Station Automation (Holger Hannemann, ZL3IO)

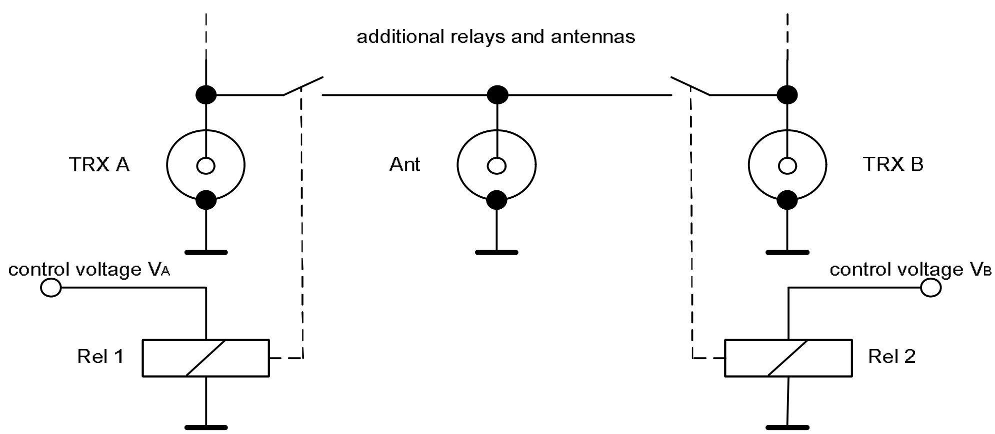
The central element of many radio stations is an antenna switch to choose between multiple antennas. For contest stations the requirement is even more complex as multiple radios need to have access to all antennas. If you have enough stations and mono band antennas you simply connect the antenna straight to the radio. But if you are limited in equipment or running classes like SO2R (single operator two radios) or M/2 (multi operators two radios) you need to share resources. Of course you can manually connect / disconnect the right antenna to your radio whenever you change bands. But this costs time, is annoying and a risk of failures, especially at the end of a 48 hour contest when concentration is going down. Being able to change frequencies and antennas within seconds is a success factor in serious contesting. Hunting or moving needed multipliers through the bands is at least as important as running fast QSO rates. So I was on the search for a comfortable switching solution that would automate the process depending on the band used.

6x2 Antenna Switch

A 6x2 switch is a good start. Six antennas cover the hf contest bands (160m/80m/40m/20m/15m/10m) and can be distributed to two radios. If more bands are needed, two of those 6x2 switches can be cascaded. There are a few commercial solutions available like the well-known *Sixpack* from Array Solutions, the *Double Six Switch* from Microham or those from 4O3A or OM Power. But including the needed control unit they easily add up to 1000-1500 NZ$. A homebrew solution is possible in the range of 300-500 $.

Antenna switching options

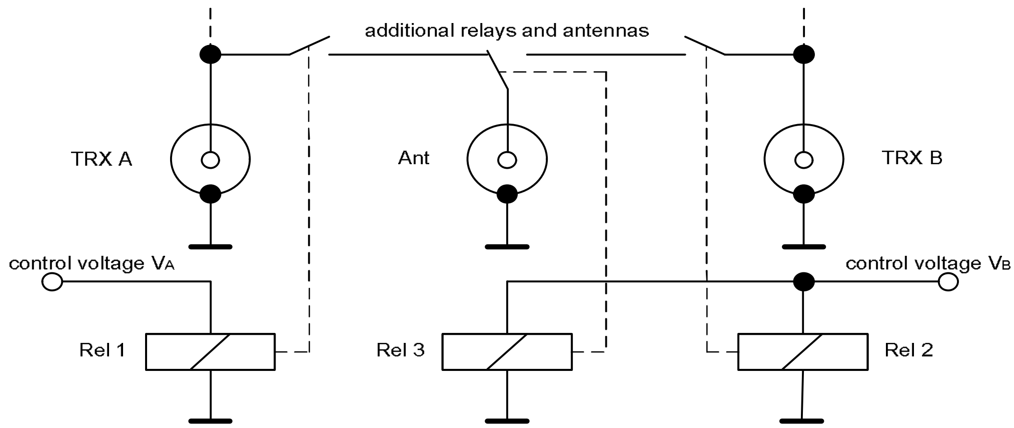
Pictures 1 & 2 show switching options for sharing antennas between two radios on the examples of one antenna. For multiple antennas additional relays circuits can be paralleled.



Picture 1: Simple relays circuit to use two radios on one antenna without protection against simultaneous connection.

Above picture is the simplest way to allow two radios to use the same antenna. If relay one is powered Radio A is connected to the antenna. If relay two gets power, it connects radio B to the antenna. If both relays are activated via e.g. mechanical switches from different location no interlocking is possible. Both radios would access the antenna at the same time. Any transmitter sending would destroy the receiver of the other radio as he is directly wired to the antenna and the other receiver.

But even with if the circuit is used correctly the two radios are not sufficiently insulated from each other if no other protection like band pass or notching filters are used. To increase the insulation a third relay is to be used as shown in picture two.

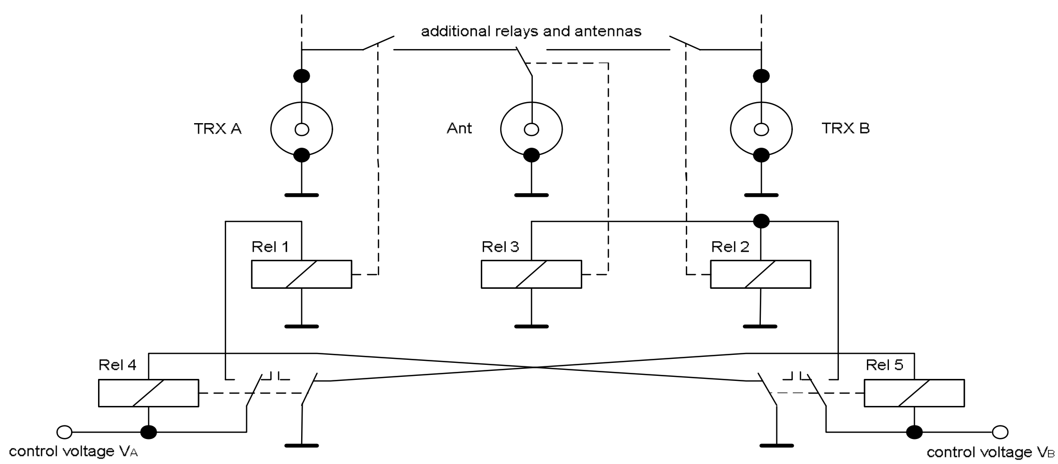


Picture 2: Adding relay 3 doubles the insulation to around 60-70 dB (depending on relays used)

Relay 3 is a big improvement for the circuit. It increases the insulation level between the radios to a level that protects the receivers but the circuit is still not safe. Are both control voltages active, all relays will switch on. Transceiver A will be disconnected from the antenna and transceiver B is on. But only relay 3 disconnects radio A from radio B. That means around 30 dB (depending from relay used) and won't be enough. Even with only 100 W output from the transmitting radio the receiver of the other radio would face about 100 mW (20 dBm, S9+95 dB, V_{SS} = 6,35 V on 50 Ω). That is too much for most receivers.

To prevent from this relays have to be interlocked in a way to ensure always 2 relays are insulating the receiving radio from the transmitting antenna. There are two ways of achieving this. Option one is an electronic interlocking like the solution especially developed for this application and described further down. KK1L e.g. offers PCBs for the relays units for about 50 USD.

The other option is an electro-mechanical interlocking. This requires two additional small relays with two changing contacts (NO/NC).

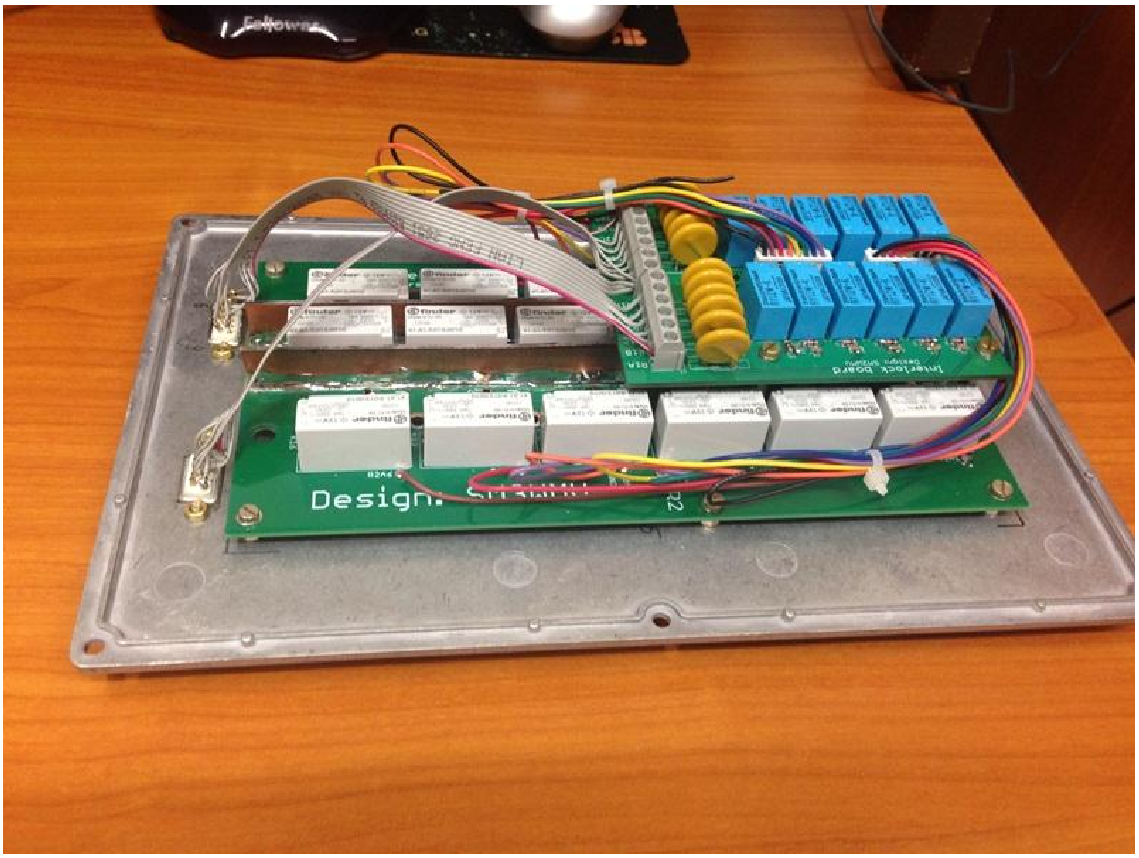


Picture 3: electromechanical interlocking for a 6x2 antenna switch

Picture 3 shows the schematic for such a circuit. Relays 4 & 5 are interlocking. If e.g. V_A is activating Rel. 4 than contact set one distributes the supply voltage to Rel.1 and contact set two interrupts the supply for Rel. 5. Even if V_B would be activated it could not switch on and also Rel 2 & 3 will stay off. The antenna is safe connected to transceiver A.

The similar procedure happens if Rel. 5 switches first with the antenna being safe connected to transceiver B.

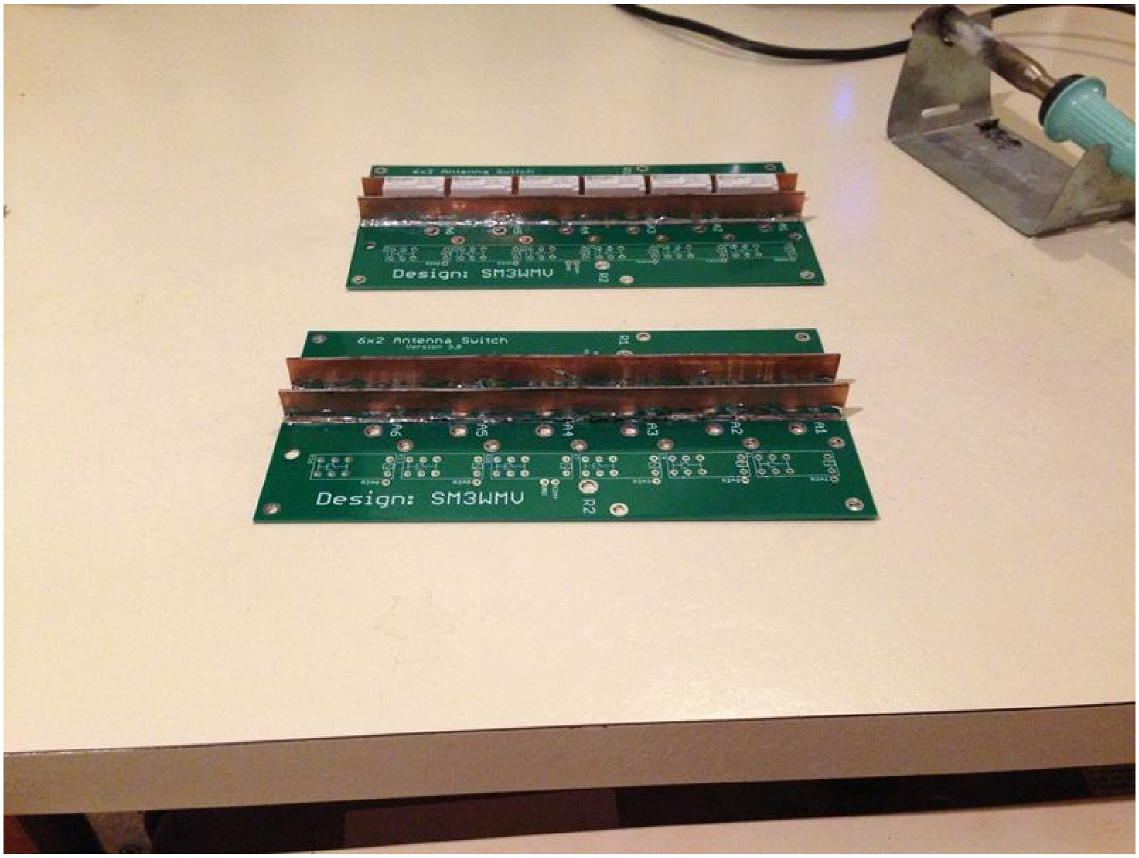
A homemade solution with 3 relays and interlocking was published by Mike Larsmark (SM2WMV / SJ2W) on his website www.sj2w.se. He offers commercially manufactured PCB's for about 50 Euro.



Picture 4: 6x2 antenna switch after SM2WMV, antenna relays board in the bottom and interlocking board sitting on top

Picture 4 shows one of the antenna switches I built based on his boards. An interesting detail is seen in picture 5. The copper stripes between the relays create additional insulation. This way up to 90 dB can be achieved on 160 m, 80 dB on 20 m and still 70 dB on 10 m.

PCB's and components are designed to handle multiple kilowatts. So sufficient reserve for the 1 kW limit we have here in ZL. The boards are installed into a Hammond "1550J" aluminum box.

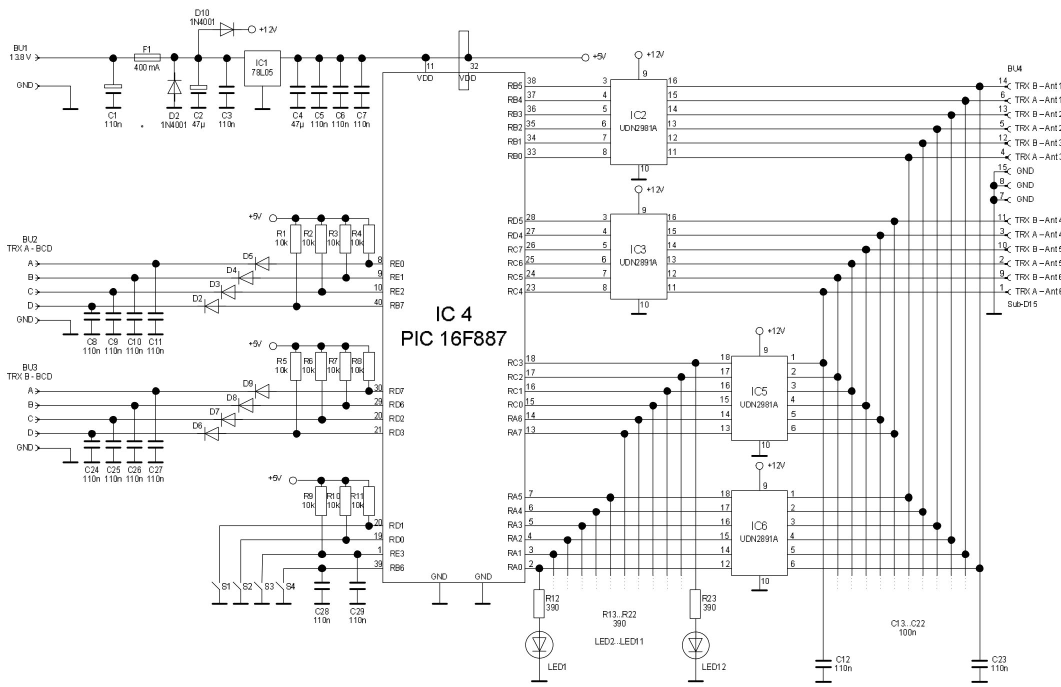


Picture 5: HF relays PCB with copper stripes between relays to increase insulation

With the described system it would be ok to use mechanical switches. But this has 2 disadvantages. First it is still a manual action and therefore has a failure risk (wrong antenna/band choice or incidentally switching while transmitting) and second we have no indication what antenna the other station is using. That is risky especially if there is a physical separation between the stations (different rooms).

Both problems are solved with stage two of the project, an automatic controller. Picture 6 shows the schematic. My German Ham friend Oli, DH8BQA was in the same situation and the outcome of the brainstorming was an easy to build solution around a PIC 16F887. We both use either Elecraft or Yaesu transceiver which offer BCD decoded band data. Most contest programs nowadays also offer BCD band data as an optional output so even if your radio does not offer BCD band data it can be triggered from the computer. Alternatively for ICOM and Kenwood transceiver an additional decoder has to be used to create BCD band data. This is a separate project I may describe later.

The micro controller reads from two transceivers the BCD band data via BU2 & BU3. The implementation of the BCD interface is conform to the standard. That means only low signals are detected. High signal are generated via pull up resistors R1-R8. This guarantees safe operation even if the BCD data are offered via open collector outputs only.



Picture 6: automatic controller for 6x2 antenna switch using BCD outputs of transceiver

S3 & S4 are used to define the band and antenna to be used. The information is stored in the EEPROM. After the next “power on” the combinations stored will be available again. The 12 V relays of the antenna switch receive their voltage via the transistor driver UDN2981A (IC2, IC3). Their output can drive up to 350 mA and therefore drive decent relays. The Finder relays used with the SM2WMV switch need only 33 mA.

Operation modes

The controller offers two modes of operation. Are both radios in the same room the can be connected to the same controller. The controller is connect to the antenna switch with 13 control lines (2 x 6 plus ground). Are the stations/radios in different rooms (e.g. two single band operators or Multi-Single/Multi-2) one controller per room is needed. Radio 1 in room 1 would be connected to BU2 of controller one. S1 would be set to ON and S2 to OFF. Radio two in room two is connected to BU3 of controller two and here S1 is OFF and S2 is ON.

S1 & S2 are enabling to choose antennas for connected radios via S3 & S4. Both controller will be connected with all 13 control lines to the antenna switch. This each controller knows its own and sees the signals of the other controller. The detection of the others controller status is done via IC5 & IC6. In this case the change the 12 V relay voltage into 5V for the LEDs.

The operator in each separate room gets an indication which antenna is used by the other station. The PIC also uses this feedback to prevent switching an already in use antenna. The controller indicates this by blinking of all LEDs. The interlocking is active until a different band is chosen at the own radio or the other station changes to a different band/antenna.

PCB & controller box

The controller pcb is (100 x 100) mm with two layers. All switches, sockets etc. are soldered onto the pcb. No additional/external wiring is needed. Except for the blocking C’s all components are wired.

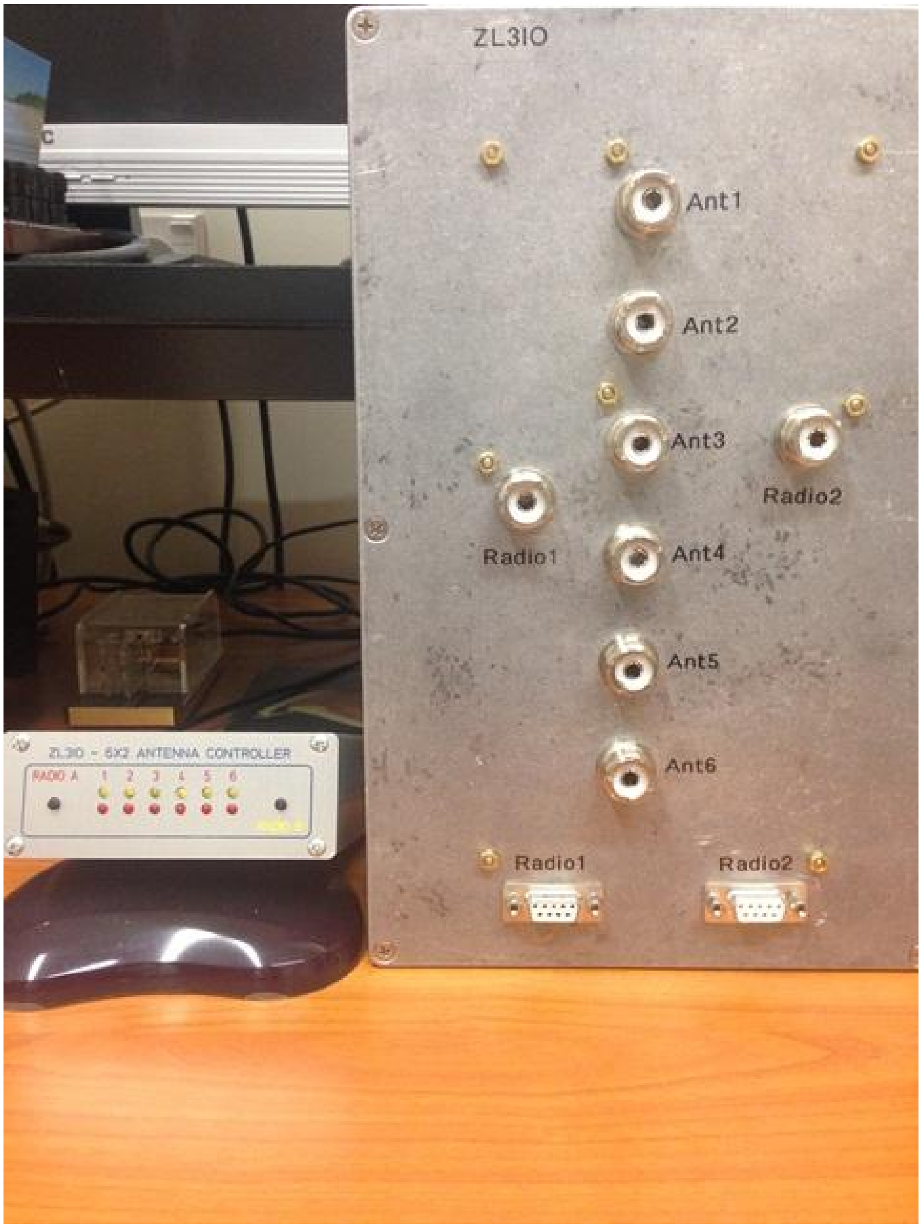
The blocking C's are 1206 types with 3.2 mm and are easy to handle even without SMD experience. Alternatively 5mm wide ceramic capacitors can be used as well.

Picture 7: controller for the 6x2 antenna switch

Picture 7 shows the completed board. The board fits perfect into a standard housing box from Fischer Electronic.

Picture 8: Controller in operation

Picture 8 gives an impression of the controller during operation with K3's. To give it professional look I got my front and back panel manufactured by www.schaeffer –ag.de. If interested I can mail layout files for the Schaeffer Frontpanel-Designer or the firmware for the PIC.



Picture 9: 6x2 antenna switch and controller

Summary

A 6 x 2 antenna switch allows a flexible distribution of 6 antennas to two radios. It is the central switching element of many contest stations. The controller presented allows automated operation from different locations with secure interlocking and status indication.