Telecoms Work in Asia** and **Making Telecoms Work in the US.**

The workshops demonstrate how engineering issues can be practically resolved and how performance gains and cost savings can be achieved.

European work shops are held at the Science Museum in Kensington West London. **Information on the next workshop is available here.**

Handset RF performance

There is a general consensus that it is useful and probably essential to improve average data rates across a cell in order to meet user broadband connectivity expectations.

This can be done by increasing cell density which adds capacity and should generally improve the link budget though the benefits of this may be offset by higher levels of interference particularly near the cell edge. There is also a capital cost and running cost implication.

The 'data wave' is used as a basis for lobbying for more spectrum to be made available. This includes a broadening of existing bands or the allocation of additional bands. Either option adds direct cost (additional RF components in the handset) and indirect cost (loss of RF performance).

Broadening existing bands results in a loss of sensitivity in the handset. Adding new bands increases insertion loss and reduces selectivity. The trade offs are unavoidable and are the consequence of RF component and circuit resonance and handset RF architecture constraints.

Arguably it would be more economic to use already allocated spectrum more efficiently.

For example a five band hand set covering Band I (1900/2100 MHz), Band II (US PCS 1900), Band III (1800 MHz), Band V (US850) and Band VIII (900 MHz) can theoretically access a total bandwidth of 510 MHz.

Add another five bands including 700 and 800 MHz and 2.6 GHz and the amount of bandwidth increases to nearly 1 GHz.

This is not all available at any one place but much of it could be if national roaming were more aggressively implemented.

Self evidently if a handset has 500 MHz or more of available bandwidth to choose from it is more likely to be able to find a local strong clean signal. Adopting this best connect strategy would significantly increase coverage and capacity and decrease user power consumption without a net increase in network investment and cost.

Search times and signalling overhead could be an issue but it would not be beyond the wit of man to develop best connect session establishment and handover algorithms that would deliver significant spectral and power efficiency gains and significantly faster and more consistent average data throughput. The scheduling algorithms in LTE at least ensure that the signalling overhead is localised.

Overcoming commercial barriers might be more challenging but present network sharing initiatives are probably a precursor of more closely integrated and comprehensive RAN sharing on a country by country basis.

However we have said that adding extra bands to a five band transceiver introduces additional cost and compromises performance. This is particularly true in LTE bands where TX to RX filtering requires careful implementation.

The additional component count consists of multiple power amplifiers on the TX path, multiple low noise amplifiers on the receive path, multiple filters and multiple switch paths. The additional paths reduce isolation and increase insertion loss. These factors presently off set the potential user experience benefits that an extended multi band platform might deliver. The additional costs off set any potential economic benefits that the additional spectrum might realise.

However progress is being made on several fronts.

We start this month on the switch path as a precursor to looking in later months at component innovations in other areas.

We have drawn on a technical paper, **Requirements and Solutions for Switching in 3G/4G RF front ends** provided by **Peregrine Semiconductor**

If you would like to have a copy of Peregrine's technical paper forwarded to you please visit **www.makingtelecomswork.com**, go to the Resources section and fill in the request form.

The paper will be sent to you by return.

The switch performance requirement
The more throws that are added to a switch the harder it gets to maintain the performance of the switch.

The need for a multi throw switch is dictated at least to some extent by spectrum allocations on a country by country basis.

Handset vendors and operators would be able to realise substantial inventory management savings if one phone could be shipped to all markets.

The user experience would be maximised if the phone was then capable of working across the allocated cellular spectrum in those markets particularly if inter band inter operator best connect algorithms were supported.

However consider the bands that need supporting;

Band	3GPP	Allocation	Uplink	Duplex spacing	Downlink	Region
I	2100	2x60 MHz	1920-1980	190 MHz	2110-2170	Present UMTS
II	1900	2x60 MHz	1850-1910	80 MHz	1930-1990	US PCS
III	1800	2x75 MHz	1710-1785	95 MHz	1805-1880	Europe, Asia, Brazil
IV	1700/2100	2x45 MHz	1710-1755	400 MHz	2110-2155	US AWS
V	850	2x25 MHz	824-849	45 MHz	869-894	US and Asia
VI	800	2X10 MHz	830-840	45 MHz	875-885	Japan
VII	2600	2x70 MHz	2500-2570	120 MHz	2620-2690	New
VIII	900	2X35 MHz	880-915	45 MHz	925-960	Europe and Asia
IX	1749.9-1784.9	2x35 MHz	1750-1785	95 MHz	1844.9-1879.9	Japan
X	1700/2100	2X60 MHz	1710-1770	400 MHz	2110-2170	Extended Band IV
XI	1500	2X32 MHz	1427.9-1452.9	48 MHz	1475.9-1500.9	Japan

Supporting band XII, US 700 MHz and the European DSO band at 800 MHz and adding GPS at 1.5 GHz to the mix above implies a phone that can process at least ten, eleven or twelve bands with more to follow.

Not all bands are or possibly ever will be LTE but clearly there is an emerging design requirement for a ten or twelve throw switch that can perform as well as a five throw switch with minimum or no increase in occupied real estate. Adding functionality to an existing device footprint implies more densely packed switch paths. This makes the performance parameters harder to achieve.

The key performance parameters for such a device include

RF voltage handling
An ability to handle RF voltages that can exceed 20Vpk. If low voltage FETS are used, they can be stacked in series for high voltage handling in the off condition but this requires a low loss insulating substrate. More densely packed switch paths make this more challenging.

Isolation requirement
Transceivers generally require between 30 and 35 dB of isolation loss from TX to RX. More densely packed switch paths make this more challenging.

Harmonic distortion requirement
Harmonics need to be minimised to avoid compromising the RX path and other user’s RX paths. More densely packed switch paths make this more challenging.

Intermodulation requirement
In a band I channel pair, if the switch goes non linear due to a blocking signal, for example from a GSM 1800 network, the third order product will end up in the receive band. The Band I intermodulation requirements are onerous but similar problems will occur in other bands, particularly at 700 and 800 MHz where proximate unwanted signals can be substantial.

CMOS on sapphire as an option
CMOS on sapphire has been promoted as an alternative to GaAs for some years. The theory has been that CMOS scaling will deliver lower insertion loss and a reduction in real estate and the sapphire substrate will provide the required isolation.

The challenge has been to match or improve on GaAs device performance which in turn has continued and will continue to improve. The vendor, Peregrine Semiconductor, provides an example of a nine TX path switch with isolation, insertion loss and intermodulation performance that is equal to or better than a GaAs based solution.

Peregrine point out that switch losses have more than halved in the past five years. This has allowed higher throw count and cascaded switches to be implemented.

The use of CMOS delivers the traditional benefits of scaling, integration and cost. A sapphire substrate adds to the cost but delivers the isolation needed to make the device competitive with GaAs based solutions.

New materials and new techniques
CMOS on sapphire is one example of the use of innovative materials or combinations of materials that can make a real difference to multi band transceiver functionality and performance.

Over the next few months we will study other innovations from other vendors.

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RTT Technology Topics reflect areas of research that we are presently working on.

We aim to introduce new terminology and new ideas to help inform present and future technology, engineering, market and business decisions.

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Contact RTT
RTT, the **Shosteck Group** and **The Mobile World** are presently working on a number of research and forecasting projects in the cellular, two way radio, satellite and broadcasting industry.

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