Hardware realisation of data logger system for inland excess water

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***Abstract*—Inland excess water cause considerable economic, social and environmental problems. In northern parts of Vojovodina, where inland excess waters occurs regularly, continuous measurement of groundwater level on several measurement points over long periods of time is needed for realization of hydrodynamic models. With data collecting system management innovative geographic information methods and observation techniques these models can be developed to predict inland excess water. In this paper hardware realization of data logger is described in details. Data logger system was developed and used on locations of interest in northern Vojvodina.**

Keywords- logger; measurement; inland excess water;

I. Introduction

Inland excess waters cause numerous problems in Vojvodina. As a predominantly agricultural region, the problems are related to obstruction of agricultural activities on the fields as well as causing damages to the crops (rotting, occurrence of fungal infections due to increased moisture and other). Beside these problems inland excess waters cause damage to houses, buildings, flooding from sewer pits and canals, soil contamination, impeding of local traffic and transport [1].

The occurrence of inland excess water in Vojvodina is the consequence of numerous natural and anthropogenic factors. The following are the most important: lower position of the endangered surfaces relative to the main river of the catchment; morphology and terrain inclination (predominantly flat area), the vicinity of rivers and canals; climatic conditions (successive rainy years and uneven yearly distribution of the precipitation); shallow first aquifer and impervious layer; reduced flow on watercourses.

This system is developed for continuous measurement of groundwater level on several measurement points over long periods of time (several years), which is needed as input data for hydrodynamic models. With this model some excess water types could be forecasted, and actions could be taken [2].

In this paper acoustic measurement is used for determination of water level in wells. Acoustic measurement was chosen over industry solutions because of its low cost and small dimensions of the sensors. This type of measurement is very similar to ultrasonic, but lower frequencies of measurement signal were chosen because lowering the frequency decreases reflection from the walls of the well .

II. Data logger system

Data logger system is shown in **Fig**. 1. To measure level of inland water, a series of wells are drilled on locations where excess water can appear. Measurement system is set at the top of the well, and by measuring time measure time of travel of sound to and from level of water inside wells information of level of groundwater is obtained [3].

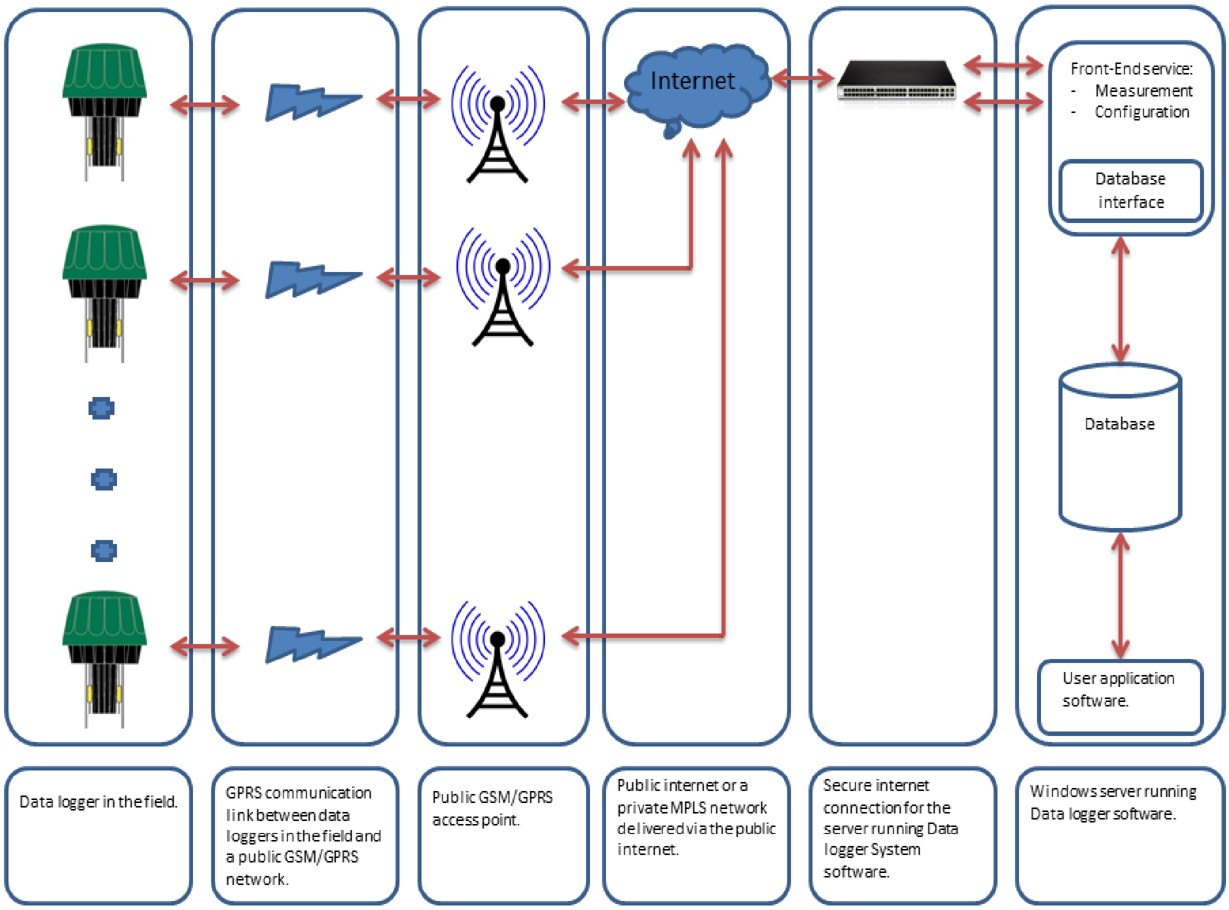

Figure 1. Data logger system

III. Hardware Realization

Data logger consists of several electronic subsystems :

- Transmitter and receiver electronic for acoustic measurement
- MCU electronic for control of data logger
- Power electronic for stable power supply

A. Transmitter electronics

Schematic of receiver electronics is shown in **Fig**. 2. KPEG-272 buzzer is used as transmitter. Since this buzzes is working with voltages up to 18V, and battery ih this system is around 3.6V, step up "boost" converter is used to supply buzzer with higher voltage of 18V, achieving higher power of audio signal. Step up convertor is realized with U1 (TPS61040) and auxiliary passive components. U7 (UCC27524) is mosfet driver, used in this circuit as switch to control power to buzzer.

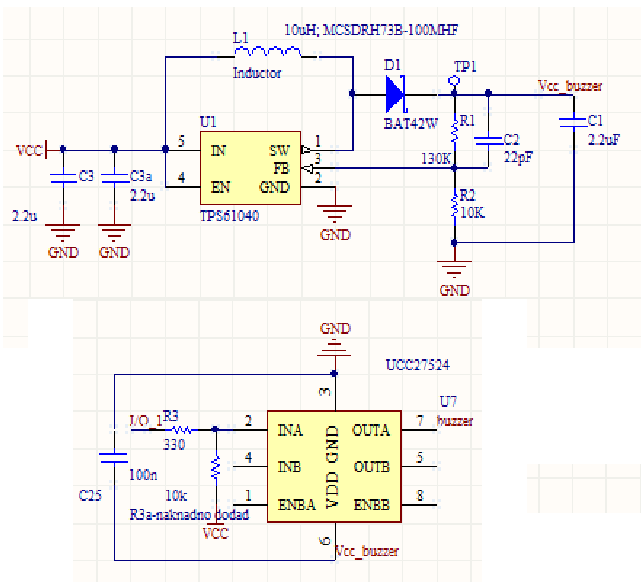

Figure 2. Schematic of transmitter electronics

B. Receiver electronics

Schematic of receiver electronics is displayed in **Fig**.3. Microphone ABM-713 is used as receiver. Since electret microphone is used, DC biasing is needed, realized with resistors R5, R6. operational amplifier (OP) MCP60022 is used as buffer and preamplifier (U2). Passive band pass filter consisted of R13, C19, C12, C1, R15 is used for first level of filtering, at frequencies of 4KHz. Additional 6-pole band pass filters is used for filtering, this level of filtering is needed since receiver microphone is wide range with bandwidth of 100Hz-20KHz. For software control of the amplification U2B and U5 is used, U2B is used as inverting amplifier whereas U5 (AD5234) is digital potentiometer connected in feedback loop of U2B. Resistance of U5 can be changed in range from 0 to 100Kohm which changes amplification of this amplifier, SPI pins of U5 connected to main microcontroller which controls its value. Voltage reference 3312 is used to generate voltage of 1,25V which is used as virtual ground in all amplifiers in this circuits, so there is no need for negative voltage supply.

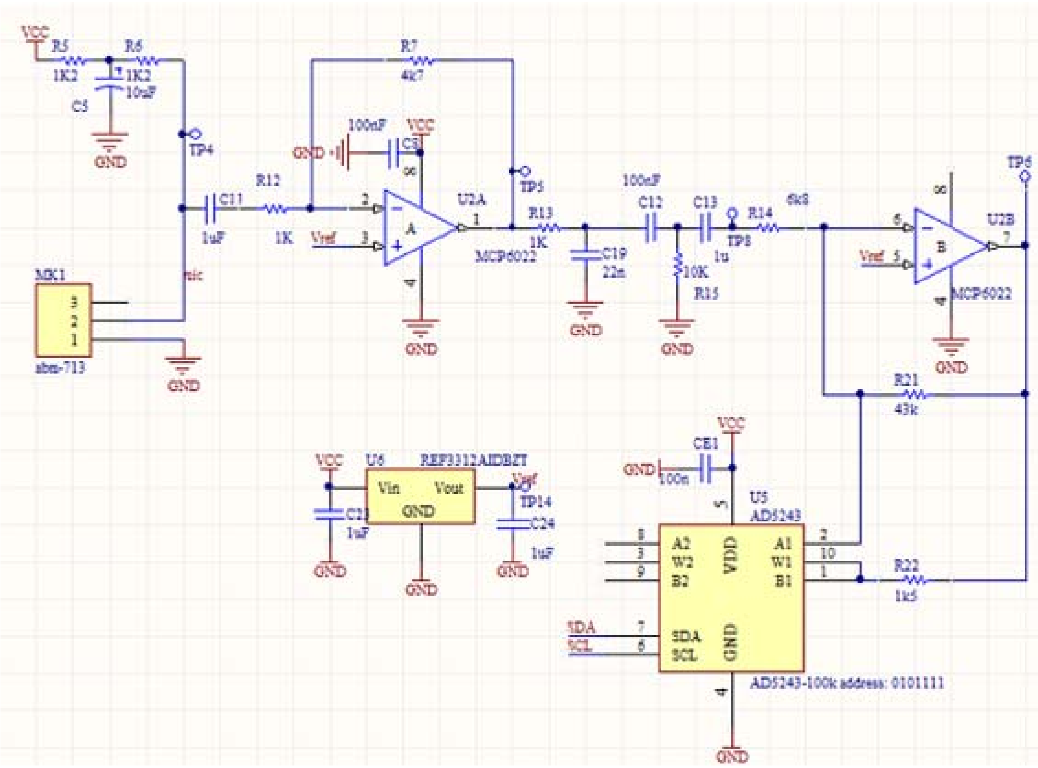

Figure 3. Schematic of receiver electronics

A measuring frequency of 4KHz is selected for measurement signal, this frequency is selected as optimum for this system after testing of well pipes with wide range of measurements signals. When signal with higher frequency was used, significant reflections from joints of pipes appeared making it impossible to distinguish them from useful signals. For lower frequencies received signals had tendency of uniform amplitude, making it hard to precisely measure the travelling time of measurement signal, which significantly decreased measurement resolution of the system.

IV. MCU BLOCK

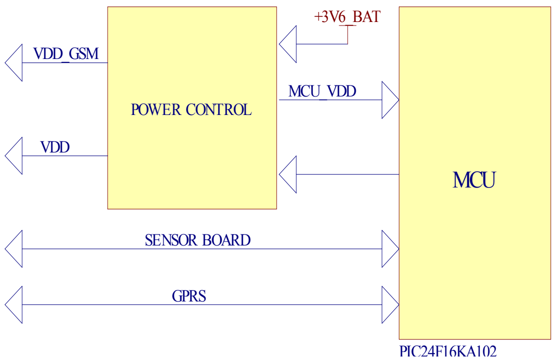

Figure 4. MCU block

MCU block is shown in **Fig**.4. It has several functions:

- To communicate with GPRS module by sending and receiving data over serial port.
- To control the transmitter on sensor board, and to perform A/D conversion of receiver signal
- To control power for the rest of the circuitry

MCU used in this system is PIC24F16KA102, extreme low power consumption microcontroller. It has the ability to go into "deep sleep" mode, where current consumption is under 1uA. This MCU has internal 10-bit ADC converter, more than adequate for this system.

In order to minimize consumption, and so prolong battery life, between measurements the power for all the rest of the electronics, including the modem and the sensor block is completely shut down. By using the power control circuit shown in **Fig**. 5, power supply to other blocks is allowed only when necessary.

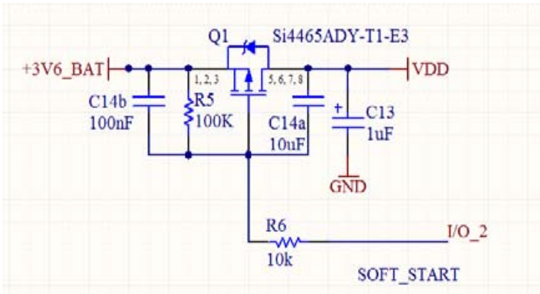

Figure 5. Schematic of power control circuit

Si4465 mosfet is used as a power switch because of its low on resistance and low leakage current [4]. C14a and R6 provide a slower turn on to limit the initial inrush current

Battery used in the system is 3,6V, so it can directly supply the MCU. Also the MCU can be supplied from a usb/serial converter which is occasionally used to read data from the controller in the debugging process. Having this external supply attached, it is possible to take the battery out and change it without losing real-time clock data. Also, during the modem operation, the boosted modem power supply VDD_GSM is brought to the MCU to additionally backup the battery and prevent controller resets due to voltage drops caused by current surges of the GPRS module. The multiple power sources are automatically managed by a sort of a wired OR diode circuit which is shown in **Fig**. 6.

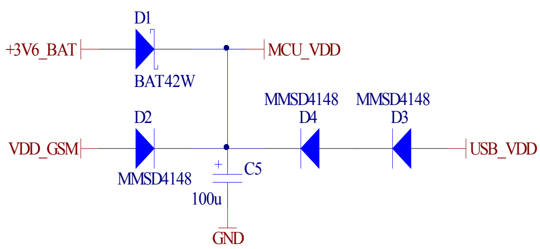

Figure 6. Schematic of wired OR power suppy managing circuit

V. Power Supply

Schematic of power supply is shown in **Fig**. 7. Power supply used in this circuit is step-up convertor which enables stable voltage of 4V for whole system. Since battery used for this system are Lithium Thionyl Chloride type with voltage of 3,6 V, value which is adequate for all electronic elements in system, there would be no need for additional electronics in power supply if voltage level for type of batteries was stable enough. Output voltage of this batteries significantly depends on temperature, and when external temperatures falls below zero, voltage that this battery gives is around 3V, which is not sufficient for GSM module, which input voltage is between 3.4V and 4.2V. For this reason step-up convertor U1 (ADP1612) and auxiliary passive components are used, with maximum current of 3A, needed for GSM module when transmitting. ADP1612 is selected because of its ability of working properly with minimum voltage difference in input and output voltage. High-quality capacitors C1,C3 and C9 were used to reduce voltage peaks from switching power supply, to minimize its influence on measurement signal.

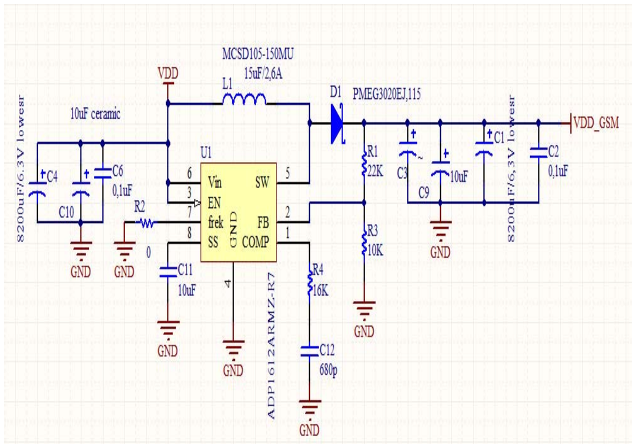

Figure 7. Schematic of power supply

VI. Measurement Results

Data loggers were realized, tested in laboratory conditions and then placed in 25 locations in north Vojvodina. Currently they are in use for several months, measurement are made once a day and send via GSM network once a week, to extend the battery life. In **Fig**. 8. measurement results are shown with graph display on every location. Secure internet connection for the server is running data logger system software realized as web based application. This application serves as database for all measurement, and also as control interface for configuration of data logger parameters.

Monitoring system was tested in several wells, measurement error of the system was up to 0.7%, which is adequate for this application. Measurement resolution of 1 cm was obtained, with measurement range of 15 meters. Similar measurement error were obtained in [5], and industrial solutions [6] have slightly better results, but these solutions are realized with ultrasonic measurement signals which cannot be used in relative small plastic pipe because signals would be reflected from walls of the pipe giving false measurements.

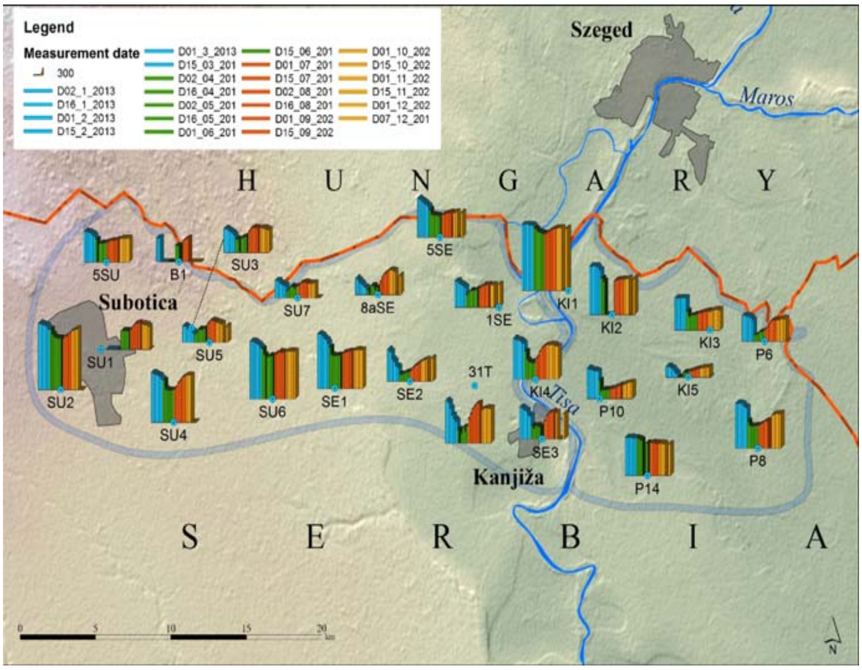

Figure 8. Measurement results

VII. Conclusion

In this paper hardware realization of data logger system is presented. Schematic of all elements of the system are shown and described in details. This system was tested in several wells, is realized as low-cost and robust system for measurement of level of groundwater. Using GSM network for sending data and battery for power supply, system is realized as stand alone, with autonomy of around one year, when batteries needed to be replaced.

Measurement result from this system are used for prediction of level of groundwater in region of northern Vojvodina [6].

This monitoring system can be easily adapted to be used in wide range of environmental and other measurements. With addition of solar power supply, it can be completely autonomous for several years on every location with GSM coverage.

Acknowledgments

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