MW EME Doppler Shift Compensation without Compromise

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On 3 cm band at very weak signals which are not only below hearing levels but also difficult to notice on the waterfall immediately, two things are fundamental. The first thing is to operate on precise frequency in order of tens Hertz. The synchronization of microwave transverter by GPS or another atomic oscillator is necessity. But it appears to be useful when IF transceiver operating around 145 or 432 MHz is synchronized the same way as well, because otherwise a frequency uncertainty can be in order of hundreds Hz. Most of transceivers do not have built-in connector for external frequency standard connection, so an intervention into transceiver hardware is needed.

The second thing is a Doppler shift compensation. The Doppler shift on 10 GHz achieves +/- 30 kHz. On 24 GHz 2.5 times more and on 5 GHz a half of the value, because it is proportional to the operating frequency. Receiving side is not a big problem. Frequencies of most radios can be controlled by CAT system with small step so that suitable program can solve this compensation for incoming signals. However working experience shows that so called “Full Doppler” compensation is very valuable when corresponding station may not compensate shift of incoming signal. Full Doppler means that one of corresponding station changes the frequency of own receiver as well as of own transmitter according mutual Doppler shift while the second station is tuned on fixed nominal frequency. The perspective mode is “Constant frequency on the Moon” when both corresponding station provide one half changes of mutual Doppler at both rx and tx side as well. Advantage of this mode is that a third station can monitor both corresponding stations on the same frequency. Automatic frequency change of rx and tx is needed in both mentioned modes. Unfortunately, a lot of transceivers cannot change the frequency during transmitting by CAT.

For this reason an IF transverter has been designed and built. Direct Digital Synthetizer (DDS) is applied as local oscillator synchronized by the same atomic frequency standard as microwave transverter. The IF transceiver is working then on low frequency where a frequency uncertainty is in required order of ten Hertz. DDS frequency step can be below 1 Hz and frequency compensation very fine. Block diagram of the transverter 148/18 MHz is in the Figure 1.

DDS is controlled by program “Dopp” developed in MATLAB environment. Figure 2 shows fronted GUI of this application. Doppler shift data are obtained from azel.dat file of WSJT. That means the right corresponding callsign and its locator need to be written in WSJT main window. Reading interval is optional parameter of program’s main method. For example Dopp(1) provides reading interval of 1 sec. Switching between

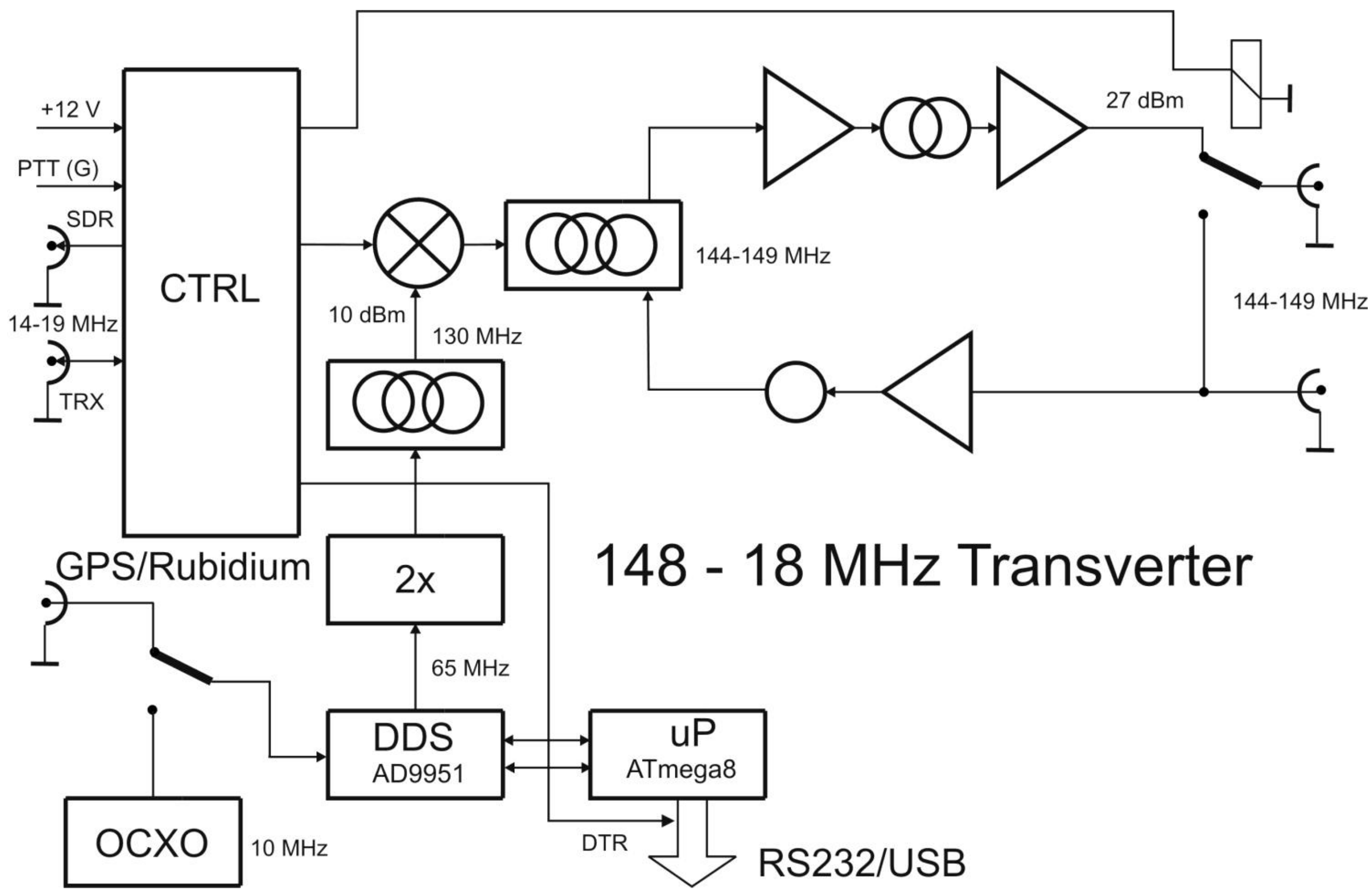


Figure 1. Block diagram of the IF transverter

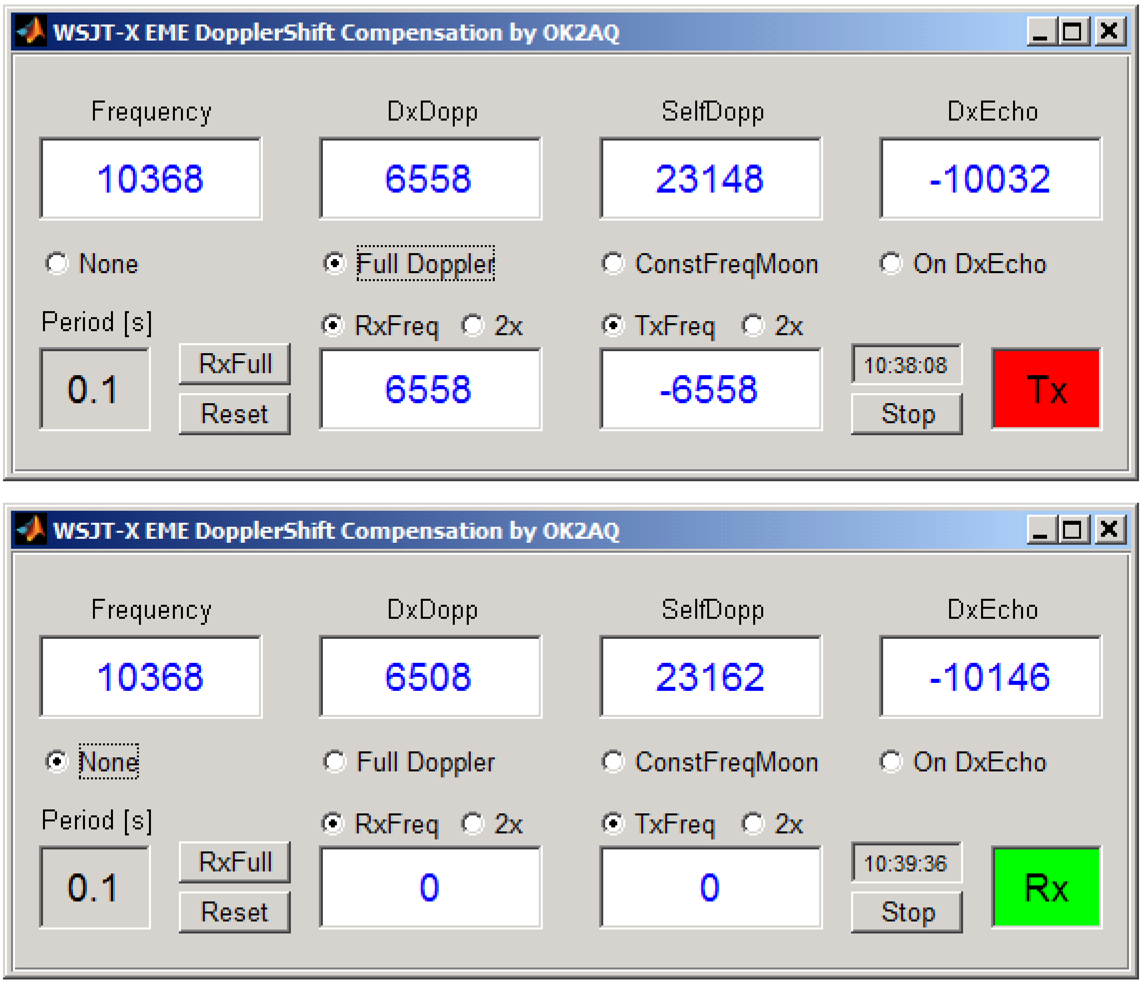
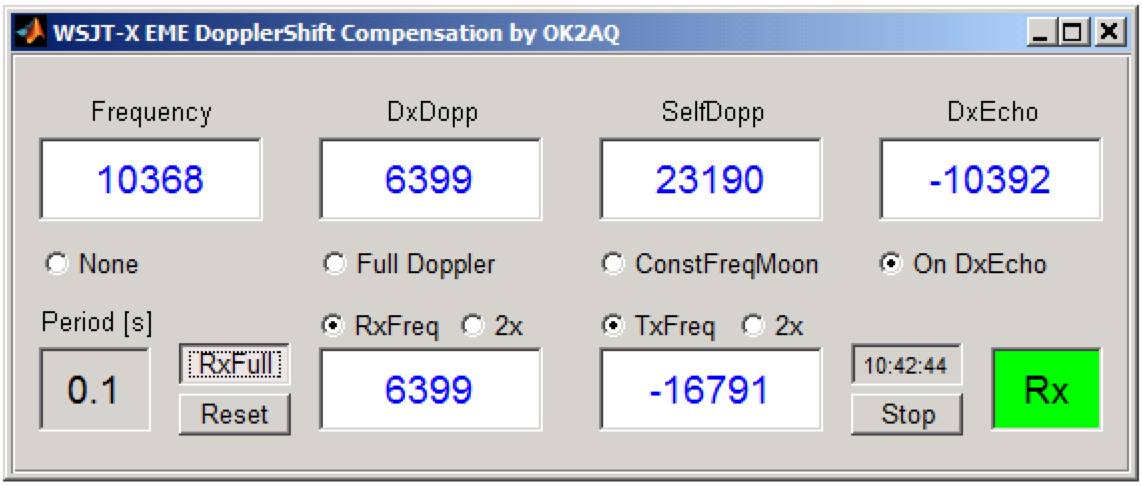


Figure 2. The GUI of the control program. Above FullDopp in Tx period and below None compensation is chosen.

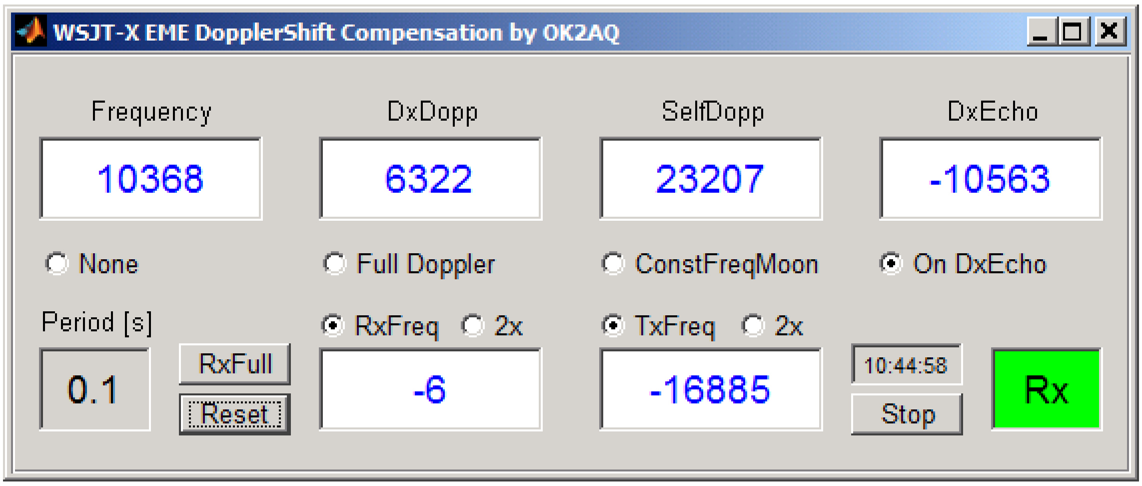
Rx and Tx interval is taken care of by DTR wire of RS232 bus and is indicated by red color in the right lower corner of GUI. In all cases it is possible to switch off compensation independently in Rx as well as TX period. Next, you can see several situation examples which can occur, Figure 3.

Besides standard 1) “Full Doppler” and 2) “Constant Freq on the Moon” we can encounter a situation:

3) Station announced calling CQ, tx frequency and listening on own echo:

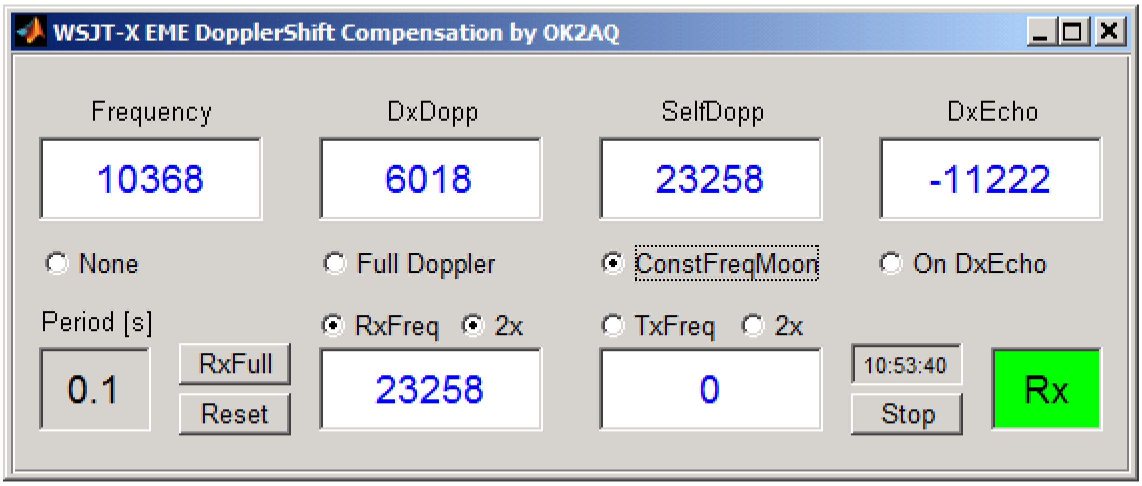


4) We find the station calling cq and suppose that it is listening on own echo (random qso):



If the corresponding station uses own rx compensatition then switch Tx off.

5) You can see own echo Rx compensated:



The same adjustment is if we are calling CQ and listening on own echo.

6) You can see own echo Dopp compensation on Tx side:

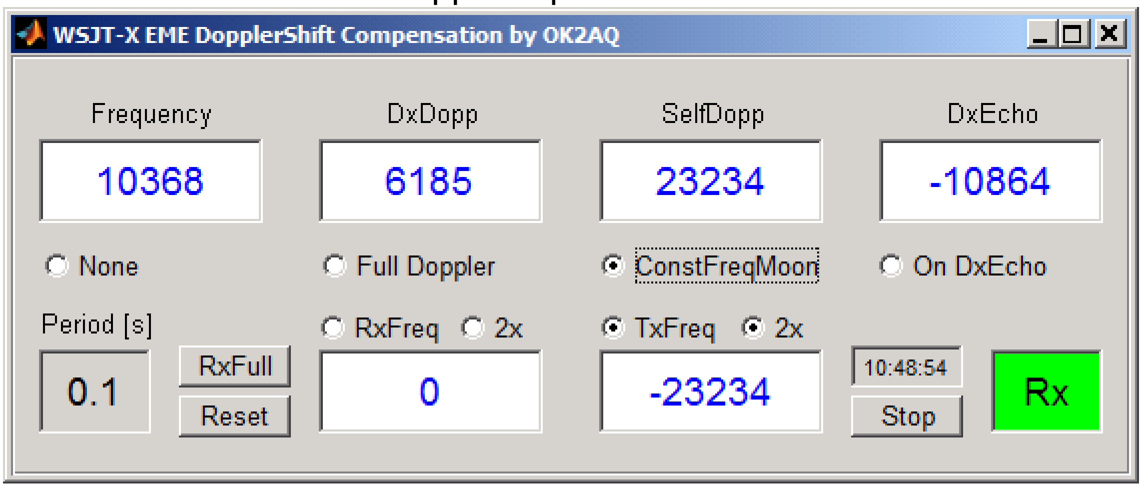


Figure 3. Several examples of the EME Doppler shift comepsation

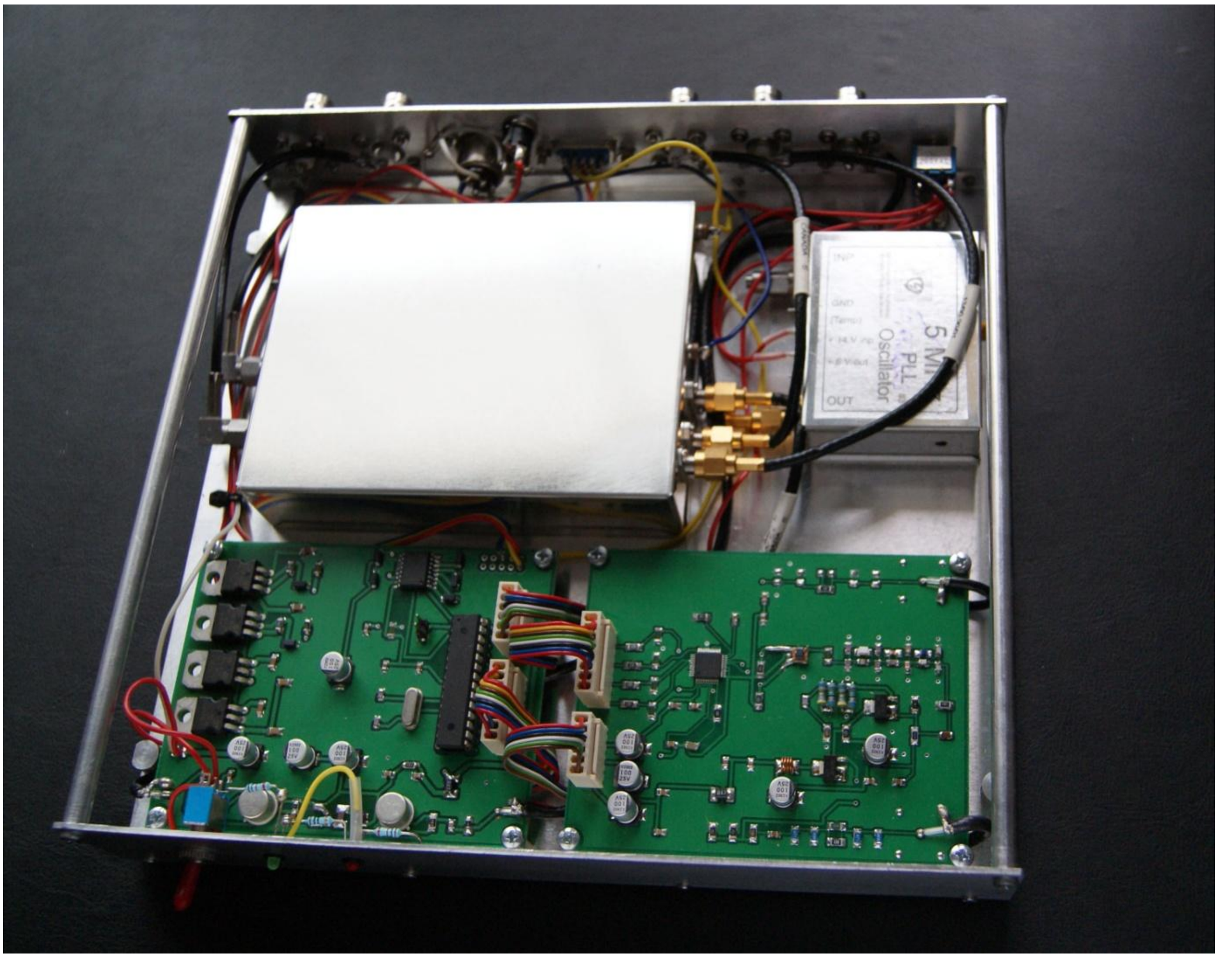


Figure 4. 144-149 MHz/14-19 MHz Transverter

Figure 5. EME receiver SDR, transverter and IF transceiver

References:

[1] VK7MO, K1JT: Small Station EME at 10 and 24 GHz: GPS Locking. Doppler Correction, and JT4.
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[1] G3WDG: Using WSJT-X for JT4 EME Operation.

[2] K2UYH: Understanding Doppler Shift.
http://www.vhf.cz/soubory/dokumenty/pres-k2uyh-doppler-eme.pdf