A Simple SO2R Contest Station

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Figure 1 - The SO2R Operating Position at ZS6AA

SO2R stands for "Single Operator Two Radio", and describes a single-operator station with two radios set up so that one radio may be receiving on one band while the other radio is transmitting on another band. SO2R is mostly used by contesters. Successful contest operating is all about making the most possible contacts in a limited time. To do this, contest stations can either "run" – which means calling CQ on a frequency and waiting for replies – or "search and pounce", which means tuning across the band and responding to stations that are calling CQ. The idea of SO2R is to allow the operator to run on one band, whilst simultaneously searching and pouncing on another band. A SO2R station does not need to be able to transmit on both radios simultaneously, and should have a provision to prevent this, since simultaneous transmission on two frequencies is not permitted in the single-operator categories of most contests.

When I moved house in December 2006, I was able to put up a tower and beam for the first time, and took the opportunity to make some improvements to my station. Different operating activities will dictate different station priorities, and since my favorite activity is HF contesting I decided to optimize my station for contesting as much as possible given the limitations of our suburban garden, family life and finances. This involved putting up the best triband beam that I could afford on the highest tower I could get away with and adding SO2R capability to my station.

Conventional approaches to SO2R use either two multi-band antennas, one for each radio, or a set of monobanders that can be switched between radios. Isolation between antennas is important to prevent the receiving radio's front-end from being desensed (or even damaged) by the other radio's transmissions. A conventional triband beam on the tower combined with a multi-band vertical would have given me the advantage of cross-polarization to assist in isolation between the antennas; but after several years of contesting with verticals and wire antennas, I have come to the conclusion that they don't quite make the grade from southern Africa, where the vast majority of contest QSOs are intercontinental. A second tower was out of the question, so I decided to take advantage of the unique feed arrangement of the Force-12 C-31XR triband beam, which can be fed with separate feed-lines for each band (Figure 2). This allows me to use one yagi on two bands simultaneously, albeit at the cost of some reduction in gain.

Figure 2 - Separate feeds for each band on the C-31XR

I had the tower professionally installed. Putting up the big C-31XR was an interesting exercise. It is a large antenna, with 14 elements on a 31 foot boom. Since there wasn't space for the assembled antenna in the garden, and in any case I did not want to have to haul it up the tower, I built it up on the tower with the tower in its tilted-over position. This allowed me to work at ground level, and I simply winched the tower a little further off the ground as I added each section of boom. This went well, except for a winch failure which buried the antenna boom about a foot into the ground – fortunately, it had been only six inches off the ground when the winch failed, and the ground was soft, so there was no damage to the antenna.

Because the elements for different bands are in close proximity to each other, I added a W3NQN band-pass filter to each of the antenna feed-lines to obtain sufficient isolation between antennas. I use an Array Solutions "SixPak" remote antenna switch to switch between antennas – the SixPak is ideal for SO2R as it allows each antenna to be connected to either of two radios, while preventing the same antenna from being connected to both radios simultaneously, which would almost certainly have catastrophic consequences. The remote antenna switch is driven by a home-made dual band decoder, which takes band information from my transceivers and automatically selects the correct antenna feed-line. Since Kenwood transceivers do not provide band data outputs I modified my TS-850S, buffering the internal binary band select data and bringing it out to a DIN socket.

Now all I needed was a second radio, and a way to switch audio, microphone and CW keying inputs between radios. This was originally going to be a delayed "phase two" of the project, but when a colleague who was emigrating offered me his TS-930S at a fair price, the opportunity was too good to resist. I added the PIEXX CPU upgrade board, which provides an RS-232 rig control interface and an (undocumented) band data output. Of course once I had the second radio, I just had to get the SO2R switching system to allow me to use them simultaneously! I considered building my own SO2R switching system, but eventually decided to buy a commercial product. SO2R control systems range from simple switch boxes to complex networked microcontroller-based systems. I eventually decided on the "DX Doubler" from Top Ten Devices which is on the simple end of the scale, but has the functionality I require.

Figure 3 shows the station configuration. While contesting the station is controlled by a PC running WriteLog for Windows. The logging software reads the frequencies of the two radios via two COM ports, and controls the DX Doubler via the LPT port. The DX Doubler in turn routes the microphone and CW keyer signals to whichever radio is selected for transmit, and allows the headphones to be connected to either radio or to both radios (one in each ear) under operator or computer control. The PTT line from the radios to the DX Doubler (the line that would be used to PTT a linear amplifier) provides feedback to the DX Doubler about which radio is transmitting, allowing it to connect both ears of the headphones to the radio that is not transmitting, if desired.

The operating position (Figure 1) places all important controls within easy reach of the operator. The two radios are in the centre of the operating position. The DX Doubler, CW keyer and band decoder/antenna selector are on a small shelf immediately above the radios. The antenna relay box and band-pass filters are out of the way on the top of the cabinet. Two SM-230 monitors allow me to monitor the output of the radios, and the rotator controller is at top left in the photograph.

I used an Agilent E5071C network analyzer to measure the isolation between the antenna ports, both at the coaxial cables leading to the antenna (excluding the SixPak and band-pass filters) and at the radios (including the SixPak and band-pass filters). The analyzer was set for an output power of +10 dBm, IF bandwidth of 1 kHz, and 16-point averaging. Each of the three cables feeding the C-31XR is 100 feet of RG-213. No attempt has been made to keep the cables separate between the band-pass filters and the antenna; they are bundled together and tied with cable ties, as the leakage between cables is insignificant compared to the coupling between antenna driven elements.

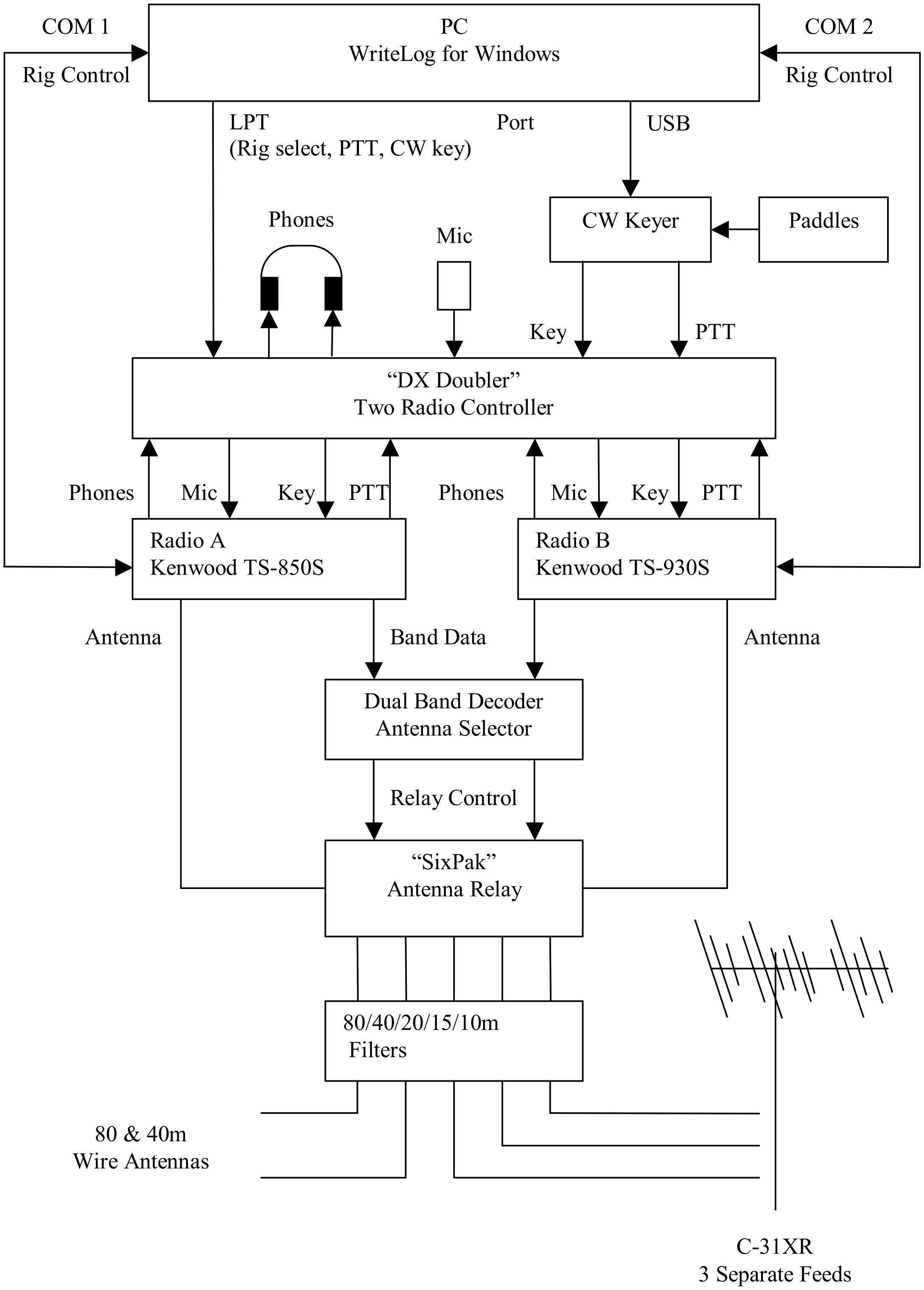

Figure 3 - Station Block Diagram

Table 1 shows the isolation (to be specific, -S21) measured at the antenna cables. Each row gives the isolation in dB measured at the frequency given by the row heading (the cell on the far left hand side of the row) when the antenna feed elements identified by the row and column headings were connected to the analyzer ports. The unused antenna feed-line was left un-terminated. The worst case is 9.2 dB isolation, measured at 21 MHz with the analyzer connected to the 14 MHz (20m) and 21 MHz (15m) feed-lines.

Freq (MHz)	**14**	**21**	**28**
14		30.0	32.2
21	9.2		21.3
28	12.6	20.6	

Table 1 - Isolation measured at the antenna cables

Table 2 shows the isolation measured at the radio antenna connectors (including the SixPak and band-pass filters). This table includes isolation on the 40m band, where the antenna is a vertically polarized "mag slot" loop with the nearest side about 21 m (70 ft) from the tower. The table also includes measurements where the row and column frequencies are the same. In this case, the SixPak antenna switch isolates one of the radios, so the measurement is an indication of the isolation of the SixPak (and associated cables, etc). It is a useful measurement as it shows the isolation if I inadvertently set both radios to the same frequency band.

Freq (MHz)	**7**	**14**	**21**	**28**
7	67.8	68.3	72.7	73.7
14	64.6	63.0	56.5	62.7
21	60.3	41.4	63.9	59.9
28	54.3	57.1	58.5	59.7

Table 2 - Isolation measured at the radios

The band-pass filters make a big difference. The minimum isolation is now 41.4 dB, measured at 21 MHz with the 21 MHz (15m) and 14 MHz (20m) antennas selected. To put this in perspective, if I am transmitting at 100W on the 15m band, then about 7 mW of the 21 MHz signal will be present at the other radio's antenna terminal when it is receiving on the 20m band.

My first opportunity to test the new setup under real contesting conditions came in the 2007 CQ WPX CW contest. I wasn't able to operate for the maximum of 36 hours due to family commitments, so I used the time available to start learning to operate SO2R. It's challenging and certainly adds interest when propagation is not good enough to attract a pile-up on the run station – which was most of the time given our generally poor winter propagation, especially at this low point in the sunspot cycle. Although my overall score (812,538 points from 729 QSOs in 22 hours) was modest, from a station engineering perspective the contest was a clear success. I was able to "search and pounce" on one band while running on another, or to alternate CQs on two bands, without any troublesome inter-station interference. At times I could hear the keying of the other radio as a slight increase in band noise, but I was able to hear even weak stations through it without difficulty.

This approach, using a single triband beam with separate feeds on each band, will not perform as well as separate antennas on two towers would. However it allows me to enjoy SO2R operation despite the constraints of a limited budget and a modest suburban garden.