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Development of an Indoor Microwave Positioning and Data Transmission System

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1. Project

- Project initiated by the company Horcher, supported by Central Innovation Programme for small and medium-sized enterprises (SMEs)
- Project partners: Horcher, Institute of Navigation (INS), German Institutes of Textile and Fiber Research (DITF)
- INS and DITF developing an alarm system for the situation: drowning while taken a bath in a bath-tub.
- Safety system comprises e.g.:
  - MEMS accelerometers and gyroscopes
  - Humidity sensor
  - Indoor Microwave Positioning and Data Transmission System (IMPDS).
- IMPDS
  - Determines the absolute position of a body in the bathtub
  - Transmits wirelessly sensor data to the central receiver and processing unit (s. Fig. 1)-

2. IMPDS Concept

- Two microwave transmitters (2.4. GHz) on the right and left shoulder fixed on an elastic belting around the chest and shoulder of a person.
- Signals coded by pseudo noise codes (PN codes) for ranging and data transmission.
- Possible data: air pressure-, IMU- and humidity-data
- Slant range and the carrier phase of each receiver is linked to the central processing unit (CPU)
- CPU estimates the transmitters positions out of the receivers slant ranges, evaluates the sensor data and determines the alarm condition.
- 3 alarm levels: fine, movement could cause drowning, drowning takes place.

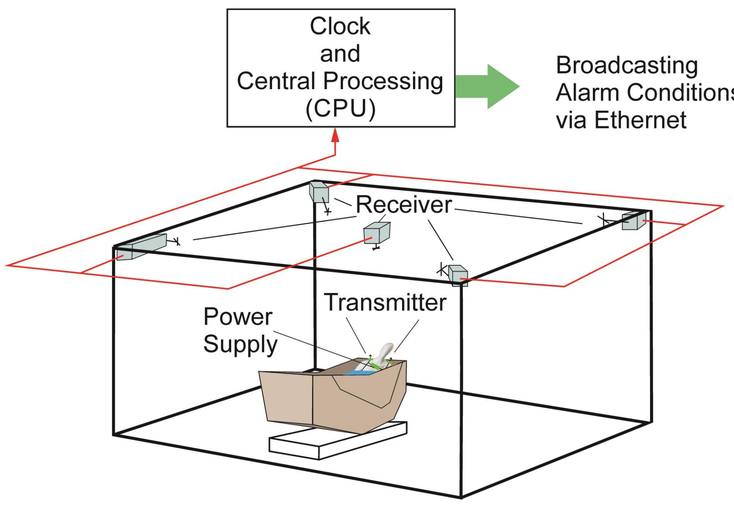

Fig. 1: IMPDS Setup

Table 1: Projected System Data

Number of Receivers	5
Transmitter on Body	2
Range	10 m
Carrier Frequency	2.4 GHz
Coding	PN
Positioning Accuracy	1 cm³
Ranging Accuracy	1 mm
Measurement Rate	10 Hz

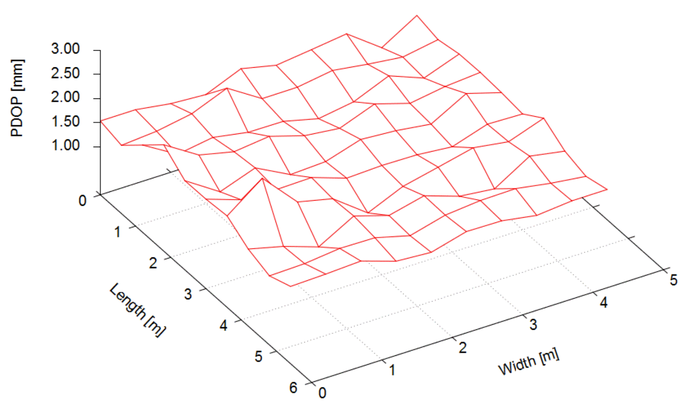

Fig. 2: PDOP at 1 m above ground with σ_{slant} = 1 mm

3. Transmitter

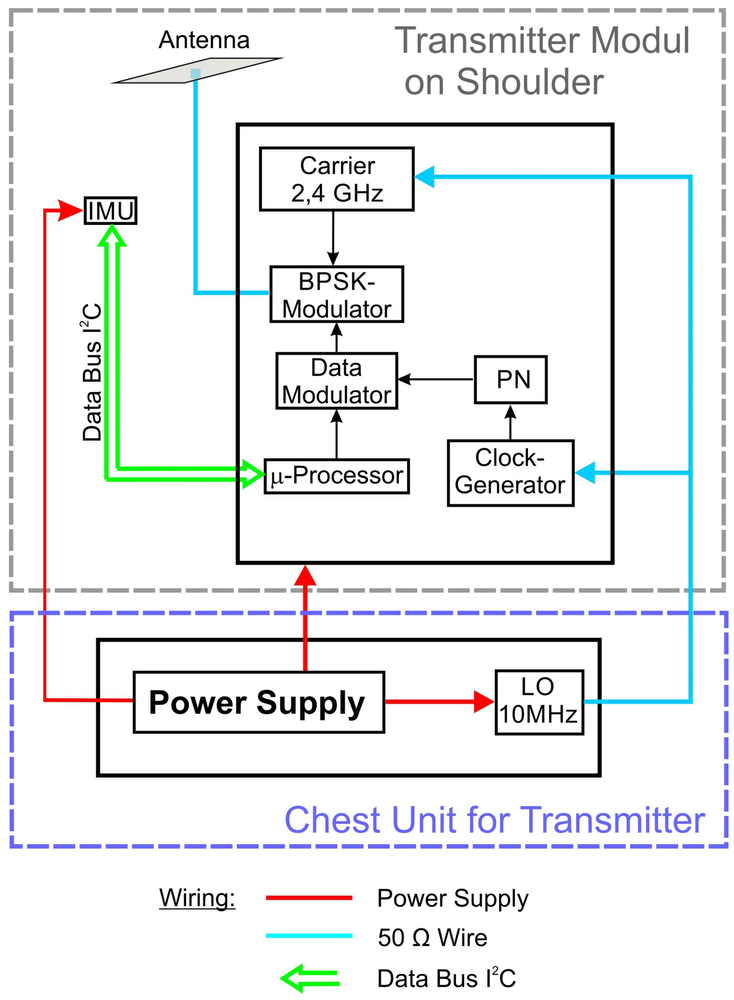

Fig. 3: Transmitter for Shoulder

Fig. 3 shows the block diagram of one transmitter. It generates the PN-ranging signal modulated with e.g. IMU data. The signal is transmitted by an antenna mounted on the shoulder covering the hemisphere.

4. Receiver

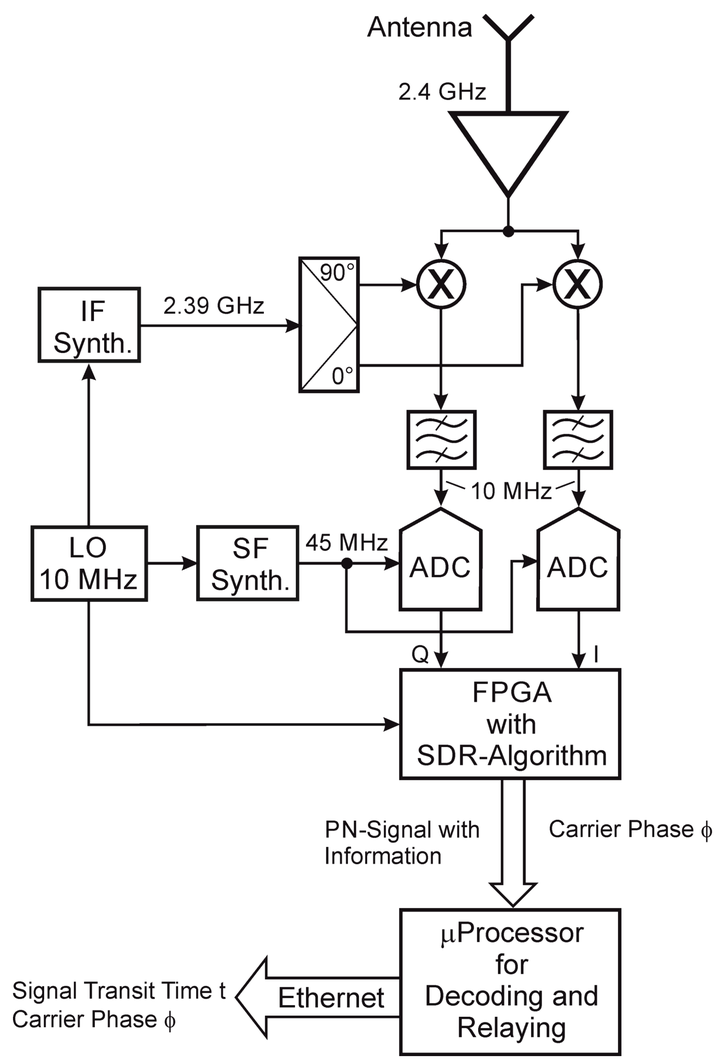

Fig. 4: Receiver Concept

The 2.4 GHz signal is mixed down to an intermediate frequency of 10 MHz and is sampled by 8 bit analog to digital converters (ADC). These 8 bit complex values (I and Q) are processed in an FPGA applying software defined radio algorithms (SDR). The output of the FPGA is the PN-Signal biphase modulated with sensor data (e.g. IMU) and timing data and the carrier phase Ø determined by DLL. The µP performs decoding and relaying the data to the central processing unit.

5. Hardware

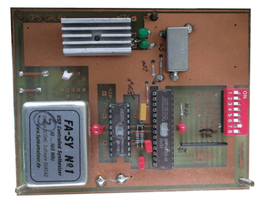

Fig. 5: Transmitter without Power Supply

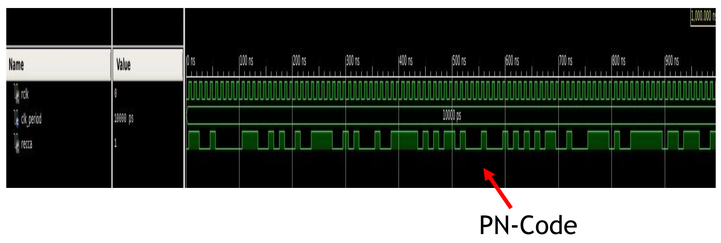

Fig. 6: Simulation result of generated PN code

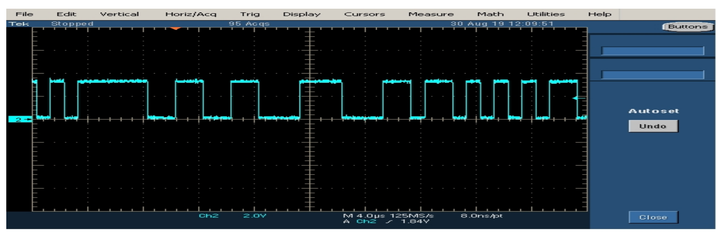

Fig. 7: Measured base band PN signal

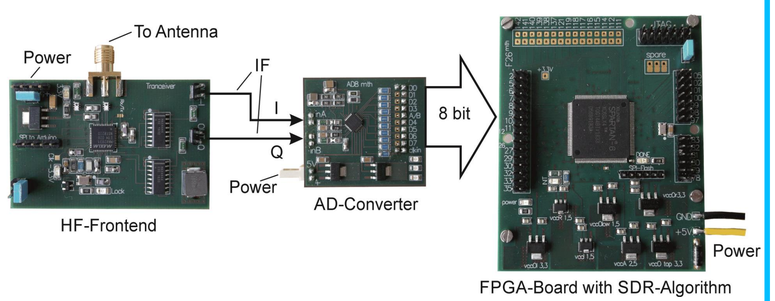

Fig. 8: Receiver Breadboards without µProcessor

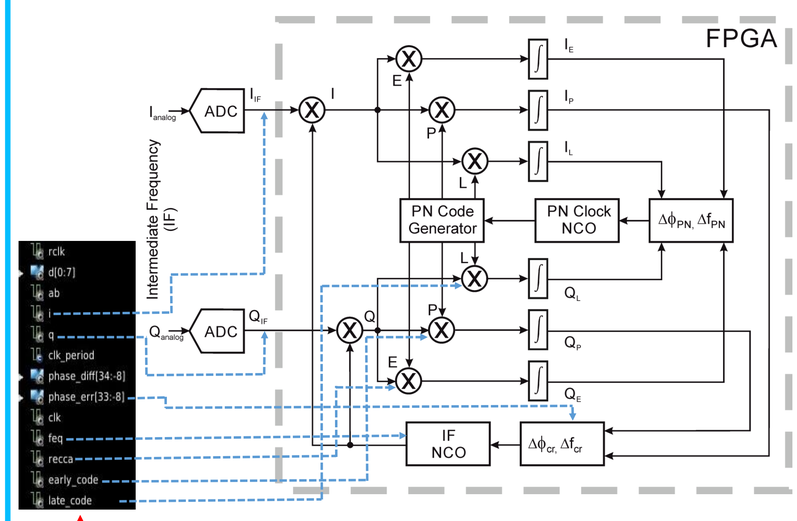

Fig. 9: Flow chart of receiver FPGA module

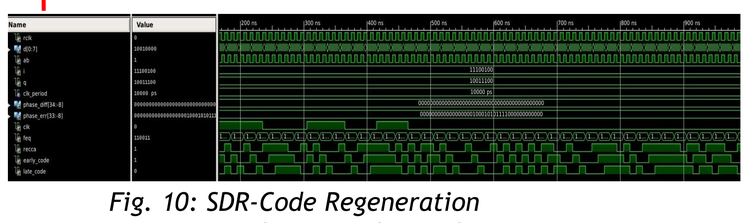

Fig. 10: SDR-Code Regeneration (Simulation with Vivado Design Suite)

6. Conclusion and Outlook

The concept of an Indoor Microwave Positioning and Data Transmission System is presented. Signal simulations and measurements on the demonstration board proofs the printed circuit design concept. Calculations concerning PDOPs confirm, that a slant range accuracy of 1 mm assures the projected accuracy of 1 cm³. Next, the total link will established followed by tests with a five link system.

7. Acknowledgements

The project is supported by Central Innovation Programme for small and medium-sized enterprises (SMEs) funded by the Federal Ministry for Economic Affairs and Energy .

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