Extended multi band
Design and testing LTE user equipment

A two day workshop for engineers and team leaders involved in designing and developing and testing broadband multi band multi standard cellular transceivers.

The programme is also relevant to operator engineering teams needing to quantify how the connectivity performance of user devices including smart phones, tablets and slates, net books and lap tops and network devices including cellular base stations determine user bandwidth cost and user bandwidth value.

The workshop includes practical test sessions and the design and performance implications of supporting other receive functions such as GPS and ATSC/DVBT2 tuners.

Background

Modern design procedures draw on a wide range of computer modelling tools but successful design is still dependent on engineers having an in depth understanding of component and circuit behaviour.

Open and closed loop adaptive techniques implemented at base band have to be closely coupled with RF measurement and RF circuit behaviour over a wide range of operating conditions.

The programme draws on over 40 years of practical design experience combined with an in depth exposure to modern simulation and RF and baseband optimisation techniques and includes a comprehensive review and analysis of new passive and active materials, new components and innovative circuit techniques, adaptive control techniques and conformance and performance testing.

Objectives

- To review UHF and multiband transmitter/receiver architecture options, particularly the main performance influencing parameters in extended multiband multi standard transceivers. To characterise these parameters and consider how they can be optimised in terms of device and design options, 'good practice' circuit layout techniques and system implementation.
- Delegates will learn how to optimise design processes to achieve:
  - Optimisation of key UHF and extended multiband and multi standard RF parameters including noise, gain, stability, sensitivity, selectivity and power efficiency (including antenna design optimisation).
  - An understanding of individual parameters and how they influence RF and baseband system performance and overall network performance.

Scope

This is a **practical** rather than academic programme focusing on real life design processes and performance optimisation techniques.

The programme goes 'behind the results' to understand how RF circuits and related base band functions behave under a wide range of operational conditions. We review the 'do's and don'ts' of RF and base band design and test procedures to ensure greater consistency in end product performance.

The techniques addressed in the programme will assist design and product engineers to make more informed device, design and architectural choices and to implement those choices with greater confidence. Operator engineering teams will gain insights on present challenges and future competitive advantage opportunities.

The Design Challenge

Design and manufacturing teams are being asked to produce mobile phones, smart phones, tablets, slates net books and lap tops that cover at least five frequency bands. Network devices (the E node B in LTE) have similar requirements.

However the design brief is broadening to include UHF transmit and receive capability either in the 700 MHz band (USA and parts of Asia) or 800 MHz band (Europe and other parts of Asia).

Some devices are also expected to receive DVB-T or ATSC TV broadcasts and there are present discussions on the viability of re broadcasting TV using cellular base station hardware.

The 700 and 800 MHz UHF bands introduce specific design challenges both in terms of operational bandwidth and size constraints including a need to implement adaptive matching and other adaptive techniques in order to increase operational bandwidth beyond traditional 'good practice' limits. Adding D band and national public safety broadband connectivity introduces additional challenges.

These transceivers have to co exist at a minimum with the 850 MHz and 900 MHz bands, 1800 and 1900 MHz bands, 1.9/2.1 GHz (Band 1) and other radio functions, for example Wi Fi and Bluetooth at 2.4 GHz and GPS and FM receivers.

In the longer term there will be a need to support 2.6 GHz and additional regionally specific allocations. Integrated 'White Space' cognitive transceivers have also been proposed and ATC networks combining LTE and satellite connectivity will require dual band transceivers capable of accessing L band at 1.4, 1.5 and 1.6 GHZ and S band spectrum adjacent to present band 1 allocations.

A requirement to support multiple standards introduces complexity, for example a need to support higher order modulation options and symbol orthogonality implies a need to control linearity and minimise noise and distortion in all parts of the transmit and receive chain.

In parallel, an assumed market need for high peak average data rates suggests a need to deliver base band processing across extended 10, 15 or 20 MHz channel bandwidths.

Present design solutions for multi band have used tried and trusted architectures and RF design options that have relied on discrete switch paths for each band. This results in component duplication but also introduces additional insertion loss and poor isolation.

Other options exist but need to be carefully implemented to realise performance gain within acceptable cost parameters.

UK Dates and venues

If you are interested in attending this programme please e-mail **geoff@rttonline.com** for information on availability

Other venues

US and Asia on demand.

Agenda

DAY ONE

09.00 – 09.30	**Band plan and standards over view – RF and baseband design and performance requirements**
09.30 – 10.30	**Specification and performance needed to achieve co existence** *The Receiver Front End* – how receiver front-end performance is a key factor in determining overall sensitivity. Selectivity – the distribution of bandwidth to achieve co-channel and adjacent channel performance. Gain distribution to achieve dynamic range. Image response suppression in the superhet receiver. RF filter

specifications. The Direct Conversion (Zero IF) receiver approach versus the Superhet.
The Receiver Backend – how modulation type and transmit/receive oscillator stability influence/determine IF bandwidth. Demodulation processing gain – digital processing gain.
The TX chain – RF PA operational bandwidth constraints and PA efficiency versus linearity implications.

10.30 – 11.00 **Coffee**

11.00 – 12.30 **Current specification and performance limitations**
Present TX/RX bandwidth limits and performance trade offs including matching considerations
Impedance Matching – defined matching objectives with simple and complex loads. Frequency conscious matching networks (Pi & T), Q
The Smith Chart - a tool to display matching efficiency
'S' Parameters – using the forward (incident) and reverse (reflected) power concept to understand 'S' parameters. The practical benefits of using 'S' parameters to define 2 port network characteristics.
VSWR – as a measure of power transfer (hence matching) efficiency – the effect on transmit stability.

12.30 – 13.30 **Lunch**

13.30 – 15.00 **Improving performance through the use of new active and passive materials**
In this session we review new passive materials, new active materials and their present and possible future potential in delivering flexible RF front ends that can meet present and future cost and performance expectations. The session includes a study of RF MEMS, silicon on sapphire and BST based devices and related functional and system performance and reviews *a*daptive matching & tuneable filter options including techniques to improve efficiencies over wide bandwidth TX and RX, bandwidth limits, stability, response times and architectural considerations including control line implementation issues.

15.00 – 15.30 **Tea**

15.30 – 17.00 **Test session**
This session is a practical conformance and performance test session. Using an LTE base station emulator test platform we look at the following performance metrics: Spectral comparisons between GSM, WCDMA & LTE 5 – 10 & 20 MHz, occupied bandwidth, ACP & the effect of 'overdriving' the PA – emulated with a signal generator, signal complexity, symbol rate, bits/symbol & radio signalling channel overhead, spectrogram outputs, CCDF & Demodulation. Sensitivity & selectivity including LTE/WLAN UE testing. The challenges of measuring RX sensitivity in modern error protected, protocol aware transceiver. BER & BLER concepts. BLER versus signal level measurements. Adding noise and/or interference to show degradation of demodulation. MIMO – two channel generation – two channel reception – analysis using pre-recorded signals.

Our thanks to Agilent for providing product and test support for this session.

DAY TWO **The practice of receiver and transmitter design**
In each case study we use an example reference design to highlight layout constraints including antenna layout for SIMO and MIMO devices and practical matching considerations.

09.00 – 10.30 **Design Study 1 – present co existence architectures**
Case study of a **five band GSM/HSPA+ phone,** typical architecture and RX/TX performance, possible performance gain opportunities using open or closed loop adaptive matching and other 'new' component and circuit optimisation techniques and related system implementation considerations.

10.30 – 11.00 Coffee

11.00 – 12.30 **Design Study 2 – future co existence architectures**
Seven band/eight band multi standard handset including an **LTE UHF 700 and 800 MHz transceiver**. Device and design options, cost and performance benchmarks.

12.30 – 13.30 **Lunch**

13.30 – 15.00	**Design Study 3** **Seven band/eight band** multi standard handset including an **LTE UHF 700 and 800 MHz transceiver** and **DVB T/ATSC UHF receiver.** Device and design options, cost and performance benchmarks.
15.00 – 15.30	**Tea**
15.30 – 17.00	**Design Study 4** **Ten band** multiband handset including an **LTE UHF 700 and 800 MHz transceiver, LTE 2.6 GHz transceiver, DVB T/ATSC receiver** and **extended LTE 10, 15 and 20 MHz channel spacing**. Device and design options, cost and performance benchmarks.
17.00-17.30	**Summary and close**

About RTT

Since 1986, RTT has been specialising in providing an international client base with technology assessment and technology related seminar programmes. The company's knowledge and experience is principally in mobile terrestrial communications. RTT works closely with members of the 3GPP Mobile Experts Groups within ETSI (European Telecommunications Standards Institute), and the international academic, scientific and industrial research community. RTT's present research focus centres primarily on the issues of wireless design and implementation, appliance design, air interface and network design – areas of particular expertise include RF and IF processing (3G DSP), noise and gain budgets (including coding and correlation gain),active and passive device options, design and test analysis.

About the Presenters

Roger Belcher

Roger Belcher has a background of over 30 years in the RF communications industry, including an apprenticeship at Marconi, design and development of antennae and radar processing equipment for Plessey Radar, technical marketing for Texas Instruments, antennae and modem design for satellite communications for Racal and design of RF test equipment and associated hardware/software development for Rohde and Schwarz. He has been Technical Director of RTT since 1985.

A co-author of the 'Mobile Radio Servicing Handbook' - (Heinemann Butterworth, UK), 'Data Over Radio' - (Quantum Publishing, Mendocino, USA) and '3G Handset and Network Design' – (Wiley Publishing, New York). Mr Belcher also writes regularly for a number of European trade and scientific journals.

Mr Belcher's most recent project has been to develop a series of 3G Design programmes targeted at the transnational system silicon, manufacturing, network operator and regulatory community.

In addition to public programmes, Mr Belcher also regularly presents In-house programmes to US, Asia and/or European companies involved in developing or implementing next generation wireless products and protocols.

Geoff Varrall

Geoff Varrall joined RTT in 1985 as an executive director and shareholder to develop RTT's international business as a provider of technology and business services to the wireless industry.

He co-developed RTT's original series of design and facilitation workshops including 'RF Technology', 'Data over Radio', 'Introduction to Mobile Radio', and 'Private Mobile Radio Systems and developed 'The Oxford programme', a five day strategic technology and market programme presented annually with the Shosteck Group. Over the past twenty years, several thousand senior level delegates have attended these programmes. A co-author of the Mobile Radio Servicing Handbook (Heinemann Butterworth, UK), Data Over Radio, (Quantum Publishing, Mendocino, USA and 3G Handset and Network Design (John Wiley, New York), Geoff also writes regularly for a number of European trade journals and chairs a broad cross section of industry conference and trade events. He is the lead author of RTT's latest study 'LTE User Equipment, network efficiency and value.'

As a Director of Cambridge Wireless, Geoff is actively involved in a number of wireless heritage initiatives that aim to capture and record past technology and engineering experience.