COMMUNICATOR WITH THE ADDITIONAL FUNCTION OF CONVERSION OF COMMUNICATION PROTOCOLS

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ABSTRACT

This paper has described the GSM/GPRS communicator that supports both IEC 62056-21 and IEC 62056-31 communication protocols as well as the additional function of IEC 62056-21 to IEC 62056-31 conversion and vice versa.

INTRODUCTION

Interoperability and interchangeability requirements for metering equipment with respect to different communication protocols, modulation techniques and interfaces are usually solved by device manufacturers at the level of head end systems. As services provided by the smart grid are getting more complex, maintenance of the interfaces between meter data management system used by utility company and different data collection applications is becoming more demanding.

The main idea behind the approach presented in this paper is to keep single meter data collection system while requirements for interoperability are delegated to the manufacturers of lower system components such as GSM/GPRS communicator.

Data collection system that has been used supports the IEC 62056-21 protocol but lacks support for the IEC 62056-31. In many cases, both technologies have already been used at same locations in the grid. Regardless of the possibility to automatically read IEC 62056-31 electricity meters through transparent channel without conversion of protocols by using another head end system, single data collection system has been found more convenient with active function of IEC 62056-21 to IEC 62056-31 conversion at GSM/GPRS communicator level.

GSM/GPRS communicator, as shown in figure 1, exchanges data with head end system through public mobile network only with IEC 62056-21 communication protocol. Upon receiving the IEC 62056-21 request, communicator autonomously makes intelligent decision by configuring appropriate interface and the request is forwarded. If the meter is connected using RS485 bus, the transparent channel will be opened without protocol conversion. On the other hand, if the meter is connected using IEC 62056-31 bus, communicator will execute conversion from IEC 62056-21 to IEC 62056-31 protocol before sending a request to the meter. When the IEC 62056-31 answer is received from electricity meter, the communicator assigns the corresponding OBIS marks to metering results using conversion into IEC 62056-21 protocol and sends answer to data collection system.

IEC 62056-21 TO IEC 62056-31 CONVERSION

IEC 62056-21 and IEC 62056-31 standards

Applied head end system always sends IEC 62056-21 message in protocol mode C that has been formatted as shown in Table 1 to GSM/GPRS communicator.

<table>
<thead>
<tr>
<th>Message</th>
<th>Format definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>REQUEST</td>
<td>/? Device address : CR LF</td>
</tr>
<tr>
<td>IDENTIFICATION</td>
<td>/XXX X Ident CR LF</td>
</tr>
<tr>
<td>ACKNOWLEDGMENT</td>
<td>ACK 0 2 Y CR LF</td>
</tr>
<tr>
<td>DATA READOUT</td>
<td>STX DATA 1 CR LF ETX BCC</td>
</tr>
<tr>
<td>OPERAND</td>
<td>SOH P 0 STX (d . . d) ETX BCC</td>
</tr>
<tr>
<td></td>
<td>SOH P 0 STX (d . . d) EOT BCC</td>
</tr>
<tr>
<td>COMMAND</td>
<td>SOH C D STX a . a (d . . d) ETX BCC</td>
</tr>
<tr>
<td></td>
<td>optionally: SOH C D STX a . a (d . . d) EOT BCC</td>
</tr>
<tr>
<td>DATA</td>
<td>STX (d ... d) ETX BCC</td>
</tr>
<tr>
<td></td>
<td>optionally: STX (d ... d) EOT BCC</td>
</tr>
<tr>
<td>ERROR</td>
<td>STX ( . . . ) EOT BCC</td>
</tr>
<tr>
<td>BREAK</td>
<td>SOH B 0 ETX BCC</td>
</tr>
</tbody>
</table>

Table 1 – Format definitions of IEC 62056-21 messages in protocol mode C (source [1])

Local bus data exchange between communicator and IEC 62056-31 electricity meters is achieved by two communication services: remote reading data (ENQ exchange) and remote programming of data (REC exchange). The ENQ exchange consists of two frames arranged in one sequence and the REC exchange consists of four frames arranged in two sequences. Details of data exchange rules and frame structures are specified in [2].
Conversion of IEC 62056-21 messages into IEC 62056-31 frames and vice versa

Protocol conversion has been realised through translation of IEC 62056-21 messages into IEC 62056-31 frames as follows.

Conversion of request message

On request message, converter tries to read meter on IEC 62056-31 bus if ADS has length of 12 characters.

Conversion of identification message

If meter responds, converter generates identification message towards client. Meter is found on IEC 62056-31 bus.

Conversion of acknowledgement/option select message

Acknowledgement message for readout (Y=0) is translated into one or more IEC 62056-31 remote reading frames (COM=ENQuery) with different TAB’s. If Acknowledgement message is for programming (Y=1), converter returns OPERAND message (Programming command message where C=P and D=0). These translations are shown on Figure 2.

Conversion of data message (except in programming mode)

All messages which are read in readout are translated into IEC 62056-21 format by adding OBIS code. Converted data from IEC 62056-31 to IEC 62056-21 are sent towards application as depicted in Figure 3.

Conversion of acknowledgement message

Converter generates acknowledgement message if IEC 62056-31 meter programming was successful as shown in Figure 4.

Conversion of repeat-request message

If programming wasn’t successful, converter generates NAK message as presented in Figure 5.

Conversion of programming command message

On programming command, converter performs remote programming exchange with IEC 62056-31 meter (COM=REC and COM=AUT).

Conversion of programming command message using optional partial blocks

Not supported in protocol conversion mode.

Conversion of data message (programming mode)

Not supported in protocol conversion mode.

Conversion of error message (programming mode)

Not supported in protocol conversion mode.

Conversion of break message (programming mode)

Not supported in protocol conversion mode.

Examples of readout and clock synchronization

Supported IEC 62056-21 messages in protocol conversion mode can be presented in readout and clock synchronization processes as shown in Figures 6 and 7.

Conversion of data message (programming mode)

Not supported in protocol conversion mode.

Conversion of acknowledgement message

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Conversion of repeat-request message

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Conversion of break message (programming mode)

Not supported in protocol conversion mode.

Examples of readout and clock synchronization

Supported IEC 62056-21 messages in protocol conversion mode can be presented in readout and clock synchronization processes as shown in Figures 6 and 7.
When head end system application sends acknowledge message and option for readout, converter reads different TABs from IEC 62056-31 meter. On each received frame, payload is extracted and converted into data format of IEC 62056-21 message (generic ASCII characters with added OBIS codes) that communicator/converter sends towards application.

During remote clock synchronization process, after AMR application has been sent an acknowledge message and option for programming, converter should generate an operand message to head end system.

Upon receiving operand message from converter, data collection application sends programming command message for date and time. Communicator/converter reads actual date and time from IEC 62056-31 meter and creates REC frame with date and time received from AMR application. When internal programming sequence exchange between communicator and IEC 62056-31 meter ends, converter should return ACK to head end system. On the other hand, converter should generate NAK message if negative response (ARJ or DRJ) has been returned to IEC 62056-31 meter.

**List of functional tests**

Each process of functional testing is briefly specified including fit criterion. The list of the originally developed test procedures for communicator functionalities follows.

**Functional test CSD-RO**

On each sequential passing, all meter’s readouts should be read by head end system application using CSD channel regardless of supported communication protocol IEC 62056-21 or IEC 62056-31 by meter device. If each readout sequence has been stored in data collection system database, communicator passed the test. If electricity meter has been disconnected from the grid during one sequential passing, only disconnected meter’s readout must be missing.

**Functional test CSD-SYNC-LB**

On first sequential passing all meter’s date and time should be adjusted with application server system clock using CSD channel regardless of supported protocol IEC 62056-21 or IEC 62056-31 by meter device. In second sequential passing all meter’s log books should be read and stored in head end system database. Each log book in database must have records about clock synchronization.

**Functional test CSD-LP**

Only IEC 62056-21 meters with stored load profile for requested period should be read in real time by head end system application using CSD channel and optional for converters with activated load profile storing in their internal memory for IEC 62056-31 meters. Test is passed if each load profile has been stored in AMR database.

**Functional test PARAM-IP**

Manufacturer’s service software for programming parameter data set of communicator must store APN, username and password data requested for utility VPN network using CSD channel. If sending of IMCP packets or reading of readout using GPRS service has been successful, communicator has passed the test.

**Functional test IP-RO-SYNC-LB**

When all internal clocks inside meters are unadjusted manually, all meter readouts, clock synchronization with application server system time and meter log books should be executed by head end system application using GPRS service regardless of supported communication protocol IEC 62056-21 or IEC 62056-31 by meter device. If each readout and log book has been stored in head end system database, communicator has passed the test.
Functional test IP1-CSD2-RO
During the first sequential passing at least one IEC 62056-21 and one IEC 62056-31 meter should be disconnected from the grid. All meter’s readouts of connected meters to the grid should be read by data collection system using GPRS service. During the second sequential passing all meters should be connected to the grid and head end system has to read only readouts of reconnected meters using CSD channel. If each readout sequence has been stored in head end system database, communicator has passed the test.

**Conclusion for functional testing**
All types of tested communicators (from two different manufacturers) have passed each functional test as well as conformance test for used head end system.

**MASSIVE INSTALATATION IN GRID**
GSM/GPRS communicators with additional function of conversion of communication protocols enable connection of thousands already installed (using IEC 62056-31 protocol) household electricity meters via compliant local busses. Also, hundreds of electricity meters using IEC 62056-21 protocol, aimed for small business premises, can be locally connected to RS485 busses on the same communication devices.

Table 2 provides a statistical analysis about massive installation in utility grid of these communication devices with installed meters locally connected to appropriate communication busses.

<table>
<thead>
<tr>
<th>Communicator with function of protocol conversion</th>
<th>Installed meters connected to RS485 bus</th>
<th>Installed meters connected to IEC 62056-31 bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1 Manufacturer 1</td>
<td>422</td>
<td>744</td>
</tr>
<tr>
<td>Type 2 Manufacturer 1</td>
<td>311</td>
<td>265</td>
</tr>
<tr>
<td>Type 1 Manufacturer 2</td>
<td>18</td>
<td>6</td>
</tr>
<tr>
<td>Type 2 Manufacturer 2</td>
<td>41</td>
<td>37</td>
</tr>
</tbody>
</table>

Table 2 – Distribution of communicators with function of conversion of protocols and appropriate meters

Table 3 shows distribution of electricity meters by communication technology, manufacturers and different types connected to communicators with additional conversion function.

<table>
<thead>
<tr>
<th>Technology of communication / manufacturer of meters</th>
<th>Meter types</th>
<th>Meters in grid</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC 62056-31 / Manufacturer 1</td>
<td>27</td>
<td>8884</td>
</tr>
<tr>
<td>IEC 62056-21 / Manufacturer 1</td>
<td>2</td>
<td>205</td>
</tr>
<tr>
<td>IEC 62056-21 / Manufacturer 2</td>
<td>9</td>
<td>746</td>
</tr>
<tr>
<td>IEC 62056-21 / Manufacturer 3</td>
<td>10</td>
<td>101</td>
</tr>
</tbody>
</table>

Table 3 – Meter analysis by technology and manufacturers

Several specific examples should be described in order to highlight the diversity of the installed metering equipment. In first case, one communication unit is connected to IEC 62056-31 local bus to nine different types of electricity meters, in total 151 devices. Another communicator device has managed communication with 26 meters of same type locally connected to RS485 bus and 39 meters of two types connected to IEC 62056-31 bus. On third location, the communicator has successfully managed reading four different types of IEC 62056-31 meters, in total 16 devices, and three different types of IEC 62056-21 meters, in total 7 devices. Considering more types of meters, technologies and communication devices with function of protocol conversion as well as different manufacturers it can be concluded that interoperability and interchangeability issues are achieved.

**CONCLUSION**
This solution has shown satisfying degree of interoperability, interchangeability and in a certain way technology coexistence requirements. One data collection system is easy replaceable with advanced version requiring only a similar interface to meter data management system.

**REFERENCES**