RACOM
RADIO DATA NETWORKS

SEP protocol for MORSE

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1. Introduction

The SEP protocol serves for communication between the MR25 or MR400 communication unit and the SEP technological measuring unit. It enables data to be transferred from 8 binary inputs with 8 counters, 8 binary outputs, 8 analog inputs and 2 analog outputs and.

A description of the SEP technological unit can be found in the: Products/Hardware/Accesories/SEP[1] section on the Racom pages, www.racom.eu[2].

2. Data Format

The structure of the SEP packet transmitted from the protocol to the MORSE network is given below:

```
| BO/8 | BI/8 | 8xAI/16 | temp/16 | 2xAO/16 | 8xcount/32 | crc/16 |
```

BO - binary output – 1 represent a triggered relay
e.g. `BO/8 = 0xFE = 1111 1110` = binary output No.0 is off

BI - binary input – 1 is level H, i.e. the terminal is not tied to ground
e.g. `BI/8 = 0xCF = 1100 1111 =` bin. inputs 4 and 5 are on level 0

AI - analog inputs in order `AI0` to `AI7`

temp - analog. Temperature of the processor

AO - analog outputs in order `AO0` to `AO1`

count - counters in order `C0` to `C7`

The SEP protocol uses the MODBUS industry standard in RTU mode when communicating with the SEP unit. The reference manual of this standard can be found at www.modicon.com and therefore its description is not included in this document. The protocol does not support the whole set of MODBUS functions; only functions for work with inputs/outputs and certain types of registers are implemented.

The format of modbus commands is also given in the article "Format of MODBUS frames for MORSE" (MODBUS – format).

[1] http://www.racom.eu/eng/products/sep.html
[2] http://www.racom.eu

Area	Func	Type	Range of addr(hex)	Content
Dout	0x01	R	00-07 bit, F0 bit	Reading from binary outputs
	0x05	W	00-07 bit	Entry to binary outputs, 1 bit at a time
	0x0F	W	00-07 bit, F0 bit	Entry to binary outputs, flash lock
Dinp	0x02	R	00-07 bit	Reading from binary inputs
Ainp, Aout, Count	0x04	R	00-08 word	Reading from analog inputs
			09-0A word	Reading from analog outputs
			10-20 word	Reading the content of counters
	0x06	W	100-101 word	Entry to analog outputs
			110-130 word	Entry of init. state to counters
Flash	0x03	R	00-FF word	Reading from flash, (00-21 calibration constant)
	0x06	W	00-FF word	Entry to flash

The `0x1E` function, which simplifies communication between SEP and the higher-level system, was added to the standard functions. It simultaneously enables all SEP states to be read and the necessary outputs to be set during one poll.

2.1. Principle of operation

The higher-level processor takes on the role of the master device. The connected SEP is always the slave. This configuration is firmly fixed and cannot be altered. So, as the standard MODBUS commands, the master cyclically polls individual slaves and processes their responses.

For orientation purposes we show the structure of normal packets and the principle of CRC generation:

Query (from master):

```
|Adresa/8 |Funkce/8 |Start/16 |Number/16 |CRC/16 |
```

Response (from slave):

```
|Adresa/8 |Funkce/8 |Count/8 |Data/8x count |CRC/16 |
```

The CRC uses polynomial 0xA001. It can be generated from a table or by means of a cycle and bit rotation. Generation using a table is eight times faster than a calculation in a cycle because there is no need for rotation of each byte in bits.

2.2. Description of protocol functions

`0x01` – READ_OUTPUT_STATUS

This function serves for reading binary outputs. Address space for this function is as follows:

`Start: 0x00 - 0x07, 0xF0`
`Number:0x01 - 0x08` , at address `0xF0 1` is obligatory

These numbers represent the start address and number of required elements. It should be emphasised that the address sum and number of elements cannot exceed the highest possible address. Upon exceeding a random value outside the permitted range an `EXCEPTION_RESPONSE` is returned. This rule applies to all functions without exception.

0x02 – READ_INPUT_STATUS

This function serves for reading binary inputs. Address space for this function is as follows:

```
Start: 0x00 - 0xFF
Number:0x01 - 0x08
```

0x03 – READ_HOLD_REGS

Memory registers are read with this function. Internal flash memory, in which constants for analog inputs/outputs are stored, is also mapped into these registers. Address space for this function is as follows:

```
Start: 0x00 - 0x07
Number:0x01 - 0x08
```

0x04 – READ_INPUT_REGS

Analog inputs and counters are read with this function. Values (except for counters), returned by this function, are converted to the set range, i.e. the analog input range (e.g. 4– 20 mA) is converted to the size of the physical variable. Limits for conversion are stored in flash memory and they can be modified using program `conf.exe`. Each input can be configured separately. Counters can be set and reset. Address space for this function is as follows:

`Start: 0x00 - 0x08` – for analog inputs
`0x09 - 0x0A` – for analog outputs
`0x10 - 0x20` – for counters

Counters are read as normal 16-bit registers although their actual capacity is 32-bit. This means that it is a good idea to read at least two registers at a time (from even addresses) so that the complete contents of a counter are obtained.

It should also be emphasised that these counters have an order of bytes which is more jumbled than usual. A normal 32-bit word is organised as follows:

0	1	2	3
MSB			LSB

Example 1. state of counter 00000124 in the SEP packet in the MORSE network:

```
08:28:22.401|                |69112202 69112201|S00I   OUT   58| 89 0user
FF7E 0391 00A4 032C 02D6 0317 033D 02E3 02EE 000E 0016 0000 0000 0124 0000
                                                            ---- ----
```

As MODBUS is bit-oriented and not word-oriented the order of bytes becomes jumbled in counters. This fact should be taken into consideration in the higher level system. The order of bytes in counters now looks as follows:

3	2	1	0
LSB			MSB

Example 2. state of counter 00000124 in Modbus frame on the RS485 link:

```
08:28:22.351 tx      8 | S00
0104 0010 0010 F003
08:28:22.396 rx;i   37 | S00
0104 2024 0100 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0004 0000
       -- ---- --
```

0x05 – FORCE_SINGLE_OUT

This function serves for setting binary outputs. Address space for this function is as follows:

`Start: 0x00 - 0x07`

0x06 – FORCE_SINGLE_OUT

Memory registers can be modified with this function. Since internal flash memory is also mapped into these registers this memory needs to be unlocked by making an entry to a “special binary output“. The memory is automatically locked again after a successful entry or after 10 sec. This prevents unwanted overwriting of the constant in SEP during labouring or in the case of an unsuitably programmed master. In practice this means two acts:

- Entry of log. 1 to the reserved address 0xF0 in binary outputs, the chip acknowledges this entry in the normal manner.
- Entry of the value into flash memory. Memory is then automatically locked. Entry is again acknowledged in the normal manner.

f the flash memory is not unlocked beforehand SEP will still acknowledge that the entry is correct but will not actually do anything. The state of memory locking can also be read with a `0xF0` binary output status request. `Log. 1` signifies it is unlocked. It is not necessary to maintain the immediate order of unlocking, entry, as it is possible to insert the order of other queries between these two actions. It is only necessary to take automatic time locking into account. When setting up counters it is necessary to be aware that they are 32-bit counters and that the whole counter needs to be written to – two consecutive entries or use function `0x10`.

Address space for this function is as follows:

`Start: 0x00 - 0xFF` – for flash
`0x100 - 0x101` – for analog outputs
`0x110 - 0x130` – for counters

0x0F – FORCE_MULTIPLE_OUTS

This function can be used to advantage for setting up binary outputs. This function is able to set up all outputs according to the applied mask. Address space is as follows:

`Start: 0x00 - 0x07, 0xF0`
`Number:0x01 - 0x08,` – at address `0xF0 1` is obligatory

0x10 – RESET_MULTIPLE_REGS

This function serves for mass setting of memory registers. What applies to function 0x06 applies to this function. Address space is as follows:

`Start: 0x00 - 0xFF` – for flash
`0x100 - 0x101` – for analog outputs
`0x110 - 0x130` – for counters
`Number:0x01 - 0x08`

This function is not yet fully supported. We recommend using multiple polling of function 0x06 (FORCE_SINGLE_REG) instead.

0x1E – READ_ALL

This new function was added to the protocol for easier overall control of SEP. The query/response pair enables the reading and setting of all inputs- outputs in one communication cycle. The form of queries and responses is somewhat different from the standard so a more detailed description is given below:

```
|Adresa/8 |Funkce/8 |Bin.Out/8 |An.Out1/16 |An.Out2/16 |Rez./8 |CRC/16 |
```

The states of binary and analog outputs are contained in a query, as is obvious. Binary states form an ordinary bit mask which is copied to SEP outputs after being correctly received. Analog values are first converted according to limits from flash memory and then set to the actual outputs.

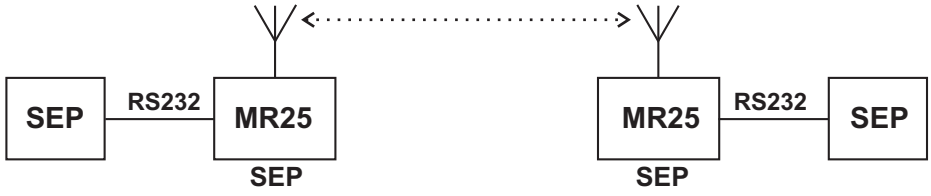
```
|Addr/8|Funkce/8|Count/8|Bin.Out/8|Bin.In/8|An.In/9x16|An.Out/2x16|CRC/16|
```

Inputs and outputs in the response are up-to-date from the instant of reading from SEP. The temperature of the AD converter chip is also contained in analog inputs (input `0x08`). Since this has a negligible temperature rise this data can be taken as the ambient temperature. This data is not converted because the unit is not designed for measuring temperature – it is up to the higher-level system how this value is handled.

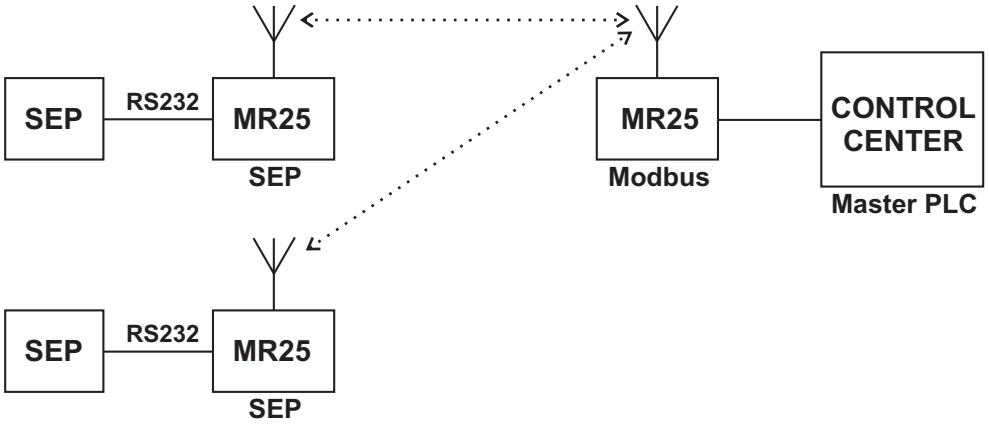
3. Implementation in Morse

SEP units can be arranged in different ways:

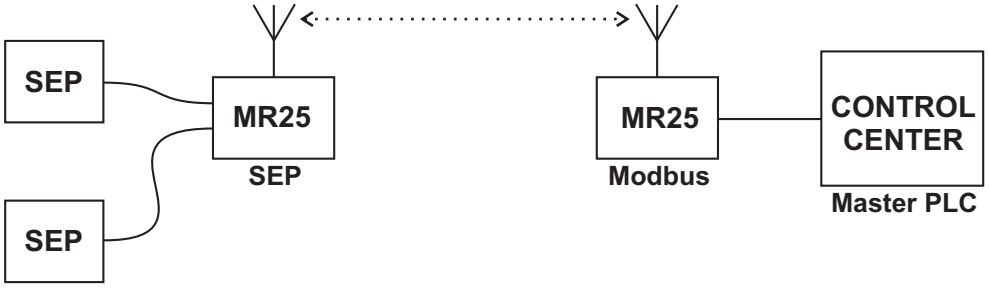
1. Connection of two SEPs via a radio link. States of inputs Dinp 0-7 and Ainp 0-1 are transferred to outputs Dout 0-7 and Aout 0-1 of the opposite station.



2. Connection of a greater number of SEPs to a control center. SEPs are Slaves and the states of their inputs Dinp 0-7 and Ainp 0-7 are transferred to the center. Outputs Dout 0-7 and Aout 0-1 are controlled from the centre.



3. Connection of 1-3 SEPs over an RS 232 link to a common MR25 with control center. Functions as in example 2.



The SEP protocol uses the following functions for communication between the CU and SEP PLC:

`04` - for reading states of counters

`1E` - for writing and reading from binary and analog inputs and outputs

The resulting record of the state of the SEP is held in the CU memory. If this record is changed so that the different is greater than set limits a SEP packet containing the current state of the SEP is sent to the opposite station or to the center.

In the case of connecting two SEPs (fig. 1 above) this state is transferred to the opposite SEP.

In the case of the center (fig. 2) the SEP packet is stored in cache memory in the central CU, where it waits for a routine query from the Master PLC, which works in the Modbus protocol. Commands from the centre are sent as Modbus commands to the CU with the SEP protocol. They are transferred from here to the SEP PLC using functions `04` and `1E`.

3.1. GROUP function

This function enables one SEP to communicate with several different opposite stations. Digital and analog inputs are divided into 8 groups:

```
Skupina:   obsahuje tyto kanály:
  No        Din  Dout  Ain  Aout
  0         0    0     0    0
  1         1    1     1    1
  2         2    2     2
```



```
3         3    3     3
4         4    4     4
5         5    5     5
6         6    6     6
7         7    7     7
```

Each group has its own target address defined in the "(g)roup parameters" menu. These addresses can only differ in the last byte. Each group has its own opposite group assigned. Addresses and groups at both ends of the radio link must be defined reciprocally; see the configuration example.

The threshold "ani" for analog inputs and "cnt" for counters are individually defined for each group. Fields (t)hr and (c)thr in the SEP parameters menu are not used in Group mode.

3.2. Communication examples

These are given in the separate article Protocol SEP for MORSE – examples.

A short example is given here only – the SEP packet and the Debug message at the parameter "(D)ebug level:1":

```
Monitoring: source 690F0002|5.
07:05:11.532  INPUTS CHANGED. SENT TO 690F0001
state: di 007F do 0002 anai0 0066 anai1 0057 anai2 0049 anai3 0057 anai4
005C anai5 0057 anai6 0049 anai7 0057 ao0 0000 ao1 000C
07:05:11.532|                 |690F0001 690F0002|S01I   OUT   58| 89 0user
027F 0066 0057 0049 0057 005C 0057 0049 0057 0045 0000 000C 0000 004C 0000
0004 0000 0000 0000 0000 0000 0000 0000 0000 0000 0019 0000 0000 8D66
```

The Debug message contains the state for Digital input, Digital output, Analog input, Analog output.

The SEP packet content:

02 - digital output

7F - digital input

0066 0057 0049 0057 005C 0057 0049 0057 – analog input 0 to 7

0045 - chip temperature

0000 000C - analog output 0 a 1

0000 004C 0000 0004 0000 0000 0000 0000 0000 0000 0000 0000 0000 0019 0000

0000 - counter states 0 až 7, counter state 0 is 0000 004C

8D66 - CRC

4. Configuration Parameters

```
SEP parameters:
p(a)rtner:690F0001h  t(i)me:60s  (p)oll:20*10 ms
net dead timeo(u)t:120s
analog (t)hr:250*10  (f)ilter:0
(c)ounter thr:2  (m)ask:FFh
init (d)igi outs value:0
i(n)it ana outs mode:all low value (0/4mA)
(N)egate digi outs mask:0h
(e)rr:SILENCE  (v)er:SEP 1.03 (old - before 11.2001)
(G)roup mode:OFF
(g)roup params
c(o)mpatibilty:OFF
for(M)at:SEP  (s)end counters:OFF
(A)out:4mA - 20mA  g(l)ue to resp:OFF
(D)ebug level:0

(T)est menu
(P)roduction
(o)ld menu (sw < 5.94)
(q)uit
>>
```

Note

each parameter should be fulfilled, the value "???" must not remain

p(a)rtner:690F0001FFh
- - address of opposite station (in SEP-SEP mode or SEP-ADIO module)
- - or address of control center (in the mode of more SEP slave stations in the network)
- - or arbitrary non-zero address, which is not contained in the connected network, e.g. 00000001 for test purposes (controlled from `(T)est` menu)
- - 3 upper bytes are used for address creating in the `(G)roup` mode

t(i)me:60s
- - transfer to the center takes place after this time irrespective of the change of measured values or the setting of threshold value
- - for `t(i)me:0s` transfer does not take place

(p)oll:20*10ms
= 200ms
interval of measuring and transfer of values between SEP and MR25, min. time is 100 ms

net dead timeo(u)t: 120s
No traffic timeout parameter. When timeout expires, outputs (digital and analog) are set to initial values according to (d) and (n). These initial values are are replaced with actual values.

analog (t)hr:250*10
= 2500
optional `0*10` až `255*10`
sensitivity threshold of analog inputs for causing message transfer to the control center; entered in the same units as it is measured, this is 10 to 2550 µA for range 0–20 000 µA
`0` – function disabled, the transfer occurs after each change

(f)ilter:3 — recomended values 1 (weak filtration) to 10 (strong filtration) filter (low-pass filter) for limiting interference by quick changes on the analog inputs
`0` – filtering disabled

(c)ounter thr:1 — sensitivity threshold of counters for causing transfer to the center, number of pulses
0 – threshold disabled, the transfer occurs after each change

(m)ask:FFh — binary inputs, whose changes should be transferred are marked with a bit mask `00-FF`. Unmarked input report a stable level L; the counter function is maintained as well as the `(c)thr` function

init (d)igi outs value:0 — The default values of digital outputs. They are also used by communication failure, see "net dead timeo(u)t:".

i(n)it ana outs mode:all low value (0/4mA) — The values of analog outputs after launch and after failure of communication. Optional:
net dead timeo(u)t:
net dead timeo(u)t:

(N)egate digi outs mask:0h — Digital outputs are negated according to the selected mask.

(e)rr:SILENCE — type of error message for a failure of SEP and higher-level system query:
- `(s) SILENCE` – no response
- `(a) ASCII` – ASCII message "sep is dead"
- `(m) NO` – last known state of SEP sent

(v)er:SEP 1.03 — Select the firmware version of the connected SEP.
- `(a)` SEP 1.03 (old - before 11.2001) = from 11/2001 and older
- `(b) SEP 1.10` (new)

(G)roup mode:OFF — Volba režimu Group
- `(o)n` – communication with addresses according to "`(g)roup params`"
- `o(f)f` – communication with "`p(a)rtner`" address

(g)roup params

```
Group processing:

(c)enter:OFF
local   threshold |      remote
group   tai  cnt  | address  group
------------------+--------------
 (0)    100  010   |   05h      1
 (1)    050  001   |   06h      0
 (2)    000  000   |   00h      0
 (3)    000  000   |   00h      0
 (4)    000  000   |   00h      0
 (5)    000  000   |   00h      0
 (6)    000  000   |   00h      0
 (7)    000  000   |   00h      0
(q)uit
>>
```

(c)enter
- `(o)n` – a copy of each message is also sent to the `p(a)rtner` address

- `o(f)f` – communication only with addresses according to "`(g)roup params`"

(0) Parameters are set individually for groups (0) to (7):

```
>>0
Group processing:
(t)hreshold:100*10
(c)ounter threshold:10
remote (a)ddress:05
remote (g)roup:1
(q)uit
>>
```

(t)hreshold:100 - sensitivity threshold of analog inputs for causing transfer

(c)ounter threshold:010 - increase in counter value for causing transfer

remote (a)ddress:05h - lower byte of opposite station address, 3 upper bytes are taken from parameter p(a)rtner; address 00h disables the group from operation

remote (g)roup:1 - number of group in the opposite station

c(o)mpatibility:OFF
- `(0) OFF` – normal settings
- `(1) BVAK` – special customer mode: parameter `p(a)rtner` is divided in two parts and contains two dst addresses for the message, 16 bit mask is used in SIe menu;

  two more words are located in the beginning of data packet, contain customer application data

for(M)at:SEP
- (s) SEP – packet into MORSE network is sent in SEP format
- (m) MTF – the packet uses the all-purpose Morse Technology Format
- (b) SEP+MTF - transmits in MTF, can receive both formats with some limitations

(s)end counters:OFF - for MTF only
- `on` – MTF packet contains aswell the state of counters
- `off` – MTF packet does not contain state of counters

(A)out:4mA - 20mA Analog input and output range (Only in MTF mode)
(4) 4mA - 20mA
(0) 0mA - 20mA

g(l)ue to resp:OFF glue content of cache to transparent responses

(D)ebug level:1
- 0 – the Debug message is not generated
- 1 – the Debug message containing the I/O state is sent to the address according menu "`ise1`"

(T)est menu – Used for test purposes


```
Test:
Bin(O)ut  (A)n out  (G)et values (C)ounters
(q)uit
>>
```

Bin(O)ut (A)n out — Insertion of values of binary and analog outputs

(G)et values
- - simultaneous reading of all monitored inputs (an.inp: 08 contain the chip temperature, an.out: 00, 01 are analog inputs monitoring value An.out 0,1)
- - the last sent values are displayed, no the current state

```
>>
output: 0x00
input:  0x00
an.inp: 00 | 0000
an.inp: 01 | 0000
an.inp: 02 | 0000
an.inp: 03 | 0000
an.inp: 04 | 0000
an.inp: 05 | 0000
an.inp: 06 | 0000
an.inp: 07 | 0000
an.inp: 08 | 0000
an.out: 00 | 0000
an.out: 01 | 0000
>>
```

(C)ounters
- - simultaneous reading of all counters (numbers of rising edges on binary inputs)
- - the last sent values are displayed, no the current state

```
counter: 00 | 0
counter: 01 | 0
counter: 02 | 0
counter: 03 | 0
counter: 04 | 0
counter: 05 | 0
counter: 06 | 0
counter: 07 | 0
>>
```

(P)roduction — - only for servicing purposes

5. History

```
Applies for fw 10.0.10.0
```