Coaxial Cable RF Feedline and VSWR

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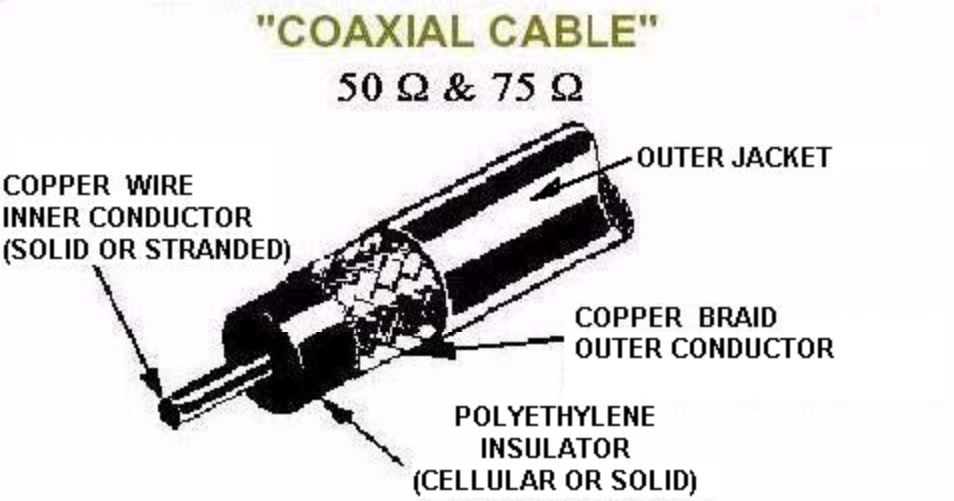

Figure – 1: 50Ω and 75Ω Characteristic Impedance ('Zo') Coaxial Cable

1. Definitions:

    a. Radio Frequency Communication-Electronics Station (**'RFCES'**)
    b. Radio Frequency Communication-Electronics Equipment (**'RFCEE'**)
    c. Impedance (**'Z'**)
    d. Characteristic Impedance (**'Zo'**)
    e. Radio Frequency (**'RF'**)
    f. Intermediate Frequency (**'IF'**)
    g. Audio Frequency (**'AF'**)
    h. Alternating Current (**'AC'**)
    i. Cycles Per Second (**'CPS'**)
    j. Hertz (**'Hz'**)
    k. Local Oscillator (**'LO'**)
    l. Source impedance (**'Zs'**)
    m. Load impedance (**'Z_L'**)
    n. Voltage Standing Wave Ratio (**'VSWR'**)
    o. Current Standing Wave Ratio (**'ISWR'**)
    p. Standing Wave Ratio (**'SWR'**)
    q. Impedance Matching Network (**'IMN'**)
    r. RF Power Amplifier (**'RFPA'**)

2. When setting up a **'RFCES'** one of the most important requirements for proper performance, is to ensure that there is an an **'Z'** match between each piece of **'RFCEE'** and the **'Zo'** of the Coaxial Cable RF Feedline used to connected them.

    a. Each piece of Station Equipment has a RF 'Input' / 'Output' connector (normally a UHF type SO-239) with an **'Z'** of 50 Ohms by design. This Impedance is the

'Source' Impedance in the 'Transmit Mode' and the 'Load' Impedance in the 'Receive Mode'.

b. This necessitates that the Coaxial Cable RF Feedline used have a **'Zo'** of 50 Ohm.

c. The Coaxial Cable RF Feedline 50 Ohm **'Zo'** will then match the 50 Ohm SO-239 **'Z'** of the each piece of inline **'RFCEE'** .

d. This is a critical requirement for a maximum transfer of power, longevity and overall performance of all **'RFCEE'**.

e. An improper impedance match between any **'RFCEE'** will reduce available power and cause the stages to run much hotter, which could lead to a premature failure due to excessive heating.

3. The term '**RF'** is used to describe the quantity of **'AC' 'CPS'**, measured in **'Hz**', which is suitable for Radio Transmission and Reception.

4. The term '**IF'** is used to describe the quantity of **'AC' 'CPS'**, measured in **'Hz'**, that is created when a Transceivers **'LO'** Frequency mixes with:

   a. Any **'RF'** and '**IF'** in the Receive stages.

   b. Any '**IF'** and **'RF'** in Transmit stages.

5. The term **'AF'** is used to describe the quantity of **'AC' 'CPS'**, measured in **'Hz**', which is within the hearing range of the Human Ear.

   a. *In a Receive Mode*, **'RF'** is passed from the Active Antenna to the first Receiver mixer circuit and mixed with the Frequency of first Receiver **'LO'**, which creates the first Receiver '**IF'** and then this is passed to subsequent mixer circuits to generate other '**IF'** after mixing with other **'LO'** Frequencies and then finally the **'AF'** is detected from the last '**IF'.**

   b. *In the Transmit Mode*, **'AF'** is created by the Microphone then passed to the first Transmitter mixer circuit and mixed with the Frequency of the first Transmit **'LO'** Frequency which creates the first Transmit '**IF'** and then is passed to subsequent mixers to be mixed with other **'LO'** Frequencies to generate other '**IF'** and then passed to the final Transmit mixer stage to mix with the final transmit **'LO'** Frequency which creates the **'RF'** measured in Hertz (Hz).

6. Standing Waves **('SW')** of AC Voltage and Current are created on all RF Feedlines connected between every piece of **'RFCEE'**, when there is a mismatch between the **'Zs'** and the **'ZL'**. This is an undesirable condition and will reduce overall efficiency of the system.

7. All Active Antennas used in a **'RFCES'** are the '**Final Load'** in the Transmit mode and the **'First Source'** in the Receive mode.

a. Most Active Antennas do not have a 50Ω **'Z**' by design, which is the required impedance to match the source 50Ω **'Zo'** of the Coaxial Cable RF Feedline connected to it, which would allow the maximum transfer of power.

b. **Figure-1** above shows the design of 50Ω and 75Ω Characteristic Impedance Coaxial Cable.

1. 50Ω **'Zo'** Coaxial Cable is normally used in RF Communication-Electronic Station Systems, in Transmit and Receive modes.

2. 75Ω **'Zo'** Coaxial Cable is normally used in Cable TV Systems in the Receive mode only.

8. In a **'RFCES'** every piece can be a 'Source' and a 'Load'.

a. An Impedance mismatch can happen when any Source Impedance and Load Impedance differ.

b. Examples of the 'Sources' and 'Loads' in a Transmit Mode using the following Station Equipment: Transceiver, 'RFPA', 'IMN', Coaxial Cable RF Switch, Active Antenna and the Coaxial Cable RF Feedlines connecting all the pieces:

- 1st Source = Transmitter Stage of Transceiver
- 1st Load = Transmitter Coaxial Cable RF Feedline Jumper - 1
- 2nd Source = Transmitter Coaxial Cable RF Feedline Jumper - 1
- 2nd Load = 'RFPA'
- 3rd Source = 'RFPA'
- 3rd Load = 'RFPA' Coaxial Cable RF Feedline Jumper - 2
- 4th Source = 'RFPA' Coaxial Cable RF Feedline Jumper - 2
- 4TH Load = 'IMN'
- 5th Source = 'IMN'
- 5th Load = 'IMN' Coaxial Cable RF Feedline Jumper - 3
- 6th Source = 'IMN'Coaxial Cable RF Feedline Jumper - 3
- 6th Load = Coaxial Cable RF Switch
- 7th Source = Coaxial Cable RF Switch
- 7th Load = RF Switch Coaxial Cable RF Feedline Jumper - 4
- 8th Source = RF Switch Coaxial Cable RF Feedline Jumper - 4
- 8th Load = Active Antenna

c. Examples of the 'Sources' and 'Loads' in a Receive Mode using the following Station Equipment: Transceiver, 'RFPA', 'IMN', Coaxial Cable RF Switch, Active Antenna and the Coaxial Cable RF Feedlines connecting all the pieces:

- 1st Source = Active Antenna
- 1st Load = Active Load Coaxial Cable RF Feedline Jumper - 4
- 2nd Source = Active Coaxial Cable RF Feedline Jumper - 4
- 2nd Load = Coaxial Cable RF Switch
- 3rd Source = Coaxial Cable RF Switch

- 3rd Load = RF Switch Coaxial Cable RF Feedline Jumper - 3
- 4th Source = RF Switch Coaxial Cable RF Feedline Jumper - 3
- 4TH Load = 'IMN'
- 5th Source = 'IMN'
- 5th Load = 'IMN' Coaxial Cable RF Feedline Jumper - 2
- 6th Source = 'IMN' Coaxial Cable RF Feedline Jumper - 2
- 6th Load = 'RFPA'
- 7th Source = 'RFPA'
- 7th Load = 'RFPA' Coaxial Cable RF Feedline - 1
- 8th Source = 'RFPA'Coaxial Cable RF Feedline - 1
- 8th Load = Receiver Stage of Transceiver

9. **'VSWR' / 'ISWR'** are the abbreviations used for the ratio measurement of:

    a. **'VSWR'** is the Maximum Voltage (V) to the Minimum Voltage (V) present on the Coaxial Cable RF Feedline when a mismatch of impedance exists between it's 'Source' and it's 'Load'.

    b. **'ISWR'** is the Maximum Current (I) to the Minimum Current (I) present on the Coaxial Cable RF Feedline when a mismatch of impedance exists between it's 'Source' and it's 'Load'.

    c. Normally **'VSWR'** and **'ISWR'** are usually abbreviated as **'SWR'.**

10. ***SWR <u>is</u> a 'RF Feedline' property.***

    a. An appropriate impedance match is determined by measuring the **'SWR'** ratio on the Coaxial Cable RF Feedlines connecting <u>all</u> the **'RFCEE'** from the Transmitter to the **Active Load (*Active Antenna*)** or the **Dummy Load (*Dummy Antenna*).**

11. ***SWR <u>is not</u> an 'Antenna' property***.

    a. Antennas only have **'Z'** that vary with the Frequency of the **'RF' 'AC'** energizing them.

    b. **'Z'** of an the Antenna refers to the ratio of the Voltage Field to the Current Field flowing within the Antenna.

12. ***SWR*** is often verbally ***erroneously*** stated in one of following methods.

    a. "My *Antenna* displays a SWR of (value)."

    b. “My *Antenna* SWR’s are (value).”

    c. “My *Antenna* Suwers are (value).” ('Suwers' is a slang word ***improperly used*** by some Radio Operators, instead of spelling the letters individually).

13. A **'SWR'** meter placed in a **'RFCES'** as the last piece of equipment before the Active Load will show the impedance match between the 'Source' 50 Ohm **'Zo'** of the Coaxial Cable

RF Feedline and the Complex Impedance **'Z'** of the Active Antenna 'Load' Feedpoint in Transmit mode.

14. What is an acceptable **'SWR'** measurement on a Coaxial Cable 50 Ohm **'Zo'** RF Feedline connecting all station equipment?

    a. It should be noted that obtaining a theoretical ideal **"1.0:1"** ratio 'Source' to 'Load' **'SWR'** match on a Coaxial Cable 50 Ohm **'Zo'** RF Feedline, is normally impractical in real-world conditions. This 1.0:1 ratio is also referred to as a "**Flat Match**".

    b. However the closer the **'SWR'** is to a theoretical ideal 'Source' to 'Load' **'SWR'** ratio of **"1.0:1",** the fewer the reflections of power there will be and this condition will allow a more efficient power transfer.

    c. Normally when only using a 100 ~ 200 Watt PEP output Transceiver a ratio of **"1.5:1"** on a 50 Ohm **'Zo'** Coaxial Cable RF Feedline is considered satisfactory.

    d. When using an External **'RFPA'** placed inline after the Transceiver, which has a range of 500 ~ 1500 Watt PEP output, and there is no IMN placed after the **'RFPA'** output and the RF Feedline connected to the **'RFPA'**, *as a general rule*, a **'SWR'** of **"1.8:1"** should not be exceeded on a 50 Ohm **'Zo'** Coaxial Cable RF Feedline. This will ensure that the heat dissipated within the amplifier caused from mismatch reflections is within tolerable limits.

15. What is the proper procedure for measuring the 'SWR' ratio?

    a. With the use of a quality **'SWR'** meter and appropriate length adjustments of the Active Load radiators, a satisfactory impedance match can be accomplished. This assures the coolest possible operating temperatures and maximum RF power transfer.

    b. **IMPORTANT** – Insure that the **'SWR'** meter used for measurements can handle the maximum power output levels, from both the Transmitter as well as any External Inline RFPA used.

    c. **Follow these steps for proper 'SWR' measurements and adjustments:**

        1. **Figure-2** below shows where to insert a **'SWR'** meter in a Radio Frequency (RF) Communication-Electronics Station.

        2. If your have a IMN and it has a built in **Power / 'SWR'** meter, an external **'SWR'** meter is not necessary.

        3. Ensure that the IMN is placed in a 'By-Pass' mode.

        4. Refer to your **'SWR'** meter instruction manual for exact **'SWR'** measurement procedures for the particular model of **'SWR'** meter.

        5. Key the Transceiver's Transmitter Stage or Transmitter and write down the **'SWR'** measurement. If the **'SWR'** is greater than a "1.8:1" on the 50 Ohm

'Zo' Coaxial Cable RF Feedline, change the length of the Active Antenna's Radiator by making it longer or shorter as necessary and then re-measure the **'SWR'**.

6. Repeat the Active Antenna Radiator Length adjustments and repeat the **'SWR'** measurements as necessary until a ratio of "1.8:1" or less is achieved.

7. Once the Active Load (Active Antenna) Radiator Length adjustments are finalized, the IMN may be put in the Operate mode and used to match any variations of impedance mismatch seen on the 50 Ohm **'Zo'** Coaxial Cable RF Feedline to the Active Antenna and establish a 50 Ohm **'Z'** for all equipment in line before it by reducing the SWR a 1.0:1.

Figure – 2: Example RF Communication Electronic Station (RFCES)