Outdoor Installation 1:

Physical Installation & Power over Ethernet (POE)

Training materials for wireless trainers

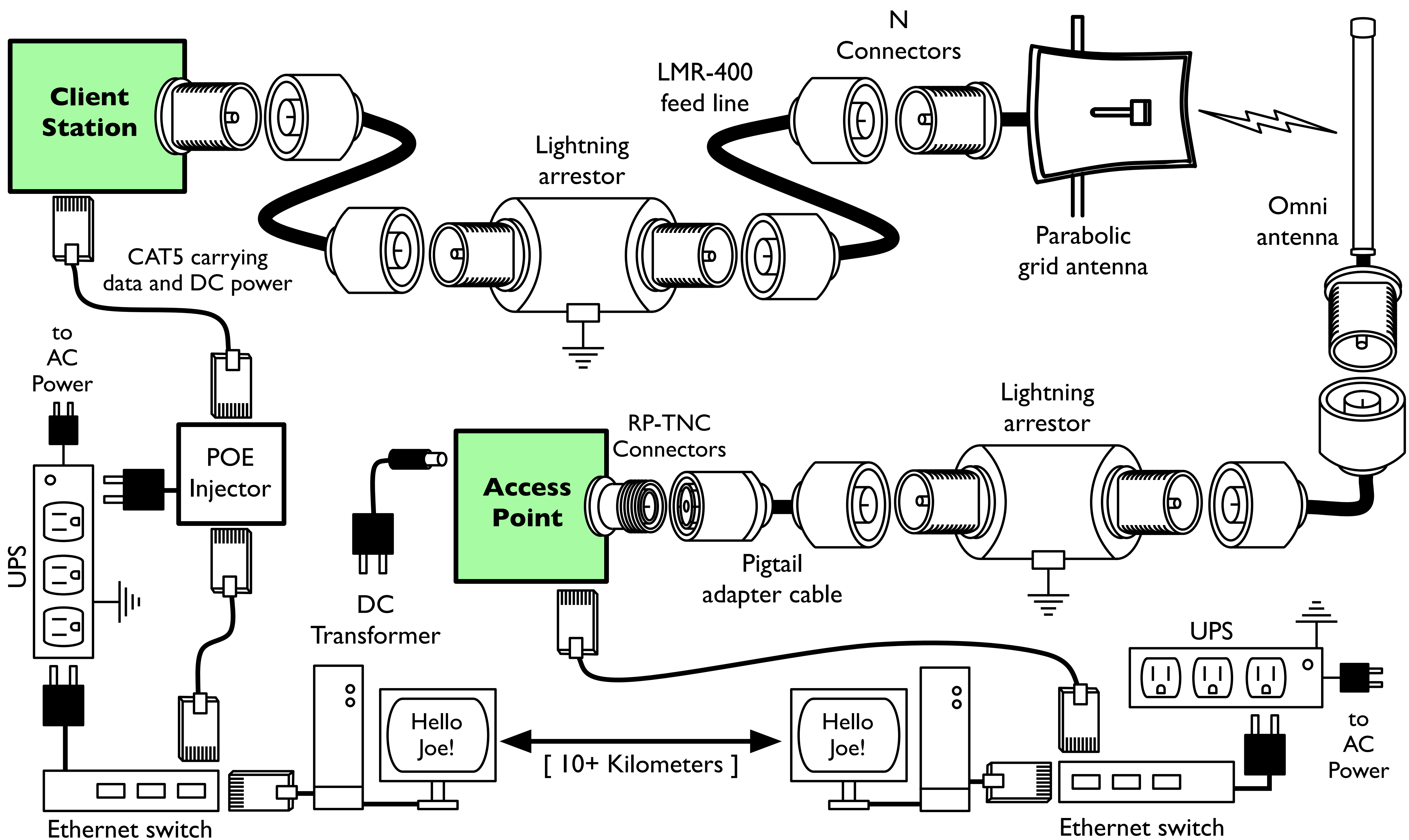
The Abdus Salam International Centre for Theoretical Physics

United Nations Educational, Scientific and Cultural Organization

Goals

- To understand the different kinds of successful tower structures
- To see examples of proper equipment weatherproofing
- To review common sense installation safety procedures

Connections



Typical installation

Installed equipment typically includes:

- One or more ***wireless routers***
- ***Antennas*** and mounting brackets
- ***Antenna mount*** (non-penetrating, wall mount, etc.)
- 50 Ω ***transmission line*** (LMR 400)
- ***PoE injector*** and twisted pair cable (UTP, FTP or STP)
- Appropriate ***connectors*** or ***adapters***
- ***Lightning arrestors*** and ***grounding cable***
- Self-amalgamating (mastic) tape or compound

Base station mounting requirements

In a point to multipoint deployment, the ***location of the base station*** (access point) is by far the must important concern, in order to have the best possible coverage.

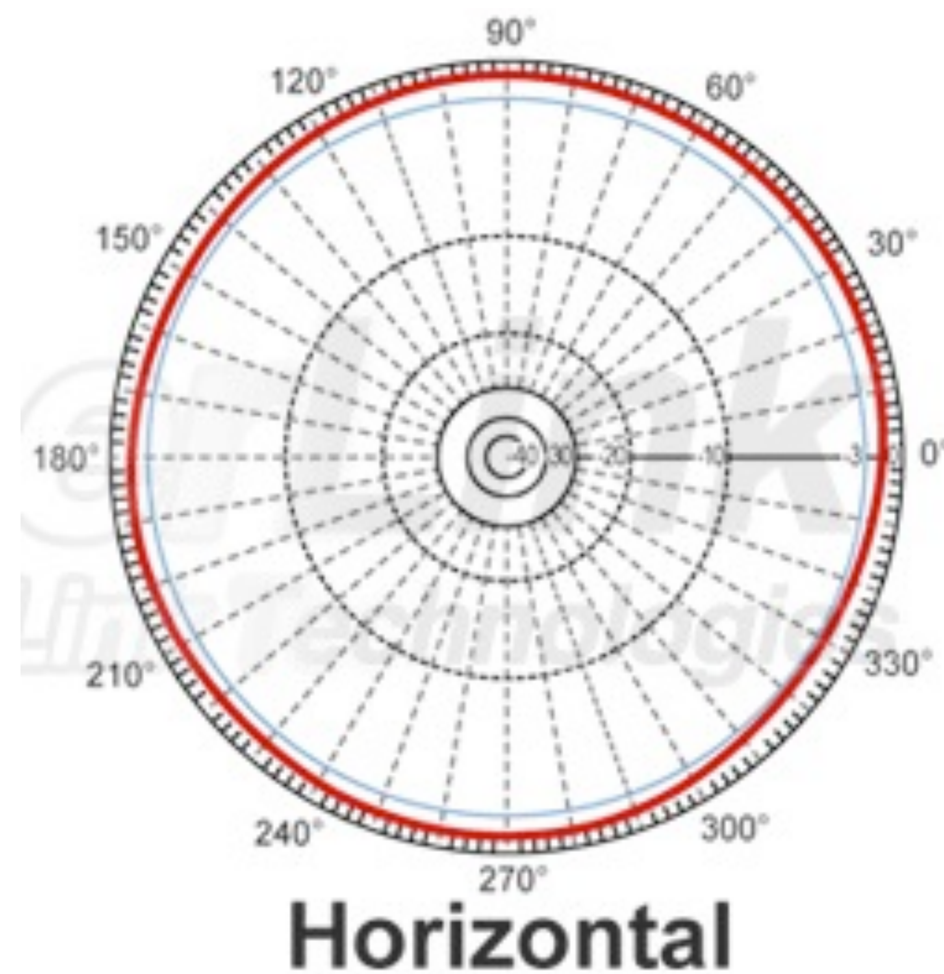
Other important considerations:

- Access to the power grid
- Physical security of the equipment
- Accessibility of the site
- Antenna placement on the building or tower

Horizontal radiation pattern

The horizontal pattern of an omni antenna approaches a circle. A small pipe near the antenna (such as part of the mount) can act as a reflector, changing the gain up to 3 dB in some directions, disrupting the radiation pattern.

A large object, such as the back of a parabola, can completely block the signal in a given direction.

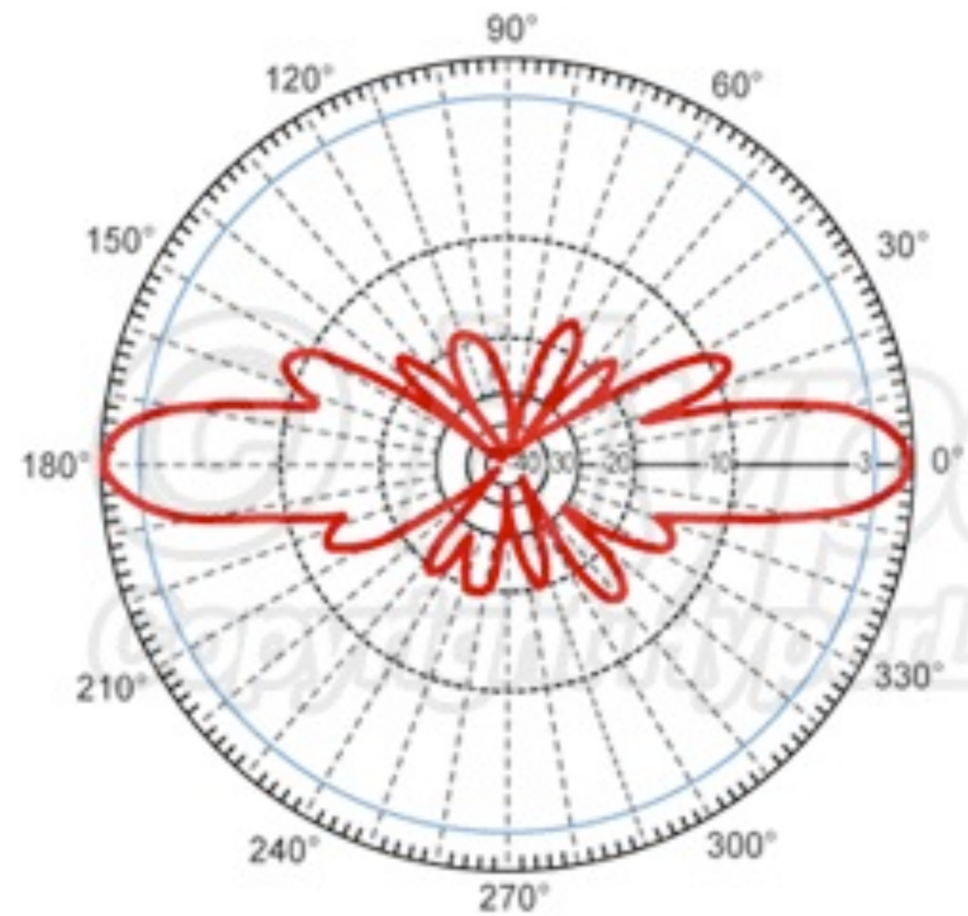


Vertical radiation pattern

The gain of an omni is obtained by narrowing the vertical radiation pattern.

This applies when the antenna is far from conducting objects, and constitutes a good approximation when the antenna is at the very top of the tower.

The vertical radiation pattern will change substantially if the omni is located further down on the tower, as it interacts with the physical structure.



Vertical

Tower angle

A self-supporting tower often has a tapered design, becoming narrower with height. This will tilt the beam upward up to 5 degrees.

A typical 15 dBi omni has an 8 degree vertical beamwidth.

The beam can be tilted upwards so much that the signal will be sent where it does no good at all.

Downtilting

Sectorial antennas are less affected by the tower and can easily be downtilted.

This is particularly necessary when the client is close to the base station, or when the base station is much higher than the client.

Mechanical downtilting can compensate for the effect of the structure.

Electrical downtilting can be accomplished by changing the phase of the feeding elements.

Antenna mounting considerations

- Locate the antennas so that they have clear line-of-sight to each other.
- There should be no obstructions within 10 degrees azimuth of the antenna bore sight.
- Beware of possible reflecting structures in or behind the path.
- Beware of trees whose growth might obstruct the path.
- Avoid trajectories over bodies of water.
- On rooftops, mounting the antenna close to the edge helps to avoid problems with reflections.

Self-supporting towers

Self-supporting towers are expensive to build, but are often the best choice for the base station.

An existing tower can usually be used, although AM transmitting station antennas should be avoided because the entire structure is an active element.

FM transmitting stations are acceptable, but be sure to use shielded twisted pair cable on long Ethernet runs.

Guyed towers

A climbable ***guyed tower*** is normally made of aluminum with a triangular cross section, about 30 cm per side.

Each section is about 3 m long and several sections can be bolted together to attain the required height.

The tower must be properly guyed to withstand the expected wind in the area, as well as to support the weight of the equipment and one or two people.

Free-standing pole

A ***free-standing pole*** is often less expensive to build than a tower.

Such a tower can be built cheaply by attaching foot rests to any sizable pipe.

Tower installation safety

Many countries require special training for people to be allowed to work on towers above a certain height.

Avoid working on towers during strong winds or storms.

Always work on towers with a partner!

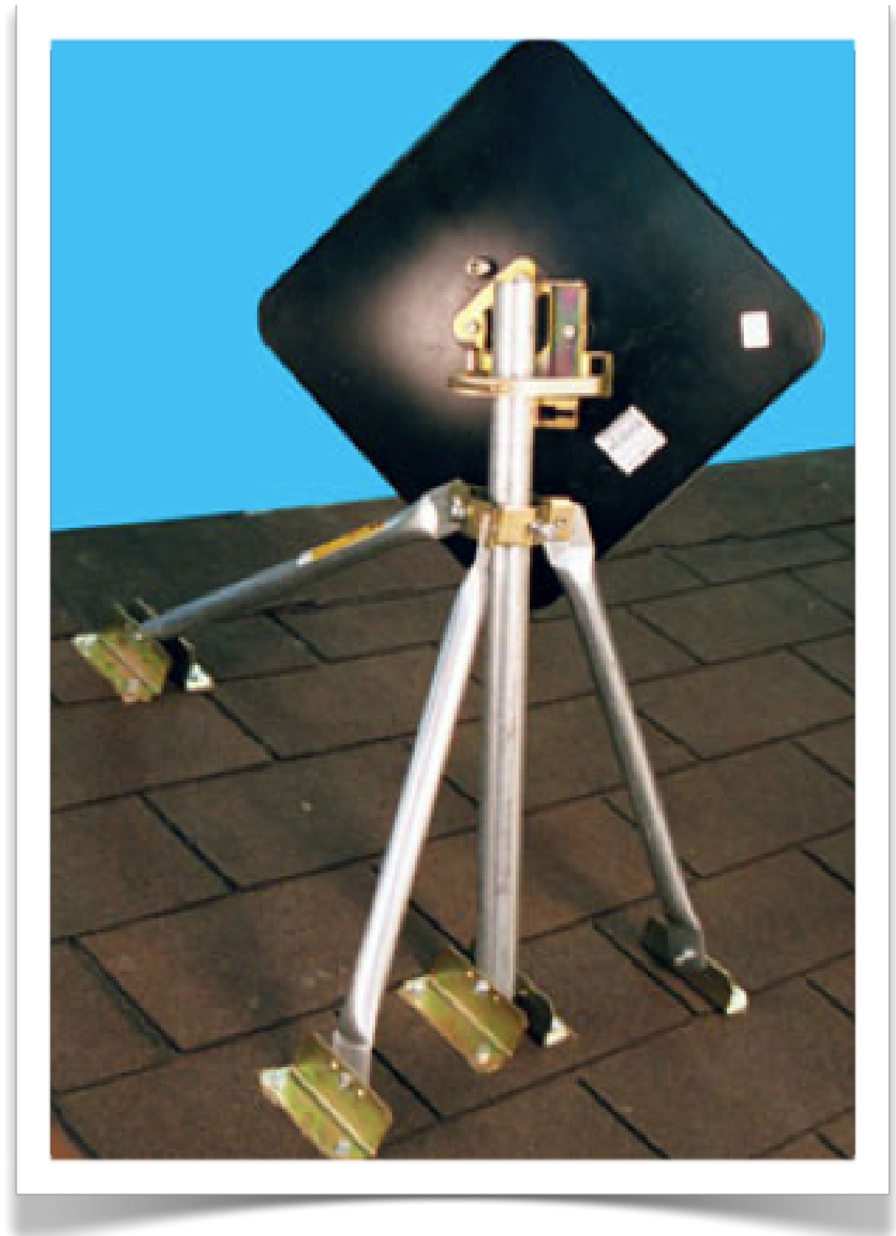
Always wear a harness securely attached to the tower when working at heights.

It is **extremely** hazardous to work in the dark. Give yourself plenty of time to complete the job long before the sun sets.

Penetrating roof mounts

Care must be taken in order to prevent water from seeping in through the attachment bolts.

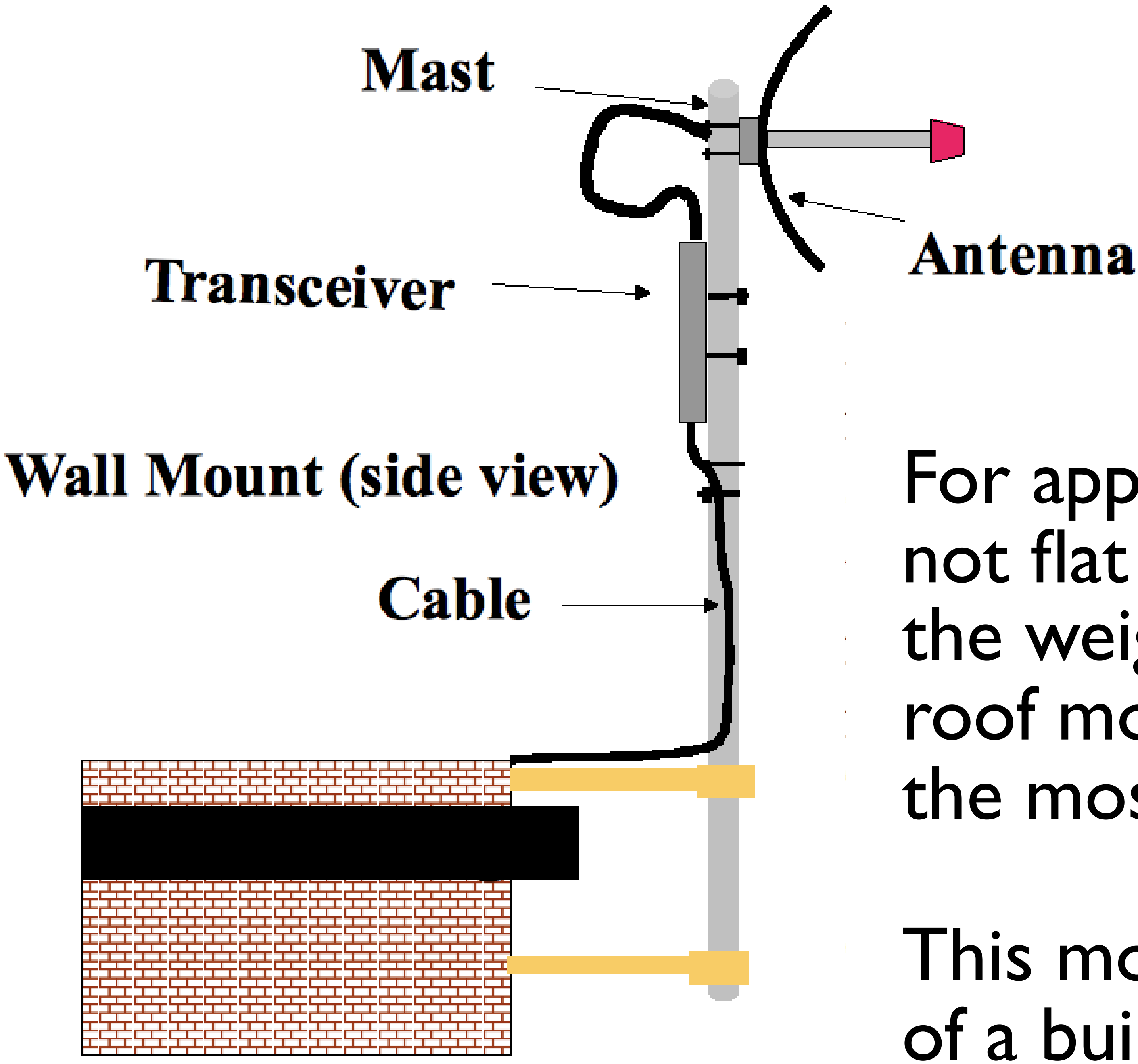
Seal all penetrating holes with appropriate sealant (such as amalgamating putty or silicone sealant).



Non-penetrating roof mounts

This metal base can be weighed down with sandbags, rocks, or water bottles to make a stable platform without penetrating a roof.

Wall mounts



For applications where the roof is not flat or strong enough to hold the weight of a non-penetrating roof mount, the ***wall mount*** is the most effective solution.

This mount is affixed to the side of a building, wall, or chimney.

Installation tips

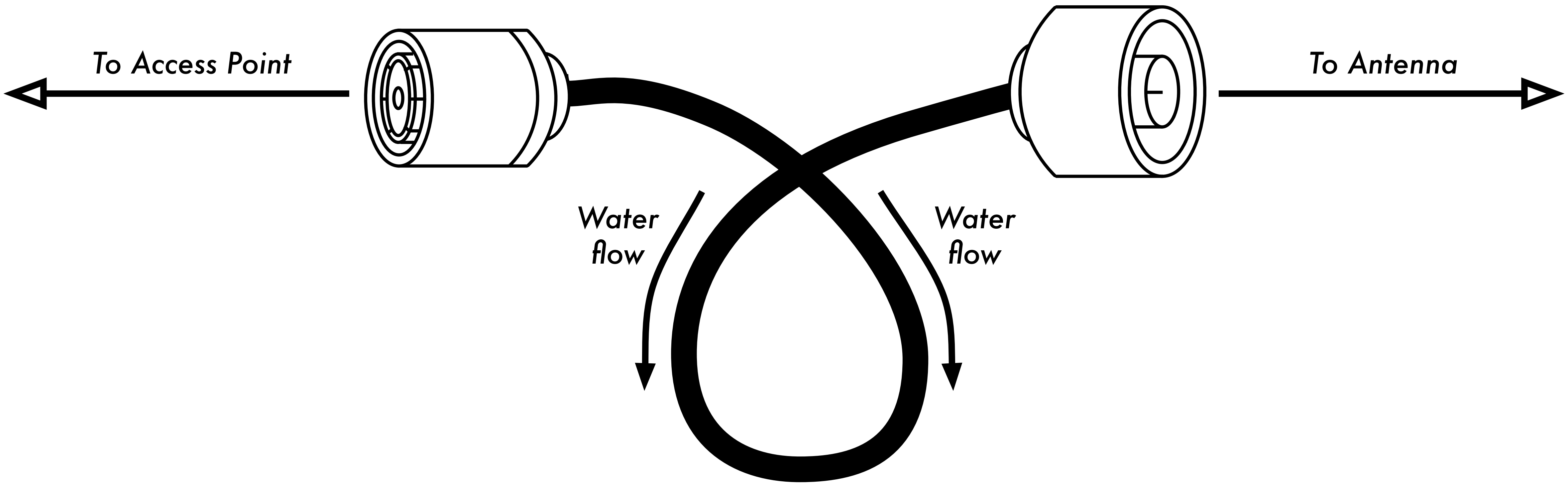
- Do your AP and client configuration in the lab, not in the field!
- Keep coax lines **short**: no more than 15 meters!
- Tape and secure all connectors
- Use weatherproofing tape (**not** electrical tape or duct tape)
- Use black nylon zip ties (white ties break down in UV)
- Whenever possible, use conduit for cables.
- If using PoE, use weatherproof UTP and connectors.
- If possible, shield the radio from sun and rain.

Weatherproofing antennas

Most antenna problems are caused by coaxial cable connections that loosen due to vibration, allowing moisture to penetrate the connector interface.

Weatherproof all outdoor connections.

Drip loops



By adding a small loop to antenna and Ethernet cables, you can direct rainwater to flow away from the connector. This can greatly extend the life of your equipment.

This is important even when using sealed "waterproof" connectors.

Weatherproof Enclosures

When buying enclosures that are to protect equipment installed outdoors:

- Make sure that they can withstand the prevailing conditions of the site.
- There are two organizations that have developed widely adopted standards for enclosures:
  - *National Electrical Manufacturers Association* (*NEMA*) in North America
  - *International Electrotechnical Commission* (*IEC*) in Europe with its Ingress Protection specifications

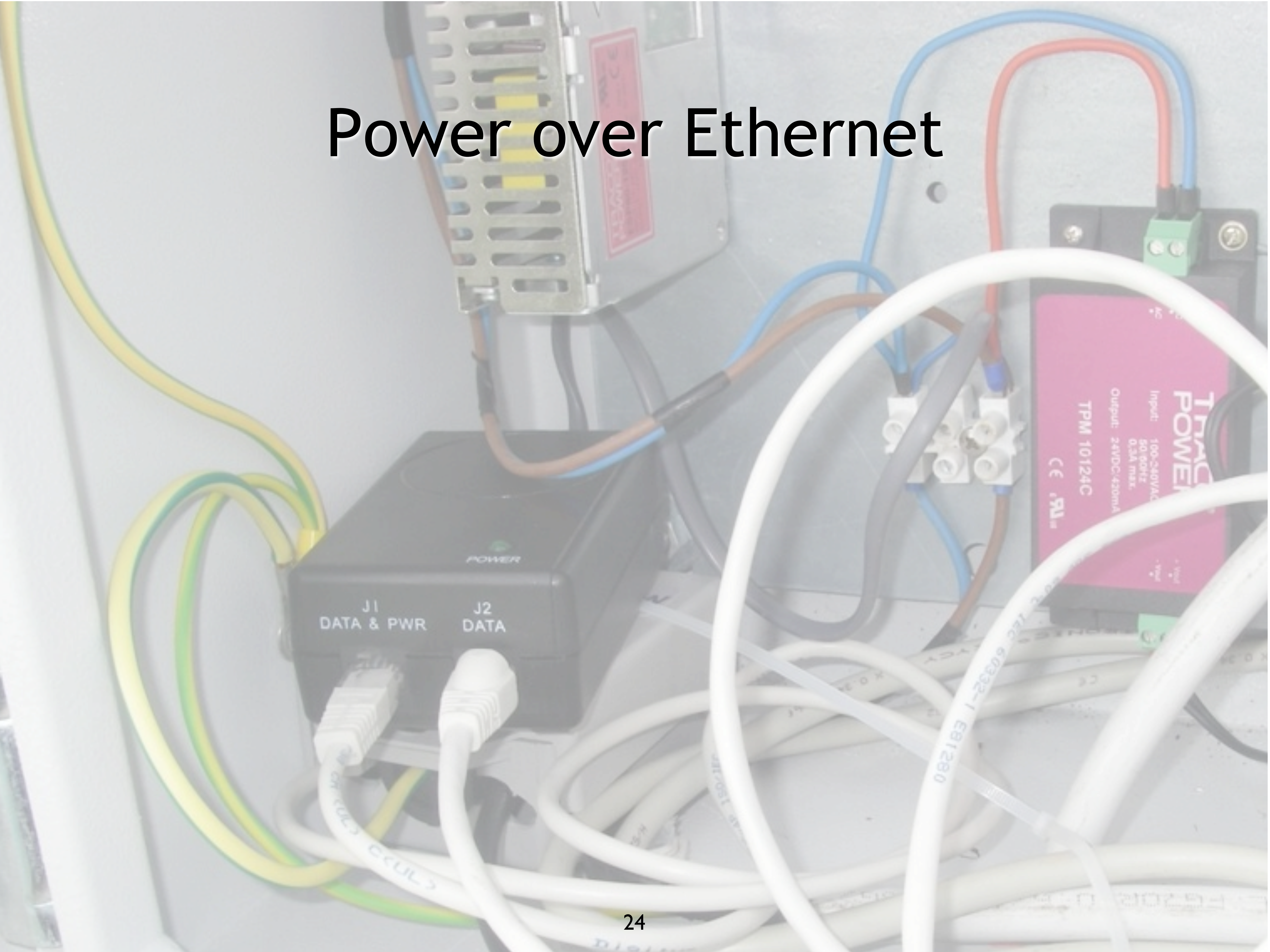
IP Ratings

1st digit	Definition	2nd digit	Definition
0	no protection	0	no protection
1	Against penetration of solid objects of 50 mm diameter or more	1	Against vertical dripping water
2	Against penetration of solid objects of 12.5 mm diameter or more	2	Against vertical dripping water at an angle of up to 15°
3	Against penetration of solid objects of 2.5 mm diameter or more	3	Against vertical dripping water at an angle of up to 60°
4	Against penetration of solid objects of 1 mm diameter or more	4	Against splashing water in all directions
5	Protected against dust	5	Against water jets in all directions
6	Dust-proof	6	Against powerful water jets in all directions
		7	Against temporary immersion up to 1m
		8	Continuous immersion under specific conditions

Correspondence between NEMA and IP

NEMA type	NEMA definition	IP class
1	Protection against dust, light, indirect splashing, but is not dust-tight	IP10
2	Drip-tight. Similar to type 1 but with additional drip shields where condensation may occur	IP11
3 and 3S	Weather resistant. Protects against rain and sleet.	IP54
3R	Protection against falling rain and ice	IP14
4 and 4X	Watertight against jet directed water	IP56
5	Dust-tight	IP62
6 and 6P	Submersible depending on specified conditions of pressure and time	IP67

Power over Ethernet



Why Power over Ethernet (PoE)?

- Saves money and installation time
- More flexibility in the placing of devices
- Quite useful for outdoor installs, allowing for a long distance between the AP and the computer
- Does not require an electrician to install
- Saves copper !

PoE issues

- Standard or not?
- End Span or Mid Span?
- Requires Cat5e or Cat6 with less than 25 Ω loop
- Pin assignment type A or B?
- Measured resistance for 100 meters = 10 Ω
- Should use outdoor rated twisted pair cable
- Some equipment requires "good power" signature

IEEE standard 802.3af-2003

- Powering Ethernet devices through data cables
- Standard Title: Data Terminal Equipment (DTE) Power via Media Dependent Interface (MDI)
- Approved June 2003
- Supports up to ~13W on a single cable

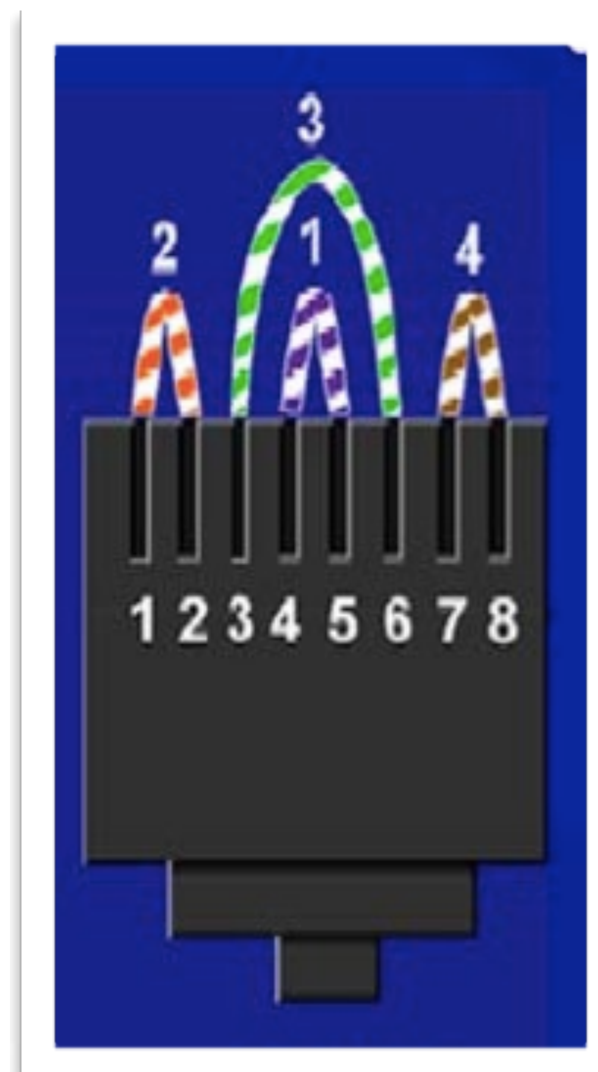
IEEE standard 802.3at-2009

- Extension to 802.3af-2003
- Approved September 2009
- Supports up to 25W per cable
- Proprietary extensions can support up to 51W!

End span or mid span

- PoE (802.3af) runs at 48V DC, with a max current of 350mA, capable of feeding a maximum load of 12.95W accounting for the cable losses

- **End span 802.3af** provides power on either the data pairs (1+2, 3+6) or spare pairs (4+5, 7+8)
- **Mid span 802.3af** provides power on the spare pairs (4+5, 7+8).



Example: 20 meter cable

Assume your power supply provides 12 VDC @ 1.5 A, for a total available power of:

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12 V * 1.5 A = 18 Watts
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But this assumes a feed line of zero resistance. Typical CAT5e resistance is about 0.1 Ω per meter, per conductor. When using two pairs of wire, the total loop resistance of a 20 meter CAT5e cable would be:

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0.1 Ω/m * 20 m * = 2 Ω
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Example: 20 meter cable

Because of line resistance, we will lose some voltage at the other end of the cable. The voltage drop will be:

$$V_{drop} = 1.5\ A * 2\ \Omega$$
$$V_{drop} = 3$$

After subtracting the drop, the actual expected voltage at the far end will be:

$$V = 12 - 3$$
$$V = 9$$

Your output voltage is only about 9 volts, far less than your equipment is expecting!

Providing enough power

To provide the proper voltage, you will need to use a different power supply. It should provide at least V_{drop} higher voltage at the same current as the original supply (in this case, a 15 V @ 1.5 A power supply should be sufficient).

It is also important to provide sufficient current to power your device. If you install an access point, and later add more radio cards, the additional power draw may be more than your supply can provide. Be sure to add the power requirements of all of the components (radio cards when transmitting, motherboard, etc.) when determining the proper power supply for your installation.

Conclusions

- Outdoor equipment must be properly mounted and protected from the weather.
- There are a variety of methods for installing radio equipment on roofs, walls, and towers.
- Antennas should be placed so that most of the energy is directed towards the other end of your link while avoiding reflections.
- Powering equipment with POE can simplify installations.

Thank you for your attention

For more details about the topics presented in this lecture, please see the book ***Wireless Networking in the Developing World***, available as free download in many languages at:

http://wndw.net/