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DATA TRANSFER OF ENVIRONMENTAL MEASUREMENTS USING COMPACT FTP MODEM FOR FURTHER DATA PROCESSING PURPOSES

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ABSTRACT

The aim of this study is to verify the reliability and functionality of a special compact modem developed for the purpose of operational data transfer from environmental metering devices to an FTP server over the mobile network for further processing. The modem, based on predefined parameters on the Modbus line, addresses individual devices and reads the measured data. Then sends it over the mobile network to the FTP server.

KEY WORDS: *Data transfer, FTP server, Modbus, Environmental measurement*

Introduction

There are wide variety of methods of data transfer from measuring devices to data loggers or computers used in technical practice. At present, there is an increasing demand for direct data transfer from the metering device to a server for further processing. Modern devices use the Modbus protocol for the data transmission. Using this protocol, it is possible to transfer data from several devices on one line to one target server.

Environmental sensors

Each environmental sensor is configured to detect and/or measure one or more of the following types of environmental information: climate, humidity, temperature, pressure, barometric pressure, soot density, airborne particle density, airborne particle size, airborne particle shape, airborne particle identity, volatile organic chemicals (VOCs), hydrocarbons, polycyclic aromatic hydrocarbons (PAHs), carcinogens, toxins, electromagnetic energy, optical radiation, X-rays, gamma rays, microwave radiation, terahertz radiation, ultraviolet radiation, infrared radiation, radio waves, atomic energy alpha particles, atomic energy beta-particles, gravity, light intensity, light frequency, light flicker, light phase, ozone, carbon monoxide, carbon dioxide, nitrous oxide, sulfides, airborne pollution, foreign material in the air, viruses, bacteria, signatures from chemical weapons, wind, air turbulence, sound and/or acoustical energy, ultrasonic energy, noise pollution, human voices, animal sounds, diseases expelled from others, exhaled breath and/or breath constituents of others, toxins from others, pheromones from others, industrial and/or transportation sounds, allergens, animal hair, pollen, exhaust from engines, vapors and/or fumes, fuel, signatures for mineral deposits and/or oil deposits, snow, rain, thermal energy, hot surfaces, hot gases, solar energy, hail, ice, vibrations, traffic, the number of people in a vicinity of the person, coughing and/or sneezing sounds from people in the

vicinity of the person, loudness and/or pitch from those speaking in the vicinity of the person, and/or other environmental information.[1]

Data transfer

It is fairly obvious that data, in the process of being archived or transferred from one location to another, will pass through various phases where different operations such as compression, network transfer, storage, etc. will take place on it.[2]GPRS is a mobile data service that is developed on the basis of GSM, transmitting data in encapsulation way. It has lots of advantages: super speed transmission, always on-line and charging according to rate of flow.[3]GSM/GPRS MODEM is a class of wireless MODEM devices that are designed for communication of a computer with the GSM and GPRS network. It requires a SIM (Subscriber Identity Module) card just like mobile phones to activate communication with the network. Also they have IMEI (International Mobile Equipment Identity) number similar to mobile phones for their identification.[4]

The primary purpose of a database is to make data rapidly and conveniently available to users. The data may be available to users interactively in a computer database, through a number of customised routines or by means of standard tables and graphs.[5] Nowadays, there is a very common to send the data through a mobile net into a server, directly. Usualy, the data are being sent as an excel file, which provides then easy way of visualisation, datalogging or other way of processing to be needed.

Modbus

The Modbus protocol and its variants are widely used in industrial control applications.[6]Modbus Remote Terminal Unit (RTU) fieldbus uses RS485 as a transport media[7]to request data from Substations using pre-defined control function commands and Substations to respond by transmitting the requested data.[8] The protocol defined the number of addresses that could be used to identify the network devices.[9] RTU (Remote Terminal Unit) collects the site data and sends it to a station via a co mmunications system.[10]The RTU's are designed to monitor and control assets in environmentally exposed installations and to receive supervision regarding that mission from a remotely located data center. As a result, flexible communication to data center computers is a key capability.[11] The user interface can be adapted to display one or more measured parameters of each monitored circuit

[1] LEBOEUF, Steven Francis; TUCKER, Jesse Berkley; AUMER, Michael Edward. *Physiological and environmental monitoring systems and methods*. U.S. Patent No 8,157,730, 2012.
[2]IGNATIUS, Paul, et al. *High speed data transfer mechanism*. U.S. Patent No 7,209,972, 2007.
[3]ZHANG, Zexin, et al. The design and implementation of remote real time monitor system for embedded devices based on gprs. In: *Computer Science and Electronics Engineering (ICCSEE), 2012 International Conference on*. IEEE, 2012. p. 432-436.
[4]AGNIHOTRI, N. 2010. ENGINEERSGARAGE. GSM/GPRS Module : All You Need To Know. - [on-line] available on URL:https://www.engineersgarage.com/articles/gsm-gprs-modules.
[5]CHAPMAN, Deborah V., et al. Water quality assessments: a guide to the use of biota, sediments and water in environmental monitoring. 1996.ISBN 0 419 21590 5 (HB) 0 419 21600 6 (PB)
[6]HUITSING, Peter, et al. Attack taxonomies for the Modbus protocols. *International Journal of Critical Infrastructure Protection*, 2008, 1: 37-44.
[7]KOUMPIS, Konstantinos, et al. Wireless industrial control and monitoring beyond cable replacement. In: *2nd Profibus International Conference*. 2005.
[8]MAJDALAWIEH, Munir; PARISI-PRESICCE, Francesco; WIJESEKERA, Duminda. DNPSec: Distributed network protocol version 3 (DNP3) security framework. In: *Advances in Computer, Information, and Systems Sciences, and Engineering*. Springer, Dordrecht, 2007. p. 227-234.
[9]ZAPOLIN, Richard E. *Remote terminal industrial control communication system*. U.S. Patent No 5,122,948, 1992.
[10]IDACHABA, Francis Enejo; OGUNRINDE, Ayobami. Review of Remote Terminal Unit (RTU) and Gateways for Digital Oilfield delpoyments. *IJACSA) International Journal of Advanced Computer Science and Applications,*, 2012, 3.8: 157-160.
[11]OSBURN III, Douglas C. Remote terminal unit. U.S. Patent No 6,628,992, 2003.

branch.[12]Although Modbus is a widely used protocol in industry, it is not recognized as a form ally adopted standard in the way RS485 is. Modbus is a serial communications pr otocol that was originally created in 1979 by Modicon and has since become a de facto standard through its use in many commercial electronic devices.[13]

Medul 1

There was a special type of modem developped for applications in environmental field of monitoring. This module is also capable of extracting information about network flow traffic.[14] The only task of this modem is to process signals from sensors and transmit the data in a suitable format.[15] Read out the data from a sensor, device or a controller with Modbus protocol communication capabilities and offers an array of information that can be acquired via a Modbus interface[16],and send it to FTP server. Of course, there are several types of modems with such function, but the modems include much more functions and it increases their prise. The mentioned modem is shown on the Figure 1.

Figure 1 Data transfer modem Medul 1.

A system of measurement and monitoring devices in communication with other devices as well, such as one or more personal computers or computer terminals, for example, for display, for data input or processing or other desired functions[17], integrates a wide variety of environmental sensors of different types[18]. An example of a data transfer communication model is shown on the Figure 2.

[12]BILAC, Mario; ZHANG, Bin; TERRICCIANO, Paul. *Devices, systems, and methods for monitoring energy systems*. U.S. Patent No 9,501,803, 2016.
[13]PAPASIDERIS, Kosta, et al. Environment temperature control using modbus and RS485 communication standards. *Engineering Technology and Industrial Distribution Department Texas A&M University Faculty Advisor: Dr. Joseph Morgan, DE, PE January*, 2009, 10.
[14]CRUZ, Tiago, et al. Improving network security monitoring for industrial control systems. In: *IM*. 2015. p. 878-881.
[15]JANG, Won-Suk; HEALY, William M.; SKIBNIEWSKI, Mirosław J. Wireless sensor networks as part of a web-based building environmental monitoring system. *Automation in Construction*, 2008, 17.6: 729-736.
[16]MCCOY, Robert, et al. *System, method, and apparatus for command and control of remote instrumentation*. U.S. Patent No 7,672,262, 2010.
[17]COLTON, Laurence J. *System and method for communication between remote locations*. U.S. Patent No 5,986,574, 1999.
[18]LUTZ, Donald G.; DUGGAN, Daniel. *Environmental monitoring system*. U.S. Patent No 6,888,453, 2005.

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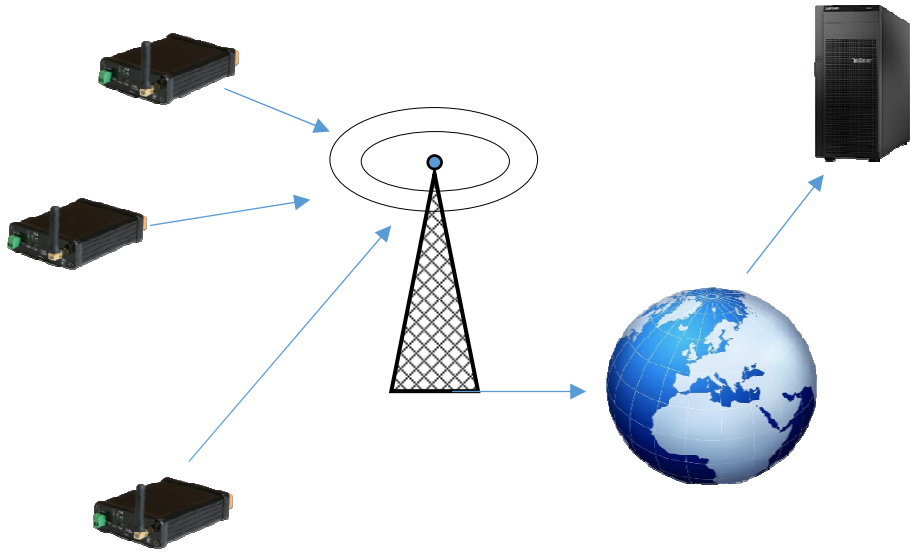

Figure 2 Data transfer communication model.

The modem Medul 1 is designed to communicate with peripheral devices through Modbus protocol. Primarily, the modem has been made for data transfer from ultrasonic flow monitors to FTP server, where the data are logged and the trends according this data visualised. Such model is shown on the figure 3. The flow meter control units must be equipped with the Modbus output communication module. This is an optional issue and not each flowmeter does it have. In case a control unit does not have such Modbus module, there is possibility to use an interface module between the modem and the control unit. Interface modules have usualy a variety of inputs and outputs. Such way can be a control unit connected with the interface module i. e. by current loop 4-20 mA. This solution could be inconvenient if the whole system should have as low energy consumption as possible, i.e. when there is no possible to supply the system from power net and it is powered by a battery or accumulator.

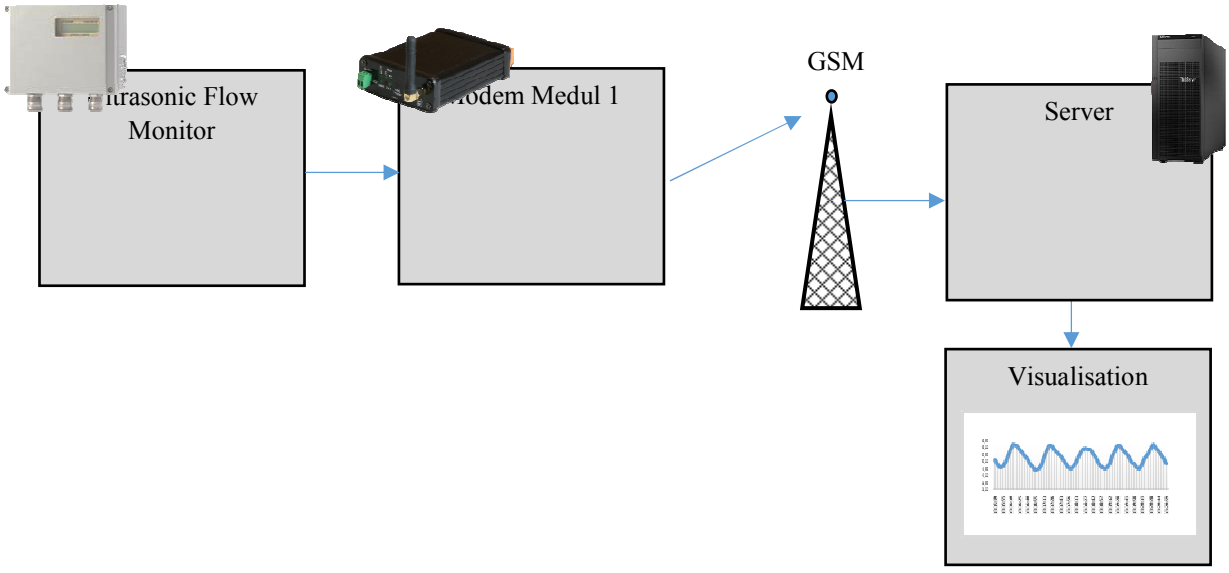

Figure 3 Flow monitoring data transfer model.

Power supply and energy

As mentioned, there are cases when there is no possibility to supply the system from power net. When there is no power outlet "in the middle of a corn field"[19], the system including the data transfer is often supplied from an accumulator supported by a solar panel. Depending on the modulation used by the module and its power class, cellular modems require large variations in transmit power.[20]

Saving energy is important. It can be achieved by increasing the system dormant time.[21] Normaly, the modem remains in a low-energy mode until the data source has collected a predetermined amount of information. The modem then awakes and initiates a network session by transmitting a short request packet on a narrow asynchronous channel, which is common to all modems.[22]

Medul 1 V2 has a special program implemented in the software that allows to control two external relais. Using this relais is possible to wake up the systems to performed required operations, the collected data to be read out and put the systems back into sleep mode, or switch the system on and off. Furthermore, by the second version there are 4 additional digital inputs.The digital outputs are programmed according following sequence:

[digitaloutput];key=type (switch ...), mode NO/NC (default = NO), lead-time (sec. default=0), fall-time (sec. default=0)
dout0=switch,NO,15,10
dout1=switch,NO,30,5

Hardware description of Medul 1

The front and back panels are shown on the figures 4 and 5. On the front panel, there is connector for power supply, connector for antenna, port for SIM card, reset button, Rec & Transfer button, signal status LEDs, power on LED, alarm LED and the data transfer indication LED. The technical specification is shown in the Table 1.

[19]PALLER, Gábor; SZÁRMES, Péter; ÉLO, Gábor. Power consumption considerations of gsm-connected sensors in the agrodat. hu sensor network. *Sensors & Transducers*, 2015, 189.6: 52.
[20]MICREL. ANLPS300: How to Power GSM/GPRS/EDGE/3G/HSPA M2M Modems. Optimized Power Scheme for High - Efficiency, Low Power Dissipation and Best RF Performances. - [on-line] available on URL:http://ww1.microchip.com/downloads/en/AppNotes/ANLPS300.pdf.
[21]QUAN-XI, Li; GANG, Li. Design of remote automatic meter reading system based on ZigBee and GPRS. In: *Proceedings of the Third International Symposium on Computer Science and Computational Technology (ISCSCT'10)*. 2010. p. 186-189.
[22]CATIPOVIC, Josko; ETCHEMENDY, Steven. Development of underwater acoustic modems and networks. Oceanography, 1993, 6.3: 112-119.

Table 1 Technical description of FTP modem Medul 1.[23]

Power supply	9-35VDC/200mA
Max. power consumption	15W
Power supply connector	2 pin terminal
IO connector	10 pin terminal
2x digital output photoMOS type AQY214	+/- 48V/100mA, R_{ONmax} = 35Ω
4x isolated digital input	< 8V = open, 10-30V = close
GSM SIM	MicroSIM
SD card	MicroSD HC, cap. 4, 8, 16GB
GSM Antenna connector	SMA
USB connector (programming port)	Mini USB
Modbus RS485 connector	4 pin terminal
Status LED	
LED 1,2,3, green, RSSI signal quality	
LED 4, green, RUN	System running
LED 5, red, communication error	Modbus data transfer error
LED 6, green, MODBUS communication running	Modbus data transfer
Dimensions with connectors and antenna	130 x 80 x 20mm

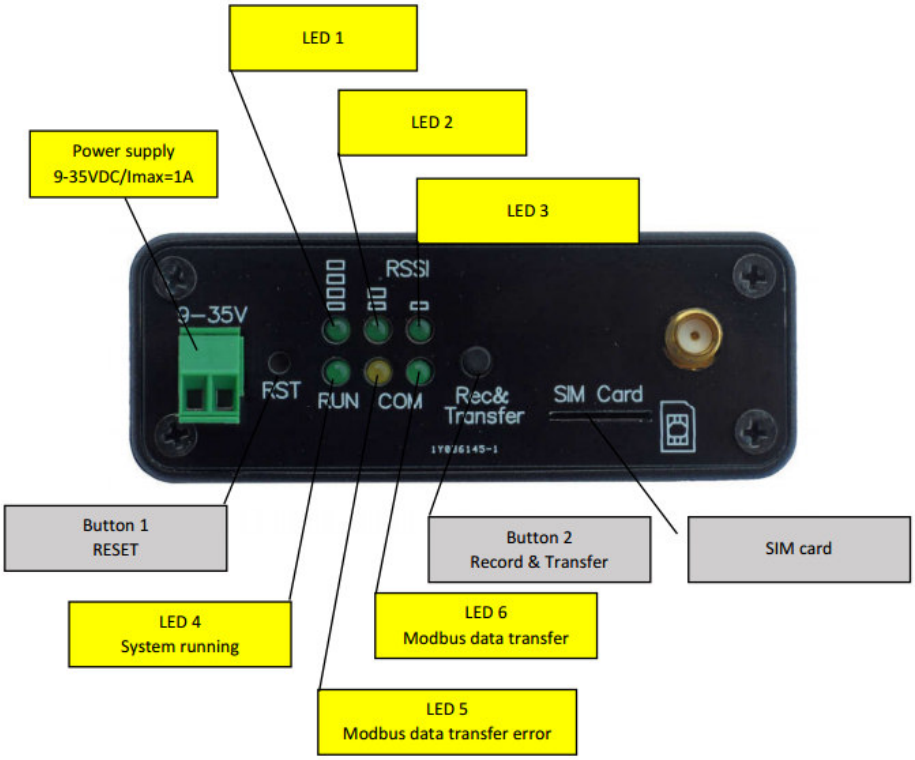

Figure 4 Front panel of the FTP modem Medul 1.[24]

[23]COMERGON. MODBUS Master to FTP transfer modem. User`s manual. MODBUS TO FTP TRANSFER MODEM. Basic characteristic.- [on-line] available on URL:http://www.comergon.sk/images/en_manual/en_pro70man.pdf.
[24]MEDON. *Bedienungsanleitung Medul-1. Internal document of Medon GmbH.*

On the back panel, there is connector for Modbus connection, slot for SD card, where the all configuration is stored. USB connector for external configuration and the connector for digital inputs and digital outputs connections.

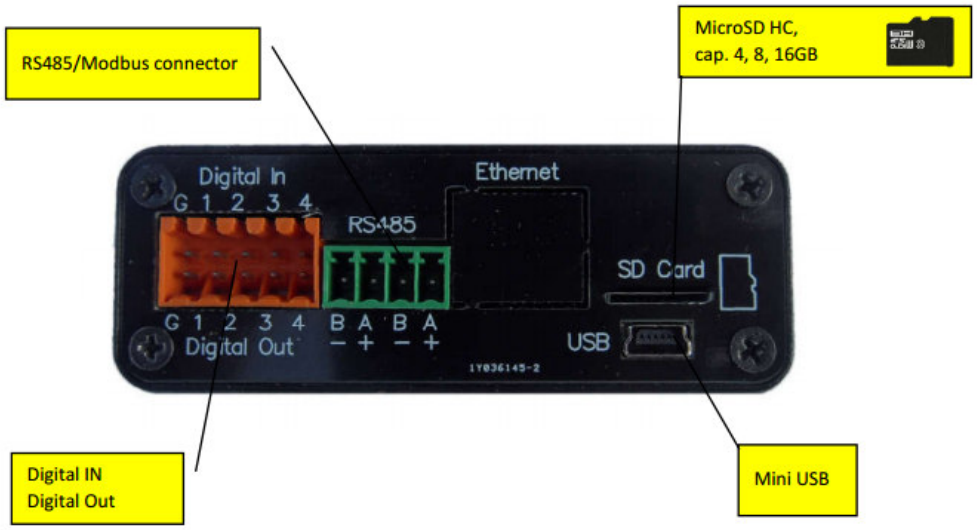

Figure 5 Front panel of the FTP modem Medul 1.[25]

Data format

The data are being sent to the FTP in MS Excel spreadsheet format. A pattern is shown on Table 2.

Table 2 Format of the transferred data to FTP.

date/time (SER UTC+01,00)	dig vals0	dig vals1	ana1 vals	digital IN0	digital IN1
29.10.2018 19:23	15	15	6691	0	0
29.10.2018 19:24	15	15	6693	0	0

The shape of the table depends on the configuration in the configuration file saved on the SD card of the modem. The file must be configurated according the register map of the device the data are being read out.

Further fields of use

Regarding to the European countries' top priority to reduce energy consumption in all field of its use, it is essential to find solutions to the economical use of energy resources.[26]Energy costs are on a continuous upward trend in Europe. In 2015 the average residential consumer's electricity price was 20.8 cents per kilowatt hour (cents/kWh), a 24% increase from the average price of 16.7 cents/kWh in 2010.[27] Applying such data transfer and energy control management can be the energy consumption either on small unit or big complex regulated.

[25]MEDON. *Bedienungsanleitung Medul-1. Internal document of Medon GmbH.*
[26]KRÁLIKOVÁ, R., KEVICKÁ, K. *Optimalization of the operation of the lighting system in industry.* Management of Environment 2011. – Proceedings of the 11rd International Scientific Conference, Bratislava, 7-8 November 2011. Žilina: Strix, First Edition. Edition ESE-6, ISBN 978-80-89281-78-7, 204 p.
[27]HALENÁR, R. 2018. *Visualization of costs associated with domestic electricity consumption in Slovakia.*Megatrends and Media : Reality and Media Bubbles : Conference Proceedings from the International Scientific Conference / editors: Martin

Practice

The modem was integrated to a IP65 case and installed to two well bunkers to measure the niveau of drinking water. One of them takes data from two wells in one geographical point and the second one from one well on the other point. Both devices send data to one server for further processing and the visualization.

Figure 6 Modem FTP Medul 1 in IP65 case.

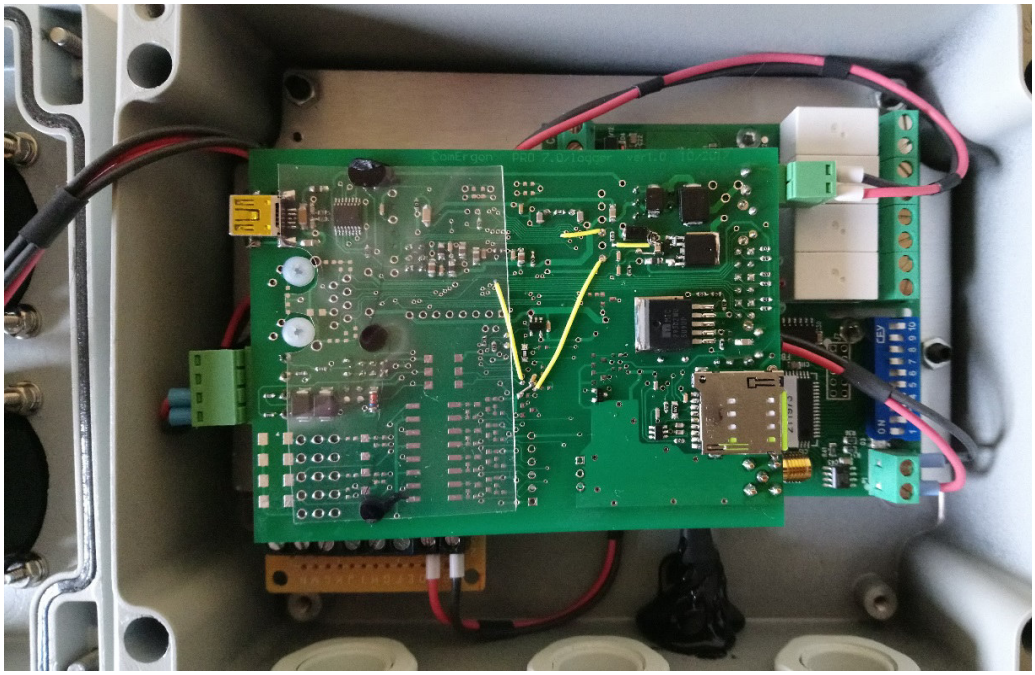

Figure 7Medul 1 integrated to IP65 case.

Prepared devices were mounted on the chosen points. First point are two bunkers with one well. Each well is equipped with one diving water level sensor. Signal from the sensor is lead to the modem through current loop of 4-20 mA and converter current in/Modbus. The model Medul sends just the value of the current in the range of 4-20 mA to the server. The current value is then processed to real level of water according the predefined range.

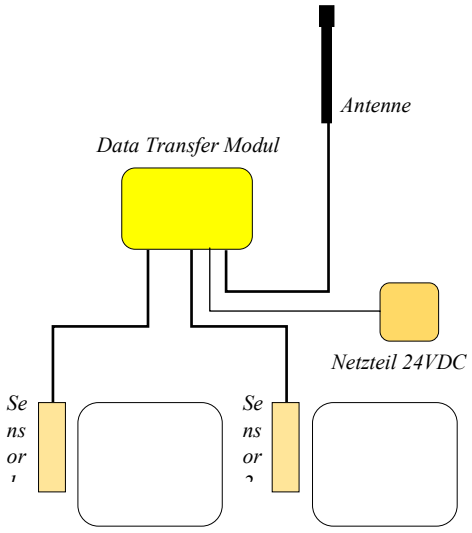

Figure 8 Configuration of the sensors and modem into the functional block.

The terrain of the wells is shown on the Figure 9.

Figure 9 Terrain of the first measuring point. Two bunkers with one well inside.

Figure 10 Mounting of the high gain antenna.

Specification of the antenna is shown below:

- Outdoor/indoor antenna GSM / WIFI
- Impedance: 50 Ohm
- Frequency: GSM 900-1800 MHz / PCN / 1.9 GHz USA / 3G / UMTS / 4G / LTE (699-960 / 1710 – 2690 MHz) / WIFI / BLUETOOTH (2.4 GHz)
- Polarisation: vertical
- Gain: 2.2 dBi
- VSWR: <1.5 / 2
- Cable: 2.5 m RG 58
- Connector: SMA/male
- Dimensions: 298 x 17 mm
- Operation temperature range: - 40 °C to +85 °C.[28]

The collected data on the server are available for the operator either as a trend or as a csv file as shown in the table 3.

[28]SpeedTech. Domová GSM / WIFI anténa - vonkajšia / SMA konektor. - [on-line] available on URL:https://www.speedtech.sk/product/38770/domova-gsm-wifi-antena-vonkajsia-sma-konektor.

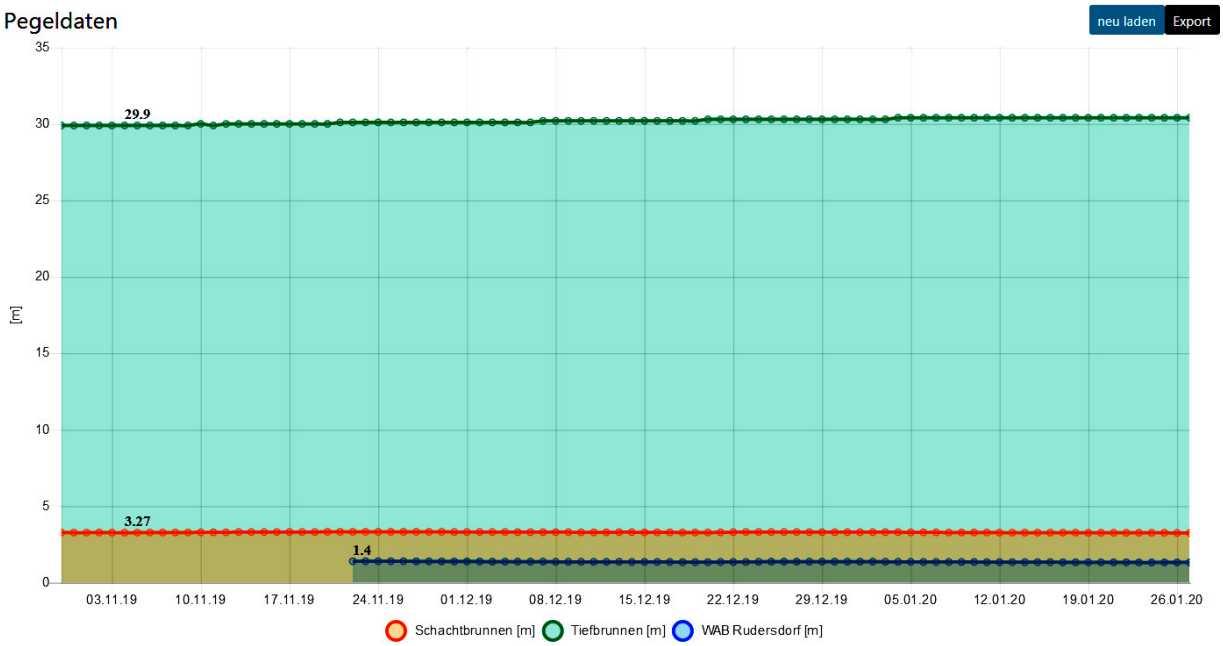

Figure 11 Data visualisation on the FTP server.

Table 3 Spreadsheet of the collected data exported from the FTP server.

Zeitstempel	Schachtbrunnen [m]	Tiefbrunnen [m]	WAB Rudersdorf [m]
20.1.2020 0:59	3,26	30,4	1,33
20.1.2020 1:00	3,26	30,4	1,33
20.1.2020 1:01	3,26	30,4	1,33
20.1.2020 1:02	3,26	30,4	1,33
20.1.2020 1:03	3,26	30,4	1,33
20.1.2020 1:04	3,26	30,4	1,33
20.1.2020 1:05	3,26	30,4	1,33
20.1.2020 1:06	3,26	30,4	1,33
20.1.2020 1:07	3,26	30,4	1,33
20.1.2020 1:08	3,26	30,4	1,33
20.1.2020 1:09	3,25	30,4	1,33
20.1.2020 1:10	3,26	30,4	1,33
20.1.2020 1:11	3,26	30,4	1,33
20.1.2020 1:12	3,26	30,4	1,33
20.1.2020 1:13	3,25	30,4	1,33
20.1.2020 1:14	3,26	30,4	1,33
20.1.2020 1:15	3,26	30,4	1,33
20.1.2020 1:16	3,26	30,4	1,33
20.1.2020 1:17	3,26	30,4	1,33
20.1.2020 1:18	3,26	30,4	1,33
20.1.2020 1:19	3,25	30,4	1,33

Conclusion

The Medul-1 modem is in operation for one year. Data transfer is reliable, the problems that during operation occurred were caused by a change in operating conditions of the mobile network operator and related to the registration of the user. After the registration, the data transfer was restored and the system works properly without any technical problems.

The data exported in the csv file is possible to take for further processing. The data transfer is limited by time between the transfer procedures. It must be taken on mind by designing of control systems where a fast response from controlled point to be ensured.

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