Amateur Radio Service (ARS),

RF Communication-Electronics Fixed Station (RFCEFS),

RF Communication-Electronics Equipment (RFCEE),

Using Radiotelegraphy (RTGY) and/or Radiotelephony (RTPY),

Proper Setup Instructions

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When setting up **R**adio **F**requency **C**ommunication-**E**lectronic **E**quipment (**RFCEE**), at a **A**mateur **R**adio **S**ervice (**ARS**), **R**adio **F**requency **C**ommunication-**E**lectronic **F**ixed **S**tation (**RFCEFS**), using **R**adio**T**ele**P**hon**Y** (**RTPY**) and/or **R**adio**T**ele**G**raph**Y** (**RTGY**) modes, whether it is a **'New Station'** or a **'Refurbishment of a prior Existing Station',** the following **'10 Steps'** *should* be followed in strict order to **'Optimize'** the station. The most important portion of any station is the **'Antenna System'** and the first three steps, concern this portion, and are interrelated and dependent on each other.

1. **Antenna System Polarization Requirements** - Based on the Frequency range to be operated on, determine the Antenna System polarization requirements for the desired communications. The decision should be based on the following facts:

    a. If operations will be on Medium Frequency (MF), 160 Meters (1.8 ~ 2.0 MHz), *ground wave transmission is used extensively*. so for this reason, it is necessary to use *vertical polarization*. Vertical lines of force are perpendicular to the ground, and the radio wave can travel a considerable distance along the ground surface with a minimum amount of attenuation (loss). Because the earth acts as a fairly good conductor at low frequencies, horizontal lines of force are shorted out limiting the useful range of horizontally polarized waves.

    b. If operations will be on High Frequency (HF), 80 ~ 10 Meters (3.5 ~ 29.7 MHz), *sky wave transmission is mainly used*, so it makes little difference whether horizontal, vertical or circular polarization is used. The sky wave reflected by the ionosphere, arrives at the receiving antenna *'elliptically'* polarized. Therefore, the transmitting and receiving antennas can be mounted horizontally, vertically or circularly. Horizontal antennas are preferred because they can be made to radiate effectively at high angles and have inherent directional properties.

    c. If operations will be on Very High Frequency (VHF), 6 ~ 1.25 Meters (54 ~ 225 MHz) *'**or**'* Ultra High Frequency (UHF), 70 ~ 23 Centimeters (420 ~ 1300 MHz), *direct wave transmission is mainly used*, so either horizontal or vertical polarization is satisfactory. Since the radio wave travels directly from the transmitting antenna to the receiving antenna, the original polarization produced at the transmitting antenna is maintained throughout the travel of the wave to the receiving antenna. Therefore, if a horizontal half-wave antenna is used for transmitting, a horizontal antenna must be used for receiving. If a vertical half-wave antenna is used for transmitting, a vertical antenna must be used for receiving.

2. **Antenna System Construction Requirements** - 'Build from Scratch' or 'Buy Commercially' the appropriate type of antenna system that will match the polarization choice decision from step 1, which could be a 'Hertz (Dipole)', 'Marconi (Vertical)', 'Yagi-Uda (Parasitic Array Beam)', 'Quad (Beam)' or 'Log Periodic (Driven Array Beam) ' Antenna System.

3. **Antenna System Site Selection Requirements** - Technical factors that effect Antenna site selection, which will accommodate the Antenna System chosen from step 1 and Scratch built or bought in step 2 include:

    a. Available Space
    b. Bridges
    c. Buildings
    d. Foliage
    e. Ground conditions
    f. Location
    g. Manmade obstruction
    h. Noisy areas
    i. Other electrical equipment
    j. Roads
    k. Suspended power lines
    l. Terrain

4. **Transceiver Selection** - The choice of a Transceiver should be based on the following facts:

    a. **Receiver Module:** The performance of a Transceiver depends first and foremost on the quality of its Receiver.

        i. *The Receiver Module selection decisions should be based on the following:*

            1. The first quality factor of a receiver concerns 'Sensitivity'. *It is the measure of a receivers ability to detect very weak signals against normal background.*

            2. The second quality factor of a receiver concerns the 'Selectivity'. *It is the measure of a receivers ability to receive a desired signal and to reject any nearby undesired signals*. This is the first feature where the receiver will show its best performance.

                a. A Blocking Dynamic Range (BDR) of *20 kHz spacing 'is sufficient'* for *Normal Conversation Operations (Rag-Chew).*

                b. A Blocking Dynamic Range (BDR) of *5 kHz or 2 kHz spacing 'is required'* for *DX Contact Operations in pile-up conditions.*

                c. A Blocking Dynamic Range (BDR) of *5 kHz or 2 kHz spacing 'is required'* for *Contest Operations in crowded band conditions.*

3. The third quality factor of a receiver concerns the 'Intermodulation Distortion (IMD) – Dynamic Range (DR)'. *It is the measure of a receivers ability to perform in the presence of multiple strong nearby signals in relation to its Sensitivity.*

b. **Transmitter Module:** RF signals produced by the Transmitter module, require fewer components and use the same Intermediate Frequencies (IF) as the Receiver.

   i. *The Transmitter Module selection decisions should be based on the following:*

      1. Choose one with the desired RF Peak-Envelope-Power (PEP) output. (100, 200 or 400 watts).

      2. Choose one with the best Spectral Purity. (Suppression of Spurious Emissions).

      3. Choose one with the best reduction of Odd Order Harmonic Intermodulation Distortion (IMD) products possible. (i.e.: 3rd, 5th, 7th, and 9th IMD etc.).

5. **Transceiver Item Impedance Matching** - The following 'four' pieces of station equipment 'must' have an appropriate 'Impedance Match' between the 'Source' [Audio Frequency - Alternating Current Generator (AF-ACG) *or* Radio Frequency - Alternating Current Generator (RF-ACG)] and the 'Load':

   a. Microphone - Match the Microphone output impedance in 'Transmit' = '(Source'), to the Transceivers microphone input jack impedance = ('Load').

   b. External Speaker - Match the Transceiver Speaker Output Jack impedance in 'Receive' = ('Source'), to the External Speaker input impedance = ('Load').

   c. Transceiver 'Transmitter' Module - Match the Transceiver 'Transmitter' Module designed output 50 Ohm impedance in 'Transmit' = ('Source'), to the connected 50 Ohm Characteristic Impedance Coaxial Cable Feedline = ('Load').

   d. Transceiver 'Receiver' Module - Match the connected 50 Ohm Characteristic Impedance Coaxial Cable Feedline in 'Receive' = ('Source'), to the Transceiver 'Receiver' Module designed input 50 Ohm impedance = ('Load').

6. **Impedance Matching Network (IMN)** - The requirement to use an IMN with the various different types of antenna systems is a *'must'*, to provide appropriate impedance matching between the stations RF Feedline and Active Load.

   a. *An IMN is Commonly called an 'Antenna Coupler', 'Antenna System Coupler', 'Antenna Tuner', 'Antenna System Tuner', 'Transmatch', or 'Tuner'.*

   b. Choose a IMN to provide an appropriate impedance match between the station equipment designed input and output impedance (normally 50 Ohms) and the complex impedance presented to that equipment from the input end of the Antenna

Systems Feedline. This must be done no matter what type of RF Feedline is used (*'Unbalanced'* 50 Ohm characteristic impedance 'Coaxial Cable', 75 Ohm characteristic impedance 'Coaxial Cable' or *'Balanced'* 300 Ohm characteristic impedance 'Twin Line', 450 Ohm characteristic impedance 'Window Line', 600 Ohm characteristic impedance 'Ladder Line').

i. The condition required for a maximum absorption of power delivered to a Load from a Source, is when the Load Impedance (Z_L) equals the Source Impedance (Zs) of the AC Generator. *This is referred to as a 'conjugate match'.*

1. The term '*conjugate match*' means that if in one direction from a junction the impedance is R + jX, then in the opposite direction the impedance will be R – jX.

ii. There is a crucial difference between the 'Classical' AC generator and the output circuit of a real-word RF Power Amplifier (RFPA) 'AC Generator', because of the complex nature of various relationships between voltages and currents during normal operation the internal Source Impedance (Zs) of the RFPA, is almost never equal to its optimum Load Impedance (Z_L).

1. Therefore because of the different values of impedance existing between the source and the load when we complete a matching operation, we do not have a true 'Conjugate Match'. when an RFPA is coupled to a IMN and then to an Active Antenna RF Feedline, the IMN is matched to the optimum Load Impedance (Z_L) of the RFPA, but it is conjugately mismatched to the Source Impedance (Zs).

c. Ensure that the IMN can handle the total RF Peak Envelope Power (PEP) Output from the Transceivers Power Amplifier (PA) stage, and if used, the total RF Peak Envelope Power (PEP) Output from any In-Line ExternalRF Power Amplifier (RFPA). This means that the power handling capability of the IMN should be approximately '2 ~ 3' times the PEP output of the Transceivers RFPA stage and any In-Line External RFPA.

7. **In-Line ExternalRF Power Amplifier (RFPA)** – If it is decided to use a In-Line External RFPA, then the type of amplifying device choice must be made.

a. Either an Electron Tube (Glass or Ceramic Envelope Type) or a Solid State Semi-conductor (BJT or MOSFET Type).

b. The RFPA must be able to match the transmission mode used by the Transmitter.

c. Whatever the RF Peak-Envelope-Power (PEP) Output level the RFPA is capable of generating, base the decision on the following facts:

i. If your Transmitter emissions are of a 'Linear Mode' (Class 'A', 'AB1', 'AB2', or 'B') *such as 'J3E' - Amplitude Modulation - Single Side Band Suppressed Carrier (AM-SSBSC) Telephony Mode,* then the In-Line External RFPA *'must'* be a 'Linear Mode' (Class 'A', 'AB1', 'AB2', or 'B').

ii. If your Transmitter emissions are of a '<u>Non-Linear Mode</u>' (Class 'C') *such as 'A1A' - On and Off Keying (Interrupted) Continuous Wave (CW) Telegraphy, 'F1B' - Frequency Shift Keying (FSK) Radio Teletype (RTTY), 'F2B' - Audio Frequency Shift Keying (AFSK) Radio Teletype (RTTY), 'F3E' - Frequency Modulation (FM) Telephony, or 'G3E' - Phase Modulation (PM) Telephony*, then the In-Line External RFPA *<u>'may'</u>* be either a '<u>Linear Mode</u>' (Class 'A', 'AB1', 'AB2', or 'B') or '<u>Non-Linear Mode'</u> (Class 'C').

8. **<u>Grounding</u>** - All RF Communication-Electronics Stations *<u>must</u>* be grounded. Grounds fulfill *<u>three</u>* distinct functions. *The best ground for one function isn't necessarily the best for another.* The three grounds are:

   a. <u>Electrical Safety Ground (ESG)</u>. The requirements for this ground are spelled out in the National Electric Code (NEC). This protects you from a shock hazard if one of the Commercial Mains high voltage power supply wires contacts the chassis due to some kind of fault.

      i. <u>NEC Code.</u> You must connect (bond) all of your grounds together to prevent dangerous voltage differentials. Although RF, Electrical Safety and Lighting Protection ground systems require separate sets of hardware, the NEC requires that we bond all three systems together. You should contact a Licensed Electrician, Professional Engineer or Building Official to assist you in meeting the bonding requirements.

   b. <u>Lightning Protection Ground (LPG)</u>. Diverts <u>some</u> lightning strike energy away from the station. The requirements for a lightning protection ground are much more stringent than for a Electrical Safety Ground. The Polyphaser Corporation has some outstanding guidance.

   c. <u>RF Signal Ground (RFSG).</u> This ground is *<u>only required</u>* for certain types of antennas, which are those antennas that require current flow to ground to complete the antenna circuit. *An example is a quarter-wave Marconi (vertical) Antenna System. An effective RF Alternating Current (AC) Ground ensures that the operating position is at a low RF AC voltage by providing a low-impedance path for unwanted RF AC.*

9. **<u>Block Diagram</u>** - Draw a block diagram of the proposed station setup. Make an inventory of all existing equipment and parts that are on hand and purchase any needed appropriate equipment or parts to assemble the station.

10. **<u>Assembly of The Station</u>** - Once the block diagram has been drawn and the appropriate equipment and parts are on hand, build the station according to the block diagram and label all interconnecting cables at both ends of what they connect to, which includes all 'Audio Frequency (AF) Alternating Current (AC) Cables (i.e.: Microphones and External Speakers)', 'DC Power Cords', 'AC Power Cords' and 'Radio Frequency (RF) Alternating Current (AC) Coaxial Cables'.

    a. '<u>Examples</u>' of a Properly Setup Amateur Radio Service, Telegraphy and Telephony Radio Frequency Communication-Electronics Fixed Station, **for operations on: [MF (160 Meters), HF (80 – 10 Meters) and VHF (6 Meters)].**

i. Figure-1; illustrates an 'Example' of a properly setup Amateur Radio Service, Radio Frequency Communication-Electronics Fixed Station, using Telegraphy and Telephony and the necessary interconnecting Coaxial Cable RF Feedlines used with 'One Transceiver, One Manual Tune RF Power Amplifier, One RF Power / VSWR Meter, One Manual Tune Transmatch, and Two Loads (Active Load and Dummy Load)'. A coaxial cable switch is used so that the desired Load may be selected.

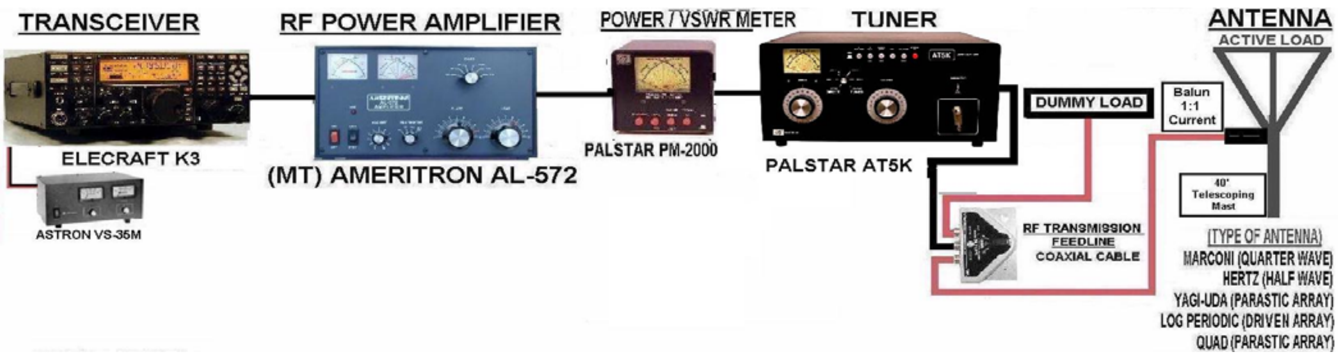

Figure-1

ii. Figure-2; illustrates an 'Example' of a properly setup Amateur Radio Service, Radio Frequency Communication-Electronics Fixed Station, using Telegraphy and Telephony and the necessary interconnecting Coaxial Cable RF Feedlines used with 'One Transceiver, One Automatic Tune RF Power Amplifier, One RF Power / VSWR Meter, One Automatic Tune Transmatch, and Two Loads (Active Load and Dummy Load)'. A coaxial cable switch is used so that the desired Load may be selected.

Figure-2

iii. Figure-3; illustrates an 'Example' of a properly setup Amateur Radio Service, Radio Frequency Communication-Electronics Fixed Station, using Telegraphy and Telephony and the necessary interconnecting Coaxial Cable RF Feedlines and Coaxial Cable switches placed inline between 'Two Transceivers, Two RF Power Amplifiers (One Manual Tune and One Automatic Tune), One RF Power / VSWR Meter, Two Transmatches (One Manual Tune and One Automatic Tune), and Two Loads (Active Load and Dummy Load)', so that the desired equipment may be selected.

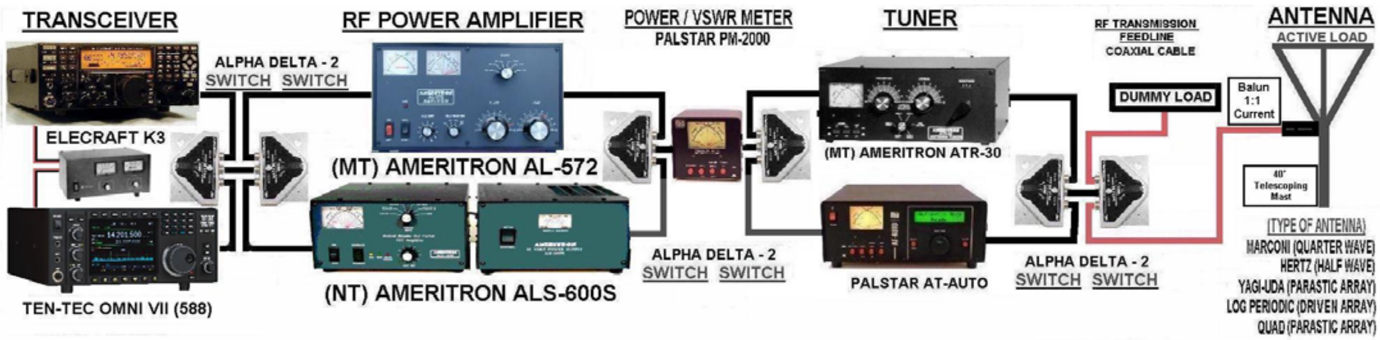

Figure-3

iv. In Figure 3, any one of following combinations may be used with either Transceiver:

v. Manual Tune RF Power Amplifier and Manual Tune Transmatch.

vi. Manual Tune RF Power Amplifier and Automatic Tune Transmatch.

vii. Automatic Tune RF Power Amplifier and Automatic Tune Transmatch.

viii. Automatic Tune RF Power Amplifier and Manual Tune Transmatch.

b. Notes for Figures 1, 2 and 3:

i. Some Transmatches contain a built in RF Power / VSWR Meter and if this is the case the external RF Power / VSWR Meter shown between the RF Power Amplifiers and Transmatches may be eliminated.

ii. Most Transmatches have connections for use with unbalanced 50-Ohm characteristic impedance (Zo) coaxial cable RF Transmission Feedlines. Some Transmatches have a built-in Balun transformer that allows it to be used with balanced 300-Ohm, 450-Ohm, or 600-Ohm characteristic impedance (Zo) RF Transmission Feedlines.

iii. Some older Electron Tube RF Power Amplifiers don't have 'Tuned' 50-Ohm input impedance. If this is the case, a Transceiver with a built in Automatic Transmatch, can be used to match the Transceivers 50-Ohm output impedance to the RF Power Amplifiers input impedance for an optimal transfer of RF power from the Transceiver to the RF Power Amplifier.