2005 Central States
VHF Conference

Sequencer Logic

One of the most popular non-RF accessory components in a VHF/UHF/Microwave station is the T/R sequencer. Sequencers are manufactured by many companies and individuals. Designs have been published in the ARRL handbook and other periodicals. These designs vary from “simple” relay lockout circuits to “over the top” microprocessor driven matrixes. They all are capable of functioning correctly and precisely in any amateur radio station. However, due to misconceptions of how sequencers should be installed and operate, we still hear the horror’s and misfortunes of individual’s failures of relays, receive preamplifiers, transverters, and power amplifiers.

What could go wrong if you install a Sequencer in your system? It is there to “guaranty” there would not be a failure of equipment during a transmit cycle. Then you find out after installation you have a catastrophic failure at best. Is it a “bug” in the design of the sequencer? Could it be a quirk in any of the sequenced equipment in the station? Since all of us have “highly personalized” systems, how about analyzing our logic and understanding of how a sequencer should be installed and operated.

This paper will discuss the thought process and common sense of installing a sequencer in any transmit/receive functioning system. It will show generic how’s and why’s while providing examples with strong reasoning. It is the hope that this paper will solve some existing problems, and prevent future plaguing ones. Even if you think installing a sequencer in a system is simple, this paper is worth reading for tips to help others that are in the hobby and are contemplating the jump from simple transceiver/antennae systems to more complex Weak Signal stations.

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Preface:

There are many different manufactures of sequencers and many "roll your own" designs available to anyone that is willing to do the research. Sequencer designs can be relay lock out, RC timing circuits, PIC based logic, microprocessor based, and even having a PC generate the "sequence" to a RS-232 switching matrix. They can be simple designs or complex in nature depending on what you think you require and how you want to implement one into your station. No mater what design you chose, the sequencer is nothing more than a "Black Box". It has inputs, outputs, and basic fundamental requirements. The main requirement is to be installed in the system correctly if you expect perfect results! If you do not take the time to understand what purpose a sequencer serves and how it functions along with the understanding of why you need one, it is not possible to expect it to be installed in your system correctly. It cannot perform its function if you do not allow it.

A sequencer is a circuit that you connect somewhere between your ***Transmit Activation Switch*** and the equipment you wish to control in a sequenced, orderly manner. This sequencer circuit is then only responsible for the order of each apparatus being placed into its own transmit mode. Then to switch back to receive, the sequencer is then responsible for the descending order of the same apparatus. What determines this order depends on how your station is equipped and operated. Now, please notice the term "***Transmit Activation Switch***". This term will be used throughout this paper and is considered the single most important aspect of the sequencing process. This switch can be anything including your transceiver, transmitter, transverter, knife switch, pull chain, or a foot switch. **One must first understand what the Transmit Activation Switch is in one's station before sequencing and determine if this same switch will be responsible for activating the sequencer in your new system set-up!** Sounds simple right?

Basics:

First, lets look at some basics. Figure 1 shows a standard transceiver and antennae set up. This can be a home, portable, or mobile station. It's as basic as it gets. It's simple to set up and use. Plug in the rig and connect the antennae. Then hit the MIC button or grab the CW key, which is both, in this case, the ***Transmit Activation Switch.*** Its probably the way most of us first started in VHF. It's a very simple and very basic kind of operation. For me personally, it was a bit restrictive but it didn't stop my operating. "CQ CONTEST, CQ CONTEST"!

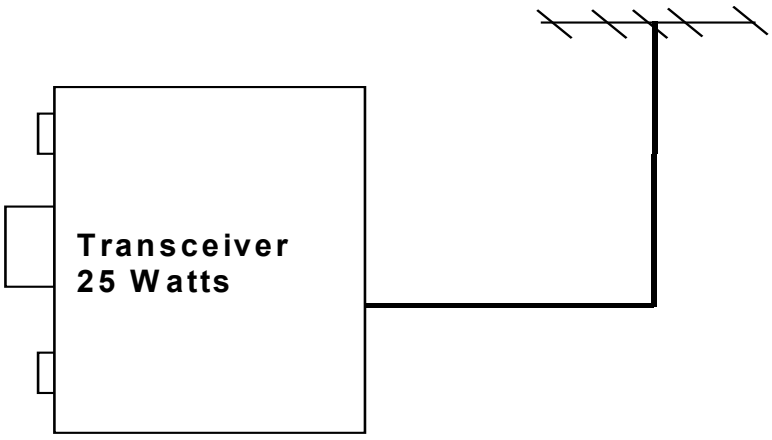


Figure 1.

If you like me started this way, there came a time when you felt you were limited in operation. You had allot of fun and the VHF bug bit hard! The only disappointments you would have was when you remembered hearing stations calling you but you could not make the contact because you were not hearing them well enough. So you decide to add a receive preamplifier to your "system" or better yet, a solid-state amplifier with a receive preamplifier built in. Well that's simple. Just buy it or build it and put it in line as the manufacture specifies it or as you designed it to operate. See Figure 2. for the installation.

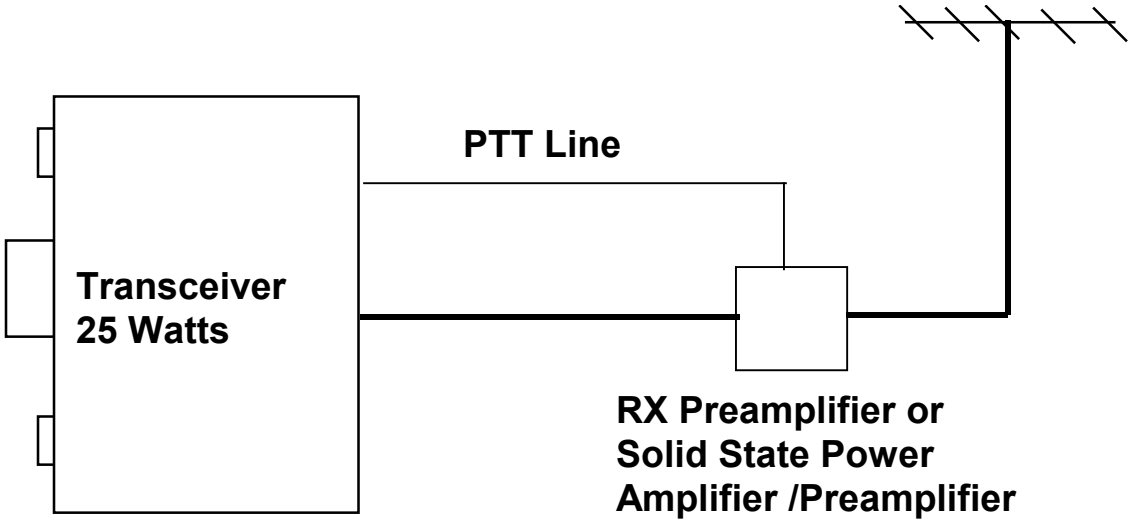


Figure 2.

The above figure shows the next step in a basic system with the "Solid State Amp" installed in the coax line somewhere between the antennae and the transceiver. The positioning of this amplifier/preamplifier between the transceiver and antennae should be of some concern but because we are discussing sequencers, it will just be considered a device in the coaxial line that can be damaged by the

transceiver if not used correctly. Therefore, depending on the manufactures specifications or the design you may be using, you may or may not have the added transmit by-pass switching activated by an RF sense circuit or the transceivers PTT (Push –To –Talk) circuit. Yes, there will be a transmit bypass circuit of some type installed in or around the amplifier or preamplifier. It is to prevent the transmitted or amplified transmitted signal from entering the preamplifier and damaging it. It also allows the received signal to pass through the power amplifier un-attenuated.

Does this particular apparatus need to be sequenced? Most likely not if it is a commercially manufactured unit. The necessary "timing circuits" should be built in. If you have built your own power amplifier only, you will not need to sequence it. However, if you have assembled a power amplifier with a receive preamplifier combination, maybe you should sequence it! Yea I know! Just the answer a neophyte wants to hear but it's the truth! It is totally up to the individual to decide what is best for their system or type of operation. If you have designed the added apparatus, then you will know how to operate it. If it is purchased from a manufacture, follow their instructions.

Sequencer Guidelines:

Lets look at some details that should be guidelines in determining when sequencing should be implemented or not. As discussed previously, sequencing is not required after simply installing an apparatus into the coaxial system beyond the simple transceiver/antennae combination, but it may be desired. Most of the details that will be discussed will help you determine if you will require or desire a sequencer in your system or not. Lets start with apparatus that includes RF sensing circuits.

RF sensing circuits are installed in apparatus to provide ease of operation and fast installation for any consumer. Most RF sensing circuits control transmit bypass switching circuits and are the best for protecting a receive preamplifier. If any RF power is sensed on the coaxial line, the preamplifier will be bypassed automatically. If one mistakenly hits the CW key in semi break-in, or MIC button, (both considered the *Transmit Activation Switch* in this case) the preamplifier will be safe no matter where it is in the system. What is annoying about RF sensing circuits with relays as the bypass mechanisms is what seems to be endlessly long delays of the system being transferred back to receive during a contest or band opening. In a "Rag-chew", its not so bad but the relays are opening and closing during long pauses in the transmission if using SSB or CW. This relay "Chatter" is not heard in a mast mount preamplifier but can become annoying back round noise in a solid state power amplifier and "chop" your transmitted signal if not set up perfectly. If you are a CW buff and enjoy operating "full-break-in" two or three extra relays in the system are going to interfere with the receive operation, (the delay time) and most likely prematurely fail because of excess switching per QSO. PIN diode switching circuits are recommended for "full-break-in" operations but for VHF and above use, PIN switches should only be considered if you can allow some insertion loss in the receive path and limit yourself to solid state amplifier power levels.

So, the question is, do you need a sequencer with a RF sensed preamplifier or power amplifier/ preamplifier combination? The answer is no. However, do not try to operate two separate “RF sensed” devices in the same system. It is highly unlikely that both sensing circuits will share the same RC time constants and make even the casual operation less then pleasurable! If two independent devices are to be used, the RF sense circuits should be eliminated or bypassed and the possibilities of a sequencer should then be considered but still not required. Most manufactures of accessory apparatus have the “Hard Keying” option available in their units. So, what is “Hard Keying”?

If you are to ask any avid VHF/UHF/Microwave operator, they will usually recommend to “Hard Key” every apparatus in the coaxial system. The term “Hard Key” means to positively place any system apparatus into transmit for as long as the operator desires with the *Transmit Activation Switch*. The process may utilize the “PTT” output connection of most transceivers. This method of operation will not promote “Full break-in” operation and will restrict “semi break-in” operation unless you are willing to damage all mechanical relays in the system! When operating any voice or data mode, once the PTT line is keyed by the *Transmit Activation Switch*, the system’s apparatus is transferred into their own independent transmit functions. If we operate a solid-state amplifier with a built in preamplifier, the PTT input of this device may be connected to the PTT output of the transceiver as shown in figure 2. This will eliminate all relay chatter on SSB and will enable the quickest possible change over back to receive. With one device in the system, the PTT circuit is the simplest and the best way to key accessory circuits in VHF/UHF/Microwave systems. For CW use, the PTT line may be “Buffered” with a built in “Hold” circuit for “Semi Break-In” operation but you should give up the thought of using full break-in because of the relay abuse in the accessory equipment. It’s plain and simple to connect and operate. Do you need a sequencer? Not yet, but what if you were to place the preamplifier at the antennae and have the power amplifier with your transceiver as shown in figure 3.

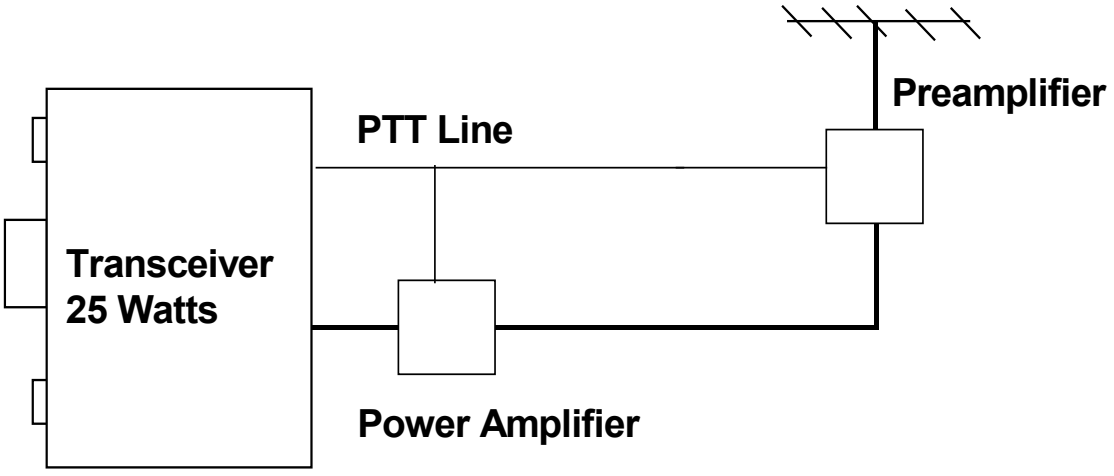
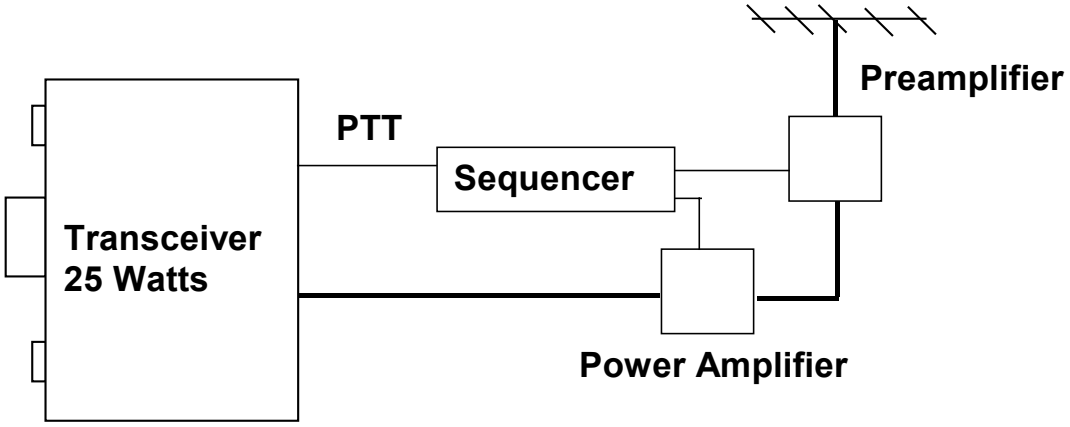


Figure 3.

Sequencing Logic Time:

Chances are that this system would work forever if you "hard keyed" it and only used SSB. If you then decided to operate CW by using the MUX or transmit button and not semi break in, the system would work fine. If you then tried to operate semi-break-in where the PTT line of the transceiver is triggered by the CW key, the *Transmitter Activation Switch*, or FM where the MIC is the *Transmitter Activation Switch*, the chances of the preamplifier surviving will greatly diminish. If you "hard key" the power amplifier and allow the receive preamplifier to be RF sensed, it will reduce the problem. Since this is a discussion about sequencers, the question is, "Will a sequencer attached to the PTT output solve the any of the potential problems? " Here is where the Logic part of this discussion begins.

Yes, lets get a sequencer and hook it up in the system as shown in figure 4. You make a choice and come up with a master plan. You draw the timing charts or block diagrams, and then make the connections. Now you turn the system on, grab the CW key (the *Transmitter Activation Switch* in semi-break-in*)* and what you considered the most precious component in your system has now been treated with extreme prejudice! You have blown up your receive preamplifier with one transmission! What happened? Was it the sequencers fault? Lets look at Figure 4 and examine how this basic sequencer was installed. Is it correct?



What appears to be perfectly connected is a disaster waiting to happen. Disregarding the functions of the power amplifier, when the transceiver's *Transmit Activation Switch* is energized in FM or "semi-break-in" CW, the transceiver begins to enable the sequencer at the same time that its 25 watts of RF is running up to the preamplifier. It becomes a race between the RF in the coax traveling near the speed of light (less the velocity factor of the coax) and the PTT signal, attempting to energize the transmit by-pass relays after being delayed by the sequencer. In this case, the sequencer will induce the catastrophic failure! **This is the #1 cause for preamplifier damage after a simple sequencer installation!** But why?

In CW mode, if you use the MUX button, which is the *Transmit Activation Switch*, the damage may never happen. In SSB, the operation could be flawless until failure occurs after the operator gets into a pile up and yells into the microphone, the

Transmit Activation Switch, before the sequencer allows the system to transfer. So the good news is, the new sequenced system could operate for a long period without a hint of a problem. The bad news is, you now have settled into a false sense of security and considered it a random failure, overlooking the possibility of an incorrect installation. Not to mention it knocks you off the air and cost you time and money, it will happen again! So, the question now becomes obvious. Do you just repair the preamplifier and go on not attempting to develop your "DX" quality VHF/UHF/Microwave station, (Read no further) or, do you learn how to energize the transmitter last taking full advantage of the sequencer? (Read on!)

One Step at a Time:

Well, I'm glad you have decided to take control of the *Transmit Activation Switch*. It's not that big of a deal. Ask any EME operator or major player in the VHF/UHF/Microwave DX or contest arenas. They may not call it the same but they will all tell you that no matter what, to protect all of the equipment in the system from destroying itself, you must first sequence everything in the correct order and **always turn the transmitter on last!** Therefore, the sequencer is required to be the one and only *Transmit Activation Switch* in the system. Logical?

Well that sounds easy, right? -----Hey! Wait a minute! How does anyone keep his or her 100 watt six meter transceiver from transmitting no mater what mode it is in or what function is activated? Then how do you make it transmit when we want it to?

These are two good questions. The answers to both are "Read the Transceiver Manual"! Every transceiver's operating manual will determine and detail all of the accessory connections available to the user. They may be scattered about on the back of the transceiver but will be called out somehow. Some manuals may be more or less descriptive than others. Some "lower end" or mono-band transceivers may have limited accessory connections if any at all. You need to read and research. You may find that the transceiver you have, may not allow you to expand your hobby any further with out serious modifications. Then again, you may find that your transceiver has all of your new sequencing problems solved for you already. Read and absorb the manual and let the Logic flow!

While reading the manual, look for answers, that are specific to your system problems. A generic problem is activating the transmitter last in the sequence. A suggestion is that after reading the manual and before damaging any or any more equipment, remove your transceiver from its operating position and connect it to a dummy load or directly to an antennae as shown in Figure 1 of this document. Be sure to remove all accessories from the transceiver. Yes, lets get back to basics.

Start by locating an accessory connection that will activate the transmitter in your transceiver. All manufactures have various different names for the same functioning item. It sometimes helps if there is a brief description such as:

"SEND- The transceiver switches to the transmit mode when this pin is grounded"

Be sure to review all of the pins in the connector and or connectors. Some “SEND” connections may be band specific in multi-band transceivers and will be labeled “HSEND” or “VSEND”. It could also be quite detailed such as the following:

“PTT- This yellow phono control input jack can be used to activate the transmitter remotely by shorting the contacts. Open circuit voltage is 13.5VDC and closed circuit current is 15 mA.”

If any of these transceivers pins were connected to the last step on a sequencer, the transmitter would be keyed last when the sequencer is placed in the TX mode and un-keyed first in the RX mode. That is the perfect situation. Now you need to test it by providing the signal requested by the manufacture, (Voltage or Ground) will place the transceiver into transmit. Once the transceiver is placed in transmit, pass some audio through the Microphone and send some CW. Yes, change modes to verify the functions. Not all manuals are perfect! When you are satisfied with the results of the first test, it is then time to develop a method to keep the transceiver from inadvertently transmitting when it is desired the least.

Full or semi break-in functions are killers in a sequenced system. If you have the transceiver in CW and you bump the keyer, it will send RF out the coax line and find something small and precious to burn up somewhere! So, look for that “Break-In function” disconnect. It could be as simple as a slide switch on the back of the transceiver, or a software command. If it’s a button on the front of the transceiver, consider that a problem because an accident could happen if it is touched inadvertently. If the transceiver does not have a “fool proof” method of disabling the “Break-In” function, consider using one of the sequencer positions in between the transceiver’s KEY input and the CW Key or keyer as a safety switch. This way, the CW key can only key the transceiver after the sequencer allows it too. In this specific case, the last step in the sequencer should be used for the CW Key line. It will then transfer the *Transmit Activation Switch* function of the CW KEY line to the sequencer. This is difficult to do with transceivers with built in keyers. Keyer paddles are two circuit devices and will require some fancy wiring within a sequencer but could be done. The transceiver’s PTT should also be connected to the last step but could be connected to the previous step if the sequencer does not have multiple ports per step. See figure 5.

Transmit sequence

Step 1	Preamplifier/Relays
Step 2	Power Amplifier
Step 3	Transceiver/PTT
Step 4	CW Keyer

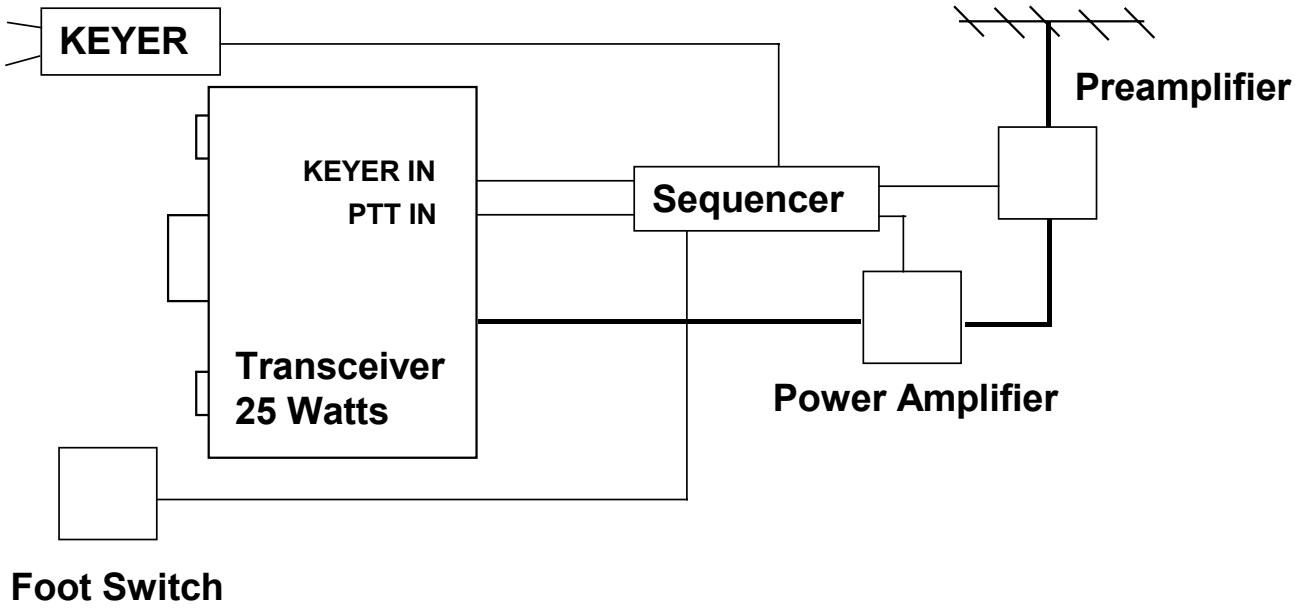


Figure 5

To have this system work correctly, it is essential that the microphone PTT be disabled from any hand or desk microphone to keep you from grabbing it in your haste to work the DX. It does not need to be connected to the sequencer because the PTT line of the transceiver will be keyed with the sequencer. If you use a headset, and it has a push button control, you will need to disable it. Do not connect the foot switch input to the head set. Connect the foot switch to the PTT input of the sequencer.

The system is complete. Simply step on the foot switch and the sequencer will fire in the sequence listed in the previous matrix. It will not make a difference what mode you operate. The foot switch is now the *Transmit Activation Switch.* Nothing happens unless the foot switch is depressed. The foot switch may be replaced with the MIC button if you desire or your computer can send the PTT signal directly to the sequencer if you are using digital modes. The important thing is that the transceiver is setup or modified so it cannot damage the rest of your system.

The higher power transceivers are complicated systems to sequence because the manual transceive functions (MIC button, CW Key) need to be disabled or the transmit level will damage a preamplifier. What happens if you have a transverter system? Contrary to the belief that transverter systems are complicated, sequencing a system with a transverter is simpler. If the transceiver has low-level transverter ports, all functions of the transceiver can remain intact. The transverter is the transmitter controlled by the *Transmit Activation Switch* and the transceiver is an accessory that can perform any function without damaging any component in the system. The sequencer can be activated by the PTT output of the transceiver. Semi-

break- in and VOX can be used because the **transverter** will not generate any power until it is placed into transmit by the sequencer which is the *Transmit Activation Switch*. The transmit sequence can be as follows after being initialized by the transceiver:

Transmit sequence

Step 1	Preamplifier/Relays
Step 2	Not used
Step 3	Power Amplifier
Step 4	Transverter

Use of a Transverter with a low level transceiver may not require many sequencer steps. You can bypass one or use a sequencer with fewer steps. Of coarse, transverter systems could become a very complicated RF system but this complication does not need to include the sequencer system. Just decide what apparatus you wish to have sequenced and in what order, then do it as long as the transmitter (the transverter in this case), is activated last. See figure 6, and compare it to the transceiver version in Figure 5.

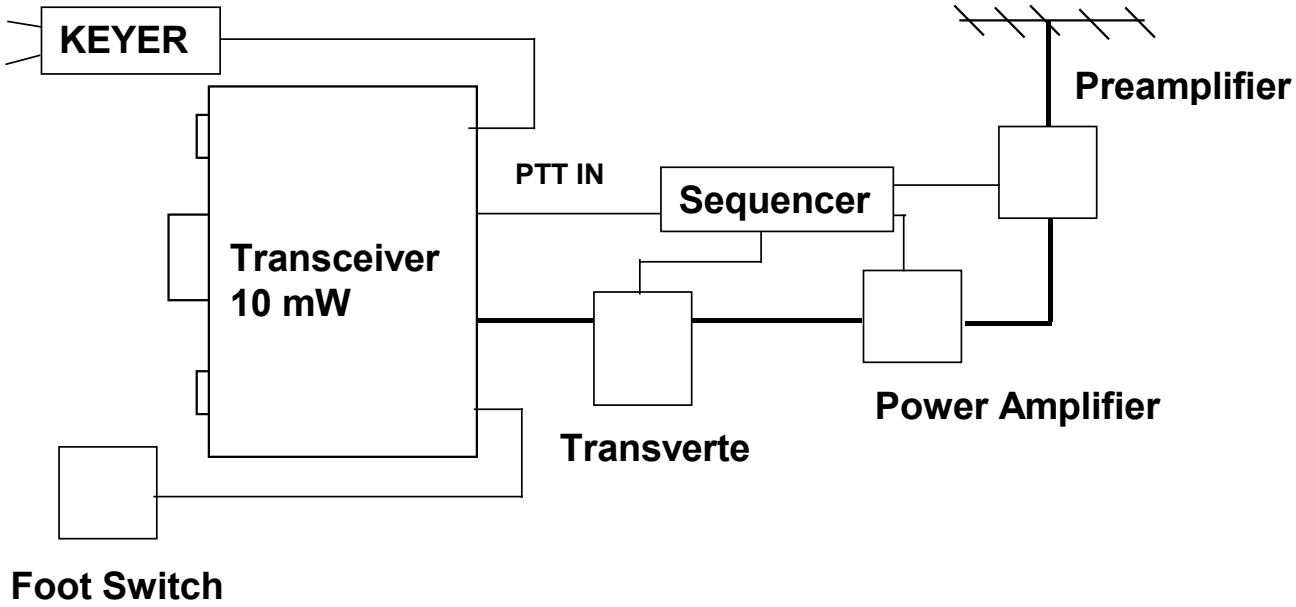


Figure 6.

What will make a transverter system more complicated is special interfacing between high power transceiver and the transverter. For instance, if you have a 10 watt, Two meter transceiver interfaced to a transverter system, it is important to have the transverter in the transmit position before applying the 144 MHz. drive. If not, the 10 watts output of the transceiver may damage the transverter's receive IF circuitry. If this were the case, the transceiver could only damage the transverter but the transverter can damage all other RF equipment in the system. The answer is to sequence the steps so the transceiver is activated last, with the transverter preceding it. If the transceiver requires a sequenced step on the semi break-in CW line, make it the last step or share the step with the transceiver. What is important is that the transverter will not transmit into the preamplifier and the transceiver will not transmit into the transverter unless the whole system is all into their individual transmit modes. The ultimate answer for simplicity and versatility is to have a low drive transceiver for a transverter system. Details of this more complicated system are shown in figure 7.

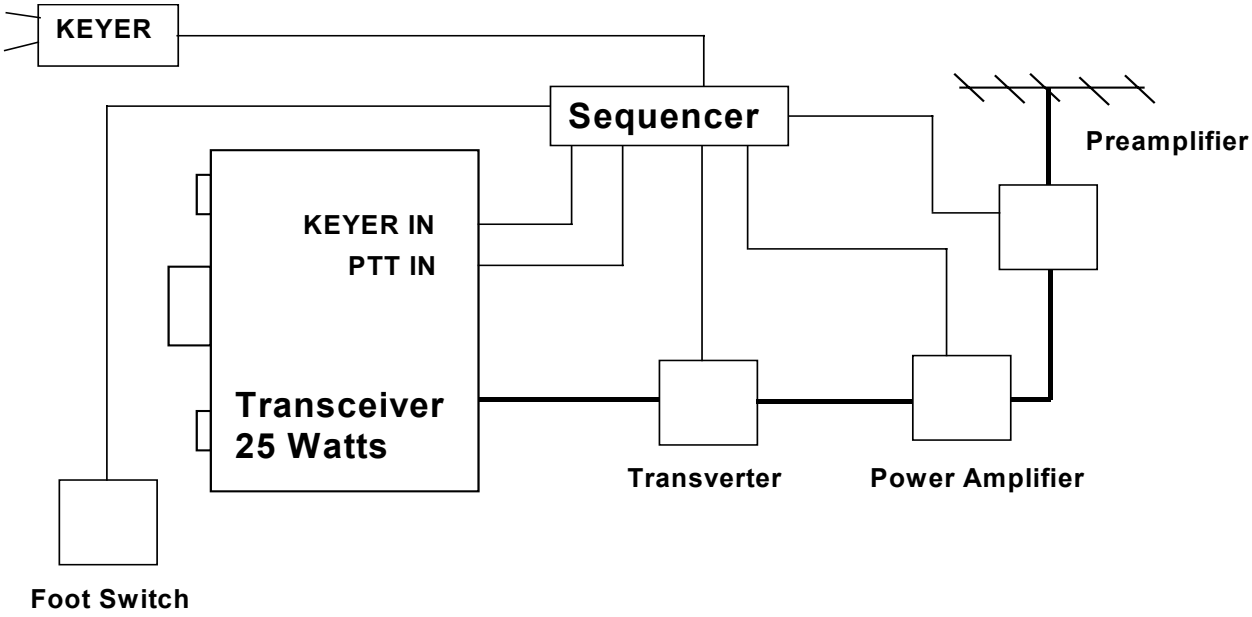


Figure 7.

Transmit sequence

Step 1	Preamplifier/Relays
Step 2	Power Amplifier
Step 3	Transverter
Step 4	Transceiver / Keyer

Figures 5 through 7 are generic examples of sequencer set-ups. However, your system may vary in types of equipment, and amounts of equipment. Most likely, your system could be modeled after one of these examples. Simply draw a block diagram and decide which *Transmit Activation Switch* needs to be disabled if any and what would be the best possible sequence to use. Think it through and test it without the RF connections made or have the transmitters connected to dummy loads. Look for problems and then solve them. Nothing is absolutely "fool proof" but striving for it is worth the effort.

Quirks and Tid-Bits:

This is what you want to hear about after you just finished your "almost fool-proof" system! Quirks? If the number one priority of a sequencer is to protect the preamplifier, further thought is required after the sequencer system is designed. Go over all of the "What Ifs". Such as, what if your sequencer is powered from a different source than your transceiver. For that mater, what about the preamplifier, relays, and the rest of the system. A simply lapse in memory during that band opening could cause lots of damage if you forget to switch on the "other power supply" Be sure to have a common power supply for all of the equipment in the same system or failsafe it.

The sequencer is the safety switch and will not allow anything to function in the transmit mode if it does not have power, but this is only if you have configured the system correctly! Test this function before operating. What if you have a fused output from the sequencer to one apparatus and the fuse is pressed into action? What damage could occur to the rest of the system? Think about it! If the main fuse for the sequencer opens you should be safe.

Other problems stemming from proper mast-mount preamplifier operating are always a topic. Should you remove the voltage from the preamp during transmit or not? There are pro's and con's. If you remove the voltage from the LNA (low noise amplifier) in your mast mount preamplifier, you will not need to terminate it. If you switch the LNA out of line and leave the voltage on, you should terminate it because it could oscillate. It could also cause a feedback from a low isolation relay if left powered on during transmitting.

When you shut the sequencer off, it should remove all power from the preamplifier. It should also disconnect your antennae from your receiver. You may also desire a "Preamp Bypass" when receiving strong stations. Adding a separate switch to the sequenced line of your preamplifier may be desired. All of these switching scenarios need to be thought about before implementing. Remember, you don't get a chance to make a mistake with a preamplifier and expect survival.

With mast mount preamplifiers, long runs of coax and wire may contribute to voltage drop between the sequencer and preamplifier. Be sure to test it. With high dynamic range LNA's and multiple relays, it is easy for the current drain to add up and drop the voltage through inadequate wiring. Test it. It is best to configure the

system so that the mast mount preamplifier is in the bypass mode with all DC power removed.

If designing and assembling your own mast mount preamplifier, be sure of the isolation of the by-pass relays. Don't blame the sequencer when the relays are not adequate for he job. Give your self some margin because mechanical equipment wears out over time and will become stressed from excessive through power. Measure and know the specifications of the relay before use.

It is easy for a sequenced system to "Grow" beyond the original expectations. Keep detailed documents of the system timing, voltage, and current drain. When connecting something new to the system, it will help you decide where it should go in the timed sequence along with where it can be the least stress to the system. You don't want to rob performance from the other equipment in the system in order to satisfy the new apparatus requirements.

As for other non-preamplifier equipment in the system such as power amplifiers with high voltage supplies, grounding is very important for functionality and safety. If you are keying a PTT line for an amplifier, check polarity, voltage differential and common ground connections for any unusual characteristics. Unsuspected events such as reversed voltages, high voltage, and open connection voltages being supplied to the other apparatus in the system could cause damage.

Conclusion:

As you may have surmised, the paper could go on and on with particular details that may only be pertinent to a few individuals or circumstances. The idea of this paper was to stimulate the thought process and motivate one to thoroughly think out one's system. This in turn will prevent costly (both money and time) problems when implementing a sequencer. It can be as simple or as complicated as anyone wants but with out the correct sequencer logic, very little works correctly.

Thanks for reading this paper. Share this information and your own knowledge of sequencers with others to allow everyone to enjoy our great hobby! Have fun and see you on the bands!