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60 GHz Ultra Wideband Multiport Transceivers for Next Generation Wireless Personal Area Networks

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1. Introduction

Ultra wideband (UWB) communications is one of the most promising recent developments in wireless world for high-speed applications as shown in figure 1. In addition, the use of millimeter-waves has allowed in recent years the development of wireless communications: unlicensed short-range (57 – 64 GHz), outdoor semi-unlicensed point to point links (71 - 76 GHz, 81 - 86 GHz, and 92 - 95 GHz), automotive radar (76 - 77 GHz), and imaging sensor (84 – 89 GHz and 94 GHz) systems.

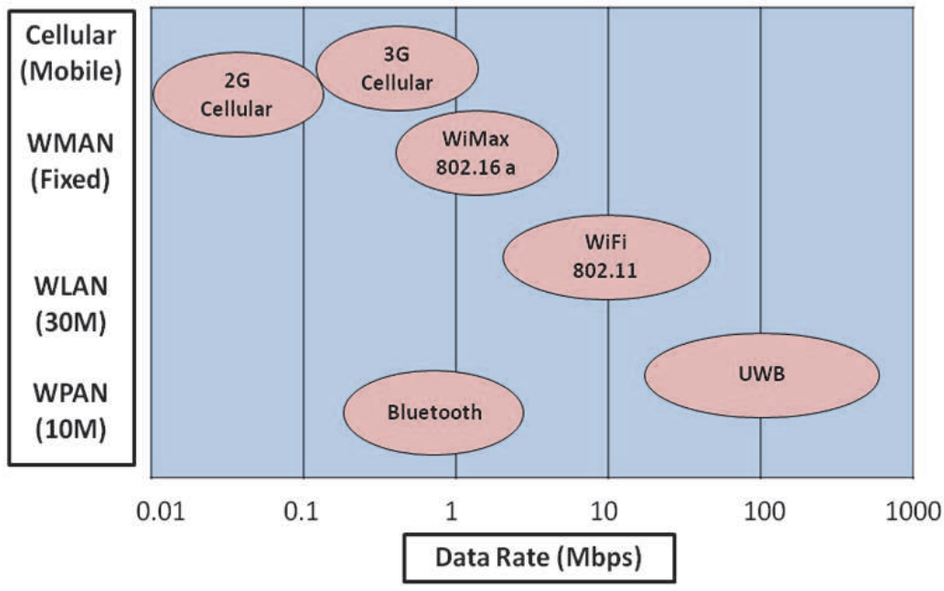


Fig. 1. High-speed wireless applications

The use of microwave frequencies (3.1–10.6 GHz) for UWB systems is actually subject of intensively research. In order to analyze a different very promising approach, this chapter proposes the use of a millimeter-wave carrier for UWB communication systems. Through

the very recent researches, it is known that millimeter-wave technology enables the design of compact and low-cost wireless transceivers which can permit convenient terminal mobility up to Gb/s data-rates.
The chapter is organized as follows:

- Section 2 provides an overview of millimeter-wave technology (60 GHz), compared with other microwave band communications (5 GHz).
- Section 3 states the UWB conventional definition, given by Federal Communications Commission (FCC), and how to use this special technology into millimeter-wave range.
- Section 4 analyses a proposed 60 GHz wireless multiport millimeter-wave system dedicated to high-speed UWB communications.
- Conclusions are summarized at the end of the chapter.

2. Millimeter-wave technology for high-speed communications

Due to the recent dramatic growth of high-bandwidth commercial wireless communications, the microwave communication bands are becoming over crowded. Moreover, the ever increasing high-speed and large-channel capacity digital data rates used in multimedia wireless communications are requiring millimeter-wave bandwidths (frequencies between 30 GHz and 300 GHz). For example, a TV at home will be able to access all sources in the house: a "box" in the lounge, a PlayStation in the bedroom, or a DVD reader in another room through a wireless system focusing on the 60 GHz band.
The 60 GHz band is of much interest since a massive amount of unlicensed spectrum (5 GHz) has been allocated worldwide for dense wireless local communications (Cabric et al, 2006; Park & Rappaport, 2007; Engen, 1977; Yacabe et al, 2001). A couple of multimedia applications calling for wireless transmission over short distances are existing, such as wireless IEEE 1394 (actually this is an international standard digital interface that can run up to 400 Mb/s over a thin cable), wireless high-resolution TV and videoconferences, wireless internet download of lengthy files, wireless direct communication between notebooks and related devices, patient monitoring in hospitals (patients can freely walk within the hospital grounds with devices that transmit ECG (Electro-Cardio-Gram), blood pressure information, etc), remote controls, and wireless embedded systems, etc. This wide range of applications requires low–cost equipment operating at hundred of megabits per second.
In the European Advanced Communication Technology and services (ACTS) program, the 40 and 60 GHz have been addressed by various research projects with target radio bit rates of 150 Mb/s. In Japan, the Multimedia Mobile Access Communication (MMAC) committee is looking into the possibility of Ultra-high speed wireless indoor LANs supporting 156 Mb/s using 40 and 60 GHz. In the United States, the Federal Communications Commission (FCC) sets aside the 59-64 GHz frequency band for general unlicensed applications. This is the largest contiguous block spectrum ever allocated. Thus, a spectral space has been assigned around 60 GHz having a worldwide overlap, as shown in figure 2.
The 60 GHz band can not only achieve very high data rates several Gbit/s but has many other characteristics for applications in millimeter wave range:

- An atmospheric oxygen absorption of 10-15 dB/Km. Indeed, the oxygen have a resonant frequency of 60 GHz. So the transmitted energy is absorbed very quickly by oxygen in the air. (90 % of energy is absorbed by oxygen at 60 GHz).
- 88 dB/Km due to the free space path loss as demonstrated using Friis transmission equation:

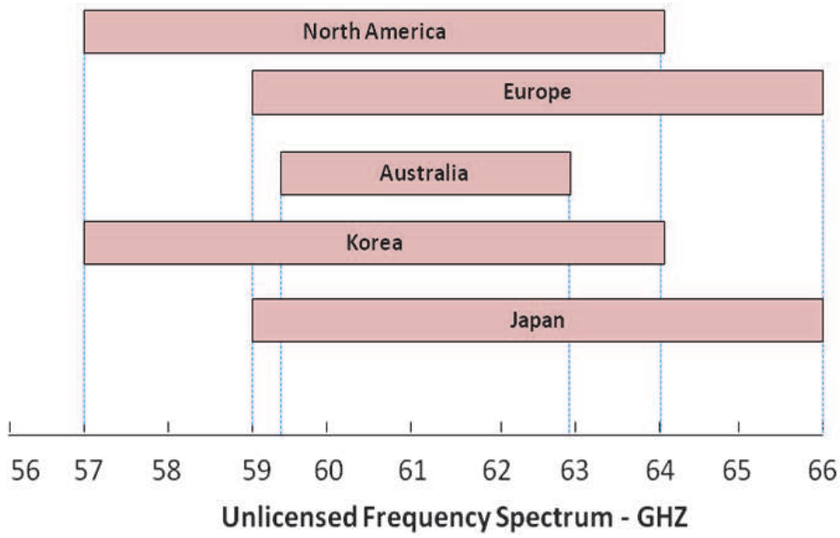


Fig. 2. Unlicensed bandwidth – 60 GHz

$$\frac{P_r}{P_t} = \frac{G_t G_r \lambda^2}{(4\pi R)^2} = G_t G_r A_{fs} \tag{1}$$

P_r and P_t= Power of the received and transmitted signals, respectively
G_r and G_t=Gain of the antennas of receiver and transmitter, respectively
λ = free-space wavelength
R= distance between transmitter and receiver

$$A_{fs} = \frac{\lambda^2}{(4\pi R)^2} \tag{2}$$

$$\lambda = \frac{c}{f} = \frac{3 \cdot 10^8}{60 \cdot 10^9} = 5mm \tag{3}$$

c = speed of the light
f = frequency
The Friis path loss equation shows that, for equal antenna gains, path loss increases with the square of the carrier frequency. Therefore 60 GHz communications must content with an additional 22 dB of path loss when compared to an equivalent 5 GHz system. Then, the free space path loss will be around 88 dB for 10 m and 68 dB for a distance of 1 m, at this very high carrier frequency. The space path loss attenuation for a distance of 10m is calculated for different frequencies, as shown in table 1.

- One of the major limitations of the maximum range for a link at 60 GHz is the attenuation due to rain. In fact, the rainfall of a region is even considered as limiting factor more than the absorption of oxygen. The 60 GHz links shall be constructed in specific way to be able to overcome the rain limitations and will therefore vary according to different regions. The maximum distance increases when the rate of rainfall decreases. In regions with moderate rainfall, attenuation due to rain can be twice higher than oxygen and can be up to three times higher in regions with high rainfall.

Frequency	Wavelength	Free Path Attenuation
2.4 GHz	125 mm	30 dB
5 GHz	60 mm	66 dB
60 GHz	5 mm	88 dB

Table 1. Space attenuation for different frequencies

- The very high attenuation suffered by the 60 GHz links permits the frequency reuse in very close areas. Thus it is possible to deploy multiple devices operating at the same frequency in a high density pattern and without any risk of interference between them.
- The 60 GHz band advantage is to be in the millimeter wave length range. Thus, it is very small, allowing high degree integration for all elements: filters, passive components and antennas. The 60 GHz antennas have a smaller form factor than 5 GHz antennas, as antenna dimensions are inversely proportional to carrier frequency. For example, to obtain an antenna with a gain of 40 dBi and beam width of 1°, the size of the antenna at 60 GHz will be ten times smaller than at 6 GHz. Therefore, at 60 GHz it is possible to produce very compact low-cost antennas with higher directivity. In fact, future high data-rate WLAN will be certainly realized using smart antennas to reduce the power consumption, the link budget and the multipath effects.

This high and severe attenuation makes the 60 GHz band unsuitable for long-range (>2 Km) communications, so it can be entirely dedicated for short-range use (<50 m), where this supplementary attenuation has no significant impact. This makes the 60 GHz band of hugely interesting for many types of short-range wireless applications, as WPANs (Wireless Personal Area Networks) and WLANs (Wireless Local Area Networks). These products are proprietary systems or based on the IEEE 802.11 standards. These products operate in the 2.4 and 5.8 GHz bands and provide a user capacity up to 54 Mb/s. Currently, IEEE 802.15.3c and WirelessHD, the two well-known 60 GHz standards for WLANs and WPANs, are capable to deliver Gb/s streamed video and audio (Daniels & Health, 2010).

In the last decade, intensive researches have been done, especially in terms of designing new millimeter wave components operating over the V-band frequency (50 - 75 GHz). Through those papers and publications, it has been proved that the millimeter-wave frequencies enable the design of compact low-cost wireless millimeter-wave communications front-ends which can permit convenient terminal mobility up to Gb/s data-rates (Smulders et al, 2007; Smulders, 2002; Collonge et al, 2003; Tatu & Moldovan, 2007).

3. UWB in millimeter-wave communications

Before explaining how the UWB characteristics can be reflected in millimeter-wave communications, let's first give a brief description of UWB principles.

The recent development of digital technologies in civil and military fields (radar, instrument for earth observation and space, etc...) associated with the telecommunications (WiFi / WiMAX, WLAN, GPS) demonstrates the great possibility to optimize the use of allocated frequency bands. The FCC defines UWB as "any radio technique that has a bandwidth exceeding 500 MHz or greater than 25% of its center frequency". The UWB technology is

dedicated for transmitting wireless data with a throughput up to several hundreds of Mbit/s. UWB presents itself as an evolution of both Bluetooth and USB wireless. It is a radio technology based on the generation of very short duration pulse over a wide frequency band, hence its name.
In the United States, the FCC has reserved microwave frequency bands between 3.1 and 10.6 GHz for UWB devices. However, in Europe, the frequencies are reduced to the band between 6 and 10 GHz (3 GHz less than in the U.S.). UWB technology is used for radar/sensors, communications, radio astronomy, imaging systems and automotive anti-collision systems. Currently, UWB is already authorized for licensed use in the United Kingdom for the defects detection in runways.
UWB is a good alternative for domestic radio networks (WLAN and WPAN) that is found in the networked home, hotel, conference locations, administrative sites, and all places that do not want the hassle of wiring. Figure 3 gives an idea about the possible applications of UWB, regarding the mobility, costs, speed, and cost, etc.

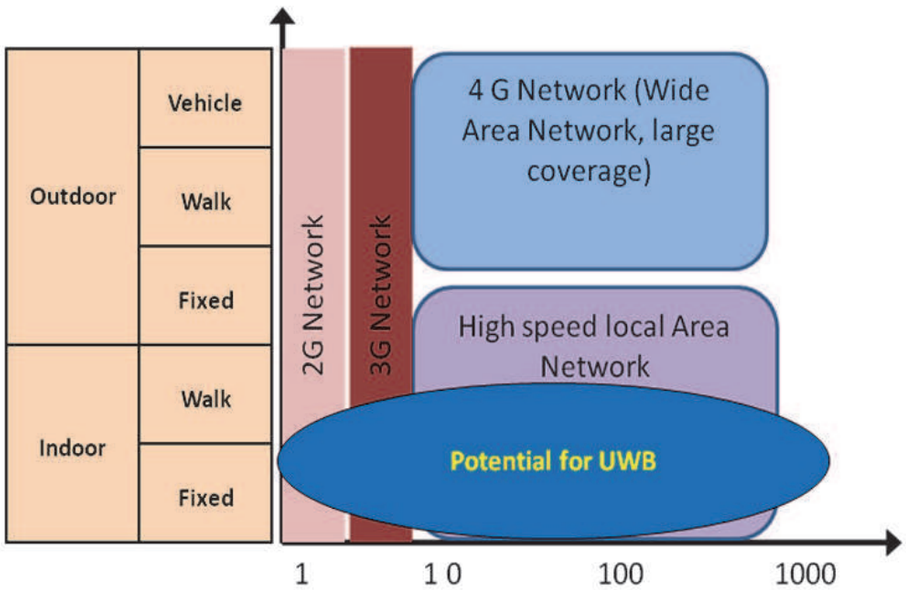


Fig. 3. UWB applications

Although these excellent advantages for microwave UWB, there are some disadvantages at the same time:

- Relatively low frequency carrier
- Low data rate compared to huge ones required in the actual market
- Frequency distortion over wide bandwidth

Compared to conventional microwave UWB technology, 60 GHz millimeter-wave communications will operate in currently unlicensed spectrum (57 – 64 GHz) and will provide high data-rates up to several Gb/s, as detailed in paragraph 2. Hence, the millimeter-wave communications can be largely considered to be used for UWB purposes (WLANs and WPANs). This is the main concern of the following paragraph.

4. UWB at 60 GHz: different approaches

There are many different ways to use the UWB at millimeter-wave frequencies. In this paragraph, two approaches are considered:

- Transposition of conventional impulse radio at millimeter-wave
- Direct use of inherent wide-band into a multi-port interferometer

4.1 Up-conversion of an UWB impulse radio signal (IR-UWB) in the 60 GHz frequency range.

(Deparis et al, 2005) have demonstrated that the impulse radio-UWB used in the 60 GHz band can provide both transceiver simplicity, and high data rate. Their proposed transmitter contains a voltage controlled oscillator (VCO) working at 30 GHz, a double frequency up-converter to reach the 60 GHz frequency, and a pulse generator (1st pulse generator) to generate the pulse position modulation (PPM) pulses in order to modulate the transmitted signal at 60 GHz. This modulation is realized with a switch in ∏-topology, as shown in figure 4. After amplification, Gaussian pulses are transmitted over several GHz bandwidth centered into the 60 GHz band (Tatu el al, 2009).

At the meanwhile, the receiver is composed of a low noise amplifier (LNA), a detector at 60 GHz, and a fast sampling and hold - S/H (Win & Scholtz, 2000; El Aabbaoui et al, 2005; Deparis et al, 2004). A pulse generator (2nd pulse generator) is used to control the S/H circuit. The receiver may contain either a mixer or a detector. If a mixer is implemented, a millimeter-wave oscillator is needed. However, the oscillator is not needed when a topology with detector is chosen, as shown in figure 5.

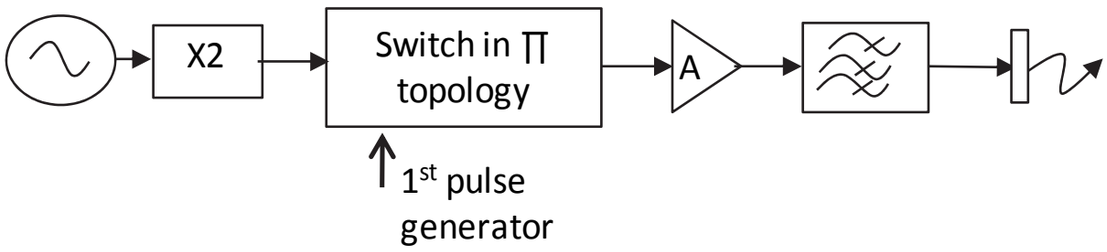


Fig. 4. Transmitter at 60 GHz.

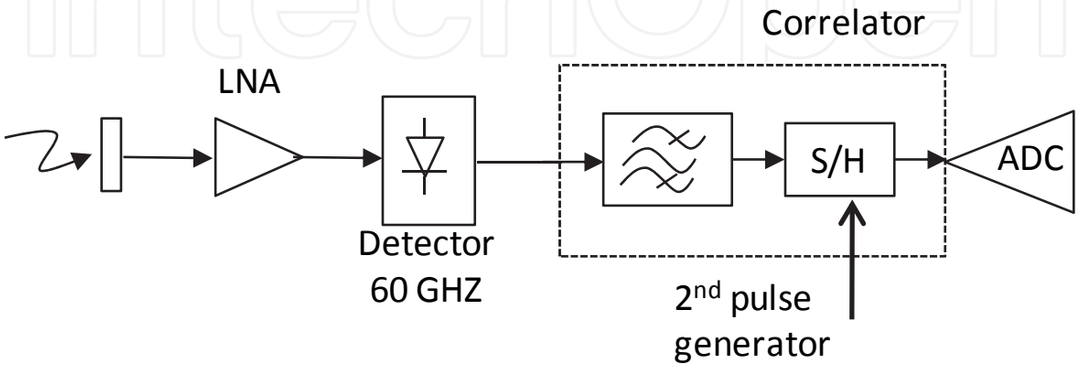


Fig. 5. Receiver at 60 GHz.

The main advantage of this architecture is that no phase information is needed, and thus, no sophisticated coherent stable sources or carrier recovery circuits are involved. This impulse radio-UWB/60 GHz approach can offer transceiver simplicity, high-data rate and is suitable for future low-cost high speed wireless transceivers.

4.2 Proposed 60 GHz transceiver based on six-port circuits

The main objective of this paragraph is to analyze and discuss a 60 GHz transceiver based on six-port circuits. Our target is to provide a transmission bandwidth exceeding 500 MHz, so the proposed architecture can be considered as part of UWB communications systems.

4.2.1 S-parameters and scattering matrix

For high frequencies and since it is very difficult to measure the voltage signal and energy, the scattering parameters [S] are used instead and considered as a convention for describing the RF and microwave waves. In microwave circuits, the required parameters are the amplitude and the phase of the signals. Many electrical properties can be expressed using the S-parameters such as the transmission coefficients, return loss and SWR (standing wave ratio) parameters. S-parameters can be calculated using analytical techniques of network analysis or measured with vector network analyzer equipment. Once identified, these S-parameters can be set in matrix form, called scattering matrix. For example, a two-port network microwave system as shown in figure 6 is represented as follows:



Fig. 6. Quadripole microwave system.

The wave's equations and the S-parameters scattering matrix are:

$$b_1 = S_{11}a_1 + S_{12}a_2 \tag{4}$$

$$b_2 = S_{21}a_1 + S_{22}a_2 \tag{5}$$

$$\begin{pmatrix} b_1 \\ b_2 \end{pmatrix} = \begin{pmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{pmatrix} \times \begin{pmatrix} a_1 \\ a_2 \end{pmatrix} \tag{6}$$

- a_i: Incident wave
- b_i: Reflected wave
- S_{11} : Input reflection coefficient
- S_{12} : transmission coefficient
- S_{21} : transmission coefficient (gain)
- S_{22} : Output reflection coefficient

4.2.2 Six-port modeling versus conventional: architecture equivalence

The six-port circuit is a conventional linear passive component, which consists of several couplers, connected by transmission lines. The idea of using a six-port structure to determine the phase of a microwave signal was first presented in 1964 (Cohn & Weinhouse, 1964). The six-port circuit can be considered as a black box with two inputs, one for the reference signal from local oscillator and one for the RF signal to identify, and four outputs. Using an appropriate algorithm, the amplitude and phase of the RF signal to identify can be determined by measuring the four power signals of the diodes at the outputs of the six-port.

The six port model used in this chapter consists of four 90° hybrid couplers interconnected by transmission lines and four power detectors, as shown in figure 7 (Tatu et al, 2005, 2006). The signals a_5 and a_6 are two normalized waves' inputs and related to local oscillator (LO) and radio-frequency signals, respectively. As known, the hybrid coupler splits

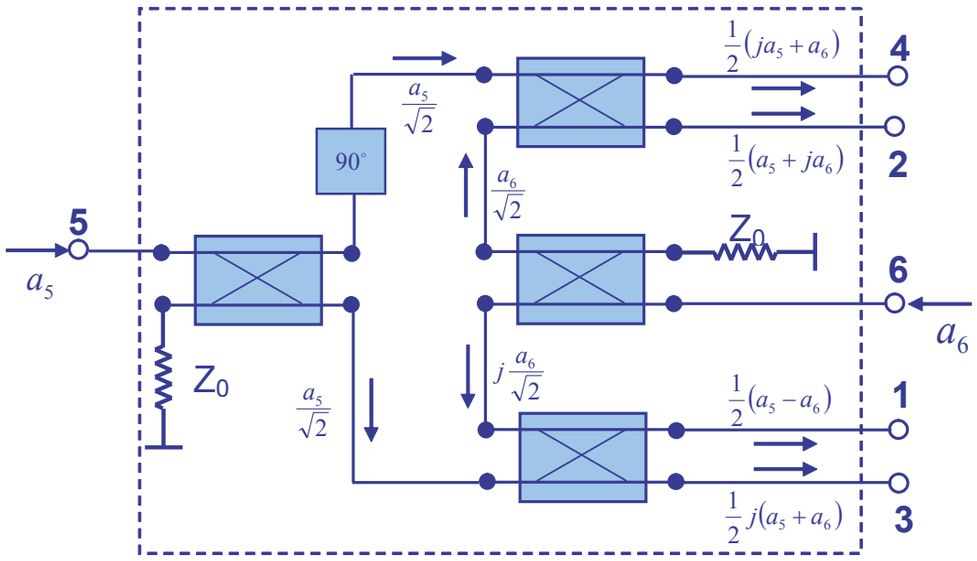


Fig. 7. Six-Port block diagram.

a signal with a 90° phase shift between output ports while maintaining high isolation between the ports. Based on this definition and using the power equations of hybrid couplers, the four outputs wave's equations b_i can be resolved as shown in the following equations:

$$b_1 = -j\frac{a_5}{2} + j\frac{a_6}{2} \tag{7}$$

$$b_2 = \frac{a_5}{2} + j\frac{a_6}{2} \tag{8}$$

$$b_3 = \frac{a_5}{2} + \frac{a_6}{2} \tag{9}$$

$$b_4 = -j\frac{a_5}{2} - \frac{a_6}{2} \tag{10}$$

A popular scheme of the conventional I/Q modulator/demodulator consists of a 90° phase shifter, two mixers and a combiner/divider. The equivalence between the conventional and the six-port demodulator has been demonstrated, as shown in figure 8. (Khaddaj Mallat & Tatu, 2007). The quadrature (I/Q) signals equations are expressed in (11) and (12).

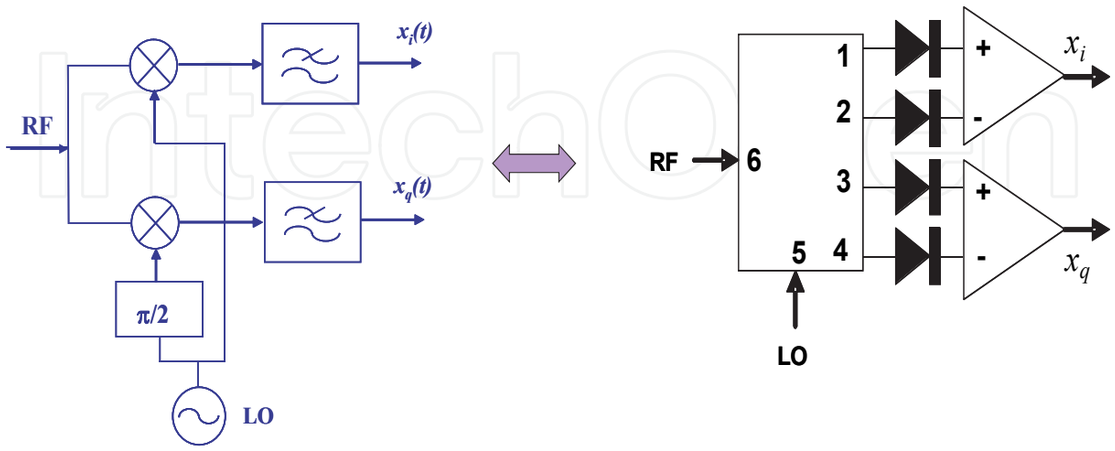


Fig. 8. Conventional and Six-Port Receivers.

$$x_i(t) = V_1(t) - V_2(t) = K \cdot \alpha(t) \cdot |a|^2 \cdot \cos\left[\Delta\varphi(t)\right] \tag{11}$$

$$x_q(t) = V_3(t) - V_4(t) = K \cdot \alpha(t) \cdot |a|^2 \cdot \sin\left[\Delta\varphi(t)\right] \tag{12}$$

In order to obtain the DC output signals, four power detectors are connected to the six-port outputs. The I/Q signals are obtained using a differential approach, as indicated in equations (11) and (12), where K is a constant, *I/Q* signals (In-phase/Quadrature-phase), V_1 to V_4 are the detectors outputs signal, a is the LO signal power, $\Delta\varphi(t) = \varphi_6(t) - \varphi_5$ is the instantaneous phase difference, and $a(t)$ is the power ratio of RF and LO.

A millimeter-wave receiver system simulation is done by Advanced Design System (ADS) of Agilent Technologies. This receiver system is composed of the proposed six-port, local oscillators, amplifiers, pass-band filters and "Sample_and_Hold" circuits (SHCs). The simulation block diagram is presented in figure 9. The operating frequency is set at 60 GHz and the modulation types discussed are M-PSK/QAM (Phase Shift Keying/Quadrature Amplitude Modulation). In the next paragraph, the simulation of the proposed receiver will be based on the measurements results of a fabricated hybrid coupler and not simulation results.

Figure 10 shows the simulation results of demodulated constellations using the proposed receiver for 16PSK and 16QAM signals respectively. It proves that this receiver is performing the analog demodulator task. For 16 PSK modulations, the constellation points (I/Q) are positioned on a circle and these points are equidistant for the 16QAM modulated signal. During this simulation, a coherent LO is used to generate the six-port reference signal. It is be noted that if the phase of the LO changes in time, the demodulated constellation turns clockwise or anticlockwise depending on the sign of this variation. Figure 11 shows the simulated constellation with additional white noise (a white noise was added in the transmission path), signal to noise ratio is 12 dB for 16PSK and 8 dB for 16QAM. The white noise effect is evident as the constellation point is not clear

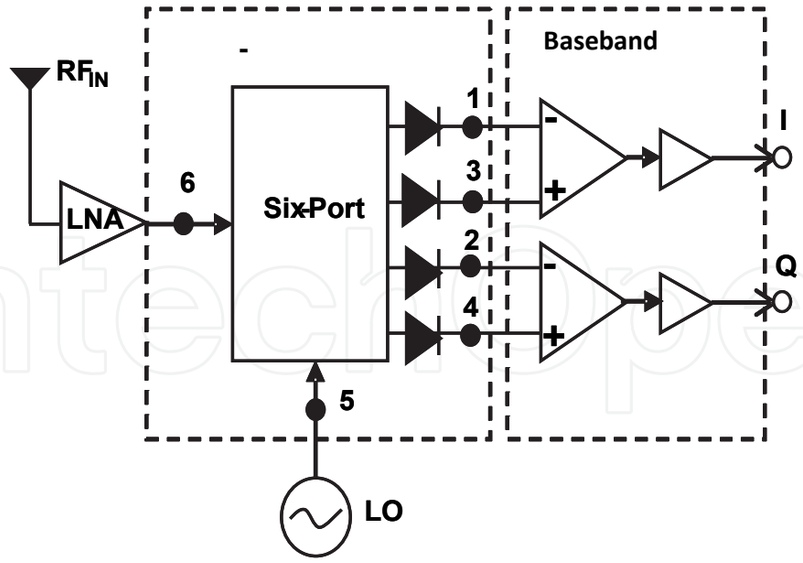


Fig. 9. Conventional and Six-Port Receivers.

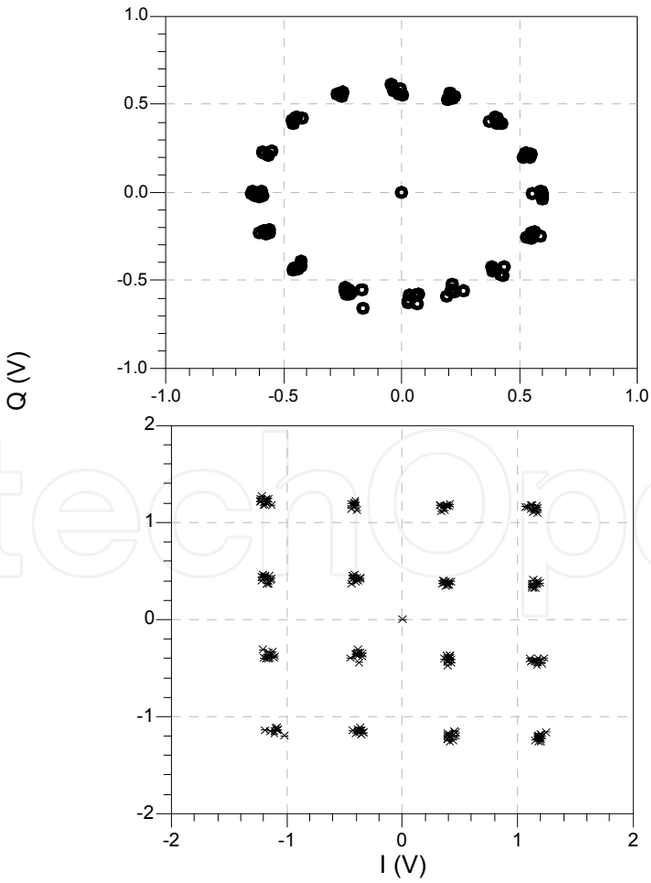


Fig. 10. Demodulated signals: 16PSK/16QAM.

as before. The noise is expressed by the "cloud" covering every point I/Q. As suggested by previous analysis, excellent simulations are obtained as well for another constellation types with reduced number of symbols (BPSK, QPSK, 8PSK). The millimeter-wave frequency conversion and direct quadrature demodulation are obtained using the specific properties of the proposed six-port circuit, avoiding the use of the conventional mixers which require a considerably increased LO power (diode mixers) or active costly devices.

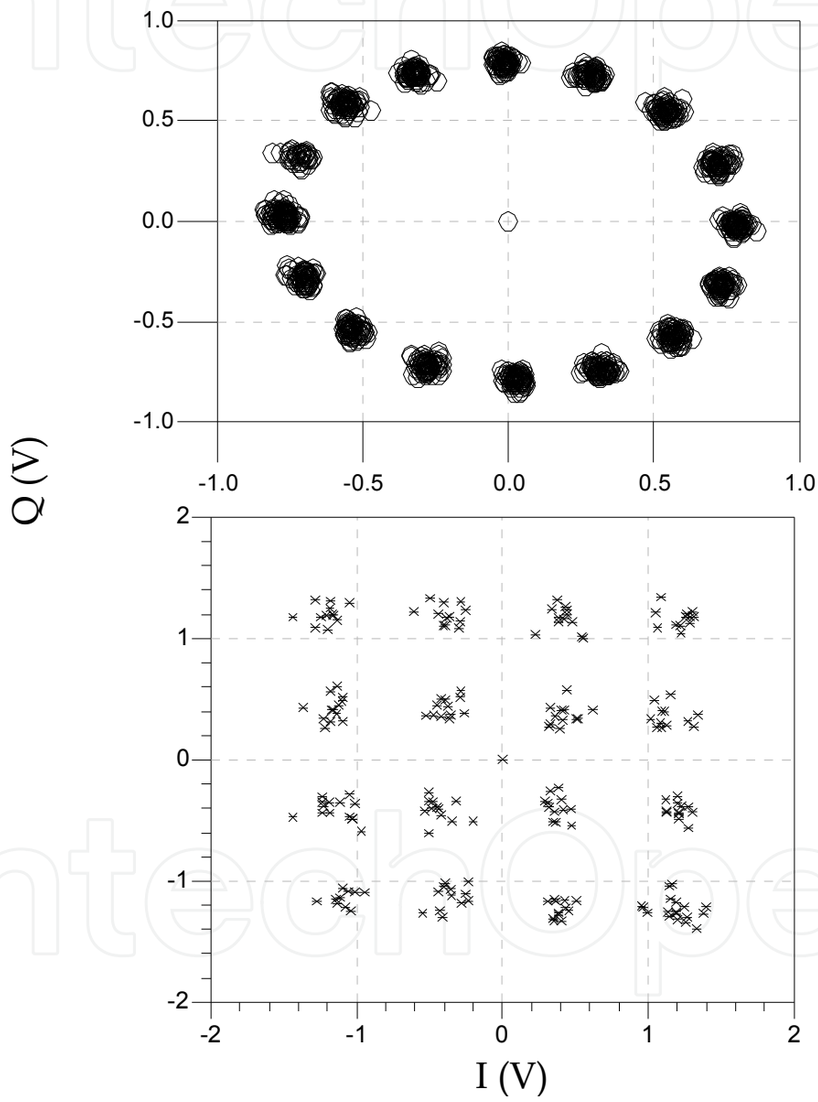


Fig. 11. Demodulated signals with white noise: 16PSK/16QAM.

4.2.2.1 Hybrid coupler characterization

In this paragraph, the four-port 90° hybrid coupler, considered as the core component of the six-port circuit is designed and fabricated to operate in V-band. This circuit is integrated on a 125 µm alumina substrate having a relative permittivity of 9.9, using a Miniature Hybrid

Microwave Integrated Circuit (MHMIC) technology. Figure 12 shows several microphotographs of the MHMIC 90º hybrid coupler. The diameter of the coupler is around 700 µm and the 50 Ω line width is nearly equal to the thickness of the alumina substrate. In order to characterize these circuits, on-wafer measurements are performed using a Microtech probe station connected to an Agilent Technologies millimeter-wave precision network analyzer (PNA) model E8362B.

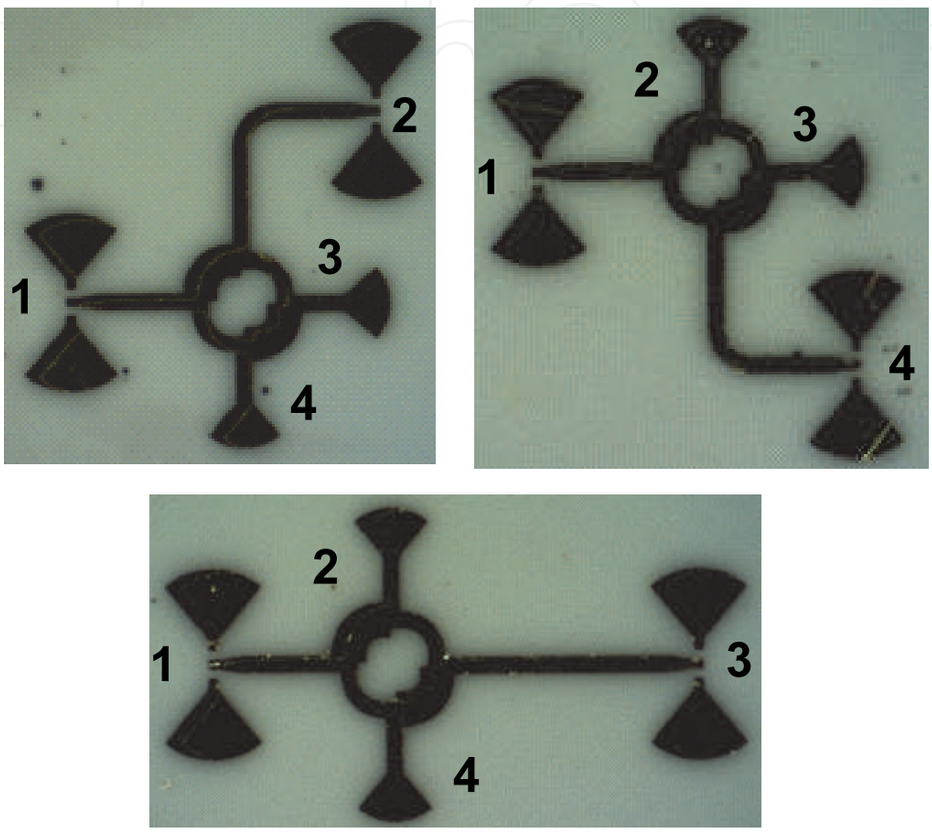


Fig. 12. MHMIC 90º hybrid coupler.

Figure 13 shows that the transmission measured phase of S_{12} and S_{13} is roughly 90°, as known for the hybrid couplers, over 4 GHz of bandwidth. Figure 14 shows that the isolation (S_{23}) and return loss (S_{11}) are higher than -15 dB and -20 dB, respectively. The measured power splits (S_{12} & S_{13}) over the band of 4 GHz are between -3 dB to -4 dB, very close to the theoretical value of -3 dB. Due to the circuit symmetry, equal measured isolations between ports 1-4 and 2-3 are obtained, as well as the return loss at all ports, S_{ii}.

The six-port model is simulated in ADS using the S-parameters measurements results of the fabricated MHMIC hybrid coupler. A matching of more than -15 dB and isolation of -20 dB are obtained for the input ports. The quadrature (I/Q) down-converted signals, using equations (11) and (12), are obtained through harmonic balance simulations for several discrete frequency points over 4 GHz band of interest. These signals have quasi co-sinusoidal/sinusoidal shapes, as requested for I/Q down-converters. The means of quadrature signals (dotted lines) are non-zero values, and, therefore, small DC offsets appear. They can be successfully eliminated using DC blocks, as shown in figure 15.

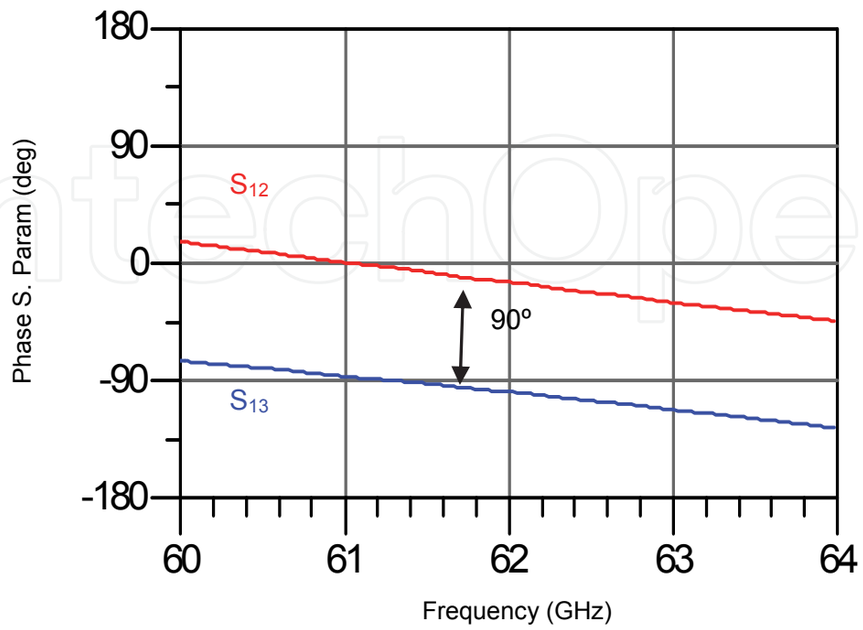


Fig. 13. S-parameters phases measurements results: Hybrid coupler.

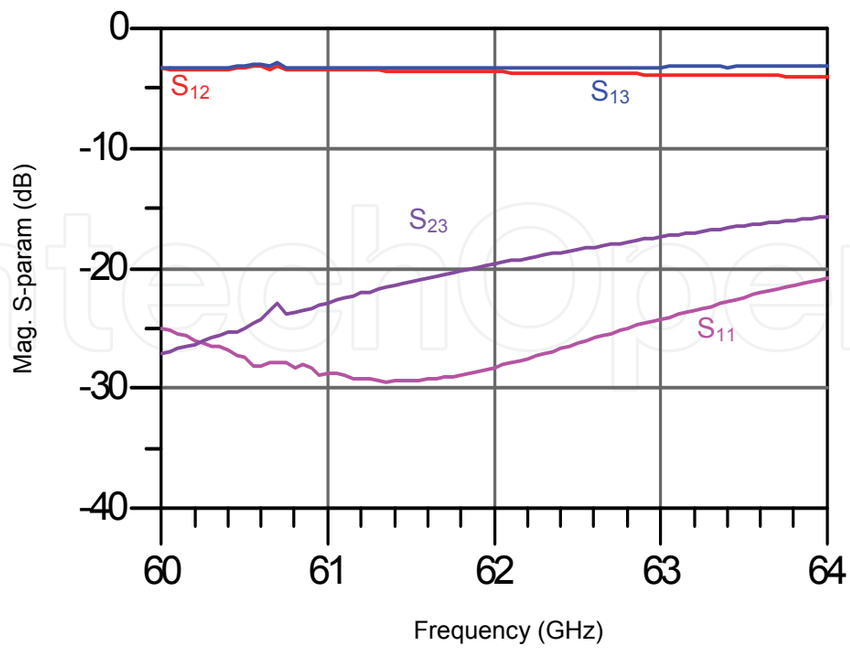


Fig. 14. Transmission, return loss, and isolation measurements results: Hybrid coupler.

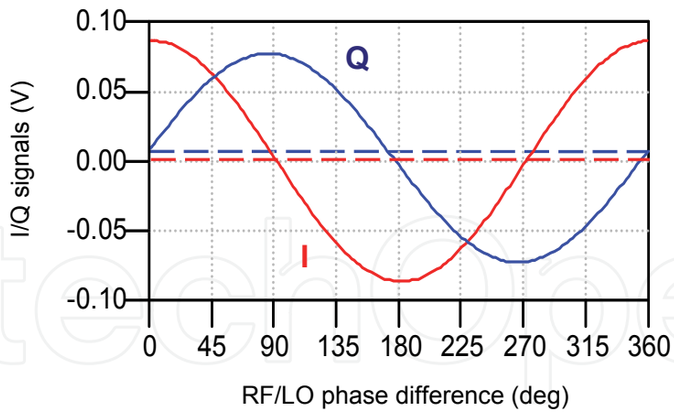


Fig. 15. Six-port harmonic balance.

4.2.2.2 60 GHz transceiver architecture for UWB

Using previous characterization results of the hybrid coupler a six-port model was built into ADS according to block diagram in Figure 7. Figure 16 shows the block diagram of a proposed wireless transceiver system working in V-band (60 GHz). The system parameters' are as follows: transmitted LO power = -25 dBm, amplifier gain (A) = +20 dB, and an antenna transmitting gain (G_T) = 10 dBi. These values are been intentionally chosen in order to obtain a transmitted signal power equal to 10 dBm (allowed by FCC for V-band communications system). The antenna receiving gain is +10 dBi, the LNA gain is +20 dB, so the six-port input signal power has a value of -38 dBm.

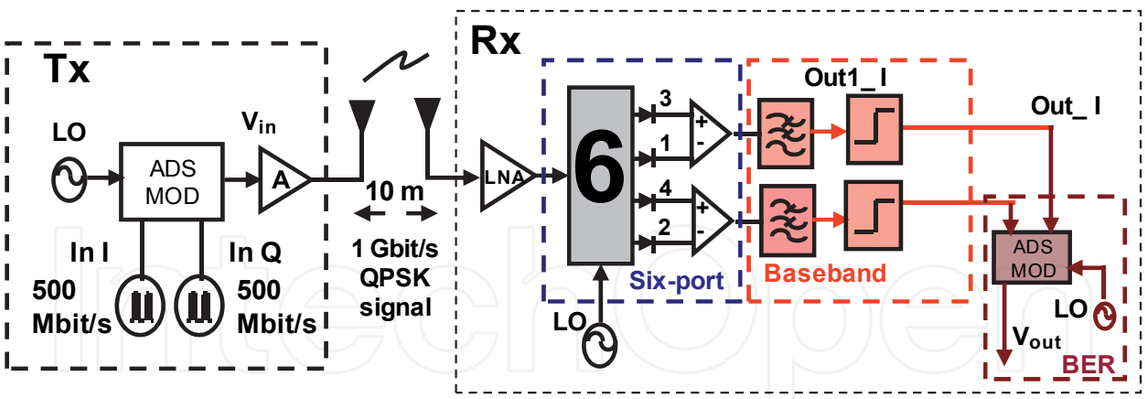


Fig. 16. 60 GHz transceiver system – UWB.

The ADS simulator is configured for an envelope simulation, at a frequency of 62 GHz, and the transmitted signals are modulated in QPSK, for 1 Gbit/s of data-rate communication. The six-port model based on the measurement results of the fabricated hybrid coupler MHMIC (discussed in the previous paragraph) and the baseband circuits are implemented in the ADS receiver model. The transmitted QPSK modulated signals are pseudo-randomly generated by ADS with a symbol rate of 500 MS / s (data rate = 1 Gbit/s). Figure 17 shows the spectrum of the transmitted QPSK signal received at the six-port receiver input. The main lobe is related to the single carrier at 62 GHz.

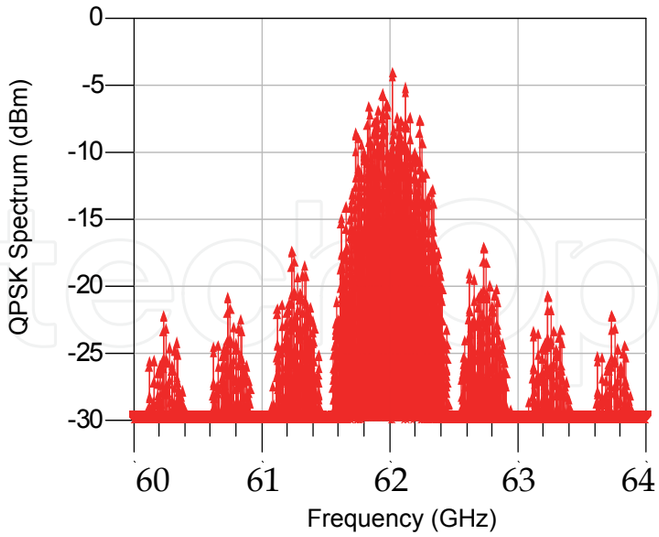


Fig. 17. QPSK spectrum of transmitted signal.

Figure 18 shows the BER variation versus energy per bit to the spectral noise density (E_b/N_0) for the same distance of 10m. Obviously, this six-port receiver architecture using the single carrier scheme has an excellent BER performance (close to the theoretical one). Using limiters in the last stage of the receiver, the output square signals are obtained, as shown in figure 19. For a bit sequence of 200 nanoseconds, the output demodulated (I) signals have the same bit sequence as those transmitted. The same conclusion is obtained for the (Q) signals.

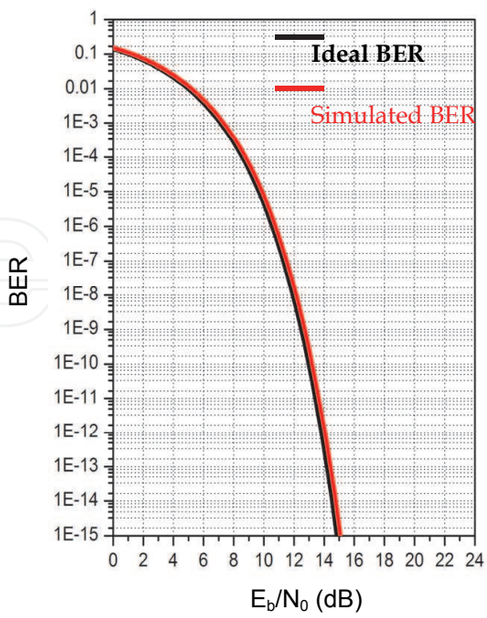


Fig. 18. BER results: QPSK signal at 1 Gbit/s

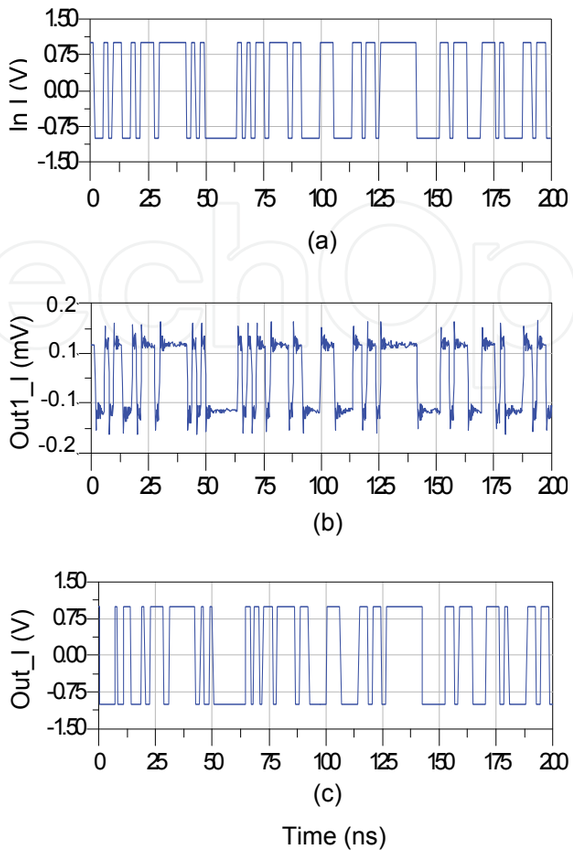


Fig. 19. Demodulation results of 1 Gbit/s QPSK pseudo-random (I) bit sequence: (a): transmitted, (b): received, after six-port, (c): demodulated, at limiter output.

5. Conclusion

The principle and the design of six-port 60 GHz transceivers dedicated to be used in future millimeter-wave UWB WLAN is presented in this chapter. It is demonstrated that the 60 GHz UWB transceiver architectures proposed can offer transceiver simplicity, high data-rate together with system miniaturization. This multiport receiver can be considered an excellent candidate for low-cost high speed future wireless communication systems.
Considerable research effort will be required to develop cost-effective, efficient and reliable designs for these wireless systems. In order to satisfy the technical requirements of wireless networks such as high data-rate and low-power consumption, it is important to design low-complexity and low-power consumption transceivers. Simple architectures are therefore requested for the future millimeter-wave UWB WLAN.

6. Acknowledgment

The authors gratefully acknowledge the financial support of the "Fonds Québecois de Recherche sur la Nature et les Technologies"(FQRNT) and the support of the "Centre de Recherche en Électronique Radiofréquence" (CREER) of Montreal, funded by the FQRNT, for the MHMIC circuit fabrication.

7. References

Cabric, D. Chen, M. Sobel, D. Wang, S. Yang, J & Brodersen, R. Novel Radio Architectures for UWB, 60 GHz and Cognitive Wireless Systems. *EURASIP Journal on Wireless Communication and Networking*, Vol. 2006, Article ID 17957, 18 pages, April 2006.

Park, C. & Rappaport, T. Short-Range Wireless Communications for Next-Generation Networks: UWB, 60 GHz Millimeter-wave WPAN and ZigBee. *IEEE Wireless Communication*, Vol. 14, Issue 4, pp. 70 -78, August 2007.

Engen, G.F. The six-port reflectometer: An alternative network analyzer. *IEEE Transactions on Microwave Theory and Techniques*, Vol. MTT-25, pp. 1077-1079, December 1977.

Yacabe, T. Xiao, F. Iwamoto, K. Ghannouchi, F. Fujii, K. & Yabe, H. Six-port based wave corellator with application to beam direction finding. *IEEE Transactions on Instrumentation and Measurement*, Vol. 50, no. 2, pp. 377-380, April 2001.

Giannetti, F. Luise, M. & Reggiannini, R. Mobile and personal communications in 60 GHz band: A survey. *Wireless Personal Communications*, Vol. 10, no. 2, pp. 207–243, 1999.

Anderson, C.R. & Rappaport, T. S. In-building wideband partition loss measurements at 2.5 and 60 GHz. *IEEE Transactions on Wireless Communications*, Vol. 3, no. 3, pp. 922–928, May 2004.

Daniels, R.C.; Murdock, J.N.; Rappaport, T.S. & Heath, R.W. 60 GHz Wireless: Up Close and Personal. *IEEE Microwave Magazine*, Vol. 11, Issue: 7, Part: Supplement. pp. 44-50. 2010.

Smulders, P; Yang, H; & Akkermans, I. On the design of Low-Cost 60 GHz Radios for Multigigabit-per-Second Transmission over Short Distances. *IEEE Communications Magazine.* 8 pages. 2007.

Smulders, P; Exploiting the 60 GHz band for wireless multimedia access: prospects and future directions. *IEEE Communication Magazine.* Vol. 40. no.1. pp.140 -147. 2002.

Collonge, S; Zaharia, G; & El Zein, G. Wideband and Dynamic Characterization of the 60 GHz Indoor Radio Propagation-future Home WLAN Architectures. *Annals of Telecommunications*. Vol. 58. N° 3-4. pp. 417-447. 2003.

Tatu, S.O. & Moldovan, E. V-band Multi-port Heterodyne Receiver for High-speed Communication Systems. *EURASIP Journal on Wireless Communication and Networking*. Vol. 2007. Article ID 34358. 7 pages. 2007.

Deparis, N.; Bendjabballah, A.; Boe, A.; Fryziel, M.; Loyez, C.; Clavier, L.; Rolland, N.; & Rolland, P.-A. Transposition of a Baseband UWB Signal at 60 GHz for High Data Rate Indoor WLAN. *Microwave and Wireless Components Letters, IEEE*. Volume 15. Issue 10. Pages: 609 – 611. 2005

Tatu, S.O.; Moldovan, E.; & Affes, S. Low-Cost Tranceiver Architectures for 60 GHz Ultra Wideband WLANs. *EURASIP Journal on Wireless Communication and Networking*. Vol. 2009. Article ID 382695. 6 pages. 2009.

Win, M. Z. and Scholtz, R. A. Ultra-wide-bandwidth time-hopping spread-spectrum impulse radio for wireless multiple-access communications. *IEEE Transactions on Communications*. Vol. 48. No. 4. pp. 679–689. 2000.

El Aabbaoui, H.; Rolland, N.; Benlarbi-Delaï, A.; Fel, N.; Allouche, V.; Leclerc, P.; Riondet, B.; & Rolland, P. A. Design of a fully HBT 40 GS/s sampling circuit for very large bandwidth non repetitive signal analysis. *IEEE Microwave Symposium Digest*. 2005.

Deparis, N.; Loyez, C.; Fryziel, M.; Boe, A.; Rolland, N.; & Rolland, P. A. Transposition of a base band ultra wide band width impulse radio signal at 60 GHz for high data

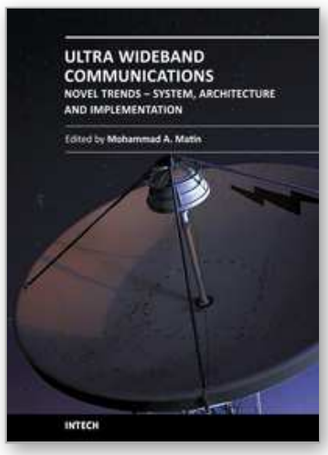
rates multiple access indoor communication systems. *34th European Microwave Conference. EuMW-ECWT*. Amsterdam, The Netherlands. 2004.

Cohn, S.B. and Weinhouse, N.P. An Automatic Microwave Phase Measurement System. *Microwave Journal*. Vol. 7. pp. 49-56. 1964.

Khaddaj Mallat, N. and Tatu, S.O. Six-port receiver in millimeter-wave systems. *Systems Man and Cybernetics (SMC), 2010 IEEE International Conference*. pp. 2693 – 2697. 2007

Tatu, S.O.; Moldovan, E.; Wu, K.; & Bosisio, R.G. Analog Signal Treatment in Six-Port Technology. *Canadian Conference on Electrical and Computer Engineering (CCECE)*. Montreal, Canada. Vol. 3. pp. 1925-1928. 2003.

Tatu, S.O. and Denidni, T.A. Millimeter-Wave Six-Port Heterodyne Receiver Concept. *IEEE MTT International Microwave Symposium*. San Fransisco, California. 2006.



Ultra Wideband Communications: Novel Trends - System, Architecture and Implementation

Edited by Dr. Mohammad Matin

ISBN 978-953-307-461-0
Hard cover, 348 pages
Publisher InTech
Published online 27, July, 2011
Published in print edition July, 2011

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Nazih Khaddaj Mallat, Emilia Moldovan, Serioja O. Tatu and Ke Wu (2011). 60 GHz Ultra Wideband Multiport Transceivers for Next Generation Wireless Personal Area Networks, Ultra Wideband Communications: Novel Trends - System, Architecture and Implementation, Dr. Mohammad Matin (Ed.), ISBN: 978-953-307-461-0, InTech, Available from: http://www.intechopen.com/books/ultra-wideband-communications-novel-trends-system-architecture-and-implementation/60-ghz-ultra-wideband-multiport-transceivers-for-next-generation-wireless-personal-area-networks

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