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Federal Department of the Environment, Transport, Energy and Communications DETEC

Federal Office of Communications

Technical Guidelines

concerning

FTTH In-House Installations Layer 1

Edition 1.0: 6.10.2009

This standard was created by an industry working group under the aegis of the Federal Office of Communications. The document can be downloaded from www.bakom.ch .

Contents

1 General

1.1 Scope

The present document defines a standard for the physical layer of the in-house installation part of fibre to the home networks. It was written by a telecommunications industry working group including operators, suppliers, associations and regulator. The goal of the standard is to ensure that the in-house installation can be shared by two or more fibre networks serving the same location. This has the benefit that the in-house installation in any given building need only be done once.

The in-house installation extends from a building entry point, typically in the basement of a building, to an optical telecommunications outlet (wall-socket) in the subscriber's premises. The standard describes a reference model and specifies physical infrastructure elements. Neither access networks nor home networks are specified in this standard although they are relevant for their influence on the in-house installation. This standard is based as far as possible on recognised international standards.

The technology of fibre optic networks is undergoing constant development. The working group observes this development and revises the standard as necessary to take new developments into account.

The standard is a voluntary one and there is no legal obligation for any party to observe it. The working group recommends however that any party constructing a fibre to the home in-house installation observe the standard.

1.2 Participants

The following organisations contributed to the work:

ABL AG
Cablecom
Dätwyler Cables
Diamond SA
Federal Office of Communications
Fibre Lac SA
Huber + Suhner
IWB Telekom
Reichle & De-Massari AG
Sankt Galler Stadtwerke
Saphir Group Engineering AG (ASUT)
Sateldranse SA
Sierre Energie SA
Sunrise
Swisscable
Swisscom
Telecom EWZ
Valaiscom AG
VTX Services SA

1.3 References

[1] EN 50173-1 Information technology. Generic cabling systems. General requirements

[2] ITU G.652 Characteristics of a single-mode optical fibre and cable

[3] ITU G.657 Characteristics of a Bending Loss Insensitive Single Mode Optical Fibre and Cable for the Access Network

[4] IEC 60793-2-50 Optical fibres - Part 2-50: Product specifications - Sectional specification for class B single-mode fibres

[5] IEC 60304 Standard colours for insulation for low-frequency cables and wires

[6] IEC 60794-5 Optical fibre cables - Part 5: Sectional specification - Microduct cabling for installation by blowing

[7] IEC 60794-3-11 Optical fibre cables - Part 3-11: Outdoor cables - Detailed specification for duct and directly buried single-mode optical fibre telecommunication cables

[8] IEC 60794-2-20 Optical fibre cables - Part 2-20: Indoor cables - Family specification for multi-fibre optical distribution cables

[9] IEC 61756-1 Fibre optic interconnecting devices and passive components - Interface standard for fibre management systems - Part 1: General and guidance

[10] IEC 61754-20 Fibre optic connector interfaces - Part 20: Type LC connector family

[11] IEC 61755-3-2 Fibre optic connector optical interfaces - Part 3-2: Optical interface, 2,5 mm and 1,25 mm diameter cylindrical full zirconia ferrules for 8 degrees angled-PC single mode fibres

[12] IEC 61755-3-6 Fibre optic connector optical interfaces - Part 3-6: Optical interface - 2,5 mm and 1,25 mm diameter cylindrical 8 degrees angled-PC composite ferrule using Cu-Ni-alloy as fibre surrounding material, single mode fibre

[13] IEC 61755-3-8 Fibre optic interconnecting devices and passive components - Fibre optic connector optical interfaces- Part 3-8: Optical interface, 2,5 mm and 1,25 mm diameter cylindrical 8 degrees angled-APC composite ferrule using titanium as fibre surrounding material, single mode fibre

[14] IEC 61755-1 Fibre optic connector optical interfaces - Part 1: Optical interfaces for single mode non-dispersion shifted fibres - General and guidance

[15] IEC 61753-021-2 Fibre optic interconnecting devices and passive components performance standard - Part 021-2: Grade C/3 single-mode fibre optic connectors for category C - Controlled environment

[16] IEC 61280-4-2 Fibre optic communication subsystem basic test procedures - Part 4-2: Fibre optic cable plant - Single-mode fibre optic cable plant attenuation

[17] EN 50173-4 Information technology. Generic cabling systems. Homes

[18] EN 50083 series (1-10) Cabled distribution systems for television and sound signals.

All texts of laws with SR references are published in the systematic collection of federal law and can be consulted on the www.bk.admin.ch website. They can also be obtained from the Federal Office for Construction and Logistics (BBL), CH-3003 Berne.

The technical and administrative regulations as well as the numbering plans can be consulted on the www.bakom.admin.ch website. They can also be obtained from the Federal Office of Communications OFCOM, 44, Postfach, CH-2501 Biel-Bienne.

The ITU-T Recommendations can be obtained from the ITU, Place des Nations, 1211 Geneva 20 (www.itu.int).

The ETSI standards can be obtained from the European Telecommunications Standardisation Institute, 650 route des Lucioles, 06921 Sophia Antipolis, France, (www.etsi.org).

The ISO standards can be obtained from the central secretariat of the International Organisation for Standardisation, 1, rue de Varembé, 1211 Geneva, (www.iso.ch).

The IEC standards can be obtained from the IEC Central Office, 3, rue de Varembé, CH-1211 Geneva 20, Email: inmail@iec.ch, (www.iec.ch).

The Swiss standards (SN) can be obtained from Swiss Association for Standardisation, Bürglistrasse 29, 8400 Winterthur, (www.snv.ch).

The W3C Recommendations are available at www.w3c.org.

The IAB's RFCs are available at www.ietf.org.

1.4 Definitions and Abbreviations

1.4.1 General Definitions

For the purposes of this industry standard the following definitions and abbreviations apply. The definitions and abbreviations are based on the European Standard for the EN50173 series, e.g. [1].

administration
methodology defining the documentation requirements of a cabling system and its containment, the labelling of functional elements and the process by which moves, additions and changes are recorded

building entrance facility
facility that provides all necessary mechanical and electrical services, that complies with all relevant regulations, for the entry of telecommunications cables into a building and which may allow for transition from external to internal cable

cabling
system of telecommunications cables, cords and connecting hardware that supports the operation of information technology equipment

connection
mated device or combination of devices including terminations used to connect cables or cable elements to other cables, cable elements or application specific equipment

cord
cable unit or element with a minimum of one termination

distributor
term used for the functions of a collection of components (for example, patch panels, patch cords) used to connect cables

equipment interface
point at which application-specific equipment can be connected to the generic cabling or network access cabling

home distributor
the distributor within a home where cables terminate

interconnect
method of connecting a cabling subsystem to equipment (or another cabling subsystem) without the use of a patch cord or jumper

layer 1
layer 1 of the ISO OSI model, equivalent to 'physical layer'

optical fibre cable (or optical cable)
cable comprising one or more optical fibre cable elements

optical fibre duplex adapter
mechanical device designed to align and join two duplex connectors

optical fibre duplex connector
mechanical termination device designed to transfer optical power between two pairs of optical fibres

small form factor connector
optical fibre connector designed to accommodate two or more optical fibres with at least the same mounting density as balanced cabling interfaces in accordance with EN 60603-7 series

splice
joining of conductors or fibres, generally from separate cables

telecommunications
branch of technology concerned with the transmission, emission and reception of signs, signals, writing, images and sounds; that is, information of any nature by cable, radio, optical or other electromagnetic systems

telecommunications outlet
fixed connecting device where the ICT home cable terminates. The telecommunications outlet provides an interface to the terminal equipment cabling for ICT applications

terminal equipment
equipment (e.g. telephone handset) that provides user access to an application at an application outlet

terminal equipment cabling
cords and other devices connecting the telecommunications outlet or broadcast outlet to the terminal equipment

test interface
point at which test equipment can be connected to the generic cabling

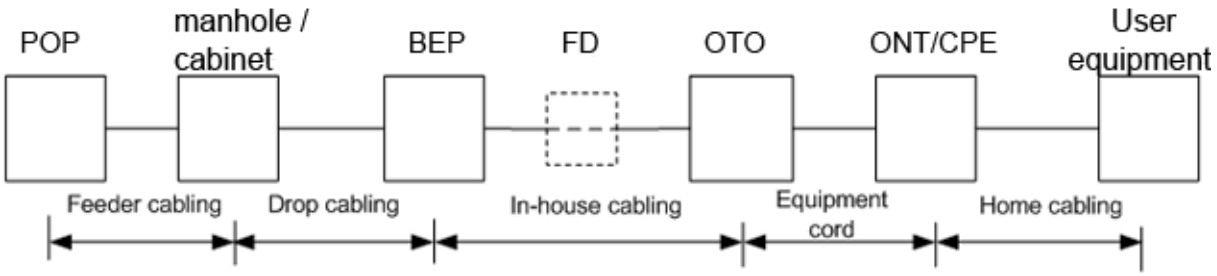
transmission equipment
active and passive equipment used to distribute applications from distributors to other distributors and to outlets

1.4.2 Abbreviations

APC	Angled Physical Contact
BEP	Building Entry Point
CAT	Category
CATV	Cable Television
CPE	Customer Premises Equipment
DSL	Digital Subscriber Line
FD	Floor Distributor
FITH	Fibre in the Home
FTTH	Fibre to the Home
HF	High Frequency
ICT	Information and Communication Technologies
IEC	International Electrotechnical Commission
IP	Ingress Protection

ITU	International Telecommunication Union
L1	Layer 1 of the ISO OSI model
LAN	Local Area Network
ONT	Optical Network Termination
OTDR	Optical Time Domain Reflectometer
OTO	Optical Telecommunications Outlet
OTU	Optical Termination Unit
PC	Physical Contact
POP	Point of Presence
TBD	To Be Decided
TEL	Telephone
TO	Telecommunications Outlet
TP	Twisted Pair

2 Reference Model



Key

BEP	Building Entry Point
CPE	Customer Premises Equipment
FD	Floor Distributor
ONT	Optical Network Termination
OTO	Optical Telecommunications Outlet
POP	Point of Presence

Figure 1 FTTH In-House Installation Reference Model

2.1 Building Entry Point (BEP)

The BEP allows the transition from external to in-house cable. The type of transition may be a splice or a removable connection.

2.2 Floor Distributor (FD)

The floor distributor is an optional element which allows the transition of the vertical to the horizontal in-house cable.

2.3 In-House Cabling

The in-house cabling links the BEP to the OTO. The main components are an optical in-house cable or other, blowing-based, installation of fibre elements.

2.4 Optical Telecommunications Outlet (OTO)

The OTO is a fixed connecting device where the fibre optic in-house cable terminates. The optical telecommunications outlet provides an optical interface to the equipment cord of the ONT/CPE.

2.5 Optical Network Termination (ONT)

The ONT terminates the FTTH optical network at the customer premise. It includes an electro-optical converter. The ONT and CPE may be integrated.

2.6 Customer Premises Equipment (CPE)

The CPE is any active device, e.g. set-top-box, that provides the end-user with FTTH services (high-speed data, TV, telephony, etc.). The ONT and CPE may be integrated.

2.7 Home Cabling

The home cabling supports the distribution of a wide range of applications TV, telephone, Internet access etc. within the premises. Application-specific hardware is not part of the home cabling.

2.8 User Equipment

The user equipment TV, Phone, personal computer, etc. allows the user to access the FTTH services.

3 Specification at Building Entry Point (BEP)

Following specifications are related to point-to-point systems and new installations only.

3.1 Fibre Characteristics

The fibre characteristics are given in different international standards. Most commonly, fibre codes from ITU and IEC are referenced. Both codes will be used in this document: see [1], [3], [4].

The choice of the fibre type at the BEP is determined by several parameters. The type of the fibre is single mode fibre. A given type of single-mode fibre may have different specifications by optimising several of the following parameters:

- mode field diameter,
- chromatic dispersion coefficient,
- slope of the chromatic dispersion curve,
- cable cut-off wavelength.

At the BEP fibres from the drop cabling (outdoor cable) and the fibres from the in-house cabling (indoor cable) have to be connected. The specifications of these fibres are described in the different standard fibre categories. They have to fulfil certain requirements which are described in the following.

Drop and in-house cabling can be realized by using blowing techniques in microducts.

Fibre characteristics in the outdoor and indoor cables are as follows:

Table 1 Fibre Characteristics

Fibre type	ITU Code	IEC Code
Outdoor cables	G.652 D	IEC 60793-2-50 B1.3
Indoor cables	G.657 A	IEC 60793-2-50 B6_a

3.1.1 Splicing Compatibility Between In-House and Drop Cable Fibre

The different mode field diameter mean values, as well as their tolerances, have an effect on splice losses when fibres of different categories and families are spliced together.

Care must be taken to properly adjust splicing equipment and to correctly evaluate the splicing losses among different fibre families, which can show increases in comparison with conventional splice losses.

In order to evaluate the correct splice loss value OTDR bidirectional measurements shall be made.

Since recent advances in fibre manufacturing technology and improved fibre geometry – with fibre core concentricity errors typically less than 0.5 µm – the splice losses encountered are usually ≤ 0.1 dB. However splice losses determined by using OTDR unidirectional measurements show values up to 0.5 dB.

3.1.2 Colour Coding of the Fibres

Fibres within buffer tubes, as well as buffered fibres, are colour coded to differentiate the fibers within the cable. This colour coding enables installers to easily identify cables at both ends of the

fibre link and also indicates the appropriate position of each fibre in the cable and on a patch panel.

Colours shall correspond to standard colours in IEC 60304 [5].

For fibre counts above 12, additional groups of 12 fibres should be identified by combining the above sequence with an added identification (for example, ring marking, dashed mark or tracer).

Fibre colour and numbering for drop cabling shall be according to the following table:

Table 2 Colour Coding for Fibres in Drop Cables

Fibre No.	Colour	Fibre No.	Colour
1	red	13	red + marking
2	green	14	green + marking
3	yellow	15	yellow + marking
4	blue	16	blue + marking
5	white	17	white + marking
6	violet	18	violet + marking
7	orange	19	orange + marking
8	black	20	transparent + marking
9	grey	21	grey + marking
10	brown	22	brown + marking
11	pink	23	pink + marking
12	turquoise	24	turquoise + marking

Loose tube colours in drop cables shall be as follows:

Table 3 Loose Tube Colours in Drop Cables

Loose tube no.	Colour
1	red
2	green
3	non colour or white
4	non colour or white

Count direction is indicated by green loose tube.

Fibre or tube colour and numbering for in-house cables shall be according to the following table:

Table 4 In-House Cable Fibre or Tube Colours

Cable type	Fibre or buffered-fibre colour
4-fibre cable:	
Fibre No.1	red
Fibre No.2	green
Fibre No.3	yellow
Fibre No.4	blue

3.1.3 Bending Radius Requirements

Bending radius for standard single mode fibre such as G.652 D [1] or IEC 60793-2-50 B1.3 [4] shall be 30 mm and above.

In-house cabling operating conditions require bending radii as small as possible, compatible with lifetime expectations and acceptable losses. Low bending sensitivity single mode fibres were developed for such applications. They are suitable for use in FTTH networks, including FITH at the end of these networks. G.657 A fibres [3] are suitable to be used in the O, E, S, C and L-band (i.e. throughout the 1260 nm to 1625 nm range) with a bending radius of 15.0 mm and above as well as to meet the requirements of connecting with B1.3 fibres [4].

Mechanical reliability expectation for optical fibres related to stresses caused by low bend radii shall be at least 20 years.

3.1.4 Installation Requirements at the BEP

Optical fibre cables used in FITH are designed so that normal installation practices and equipment can be used wherever possible. They do, however, generally have a strain limit rather lower than metallic conductor cables and, in some circumstances, special care and arrangements may be needed to ensure successful installation.

It is important to pay particular attention to the cable manufacturer's recommendations and stated physical limitations and not exceed the given cable tensile load ratings for the outdoor and indoor cable as well as their different bend radius requirements. Damage caused by mechanical overloading during installation may not be immediately apparent but can lead to failure later in its service life.

Installation of an optical fibre cable and connecting elements at the BEP can be influenced significantly by careful planning and preparation of an installation specification. The installation specification should consider:

- the cabling infrastructure,
- cable routes,
- potential hazards and installation environment,
- provide a bill of materials and technical requirements for cables, trays, splices, boxes,
- details of any additional work, route preparation (including ductwork, tray-work and trunking),

- clear indication of responsibilities and contractual interfaces, especially if there are any site or access limitations,
- post installation requirements for reinstatement, spares, ancillary services and regulatory issues.

3.2 Cable Type

Optical fibre cables used for installations at the BEP are covered by the IEC 60794 series of specifications, and the particular aspects of the microduct cabling for installation by blowing technique are covered by IEC 60794-5 series [6].

3.2.1 Outdoor Cable

Outdoor cables are covered by IEC 60794-3-11 [7].

Operating temperature range is between -30°C and 70°C.

3.2.2 Indoor Cable

In-house cables are covered by IEC 60794-2-20 [8] and shall provide 4 fibres between the BEP and each OTO.

Operating temperature range is between -20°C and 60°C.

3.2.3 Microduct Cabling for Installation by Blowing

In the following the requirements for microduct optical fibre cables, microduct fibre units, microducts and protected microducts for installation by blowing for outdoor and/or indoor use are given. It shall be possible to install or remove the microduct optical fibre cable from the microduct or protected microduct by blowing during the operational lifetime.

A microduct suitable for installation of microduct cables is a small, flexible, lightweight tube with an outer diameter typically less than 16 mm.

Microduct optical fibre cables, fibre units, microducts and protected microducts for installation by blowing are defined in the IEC 60794-5 series [6].

3.3 Fusion Splice at the BEP

The requirements for fusion splices and splice protectors to be used at the BEP are summarized in the following table:

Table 5 Fusion Splice at the BEP

Characteristics	Requirement
Max. attenuation of splices	0.15 dB
Return loss	> 60 dB
Operating temperature range	- 25°C to 70°C

Splice protector types shall be heat shrink or crimp. Dimensions are defined in IEC 61756-1 [9].

3.4 Connection Box at the BEP

To fulfil the requirement for 4 fibres to each OTO, single circuit management systems are required, as defined in IEC 61756-1 [9].

The connection box at the BEP is mounted on the wall inside or outside the building and has the following main functions:

- to fasten incoming outdoor and outgoing indoor cables
- to mount the required number of splice trays
- to allow management of single circuits (fibre circuit disturbance)
- to manage classical installation and installation by blowing
- to allow locking if needed
- to store unused fibres
- to provide means for fibre identification

The degree of protection for BEP indoor installation shall be IP20 and for outdoor IP44.

Operating temperature range for indoor applications is between -10°C to 60°C and for outdoors -25°C and 70°C.

The following table gives the requirements for overlengths in the connection box or splice tray.

Table 6 Overlengths

Element	Requirement
Fibre or buffered-fibre overlength	1.5 m
Loose tube overlength	2 m

3.4.1 Splice Tray

One splice tray for each OTO shall be used. Splice trays have to store 4 splices and 4 splice protectors. Strain relief shall be available.

The fibre and buffered fibre overlength is typically stored in the same tray as the splices. It shall permit the movement of the splice to the splicing equipment or tools and back to the splice holder. The length should be such that it allows 3 re-splices. Often the fibres are stored in loops near the splice area. For optimised handling and to avoid violating the minimum bending radius, guiding elements are needed.

The splice tray provides internally a place for 4 splice holders. Different types are specified by:

- splice protection type;
- fixing method.

The tray has to fulfil the needs for fixing or stacking.

4 Specification at the Optical Telecommunication Outlet (OTO)

The optical telecommunication outlet shall be designed to fulfil the requirements to manage 4 fibres with a minimum bending radius of 15 mm. The outlet shall provide space for fibre overlengths, 4 splices, 4 LC/APC adapters and 4 LC/APC optical connectors.

Means for identification shall be provided for:

- passive optical ports,
- fibres.

4.1 Fibre Characteristics

Fibre characteristics at the OTO shall be as defined in IEC 60793-2-50 B6_a [4].

4.2 Connection Outlet

The design of the outlet shall fulfil the following:

- the requirements for fibre connection as defined in §4.3,
- storage of fibre overlength.

4.3 Connection Type

The fibre connection at the OTO can be:

- pre-terminated cable assemblies,
- spliced pigtails,
- field mountable connector.

4.3.1 Optical Connectors

The type of the optical connector is LC/APC

The mechanical intermateability is defined in IEC 61754-20 [10]. The dimensional and material requirements of the ferrule endface after termination for LC/APC connections are defined in IEC 61755-3-2 (zirconia) [11], IEC 61755-3-6 (Cu-Ni-alloy) [12] and IEC 61755-3-8 (titanium) [13].

Optical connections at the OTO shall be Grade C for attenuation and Grade 1 for return loss as defined in IEC 61755-1 [14].

The mechanical and climatic requirements are defined in IEC 61753-021-2 [15] for category C (controlled environment) with a temperature range of -10°C to +60°C.

4.3.2 Splices

The requirements for splices at the OTO are summarized in the following table.

Table 7 Splice Requirements at the OTO

Characteristic	Requirement
Max. attenuation	0.25 dB
Return loss	> 60 dB
Operating temperature range	- 10°C to 60°C

5 Testing of Optical Fibre Cabling (BEP–OTO)

The testing of optical fibre cabling shall be done as defined in IEC 61280-4-2 [16].

The measurements can be carried out as follows:

1. End to end measurement from POP to OTO
2. Unidirectional OTDR measurement from the OTO

6 Annex 1 Home Installation

6.1 General Recommendations

The installations should be structured, conform to EN50173-4 [17] and allow operation of Ethernet/LAN, CATV/HF-Broadcast and telephony at every multimedia connection point.

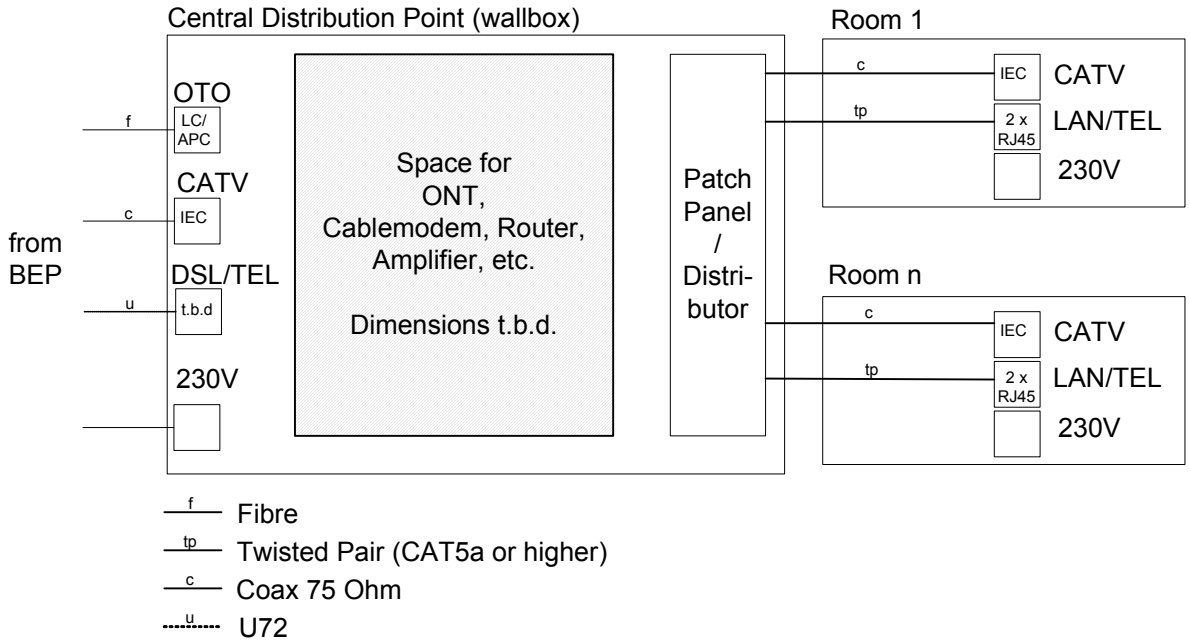
The cabling from the central distribution point should be constructed with a ‘star’ architecture and in the basic version consists either of high quality twisted-pair cables or a combination of twisted-pairs and a 75 Ohm coaxial cable.

In principle at least one multimedia access point per room should be provided. If the communications infrastructure is not completed for all rooms in the initial building phase at least the conduits and mounting boxes for the sockets should be installed to simplify the subsequent installation of the remaining communications infrastructure.

The high-frequency broadcast part of the structured cabling should be bi-directional and fulfil the electrical requirements according to EN50083-x, e.g. [18].

6.2 Example With Central Home Distribution Rack or ‘Wall Embedded Box’

This generic structure should be applied in single family houses or apartments with more than 3 rooms.



6.3 Example Without Central Distribution Rack or 'Wall Embedded Box'

This simple structure can be applied in smaller apartments up to 2/3 rooms.