Passive elements array antenna for wireless sensor networks

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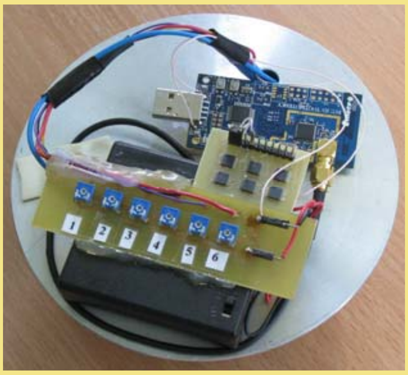
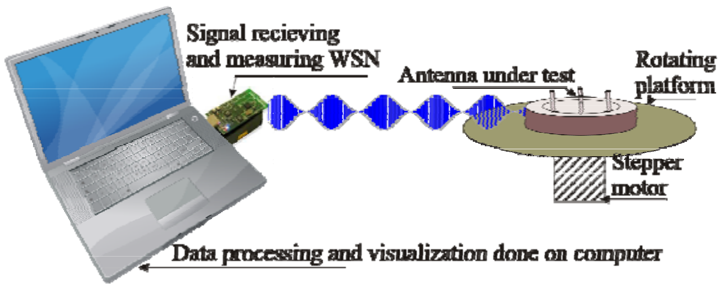
Overview

Low power consumption is crucial for the long term operation of wireless sensor nodes. Typically, radio is the biggest energy spending device in WSN. We show that radio power consumption can be reduced with no adverse impact to transmission quality or link distance, and that the distance can be extend without increasing the power consumption using a passive element antenna array (**PEAA**) for data communication. PEAA decreases the received signal noise significantly thus increasing the link quality. It is easy to change the transmission direction with PEAA, because it is done electronically.



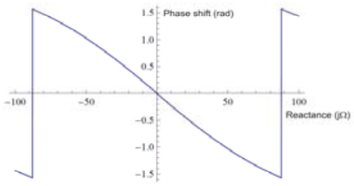
Antenna radiation transmitt setup



Shematic representation of built testbed

PEAA prototype description

PEAA consists of a central radiator and passive elements located at equal distances around it. The central radiator is half wave monopole fed by 50 ohm signal cable. Passive elements are fed by transmission lines and terminated by varactor's (variable capacitance diode). Transmission line length is calculated so that the signal received by passive element at the end of transmission line is shifted in phase by $\pi/2$ rad. Capacitance of varactor's is controlled by voltage and voltage is controlled indirectly by TELOSB mote via I2C bus and digitally controlled potentiometer chip. The transmission lines and the elements supporting operation of passive elements are placed on FR-4 fiberglass PCB.

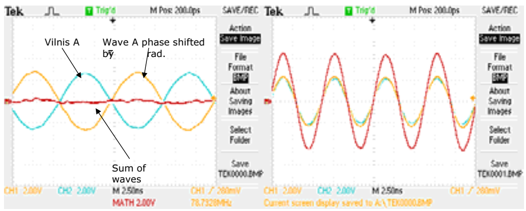


Phase shift due to variable load reactance

Built Passive element array antenna prototype

PEAA operation principles

Radio waves are being transmitted via monopole and then reflected by passive elements. In each passive element the signal is guided to the transmission line and then along the transmission line to a varactor connected to the ground plane. Then the signal is reflected and travels back the same way to the passive element being re-radiated to ether. Since the transmission line is designed to shift the signal phase by $\pi/2$ radians and due to the variable reactance of varactor the total phase shift from 0 to π is achievable. Because of superposition of waves and phase shift made by the passive element circuit the signal in each particular direction could be amplified or attenuated according to the capacitance of the varactor. Therefore, using different capacitances in the passive element circuits the directionality of the transmitted signal is achieved. The direction is controlled by a sensor node via I2C connected to a digital potentiometer. Finding of right capacitances complex task. However, for the purposes of antenna test, a simple technique was used.

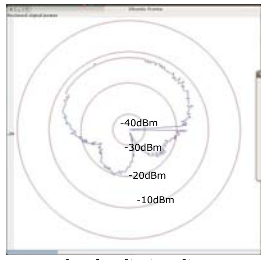


Sum of phase shifted and equal phase waves

Rotating antenna test tripod made from wood to achieve less refelction. Stepper motor is used to control direction. Resolution of stepper motor is 0.9 degrees. Stepeer motor control is made by computer software also controlling sending and recievieng wireless sensor nodes

Testing

We have made a testbed for PEAA using a stepper motor controlled rotation platform for the transmitting node with PEAA. The receiving node is connected to the computer for data collection and interpretation. We have made initial radiation pattern tests as well as the beam width measurements in horizontal and vertical planes.



Example of radiation diagramm of our built PEAA.

Summary and future work

PEAA is good alternative for energy savings and increased radio coverage in WSN's. Radio link distance could be extended up to four times and radio noise reduction could be attenuated up to 5dB. Front to back signal level of 20 dBi was measured. In future, we will work on finding optimal passive element configuration and PEAA MAC level integration with TinyOS as well as real life measurement of PEAA direction switching speed and energy savings.