# COMMUNICATION INTERFACES FOR MEASURING SYSTEMS

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**SUMMARY**

*The presented paper deals with the proposal of the measuring chain assigned for remote measuring of parameters of distributed industrial systems. The designed solution should be able to do automatic measurement of all required parameters and to send obtained data to the remote centre, where they could be analyzed by telemeter based on the expert system.*

**Keywords:** *measuring system, communication interface, mobile measuring*

## 1. INTRODUCTION

The behavior of communication interfaces is different under different physical conditions. The paper is dealing with determination problem, which of the used communication interface for measuring systems is convenient from the point of view of sample rate speed, modulation, distance, data transfer quality and other properties important for measuring quality. An advantage of remote measurement system using exists in the case of distributed technical system, where the measured data are processed and evaluated by central computer. Information exchange between individual system components is usually done by standard communication interfaces, which includes also GSM, USB, Ethernet or WPAN.

## 2. VIRTUAL MEASURING SYSTEM

The measuring systems are evolving with a development of new technologies. Even more and more powerful A/D converters produce even large quantity of data, which are processed in remote place, where they are transferred in a real time. Measurements of variables with subsequent remote data transfer into devices, which will to analyze, display and store measured data is described as a virtual measurement system. The main task for improving such measuring system properties is to find out, which communication interface is suitable in a particular situation of measurement.

The following model, by which were trying to determine the optimum communication interface, were set as a measurement chain.

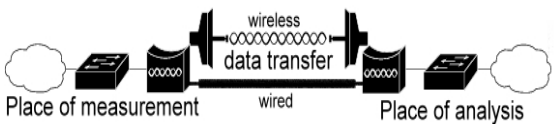


**Fig. 1** Measurement chain

The main focus was concentrated on conditions stated in Tab.1.

Tab. 1

| | |
|---|---|
| **Measured data** | • Speed of data transfer<br>• Volume of transferred data<br>• Distance of transferred variables<br>• Resistance against interference |

### 2.1. Communication technology

The communication technology selection was done from technologies listed below:

- Wired - USB, Ethernet, Fiber Optic
- Wireless - WiFi 802.11, IrDA, Bluetooth, GSM

To perform tests, the own communication interface working in ISM band and utilizing FSK modulations was used. The integral part of research activity were practical tests execution on following models:

- Model of measurement and acoustic data transfer with VoIP using.
- Remote measurement of the position using GPS with transfer through wireless.
- Mass collection of telemetric data, wireless transfer in Bardejov.
- Measurement of loudness in shopping centers – wireless transfer.

All these measurements help us to classify the importance of individual transfer channel properties and parameters on distance remote measuring system quality.

### 2.2. Modulations

In case the measurement contains a large volume of data, an appropriate modulation has to be chosen, as we are able to transfer sufficient volume of data

(Tab.2). Also the influence of the environment must be taken into account, because sometimes does not enables to use high capacity modulation. As an example can be quoted QAM modulation, which is useful only in environment without signal reflexes, i.e. transfer in microwave bandwidth, or in coaxial cable. On the other hand, QPSK can be used also under conditions with signal reflexes. GSM uses QPSK modulation, which proved to be the most suitable for mobile data transfer.

Tab. 2

| Modulation | Number of state | Transferred bits |
|---|---|---|
| BPSK | 2 state | 1 bits |
| 2FSK | 2 state | 1 bits |
| QPSK | 4 state | 2 bits |
| QAM256 | 256 state | 8 bits |

### 2.3. Communication protocol

Basic parts of communications are represented by communication protocols. Their role is to provide supervision on communication and deal with errors during data transfer. As a sample of communication model digital audio transfer was used, which was tested using several communication protocols.

In the majority of cases our own communication protocols were used, which supervised the addressing of measuring points, time of the response as well as repeated transfer in case error occurred. The method of protocols proved to be most useful, because it was tailored to our needs.

As a practical model was tested model of situation measurement and telemetric data transfer in Bardejov town, where the properties of particular protocols were analyzed. Obtained results confirmed, that the choice of the right protocol makes the communication easier and improves its quality. TCP/IP communication protocols were also considered for use, however the technical and economical requests were too expensive. The best solution was obtained by single purpose protocol, which was handled by ordinary one chip processor of AVR.

Different modern protocols utilizing were tested also in voice transfer in LAN network. The new model of VoIP telephone was created and carried out measurements using protocols TCPIP, UDP, RTP was done. The protocol UDP seems to be definitely the most suitable, together with protocol RTP. In final solution the RTP protocol was not used, because changes in the order of received packets occurred, what resulted in decreased quality of transferred voice.

For simple measurement using lower leveled communication is the best solution the using of developed protocol, which was providing satisfactory results for a majority of measurements (measurements with low capacity). Use of higher rank protocols demands the powerful processor as well as another supporting software, which made the whole application more complicated. Every of modern communication interfaces uses its own protocol, majority of them is compatible with TCP/IP. In the most cases the protocol, which is data collection charging, creates an upper layer of particular interface communication protocol.

### 2.4. Measurement speed and accuracy

The attention was focused also on large volume data transfer in analyzed problem. The big problem of data transfer accuracy is generating at the moment when the volume of transferred data increases in 3-10 times. Also for such cases the optimal choice of communication interfaces was done. For measurements, which required high speed and high accuracy, the most suitable were wired solutions. The possible data transfer speed is 10 till to 100 times higher than with wireless solutions. With distance shorter than 100 m, there are no significant differences between metallic and optic cables. In case of environment with electromagnetic field interferences, the metallic cables are not suitable. There are real limits for wired solutions, which is difficult to use with longer distances. That is why we tried combination of various communication interfaces. As a tested model was created fiber-optic ring, available at Kosice –Terasa. To it, we added as a last mile net wireless solution, which achieved very good parameters within distance of 500 m (10-15 Mbit). The combination of both used interfaces (Fig. 2.) we were able to provide the measurement of data and their fast transfer from variable place within its range (500m-fiber-optic + 500m-wireless). This combi-nation proved to be the best one, because it uses most of advantages of optic and wireless solution.

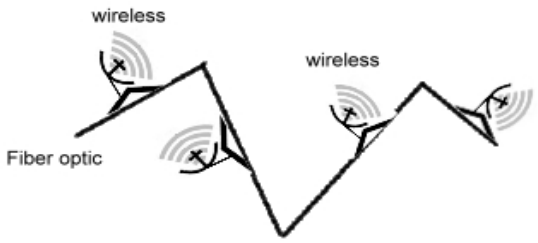


**Fig. 2** Combination of wired and wireless interfaces

## 3. GSM SYSTEM

The GSM (Global System for Mobile) system and its services belong between unthinkable components of our life today. The mobility, wireless communication, worldwide covering and also simple interconnection of existing computer nets are its great advantages. From the date of its creation, the GSM system passes through several generations, which was focused mainly on data communication velocity increasing. Its structure is presented in figure Fig. 3.

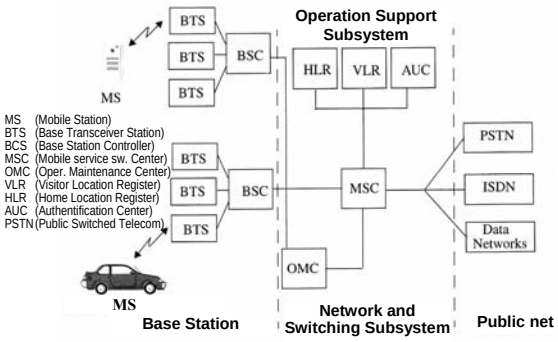


**Fig. 3** Block diagram of GSM system

In the case that the measuring produce small data amount, which is sufficient send to center within the period of some minutes, then the GSM SMS (Short Messaging Services) is possible to use. As example the distance measuring of warmth consumption in individual residential units can be presented. Such measured information has obviously largeness, which is within the range of one SMS transfer capacity. It means maximum 160 bytes (7 bits) or 140 bytes (8 bits). Block diagram of described measurement system is shown in figure Fig. 4.


**Fig. 4** Measurement system with GSM interface

The main attention is necessary to focus on the control unit module, which prepares data for communication via GSM. The data obtained from A/D converter are processed into format shown in figure Fig. 5 for the next transmitting by protocol.

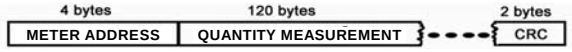


**Fig. 5** Communication packet

In common case the control unit communicates with the GSM module via USART and with the A/D converter via the $I^2C$ or SPI interface. Mode of measured entities sending is predetermined by the GSM module depending on communication velocity request, for example as SMS mode.

The AT commands are used for communication with GSM module, which set up required communication parameters:

```
AT+CMGF=0       //switch into PDU mode
AT+CSMS=0       //proof of SMS commands support
AT+CMGS=23      //SMS sending, 23 octets
>0011000B916407281553F80000AA0AE8329BFD4697D9EC37
```

In the last raw the data as protocol type, phone number, on which the data should be sent, and also the transferred data, in our case it is temperature with value 22.5°C, are written.

## 4. USB - TEST AND MEASUREMENT CLASS

New standard, labeled as USB TMC, is able to work with the basic signals assigned for measurement equipment controlling and also to accept interruptions and requests of these equipments. Physical level is the same as classic USB, which means the high user comfort in the field of connectivity. The interface enables connection possibility of 127 equipments and maximal transfer velocity 480 Mbit/s. Plug-and-Play support permit the equipment connection during its running. After its successful recognition the addressing of all connected equipments will be done automatically, without necessity of user intervention.

## 5. ETHERNET

**10GBase-CX4 –** This standard labeled also as IEEE 802.3ak, is assigned for 10 Gigabit Ethernet transfer through four pairs of twinaxial cooper cable. Achieved distance should be limited at 15 m or less. Standard was prepared in 2004 and the first products was made in 2005.

**10GBase-T –** Specified communication standard received designation as IEEE 802.3an. It is assigned for 10 Gigabit Ethernet transfer via twisted two-wire line with the standard used category 5. The standard reflects two requirements:

1. Distance preference toward the velocity - the traditional 100 m remain well preserved, but the velocity 10 Gb/s will be possible to reach only by the cabling category 7.
2. Velocity preference toward the distance - the real velocity 10 Gb/s is possible to reach by all cabling types, but the reachable distance will be variable. By the cabling category 5 it will be possible to reach the distance 40 - 50 m.

## 6. WPAN

The exemplificative comparison of WPAN nets is possible to do based on knowledge and data presented in table Tab. 3.

Tab. 3

| Technology / Parameter | Bluetooth | WiMedia | UWB MBOA, DS-UWB |
|---|---|---|---|
| Maximal reach | 10m, 100m | 50m | 10-20m / 2-3m |
| Maximal velocity | 1 Mbit/s | 55 Mbit/s | 480 Mbit/s 1,3 Gbit/s |
| Number of connected equipments | 8 | 128 | 256 |
| Average battery holding time | weeks | more as Bluetooth | unreported |
| Interference impact | minimal | small | small |
| Entry method | TDMA | TDMA | TFC / CDMA |
| Modulation | GFSK | QPSK, DQPSK, QAM | QPSK/ BPSK, QPSK |
| Band exploitation | FHSS | SC | OFDM / DSSS |
| Informative price | 5$ | 4$ | unreported |
| Primary specification | cable substitute | multimedia | nets, USB and FireWire substitutions |

Tab. 3 – continue

| Technology / Parameter | ZigBee | Wireless USB | Liberty-Link |
|---|---|---|---|
| Maximal reach | 50m | 50m | 2-3m |
| Maximal velocity | 250 kbit/s | 62,5 kbit/s | 1 Mbits |
| Number of connected equipments | 65 536 | 6 | unreported |
| Average battery holding time | years | months | months |
| Interference impact | small | minimal | none |
| Entry method | CSMA/ CA | CDMA | unreported |
| Modulation | BPSK, O-QPSK | GFSK | GMSK |
| Band exploitation | DSSS | DSSS | unreported |
| Informative price | under 2$ | 1$ | 5$ |
| Primary specification | remote controllers and sensors | USB substitute | cable substitute |

From the table it is evident, that any from above mentioned technologies cannot be used as upright competitor of the Bluetooth. WiMedia communication is first of all assigned for multimedia interconnection and so it provides much higher velocity. For UWB (Ultra Wide Band) technology the situation is not totally clear yet, but if any standard will be preferred, it will be assigned for applications requiring the high velocities, mostly as USB and FireWire replacement. ZigBee is oriented for low energy consumption and so it should be used in many small equipments, inside which the request for long time supplying is dominant. Wireless USB is not standard to this moment due to its distribution is momentary delimited. LibertyLink is very interesting technology, mainly due to its robustness against interference and excellent propagation.

## 7. MEASURING SYSTEM DESIGN

Based on previous analyses the measurement system design was done, the block diagram of which is presented in figure Fig. 6.

The measurement ability of 2N analog and digital input entities is supposed.

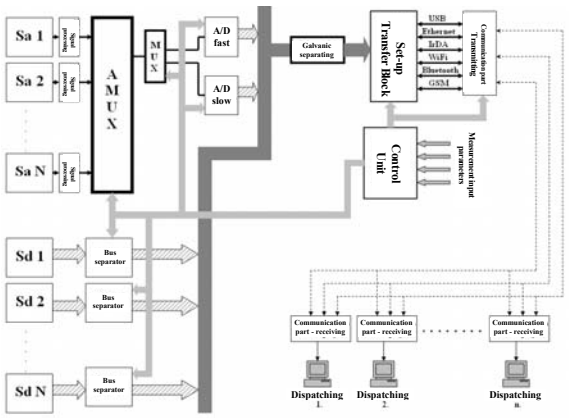


**Fig. 6** Block diagram of designed measurement system

Control unit has task to secure the total control of measurement system. By sophisticated method the best suitable sensor and A/D converter is selected based on required parameters. Based on situational control the control unit also will select the optimal communication interface. One of the control unit tasks will be also to secure the measurement system reliability by the reserve communication channel selection.

The main purposes of set-up transfer block are to choice the communication protocol and prepare data for communication interface. In dependence on the reliability, velocity, amount and reach of transferred data the following types of interfaces are supposed to use: GSM, USB, ETHERNET, WPAN.

The designed virtual measurement system will make also visualization and evaluation of the measured data by the suitable designed program.

## 8. CONCLUSION

The purpose of the done analyze was to evaluate the utilization of various communication interfaces for distance remote measurement systems. The main attention was focused on the data transfer between the place of measurement and the place of data analysis. Possibilities offered by Antik company and communication was used, which enables us to perform the measurements. At this stage the investigation was focused on Ethernet, based on metallic and optic cable and WiFi, together with own developed communication interfaces (modulation FSK), which fulfilled all the demands on data transfer of the measured valuables.

The next extension of this research activity will be done by evaluation of Bluetooth and GSM technologies, and wired USB solution, which are currently of wide use.

Presented measurement system block solution was designed from the viewpoint of optimal data transfer, which depends on the data volume, required for the next processing and also on the data reach with the accent to the sufficient control unit intelligence, affected by the measuring parameters. The utilization of selected metal and wireless communication technologies is supposed, which are regarded as today's age modern communication interfaces.

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## BIOGRAPHIES

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