Wireless sensor network for distributed measurement of electrical field

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Outline

- Introduction
- Wireless implementation
- Structure of system
- Wireless data transmission
- Experimental setup and results
- Conclusions

Introduction

- Power transmission lines are most important energy suppliers to consumer
- Serious power quality problem is unbalance, it appears when all three-phase voltages don't have the same amplitude value
- Electrical field intensity measurement is one of options for non-contact diagnostic of power lines
- Wireless communication is a solution to minimize interference with electrical field that is measured

Wireless implementation

▸ Wireless sensor network consists of 13 sensor nodes and a master device connected to PC

▸ Master device sends start data package which synchronizes all sensors and starts data sampling

▸ All sensors are measuring electrical field strength simultaneously

▸ Measured data are stored in microcontroller memory

▸ Time division approach is used to send data to master device

Structure of wireless sensor

- Electric field sensor
- Amplifier
- MSP430 microcontroller with built in 10bit ADC
- In addition to external amplifier internal MSP430 op-amp is used
- Transceiver Nordic Semi nRF24L01*(2,4GHz band, 2Mb/s, 100m range)*
- Energy source is two AA type batteries
- It measures electric field intensity and sends data to master device
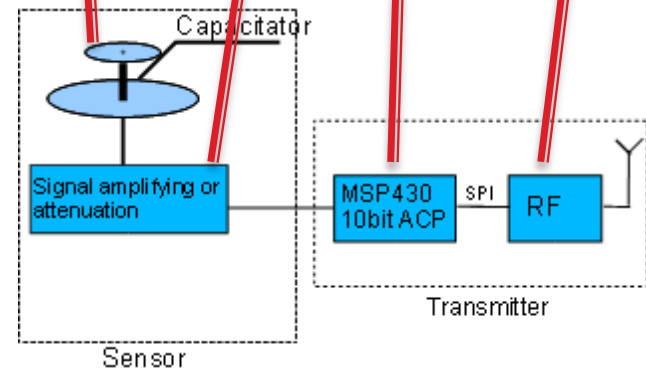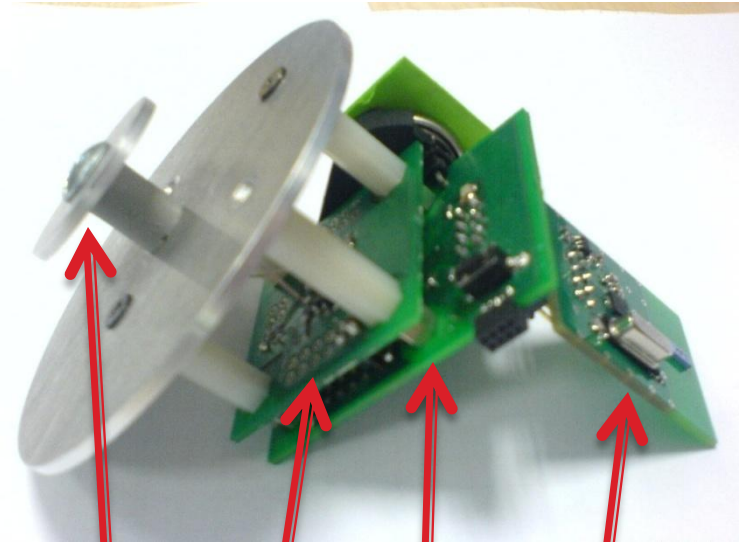
Operation of wireless sensor node

- MSP430 built in 10 bit ADC is used, sampling frequency is set to 1kHz
- 96 samples are stored in microcontroller memory
- 32byte data packages are formed to transmit to master
- Each sensor is sending 3 data packages to master device
- For data transmission all sensors are using the same frequency channel and address
- Each sensor has unique assigned identification number (ID) which is located at first byte of data package
- Master device is checking received ID and identifies the sender of data

Master device

- Transceiver Nordic Semi nRF24L01
- MSP430F5437 microcontroller
- USB to UART converter
- PC with Labview8.5 software
- <u>Sends start command and settings(gain) to sensors</u>
- <u>Data gathering from sensors</u>
- <u>Sends data to PC</u>
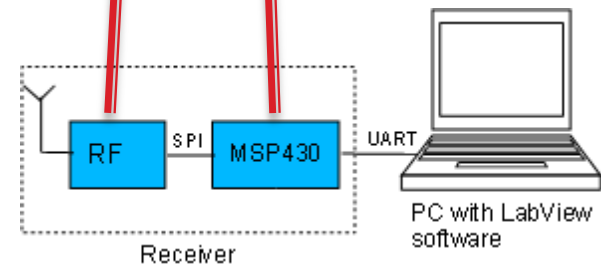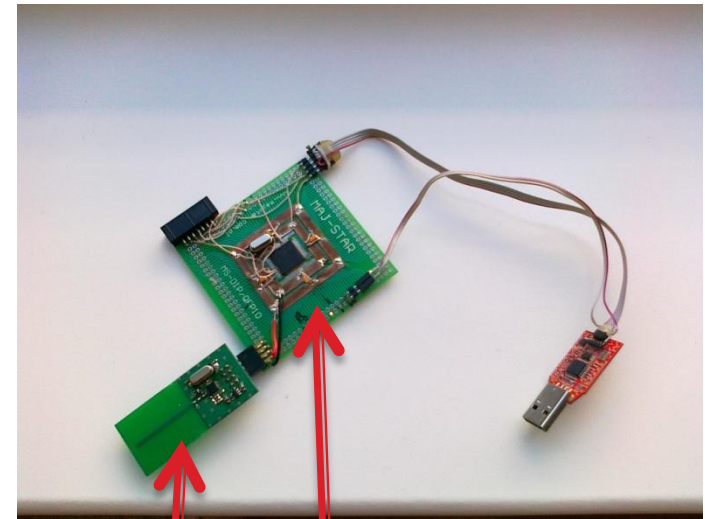
Wireless data transmission

- Initially master device is configured to transmission mode (TX), all sensors – to receive mode (RX)
- If sensor has received command from master device, it goes to TX mode and its ADC starts sampling
- When sampling operation is completed, each sensor has it's own 3ms time window to transmit data to master device
- When all sensors complete data transmission, they are configured to RX
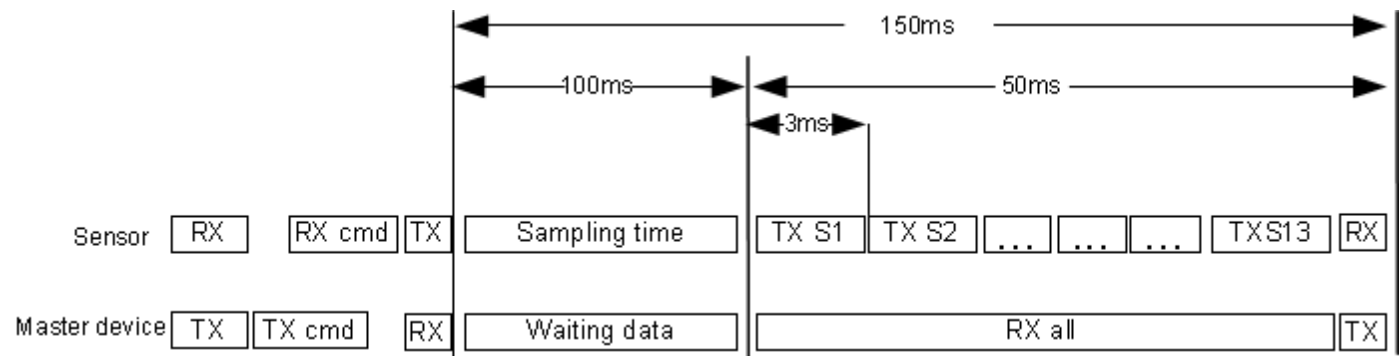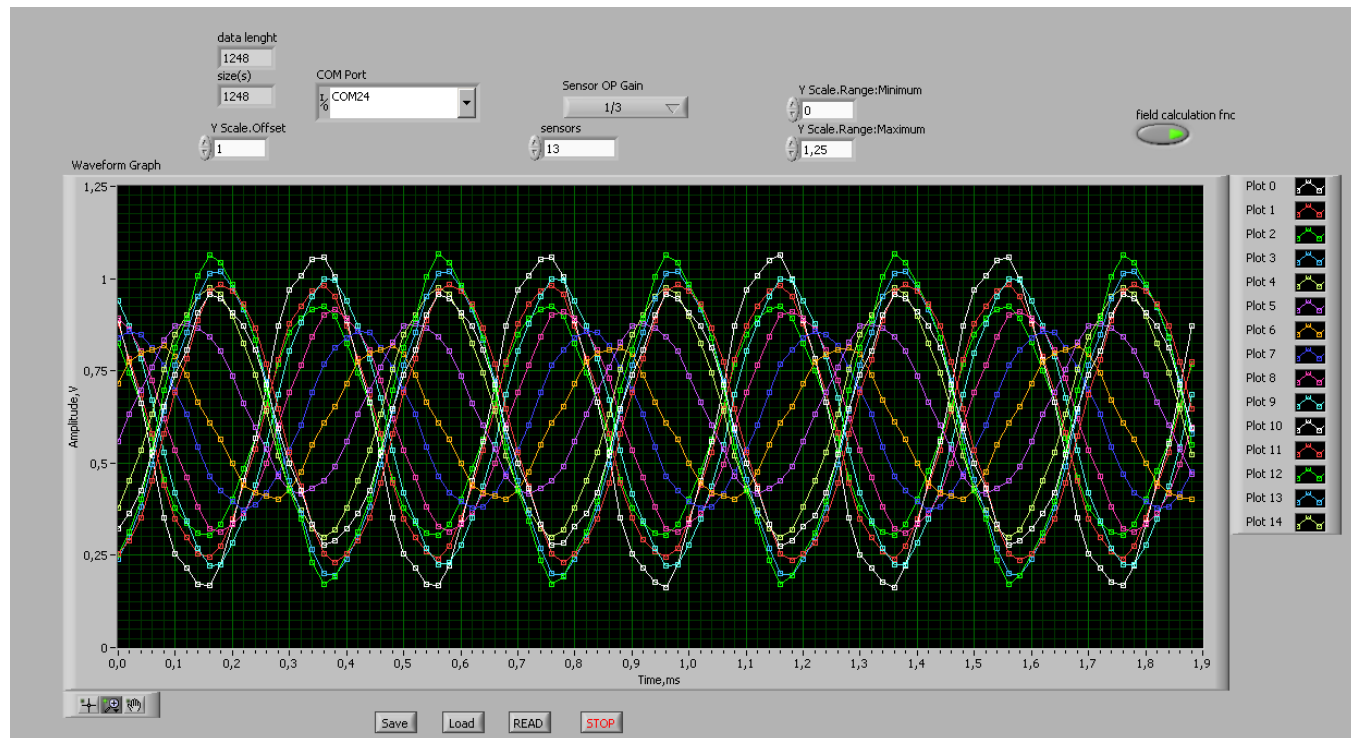
Experimental setup and results I

110kV transmission line
H ≈ 11m D ≈ 8m h=1.9m

- 110kV transmission line
- 13 sensors are used in experimental measurements, distance between them is 3m
- Sensors are placed on plastic tubes 1,9m above the ground surface
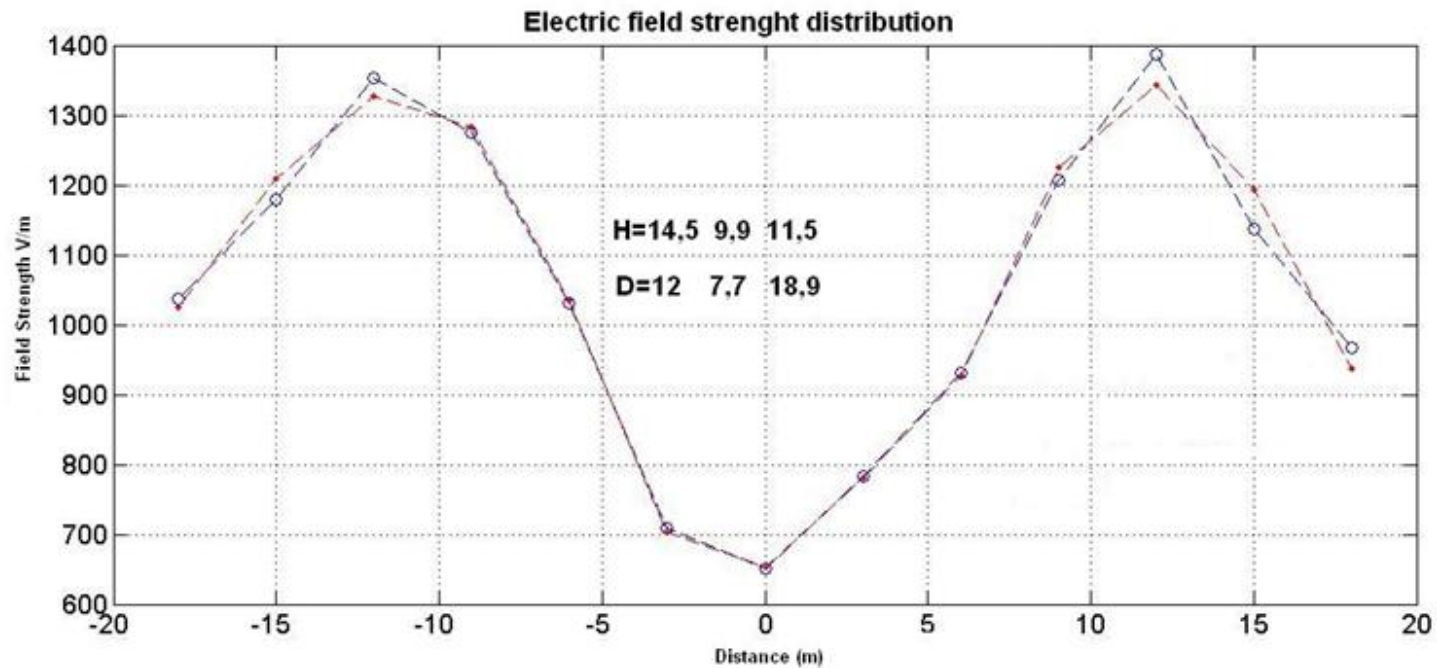- PC with master board is located 45m from farthest sensor
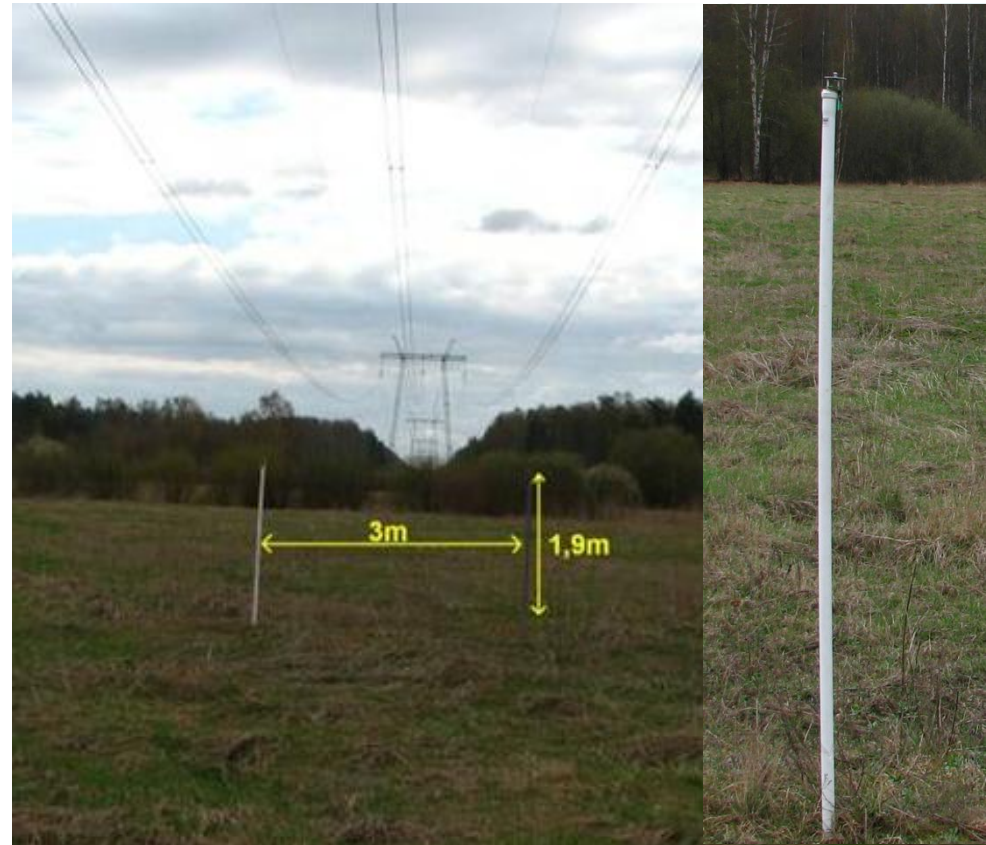
Experimental setup and results II

▸ LabView 8.5 graphical user interface
▸ Data from 13 sensors

Experimental setup and results III

▸ Measurement results of 110kV line
▸ Data from 13 sensors

blue circles - measurements
red dots - pattern

Conclusions

- Developed sensor network is applicable for non-contact diagnostics
- Experimental test measurements demonstrates possibility to estimate power line parameters (height, distance)
- Wireless data transmission range ~45m
- Better precision can be obtained increasing number of sensors

Thank You!