Implementing SO2R at N4XL

By N4XL

Introduction

The internet is full of explanations about what SO2R is and how it is done. If you are unfamiliar with SO2R, please spend a bit of time looking over some of that information. This article focuses on the rationale behind choices made at my station when implementing SO2R. Determining if those were wise choices remains to be seen. If you are thinking about exploring SO2R then perhaps it may be useful.

Some areas of concern were:

1. Protect the seconds receiver when the first was transmitting.
2. Eliminate interstation interference between radios to the point where you are unaware Radio 1 is transmitting while trying to pull out the call of a weak station on Radio 2.
3. Integrate antenna and band pass filter switching so each automatically follows the band selected by either N1MM or when selected at the radio.
4. Allow for more than one antenna per band, a receive antenna for the low bands, and an easy method to quickly switch while at the operating station.
5. Interlocks to prevent the radios from sharing the same antenna or transmitting simultaneously.
6. Idiot proof the station as much as possible so the idiot (me after 30+ hours of sleep deprived contesting) can still effectively operate it.
7. Use a single computer, keyboard, paddles, microphone, and headphone to control both radios.
8. Final configuration is such that should a single component fail contesting can continue.

Band Pass Filtering

An outstanding reference for this is *Managing Interstation Interference, Revised Second Edition*, by W2VJN, George Cusogeorge. Further internet research supported the information contained in the book leaving me with a target attenuation goal of >50 dB between my two 100 watt TS590 radios to protect them and with >70 dB being desirable for complete isolation. To accomplish that I considered using band pass filters, tuned stubs, antenna separation, and cross-polarization. Some had suggested relay protection for the second radio, but that negated the primary advantage of SO2R – listening to the second radio while the first is transmitting.

All band pass filters are not created equal. Some online review data for the popular I.C.E. filters were critical of their isolation abilities. Since I already owned a set and used them at two Field Day sites I agreed with those review. Mine were not sufficiently well designed to meet my goals. Although rated at 35 to 40 dB, actual measurements (made by others) reveal the attenuation curve is far from flat and signal reductions of only 20 dB are present at some frequencies. Their 100 watt rating is also said to be very optimistic. I have had a 15 meter I.C.E. filter fail during Field Day. When I looked online to see how others have repaired them I discovered it is a known weak performer in that

series of filters. Fellow hams recommend using 50 watts or less when contesting or at Field Day with these filters. The I.C.E. line has been sold and upgraded so they may work for you. Upgrades included more robust components and putting all HF filters in a single switchable box. I decided to seek a more proven filter. The W3NQN design is the accepted standard. I considered wrapping my own but elected to go commercial for other reasons discussed later. It became clear proper use of well-designed band pass filters and their implementation was critical to meet my SO2R goals of rig protection, automation, and fool proof operation.

Another critical consideration for the filters often overlooked is the SWR at the 50 ohm filter output should be below 2:1. If not, they are prone to failure from overheating and their filter attenuation curves suffer from antenna system reactance. Some manufacturers recommend terminating unused antenna ports on filters (such as a duplexer or triplexer, or unused single filters) that are connected to the rig on the power inlet side but not to an antenna on the outlet side be terminated with 50 ohms. Failure to do so upsets the attenuation curves of the other active ports. I chose to ignore that recommendations. As discussed below it has not proven to be an issue of concern in my low power station.

Although the cost was much more than expected when I began this project, I settled on Hamation equipment as marketed by Array Solutions. Specifically, the Filtermax IV Band Pass Filter System. It is used by many top contesters. One is needed for each radio. An IC-8 Hamation Integrated Controller interfaces the two filters with a Hamation 8x2 automatic antenna switch and the radios. Reasons for that choice for a filter box were:

- Use commercial vs homebrew equipment due to available time to wrap my own, reliability, and integration with the automatic and fool proof operating needs of my SO2R system design criteria. These filter boxes contain control circuits for automatic switching and protection.
- The attenuation curves showed they met desired dB reduction goals for all bands. Attenuation from these filters range from 50 to 80 dB, with much of their curves being in the 60 and 70 dB range. An exception was for a portion of 10 meters which dipped into the high 40's.
- Filter selection can be quickly controlled from the front panel should automatic switching fail. They were designed to interface with the Array Solutions 8-pack antenna switch I had chosen which would allow semi-automatic operation of that part of the shack possible should there be a failure in antenna switching control signals.
- Software applications existed to support seamless antenna switching coordinated with band pass filter operation. This included not only antenna selection for a single band, but also for easily selecting multiple antennas within a band. The control software has locks to prevent you from assigning two rigs to the same band – even if using different antennas – which further reduces the chance of receiver damage.
- The controlling software application protocol is the same used for the microHAM SO2R controller I am also using. The protocol is supported by N1MM. Many contesters use this protocol and I felt it likely future upgrades to Microsoft Windows that affected the software integration of my shack would be addressed by the N1MM and microHAM programmers.

- The Hamation control system can easily be expanded should my antenna farm grow in the future.

I also use a Low Band Systems (LBS) duplexer and triplexer (available from DX Engineering). These give added filtration allowing both radios to share the triband yagi or loop. I can run on 20 meters while easily copying a station on 15 or 10 – even when the run radio is transmitting. Simultaneous loop operation is possible on 40 and 80 meters with the duplexer. When the duplexer and triplexer are used alone they do not give enough attenuation so additional single band filters from LBS are also used to provide further protection when rigs are sharing the tribander. The LBS equipment is in addition to the Filtermax IV's and on the output of the 2x8 antenna switch. It should be noted there is some cross-talk between antenna ports internal to the switch and the LBS filters do are not positioned to reduce it.

Although the amount of filtration used exceeds that needed for rig protection a priority goal was transmitting transparency. The filter system at N4XL works very well and only occasionally is a signal from the operating transmitter heard on the receiving radio. This is true even for transmitted harmonics. I have considered adding tuned stubs to the arrangement to remove even those few minor S1-S3 signals. Since they are hardly ever noticeable, I have no plans to do the extra work. Especially since QRN or QRM from other contest stations is usually stronger than what I cause to myself. The attenuation available should be adequate to support adding an amplifier to my low power station if I so choose without the need to upgrade filters any further.

Antennas

Although there are better switches available on the market (4O3A reportedly makes an excellent switch for example) I elected to use the 2x8 antenna switch offered by Array Solutions. Being a mature product, it is very reliable. It is controlled by a software application common throughout the shack. It has built in hardware interlocks to prevent both rigs from selecting the same antenna. It grounds unused antennas when not in use. It has a large enclosure which helps minimize cross-talk between antenna ports which can reduce the effectiveness of your band pass filters.

The switch accepts input from both radios and routes it to my antennas. Currently, three of the eight antenna ports are connected to the tribander through the LBS triplexer for 10, 15 and 20. Both radios can share the beam. Two ports run to the loop for 40 and 80 operation through a LBS duplexer. Both radios can share the loop. One port goes to the 40/80 top loaded vertical at the back of the property. One port goes to the loop for 160 and the last port goes to a dummy load. The 160 and 40/80 lines from the switch to the loop contain the only manual switch in the arrangement. I am likely overly cautious here, but being low power I do not spend a lot of time on 160 so elected not to purchase an additional LBS filter for 160. A manual switch allows loop operation to either be 40/80 or 160, but not all three at the same time. SO2R operation while on 160 using the loop is still possible using the 40/80 vertical with one rig and send the power from the second rig to the loop.

The 2x8 switch works in conjunction with the (2) Filtermax IV's and the (2) IC-8 Integrated Controllers so that a single USB line from the computer to any of the Hamation components will automatically control all switching of filters and antennas. Switching happens automatically from band changes initiated within N1MM, by pushing a band button on either TS590's, or from clicking an icon on the ShackLan Control Center antenna switch software. The latter sits in a small window of your monitor and clearly displays status of the switch configuration. LPT port control is allowed by the Hamation equipment if so desired.

Hamation antenna selection software works automatically but is very versatile and capable of handling virtually any antenna setup from that used by Little Pistols to a Super-Station. A small open window sits on the computer desktop. A single mouse click allows changing from the 40 meter loop to the 40 meter vertical or to a dummy load. The same is true for both radios and all antennas. The software also has touch screen monitor support.

SO2R Box

The contest logging program (N1MM here), headset, CW paddles, and footswitch must interact with both rigs. At least the headset does because you can't be expected to change headsets to use one rig or the other. The SO2R box fills that function. I have had good experiences with the microHAM microKeyers and N1MM has committed to supporting that brand so I looked around and found a good price on a used u2R unit.

It is a very capable box allowing for personalization of audio routing to meet virtually every operator's needs. That topic will be discussed further in another article, but here are some of the modes allowed: 1 rig into both ears. 1 rig into Left ear and the other into the Right – or vice versa. Listen to both rigs separately in each ear until one transmits, then all you hear is audio from the rig in receive in both ears. When transmission stops it goes back to both rigs separately.

N1MM transmit control can be to both radios as selected by N1MM, or manually overridden and sent to either rig only.

The u2R preset routing choices can easily be overridden and returned to normal by pushing front panel switches. It contains a Winkeyer to remove CW handling overhead from the computer CPU. And it supports FSK RTTY. Should I choose to further enhance its capabilities I can use it in conjunction with the microKeyer's I already own.

Software

Besides being the #1 used contesting program, extensive effort has been done by the N1MM programmers to support SO2R radio operation. That will not be covered here. Suffice it to say if you want your SO2R station to do something that capability probably already exists in N1MM. If not, give them a reason why it is worthwhile to contesters in general and they will likely program the feature for you and others to use.

ShackLan software using the microHAM protocol is used to allow communications between the computer, the Integrated Controllers and the antenna switch. Two programs are used. ShackLan-4 Band Decoder and ShackLan Control Center. These programs allow for automatic operation of antenna farms from little pistol size to extremely large super-stations. It is ready to grow as you do. A single USB line is all that is needed for even very complex stations.

The software reads band data from the TS590s and selects filters and antennas based on the band they are selected to. Software and SO2R box interlocks prevent both rigs from transmitting on the same band – and transmitting at the same time. The 2x8 antenna switch internally prevents both transmitters from sharing the same antenna.

Failures

In the event of antenna switch failure coax jumpers from each Filtermax IV to the switch can be manually reconnected to the switch outlet port coax for the desired antenna. Some SO2R operators use that form of switching, like an old time telephone switchboard patching system, as their normal mode of operating to save the cost and complexity of an automatic antenna switch.

In the event of an IC8 Controller failure the Filtermax IV's band pass filters can be manually selected or the filters bypassed completely. I do not know if the ShackLAN software would still control the antenna switch without a functioning controller, but if not the work around is the patch system described above.

In the event of a rig failure contesting can continue with the second rig.

In the event the SO2R box fails the computer can be reconfigured to control a single TS590 directly. Headset and paddles would be moved from the SO2R box to the rig.

Each band (except 160) has two or more antennas available. Failure of one would not halt operations.

I like contesting with a computer so if it failed, I would likely call it quits. You cannot be competitive these days in any but the more obscure entry categories without a computer.

Cost and Performance

Many hams have either built their SO2R station components themselves or used a combination of home brew and commercial. Their stations perform very well for a truly significant lower monetary expenditure. Now that I'm retired with more free time on my hands and less money for radio I would not hesitate to give that a try. However, I have no regrets opting for choosing the commercial route.

Going the commercial route is not cheap. Especially if you buy new. I have spent several thousand dollars on a belief SO2R will bring me more fun. Hope it is worth it.

As long as the station components are properly shielded bonded and grounded performance at my 100 watt level station is everything I had hoped for. The second rigs transmitter is either completely transparent or just barely noticeable when listening on the first. The only exception is on 10 meters where an S3 signal is present at times. That is consistent with the Filtermax 4 attenuation curves. I do not find it to be significant interference at this point in the sunspot cycle. Maybe I will a few years from now, but probably not. The interference is much less bothersome than trying to copy a station on the crowded 40 or 20 meter bands during a major contest.

It's also worth noting that I had a coax jumper fail and replaced it with RG58. That increased the 10 meter noise and made it more broadband. I also began hearing station to station interference on 15 meters. When building your station be sure to use well shielded cabling.