

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

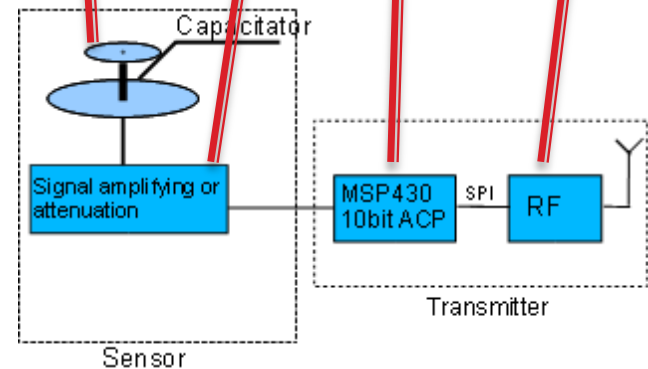
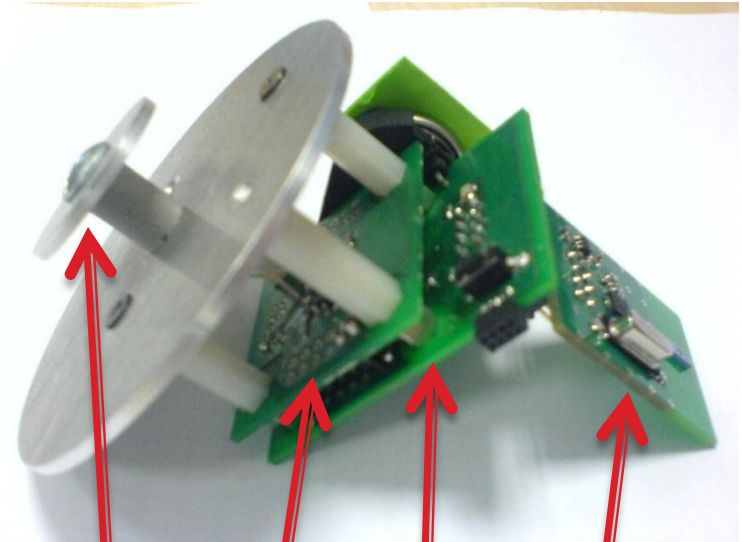
- ▶ Power transmission lines are most important energy suppliers to consumer
- ▶ Serious power quality problem is unbalance, it appears when all three-phase voltages don't have the same amplitude value
- ▶ Electrical field intensity measurement is one of options for non-contact diagnostic of power lines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

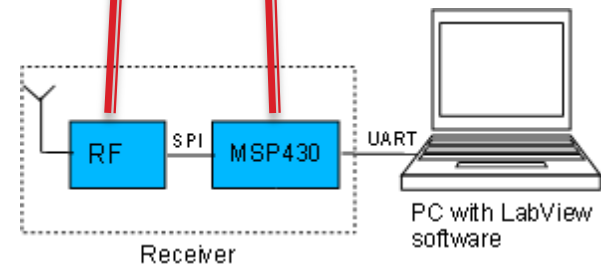
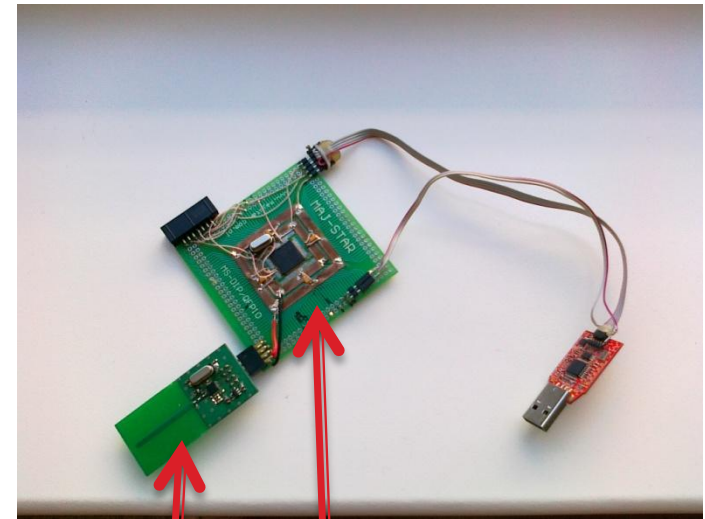


Operation of wireless sensor node

- ▶ 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

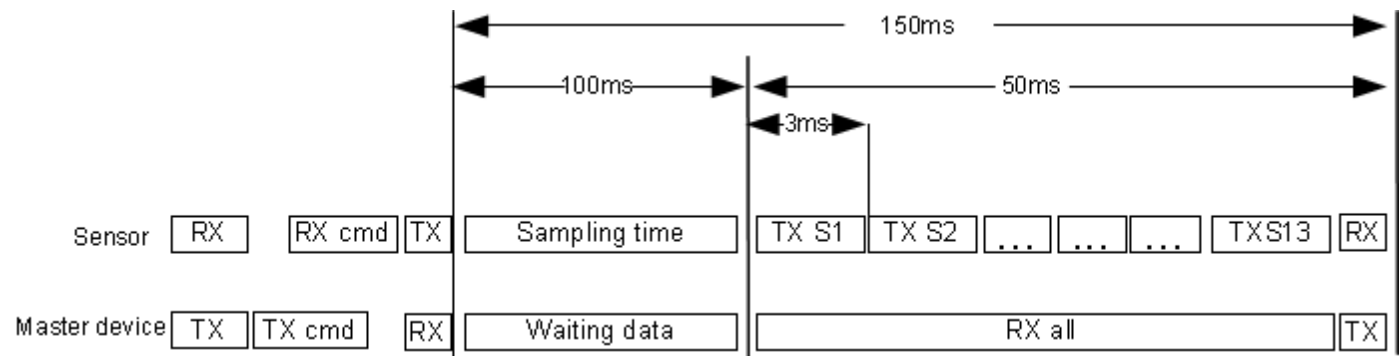
Master device

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



Wireless data transmission

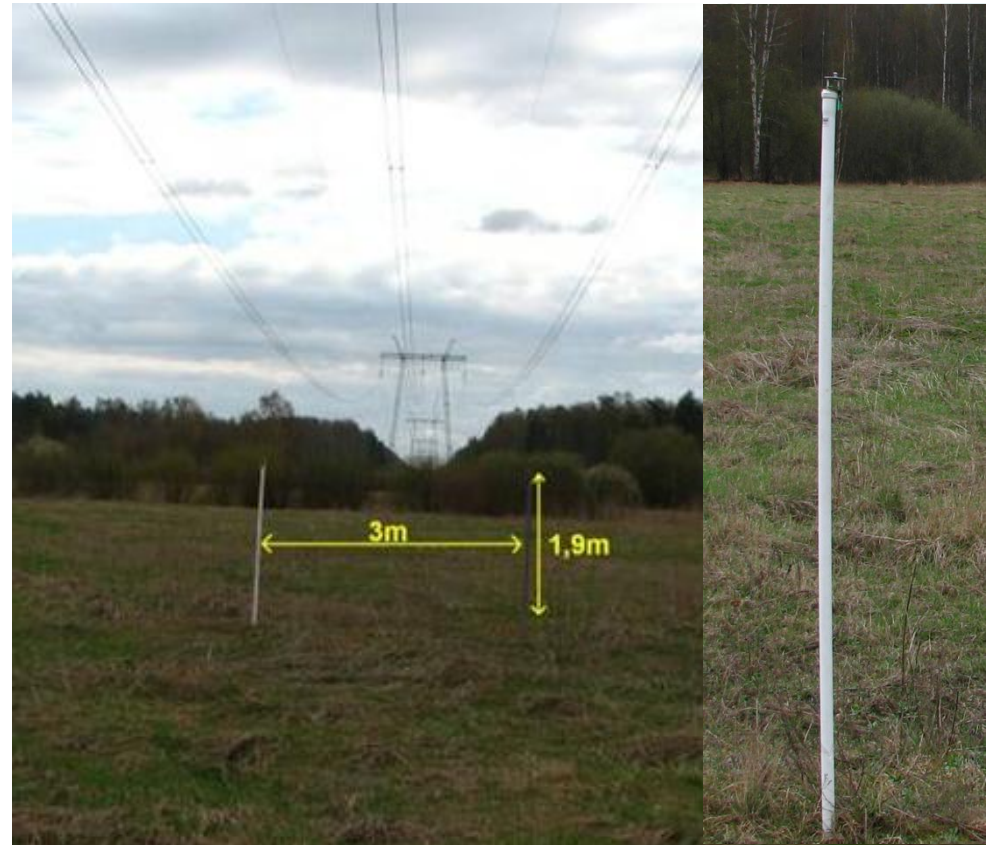
- ▶ Initially master device is configured to transmission mode (TX), all sensors – to receive mode (RX)
- ▶ If sensor has received command from master device, it goes to TX mode and its ADC starts sampling
- ▶ When sampling operation is completed, each sensor has it's own 3ms time window to transmit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



Experimental setup and results I

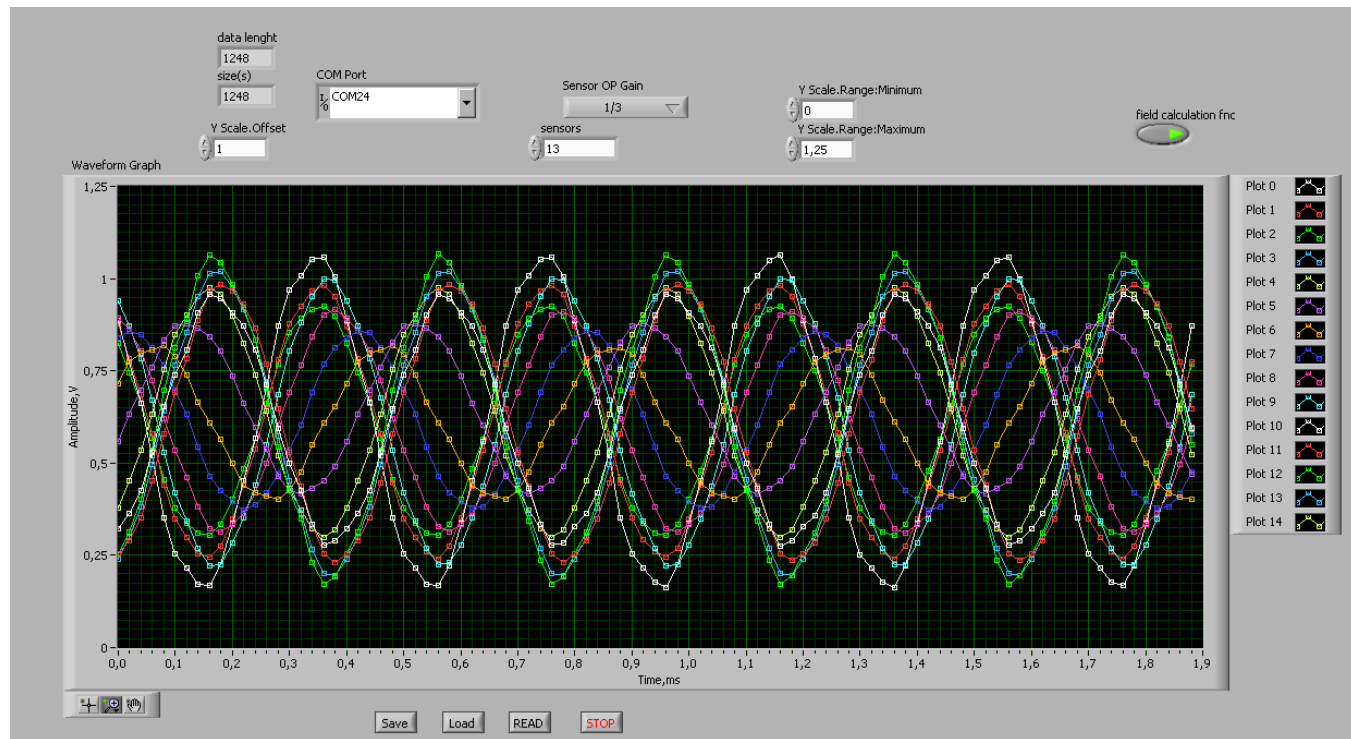
110kV transmission line
 $H \approx 11\text{m}$ $D \approx 8\text{m}$ $h=1.9\text{m}$

- ▶ 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



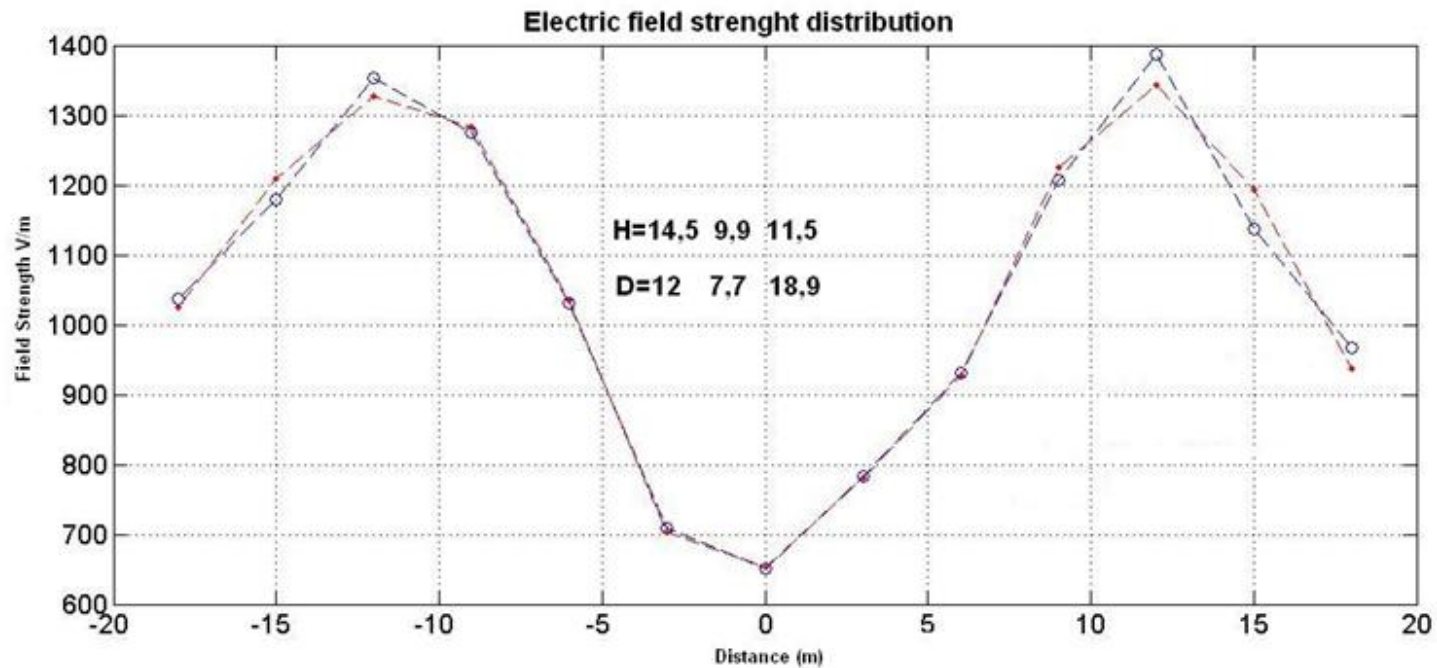
Experimental setup and results II

- ▶ 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!

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