

# Software Defined Radio for Mobile Radio Networks

## Next Generation of Multi-Standard & Multi-Band Radio Base Station

Wireless communication standards (GSM, UMTS-FDD, WiMAX, etc.) are evolving very fast, leading to an exploding product diversity. To allow the operators of the infrastructure to reuse their existing sites, Alcatel's research is in the process of merging different air-interface standards into a single base station architecture. It is based on Alcatel's Node B and uses a software-defined radio approach. As a result, a single hardware solution will provide highly flexible usage of multiple frequency bands and multiple standards.

### Architecture of a Multi-Band/Multi-Standard base station

The Software Defined Radio (SDR) base station hardware currently under research at Alcatel aims to support more than one Radio Access Technology. SDR base station resources need to be highly scalable to meet application and operator needs, as is already the case with existing GSM and UMTS base stations. Once the hardware can support different Radio Access Technologies, the base station will be able to run several Radio Access Technologies in parallel and even dynamically scale the performance assigned to the different Radio Access Technologies up or down. Alcatel's SDR technologies focus on Multi-Band, Multi-Standard solutions. Figure 1 shows the principle architecture of a Multi-Band/Multi-Standard base station.

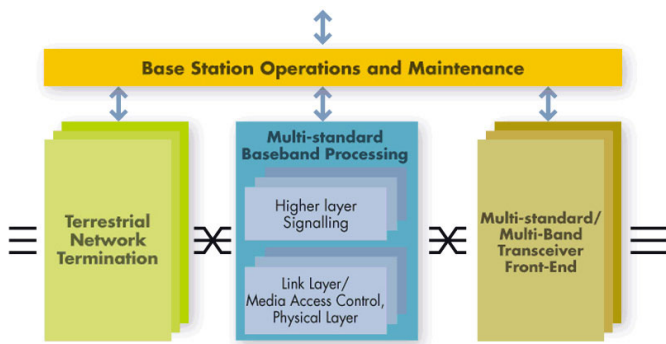


Figure 1: Principle base station architecture

An enabling component of the Multi-Band/Multi-Standard base station is the Multi-Band Transceiver, which is a radio front-end that can be operated in a number of frequency bands. The frequency bands can be changed easily by software without modifying hardware, giving network operators considerable flexibility. Figure 2

depicts the modules deployed in the Multi-Band front end. Each of them must meet much more stringent requirements than those for a single-band approach. The SDR approach splits the transceiver front-end into a dedicated and a common part.

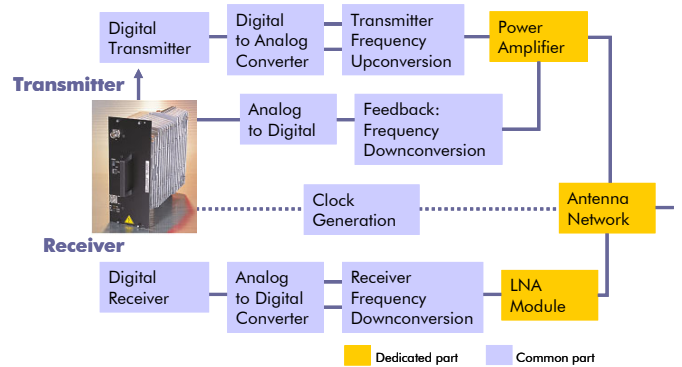


Figure 2: SDR Transceiver architecture

The dedicated part consists of the power amplifier, the antenna network, and the Low Noise Amplifier module (LNA). This is necessary because of the large frequency range and the different power classes that need to be supported. Figure 3 shows a possible split of the frequency range in the power amplifier module.

### Frequency Split into three different Power Amplifier Cases

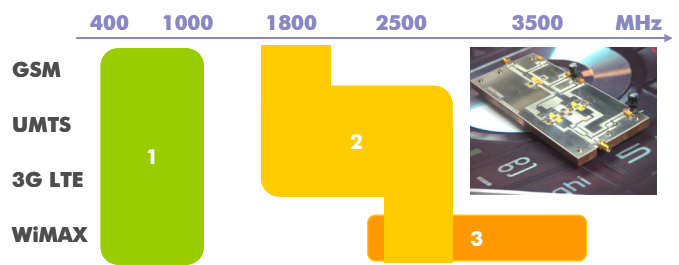


Figure 3: Split of frequency bands for power amplifier

For power amplifier case 1, an average output power of about 50 W will be envisaged; for amplifier - cases 2 and 3 - an average output power of 25 W in a first step is planned.

The common part consists of the signal conditioning units, the converters, the frequency conversion units, the clock generation and distribution unit. For linearization of the power amplifier, an additional feedback path in the

transmit unit is required. Figure 4 shows the signal conditioning unit of the transmitter. This module consists of the algorithms for the crest factor reduction, for the pre-distortion and for the image and carrier suppression, required due to imperfections of the analog transmit chain.

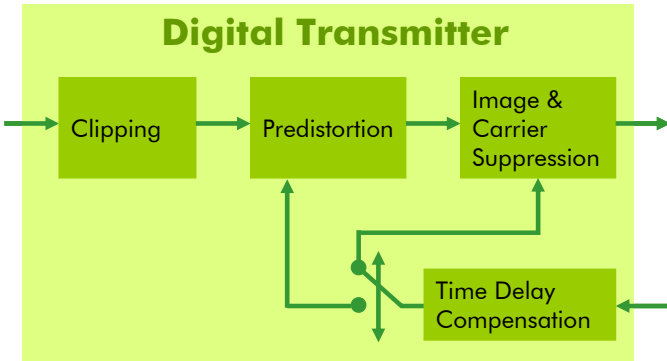


Figure 4: Signal conditioning unit of the transmitter

### Laboratory results / demonstrator

A critical building block for the transceiver common conversion module is the transmit path modulator. A broadband evaluation of a potential device is shown in figure 5: a broadband frequency conversion in the transmit path is possible with just one common modulator.

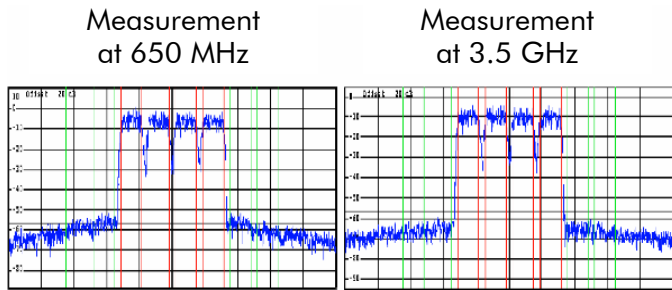


Figure 5: 4-carrier W-CDMA measurements

Figure 6 shows the evaluation of an algorithm for image and carrier suppression. The picture on the left side shows the signal with carrier and image signal caused by imperfections of the analog part of the frequency conversion. On the right, the algorithm compensates for the imperfections and the requirements defined by the standard are met.

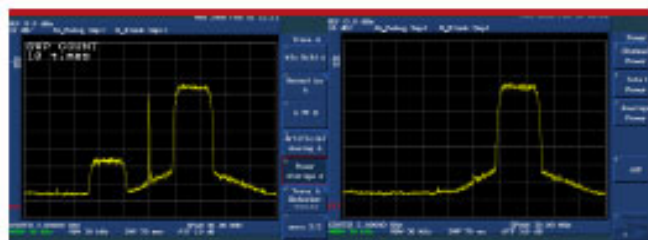


Figure 6: Image and carrier suppression

On the dedicated component side, Alcatel’s research on Multi-Band-capable GaN (Gallium Nitride)-based amplifier modules underscores the promising impression of GaN technology for wideband amplifier applications. GaN devices were investigated and a Multi-Band capability of > 1 GHz was assessed for in-house produced amplifier modules. In an initial design, this two-stage amplifier approach covered a frequency range from 1.5 GHz up to 2.5 GHz with a maximum gain of up to 25 dB and a peak output power of 43 dBm (25 W) meeting 3GPP spectral requirements.

### Benefits

Due to the increasingly heterogeneous standards and frequency bands and the extreme difficulties for service providers to find sites, the reusability of existing sites is of the utmost importance. When service providers have to introduce a new standard, such flexibility can bring significant CAPEX and OPEX savings, in addition to time-to-market competitiveness.

Multi-Standard/Multi-Band solutions are strategic choices for Alcatel that allow it to reduce development cycles, thereby cutting R&D costs and shortening time-to-market. Fewer variants mean much lower maintenance, manufacturing, and module improvement (cost reduction) efforts. In “beyond 3G” systems, new air interfaces (e.g., WiMAX) and an extension of the Multi-Standard radio resource management procedures are making SDR solutions even more relevant for base station platforms. For the operator, SDR will offer greater flexibility in different standards and multiple frequency band deployment. It can for example be used to rapidly introduce hot spots/hot zones reusing existing sites.

### Alcatel's cutting-edge innovation

A first laboratory prototype of a Multi-Band Transceiver, demonstrating technical feasibility, has been built by Alcatel’s research and is available. It is operating, not only in the UMTS core band, but also in the GSM1800 band and the 2.6 GHz extension band. Additionally, some of the used elements of the SDR technology are already on the way to becoming products.

For operators, the SDR approach is future-safe, since new standards can be implemented by software download. Furthermore, the significant flexibility can serve as the basis for future infrastructure sharing.

This project represents a common initiative between Alcatel's Research and Innovation labs and the Mobile Radio Business Division.

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