Companion 144 MHz transverter for Hermeslite HL2

Introduction

Hermeslite HL2 is a low-cost but extremely well performing DDC/DUC transceiver, covering from LF to 30+ MHz. However it needs external transverter(s) to cover VHF bands with high performance. HL2 also supports full-duplex operation (but not on the exact same frequency, due to potential feed-thru from Transmit path to Receive path).

If it is desired to use the HL2 with a traditional 144 MHz (or other band) transverter, and use the low-powered output option (without the additional N2ADR filter board), an external filter must be used covering, for example, 28 to 30 MHz. An external T/R relay may also be used to allow the use of half-duplex transverters, which is the normal situation.

With the availability of the geo-stationary Amsat QO-100, with an uplink in the 2.4 GHz band and a downlink in the 10 GHz band, if appropriate measures are taken, HL2 should be capable of supporting this full-duplex operation, provided precautions are taken to minimize feed-thru from the Transmit to the Receive path.

The transverter design presented here is based on fulfilling this need, as well as serving the more traditional need of half-duplex operation. In addition to providing the transverter function from 144 MHz to 28 MHz, selection and control functions are incorporated for up to 6 conventional microwave transverters (half-duplex) and one full-duplex split-band transverter, such as a ground station for QO-100.

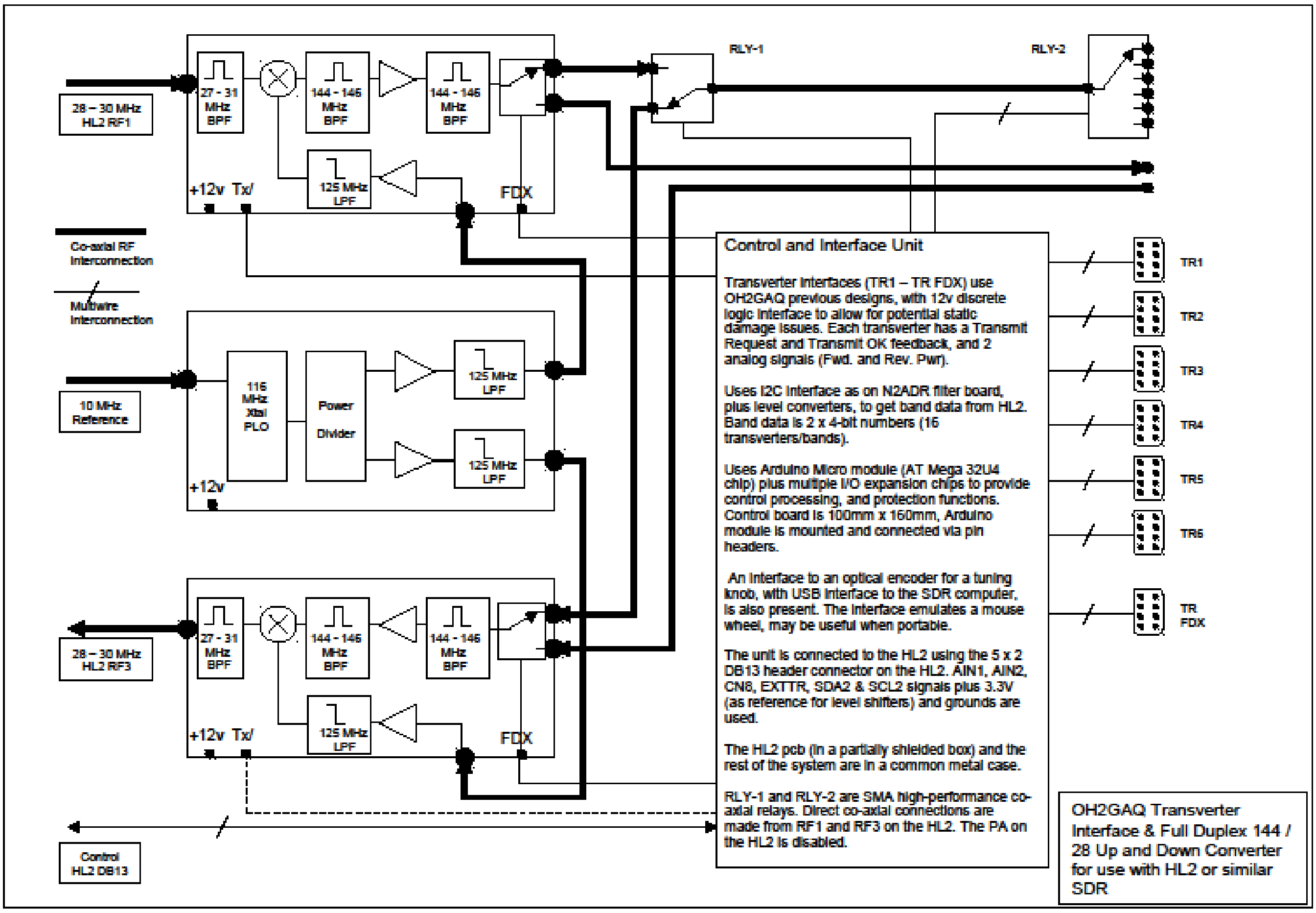

Figure 1 Block Diagram of Full Duplex 144 MHz Transverter and multi Microwave Transverter control module for use with HL2 in low power mode.

The circuit diagram for the key transverter module, and its layout, are available as separate files. A common circuit board layout has been arrived at for the Tx and Rx converters, the only difference is in the equipping of a few components. All RF modules are built-up in small 55mm x 110mm x 30 mm tinplate boxes, fitted with SMA RF connectors. The pcb's are designed so that a variety of mixers and mmic's can be used, even MMIC's with different footprints. See W6PQL website for a description of how to fit various MMIC packages into/onto the standard SOT89 package layout used in this PCB. The mixer package chosen is one of the standard metal-can mixer types, mainly because the author has a large number of these mixer types in the junkbox, with difference performance options, including several +17 dbm LO types with good dynamic range.

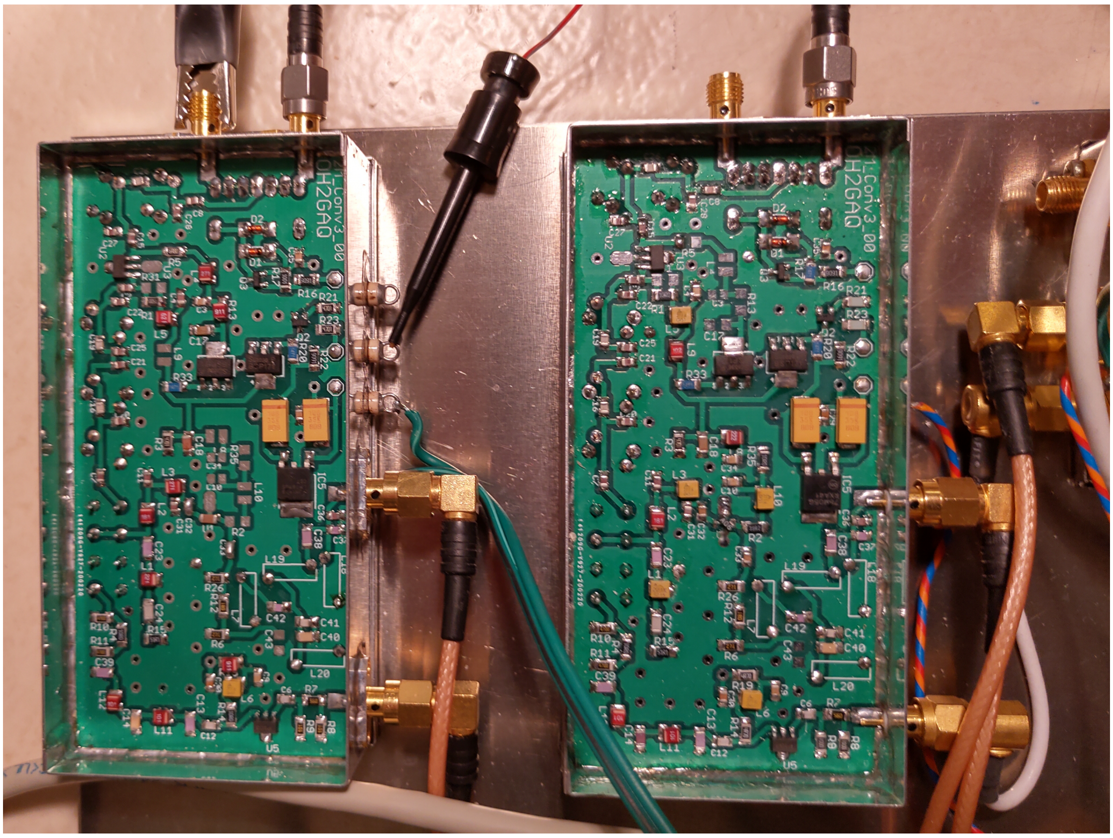

Figure 2 Transmit (Left Hand) and Receive (Right Hand) variants of the 144 / 28 MHz converters for use with the HL2.

As the intention is to also support full-duplex operation, a companion 116 MHz LO has been implemented, where there is good isolation between the two 116 MHz LO outputs. This is a completely separate unit, and also incorporates a 10 MHz reference clock input, with a splitter for the clock to the 116 MHz Xtal PLL lo-noise oscillator and a buffered external output to a distribution amplifier at 10 MHz.

The performance of the converters has been measured, including the performance of the filters, which have also been optimised by modelling. The original 28 to 30 MHz filter which was based on a Softrock design, has had its center frequency increased to give better coverage , even above 30 MHz, as the original was down several db at the band edge.

The photos below show the TX output spectrum at 144 MHz and cover up to the third harmonic. Also the closer-in spectrum was checked at lower spans, and was clean down to the level shown in this broadband scan. The Tx output level was + 13 dbm at 144 MHz (20 db pad in front of the SA). The behaviour of the Rx side is also shown, for closely spaced signals with large amplitude difference.

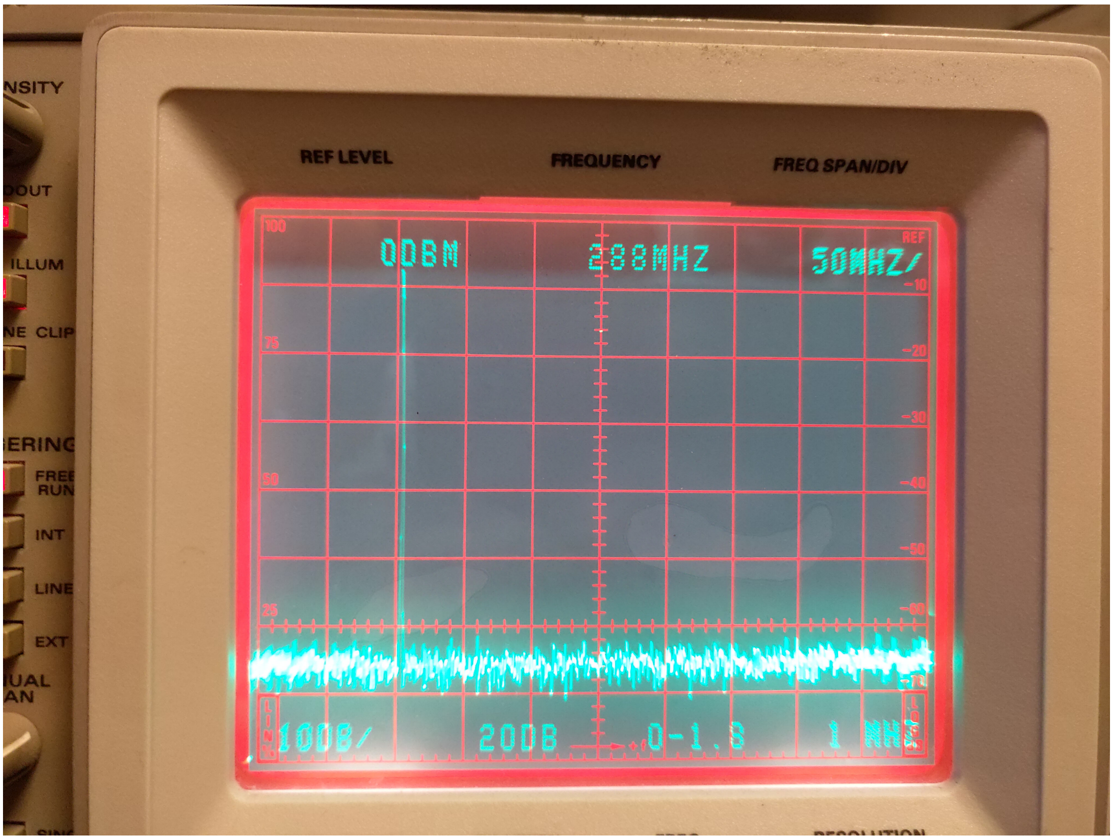

Figure 3 Broadband scan of transverter output from about 50 MHz to 550 MHz, output level +13 dbm. Driven by HL2.

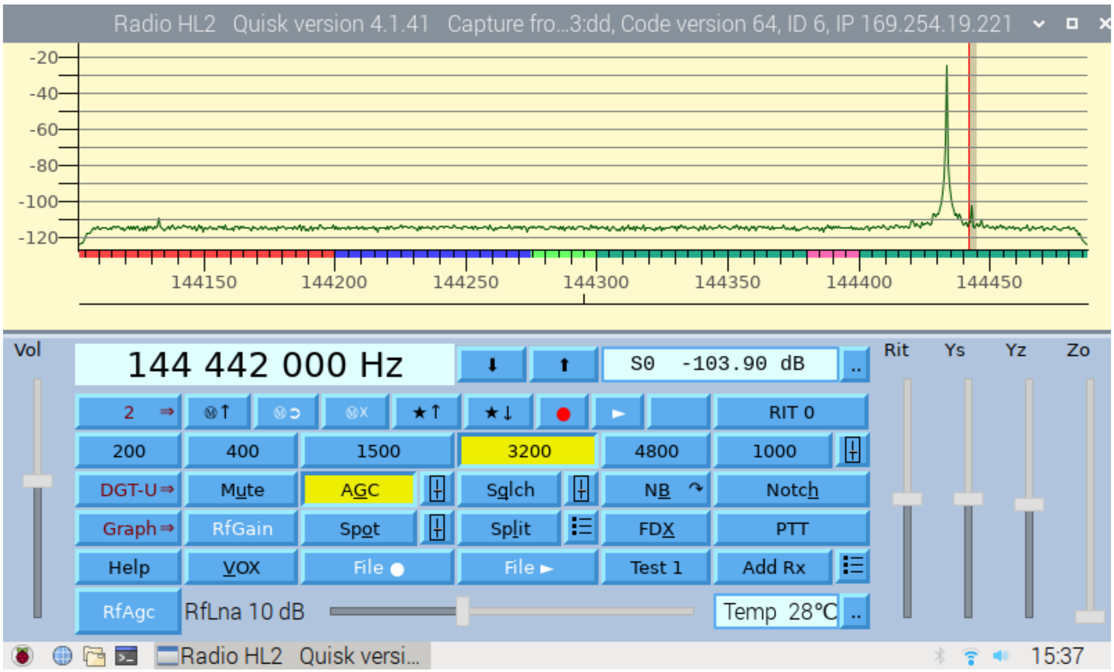

Figure 4 Attenuated beacon signal at about -104 dbm and interfering signal from a rather unclean signal generator at about -23 dbm, 10 KHz spacing. Quisk on R Pi 4 in small screen mode.

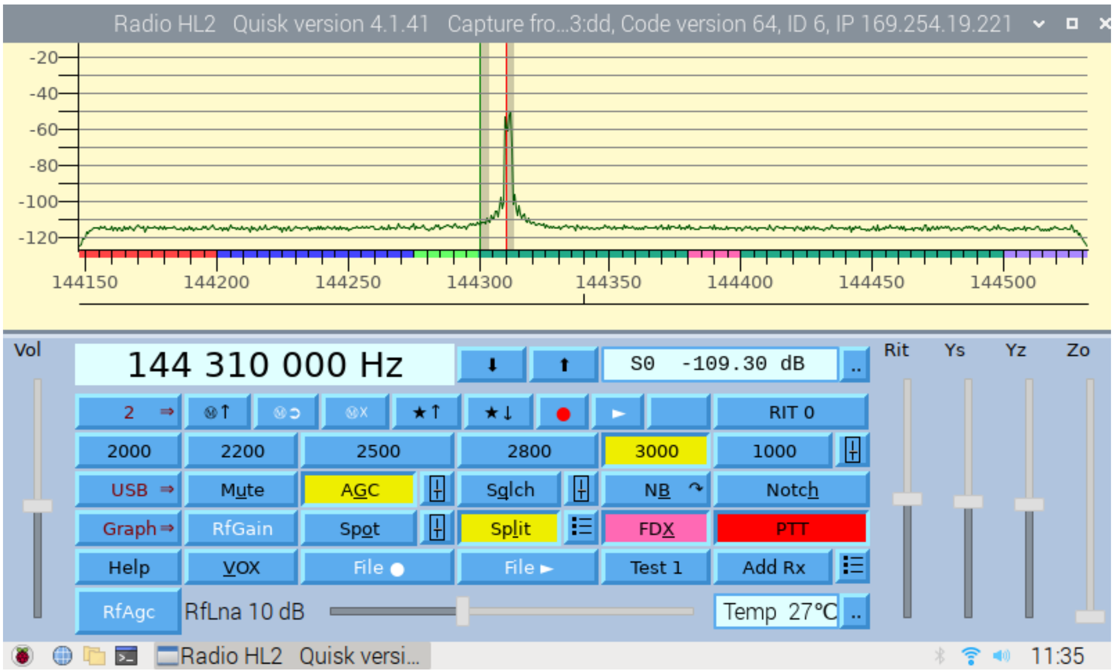

Figure 5 Quisk and transverters operating in Split mode, Full Duplex, showing the received USB SSB signal on 144.310 MHz, but with receiver frequency set to 144.300 MHz.

Some notes about Figure 5.

The Rx. Input was connected to the Tx. Output via a set of attenuators giving 66 db attenuation. The Transmit carrier is centred on 144.310 Mhz (Red cursor). The Rx frequency is 10 KHz lower, at 144.300 MHz. Only when the two are about 5 KHz or less apart can any breakthrough be noticed into the receive audio, with the filter settings chosen. In this setup Quisk is running on a R. Pi 4, audio is handled by a USB Sound Blaster using Pulse Audio interface.

Notes about the transverter design and implementation.

The 144 MHz bandpass filters have been implemented using conventional top-coupled LC resonators, using a standard Neosid nominal 170 nH inductor type. The availability of 2 and 3 stage helical filters seems quite variable over time, and getting less as time goes on, so this simple strategy was adopted here. Many MMIC types can be used in this transverter, the author has used Minicircuits PGA-103+ devices in the 144 MHz RF amplifier positions and for the 116 MHz LO amplifier. Note that these devices require a series RLC (150 ohm + 620nH + 330 pf) circuit on the input port to guarantee stability at low frequencies, unless they have a broadband termination (for example an attenuator like the LO amp. has) near the device input. These components can be accommodated on the pcb. Example circuits are included with the package. In the transmit converter U1 is not fitted, a convenient way to bridge the device pins is to use a 1206 size 4n7 MLCC, noted in the transmit converter schematic.

Controller board

The same interface to the HL2 as is used by the N2ADR companion filter board has been used. This also means that the standard Quisk or other software can in principle be used, although some modifications may make it more attractive to be used with the transverters. There are no special requirements for the gateware on the HL2.It uses the 10 pin interface connector DB13 on the HL2. Level translation is provided between the 3.3v logic on the HL2 and the 5 v logic used here. The band data from the HL2 is sent over the I2C bus to a MCP23008 chip, where it is read by the Arduino Micro module. It is treated as 2 x 4 bit nibbles, and allows the selection of 1 of up to 16 combinations of Tx and Rx transverters. It can be freely set up in Quisk and other SDR programs through their normal configuration screens.

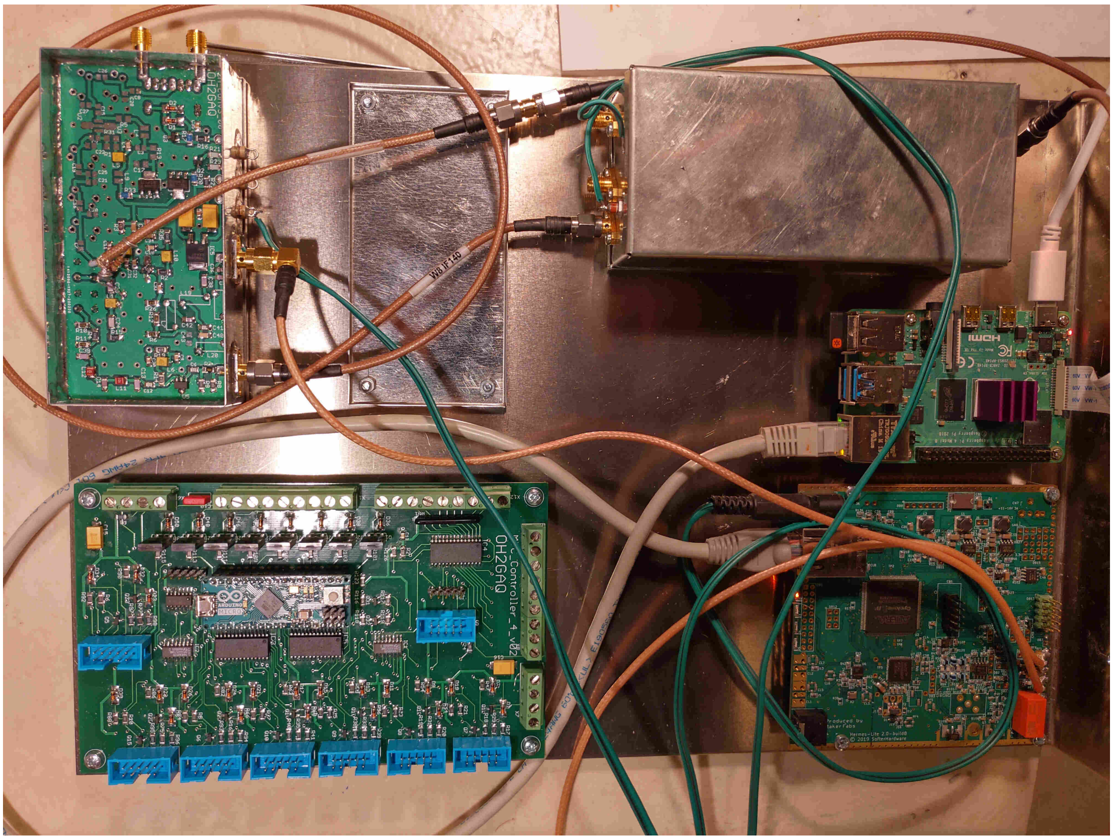

Figure 6. Prototypes modules during testing. The control board is on the lower left. The dual LO module is on the upper right. A RPi 4 with 7inch screen is in the middle right and HL2 in the lower left.

As shown in the block diagram, there are several RF co-axial relays, and a number of generic high-current relay drivers are provided from connector X1. The transistor outputs have catch diodes tied to the relay supply voltage and ground to prevent damage to the transistors. These drive the changeover RLY-1 and multipole RLY-2 in the block diagram.

Each transverter has a 4 wire plus multiple "earth" wire interface to the control module (connectors X2, 3, 4, 5, 9, 10, 11) . The basic signals are a "transmit /" command (negative true) and a response from the transverter "transmit OK /". If a transverter is not present or notices an error (such as hi VSWR, high current, high temperature) the "transmit OK /" response is either never given, or is removed. These signals are intended to be driven over long wires and use discrete transistor logic interfaces (12V logic). Two analog signals (with input voltage protection) are expected from each transverter, these would normally indicate forward and reverse power from the transverter. This interface to the external microwave transverters is described in several articles on the authors website (https://www.qsl.net/oh2gaq).

Control outputs to the various modules in the system are provided at X8, two of them can be used for driving LED indicators. The others are used for controlling the state of the 28 to 144 MHz transverter parts. Inputs are also provided on X12, these can be used for bringing in PTT switch status, or other mechanical switches, as well as for internal status signals such as Rubidium oscillator or PLL locked status..

X6 provides a connection point for an optical encoder, which can be used to provide a mechanical tuning knob in a system. Code in the Arduino Micro allows this to appear as a HID mouse scroll function on the USB interface of the Micro.

JP1 allows either a serial interface connection at 5V level, or up to 3 parallel logic signals. These can conveniently be connected to a co-located SBC such as an R Pi or Asus Tinkerboard.

JP2 provides access to up to 3 more bits from the Arduino, one important function is to allow the SW in the Arduino to disable the HID function to allow for re-programming the chip over this same USB port..

Software for the Arduino.

A simple SW module was developed to allow basic control of the units (Rx. / Tx. Switching, band changing, Half/Full Duplex switching etc.) using the Arduino Development Environment. At this stage it does not look after error conditions or precise timing issues, but has enough functionality for basic operations. Certainly the IDE allowed very rapid development, compared to what has been used in other projects, and only required a single USB cable between the PC and the Arduino board on the controller.