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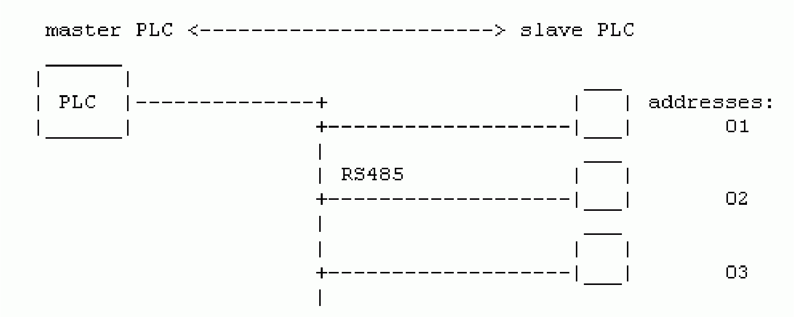
MODBUS Protocol for MORSE

Description of Protocol

version 10.0.9.0
12/12/2007

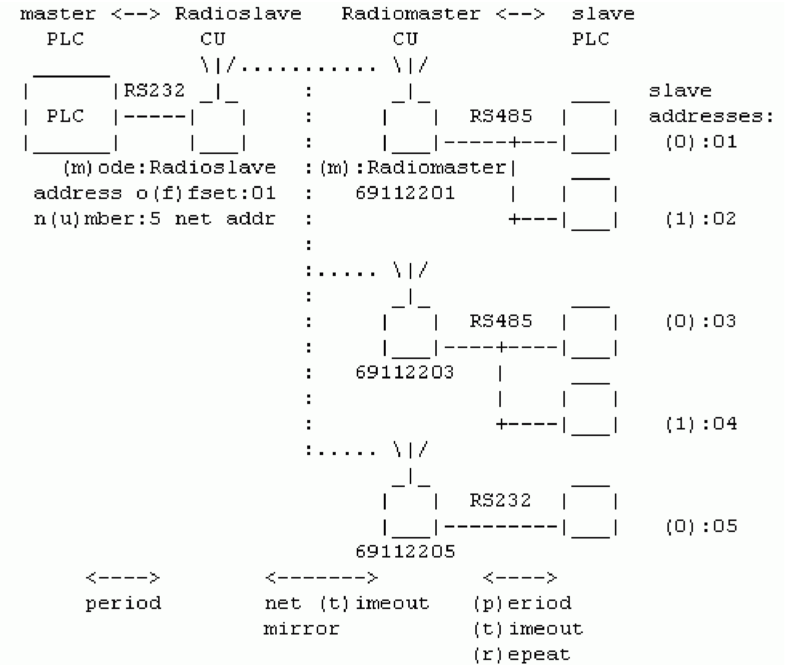
1. Introduction

The standard format of the MODBUS protocol contains a single Master and a group of Slaves connected over the RS485 network. The Master cyclically calls individual Slaves and reads data from them. According to requirements the Master sends commands for Slaves. Each command from the Master is duly acknowledged or contains a response with data corresponding to the function of the frame. The Master does not have its own address. Slaves can have addresses in the interval from 1 – 247, address 0 is used for modbus broadcast function.



```
  master PLC <-----------------------> slave PLC
   ______
 |      |                                   ___
 | PLC  |--------------+                   |   | addresses:
 |______|              +-------------------|___|      01
                       |                    ___
                       | RS485             |   |
                       +-------------------|___|      02
                       |                    ___
                       |                   |   |
                       +-------------------|___|      03
                       |
```

The next figure shows the Modbus network connected by the MORSE radio network.



```
master <--> Radioslave   Radiomaster <-->  slave
  PLC         CU             CU            PLC
 ______       \|/........... \|/
|      |RS232 _|_     :      _|_           ___   slave
| PLC  |-----|   |    :     |   |  RS485  |   |  addresses:
|______|     |___|    :     |___|-----+---|___|   (0):01
   (m)ode:Radioslave  :(m):Radiomaster|    ___
 address o(f)fset:01  :   69112201    |   |   |
 n(u)mber:5 net addr  :               +---|___|   (1):02
                      :
                      :..... \|/
                      :      _|_           ___
                      :     |   |  RS485  |   |   (0):03
                      :     |___|----+----|___|
                      :   69112203   |     ___
                      :              |    |   |
                      :              +----|___|   (1):04
                      :..... \|/
                             _|_           ___
                            |   |  RS232  |   |
                            |___|---------|___|   (0):05
                          69112205
     <---->        <------->       <---->
     period        net (t)imeout   (p)eriod
                   mirror          (t)imeout
                                   (r)epeat
```

The Slave PLCs are connected individually or in groups to the MORSE CU (communication unit, modem, radio), which locally take on the function of the Master PLC.

The Modbus bus is interrupted by an inserted radio network which mediates the connection in the following three modes. Radioslave (RS) and Radiomaster (RM) are CUs with the Modbus protocol.

Radioslave has a Modbus address the same as the lower byte of its own MORSE address. The lower byte of the CU Radiomaster address is the same as one of the addresses of connected Slave PLCs. For directing other PLCs the “multiaddressing” function in menu `(N)odes (e)dit` is used. Characters in brackets such as `(p)eriod` identify protocol parameters. An example of addresses is also given.

MODBUS protocol for MORSE can operate in three modes

- transparent
- cache
- packet

Transparent Mode

All packets that come from the connected Master PLC to the CU Radioslave are immediately transmitted through the MORSE network to the respective remote CU Radiomaster and transferred to the Slave PLC. A packet must contain the Slave address in the first byte and the Modbus function number in the second byte and then data and finally the checksum. The packet passes through the protocol and MORSE network without change. A message from the Slave PLC is only accepted as a response to a query and is sent to the questioner´s address. The mode is only suitable for small networks with a longer Master - Slave query interval.

Cache Mode

CU Radiomaster queries the connected Slave PLCs in the short interval `(p)eriod` and stores obtained data in its cache memory. Only when there is a change in the data in this memory is a packet sent through the MORSE network to the CU Radioslave. This maintains data from all Slave PLCs connected via the MORSE network. Upon a query, within a short period, it then passes data to the Master PLC. The transfer of commands from the Master to the Slave, which is less frequent, occurs in transparent mode.

Cache mode transmits only data changes (+ refresh over a longer time interval) through the MORSE network, which is why it is suitable for larger networks. A Slave can only transmit as a response to a received command. Direct Slave - Slave communication is not possible.

In Cache mode the Master serves a max. of 50 Slaves in fw 740, from fw749 max. 250 Slaves for MR400 or 50 Slaves for MR25.

Packet Mode

In packet mode periodic master <–> slave communication is maintained over wire links RS485 or RS232, i.e. Master PLC <–> Radioslave, Radiomaster <–> Slave PLC. In this case only a short descriptor is transmitted and only then in the case of new information is the whole data buffer transmitted. Based on information from the data buffer the CU generates a MORSE packet which is sent through the MORSE network to the destination CU.

This is where the differences between master - slave disappear. A Slave PLC can send a message without a call and also for another Slave PLC.

Transparent and Cache modes or also Transparent and Packet modes can operate simultaneously. Transparent mode is usually used in these cases for service work on a PLCs. All modes require that the Master is able to wait a longer time (seconds) for a response to a command from a Slave.

All modes

require that the Master is able to wait a longer time then at the communication on simple wire link for a response to a command from a Slave. The response on SCC comms after tens msec, the response on RFC can comm at wrong conditions after a number of seconds.

2. Data Format

Overview of Modbus functions for reading and entering data from various parts of the PLC memory. A more detailed description is given in article “Formatting MODBUS frames for MORSE”.

```
  function/8    unit for:     PLC
     (hex)       start/16
                number/16

     read    <--           ___________
     write   -->          |           |
                          |   Bin     |
        02   <--   bits   |    IN     |<- physical input
                          |           |<-
                          |___________|<-
        01   <--   bits   |           |
        05   -->  1bit    |   Bin     |-> physical output
        0F   -->   bits   |   OUT     |->
                          |___________|->
                          |  Analog   |
        04   <--   words  |    IN     |<-
                          |___________|
        06   -->  1word   |           |
        03   <--   words  | Holding   |
        10   -->   words  | Registers |
        17   <-->  words  |           |
                          |___________|
```

An overview of the formats of Modbus functions (No. of function, direction of transfer of information, name of function, size of unit num is 1 or 16 bits):

```
Master-Slave        REQUEST from Master   | RESPONSE from Slave
   <-->                                   |
01 <--  B_out            01               |
02 <--  B_inp            01       |
|adr/8| fce/8| start/16| num/16| crc/16|  |adr/8| fce/8| cnt/8| data/8*cnt|crc/16|

03 <--  H_Reg            16
04 <--  Inp_R            16
|adr/8| fce/8| start/16| num/16| crc/16|  |adr/8| fce/8| cnt/8| data/8*cnt|crc/16|

05 -->  B_out
|adr/8| fce/8| start/16| 0xFF00| crc/16| =set 1 bit ON
                                          |adr/8| fce/8| start/16| 0xFF00 |crc/16|
|adr/8| fce/8| start/16| 0x0000| crc/16| =set 1 bit OFF
                                          |adr/8| fce/8| start/16| 0x0000 |crc/16|

06 -->  H_Reg
|adr/8| fce/8| start/16| data/16| crc/16| =write 1 word
                                          |adr/8| fce/8| start/16| data/16|crc/16|

0F -->  B_out            01
```

```
|adr/8| fce/8| start/16| num/16| cnt/8| data/8*cnt| crc/16|
                                          |adr/8| fce/8| start/16| num/16 |crc/16|

10 -->  H_Reg           16
|adr/8| fce/8| start/16| num/16| cnt/8| data/16*num|crc/16|
                                          |adr/8| fce/8| start/16| num/16 |crc/16|

reply to the command entered incorrectly   Err
                                          |adr/8| 0x80+fce /8| excode/8| crc/16|
```

adr address of PLC on Modbus busbar

fce function which the PLC performs upon receiving a frame

start start address of data (output) which will be processed

num number of words (f03,04,10,17) or bits (f01,02,0F) for reading or writing

cnt number of bytes necessary for the transfer of the requested data

data states of read or written registers

crc security word

excode number of exceptions, specifies error

1. function number error
2. data address error
3. data content error
4. not occupy
5. acknowledged receipt of command the performance of which is slow
6. refusal, Slave is busy executing the slow command

```
Example of communication:
15:28:06.780 tx      8 | S00
0403 1000 0001 809F
15:28:06.784 rx;i    7 | S00
0403 0200 0074 44
```

04 questioned address

03 reading from Holding register

1000 from address 1000

0001 read 1 word

809F crc

04 answering address

03	reading from Holding register
02	2 byte read
0000	content of read bytes
7444	crc

3. Implementation in the MORSE system

Modem mode is set up (for SCC2 here) in menu `SPe2t`:

```
MODBUS parameters:
PLC Master - CU RADIOSLAVE ... CU RADIOMASTER - Slave PLC
(m)ode:RADIOSLAVE (wired to master)
(a)utomaster:OFF
(c)ache:ON  (p)acket:OFF  (t)rans:ON

(M)aster (S)lave
(A)utomaster
(C)ache
(P)acket
(T)rans

(s)ervices    De(f)aults menu
(O)ld menu (sw ver =< 5.74)
(q)uit
>>
```

(m)ode (m)ode:RADIOSLAVE (wired to master) - Modem position in the network

(a)uto (a)utomaster:OFF - The Radioslave can have the automaster function switched on. It then assumes the Radiomaster function when communication over RS485 is interrupted.

(c)ach (c)ache:ON - Mode selection.

(p)ack (p)acket:OFF - Mode selection.

(t)rans (t)rans:ON - Mode selection.

(M)ast This and next menus contain the parameters for chosen modes.

3.1. Modem as RADIOSLAVE

The radioslave is connected via the SCC to the PLC Master and from the Master’s point of view represents all PLC Slaves in the network. The addresses of all PLC Slaves are defined for RS using parameters o(f)fset and n(u)mber. Based on the mode defined in menu SPe2t RS then communicates with RM modems which are located by individual PLC Slaves.

```
slave parameters:
address o(f)fset:1  n(u)mber:5  net addresses
address type (o)ut: MORSE
address type (i)n: MORSE
(r)epeat discard:5 (deprecated)
d(e)vice type:PLC
Sep (a)ddress:5
(q)uit
>>
```

o(f)f address o(f)fset:1 – PLC Slave addresses form a continuous series. The lowest of them is given here, the min. value is 1

n(u)m n(u)mber:5 - Number of serviced PLC Slave (max. 50 for fw up to 740, fw 749 and higher with MR400 manages up to 250 Slaves, for MR25 the limit is 50 Slaves)

(o)ut address type (o)ut: MORSE/MODBUS - for packets leaving to the network the address of the target PLC Slave is derived either from its MORSE address or from its MODBUS address contained in data.

(i)n address type (i)n: MORSE - for packets incoming from the network the address of the source PLC Slave is derived either from its MORSE address or from its MODBUS address contained in data.

(r)ep (r)epeat discard:5 (deprecated) - Any parameters which have been cancelled or are not recommended are marked ”deprecated”.

d(e)v d(e)vice type:PLC - type of connected PLC Slave:

- PLC – Connected common PLC´s or PC with MODBUS protocol
- SEP - Connected SEP devices in old format (not MTF)
- PLC+MTD - The devices with MODBUS protocol are connected and also the Morse Technology Device, i.e. the SEP or ADIO modules using the MTF format.

(a)dd Sep (a)ddress:5 – If PLC+MTD mode is switched on then the range of addresses for MODBUS PLC and MTF devices is defined here (addresses lower than Sep Address are always MODBUS PLC addresses; addresses equal and higher than Sep (a)ddress are reserved for MTF devices - ADIO, SEP)

3.2. Modem as RADIOMASTER

Radiomaster appears in the MORSE network under an address, the last byte of which is the same as one of the M`odbus slave addr:`, e.g. `69112203`. Messages for the next of them are received using the Multiaddressing function (in menu `Ne`). The address of the respective Radioslave is given in item `(d)estination:`.

Communication over the RS485 line (or RS232 for a single Slave) occurs with a `(p)eriod:` (here 200 ms), wait for a max. period of `(t)imeout:` for a response, `(r)epeat:` number of repeats after `(t)imeout`.

```
master parameters:
(d)estination:691122FFh  destination
d(e)vice type (deprecated):PLC
```

```
Modbus slave addr: (0):3 (1):4 (2):5 (3):0
Modbus slave addr: o(f)fset:1  n(u)mber:0
address type (o)ut: MORSE
address type (i)n: MORSE
(a)ddress mask:FFh (deprecated)
(p)eriod:20 period i(n) : *10ms
(t)imeout:10*100 ms
(r)epeat:2
DPM(B) bcast compat:OFF
(q)uit
>>
```

(d)est (d)estination:691122FFh - Radioslave address in the MORSE network, uses Cache mode for sending messages RM -> RS, also for error messages.

(0) Modbus slave addr: (0):5 (1):0 (2):0 (3):0 - List of Slave stations included in the polling cycle; addresses need to be filled from the parameter (0), e.g.:(0),(1),(2); from **sw 749** Modbus slave addresses are entered in **decimal** format. If the number of Slaves is higher, then the parameters`o(f)fset`and`n(u)mber`can be used alternatively.

o(f)f Modbus slave addr: o(f)fset:1 - Defining the starting address for the longer interval of PLC addresses; multiaddressing in `Ne` menu must be used, from **sw 749**

n(u)m n(u)mber:0 - Number of PLC´s, interval begins from (o)ffset, from **sw 749**

(o)ut address type (o)ut: MORSE/MODBUS - The source PLC Slave address for packets outgoing to network is derived from it's MORSE address or from MODBUS address contained in the data.

The MORSE option is chosen for one PLC with an address that is the same as the last byte of the node. The MODBUS option is chosen in the case of more PLCs on a bus or if the address of the PLC is different to that of the node.

(i)n address type (i)n: MORSE/MODBUS - The destination PLC Slave address for packets incoming from network is derived from it's MORSE address or from MODBUS address contained in the data.

(p)er (p)eriod:20 - Period for polling Slave stations on RS485 or RS232, the time between receipt of a response and transmission of a new query, for the Cache and Packet mode. The size of time unit is defined in the next parameter.

i(n) period i(n) : *10ms / sec - the time unit for the (p)eriod is 10ms or 1sec. Here is the period set to 20*10ms = 200ms.

(t)im (t)imeout:10*100 ms - Max. time for waiting for a response on SCC. For the waiting period the SCC is not active and therefore does not even transfer any other incoming packets.

(r)ep (r)epeat:2 - Max. number of repeats on SCC

(B) DPM(B) bcast compat:OFF - Special parameter for DPMB.

3.3. Transparent Mode

In transparent mode all data is transmitted from Master to Slave over the network. It is used for transmission of executive commands from the Master in Cache mode. For bidirectional transmission transparent mode is only suitable for very small networks with a slow “timeout” polling cycle. For restricting the transmission of spurious packets we use checks in RM, as below.

After sending a packet to a Slave the Radiomaster expects, in a max. period of **SPe2tMt** (= timeout), a response from the Slave, which is then sent through the MORSE network to the Radioslave.

RM replies to the MORSE address of the source. This allows there to be more transparent RS in the network.

```
transparent parameters:
(A)rt table No:0
# ART dest:       gw:
#     mmnnffff    hhhhllll
#    mtf No Fce     high low addr (use help in default menu)
# BEWARE! IF YOU CHANGE CONTENT OF THE TABLE,
# YOU SHOULD RESTART (INIT) THIS PROTOCOL!
check (f)unction:ON
check a(d)dress:OFF
check (C)RC:OFF (deprecated)
check (n)et No:OFF
allow (r)ead req:OFF
(D)etect transp/cache<->packet by :CRC
Net(B)ase:0000  Net(M)ask:0000
(c)ommand cache:OFF  (t)im::0s
(q)uit
>>
```

(A)rt   (A)rt table No:0 - Table Art is generally not used.
Only in the case of communication in MTF format does it serve for transforming MTF functions to Modbus functions. For a more detailed description see the Cache mode section.

(f)un   check (f)unction: - This and other controls serve for barring unauthorised packets which may appear during transparent transfer.

- ON - The function must be one of the series 1, 2, 3, 4, 5, 6, F, 10, 17, 1E valid for RM and RS.
- OFF - The function number is not inspected.

a(d)d   check a(d)dress: - Checking the Slave PLC address.

- ON - The address must be one of the addresses in menu `SPe2tM0, 1, 2, 3,` i.e. one of the addresses of connected Slave PLCs. Valid for RM.
- OFF - The address is not inspected.

(n)et   check (n)et No: - Checking the packet numbers.

- ON - Checking numbers of Morse packets; response packet is labelled with the same number as the query at the Morse level; must be switched on in RM and RS.

- OFF - The number checking is set off.

(r)ead allow (r)ead req: - Inserting the transparent commands in Cache mode.

- ON - Allows centre Modbus to send transparent read commands to the network to the PLC even though they are not defined as cache. These commands are sent to RM in the transparent mode. They are only defined for RS when using CACHE mode, from **sw 749**

- OFF - In CACHE mode read commands outside of the defined CACHE are discarded. Valid for RS, from **sw 749**

(D)et (D)etect transp/cache<->packet by : - If packet mode as well as other modes are switched on simultaneously it is necessary to distinguish how an incoming packet should be processed. This setting is common for all three modes and can be set up from menu SPe2tT (T)rans or (C)ache or (P)acket. Options:

- (c) CRC - If a calculated CRC agrees, the packet is considered as Cache or Transparent; if it doesn´t agree it is considered as a Packet type

- (n) NetBase and NetMask - takes the src address and if it matches parameters `Net(B)ase` and `Net(M)ask` then it is a packet for Transparent or Cache mode. If it does not match then it is a packet for Packet mode.

(B)ase Net(B)ase:00FF - “Base” setting for distinguishing between Transparent/Cache and Packet mode. It works with down half of MORSE address only.

(M)ask Net(M)ask:FFFF - “Mask” setting for distinguishing between Transparent/Cache and Packet mode.

(c)om (c)ommand cache: - The PLC Master sends Modbus queries to RS. Some PLCs expect a response in a shorter time than the transfer time over the radio channel from RS to RM and back. In such a case the PLC repeats the query thus excessively flooding the RF channel. For this reason we use the (c)ommand cache, which sends the first query and discards the rest until the time according to (t)im has expired or until a response to the query arrives back. This is set up in RS mode.

- ON - Set on

- OFF - Set off, all packets are sent immediately in the RF channel.

(t)im (t)im:10s - Timeout for `(c)ommand` cache

3.4. Cache Mode

CACHE mode is used for collection of data from a larger number of PLC Slaves. It is supplemented by Transparent mode for transmission of (less frequent) commands in the Master `->` Slave direction.

In cache mode identical memory areas - cache - are created in the PLC and in modems. Transmission of data from Slave -> RM occurs on the link with short period `SPe2tMp` set in the range of 100 to 200ms. This maintains the current image of the status of connected Slaves in RM. If there are no changes in this image it is sent over the radio to RS in intervals `SPe2tCt`. If a change occurs in RM cache, a message for RS is sent immediately. Thus current images of the cache of all connected Slaves are maintained in RS cache with minimum loading of the radio network. PLC Master then reads this cache in RS in the same way as if it had read the status of all Slaves over the Modbus network.

On monitoring the status of cache memory the whole content of cache is transmitted over the link. Polling is controlled by the Radiomaster or the PLC Master. Information is only transmitted in the Slave -> Master direction.

```
    cache parameters:
(A)rt table No:1
# ART dest:       gw:
#     mmnnffff    hhhhllll
#    mtf No Fce     high low addr (use help in default menu)
# BEWARE! IF YOU CHANGE CONTENT OF THE TABLE,
# YOU SHOULD RESTART (INIT) THIS PROTOCOL!

(D)etect transp/cache packet by :CRC
Net(B)ase:0000  Net(M)ask:0000
net (t)imeout - mirror:30s
a(l)iasing:OFF
(g)lue to trans:off
(e)rr. report:SILENT  err. (a)dr:0h  err. (m)ask:0000h
(o)ld cache menu (since sw.630)
(q)uit
>>
```

(A)rt — (A)rt table No:1 - number of ART table where cache memory is defined, more detailed explanation follows. Fill in the Art table first and after it the SPe menu.

(D)et — (D)etect transp/cache<->packet by : - If the Packet mode and any other are used together then it is necessary to distinguish how the incoming packet should be processed. This setting is common for all 3 modes and can be set in menu SPe2tT (T)rans or (C)ache or (P)acket. Possibilities:

- (c) CRC - If a calculated CRC agrees, the packet is considered as Cache or Transparent; if it doesn´t agree it is considered as a Packet type
- (n) NetBase and NetMask - takes the src address and if it matches parameters `Net(B)ase` and `Net(M)ask` then it is a packet for Transparent or Cache mode. If it does not match then it is a packet for Packet mode.

(B)ase — Net(B)ase:00FF - Base setting for distinguishing between Transparent/Cache and Packet mode. Only low half of MORSE address is used.

(M)ask — Net(M)ask:FFFF - Mask setting for distinguishing between Transparent/Cache and Packet mode. Only low half of MORSE address is used.

(t)im — net (t)imeout - mirror:30s - Period of reporting to RS, if no change in cache occurred.

a(l)i a(l)iasing:OFF - Common cache for all functions:

- OFF - normal state - independent memory space defined for each Modbus function
- ON - only one cache memory defined, all functions written here

(g)lue (g)lue to trans:off

- off - normal state
- on - the content of cache is also connected in the same packet to the transparent response from RM to RS, so information about implementing a command gets to RS faster

(e)rr (e)rr. report:SILENT - Behaviour in the case of a loss of communication on the line RM <-> PLC/SEP:

- NONE - **RM** - error message is not sent, messages continue with interval `Spe2tCt` with old values
- NONE - **RS** - Radioslave continues answering on Master's requests
- SILENT - **RM** - upon a loss of communication transmission ends with interval `Spe2tCt`, RS ascertains the error after time `Spe2tCt` set in RS
- SILENT - **RS** - A radioslave, which over a period SPe2tCt doesn’t receive a message from RM, or receives an error REPORT from RM, stops responses to queries from the PLC Master.
- REPORT - **RM** - upon a loss of communication an error message is immediately generated, RS ascertains the error immediately, functional from version 7.65
- MASK - **RM** - upon a loss of communication on RS485 the current message is sent to the Master, but modified in such a way that set bits `(m)` are added to the selected word `(a)` of the message by operation OR. Example:

```
err. (a)dr:0h  err. (m)ask:FFFFh

10:30:47.087 tx      8 | S03
0503 0010 0003 058A
10:30:47.148 rx;i   11 | S03
0503 06AA AABB BBCC CC12 33
10:30:49.149 tx      8 | S03      ...connection on RS485 broken
0503 0010 0003 058A
10:30:52.151|                |691122FF 00000005|S03I  OUT  11||89 4usr 0
0503 06FF FFBB BBCC CC12 3A
```

Zero word of the data AAAA is changed to FFFF by operation OR.

- DATMOLUX - special format for DATMOLUX

(a)dr err. (a)dr:0h - parameter for MASK mode - address of word from the beginning of the block *cash* memory (m)ask err. (m)ask:0000h - parameter for MASK mode - a word, which is added (OR) to a selected word of memory cache

Art and CACHE tables

Memory blocks for the cache function are defined in the same way in RS and RM using Table Art. For standard Modbus communication Art defines one cache memory in each of its rows. It contains a sequence number, Modbus function and the range of reserved memory. Example:

```
ART No 1:
items: 3
default gw: 00000000 (0.0.0.0   )
dest:    gw:
00040002 00040000 (0.1.0.2    0.4.0.0   )
00050003 00020000 (0.2.0.3    0.2.0.0   ) ...length 2 word
00060003 00140010 (0.3.0.3    0.20.0.16 ) ...length 4 word
>>
```

Writing format for dest and gw:

```
| rez/8 | No/8 | rez/8 | fce mb/8 | high addr/16 | low addr/16 |
```

- rez/8 - reserve, 00
- No/8 - sequence number, arbitrary, serves for distinguishing between dest items in the case of the same modbus functions
- fce mb/8 - number of Modbus function (01, 02, 03, 04). A function recorded with an upper bit 1, i.e. 81, 82, 83, 84, creates a memory block which is not transferred immediately after a change of contents. It is only transferred to RS upon a change of another block or after time `SPe2tCt`. Valid from version 10.0.20.0.
- high addr/16 - address of high end of memory space
- low addr/16 - address of high end of memory space

For example the third row defines the cache memory for function 03 - reading registers, which contains 4 words at addresses 0010, 0011, 0012, 0013.

Responses to Modbus queries are stored in individual cache memories based on the number of the Modbus function. If there are more records with the same function number they are distinguished by their length. Memory for functions with the same number must be defined such that they can be differentiated by their length and must be listed in Art from the shortest at the top to the longest at the bottom. A PLC Slave must provide data for all cache defined in this way. If data is shorter then communication doesn't take place.

It is possible to define a max. of 8 cache memories in Art. The maximum volume of all defined cache is 1400 byte in the case of the Radiomaster. This means that upon refreshing cache in the Radiomaster -> Radioslave direction a MORSE packet of maximum size 1400 bytes of user data can pass through the network.

For the Radioslave (in the centre) the memory in the modem is a limiting factor.
Allocated memory in the centre = (NumberPLC+NumberSEP+NumberADIO) × SizeCache

- For MR25 allocated memory is < 5000 Byte
- For MR400 allocated memory is < 250 000 Byte

ADIO, SEP and MTF in the Modbus

The Master PLC can communicate with Slaves ADIO or SEP, which work with the MTF format.

These devices are defined in RS in the (S)lave menu using parameters SPe2tSe, SPe2tSa. Table Art then performs a transfer between functions MTF and Modbus. Besides CACHE memory blocks for reading from modules ADIO and SEP a RULY blocks are defined for writing. Here is the recommended configuration of Art with comments:

```
dest:    gw:                         ...CACHE, MB <-- SEP
06010001 00080000 (6.1.0.1   0.8.0.0  ) ...read Dout   8 bit
01020002 00100008 (1.2.0.2   0.16.0.8 ) ...read Din    8 bit
07030004 000C000A (7.3.0.4   0.12.0.10) ...read Aout   2 word
02040004 00090001 (2.4.0.4   0.9.0.1  ) ...read Ain    8 word
                                        ...RULY, MB --> SEP
07070006 01020100 (7.6.0.6   1.2.1.0  ) ...write Aout  2 word
06080005 00080000 (6.8.0.5   0.8.0.0  ) ...write Dout  8 bit
0609000F 00080000 (6.9.0.15  0.8.0.0  ) ...write Dout  8 bit
```

Contain of dest and gw items:

```
| mtf/8 | No/8 | rez/8 | fce mb/8 | high addr/16 | low addr/16 |
```

- mtf/8 - MTF function number, format see Protocol MTF for MORSE[1]
- No/8 - sequence number, arbitrary, serves for distinguishing between dest items in the case of the same modbus functions
- fce mb/8 - Modbus function number for CACHE (1, 2, 3, 4, version 81, 82, 83, 84 see above) or for RULY (5, 6, F)
- high addr/16 - upper end of memory space
- low addr/16 - down end of memory space,
  the address in bits or in words depending on Modbus function type, see chapter Data format

A maximum of 8 CACHE can be defined.

Memory with the same Modbus function number (here rows No 3 and 4) are again distinguished by length and listed from shortest to longest.

The table in question is suitable for communication with module ADIO and SEP. The Master PLC must send queries corresponding to the length of the connected device, e.g. for Din ADIO a query of 2 bits.

[1] https://www.racom.eu/cz/support/prot/mtf/index.html

Tab. 1: Address used in SEP

Oblast	Fce	Typ	SEP-Cache	Content
Dout	0x01	R	00-07 bit	Read binary outputs
Dout	0x05	W	00-07 bit	Write to bin. outputs in bits
Dout	0x0F	W	00-07 bit	Write to binary outputs
Dinp	0x02	R	08-15 bit	Read from binary inputs
Ainp	0x04	R	0x001-0x008 word	Read from analog inputs
Aout	0x04	R	0x00A-0x00B word	Read from analog outputs
Aout	0x06	W	0x100-0x101 word	Write to analog outputs

Radiomaster sends a regular message for RS in the interval Net timeout `SPe2tCt`. In addition to this it sends current reports about changes. Radioslave monitors whether each RM reponds at least once in time `SPe2tCt`.
If not it behaves according to the error report setting.

Cache in RS is organised according to Modbus addresses or according to MORSE addresses. If addresses do not begin with one the unused part of memory for the Slave (0 to N-1) can be left out by using offset addresses, parameter `SPe2tSf`. The number of blocks of cache can then be adapted to the total number of Slaves in the network using parameter `SPe2tSu`.

RS recognises individual Slave PLCs for their insertion into cache according to MORSE addresses from which a message was received. If it is necessary to distinguish PLCs according to Modbus addresses it is possible to set up with the type of address in parameter `SPe2tSo`, `SPe2tSi`.

3.5. Packet Mode

In packet mode two memory buffers are created in each PLC and in modems for transmission of data from Slave `->` Radiomaster (host to net, H2N) and back (net to host, N2H). The length of the buffers is min. 250 bytes (max. length of Modbus frame), max. 1600 byte (max. length of MORSE packet).

Data transfer in packet mode can take place in any direction, i.e. Master<->RS, RM<->Slave, Slave<->Slave.

Radiomaster periodically queries each Slave for the content of the first word of the buffer H2N called the descriptor. If it is non-zero the length of the pseudoframe prepared in H2N is found out and this is transmitted in the next communication to the Radiomaster. Then the descriptor is deleted which indicates to the Slave the possibility of transmission of the next frame. Communication from PLC Master - RS, which is controlled by the Master, takes place in a similar manner.

Transmission from the Radiomaster (RM) to the Slave takes place in such a way that RM reads the descriptor N2Hdesc in PLC Slave and if it is zero it writes its pseudoframe to N2H. After processing this the Slave writes a zero word to N2Hdesc on the signal that buffer N2H is again available.

```
packet parameters:
Modbus (a)ddress:5
(A)RT table No.:0 (deprecated)
(N)2H buffer:2000  (H)2N buffer:1000
Warning: Both addresses should be nonzero.
(s)imulator:OFF
(D)etect transp/cache<->packet by :CRC
Net(B)ase:0000  Net(M)ask:0000
(q)uit
>>
```

(a)ddr - Modbus (a)ddress:5 — Modbus address of modem on 485 bus.

(N)2H - (N)2H buffer:2000 — address of buffer for transfer "Net to Host", which is MORSE Net to Modbus.

(H)2N - (H)2N buffer:1000 — address of buffer for transfer "Host to Net", which is Modbus to MORSE Net - addresses in memory at which the respective buffer starts for storing data sent by Modbus in packet mode. These addresses must be selected in a similar fashion for all Modbus network subscribers.

Here the term *Net* represents the linking MORSE network starting with the node, and the *Host* is the connected PLC Slave or PLC Master.

(s)im - (s)imulator:OFF — For testing purposes it is possible to use the MORSE CU as a simulator for replacing the PLC Slave in packet mode. Parameter `(s)` then needs to be switched on in this simulator, the content of parameters `(N)` and `(H)` should be exchanged.

Pseudoframes H2Nfr and N2Hfr have headers of length 6 bytes and data. The header contains the necessary information for creating a MORSE packet and sending it to the Radioslave or another Radiomaster.

Structure of buffers:

- H2N:

  ```
  | H2Ndesc/16 | H2Nfr/modbusMRU |
  ```

- N2H:

  ```
  | N2Hdesc/16 | N2Hfr/modbusMTU |
  ```

Description of items:

H2Ndesc “host to net descriptor”, and contains the necessary information for the transfer of a packet through Modbus. N2Hdesc (net to host descriptor) also has a similar format:

```
H2Ndesc:   |ret/1|rep/1|No/2|res/1|rxsize/11|
N2Hdesc:   |ret/1|rep/1|No/2|res/1|txsize/11|
```

ret
- 0 - user pseudoframe
- 1 - routing pseudoframe (reserved for Racom)

rep repeat bit

No number of packet

res reserve, must be zero

rxsize, txsize size of pseudoframe including address and type in bytes

H2Nfr user pseudoframe

N2Hfr user pseudoframe

modbusMRU Maximum Receive Unit

modbusMTU Maximum Transmit Unit

Addresses of individual blocks of memory (H2N, N2H) are freely configured in the modem according to the requirements of the connected device. A pseudoframe contains the actual packet determined for transfer to/from the network. A header containing network information is contained inside the pseudoframe. The header is located in the buffer in the next position after the descriptor. Structure of header and data:

User pseudoframe:

```
      | T/8 | D/1 | R/4 | N/3 | A/32 | data |
```

T type of packet

D bit DTE

- if 0, sender is DCE, A is source address
- if 1, sender is DTE, A is destination address

R reserved, must be zero

N network number (transmitted over the network)

A address in network

data actual data of pseudoframe

Example:

The Packet mode frame transfering the data from RM to Slave:

```
                    AA AA      ...data
          09 0169 1122 FFAA AA      ...user pseudframe N2Hfr
     00 0809 0169 1122 FFAA AA      ...N2H descriptor + N2Hfr
```

```
0510 2000 0005 0A00 0809 0169 1122 FFAA AAE5 E6 ...Modbus frame, record
                                                   with function 0x10
```

The frame transering data from Slave to RM:

```
                      BB BB       ...data
       09 8369 1122 FFBB BB       ...user pseudframe H2Nfr
0503 0809 8369 1122 FFBB BB0F B4  ...Modbus frame, reading
                                     with function 0x03
```

When reading data from the Slave to RM the descriptor is not read again because this is transferred in the previous step of the dialog. More detailed examples[2] are given in a separate article.

Multiaddressing

Radiomaster, which serves several Slaves, uses Multiaddressing. When switching on the Multiaddressing function in the Nodes menu packets which were directed via routing to the node's link output are sent to the user output. This therefore determines that packets from the MORSE network, determined for any of its Slaves, are accepted by the Radiomaster and that they leave its user port to SCC with Modbus.

3.6. Automaster

```
Modbus automaster:
t(i)meout:0s
master mode after switching:
(c)ache:OFF  (p)acket:OFF  (t)rans:OFF
(q)uit
>>
```

t(i)meout:0s — After this idle period on RS485 the Radioslave with switched on parameter `(a)utomaster` takes on the role of the Radiomaster and continues in the mode determined by the following parameters `(c)ache:ON/OFF (p)acket:ON/OFF (t)rans:ON/OFF`. After the original Radiomaster becomes active again it returns to its role of Slave.

3.7. Service Menu

Time synchronisation in Modbus and watchdog for PLC Slave.

```
Modbus services:
(t)ime sync:OFF  (m)ode:RECEIVER  (p)eriod:0s
time (a)ddr:0000h  time sync (b)it:0000h
(d)ebug addr:00000000h (deprecated)
radiomaster only:
(w)dog bit:0000h  wd(o)g addr:0000h  wdog p(e)riod:0s  (F)unc16:OFF
(q)uit
>>
```

[2] https://www.racom.eu/eng/support/prot/mod-ex-1009/index.html

Parameters for **time transfer**:

(t)ime (t)ime sync: - Switch on function of transmission of timedata between the Radiomaster and Slave.

(m)ode (m)ode:RECEIVER - Transmitting or receiving time mode:

- SENDER - Radiomaster or Radioslave can be selected as SENDER (sends time).
- RECEIVER - Radiomaster or Radioslave can be selected as RECEIVER (sends time).

(p)er (p)eriod:0s - Period for transferring time data is only defined in Radiomaster.

(a)ddr time (a)ddr:0000h - Address for storing time, Master and Slave, set according to address used in PLC.

(b)it time sync (b)it:0000h - custom function

Parameters for **watchdog** are only entered in Radiomaster; they provide the PLC Slave with the option of checking whether a connection with Radiomaster lasts.

(w)dog (w)dog bit:0000h - Periodically written word to Slave.

wd(o)g wd(o)g addr:0000h - Address of entry to Holding Registers in Slave.

p(e)r wdog p(e)riod:0s - Period of entry.

(F)un (F)unc16:OFF - funkce Modbus použitá k zápisu do Slave

- ON - Watchdog uses function 0x16 for entry.
- OFF - Watchdog uses fuction 0x06.

Time Synchronisation

The Modbus protocol allows time to be transmitted between a MORSE CU and a connected Modbus device. In this way it is possible to link to time synchronisation in the MORSE network; see the example[3] in the separate article. In all CUs it is necessary to switch on synchronisation SPe2tst and set up the address for recording time SPe2tsa the same way. There are four configuration options:

RS receiver time from PLC Master to RS, mode receiver, function 10, period 0

RM sender time from RM to PLC Slave, mode sender, function 10, period

RS sender time from RS to PLC Master, mode sender, function 03, period 0

RM receiver time from PLC Slave to RM, mode receiver, function 03, period

[3] https://www.racom.eu/eng/support/prot/mod-ex-1009/index.html

Parameter "period 0" means that Modbus communication is controlled by the other participant. Parameter "period" is set as required, e.g. 3600sec. If more PLC Slaves are connected to RM synchronisation only takes place with the first of them.

Example - RS in function SENDER accepts a time query from the Master PLC and responds:

```
12:01:47.831 rxsim   8 | S02
0503 3000 0006 CB4C
12:01:47.832 tx     17 | S02
0503 0C47 3984 1B03 402F 010C 0D0A 6BA4 84
```

Format of Time Data

```
|gmtsec/32|R/1|ts/1|R/4|msec/10|sec/8|min/8|hour/8|day/8|month/8|year/8|
```

gmtsec Current time. GMT in seconds since 1.1.1970 (Unix time) is used

R Reserve

ts Timesavings, switch between summer/winter time (1 - summer time, 0 - winter)

msec Milliseconds in the current second

Others are generated from the above mentioned items containing local time including a correction of the time zone. In the command for writing time to the CU the following items can be arbitrary, e.g. zero:

sec Current second

min Current minute

hour Hour (0 - 23)

mday Day of month (1 - 31)

mon Month (0 - 11)

year Year (data in year format - 1900)

Structure of used example:

```
0503 0C   - Modbus address 05, function 03, 12 byte
4739 841B - Unix time, seconds from 1.1.1970
0340      - 0000bit winter time, 0x340 = 832ms
2F        - 47 sec
01        - 01 min
0C        - 12 hod
0D        - 13 den
0A        - 10+1     = 11 month
6B        - 107+1900 = 2007 year
A4 84     - crc
```

`12:01:47.832` - monitoring time corresponds with the content of the frame

Watchdog Functions

PLC Slave does not have the possibility of finding out whether communication with the Radiomaster has been interrupted or not. For that reason it is possible here to set up the Watchdog function in Radiomaster, which writes a particular word to a selected address in the PLC Slave at regular intervals. Everything is set up in menu `SPe2ts`. The PLC can then regularly read and delete this entry thus maintaining information about the existence of the connection.

3.8. Types of Packets

Short description of types of packets on the user interface.

```
|U/1|B/1|H/1|subt/5|
```

U Link security bit - 1 denotes secure transmission

B Broadcast (multicast) bit - 1 indicates a broadcast packet

H Handicap/priority - 1 indicates lower priority (handicap)

subt Subtype - assumes these basic values:

- `subt=0x09` - USER DATA - user data

  Basic type of packet for transmission of data from the source to the destination. In combination with the set bit U=1 the most frequent type of packet is generated, 0x89, i.e. secured user packet.

- `subt=0x0A` - PROT DATA

  This type of data is designed for controlling the flow of data in the user protocol. Processing both of the mentioned types of packets in the MORSE network is the same. Packets are sent to the destination address according to routing and priorities are set to participating addresses. In the case of packet loss an error message is delivered to the original sender. A packet which carries this error message may also get lost, and this time without another message.

- `subt=0x0C` - PACK ERROR REPORT - packet with error message

  A report about errors in the MORSE network. The first word is the Error Number. The next part of the message contains more detailed information about the error in the network. It is possible to switch the generation of these messages on or off for the whole network.

  Below are some of the error numbers:

  1 PACKET_NOT_CONFIRMED - packet not confirmed

  2 STORE_TIMEOUT - store timeout

  3 NO_CHANNEL_ASSIGNED - no channel assigned

  4 ACCESS_TIMEOUT_ERROR - access timeout exhausted

  6 WRONG_PACKET_FORMAT - wrong packet format

7 DEST_PROT_MISSING - protocol at destination address missing

8 WRONG_PATH - wrong path

9 WIRE_LINK_FAIL - error on wire link

- `subt=0x10` - SERVICE REQUEST - service request

  Request for MORSE service.

- `subt=0x12` - SERVICE REPORT - service report

  MORSE service report.

3.9. Examples

Examples for transparent, packet and cache mode are given in a separate article MODBUS examples[4]. Examples of packet mode are also contained in the older description MODBUS 574[5].

4. History

- This description applies for version sw 10.0.9.0 z 9.10.2007.
- Version sw 657 (4.3.2004) up to 678 also use parameters (deprecated).
- Cache menu for versions up to sw 630 is contained in “SPe0tCo”.
- Menu for versions up to sw 574 is in “SPe0tO”.
- Description for sw 574 (20.5.2002) with more detailed explanation and with examples of packet mode is in article “MODBUS 574”.

[4] https://www.racom.eu/eng/support/prot/mod-ex-1009/index.html

[5] https://www.racom.eu/eng/support/protocols_docum/bc260a_modbus574.html