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Philipp Karl Gentner
Gußhausstraße 25 - 29 / 389
1040 Wien
AUSTRIA
Phone: +43 1 58801 78938
Fax: +43 1 58801 38999
Email: Philipp.Gentner@nt.tuwien.ac.at

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Philipp K. Gentner and Christoph F. Mecklenbräuker

Institute of Communications and Radio-Frequency Engineering, Vienna University of Technology
Gußhausstraße 25/389, 1040 Wien, Austria
philipp.gentner@nt.tuwien.ac.at

***Abstract*—This contribution presents the work in progress towards an active UWB antenna array with beamforming capabilities. Small pulse generators were designed, manufactured and placed directly underneath small uwb monopoles. We show preliminary results of the first measurement campaign with a single antenna and a group antenna in the time domain.**

I. Introduction

With this research report we show a design to enable beamforming and beamsteering research for pulse-based ultra wideband applications. This topic becomes more and more interesting [1] for future wireless networks in indoor environments, for short-range and power-efficient connectivity at medium to high data rates suitable for home entertainment. An application example is the delivery of uncompressed high-definition television to a display or music streams to loudspeakers. In literature such as from Sörgel et al. [2] and [3], UWB arrays were well presented, but directional planar horn antennas were used, which have an inappropriate form factor for such devices. Furthermore due to the unique advantages of UWB, to resolve the distance from one node to another, location-aware coding can stabilize/enhance the achievable data rate and mitigate interference to/from legacy networks.
Here, small planar printed monopoles are manufactured and driven with a pulser prototype PCB (printed circuit board). This pulser creates a sharp Gaussian pulse from a baseband rectangular signal.

II. Elements of the UWB Group Antenna

A. Complex Programmable Logic Device

A commercially available evaluation kit with a Complex Programmable Logic Device (CPLD) is used to generate a rectangular signal. This solution was chosen because the fast logic device can be reprogrammed and the huge number of outputs makes it attractive for our investigations. Another advantage is that the pulser circuitry can be made smaller and battery driven, ideal for antenna measurements in an anechoic chamber, following the ideas of Mayer et al.[4]. The rectangular signal is a pseudo-random binary sequence which simulates a typical communication scenario. The rectangular signal from the logic device has an amplitude of 3.3V.

B. Pulse Shaper

Two repetitive stages consisting of a highpass, a npn-transistor and a shorted stub line, make the pulse shaper. The design from [5] was selected because the system simulation calculated a pulsewidth of 480ps with a peak-to-peak voltage of 3.09V. The first derivative shape of the simulated and measured pulse can be seen in Fig. 1, were the pulser was directly connected to the scope. We see that the pulser has less ringing and after approximatly 4ns the standard noise level of the time waveform in the measured pulse is observed. The measured pulse has a time width of 360ps with a peak-to-peak Voltage of 1.75V.

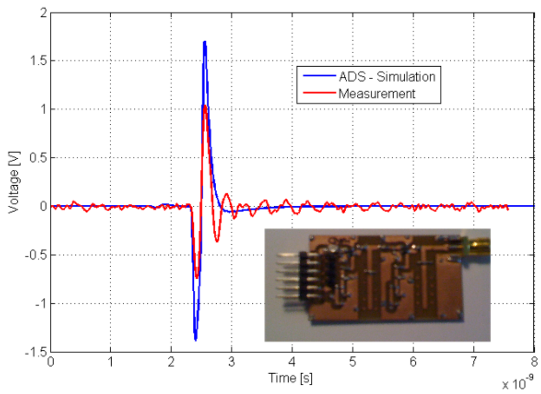

Fig. 1. Simulated and measured output of the pulse shaper

C. Wilkinson Combiner / Splitter

The microstrip Wilkinson consists of two repetitive stages, which split the input signal from the pulser into four signals. The divider is designed to operate broadband at 3.8GHz with a bandwidth of 1GHz. Its insertion loss is 8dB typically. All branches of the divider experience the same delay in the time domain.

D. Antennas

Rectangularly shaped monopole antennas are used from [6] as a reference design and an adapted smaller version of this kind of antenna. Smaller dimensions of this kind of antenna can be established if the cuts toward the feed are diagonal, resulting in a dimension of 18mm substrate width. The manufactured antennas for the array have a center frequency between 3.5GHz and 4 GHz, with a -10dBm bandwidth of minimum 0.9GHz. Fig. 2 shows the measured return loss for the small diagonal cutted antennas.

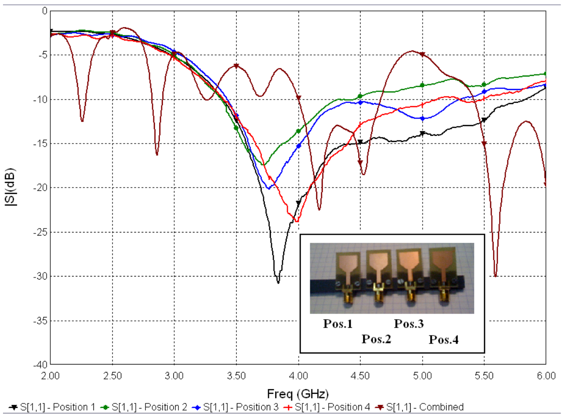

Fig. 2. Return loss measurement of the small wideband monopoles arranged in an array.

III. Measurement

Time resolved angular scans of broadband antennas are observed by rotation of the device under test with a stepper engine. At each angle a snapshot of the oscilloscope is transfered to the remote desktop computer. Two pulsers are connected directly to the CPLD, where the same pseudo-random pulse pattern is sent on each path. One pulser is connected to the device under test, consisting of the Wilkinson splitter with the four antennas, where the other goes directly to the scope for triggering purpose. At a freespace distance of approx. 0.3m a broadband horn antenna is positioned, which captures the pulse signal and send it directly to another port of the scope. The Matlab routine on the PC (Fig.3) connects the engine by a RS232 interface, where the Digital Storage Oscilloscope interfaces with a VISA Socket.

First a single monopole as introduced in Section II-D with an attached groundplane of 2x2cm at the feed is measured with this setup. (The groundplane was introduced to suppress cable currents). The result of a single antenna is shown in Fig.4. We see that the transmitted pulse is radiated almost uniformly over the azimuth angle, with two maxima in forward (broadside) and backward direction. Also it shows that the captured pulse shape is almost invariant versus the azimuth angle. On average, the Voltage peak-to-peak amplitude decreased to 70mV over the measurement distance.

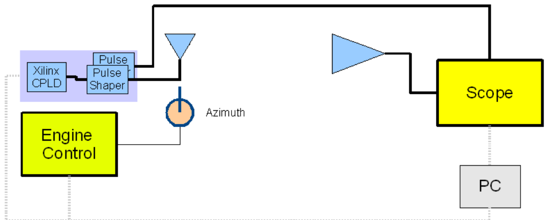

Fig. 3. Simple Time domain measurement setup with the UWB pulse shaper introduced in Section II-B.

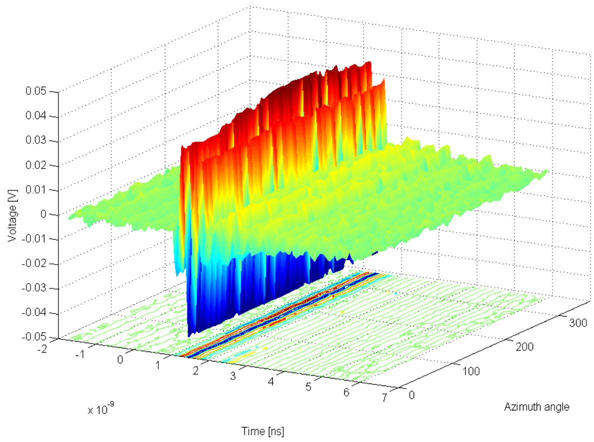

Fig. 4. This grafic shows a single broadband monopole antenna with attached groundplane turned in azimuth. On the bottom axes the azimuth angle and the time vector is shown, whereas in z-direction the measured Voltage is displayed. We see that the monopole is radiating the pulse omnidirectional in all angles with no remarkable dispersion.

The following measurement (see Fig.6) is carried out after introduction of the Wilkinson splitter between the pulse shaper and the antennas. The antennas have a spacing of 2cm with a groundplane soldered at the feed point (Fig. 5). We see that in endfire direction the assumed pulse minima due to beamforming can be measured. Another property of the UWB time domain measurement setup is obvious: By triggering the transmitted pulse instead of the reference, this measurement becomes difficult because the trigger level of the oscilloscope needs to be decreased as a function of the azimuth angle of the antenna array. Such an adaptive trigger control is needed, and will be implemented for further studies.

IV. Conclusions

We design and manufacture an environment for research on ultra wideband beamforming and beamsteering

Fig. 5. Four UWB monopole antennas arranged linear with introduced groundplane.

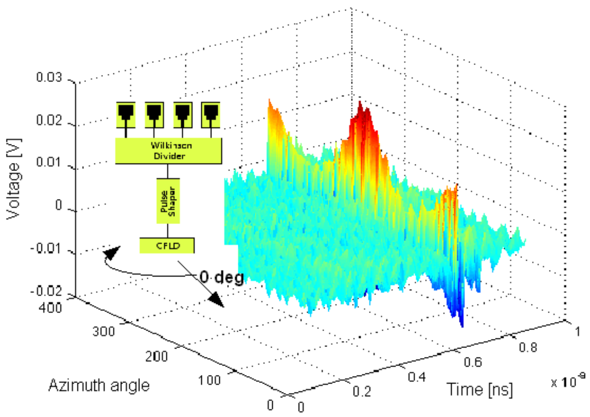

Fig. 6. Time domain antenna measurement with four linear arranged wideband monopoles.

based on UWB Impulse radio. With this setup we investigate the radiation pattern of wideband monopole or dipole arrays and their beam-tilted versions. This setup can be combined with the existing IEEE 802.15.4a [7] development platform also developed at the Vienna University of Technology [8]. For further investigations passive or active delay lines [9] can be inserted in-between the combiner and the antenna array due to the modular architecture of the elements.

V. ACKNOWLEDGMENT

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