Installation of several FG-SYS on one site.
Supervising the FG-SYS control panels using MODBUS or JBUS

1. General

The supervision of the digital FG-SYS units is achieved using the MODBUS protocol and the serial link RS232C or RS422/485. The MODBUS protocol, of type master-slave, was developed to establish a supervision of several devices (the slaves) by one or more masters connected to the same physical support (electrical, optical, radio, etc.) and all the supervised devices are simply connected in parallel, using different slave numbers. The communication is always point-to-point, type question-answer, with only one device using the connexion line at a time.
The user of our digital FG-SYS unit could configure slave numbers from 1 to 99 and thus the simultaneous connection of several central units to existing communication line is easy and very simple to do.

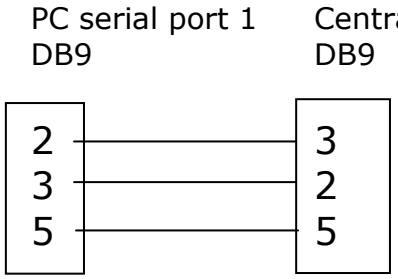
The electrical connection between the BMS and the supervised central units is based on the PC's serial port and the serial interface of the FG-SYS central unit. The use of the MODBUS protocol permits downloading all the useful information from the central units to the BMS and the association of the digital data about the liquid leaks with a pin-pointing representation of the alarms on the map of the supervised area.
For one central unit and for short serial link (up to 60 m), it is recommended to use the RS232C interface implemented on both the FG-SYS central units and virtually all BMS. If connection of several central units on the same communication link is desired, and for long distances between the supervisor (BMS) and the unit(s), the use of RS422 or RS485 is compulsory. Both these interfaces are implemented on the FG-SYS central units. These serial interfaces are not common on the computers or the workstations, so it will be necessary to use RS232C/RS422(or /RS485) converter connected with very short RS232C cable (< 1-2 m) to the computer. The cable (of type RS422) between the converter and the central unit(s) should have characteristic impedance of about 120 Ohms and the total length of this cable shouldn't exceed 1000 m.

It is also possible to use a digital 4-20 mA or fiber-optic interfaces with an appropriate converter.

Remark: *All definitions related to MODBUS in this document also apply also for JBUS-compatible devices. The FG-SYS panels are fully compatible with both MODBUS and JBUS.*

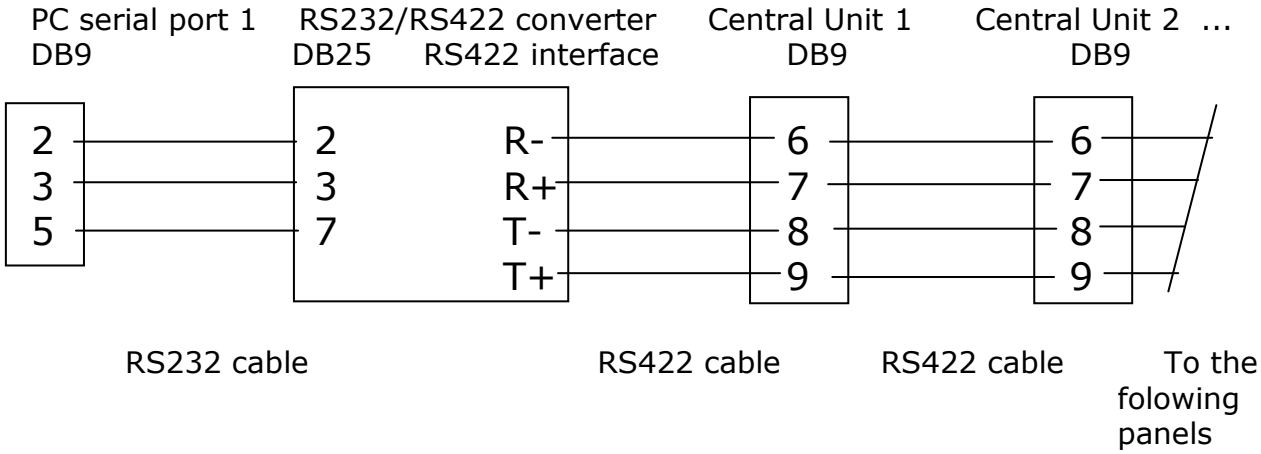
2. Electrical connections

2.1 For one central unit:

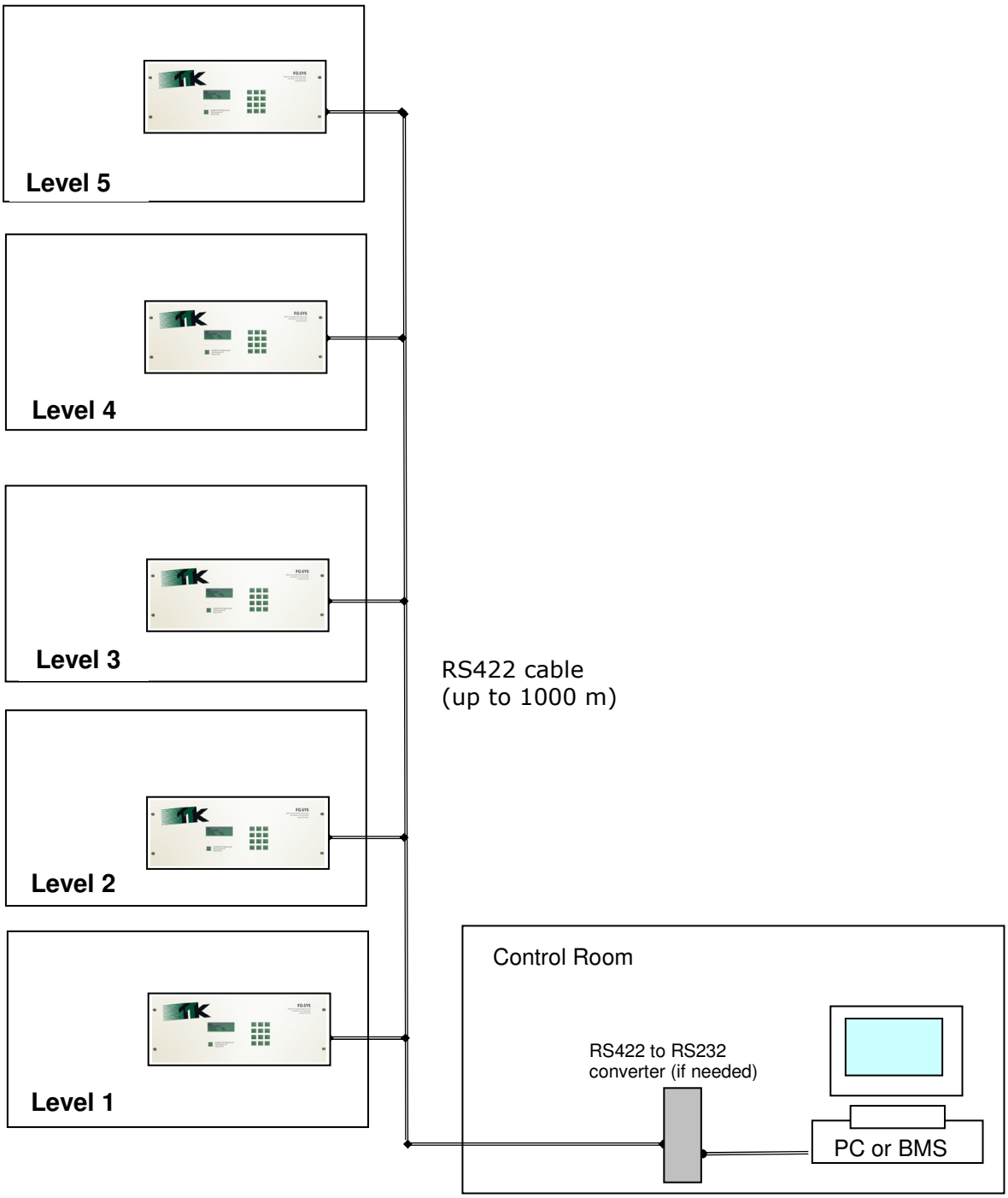


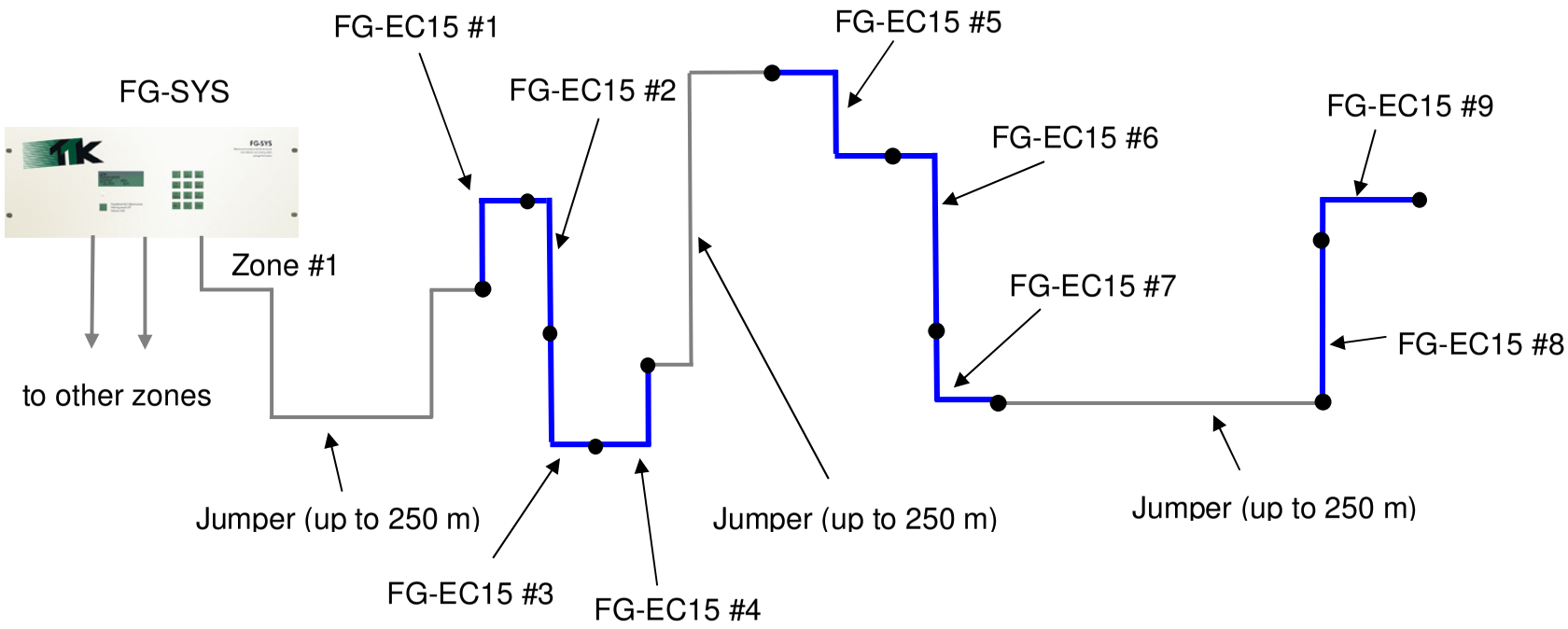
RS232 cable

2.2 For several central units or long connection:



3. Physical representation of a sample site with FG-SYS panels installed on 5 levels and connected to the same supervisor





Detail of the installation of FG-SYS on one level

Remarks:

1. The jumper cable should be Belden 8723 shielded cable or equivalent. The maximum distance for any connection with jumper is 250 m.
2. The total length of the installed cables (sensing plus jumper) per zone should not exceed 2000 m.

4. MODBUS dialogue between the supervisor and the digital FG-SYS units

The implemented on the FG-SYS central units MODBUS protocol permits the supervision of the current status of all the connected sense cables. The two types of alarms – leak and cable break – are coded using different flags and the location is represented as a half-byte. The use of this alarm coding is very easy as there is virtually no need for any treatment on the data, if the needed location of the leaks is not very critical (up to a certain sensing cable), the pin-pointing of each alarm is simply the control of the state of a flag.
The physical support of the MODBUS for both serial outputs 1 and 2 is serial interface type RS232C or RS422/485. The simultaneous use of both interfaces is impossible and the switching between them is automatic. With an appropriate converter, a 4-20 mA or fiber-optic interfaces could be used.
The link is asynchronous and the parameters are the following:

Electrical connections on the DB9:	*RS232C: 2 - RxD, 3 - TxD, 5 - Ground;* *RS422/485: 6- Rx-, 7- Rx+, 8– Tx-, 9– Tx+;*
Serial port configuration:	*9600 B, 8 data bits, 1 stop bit, no parity;*
Communication protocol:	*MODBUS or JBUS, functions 3 or 4;*
Slave number:	*1 to 99 (definition available to the user);*
Maximum number of read words:	*16 (or 32 bytes);*
Fault zone in the memory:	
Zone 1:	*61 bytes from address 07A0h;*
Zone 2:	*61 bytes from address 0FA0h;*
Zone 3:	*61 bytes from address 17A0h;*
Bytes distribution per circuit:	*1 byte per sensing cable (60 max.) +* *1 byte for the termination;*
Alarms coding in the byte:	*MSB LSB*
Normal operation:	*0 0 0 0 0 0 0 0 ;*
Cable break:	*1 0 0 0 0 0 0 x (0 ou 1);*
Leak:	*0 0 0 1 x x x x, where xxxx is the leak location in metres (0 – 15 in binary code);*

Format of the answer:

slave number	*function*	*num. of bytes read*	*byte 1*	*byte 2*	…	*byte n*	*CRC 16*
/ 1, 2, …, 99	*/ 3 or 4*	*/ up to 32*	*/ XXh*	*/ XXh*	*/ …*	*/ XXh*	*/ XXXXh /*

Remarks:

*The byte for the termination can code only cable breaks. For a circuit of **N** cables, the user needs to read **N+1 bytes** (N bytes for the sense cables + 1 byte for the termination).*

For the RS485 serial link it is necessary to connect Rx+ with Tx+ and Rx- with Tx-. In addition, the transmission line should be terminated by a 120 Ohms/1W resistor. The shield of the data transmission cable should be connected to the supervisor's ground.

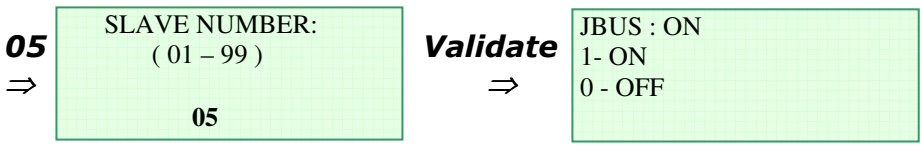
It is recommended to leave at least 200 ms between the successive requests.

Caution! Please note that in the answer the bytes 1, 3, 5, 7, etc. are placed in the MSB part of the word, and the bytes 2, 4, 6, 8, etc. – in the LSB.
Caution! The simultaneous use of both RS232C and RS422/485 interfaces will destruct the serial interface of the FG-SYS central unit. Before use, please check that the data communication cable is connected only to the used points of the DB9 connector:
- 2, 3 and 5 for RS232C;
- 6, 7, 8 and 9 for RS422/485.

The MODBUS (or JBUS) is activated using the configuration menu of the central unit. As the serial interface is used for several functions, the use of the MODBUS should be activated prior to its use. The chosen option deactivates automatically the others.

It is necessary to define the slave number when using MODBUS:

- Define the slave number for the MODBUS protocol, for example number 5:



The left key on the front panel of the FG-SYS central unit is used to validate the chosen serial communication option.

5. Example of implementation of MODBUS dialogue with FG-SYS unit

The example below will explain a typical installation of one FG-SYS connected to 62 sensing cable FG-EC15. The sensing cables are connected to circuits No.1 and No.2 and the associated in 6 different zones as shown below:

Circuit No.1:
- zone Server Room: Cables 001 to 009
- zone Data Storage: Cables 010 to 026
- zone UPS Room: Cables 027 to 037
- zone Battery Room: Cables 038 to 040

Circuit No.2:
- zone Chilled Water Pipes: Cables 061 to 073
- zone Hot Water Pipes: Cables 074 to 082

The BMS supervision will be organised using Modbus function 03 – Reading of N words, where N is comprised between 1 and 16. The FG-SYS has the sensing cables coded in one byte and for reading the status of all the cables, all useful bytes shall be read. As the Modbus has words (two-bytes) organisation, one read word will contain the information for two sensing cables.
The address of each sensing cable depends on the physical location of this cable along the circuit. The memory block is organised as bytes and both pair and impair addresses can be used. However, to obtain a valid word, the start address for Modbus function 03 requests shall be word-aligned using only pair addresses.

A special attention shall be paid to the bytes reads from FG-SYS. As FG-SYS memory is byte-based but Modbus is word-oriented, during data transfer the MSB and LSB bytes will be reversed and a byte swap in each Modbus word shall be performed. The regular Modbus answer frame to Function 03 request is:

Word 1		Word 2		Word 3		Word 4		Word 5		…
MSB byte	LSB byte	MSB byte	LSB byte	MSB byte	LSB byte	MSB byte	LSB byte	MSB byte	LSB byte	…

Modbus answer of FG-SYS is the following:

Word 1		Word 2		Word 3		Word 4		Word 5		…
LSB byte	MSB byte	LSB byte	MSB byte	LSB byte	MSB byte	LSB byte	MSB byte	LSB byte	MSB byte	…

The reader will note that there are two cables coded in each word and the byte swapping between MSB and LSB, to be taken into account during BMS programming.

For example, reading 5 words from address 07A0h will return the following result:

Word 1		Word 2		Word 3		Word 4		Word 5	
Cable 001	Cable 002	Cable 003	Cable 004	Cable 005	Cable 006	Cable 007	Cable 008	Cable 009	Cable 010

The table below depicts this example installation details:

Circuit	Zone Name	Address	Cable Number	Length	Cable Name
Circuit 1	Server Room	07A0h	001	15 m	001-SERVER ROOM
Circuit 1	Server Room	07A1h	002	15 m	002-SERVER ROOM
Circuit 1	Server Room	07A2h	003	15 m	003-SERVER ROOM
Circuit 1	Server Room	07A3h	004	15 m	004-SERVER ROOM
Circuit 1	Server Room	07A4h	005	15 m	005-SERVER ROOM
Circuit 1	Server Room	07A5h	006	15 m	006-SERVER ROOM
Circuit 1	Server Room	07A6h	007	15 m	007-SERVER ROOM
Circuit 1	Server Room	07A7h	008	15 m	008-SERVER ROOM
Circuit 1	Server Room	07A8h	009	15 m	009-SERVER ROOM
Circuit 1	Data Storage	07A9h	010	15 m	010-DATA STORAGE
Circuit 1	Data Storage	07AAh	011	15 m	011-DATA STORAGE
Circuit 1	Data Storage	07ABh	012	15 m	012-DATA STORAGE
Circuit 1	Data Storage	07ACh	013	15 m	013-DATA STORAGE
Circuit 1	Data Storage	07ADh	014	15 m	014-DATA STORAGE
Circuit 1	Data Storage	07AEh	015	15 m	015-DATA STORAGE
Circuit 1	Data Storage	07AFh	016	15 m	016-DATA STORAGE
Circuit 1	Data Storage	07B0h	017	15 m	017-DATA STORAGE
Circuit 1	Data Storage	07B1h	018	15 m	018-DATA STORAGE
Circuit 1	Data Storage	07B2h	019	15 m	019-DATA STORAGE
Circuit 1	Data Storage	07B3h	020	15 m	020-DATA STORAGE
Circuit 1	Data Storage	07B4h	021	15 m	021-DATA STORAGE
Circuit 1	Data Storage	07B5h	022	15 m	022-DATA STORAGE
Circuit 1	Data Storage	07B6h	023	15 m	023-DATA STORAGE
Circuit 1	Data Storage	07B7h	024	15 m	024-DATA STORAGE
Circuit 1	Data Storage	07B8h	025	15 m	025-DATA STORAGE
Circuit 1	Data Storage	07B9h	026	15 m	026-DATA STORAGE
Circuit 1	UPS Room	07BAh	027	15 m	027-UPS ROOM
Circuit 1	UPS Room	07BBh	028	15 m	028-UPS ROOM
Circuit 1	UPS Room	07BCh	029	15 m	029-UPS ROOM
Circuit 1	UPS Room	07BDh	030	15 m	030-UPS ROOM
Circuit 1	UPS Room	07BEh	031	15 m	031-UPS ROOM
Circuit 1	UPS Room	07BFh	032	15 m	032-UPS ROOM
Circuit 1	UPS Room	07C0h	033	15 m	033-UPS ROOM
Circuit 1	UPS Room	07C1h	034	15 m	034-UPS ROOM
Circuit 1	UPS Room	07C2h	035	15 m	035-UPS ROOM
Circuit 1	UPS Room	07C3h	036	15 m	036-UPS ROOM
Circuit 1	UPS Room	07C4h	037	15 m	037-UPS ROOM
Circuit 1	Battery Room	07C5h	038	15 m	038-BATTERY ROOM
Circuit 1	Battery Room	07C6h	039	15 m	039-BATTERY ROOM

Circuit 1	Battery Room	07C7h	040	15 m	040-BATTERY ROOM
Circuit 1	Battery Room	07C8h	End terminator	-	041-BATTERY ROOM
Circuit 1	-	07C9h	Not Used	-	-
Circuit 1	-	07CAh - 07DDh	Not Used	-	-
				-	
Circuit 2	Chilled Water Pipes	0FA0h	061	15 m	061-CHILL WATER PIPE
Circuit 2	Chilled Water Pipes	0FA1h	062	15 m	062-CHILL WATER PIPE
Circuit 2	Chilled Water Pipes	0FA2h	063	15 m	063-CHILL WATER PIPE
Circuit 2	Chilled Water Pipes	0FA3h	064	15 m	064-CHILL WATER PIPE
Circuit 2	Chilled Water Pipes	0FA4h	065	15 m	065-CHILL WATER PIPE
Circuit 2	Chilled Water Pipes	0FA5h	066	15 m	066-CHILL WATER PIPE
Circuit 2	Chilled Water Pipes	0FA6h	067	15 m	067-CHILL WATER PIPE
Circuit 2	Chilled Water Pipes	0FA7h	068	15 m	068-CHILL WATER PIPE
Circuit 2	Chilled Water Pipes	0FA8h	069	15 m	069-CHILL WATER PIPE
Circuit 2	Chilled Water Pipes	0FA9h	070	15 m	070-CHILL WATER PIPE
Circuit 2	Chilled Water Pipes	0FAAh	071	15 m	071-CHILL WATER PIPE
Circuit 2	Chilled Water Pipes	0FABh	072	15 m	072-CHILL WATER PIPE
Circuit 2	Chilled Water Pipes	0FACh	073	15 m	073-CHILL WATER PIPE
Circuit 2	Hot Water Pipes	0FADh	074	15 m	074-HOT WATER PIPE
Circuit 2	Hot Water Pipes	0FAEh	075	15 m	075-HOT WATER PIPE
Circuit 2	Hot Water Pipes	0FAFh	076	15 m	076-HOT WATER PIPE
Circuit 2	Hot Water Pipes	0FB0h	077	15 m	077-HOT WATER PIPE
Circuit 2	Hot Water Pipes	0FB1h	078	15 m	078-HOT WATER PIPE
Circuit 2	Hot Water Pipes	0FB2h	079	15 m	079-HOT WATER PIPE
Circuit 2	Hot Water Pipes	0FB3h	080	15 m	080-HOT WATER PIPE
Circuit 2	Hot Water Pipes	0FB4h	081	15 m	081-HOT WATER PIPE
Circuit 2	Hot Water Pipes	0FB5h	082	15 m	082-HOT WATER PIPE
Circuit 2	Hot Water Pipes	0FB6h	End terminator	-	083-HOT WATER PIPE
Circuit 2	-	0FB7h	Not Used	-	-
Circuit 2	-	0FB8h-0FDDh	Not Used	-	-
Circuit 3	Not Used	17A0h - 17DDh	Not Used	-	-

To cover the complete network of sensing cables of the above example installation, the BMS shall read all the bytes listed above. There is a limitation of 16 words (32 bytes) of maximum length of Modbus answer, so the Modbus Function 03 requests shall be set up as follows:

Request 1: Reading 16 words from address **07A0h** (it will cover cables 001 to 032)
Request 2: Reading 5 words from address **07C0h** (it will cover cables 033 to 042)
Request 3: Reading 12 words from address **0FA0h** (it will cover cables 061 to 084)

The data stored in BMS can be represented by the following table showing sensing cable correspondence with the values of the table:

Request	Word read from FG-SYS	
Request 1	Cable 001	Cable 002
Request 1	Cable 003	Cable 004
Request 1	Cable 005	Cable 006
Request 1	Cable 007	Cable 008
Request 1	Cable 009	Cable 010
Request 1	Cable 011	Cable 012
Request 1	Cable 013	Cable 014
Request 1	Cable 015	Cable 016
Request 1	Cable 017	Cable 018
Request 1	Cable 019	Cable 020
Request 1	Cable 021	Cable 022
Request 1	Cable 023	Cable 024
Request 1	Cable 025	Cable 026
Request 1	Cable 027	Cable 028
Request 1	Cable 029	Cable 030
Request 1	Cable 031	Cable 032
Request 2	Cable 033	Cable 034
Request 2	Cable 035	Cable 036
Request 2	Cable 037	Cable 038
Request 2	Cable 039	Cable 040
Request 2	End term.	Not used
Request 3	Cable 061	Cable 062
Request 3	Cable 063	Cable 064
Request 3	Cable 065	Cable 066
Request 3	Cable 067	Cable 068
Request 3	Cable 069	Cable 070
Request 3	Cable 071	Cable 072
Request 3	Cable 073	Cable 074
Request 3	Cable 075	Cable 076
Request 3	Cable 077	Cable 078
Request 3	Cable 079	Cable 080
Request 3	Cable 081	Cable 082
Request 3	End term.	Not Used

This same table but with numeric value, after successful reading of the used bytes and no present alarm will have the following values:

Request	Word (in decimal)	Word (in hexadecimal)	Word (in binary)	
Request 1	0	0x0000	00000000	00000000
Request 1	0	0x0000	00000000	00000000
Request 1	0	0x0000	00000000	00000000
Request 1	0	0x0000	00000000	00000000
Request 1	0	0x0000	00000000	00000000
Request 1	0	0x0000	00000000	00000000
Request 1	0	0x0000	00000000	00000000
Request 1	0	0x0000	00000000	00000000
Request 1	0	0x0000	00000000	00000000
Request 1	0	0x0000	00000000	00000000
Request 1	0	0x0000	00000000	00000000
Request 1	0	0x0000	00000000	00000000
Request 1	0	0x0000	00000000	00000000
Request 1	0	0x0000	00000000	00000000
Request 1	0	0x0000	00000000	00000000
Request 1	0	0x0000	00000000	00000000
Request 2	0	0x0000	00000000	00000000
Request 2	0	0x0000	00000000	00000000
Request 2	0	0x0000	00000000	00000000
Request 2	0	0x0000	00000000	00000000
Request 2	0	0x0000	00000000	00000000
Request 3	0	0x0000	00000000	00000000
Request 3	0	0x0000	00000000	00000000
Request 3	0	0x0000	00000000	00000000
Request 3	0	0x0000	00000000	00000000
Request 3	0	0x0000	00000000	00000000
Request 3	0	0x0000	00000000	00000000
Request 3	0	0x0000	00000000	00000000
Request 3	0	0x0000	00000000	00000000
Request 3	0	0x0000	00000000	00000000
Request 3	0	0x0000	00000000	00000000
Request 3	0	0x0000	00000000	00000000
Request 3	0	0x0000	00000000	00000000

Now let's simulate **leak at 10 m on cable 001, leak at 5 m on cable 005, leak at 15 m on cable 006, leak at 1 m on cable 065 and cable breaks at 0 m on end terminator of circuit 1 and cable 080. We will also assume that the sensing wires of cable 074 are broken and a cable break at 1 m** on this cable is displayed on FG-SYS panel. After detecting and displaying of all the alarms on the LCD of FG-SYS, BMS table will contain the following values in the table after performing the Modbus requests 1, 2 and 3:

Request	Word (in decimal)	Word (in hexadecimal)	Word (in binary)	
Request 1	6 656	0x1A00	00011010	00000000
Request 1	0	0x0000	00000000	00000000
Request 1	5 407	0x151F	00010101	00011111
Request 1	0	0x0000	00000000	00000000
Request 1	0	0x0000	00000000	00000000
Request 1	0	0x0000	00000000	00000000
Request 1	0	0x0000	00000000	00000000
Request 1	0	0x0000	00000000	00000000
Request 1	0	0x0000	00000000	00000000
Request 1	0	0x0000	00000000	00000000
Request 1	0	0x0000	00000000	00000000
Request 1	0	0x0000	00000000	00000000
Request 1	0	0x0000	00000000	00000000
Request 1	0	0x0000	00000000	00000000
Request 1	0	0x0000	00000000	00000000
Request 1	0	0x0000	00000000	00000000
Request 2	0	0x0000	00000000	00000000
Request 2	0	0x0000	00000000	00000000
Request 2	0	0x0000	00000000	00000000
Request 2	0	0x0000	00000000	00000000
Request 2	32 768	0x8000	10000000	00000000
Request 3	0	0x0000	00000000	00000000
Request 3	0	0x0000	00000000	00000000
Request 3	4 352	0x1100	00010001	00000000
Request 3	0	0x0000	00000000	00000000
Request 3	0	0x0000	00000000	00000000
Request 3	0	0x0000	00000000	00000000
Request 3	129	0x0081	00000000	10000001
Request 3	0	0x0000	00000000	00000000
Request 3	0	0x0000	00000000	00000000
Request 3	128	0x0080	00000000	10000000
Request 3	0	0x0000	00000000	00000000
Request 3	0	0x0000	00000000	00000000

We invite the reader to read page 5 of this document for more information on the alarm coding of FG-SYS.

After removing all the alarm conditions, the BMS will read only zeros as shown in the table on page 11.