Principles of RS485 interface usage

Abstract

Principles of RS485 network designing and connecting for AMiT control systems communication.

Author: Zbyněk Říha
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Appendix

File contents: –

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Contents

History of revisions

Revision	Date	Changes
001	4. 8. 2008	New document
002	7. 5. 2010	New chapter “5 Appendix A”

Related documentation

1. **232TO485PC A** – converter datasheet
   file: 2to4pc_d_en_xxx.pdf
2. **DM-232TO485** – converter datasheet
   file: dm-2to4_d_en_xxx.pdf
3. **DM-485TO485** – repeater datasheet
   file: dm-4to4_d_en_xxx.pdf

1 Used terms definition

Unit
Any control system, personal computer, expansion I/O module or any other device connected to the RS485 network.

Segment
Part of the RS485 network between two repeaters or two terminal units with connected idle state definition and terminating resistors (see below).

Network
It is composed of at least one or more segments. Terminating resistors and idle state definition are connected at both ends of each segment.

Rz
This designation (written in figures) suggests the necessity of terminating resistors and idle state definition conection on RS485 network.

1.1 RS485 network

Following figure shows a block diagram of RS485 network topology.

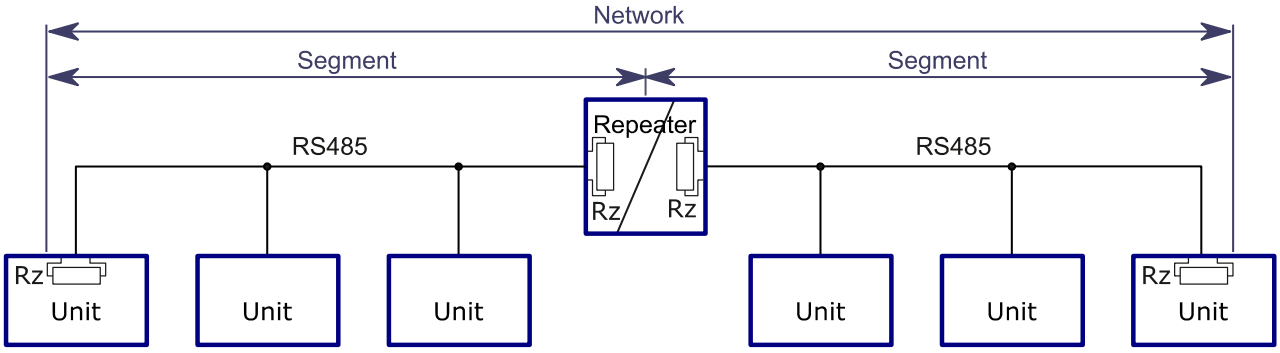

Fig. 1 – Block diagram of RS485 network topology

2 RS485 interface usage

Almost all AMiT control systems are / can be equipped (using the appropriate modules or converters) with RS485 interface. This interface is suitable for communication networks designing or point – to – point communication on longer distances in industrial environment.

RS485 interface in AMiT control systems is mainly used for
- multiple control system connection into network,
- various expansion modules connection to control systems,
- serial terminal connection.

2.1 Communication speed

The maximum cable length of RS485 network segment depends on the communication speed. The following table shows recommended maximum cable lengths in accordance to communication speed.

Communication speed [Bd]	Maximum cable length [m]
19 200	1200
38 400	600
57 600	300
115 200	150

The maximum cable length (seen above) can be used only in case that all principles mentioned in this document are complied.

If the communication speed is lower than 19 200 Bd, it is not recommended to use longer cable than 1200 m.

When it is necessary to communicate over longer distances (mentioned above), network must be divided into more segments. Each of them must comply with the principles mentioned in this document.

AMiT communication protocols allow 9600 to 115200 Bd communication speed on RS485 network (usability of these speeds depends on protocol type, control system type and NOS operating system version).

2.2 Number of units on network

The number of units on the network depends on used protocol (SW limitation) and technical parameters of connected units (HW limitation).

Generally, maximum number of units connected to individual segment is 32 (HW limitation). This number is given by technical parameters of the RS485 interface transcievers in used units. Special transcievers can be used to allow 64, 128 or 256 units on individual segment. Information about possible number of units connected to individual segment is mentioned in technical parameters of units.

AMiT products allows maximum of 32 units on individual segment, unless mentioned otherwise. When it is necessary to communicate with more units in one network or on longer distances, RS485 network must be divided into several segments. RS485 repeater, e.g. **DM-485TO485** can be used for segment separation (for more information, see chapter “3.7 RS485 repeaters”).

The maximum number of units on the network for AMiT protocols (SW limitation):
- DB-Net (CS AMiT) up to 32 units on the network (not necessary to divide into several segments).
- ARION (DM-xxx units) up to 64 units on the network (if used units do not support connection of more than 32 units per segment, it is necessary to divide the network into two segments at least).

- ASIMP (**REFACO**) up to 256 units on the network (if used units do not support connection of more than 32 units per segment, it is necessary to divide the network into corresponding number of segments).

3 Network connection

3.1 Network topology

3.1.1 Point – to – Point

In specific cases it is required to connect only two units through RS485. This is the point – to – point connection and can be used for, e.g.:

- two unit connections in case that RS232 interface is occupied,
- two unit connections for longer distances,
- terminal connection to control system.

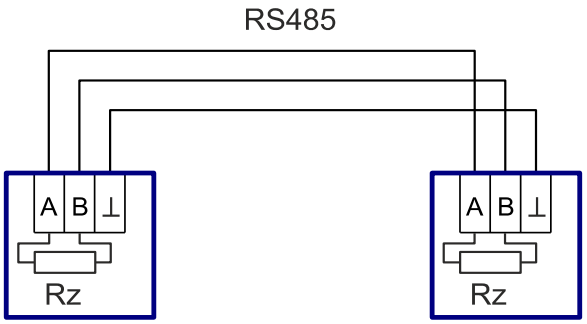

Fig. 2 – RS485 using Point – to – Point topology

Note
Although several devices are commonly connected into RS485 network, terminal connection through RS485 is considered as Point – to – Point topology. It is necessary to use this topology for terminals that do not support addressing.

Terminating resistors and idle state definition must be connected on both units in Point – to – Point topology.

3.1.2 Multiple units

RS485 network must have a line structure with two terminal units. Other (intermediate) units must be connected to this line ideally without branches. In case that these branches lead from the main line to intermediate units, their lenghts must be up to 3 m. Each branch (T segment) can only lead to single unit. The units connected through branches are not considered as terminal.

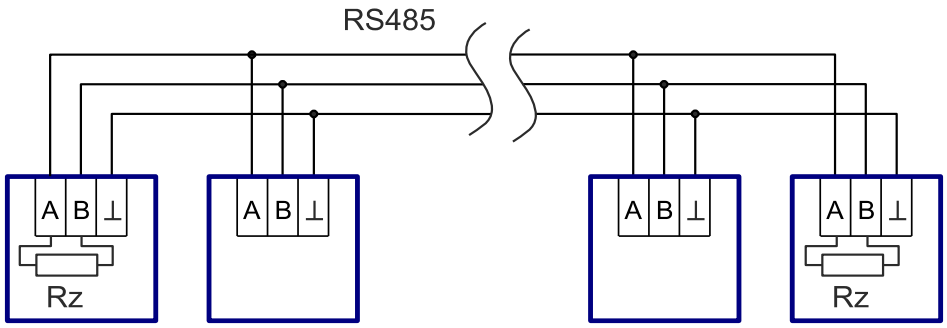

Fig. 3 – Multiple units connection through RS485 into network

It is necessary to connect terminating resistors and idle state definition on the terminal units. This definition must not be used for intermediate units (see chapter “3.6 Terminating resistors and idle state definitions”).

3.2 Cabling

It is recommended to use the following cable type: twisted shielded pair of wires, wire cross section in range of 0.35 to 0.8 mm^2 with impedance near 120 Ω ±20 %. Specially designed cables for RS485 network are an ideal solution.

It is also possible to use structured cabling, e.g. STP CAT5 or higher.

SYKFY 2x2 (3x2) cables are less appropriate but usable as well.

It is recommended to realize RS485 network wiring always by shielded cable. The wiring requires compliance with the principles written in chapter “3.4 Cable shielding connection in RS485 network”.

It is appropriate to install system in a metal switchboard and strong interference sources (e.g. inverters) outside the switchboard in case problems with communication appear due to strong interference.

3.3 Galvanic isolation

Most AMiT products with RS485 interface have galvanically isolated communication circuits (information can be found in product manual or datasheet).

Attention
Galvanic isolation does not increase network reliability.

3.4 Cable shielding connection in RS485 network

Ground potential in interface electronics (negative supply terminal) of all units (connected to network) must not be different by more than 10 V. To ensure a correct function (low error communication speed) this voltage must be even smaller (1 to 2 V). Therefore, cable shielding is also used to connect unit “working” grounds with galvanically isolated communication part. Cable shielding should be connected to the shielding terminal of RS485 interface connector and it is connected to switchboard’s PE terminals (direct earthing) only at a single point of network segment The shielding is connected to switchboard’s PE terminals over lightning arrester (indirect earthing) in other connecting points.

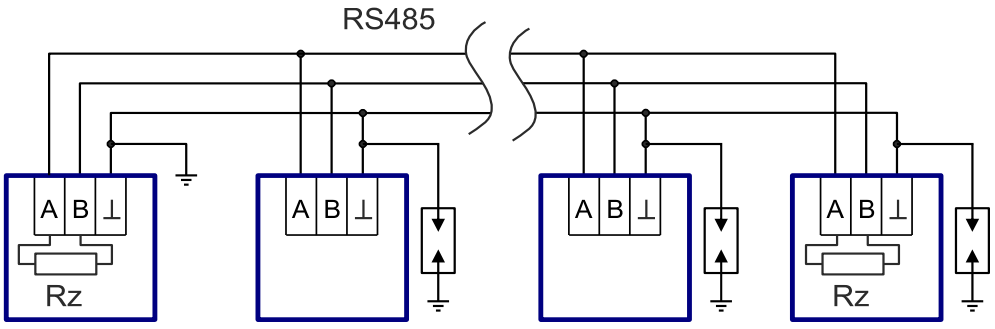

Fig. 4 – Cable shielding wiring in RS485 network

If there are two switchboards with well-connected PE terminals that need to communicate on close range, it is possible to connect communication cable shielding to local PE terminals in both switchboards. These conditions can be checked before communication connection by voltmeter that measures voltage between both switchboard’s PE terminals. Idle voltage must not be larger than 2 V DC / AC. Differential voltage can be also reduced by additional connection using higher

cross section cable (green-yellow). In any case, this is not a universal solution. It is necessary to evaluate local installation conditions frequency and character of error states in technology located in communication wires area.

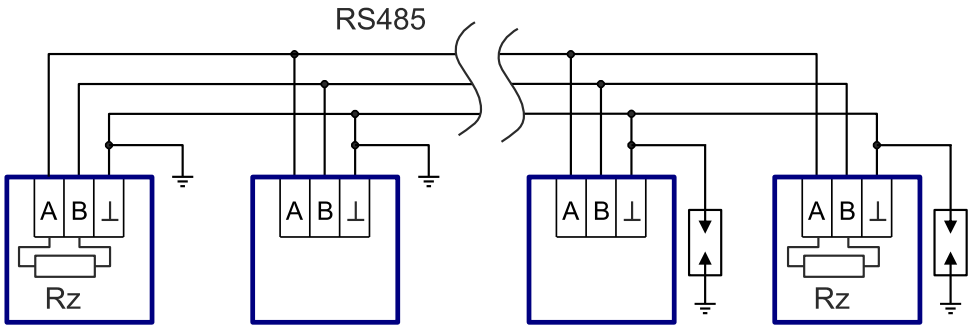

Fig. 5 – Voltage difference lower than 2 V between PE terminals wiring

DM-485TO485 repeater must be used for galvanic isolation when the switchboard's PE terminals are not connected as well.

If only one device without galvanic isolation is presented in network, local PE terminal is selected as basic reference ground of communication network.

Suggested lighting arresters are

- **H90LB** Producer Hakel spol. s r.o.

Note

Industrial networks may generate surprisingly high voltage between "working" grounds of individual network nodes even in normal state conditions. Electrical transient types: high powered devices switching ON/OFF, overloaded circuit breakers switching OFF, lightning strike to a nearby lightning protection system, etc. can cause large number of interface circuit destructions in not correctly constructed networks. In this case electronic fatigue damage should be also mentioned. The "correct" disturbance size may not destroy the electronics immediately but over time. Therefore, RS485 interface circuits of the most AMiT products are galvanically isolated from communicating device ground as well as they are also equipped with soft protection circuitry.

3.5 Surge protectors (surge protections)

Generally, it is necessary to protect communication network with surge protector in case this network leads out of one lightning protection system.

3.5.1 Surge protector types

Surge protector can by constructed as individual device containing one or more surge protectors (poles). They are generally mounted on DIN rail and shape-adapted to other installed devices, e.g. circuit breakers, protectors etc. Type 3 surge protectors can be designed as built-in. It is intended to be mounted into protected devices. They are also placed directly into installation boxes or sockets – surge protections of network and data distribution can be placed here together. Type 3 surge protectors combined with high-frequency filter are also offered.

Reccomended surge protectors for RS485

- **DTB 485** surge protector, on-wall mounting. Producer Hakel spol. s r.o.
- **DTE 485** surge protector, DIN rail mounting. Producer Hakel spol. s r.o.
- **DM-006/1 R DJ** surge protector, DIN rail mounting, direct earthing. Producer SALTEK spol. s r.o.
- **DM-006/1 3R DJ** surge protector for DIN rail mounting, indirect earthing. Producer SALTEK spol. s r.o.

3.5.2 Surge protector wiring

The following figure shows RS485 network wiring with surge protectors.

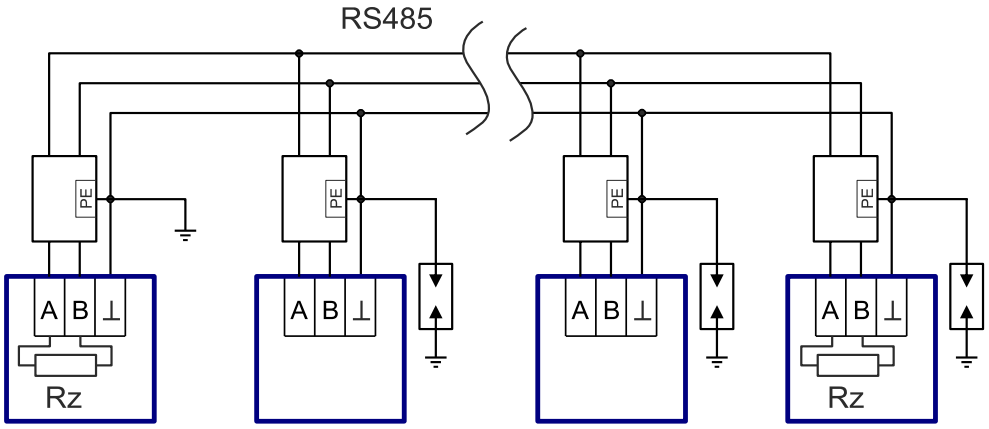

Fig. 6 – RS485 network with surge protectors – CORRECT WIRING

Attention

In case that indirectly earthed surge protectors are used, G485 terminal with connected shielding (part of RS485 interface) must be also indirectly earthed (see "Fig. 6"). If this condition is not fulfilled, serious damage not only on the control system side can happen (see "Appendix A").

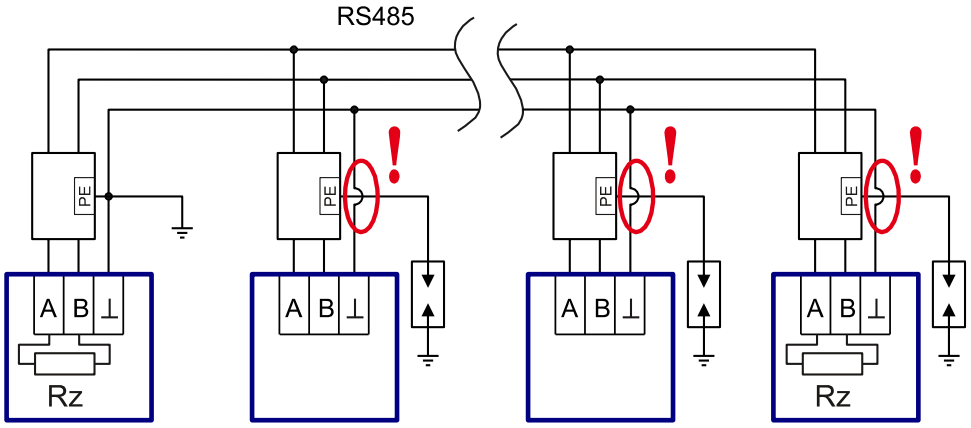

Fig. 7 – RS485 network with surge protectors – INCORRECT WIRING

3.6 Terminating resistors and idle state definitions

Impedance must be matched at the wiring ends of RS485 communication network to avoid reflections. Therefore, it is necessary to place **terminating resistors** with a value closed to the characteristic impedance (typically 120 Ω ±20 %) **on terminal units. This definition must not be used for intermediate units** – can cause interface circuitry overloading in larger networks.

It is possible that there are not any problems in short distance or low speed communication even without terminating resistors. Terminating resistor wiring is still necessary in this case.

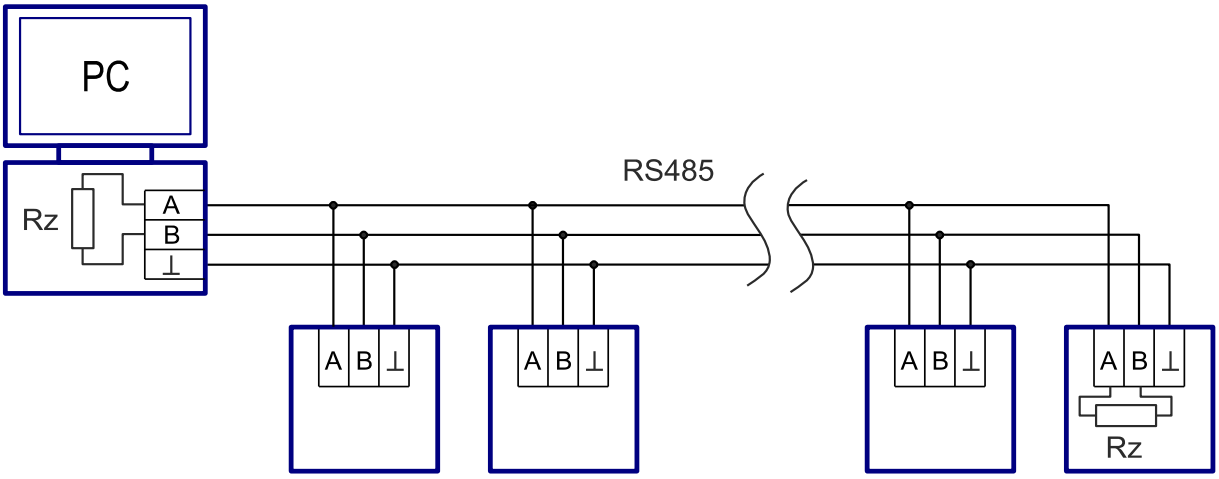

Fig. 8 – Terminating resistor wiring

If no device is active on RS485 network, all devices are in high impedance state and data cable is ended by terminating resistors. The differential voltage on signal pair in this state is low. Consequently, a low interference level induced to the cable (at some point of the network) can exceed a decision threshold. This may cause that some node starts to receive false data.

Maximum security of this state is solved by the following measures:

1) Twisted wires are used – wire twisting in the cable greatly reduces the induced voltage size into data pair loop.
2) Shielded cables are used – cable shielding has similar effect as 1).
3) Additional resistors (for idle state definition) are connected to data wires in such a way that differential potential raises artificially in idle state. Specifically, A wire is connected through 820 Ω resistor to internal +5 V and B wire is connected through 820 Ω resistor to internal ground.

If resistors for idle state definition have significantly higher value than is characteristic cable impedance, they can be situated anywhere in the network without affecting data wiring dynamic behaviour (matching, reflections). Their incorrect position can effect communication quality. Therefore, it is recommended to connect resistors for idle state definition together with 120 Ω terminating resistors on terminal stations. Most AMiT control systems and units allow connecting terminating resistors and idle state definitions together.

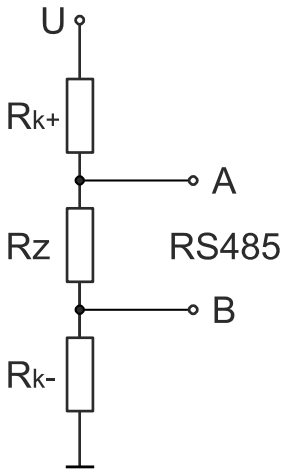

Fig. 9 – AMIT CS wiring of terminating resistor and idle state definition

3.7 RS485 repeaters

RS485 repeaters, e.g. **DM-485TO485** producted by AMiT, are used for

- Communication wiring extension for longer distances than 1200 m.
- T segment extension for longer distances than 3 m.
- More units connection into RS485 network than is allowed by electrical properties mentioned in technical parameters (also if the communication protocol allows it).
- Galvanic isolation of individual segment units.

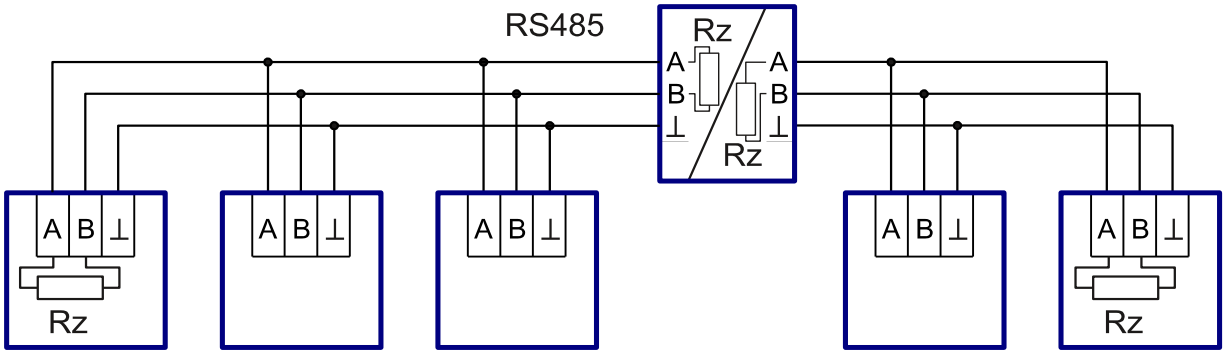

Fig. 10 – Network connection with repeater

4 RS485 design principles

- Maximum length of one segment without repeater is 1200 m at speed 0 to 19200 Bd. The length for higher speeds decreases proportionally, see chapter “2.1 Communication speed”.
- Maximum number of devices connected to one segment is typically 32 (this number depends on technical unit design). It is necessary to divide network into more segments using repeaters.
- Maximum module distance from intermediate wiring (length of T segment) is 3 m.
- 120 Ω terminating resistors and idle state definition resistors must be connected on terminal stations.
- Terminating resistors must not be used on intermediate stations.
- It is necessary to protect RS485 network using surge protection in case it leads out of one lightning protection system.
- Used cable must be twisted shielded pair of wires, wire cross section in range of 0.35 to 0.8 mm^2 with impedance near 120 Ω.
- Cable shielding should be connected to the shielding terminal of RS485 interface connector and it is connected to switchboard’s PE terminal (direct earthing) only at a single point of the network segment.
- The shielding is connected to switchboard’s PE terminal over lighting arrester (indirect earthing) in other connecting points.
- It is appropriate to install system in a metal switchboard and strong interference sources (e.g. inverters) outside the switchboard in case problems with communication appear due to strong interference.

5 Appendix A

5.1 The consequences of incorrect wiring

One of the incorrect wiring consequences (to sensor in this case) can be seen on the following figure.

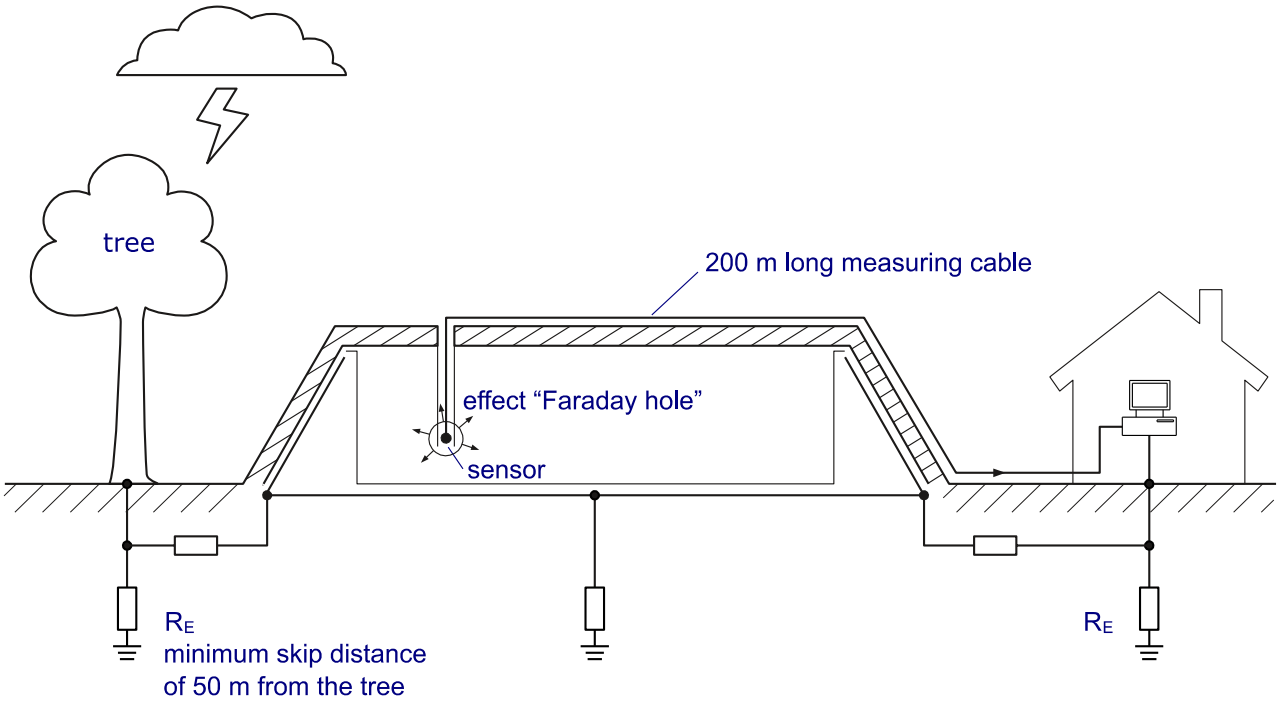

Fig. 11 – Practical example of incorrect wiring

The figure above shows undeground kerosene tank that is very well earthed. Internal tank temperature was measured by temperature sensor connected by 200 m long cable to control room (represents “foreign” distant ground). When lightning hit a tree standing beside the tank, a discharge skipped from its roots on better tank ground. It resulted in an appropriate increase of tank potential. Consequently, as a result of “Faraday hole” a spark hit measuring wiring (that represents distant ground). Kerosene mixture had been set on fire by opened spark and the whole tank exploded.

Practical example of incorrect wiring can be schematically shown, e.g. on the following figure.

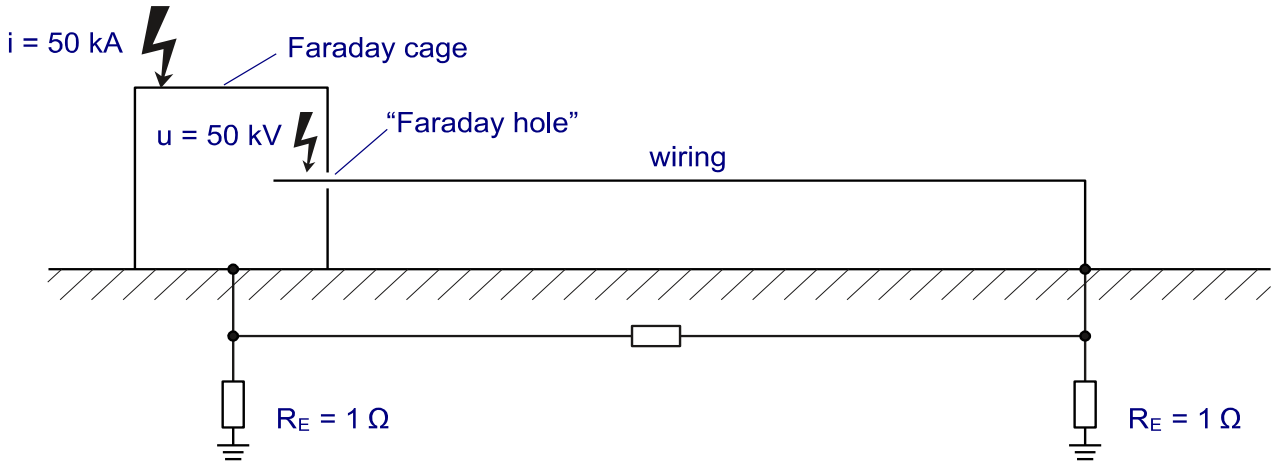

Fig. 12 – Faraday cage

The figure shows the principle of device damage when the lightning strikes Faraday cage (e.g. tank) with hole that leads earthed conduction from distant object. A relation between Faraday cage (hit by the lightening) and this “distant” ground causes voltage drop due to the passage of lightning current through earthing resistor (e.g. 50 kV showed on figure). However, common cable isolations endure lower impulse voltage. This can result in puncturing and spark creation. In case this happens in dangerous areas, not only control system but also surrounding equipment can be destroyed.

The following figure shows an example of incorrect RS485 wiring. For example, a relation between lightning strike and distant ground (second control system that communicates through RS485) will lead to potencial difference between control system grounds, circuitry destruction of RS485 physical interface and cause internal puncturing of electronics.

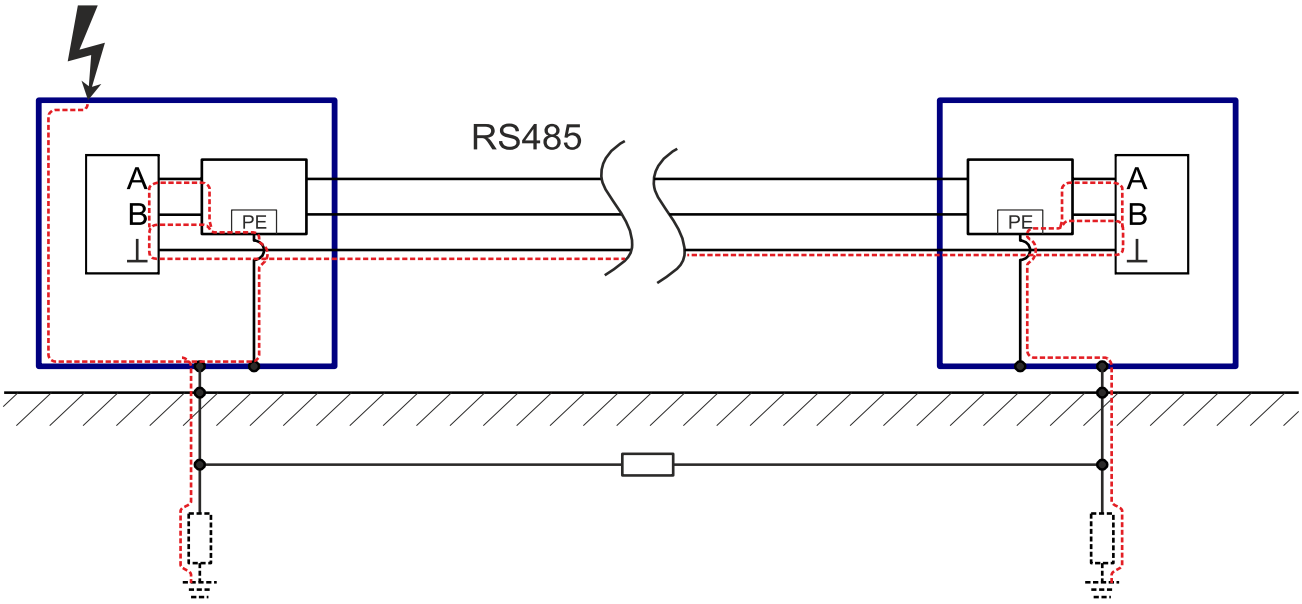

Fig. 13 – RS485 – INCORRECT WIRING example

“Less incorrect” solution can be realized by G485 terminal disconnection (part of RS485 interface) that also diconnect distant grounds and interrupt current flow. Be advised that this can happen only when voltages are so low that galvanic isolation strength is not exceeded. This obviously cannot be guaranteed and therefore final and correct solution is to respect the principles mentioned above.

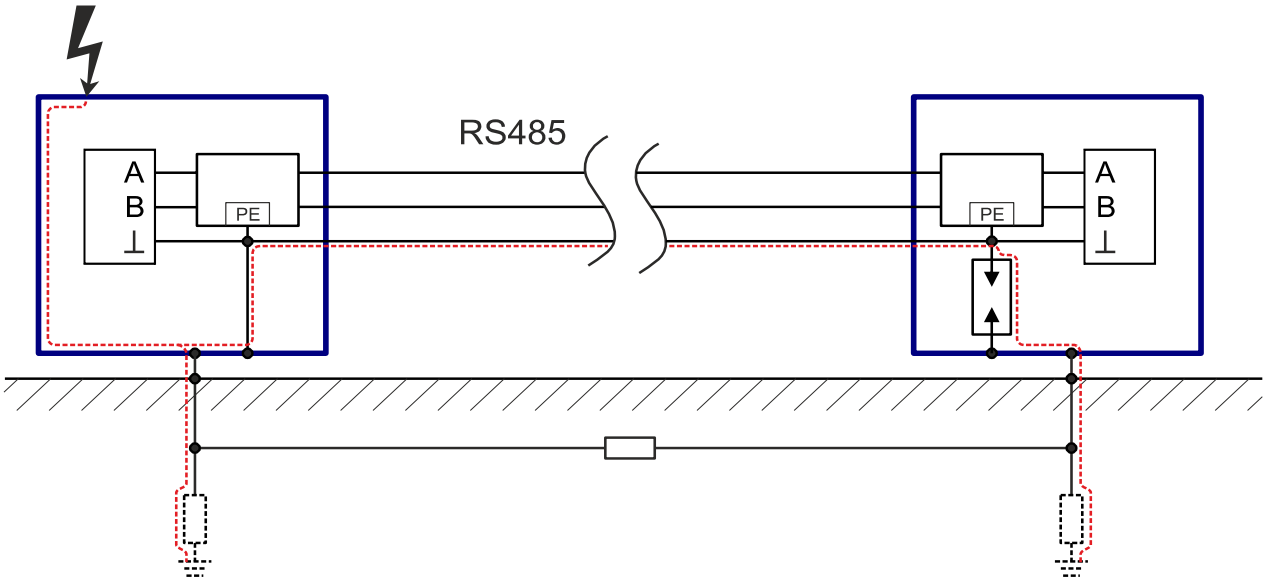

Fig. 14 – RS485 – CORRECT WIRING example

6 Technical support

All information concerning communication through RS485 network will be provided by AMiT technical support. Technical support can be most preferably contacted via email at **support@amit.cz**.

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