MODIFIED FREQUENCY DOMAIN RADIO CHANNEL MEASUREMENT SYSTEM FOR ULTRA WIDEBAND STUDIES

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ABSTRACT

This paper presents the radio channel measurement system applied to an ultra wideband (UWB) context. The channel probing is done in frequency domain using network analyser as a receiver. The system is modified to allow wireless connection between the transmitter- and receiver-ends of the system. Due to the modifications long distance radio channel measurements are possible.

I. INTRODUCTION

Ultra wideband (UWB) technology is an interesting physical layer option for the short range various data rate applications. Due to the low total transmission energy that is also spread over an extremely large bandwidth the signal is hidden inside a background noise. The current regulations for UWB set the fractional bandwidth or -10dB bandwidth requirements greater than 20% or 500 MHz, respectively [1]

Nowadays, UWB research has globally broken itself through. This set also need for reliable UWB radio channel models to be used in UWB R&D work.

One can find an introduction to the different (ultra) wideband radio channel measurement techniques e.g. from [2]. The channel can be probed either in frequency or in time domain. The duality of these methods is obvious in a static environment due to the FFT transform relationship of frequency and impulse responses.

In this paper, the modification for the conventional frequency domain measurement system is presented. Based on the modifications at the transmitter (TX) and receiver (RX) ends can be used independent devices that allows more flexible channel sounding without wired connection between them.

II. FREQUENCY SWEEPING METHOD

Typically, in frequency domain radio channel sounding systems VNA is used to transmit and receive the probing signal by itself [2,3]. This sounding corresponds to the S_{21} measurement where radio channel is now the device under test (DUT). This kind of conventional construction limits the link distance to be measured due to the cables used to transfer the probing signal to the antennas.

The modified UWB radio channel sounder based on the vector network analyser (VNA) is presented in Figure 1.

In our modified channel sounding system the narrowband probing signal is generated by external signal generator. The wired connection is avoided by sending only the triggering signal to the signal generator via radio. The channel frequency response is measured using a set of tones, not an UWB signal. Due to the wide frequency band to be measured (frequency response) the UWB channel models can be generated during the data post processing. Functionality of the modified sounding system is presented in format of impulse response in Figure 2.

All the measurement procedures are controlled by LabView™ software.

III. Measurement tools

The main device in our channel measurement system is vector network analyzer Agilent 8720ES. This device receives the probing signal and makes the calculations for S_{21} of the channel. The probing signal is sent, instead of the VNA itself, by the external sweeping signal generator (SMIQ 06B by Rohde & Schwartz). These two devices are synchronized to maintain the same frequency both in the TX and RX ends. The TX-port of the VNA is terminated to 50Ω impedance to avoid reflections from the unused RF-port.

Low noise amplifier (LNA) can be used at the receiver port of VNA to improve the noise figure of the receiver, and of course, to magnify the received probing signal level. At the transmitter end a power amplifier (PA) is used. In our installation the amplifier used is Kalmus 710FC (PA).

Function generator AFGU by Rohde & Schwartz is used to generate the triggering pulses that are fed to the SMIQ and VNA. Because of the propagation delay of the trigger pulse on radio link and different operating times from trigger pulse to actual sweep start on SMIQ and VNA the trigger pulse timing for SMIQ and VNA must be tuned (~30 ms) to make SMIQ signal propagating through the channel and VNA reference simultaneous. The devices are operating in single sweep stepping mode, sweeping the predefined frequency band using 1601 points. The frequency difference needs to be less than the IF-bandwidth of the VNA for reliable detection.

In our current system settings the sweep time is approximately 5 s and it depends only on the number of measured frequency points. If the maximum delay of the channel is small the number of frequency steps and therefore also the sweeping time can be decreased.

The timing information and all the commands and adjustments for the devices are given through LabView except for the transmitter generator SMIQ for which the settings is called from register loaded earlier by LabView. The sweep trigger for the transmitter generator SMIQ is coming through the radio link to the external trigger input. The personal computer having a LabView™ is also used to store the raw data.

A constant clock reference is used to maintain high frequency stability in the system. External 10 MHz clock reference, based on the TV stripe frequency signal, is fed to the external clock reference inputs in VNA and SMIQ. After this procedure the frequency stability of 10^{-12} at maximum is guaranteed.

During the frequency sweeps the phase difference between the generator signal and the analyzer signal is not known. However, in UWB radio channel models the phase information does not play significant role like e.g. in wideband models. Because the phase information could not be utilized in data post processing a scalar network analyser can also be used. If one likes to use continuous sweep during the measurements the sweeping time in this construction increases significantly, to approximately 30 s.

The antennas to be used in the system could be selected by the frequency range requirements. However, the antennas should have constant phase centre and they should be omni-directional when used in the radio channel measurements. Currently, HK014 antennas (Rohde & Schwartz) are used in the first experimental tests.

In our test system, military radios LV217 are used to transfer the triggering signal from AFGU to SMIQ. The output pulse of AFGU is transformed to acoustic wave and sent via LV217. At the SMIQ-end, the acoustic wave is converted back to the electrical signal and used as an external trigger in SMIQ.

The frequency band that could be measured depends on the frequency range of the VNA and SMIQ. The current devices allow the measurements in a selected band between 50 MHz and 20 GHz. However, HK014 antennas limit the frequency band between 100 MHz and 1300 MHz.

The limitation of the frequency domain channel sounding is the requirement of static environment during the recordings. The coherence time of the channel need to exceed the sweeping time (channel does not change during the recording).

IV. Conclusion

This paper introduces the modified frequency domain radio channel measurement system that allows the channel sounding without cable connections between the transmitter and the receiver when the receiver is network analyser. This modification allows more flexible measurement with longer link distances.

V. Acknowledgement

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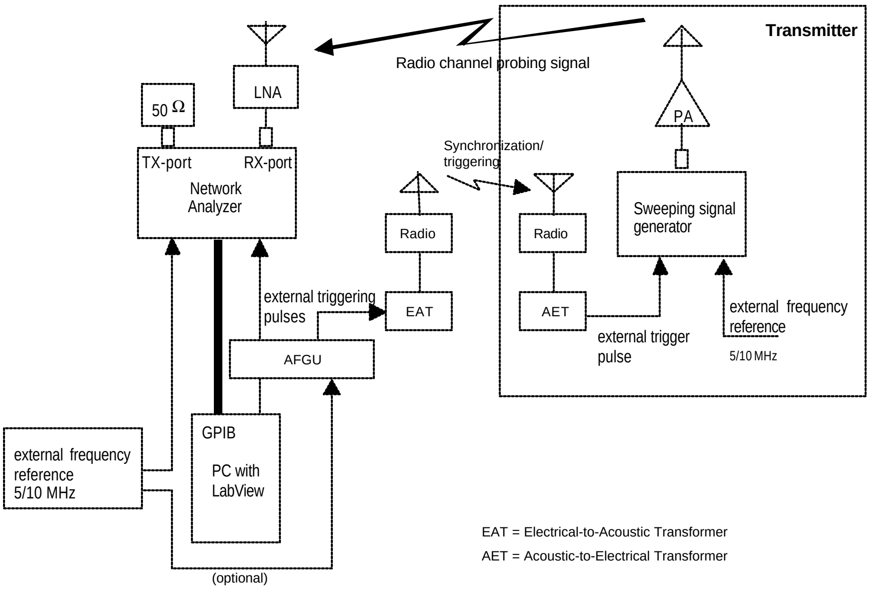

Figure 1. Modified frequency domain UWB channel sounding system.

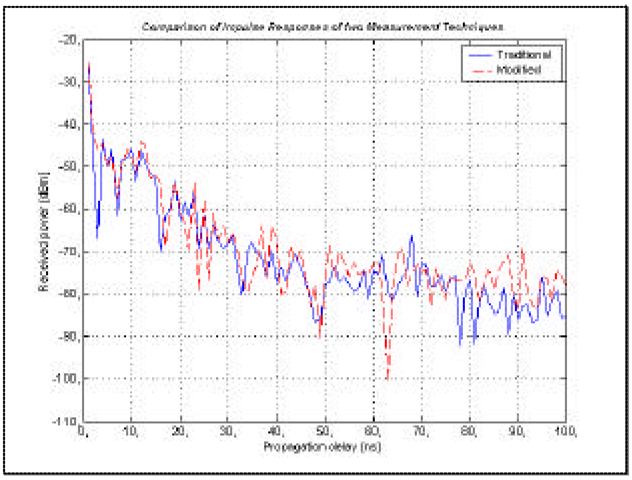

Figure 2. Comparison of impulse responses performed with traditional and modified measurement techniques.