LPI channel based on UWB technology.

The specialists in Moscow Aviation Institute (“Analog and digital radio engineering systems” Department) have been working on the development of UWB communication systems intended for transmitting various types of data for several years. His is my friend. I have cooperation work with MAI above 7 years. This article based on paper of project “ULTRA-WIDEBAND (UWB) INTERFERENCE RESISTANT SYSTEM FOR SECURE RADIO COMMUNICATION WITH HIGH DATA RATE”. Thanks engineers (MAI) for help and papers.

Introduction

The basis for this works is the conception of the use of signals without carrier frequency. The use of UWB short duration signals helps to keep the high quality of the data transmitted. Thanks to a reduction in radiated pulse duration a possibility appears for efficient resistance to multi-path signal propagation caused by signal rescattering from objects located near the communication system antenna and the line-of-sight between the signal source and the receiver. If a signal duration is 1 ns and the objects, which cause signal rescattering, are located at the distance more that 30 cm from the line-of-sight, we will have undistorted signal detection.

The block diagram of a developed system is shown in a fig. 1. The signal transmitting the information represents a sequence of zeroes and nulls; it arrives at Buffer in Transmitter Unit. Buffer performs the trans-formation of the data

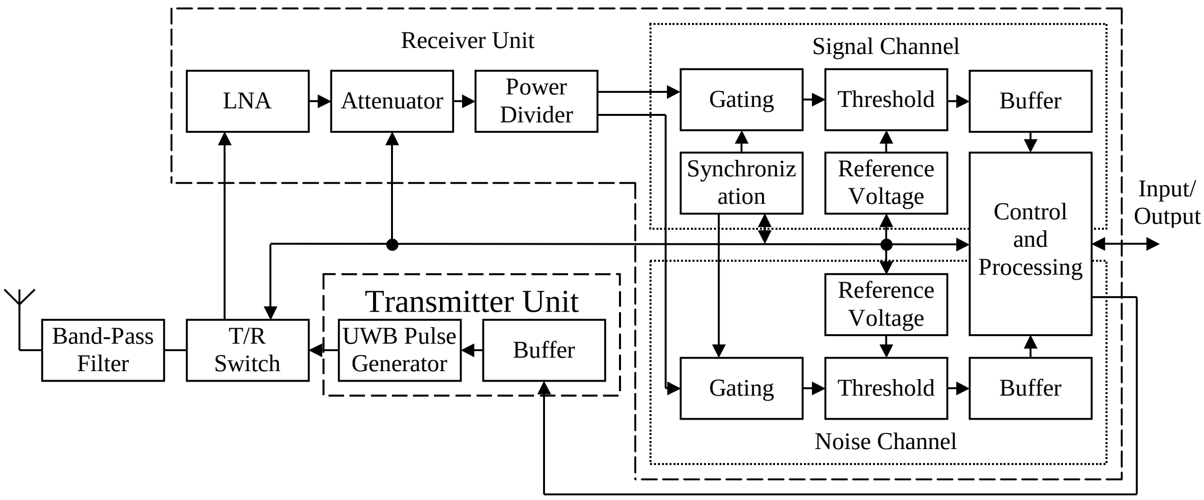

Fig. 1Block diagram of UWB transceiver

sequence into a signal, which drives UWB Pulse Generator with a “free” cut. The UWB Pulse Generator is made using diodes with quick restoration of a back resistance; it is loaded by the antenna with 50 Ohm wave resistance. 50 W power of pulse is fed from the Generator to the load with a pulse period-to-pulse duration ratio about 500. Information symbol repetition frequency is 2 MHz. Average radiated power is reduced as we have no radiation in the zero information symbol. View of one of the UWB antennas is shown in a fig. 2.

Antenna switch performs the commutation of reception/transmission operational modes. We have examined several types of UWB transmitting/receiving antennas. All antennas were made on the base of the strip technology.

Antennas’ frequency band is about 0.4-2.0 GHz.

Antennas’ sizes are from 40 to 900 cm2.

A receiver comprises a low-noise amplifier (LNA), attenuator, several high rate chips advanced CMOS logics. The digital signal processor controls transmitter/receiver operation. Programmable logic array is used in the synchronization and signal-tracking scheme.

Receiver Unit is composed of two channels, which make simultaneous reception. One channel serves for signal detection, the other channel serves to estimate the level of external interference and the signals rescattered from the objects located at the signal propagation line.

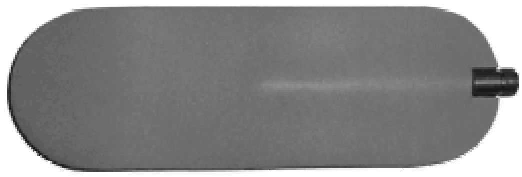

Fig. 2 View of the UWB antenna

The basic schemes in both channels are highly sensitive threshold schemes made on the base of key tunnel diodes operating in frequencies up to 20 GHz. Diodes are manufactured in Russia.

A received signal is amplified and fed to a power divider and then to threshold schemes in Signal and Noise Channels. The output signal from the threshold schemes goes through Buffers to Digital Signal Processor. The signal processor analyses both a received signal and noise. The analysis of external noise is based on the criteria processing of the signal received in Noise Channel. Digital Signal Processor performs the estimation of rescattered signals and noise level followed by criteria processing. Adjustment of receiver sensitivity is made by threshold regulation depending on the processing results. Adaptive adjustment of the receiver dynamic range is performed using the Attenuator. Synchronization scheme is also controlled using the results of the analysis.

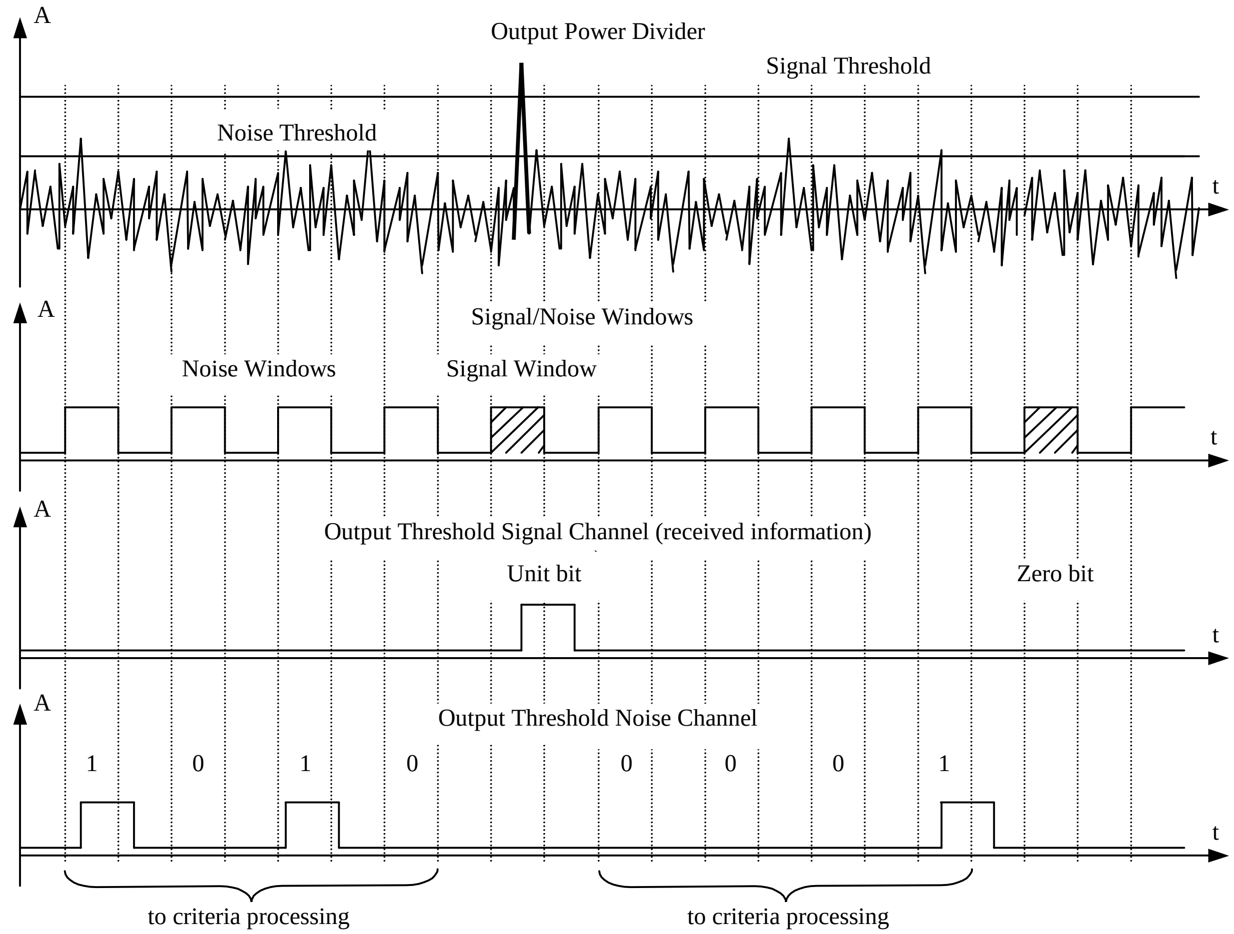

Fig. 3 Timing diagrams of operation of signal channel and noise channel

In Signal and Noise Channels, the signals are detected in the time intervals (time windows). The signal detection within the time window, not far wider than the signal duration , provides high noise resistance of the receiver. Timing diagrams of operation of signal channel and noise channel is shown in a fig. 3.

The detection of noise signals is also performed in windows with the width equal to signal window. Noise windows precede signal windows in time. The number of noise windows is variable, it depends on external noise environment. Noise signals received in the windows are processed in Digital Signal Processor. The processing criteria can be different. The type of criteria selected depends on maximum signal-noise ratio.

The structure of signal channel and noise channel is identical. The design of one channel without the block of control and synchronization is shown in a fig. 4.

Operation

Calibration mode

Before operation, the receiver must be calibrated by external noise. The aim of calibration is to determine the reference voltage fed to threshold schemes in Signal and Noise Channels. While calibrating, the threshold level in Signal Channel is set higher than the reference volt-age in Noise Channel. This also promotes high noise resistance of the receiver. The calibration is made after switching on the receiver power supply and when the signal is lost while operation.

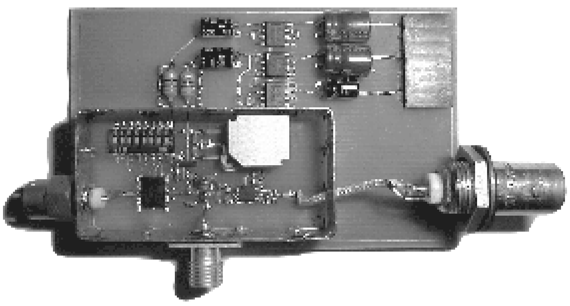

Fig. 4 The design of signal (or noise) channel

Signal searching

After calibration, the receiver converts to the signal searching mode. Signal searching means the mode when the transmitter and receiver in the communication sys-tem are going to be synchronized. The transmitter emits a special signal, which serves to state the relation between the signal and the receiver. In this mode, the receiver signal window is searching the emitted signal. The signal detected is set in the middle of the window. Such signal searching process is performed by the synchronization system after receiver power supply is switched on and when the signal is lost during operation, just as for the calibration process.

Operational mode

During the operational mode, a continuous estimation of the noise level in the noise windows is carried out. With variations of the noise level, the threshold values in Noise and Signal Channels change their values; and the input Attenuator regulates the signal level. Along with this process, the signal location in the signal window is controlled. If the signal is displaced from the middle of the window at the given minimum time interval, then the synchronization system forms a command to move the signal window at the needed time interval.
When the signal is lost (no pulses in the signal window) during some time interval , then the communication system gets out of the operational mode and goes into calibration and searching modes.

Thanks Alex Sudakov (UWB Russian Group) for help and papers.