Principles of Ethernet network usage

Abstract

Principles for Ethernet network designing and connecting for communication with AMiT control systems.

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Appendix

File contents: -

-	Not used

Contents

History of revisions

Revision	Date	Changes
001	05. 01. 2010	New document.
002	17. 05. 2010	Unit repair at Cat.3 in chapter 3.2.2.

Related documentation

1. TIA 568-B standard
2. ISO 11801:202 standard
3. IEEE802.3af standard
4. ESW06 – Operation manual of industrial ethernet switch
   file: esw06_g_en_100.pdf
5. ESW06P – Operation manual of industrial ethernet switch with PoE
   file: esw06p_g_en_100.pdf
6. Application Note AP0006 – Ethernet network communication
   file: ap0006_en_xx.pdf
7. Application Note AP0016 – Principles of RS485 interface usage
   file: ap0016_en_xx.pdf

1 Definition of used terms

IP address
It is an interface address (PC or control system) in network Ethernet and Internet. Each network device must have a unique IP address in “its network”. IP addresses can be static, dynamic, public and private. Address value is a 32 bit number. It is written as individual bytes, separeted by dots (e.g. 192.168.1.250).

Local network
It is a network of IP addressed devices that “recognize” each other. The communication with other local network is possible only through default gate (gateway). The local network can be either private or as a part of public network.

Public network
It is a network of IP addressed devices with unlimited access. This network is freely accessible from other networks. Security level is very low.

Private network
It is a network of IP addressed devices with limited access. Only devices that belong to this network can communicate with each other, thus enabling a higher security level. It is necessary to assign IP addresses in private networks to specific range of addresses (see table). Addresses in this range are not used anywhere in the Internet. Network elements (routers) assumed that this is the private network communication; therefore data are not routed to the Internet. The following table shows the mentioned address ranges:

Network type	Range – From	Range – To	Number of IP addresses
A	**010**.000.000.000	**010**.255.255.255	16 777 216
B	**172.016**.000.000	**172.031**.255.255	1 048 576
C	**192.168**.000.000	**192.168**.255.255	65 535

Patch Panel
It is a switchboard patch panel of, e.g. structured cabling where cables are ended.

2 Ethernet network usage

All AMiT control systems are / can be equipped (using the appropriate modules or converters) with Ethernet interface. 10 Mbps or 100 Mbps Ethernet interface is used according to the contol system type. All AMiT control systems can communicate throught both network type 10Base-T and network type 100Base-T (see chapter “3.3 Selected network types”).

Ethernet communication in AMiT control systems is mainly used for

- multiple control system connection to the network.
- control system remote administration.
- routing to network DB-Net (see application note “AP0006 – Ethernet network communication”).
- wireless communication between the control systems (Wi-Fi, radio transmission).

2.1 Number of units in local network Ethernet

The number of units in the local network Ethernet is primarily given by IP address range in it. IP address ranges in local networks are described in chapter “1 Definition of used terms”.

3 Network connection

3.1 Network topology

TIA 568-B.1 standard defines network topology. This application note shows two common Ethernet network connections.

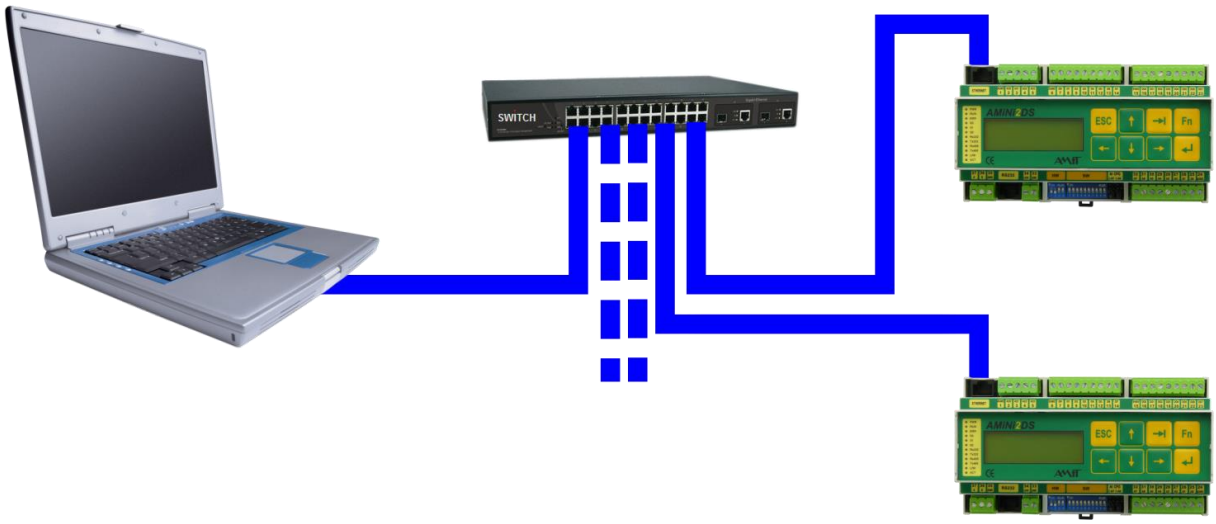
3.1.1 Point – to – Point

It is possible to communicate with only one control system in this way. **Ethernet crossover cable** with RJ45 connectors must be used. This connection is rather an emergency one and allows communication, e.g. from notebook using network interface adapter (without necessity of any other devices).

Obr. 1 - Direct PC connection with control system

3.1.2 Multiply units

If multiply stations are required in Ethernet network, **direct Ethernet cable** with RJ45 connectors and appropriate Ethernet device (switch, router, etc.) are used for network designing.



Obr. 2 - Connection of multiply units to the network

3.2 Cabling

3.2.1 Metallic cable types

- UTP (Unshielded Twisted Pair) – commonly used in office distributions and locations without any disturbances.
- STP (Shielded Twisted Pair) – all pairs are braid-shielded together.
- (S)FTP (Foiled Twisted Pair) – same as STP Shielding is done by foil.
- SSTP (double Shielded Twisted Pair) – all pairs are braid-shielded together and each pair is also shielded individually (these two shields are connected together in cable).

3.2.2 Metallic cable categories

Metallic cabling can be divided into several categories. These categories are given by two standards – TIA 568-B.2 (Cat.X categories) and ISO 11801:202 (class categories).

Cat.3 (Class C)
Data transfer cables enable transfer speeds up to 10 Mbps and frequencies up to 16 MHz. Main usage of Cat.3 was in 10BASE-T Ethernet.

Cat.4
Data transfer cables enable transfer speeds up to 16 Mbps and frequencies up to 20 MHz. Cat.4 is used in Token Ring, 10BASE-T and 100BASE-T4.

Cat.5 (Class D)
Data transfer cables enable transfer speeds up to 100 Mbps (resp. 1 Gbps) and frequencies up to 100 MHz.

Cat.5e (Class D)
Cat.5e is an improved Cat.5 standard that puts more emphasis on cable manufacturing precision. Maximum cable length between individual active elements is 100 m. It is used for 10BASE-T, 100BASE-T and 1000BASE-T (10 Mbps, 100 Mbps, 1 Gbps).

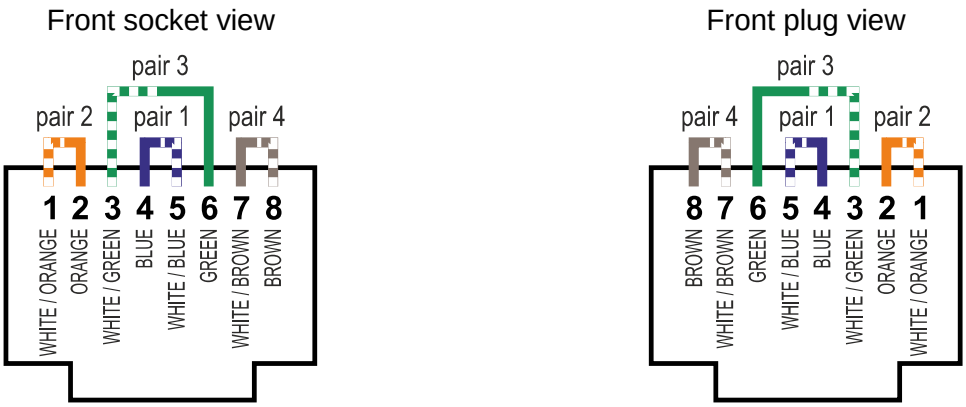
Cat.6 (Class E)
This category is designed for gigabit networks (including 10GBASE-T) and is backward compatible (100, 10 Mbit). It is shielded and unshielded twisted pair cable. Specification validity is up to 250 MHz and 100 m. Signal to noise ratio, crosstalk and attenuation should be lower than in 5e category.

Cat.6a (Class E_A)
This category works with a bandwidth up to 500 MHz. It is used for ultra-fast backbone applications in local networks and also for 10GBASE-T Ethernet (10 Gbps).

Cat.7 (Class F)
This category is designed for 10 gigabit networks and is backward compatible (1000, 100, 10 Mbit). Specification validity is up to 500 MHz and 100 m. Signal to noise ratio, crosstalk and attenuation should be lower than in 6 category. This is achived that, i.a. each pair is shielded separately. If GG45 (backward compatible with RJ45) or TERA (looks like mini FireWire or micro USB) terminals are used, Cat 7 (Class F) works at 600 MHz frequency.

3.2.3 Fixed metallic cable wiring

Four “twisted” pair cables are used for structured cabling. Individual cable pairs are colour-coded. One of the pair wires has appropriate colour and second in the pair is etheir white or variously striped in combination with white / appropriate colour. TIA 568-B standard defines following wiring.

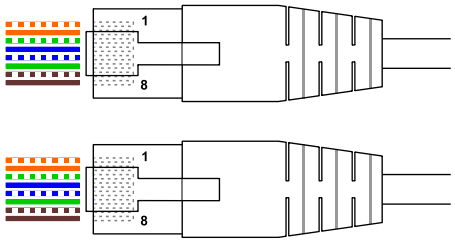


Obr. 3 - Socket and plug wiring

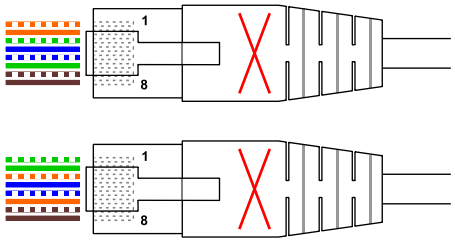
3.2.4 Mettalic cable wiring for network connection

Control system connection to active element (switch, router, etc.) is done by direct cable. If it is necessary to connect PC directly to control system or two active elements together, crossover cable is used.

Direct cable wiring

Pin numbers		Wires colour	
1 – 1 2 – 2 3 – 3 4 – 4 5 – 5 6 – 6 7 – 7 8 – 8		White / Orange Orange White / Green Blue White / Blue Green White / Brown Brown	White / Orange Orange White / Green Blue White / Blue Green White / Brown Brown

Crossover cable wiring

Pin numbers		Wires colour	
1 – 3 2 – 6 3 – 1 4 – 4 5 – 5 6 – 2 7 – 7 8 – 8		White / Orange Orange White / Green Blue White / Blue Green White / Brown Brown	White / Green Green White / Orange Blue White / Blue Orange White / Brown Brown

3.2.5 Optical cables

Optical cabling is given by TIA 568-B.3 standard. The standard defines the usage of single-mode or multi-mode fibers according to requested speed and distance. It is suitable for LAN networks between buildings and remote locations in cases that metallic connections cannot be used (because of problems with static electricity or different zero potential of building switchboards).

3.2.6 Optical cable categories

- **Single-mode optical fiber** (SM) is optical cable type used for data transfer in case of longer distances (between cities, states, continents). Single-mode fiber is more expensive than multi-mode one. This means that optical wiring using single-mode fibers is also more expensive. On the other hand, they have range of tens of kilometers. These fibers are described by ISO 11801 – OS1. This standard is based on bandwidth of single-mode optical fiber.
- **Multi-mode optical fiber** (MM) is optical cable type that is used for communication at short distances, for example inside of building or site. Transmission rate of multi-mode lines is about 10 Mbps to 10 Gbps and distance up to 600 meters. Multi-mode optical fibers are described by their size and cladding diameter. For example, 62.5 / 125 multi-mode optical fiber has core diameter of 62.5 μm and cladding diameter of 125 μm. Moreover, these fibers are described by ISO 11801 – OM1, OM2, and OM3. These standards are based on bandwidth of multi-mode optical fiber.

3.3 Selected network types

- **10Base-T** – 10 Mbps twisted pair cable is used as the transmission medium. Only two pairs out of four are used in structured cabling. Obsolete network that was replaced by a faster 100 Mbps variant in most cases.
- **10Base-F** – 10 Mbps optical fiber variant. It is used for longer distance connection or between objects, where twisted pair cannot be installed. 10Base-F usually created so called backbone network that connects smaller individual network parts. Today it is replaced by higher speeds (Fast Ethernet, Gigabit Ethernet).
- **100Base-TX** – 100 Mbps variant, called Fast Ethernet, uses two pairs of UTP or STP cable.
- **100Base-T2** – Uses two UTP pairs. It is a variant suitable for older structured cabling.
- **100Base-T4** – Uses four UTP pairs. It is suitable for older structured cabling.
- **100Base-FX** – Fast Ethernet uses two optical fibers.
- **1000Base-T** – 1000 Mbps Ethernet, called Gigabit Ethernet. It uses 4 pairs of UTP cabling and has defined its distance up to 100 meters.
- **1000Base-CX** – Gigabit Ethernet based on copper wire for short distances, used for device group connection.
- **1000Base-SX** – Gigabit Ethernet uses multi-mode optical fiber. It is designed for backbone networks at distances of several hundred meters.
- **1000Base-LX** – Gigabit Ethernet uses single-mode optical fiber. It is designed for longer larger distances up to several tens of kilometers.
- **10GBase-T** – 10 Gbps Ethernet, called Ten Gigabit Ethernet (or also EFM – Ethernet on the first mile). Category 6 cable can be used for distance up to 55 meters. Category 6a cable must be used for full distance of 100 meters. Some producers sell category 7 cables labelled as 10GBase-T compatible.
- **40GBASE** and **100GBASE** with 40 and 100 Gbps speeds should use optical fibers. Copper cables can be used for distance up to 10 meters.

3.4 Galvanic isolation

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

Attention
Galvanic isolation does not increase network reliability.

3.5 Cable shielding connection in network Ethernet

Cable shielding must be directly earthed at one end (only one) so it takes its effect. Cable shielding must be connected to switchboard enclosure (PE) at the entrance of this switchboard. For example, patch panels can be used in advantage for this purpose that also provided connection of structured cabling to sockets. Then it is possible to use UTP cabels for connections with active element within switchboard.

Obr. 4 - Shielded cabling patch panel

Switchboards with end stations can use the STP socket in the on wall frame bushing with DIN rail adapter. Socket shielding must be connected to switchboard enclosure (PE) through lightning arrester (indirect earthing). Socket and control system connection within switchboard can be done by both UTP and STP cables (control systems have galvanically isolated Ethernet interface).

Note
If Ethernet is led in low-noise level environment, shielding can be connected directly to switchboard PE without lightning arrester necessity.

Recommended lightning arrester
- **DS-B090** (producer Saltek spol. s r.o.)

Note
Shielding connection through lightning arrester uses "Bernard" terminals type (Elektro Bečov ZSA 16), e.g. Phoenix Contact (SSA 5-10).

3.6 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. The necessity of surge protection usage within one object depends on the electrical installation and lightning protection design.

3.6.1 Surge protector types

Basic categories

1. power supply protection (lv-low voltage)
   - lightning current protector (1. level)
   - surge protector (2. and 3. level)
2. data protections (Ethernet, …)
   - hard
   - fine

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. Level 3 surge protectors can be designed as built-in. It is intended to be mounted into protected devices (directly as patch panel). They are also mounted directly into

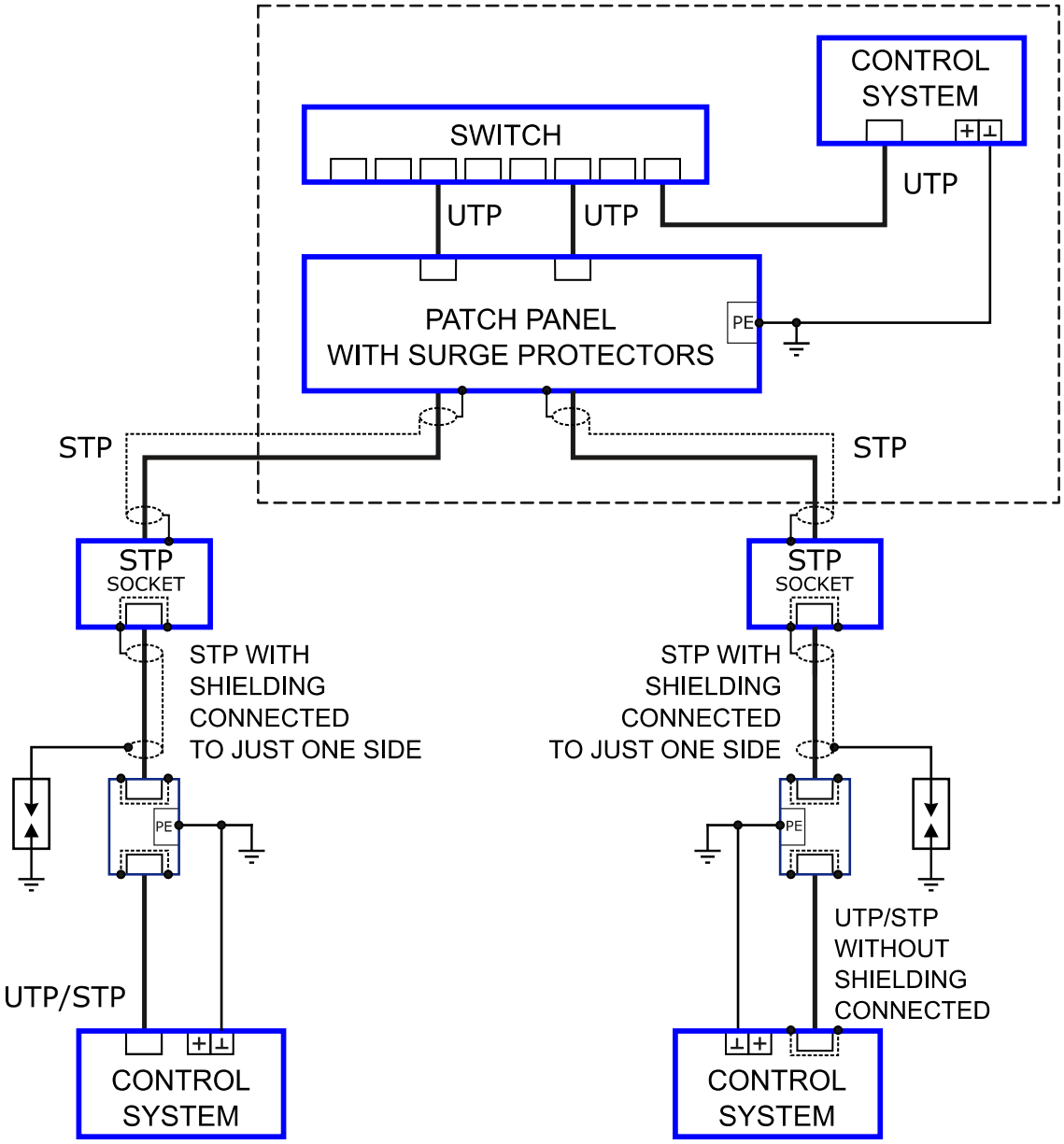
installation boxes or sockets – surge and data distribution protections can be placed here together. Level 3 surge protectors combined with high-frequency filter are also offered.

Recommended surge protectors for Ethernet

- **DL-Cat.5e XX PATCH PANEL** – Surge protection for Cat.5 or Cat.5e Ethernet for 19“ racks, producer Saltek spol. s r.o.
- **DL-Cat.5e XX RACK PANEL** – Surge protection for Cat.5 or Cat.5e Ethernet for 19“ racks, producer Saltek spol. s r.o.
- **DL-Cat.5e** – Surge protection for Cat.5 or Cat.5e Ethernet designed for one port protection, producer Saltek spol. s r.o.
- **DL-100 POE 24, DL-100 POE 48** – Combined surge protection for Power over Ethernet, producer Saltek spol. s r.o.
- **DL-1G** – Surge protector for Cat.6 Ethernet, producer Saltek spol. s r.o.

3.6.2 Surge protector wiring

The following figure shows Ethernet network connection led by STP cable with surge protectors in very noisy environment.



Obr. 5 - Surge protection wiring in network Ethernet

4 Principles of Ethernet network design

Providing of reliable control system communication through network Ethernet is done using industrial components (e.g. industrial Ethernet switch ESW06 from AMiT production). Common office components do not have to comply with the requirements given by, e.g. ambient environmental influences.

Basic principles for Ethernet network realization:

- Used cables must be in category Cat.5 and higher.
- Maximum length of one segment is 100 m (unless indicated otherwise).
- Maximum number of connected network devices is limited by IP address number in local network (IP addresses are assigned by the network administrator in most cases).
- It is necessary to protect network Ethernet using proper surge protection in case this network leads out of one lightning protection system.
- In case that cable shielding is used, this is connected at a single point to switchboard PE terminal (direct earthing).
- The shielding is connected with switchboard PE terminal over lighting arrester in other connecting points (indirect earthing*).
- It is appropriate to install system in a metal switchboard and strong interference sources (e.g. inverters) install outside the switchboard in case problems with communication appear due to strong interference.
- If communication takes place at longer distances, segment can be extended by, e.g. industrial ethernet switch ESW06 (ESW06P) from AMiT production.

*) *If Ethernet is led in low noise level environment, shielding can be connected directly to switchboard PE without lightning arrester necessity.*

5 APPENDIX A

5.1 Power over Ethernet (PoE)

Some of AMiT devices (e.g. industrial Ethernet switch ESW06P) support PoE function. This is the power supplying of Ethernet peripherals through current Cat.5 data cabling. Additional power supplies or network adapters for powered device are not necessary. IEEE802.3af standard defines power supplying options of Ethernet devices. The current version of this standard defines three power supplying variants through data wiring:

- Power supplying from active elements using data signals – two pairs of wires are used and power supply is connected to winding centres of isolating transformers.
- Power supplying from active elements using free wires – positive and negative voltage is transfered by two unused wire pairs connected together in both terminal devices. This wiring cannot be used in gigabit networks that need all 4 pairs for data transmission.
- Power supplying from inserted device (single port injector) – a power supply injector is inserted into a transmission path. Active element is connected to injector that adds the power supply voltage and leads all wires to the ouput connector. This way is offen used for injecting of atypical voltage values, e.g. 5, 9, 12 V. In this cases power supplying / injecting set is usually packed together with connected unit. It is always necessary to follow connected unit operation manual.

5.1.1 Advantages

- terminal devices use same cable for power supplying and data transmission
- usage of current Cat.5 cabling for data transmission and power supply voltage
- maximum power up to 15,4 W, typically 13 W per one port
- direct power supply voltage in range 44 to 57 V

5.1.2 Basic features

- voltage 44 to 57 V
- maximum current 550 mA
- maximum starting peak current 500 mA
- typical current 10 to 350 mA
- overload detection 350 to 500 mA
- maximum idle state consumption 5 mA

6 Technical support

All information concerning connection of AMiT control systems in network Ethernet will be provided by AMiT technical support. Technical support can be most preferably contacted via email at **support@amit.cz**.

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