meconet

consulting . distribution . service

mPOINT - Whitepaper

Preface

When we started to plan our own radio transmission system in 2007, we knew quite early on that we did not want to take the existing WLAN technique as a basis and consequently suffer from the same restrictions as all the manufacturers who just integrate complete WLAN interfaces in a mainboard with a few possible enhancements.

Of course this approach is attractive as one can make use of advantageous RF chip sets and provide them for example with a low noise receiving amplifier (LNA). This setup can be realised quickly and at low cost. Finding a suitable mainboard should not be a problem and Linux offers everything required for a radio transmission system.

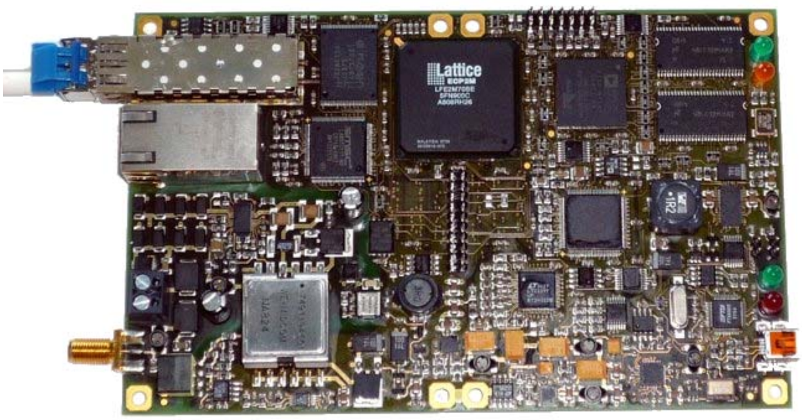
If this is your opinion you should not read on, as we have taken a completely different approach. Why? That’s easy to answer – all of the above benefits also represent the major disadvantage. WLAN is a mass product. The interfaces are produced with greater regard to price and volume than to quality. In the case of 802.11, modulation is predefined and cannot be easily changed on modules available on the market. The sensitivity of reception of any mobile phone is better than that of current WLAN chips. Integrated error correction is just not an option in this market segment. WLAN is a half duplex technology. And the list goes on.

Finally, when one wishes to leave the public domain bands, RF technology must be individually designed. So, why not also individually design for the public domain bands? Doing this gives us from the beginning the possibility of trimming the design and the complete hardware to meet the required quality, enabling us to optimise availability, range, interference resistance and data throughput for each frequency which, at 5GHz, is clearly in the triple-digit Megabit range. Try achieving that without any faults using WLAN in a point-to-point connection!

mPoint – Idea & concept

The basic concept of **mPOINT** is to develop a genuine carrier class radio transmission system for the range from 700 MHz up to 60 GHz at an affordable price, which is able to react flexibly to customers' requirements. From a technical point of view, the implementation is realized in two separate units.

The **systemboard** – provided with efficient hardware which is ready for Gigabit-Ethernet without being restricted by the hardware used. As all systems will use the same systemboard, this can be produced in larger lots. One system board supports up to two RF heads, which means that both a relay station and a high-performance link via link aggregation can be realised using a systemboard, as in the case of commercially available switches.



meconet - mPOINT

the knowledge behind wireless networking

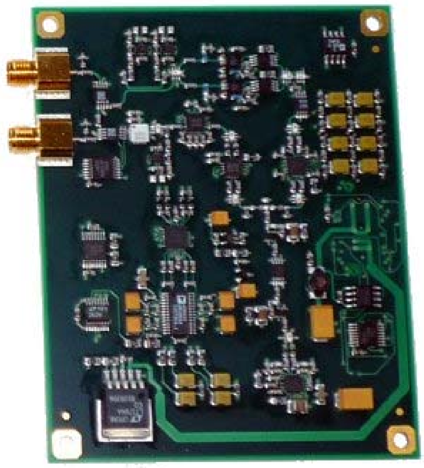
meconet e. K.
consulting.distribution.service

bottenbacher str. 78
57223 kreuztal . germany

tel. +49 2732 55856 0
fax +49 2732 55856 111

www.meconet.de
info@meconet.de

The **RF head** – separate, to allow replacement on site by the customer in a short time. The customer saves time and money when it comes to upgrading, as just the existing 5GHz head and the 5GHz antenna need to be replaced by a new 7GHz head and the appropriate antenna. It is a matter of course that mPOINT is designed as a full duplex transmission system for all bands.



Using proprietary HF technology with efficient soft radios, high-quality receiving amplifiers, band pass filters and a revolutionary new modulation technique, e. g. the 5 GHz band **mPOINT** not only complies with all regulatory specifications but also clearly outperforms all existing systems based on WLAN. This applies to the sensitivity of reception and the resistance to interference, the range and, of course, the data throughput that can be achieved in a point-to-point connection.

All this has been designed and developed without compromising in terms of quality, thus providing a unique carrier class system with a first-class price/performance ratio.

Who is behind mPOINT?

mPOINT is a proprietary development of our company in partnership with our technology partner Bartels System GmbH in Erding, Germany, that is we have developed this system from scratch. This applies to the hardware used, the systemboard and the RF heads as well as to the required firmware.

mPOINT - Brief overview

mPOINT is a professional point-to-point radio transmission system which can be operated in both frequency bands subject to licence and in public domain frequency bands. The system design is modular and discrete so as to achieve maximum flexibility of the overall system. A 10/100BaseTX inclusive Power over Ethernet (PoE as per 802.3af) and, as an option, a gigabit interface, designed as SFP (Small Form-Factor Pluggable) are available as LAN interfaces.

The complete system is designed and made in Germany.

Key facts at a glance

- Modular system design, consisting of system board and a maximum of two RF heads
- System board with software radio based on FPGA
- Dual core DSP CPU, without fan, max. 4 watt
- Separate 48 volt supply through rugged terminal clamps
- One 10/100BaseTX including PoE, 802.3af conform
- One optional 1000BaseT SFP interface, module available for copper and fibre
- Hardware encoding using AES
- 128MB RAM for optional routing software (e.g. OSPF, L2TP, PPPoE, …)

For product start-up in 2009, different RF heads will be available for a frequency range of 700 MHZ and between 5,470 MHz and 5,875 MHz. They will differ only in the hardware used and thus in the reach they are able to achieve. All 5 GHz RF heads have the following features:

- Discrete design "best in class“ with optimum modules for the various functions
- For reasons of costs no specific technology will be chosen
- Various radio components for different tasks
- Innovative CIFDM®-modulation, highly resistant to interference (patent pending)
- Radio bandwidth optionally between 10 and 40MHz
- Full duplex net data rates up to 300mbps (depending on codec)
- Compliance with all requirements in EN 301 893 and EN 302 502

meconet e. K.
consulting.distribution.service
bottenbacher str. 78
57223 kreuztal . germany
tel. +49 2732 55856 0
fax +49 2732 55856 111
www.meconet.de
info@meconet.de

The module for mean distances up to 20 kilometres is provided with a 14bit A/D converter and it works with 2/3 direct conversion with pre filters adjustable between 10MHz and 40MHz.

The long-range module for ranges of more than 50 kilometres is equipped with a 16Bit A/D converter and has, as the first system offered on the market, a serial 8B10B high-speed output; furthermore a double superhet with step-edged SAW filter is available.

Other RF heads for non public domain frequency bands between 7GHz and 60GHz are under preparation and will be available later in 2009.

Our requirements for mPOINT

In order to designate **mPOINT** as carrier class and to ensure operation with almost no interference we have set ambitious goals. The following parameters are especially important for the high-frequency range:

The noise factor for an amplifier indicates the signal-to-noise ratio between input and output, i.e. the noise of the amplifier measured in dB compared with the ideal amplifier without noise. The noise factor should be low.

The **large signal resistance**

- In the case of over modulation, there is a harmonic distortion as in the case of a low-quality audio amplifier.
- Weak signals are clipped by strong signals which leads to a problem if one's own signal is the weaker one.

Thus, the large signal resistance should be as high as possible. The benchmark is IP3, 1dB compression.

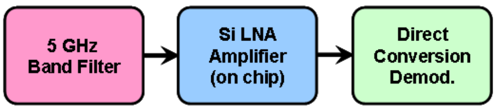
Comparison between **mPOINT** and WLAN for these important features:

	mPOINT	**WLAN (typical)**
Noise factor	max. 3dB	10dB
Large signal resistance	1dB compression by 0dBm at LNA, +30dBm	1dB compression at -20dBm

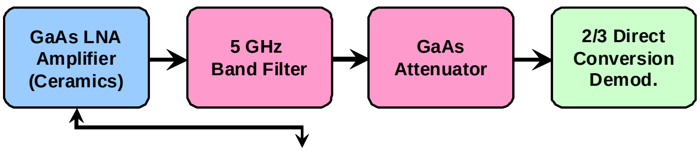
Design of mPOINT 5GHz receiver front end

Our maxim for the complete system is – cost will never be prioritised over quality when it comes to technological specifications. This can be seen when the sensitive **mPOINT** receiver unit is compared with a WLAN module.

Design of the receiver front end of a standard WLAN card:



Design of the receiver front end of ***mPOINT****:*



Qualified an extreme overmodulation resistant LNA!

The difference is obvious. As the LNA (Low Noise Amplifier) is arranged upstream of the filter, it does not increase the noise factor as in the case of WLAN. In this exposed position the LNA must be extremely resistant to over amplification, which is ensured by the use of a high-quality gallium arsenide (GaAs) ceramic LNA.

The true resistive attenuator that can be activated by software, automatically preventing the vector demodulator from over modulation, and the vector demodulator with 2/3 input frequency (3.5-4GHz) are other special features of the **mPOINT** receiver unit. For the first time, and as a world first,

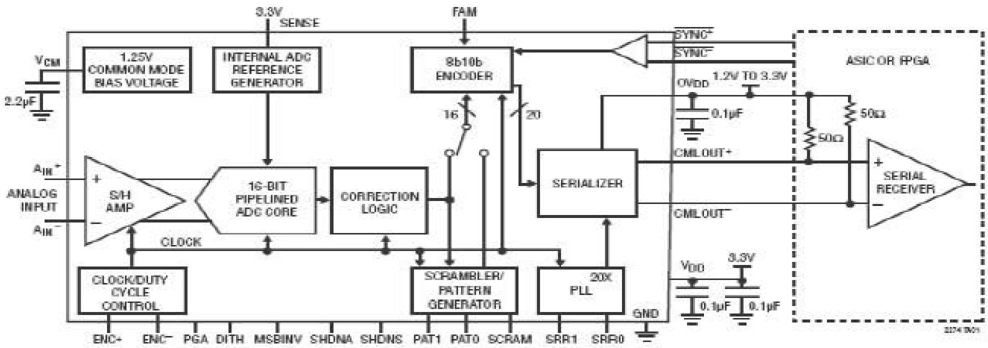
meconet e. K.
consulting.distribution.service
bottenbacher str. 78
57223 kreuztal . germany
tel. +49 2732 55856 0
fax +49 2732 55856 111
www.meconet.de
info@meconet.de

"no pull" vector modulator/demodulator ICs are used in **mPOINT**. The input frequency is generated by doubling by means of a GaAs doubler, based on a classical VCO/PLL (Voltage Controlled Oscillator / Phase-Locked Loop) with low phase noise. Thus, the quality of the receiver module is not subject to interference caused by the local oscillator and has a quality comparable to that of a double superhet.

A standard WLAN card which consists of a silicon IC is not provided with a real attenuator and has no "no pull", i.e. in comparison to **mPOINT** it is a price-orientated design with moderate RF properties.

In addition, the **mPOINT** receiver unit has a highly sensitive band pass filter with a channel bandwidth between 2MHz and 56MHz, a VGA (Variable Gain Adjustment) with adjustable amplification from 0 to 40dB with a noise factor < 3dB. A 2 * 14 bit 80MSPS transducer with double oversampling ensures the dynamics and interference resistance of the receiver. In combination with the automatic error correction, optimum results are obtained from the radio channel. The attenuator is automatically activated by a wideband detector so that the system is perfectly protected in the case of excessive input.

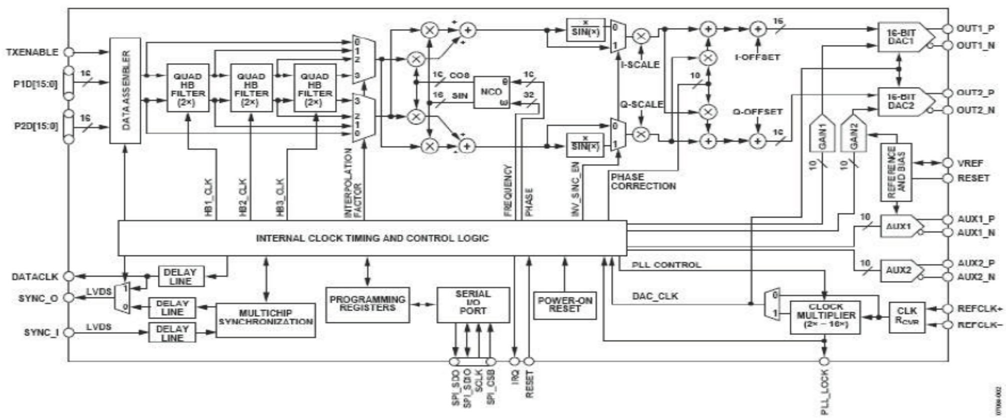
The long range receiver unit



The new Lin. Tech. 16 Bit 105MSPS A/D converter provides extreme dynamics. In order to minimise disturbing influence, the converter is accommodated - with a 28B/10B 1,8Gbit/sec. serial link – directly on the module. A classic double superhet together with a high-quality ceramic resonator filter make this module perfect. In the WLAN world this is unrivalled.

The mPOINT sender frontend

Compliance with all regulatory provisions and real full duplex transmission are basic requisites for a modern, high-capacity radio transmission system. These requisites are met by the integrated Analog Device DDS frontend with its 2 * 800MSPS 14 bit converter and the possibility of a frequency shift of up to +/- 150MHz towards the receive channel.



The power amplifier, which provides a saturated output of 3.5 watt at 5.8GHz and which is integrated in the sender frontend, is a particular highlight. This power is achieved by special GaAs InGaP heterojunction bipolar transistor amplifiers with an efficiency of 27% PAE, the symmetric PA path (the PA chip is actually provided twice) for low intermodulation and **CIFDM**® and OFDM operation with a very high crest factor. In this way, we ensure that the mean output which determines EIRP can be significantly increased.

meconet - mPOINT

the knowledge behind wireless networking

meconet e. K.
consulting.distribution.service
bottenbacher str. 78
57223 kreuztal . germany
tel. +49 2732 55856 0
fax +49 2732 55856 111
www.meconet.de
info@meconet.de

Only standard WLAN cards in the upper price segment are equipped with a small GaAs output amplifier, symmetric design is unknown.
Directional couplers provided at the output together with the wideband detector identify the backflow. If there is too much backflow, i.e. due to the absence of an antenna, the system is immediately switched off so as to avoid damage to the power amplifier.

Other details of the sender frontend worth mentioning are the PLL (phase-locked loop) with an extremely rapid switch-over time of the basic frequency of < 100µs for very quick channel change or channel search as well as channel monitoring parallel to transmission. Thus, the applicable standard EN 302 502 is fully complied with.

Furthermore, **mPOINT** features a separate input for an additional receiving antenna so that transmitting and receiving antenna can be operated separately. High-grade SMA adapters on the HF head, which cannot be compared to simple PCB connectors used for most WLAN cards, are a matter of course.

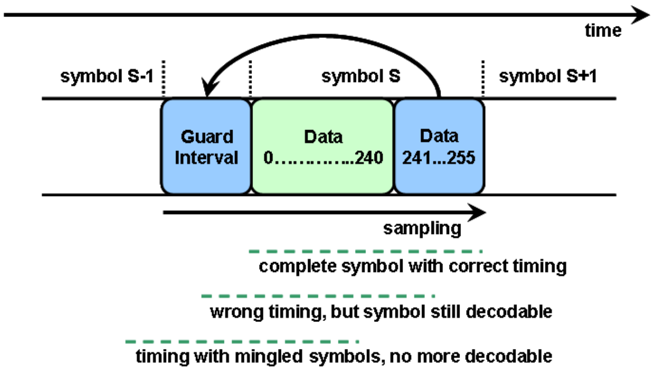
The OFDM modulation

Before going into detail about our innovative **CIFDM**® modulation method, we wish to give a concise description of the widely used OFDM modulation method and show its strengths and weaknesses.

The OFDM method (orthogonal frequency division multiplex), also known as multicarrier modulation, uses several orthogonal carrier signals for digital data transmission. First user data with high bandwidth to be transmitted are divided into several partial data streams with low data rates. Then each of these partial data streams is modulated using a conventional modulation method (BPSK, QPSK, 16-QAM, 64-QAM for WLAN) and added up. For demodulation on the receiver side, the carrier signals must be orthogonal (vertical) to each other to allow identification by the receiver.

The clear strengths of OFDM are its simple design, easy multipath correction by phase rotation and non-use of carriers deleted by interference.

The guard interval makes sure that symbols are not mingled during transmission and that the system is not disturbed during data transmission due to multipath extension.

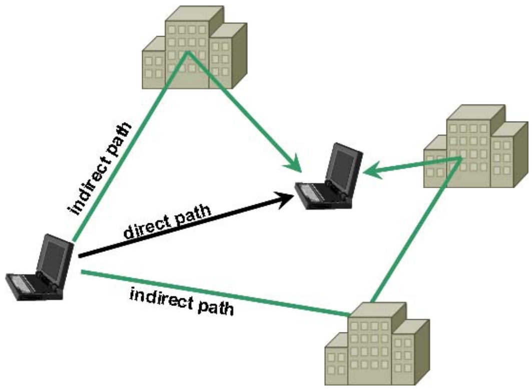


Multipath correction functions as long as it does not exceed the guard interval. If the same package arrives via another path after the guard interval has been completely received, the symbols of the first and the subsequent interval are mingled. Then correction is no longer possible and data is irrevocably destroyed.

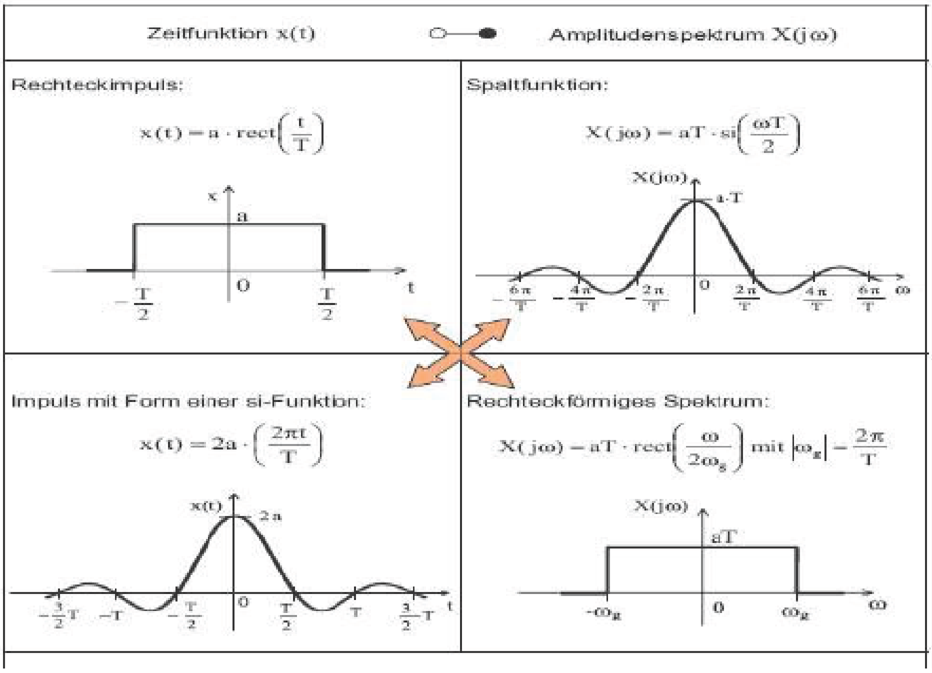
meconet e. K.
consulting.distribution.service
bottenbacher str. 78
57223 kreuztal . germany
tel. +49 2732 55856 0
fax +49 2732 55856 111
www.meconet.de
info@meconet.de

meconet - mPOINT
the knowledge behind wireless networking

The sketch below shows the cause for multipath extension in radio transmission.



What are the weaknesses of OFDM? The price to be paid for the simple design is above all the poor filtration of the subcarriers, thus the low interference resistance of this modulation method.

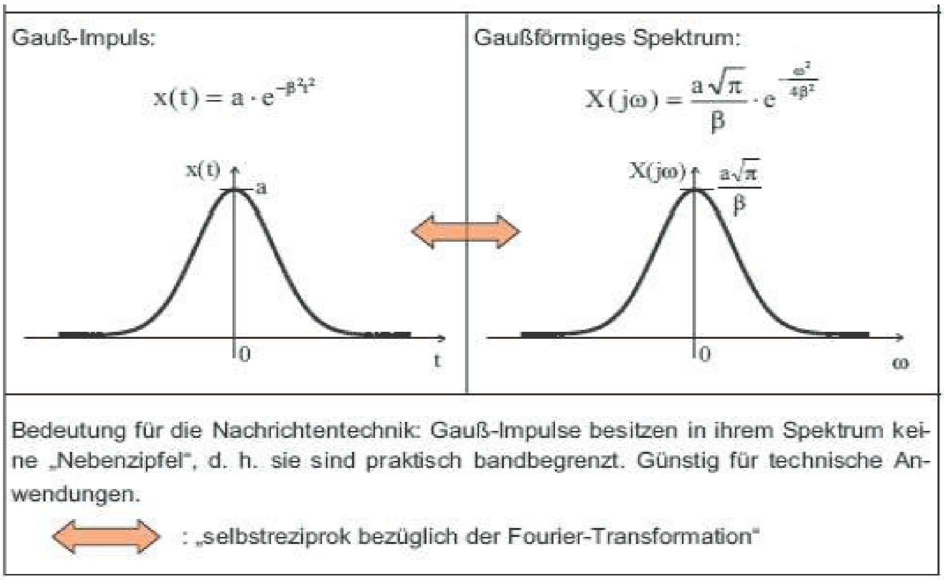


Noise levels for a subcarrier have an impact of approx. -10dB on all OFDM subcarriers. The consequent: noise due to extinction has an impact on all subcarriers which means that unused carriers adversely impact signal/noise (S/N).

The Gaussian filter is clearly better. Millions of GSM users realize this because their mobile phone even functions in closed rooms and in cellars. Theoretically, the Gaussian filter is the best possible time-bandwidth product.

meconet - mPOINT

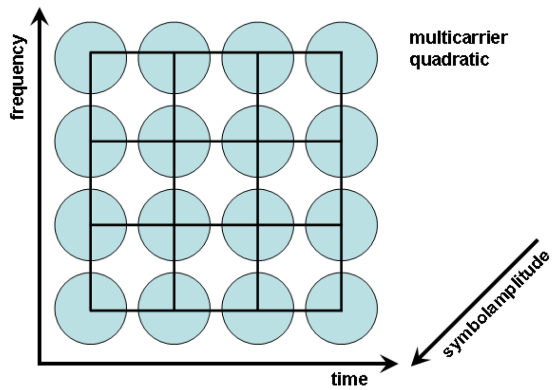
the knowledge behind wireless networking



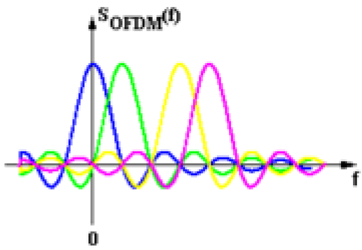
However problems are likely to occur when using the Gaussian filter for high bandwidths.

- In view of possible extinction due to interference and of the easy multipath correction a multicarrier signal cannot be dispensed with.
- An "OFDM" with Gaussian filter would no longer be orthogonal which means that the spectrum would be insufficiently used and that less bandwidth would be available. This is not a problem for Voice (as with GSM), as it is using single carriers with frequency hopping. For bandwidth transmission, however, it is a problem. This is the reason why another standard has been used for UMTS.

The drawing below shows the problem when using a Gaussian filter in a multicarrier modulation.



Improved filtering leads to unused gaps which means that potential bandwidth is wasted.



OFDM is a multicarrier method with nested single carriers, which allows the achievement of optimum packing density, thus avoiding interference between subcarriers and symbols.

By way of an arithmetic operation, the multipath effects occurring on the frequency level can be determined as long as they do not exceed the guard interval. This is relatively simple and can be done without major computing effort.

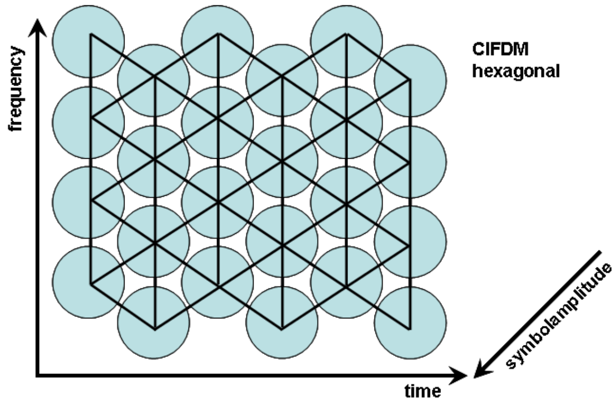
meconet e. K.
consulting.distribution.service
bottenbacher str. 78
57223 kreuztal . germany
tel. +49 2732 55856 0
fax +49 2732 55856 111
www.meconet.de
info@meconet.de

meconet

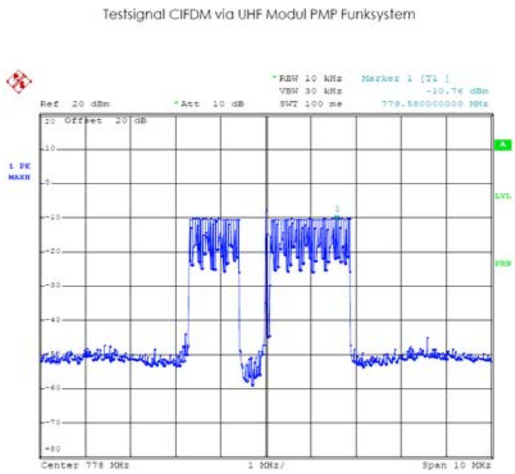
consulting . distribution . service

The CIFDM® modulation used with mPOINT

CIFDM® is the abbreviation for *Comb Interleave Frequency Division Multiplex*, a system that combines the benefits of the well-known OFDM modulation with those of conventional single carrier modulation. The data stream to be transmitted is divided up into two multicarrier blocks which are transmitted interleaved, frequency and time staggered. For each single carrier of a block, a classical modulation with a matched filter system is used and the guard interval is dispensed with. The spectral efficiency is clearly increased by the fact that an artificial zero passage is introduced for each modulation symbol. During this zero passage the other block is transmitted and separated by a synchronous change-over switch in the receiver.



The benefits of **CIFDM®** can be clearly seen, the gaps between the subcarriers are used much more efficiently when interleaving two carrier combs.

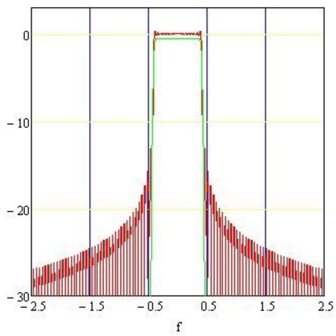


This picture imposing points a further advantage of our **CIFDM®** modulation using Gaussian filter in comparison with OFDM. There are no side lobes left or right of the used spectrum. Also – as simulated here – if some subcarriers are not used for data transmission. All flanks are nearly right angle.

So our **CIFDM®** modulation can be used directly with adjacent channels, or parallel with other non OFDM based systems, without any crosstalk and interference between them.

If you put the OFDM (red) and the **CIFDM®** (green) spectrum one upon the other, the differences clearly appear.

OFDM with side lobes and **CIFDM®** without any side lobes. So **CIFDM®** is much more effective in the given frequency range and without any impact from or for adjacent systems.



The advantages of **CIFDM®** have been already tested and verified by the German regulatory authority with the 700MHz system.

Conclusion: *The same loss of bandwidth compared with Guard Interval, significantly improved by filtering with a Gaussian filter.*

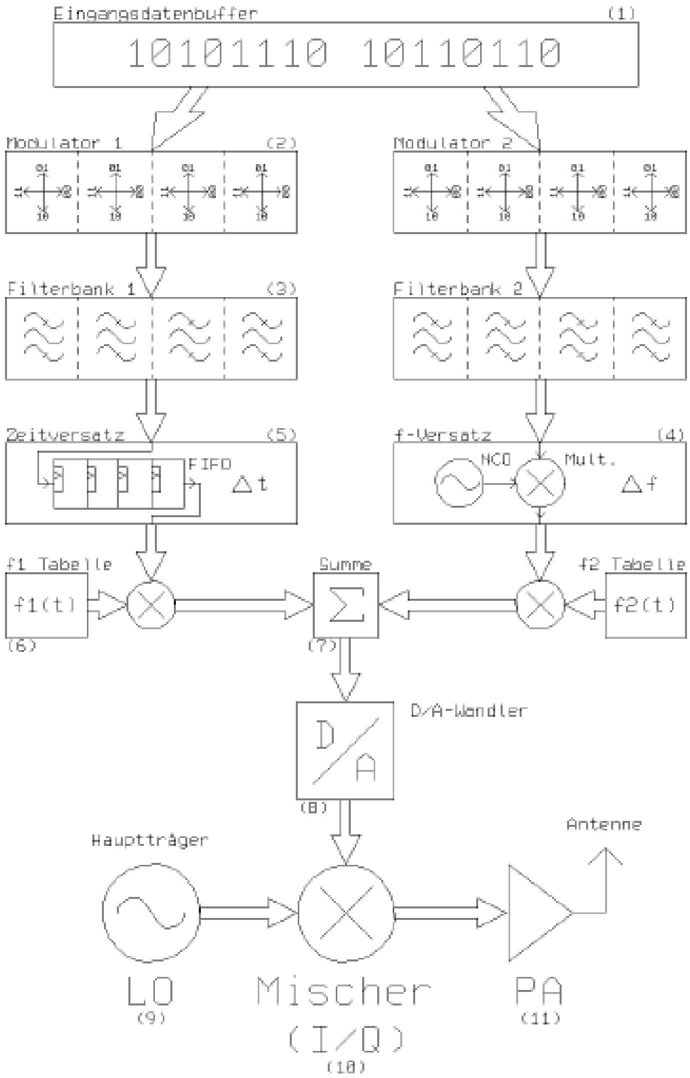
meconet - mPOINT

the knowledge behind wireless networking

meconet e. K.
consulting.distribution.service
bottenbacher str. 78
57223 kreuztal . germany
tel. +49 2732 55856 0
fax +49 2732 55856 111
www.meconet.de
info@meconet.de

The CIFDM® implementation at mPOINT

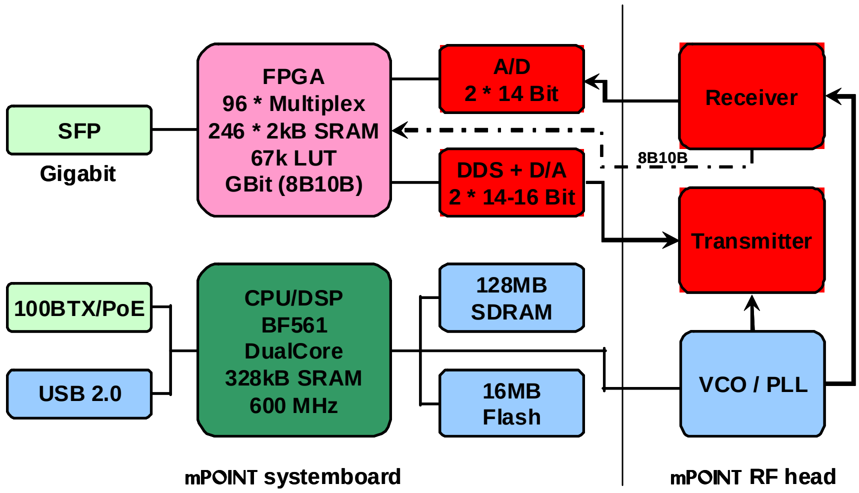
Implementation of **CIFDM®** is more complex and elaborate than that of OFDM in a WLAN card. Some years ago this would not have been possible at all from a technical point of view, because the computing power was not available. Thanks to FPGAs and its 96 parallel multiplexers it is feasible today, even in embedded devices. Another benefit of this technology is the fact that the CODEC used can be subsequently altered using firmware.



The result of the effort: *More range, more reliability, more throughput with significantly reduced susceptibility to disturbance!*

mPOINT block diagram

The following block diagram shows the modular and innovative design used by the **mPOINT** systemboard and the exchangeable RF heads.



What can we do for you?

Our motto is "We do research work for you!“. The companies Bartels GmbH and meconet have a wealth of experience built up over more than 30 years in the field of high-frequency technology, both in development and sales. We know what our customers expect and we are able to meet their expectations from the first definition of the product through engineering to the finished product.

Based on special know-how and proficiency, **mPOINT** offers a "best in class“ product in the field of wireless data transmission and, as a result of its innovation and quality awareness for every single component, outperforms several products that are much more expensive.

mPOINT with CIFDM® – more at the speed of light!

meconet - mPOINT

the knowledge behind wireless networking

meconet e. K.
consulting.distribution.service
bottenbacher str. 78
57223 kreuztal . germany
tel. +49 2732 55856 0
fax +49 2732 55856 111
www.meconet.de
info@meconet.de