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# A Survey on Implementation and Design of Femtocell Device

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***Abstract-*** **The Femtocells design and implementation for deployment in subscriber homes are non-trivial. Femtocell promises improved indoor coverage and increased throughput for mobile data services while off-loading traffic from expensive macro radio networks onto the low cost public internet. This paper involves a considerable focus on design and implementation of femtocell device and the underlying hardware architecture. Overriding all of these is the need to deliver the full set of desired features and the levels of performance required by standards and operators. In all cases this will be supported by a high volume market with significant levels of commonality of parts and functionality.**

**A Femtocell is a small private cell, which operates on a 3GPP air interface. A femtocell produces a coverage range up to 30-50 meters with a low output power level typically less than 50mW. Femtocells are used for two purposes there are coverage and capacity. In rural area the femtocell gives the coverage for the users and similarly in urban signal traffic will be more so increase capacity femtocells are used.**

***Keywords — Femtocells,*** **3rd Generation Partnership Project (3GPP),** ***Rural, Urban.***

## I. INTRODUCTION

Femtocell is a low-power access point, which is basically used to enhance the traditional mobile communication system's coverage and capacity in home and office environments. The femtocell enables users to access voice and broadband services over their own standard broadband Internet connection.

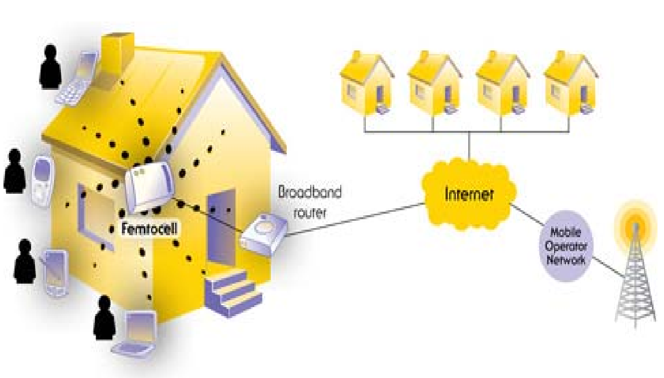


Fig. 1 Residential Femtocell

A single femtocell supports concurrent maximum voice connection support in femtocell is implementation specific i.e. different products support different amount of simultaneous voice connections in any indoor environment, permitting many authorized users to be able to connect to the femtocell to utilize services other than voice, such as text or real-time multimedia streaming etc.

A femtocell is a small base station. The femtocell unit generates a personal mobile network using a standard broadband DSL on cable service and typically supports 2 to 5 mobile phones in a residency setting. This will provide improved coverage for each user to effectively utilize the available energy sources of mobile operators.

## II. FEMTOCELL DEVICE IMPLEMENTATION CHALLENGES

The main challenges of design and implementation of femtocell device are as follows:

- signal processing
- location
- protocol implementation
- RF implementation

### *A. Signal Processing*

The emergence of sufficiently cheap signal processing to deliver femtocells is one of the critical factors for their implementation. A 3G femtocell needs several hundred MIPS (millions of instructions per second) of processing capability. While the trends in signal processing are certainly towards rapid increases in the processing capacity to be delivered at a given cost point, it is necessary to accelerate this for femtocell applications.

This requires some careful choices amongst technologies, including DSPs (Digital Signal Processors), FPGAs (Field-Programmable Gate Arrays), specialized wireless signal processors, ASICs (Application-Specific Integrated Circuits) and systems-on-chips. The appropriate selection will depend on the timescale for implementation, the market size and the mixture of features required for the application. There is also a need to adopt consumer electronics approaches rather than those that have traditionally been employed in wireless infrastructure.

### *B. Location*

To support operator and regulatory requirements, femtocells must be capable of reporting their location back to the associated management system before they start to transmit and then regularly thereafter, certainly whenever the location changes appreciably. There are numerous methods for delivering this location capability:

*a. Self-reporting by femtocell customer*

A femtocell will be registered to a particular customer address, and this gives a first indication of the expected location. In some instances this may be sufficient if the customer is given and accepts clear information as to the consequences of providing incorrect information. In other cases this will be insufficient, but it gives a useful starting point for comparison with reports delivered by the femtocell via other means.

*b. Global Positioning System (GPS)*

For navigation applications GPS delivers very poor indoor availability, given long enough time to process signals, specialized GPS receivers can detect their location at exceedingly low signal strengths, so that GPS becomes viable in many environments. This may be inconvenient for users, however, who may be requested to place femtocells close to windows and/or deploy an external GPS antenna.

*c. Macrocell detection*

By reporting the surrounding macrocell identities to the management system, the femtocell location can be determined to a good degree of precision, suitable for most regulatory purposes. Although the use of femtocells to improve coverage may suggest that macrocell coverage may not be detectable, in fact the detection of a macrocell for simply decoding its cell identity can be achieved at considerably lower signal strength than that required for delivery of acceptable service, increasing the number of environments where this is a useful approach. Additionally many 3G femtocells will detect 2G cells, which typically deliver better coverage. Similarly it has been proposed to use television transmitters as reference sources for femtocell location.

### *C. Protocol Implementation*

The femtocell requires a significant amount of protocol software in order to operate. The functional split agreed in 3GPP for WCDMA femtocells, for example, requires that the femtocell incorporates all of the functions of a conventional base station but with the addition of most of the functionality of an RNC. The relevant protocol elements are divided between the femtocells (HNB), gateway (HNB-GW) and switch (MSC). In addition, the femtocell will usually incorporate part of the functionality of a UE in order to determine the surrounding macrocell environment, plus algorithms for interference management, plus the device and security management systems. Overall there is a significant software development and maintenance effort which must be achieved efficiently in the femtocell. It must be compliant with the standard and also demonstrated to interwork with other network elements.

### *D. RF Implementation*

The femtocell requires a complete RF subsystem. Although this is a low-power device, the designer faces a number of implementation challenges:

- Price requirement comparable to that for mobile devices, but with lower volumes and different RF requirements.
- The need for a receiver operating in the downlink band as well as one for the uplink.
- The need to avoid suffering and creating interference via blocking and spurious emissions to and from nearby devices such as integrated Wi-Fi, nearby DECT etc.
- The need to support multiple frequency bands in different product variants.

Implementation of femtocell RF elements draws heavily on devices intended for handsets, but is likely to evolve rapidly towards the use of custom RF components to support the particular needs.

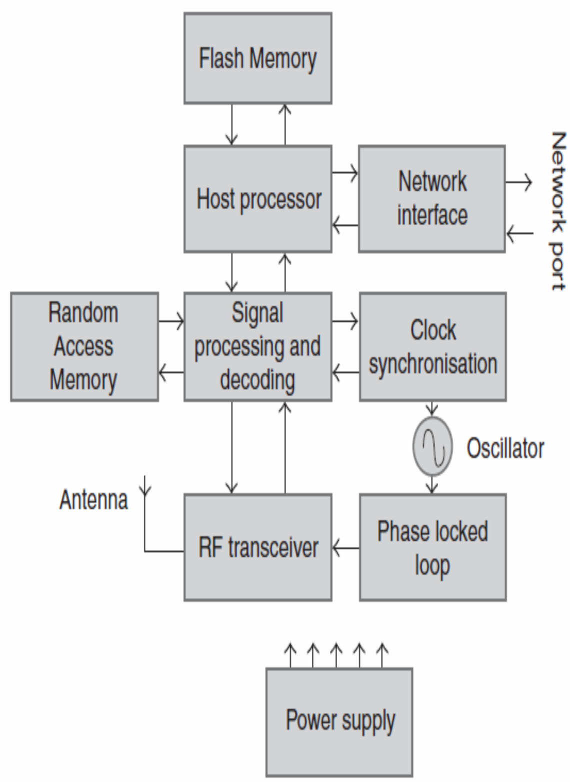


Fig.2 Example femtocell hardware architecture

## III. SYSTEM DESIGN OF FEMTOCELL DEVICE

The femtocell can be viewed as two distinct functions: the analog front end and the baseband processor. The front end, converts the digital data stream into an RF signal in the transmit circuit, and vice versa in the receive chain. The front-end design entails trade-offs between integration and performance. Although discrete solutions can be tailored to provide the best performance, the cost would be prohibitive for a femtocell design. Conversely, a fully integrated solution may provide the lowest cost, but the performance may not be sufficient.

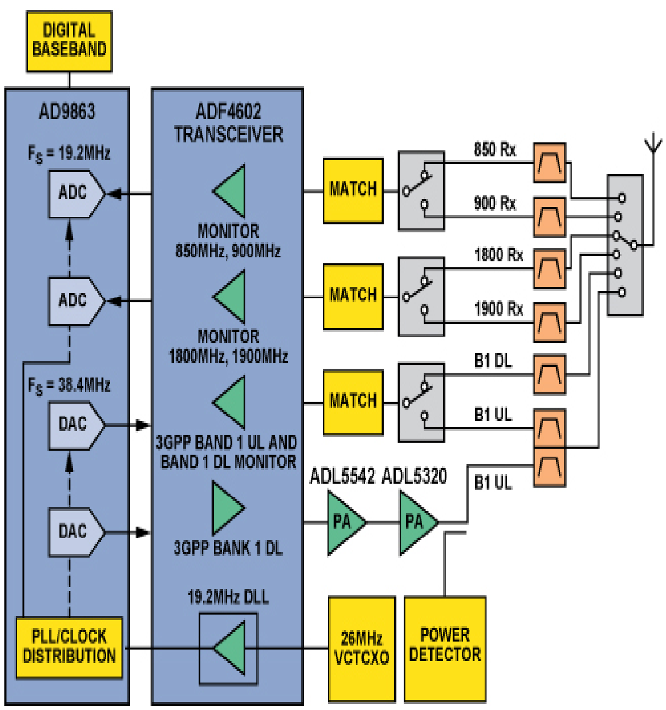


Fig. 3 Femtocell analog front-end implementation based on ADI chipset.

Figure 3 illustrates a high-level block diagram of a femtocell designed to support local base station operation in UMTS band 1 as well as monitor signals in the 850-MHz, 900-MHz, 1800-MHz, 1900-MHz, and 2100-MHz bands. Together, the AD98631 mixed-signal front-end baseband transceiver, ADF46022 integrated radio transceiver, ADL55423 and ADL53204 linear amplifiers, switches, filters, and other associated support circuitry form a compact, high-performance front end for the femtocell. A detailed description of the highlighted blocks follows.

On the transmit side, the digital baseband feeds a 12-bit parallel data stream to the AD9863, which converts it to an analog I/Q baseband signal. The baseband signal is converted to RF by the ADF4602, amplified by the ADL5542 and ADL5320 gain stages, and sent to a duplexer. A power detector monitors the RF output. A single-pole, six-throw (SP6T) switch selects which transmit or receive monitoring chain is connected to the single antenna. This signal chain provides 13dBm output power at the RF output connector, while meeting transmit ACLR specifications as defined in 3GPP standard TS25.104.

The receive chain includes surface acoustic wave (SAW) filters and SPDT switches for monitoring the main path. The matching blocks consist of a simple series/shunt inductor for each receives port. The ADF4602 has three receiver input pins: one for band 1, and one each for high- and low band monitoring functions. The band-1 receive function may be switched between 1960 MHz to receive the uplink signal and 2140 MHz to monitor the downlink frequency. The ADF4602 down converts and filters the selected RF signal to a baseband I/Q signal. The baseband signal is sampled by the dual ADCs in the AD9863 and converted to dual 12-bit parallel bit streams for the digital baseband.

This functional partition provides the designer with flexibility, ensures high performance in the signal chain, and allows the data converter's speed and resolution to be chosen to fit the application's requirements. The ADI solution enables the designer to combine the analog front end with a commercially available baseband function, accelerating time to market of the femtocell design, while maintaining the benefit of future integration of ADI technology as the femtocell market matures.

### *A. Transmit Output Power and Interference Mitigation*

To mitigate interference, the femtocell must set its output power flexibly and intelligently to account for deployments where multiple femtocells operating on the same frequency are located in close proximity to each other (e.g., in an apartment complex). Here, each femtocell will need to transmit at lower output powers to avoid same-frequency interference. Also, the femtocell cannot cause interference to geographically neighboring macrocell base stations operating on the adjacent channel, as this would create dead spots for nearby mobile phones connected to the macrocell network. The femtocell will thus have an adjacent channel protection requirement, forcing it to measure the power in the adjacent downlink channel and set its own power according to a predetermined formula so as not to obstruct the macrocell signal.

To allow the femtocell to meet the price point required and for ease of customer installation, these interference mitigation techniques must be automatic and must not require input from a trained field technician or the home user. This process should be automatically initiated when the box is first turned on by the user, and updated at regular intervals thereafter. Together, the band 1 monitoring receiver on the ADI design and the large transmit dynamic range available on the ADF4602 allow the femtocell vendor to implement these interference mitigation techniques automatically without external input. The monitoring receiver allows the power in the adjacent channel to be measured accurately and the output power to be adjusted accordingly. About 30 dB of total transmit power dynamic range will be required.

### B. ADF4602/AD9863 evaluation board

To evaluate the transceiver chipset, the transceiver lineup described above has been incorporated into an evaluation board design. The evaluation platform, shown in Figure 4, enables the independent testing of transmit and receive chains, as well as individual component.

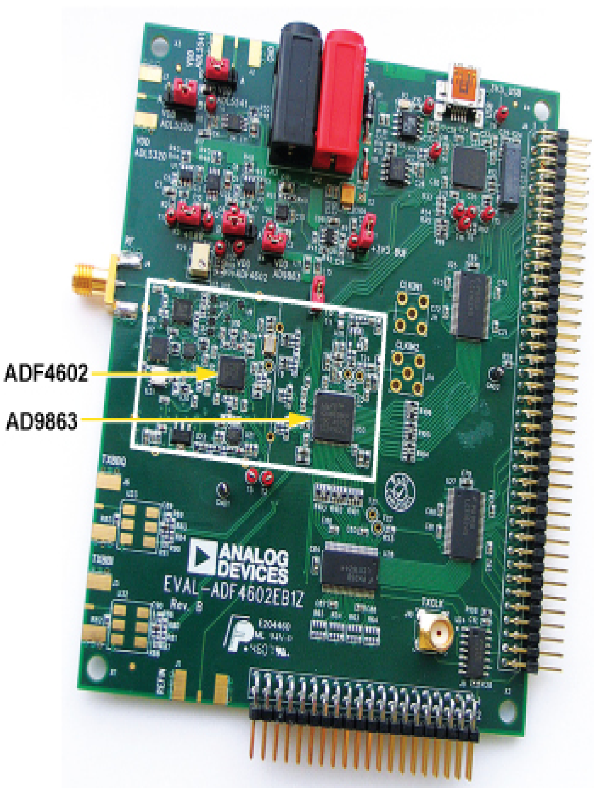


Fig. 4 ADF4602/AD9863 evaluation board

There is a critical trade-off in the design between the need to maintain flexibility, permitting the evolving standards to be reflected, addressing a wide range of operator and customer needs for new features, similar opportunity is available from integrating femtocells with a wide variety of other possible consumer devices, such as set-top boxes, home media servers, home computers, games consoles and even digital photo frames. There is also scope to harmonies the module interface for a femtocell intended for integration into another device.

A very substantial quantity of software must be written and maintained, including protocol stacks, management software, application software, security features, the algorithms for autonomous provisioning and optimization and so on. This software also represents a substantial opportunity for developers to differentiate their products and for flexibility in the features offered by operators to attract their customers. The software resides not only on the femtocell itself, but also on the gateway and management systems.

## IV. Conclusions

The successful development and manufacture of femtocells requires the coordinated operation of a range of disciplines, including digital and analogue hardware and modem, protocol and application software development. These have to be brought together to deliver standards compliant devices which also enable a differentiated feature set like design and implementation of femtocell device and the underlying hardware architecture. The overriding enablers for this are complete and timely standards and the reusability of subsystems for different applications, all enabling and being enabled by increased volumes.

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