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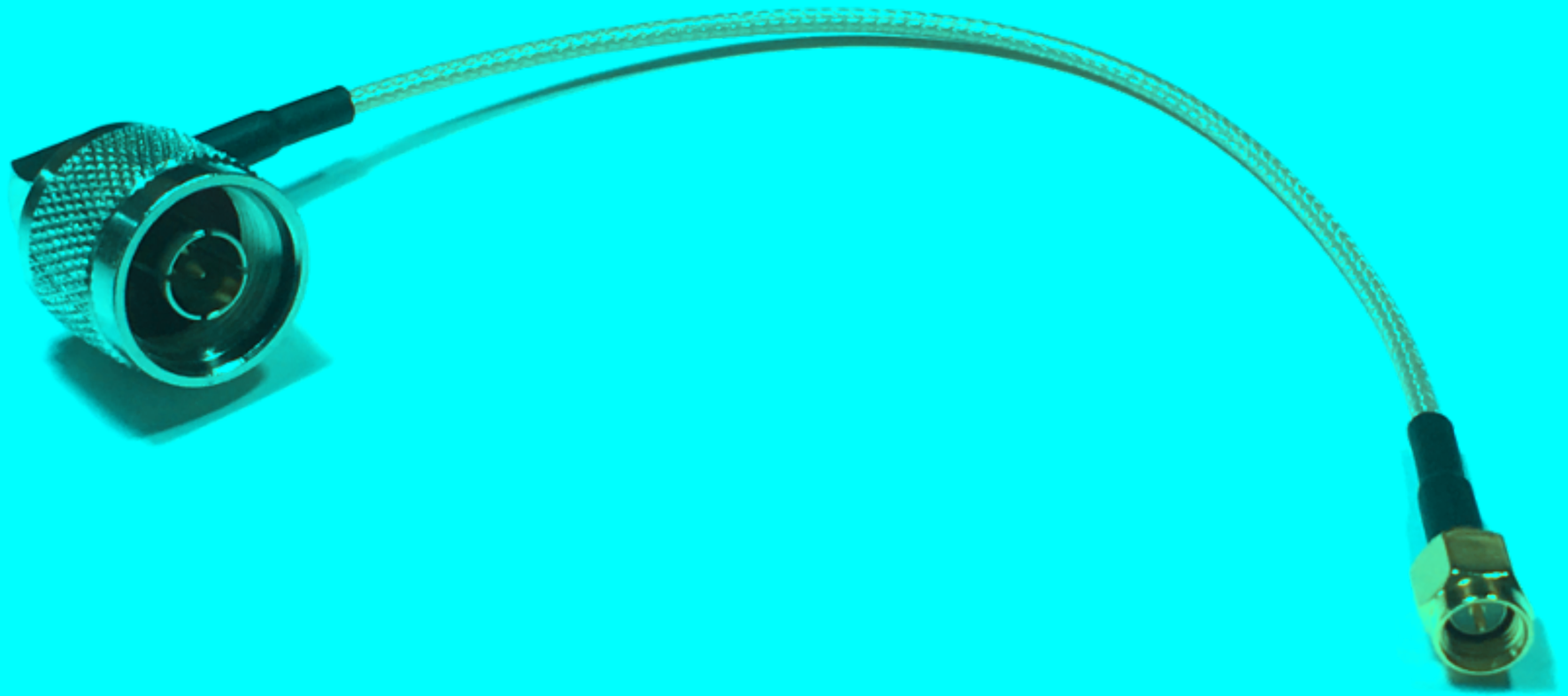
LORA / LORAWAN TUTORIAL 35

Coax Cables and Coaxial Connectors



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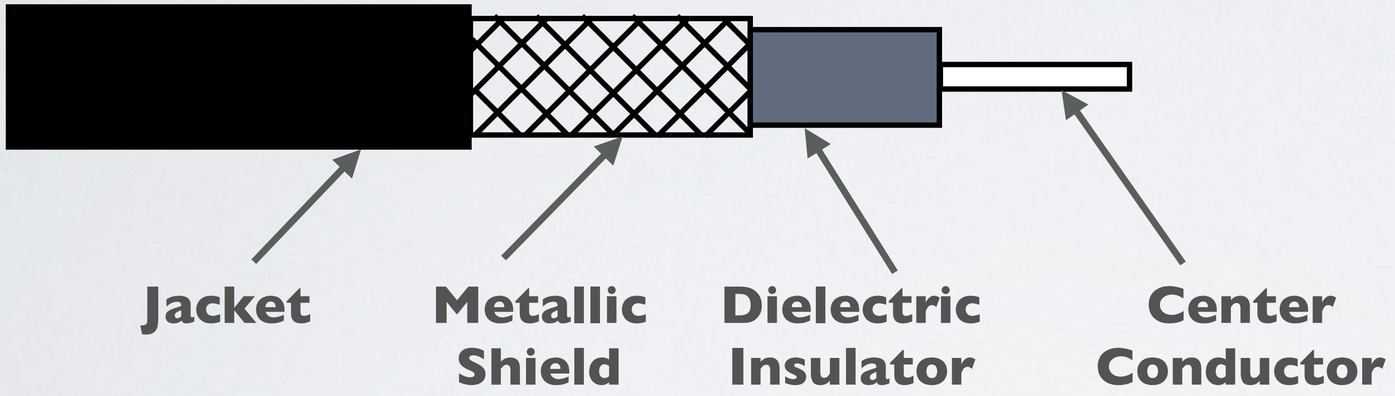
INTRO

- In this tutorial I will explain:
  - The different types of coaxial cables and connectors.
  - What characteristic impedance is and how it is calculated.
  - What the impact is of cable losses.

COAXIAL CABLE

- To transport radio frequency signals, a coaxial cable or coax cable is used.



- Coax cables uses the RG ratings and RG stands for Radio Guide.

- The number after RG refers to different cable specifications.
  For example RG58, RG174, etc.

CHARACTERISTIC IMPEDANCE

- The higher the RG number, the thinner the central conductor core is.
- The suffix U for Universal means for general utility use, for example RG 174/U.
- A coax cable (or any type of transmission line) impedance is called characteristic impedance and usually written as Z_0 and cannot be measured by an ohmmeter.
- A transmission line characteristic impedance is measured by an instrument called the time domain reflectometer or an oscilloscope.
- This impedance is a measure of resistance to the flow of electrical energy.

CHARACTERISTIC IMPEDANCE

- There are two main types of coaxial cables, ones with an impedance of 75 Ω and ones with an impedance of 50 Ω.

- In general 50 Ω coax cables are used for data communications (LoRa, WiFi, etc.) or amateur radio.

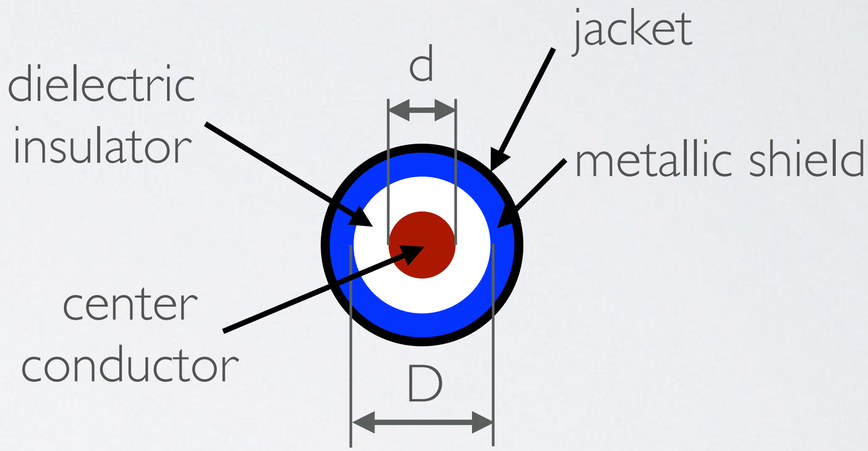
- In general 75 Ω coax cables are used for digital audio or video applications.

COAX CABLE IMPEDANCE CALCULATION

- The coax cable impedance remains constant regardless of the length of the cable.

- The coax cable impedance is calculated as follows:

$$Z = \frac{138}{\sqrt{E}} \times \log_{10} \frac{D}{d}$$



Z is the coax cable impedance in Ohm [Ω]
E is the dielectric constant
D is the inside diameter of the outer conductor (metallic shield) in millimeters [mm]
d is the outside diameter of the center conductor in millimeters [mm]

ATTENUATION

- A signal travelling thru a coax cable losses power, also known as attenuation.
  This signal power loss is measured in decibels per meter (dB/m).
  These losses are mainly caused by:

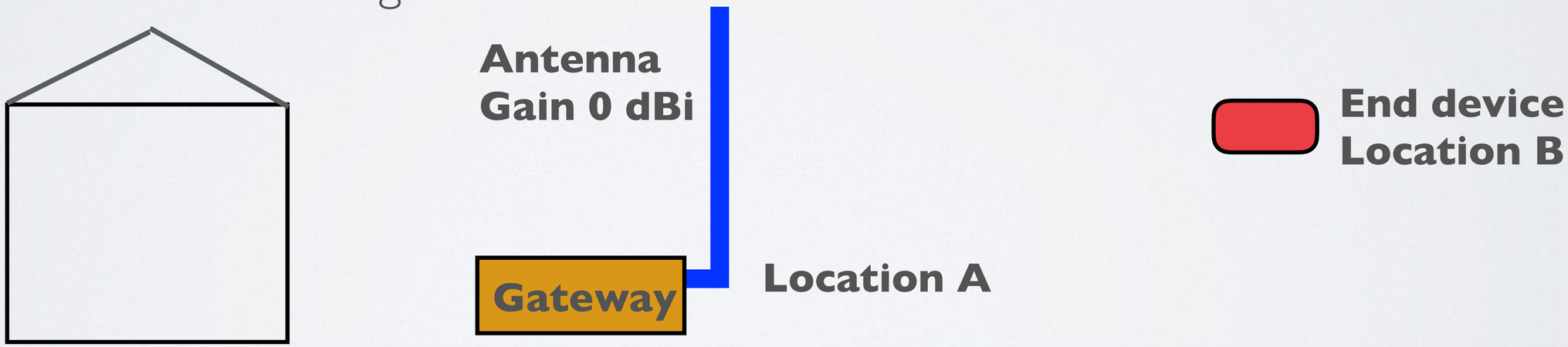
  - The conductor, in the form of ohmic losses.
    Think of impurities in the conductor.

  - The dielectric touching the conductor.
    The dielectric absorb some of the energy transported by the conductor.

ATTENUATION

- Lets assume a coax cable type RG58/U has an attenuation of 18.2 dB for every 100 ft (= 30.48 m) for frequency range 806-960 MHz.
  Note: On the Internet you can find Coaxial Cable Attenuation Charts.

- Lets assume the antenna with a gain of 0 dBi is directly attached to the gateway (EU region: 868 MHz) and placed outside at location A. An end device at location B transmits a signal and is received by the antenna at location A. The end device signal is received with a RSSI average of -75.



ATTENUATION

- Lets assume the same gateway is now placed indoors and is now connected to a 9 dBi gain antenna using a RG58/U coax cable.
  The new antenna replaces the old antenna and is mounted at the same location A.
  The cable length is 8 meters.

- The same end device, at location B, transmits a signal and is received by the antenna at location A.

EXAMPLE

- Question: What is the overall gain and the end device signal received RSSI?

- Answer:
  The coax cable loss = 8 x 18.2 / 30.48 = 4.78 dB
  The antenna gain = 9 dBi
  The overall gain (antenna gain incl. cable loss) = 9 - 4.78 = 4.22 dB

  The previous RSSI average = -75.
  The new RSSI average = -75 + 4.22 = -70.78

- It is important to minimise the cable loss by buying a quality coax cable with lower attenuation (dB/m). What if the antenna has a gain of 5 dBi?
  The overall gain = 5 - 4.78 = 0.22 dB
  In this example the cable loss cancels the antenna gain, which is terrible.

AVOID SIGNAL LOSS

- To avoid signal loss:
  - Always keep the coax cable as short as possible and preferably connect the antenna directly to the device.
  - Minimise the number of connectors.
  - As the gateway should be 50 Ω, always use 50 Ω coax cables otherwise this will result in impedance mismatch thus a bad VSWR.

COAXIAL CONNECTORS

- Coaxial connectors are used to connect coax cables to other devices and maintain the cable's shielding.

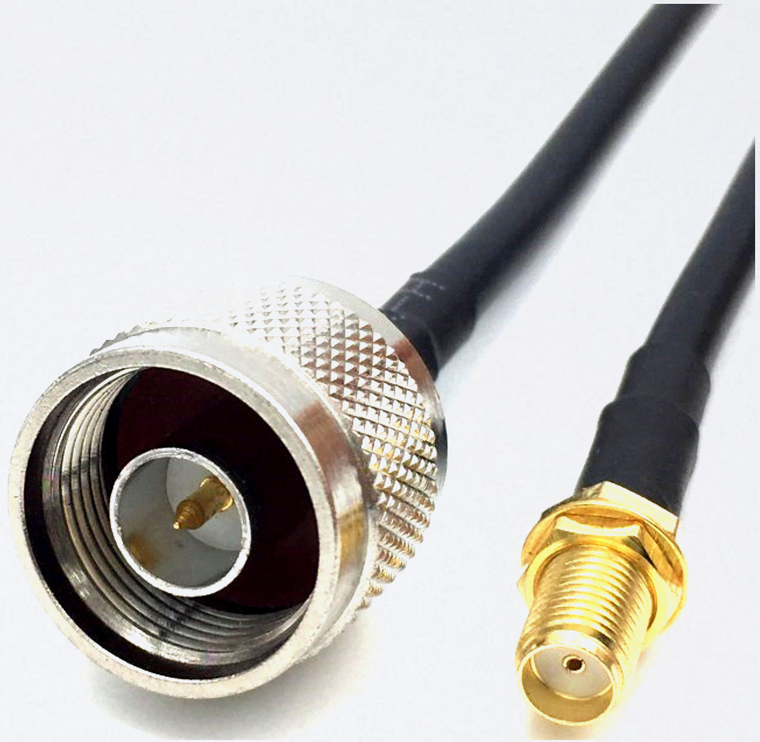
- There are two coaxial connectors types: male and female.

- A male connector (aka plug) has a metal pin which protrude from the center and a female connector (aka jack) has a recessed hole to receive the pin.

- There are several coaxial connector types. In this tutorial only two types will be discussed: type N connectors and SMA connectors.

TYPE N CONNECTORS

- Type N connectors are threaded connectors and are larger, tougher and can withstand abuse compared to SMA connectors. Type N connectors are available with 50 Ω and 75 Ω impedance. When using a thicker coax cable, than type N connector is the best choice. In general type N connectors are not waterproof.



SMA CONNECTORS

- SMA (**S**ub**M**iniature version **A**) connectors are connector interfaces for coaxial cables with screw type coupling mechanism. The connector has a 50 Ω impedance.

- SMA connectors are smaller in size and are used together with smaller size coax cables. In general SMA connectors are not waterproof.

SMA CONNECTORS

- There are two types of SMA connectors (technically they behave the same):
  - A standard polarity SMA male or SMA female connector:
    SMA male / SMA female
  - A **R**everse **P**olarity SMA male or SMA female connector:
    RP SMA male / RP SMA female

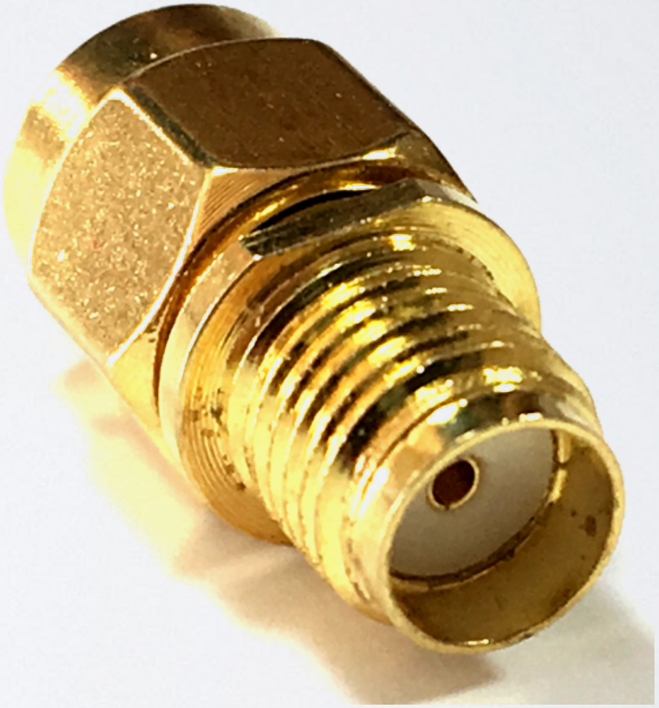
- To determine which is which is a two step process:
  1. Barrel with a thread inside: SMA male
     Barrel with a thread outside: SMA female
  2. If SMA male has a centre sleeve (hole): RP SMA male
     If SMA female has a centre pin: RP SMA female

SMA CONNECTORS

- A standard polarity SMA male connector has a center pin surrounded by barrel with inside threads, and the standard SMA female connector has a center sleeve surrounded by a barrel with outside threads.

SMA male

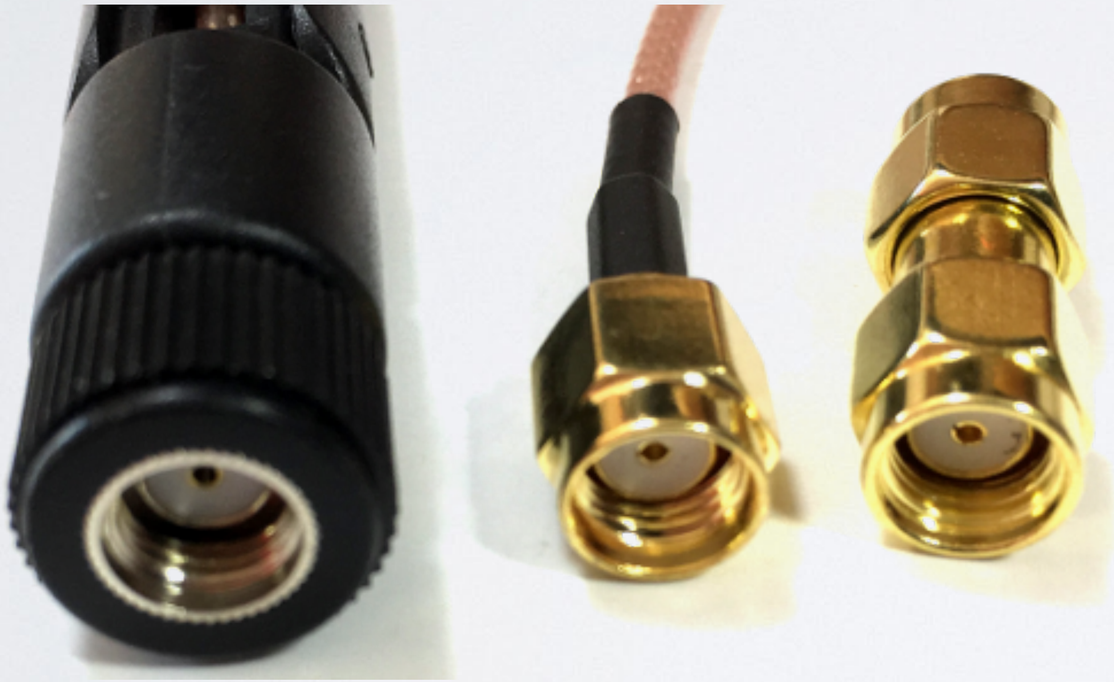
SMA female



SMA CONNECTORS

- A reversed-polarity SMA male connector has a center sleeve surrounded by barrel with inside threads, and the reversed-polarity SMA female connector has a center pin surrounded by a barrel with outside threads.

RP SMA male



RP SMA female