# Converting the NEC PASOLINK Transceiver to 47GHz

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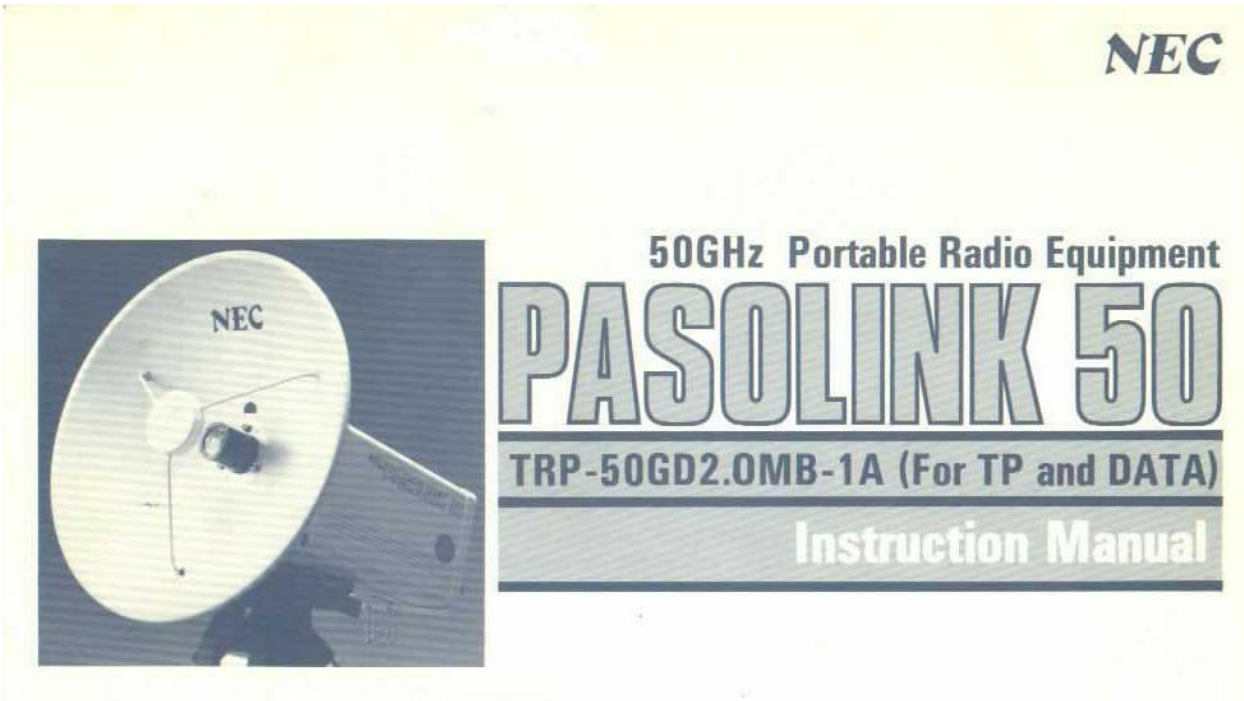


## Introduction

The NEC Pasolink TRP50GD2.0MB-1A 50GHz portable radio equipment was produced around 15 years ago to provide a full duplex 2.048MB digital and an anologue audio channel for point-to-point links at around 50GHz. It had a 500MHz transmit/receive split. The frequencies covered were 50.44 to 50.62 and 50.94 to 51.12GHz. The RF unit is approximately 5" x 9" x 7". I acquired my pair of transceivers in a "capital reduction" sale in the UK, however, in the last few years they have appeared on the surplus markets in France and I have seen them in Eastern USA (KY and FL), so it was decided it was time to describe my conversion attempts to put them on 47GHz.

## Original configuration

The original configuration of the unit is shown in Fig 1. A DRO puck is used as the main frequency-determining element of the transceiver. It is used with an NEC power device to generate around 100mW at 12.775GHz. This is then fed through an isolator to a diode multiplier which after filtering generates 15mW at 51GHz. Modulation on transmit is done by FMing the DRO. The transmit signal is fed to the antenna via a circulator. Some of the transmit power is reflected to the Rx port of the circulator and is fed to a receive mixer which uses a diode. The claimed noise figure is 15dB. The first IF at 500MHz is fed through a bipolar IF amp to a second mixer which converts to a second IF at 70MHz where de-modulation takes place. The equipment is powered from 48V, positive ground which, via DC to DC converters supplies the required plus and minus voltages for the equipment.

Three antennas are supplied with the unit with gains of 12,20 and 40dB. This is achieved by having a basic 10mm horn of 12dB gain, fitting an adaptor over it to make it a 25mm conical horn of 20dB and finally using this setup to feed a 300mm Cassegrain fed dish for 40dB gain. Not having a 50 / 47GHz antenna test range it was assumed that the antennas work satisfactorily at the lower frequency.

## Conversion options

The easiest option was to use the pair of Pasolink as a duplex WBFM rig on 47088 MHz, as has been tried by G4DDK. To do this one would tune the DRO Oscillator of one unit down to 11.772MHz generating a transmit signal on 47088 and use a WBFM Rx at 100MHz connected to the IF amplifier. The DRO Oscillator of the other unit is tuned to 11.797MHz generating a transmit signal on 47188 and also use a WBFM Rx at 100MHz connected to the IF amplifier. The problem with this scheme is that it could only work its duplex partner and be unable to work 47088MHz transverter stations. This scheme would only be feasible if the DRO oscillator could be tuned down 1GHz to around 11.8GHz. There is a tuning screw above puck, but this only moved the frequency about 100MHz, not enough, neither was application of bath sealant to the puck (as per a WA5VJB suggestion). The only real option was to replace the puck with a lower frequency one, but after much fruitless searching for one, this option was rejected.

The frequency response of the bipolar RX IF Amplifier was measured with 50 Ohm input/output; the results are shown in Table 1. From this it was decided that the ideal receive IF would be 432MHz.

Some attempts were made to make the transmit diode multiplier a sub harmonic mixer by applying 11.8GHz LO at +17dBm and 10dBm of IF. (following the W0EOM rule of thumb “don’t hit any mixer diode with more than a total of +20dBm”) Unfortunately the output was very low, around (-30dBm) so it was decided to keep the diode as a multiplier generating its massive +10dBm output on transmit and use the original mixing scheme with a 432MHz IF shown in Fig 2 on receive. The disadvantage of this approach was that two local oscillators, separated by 432MHz would be needed; requiring two switchable crystal controlled 11GHz local oscillators. On transmit one oscillator on 11.772Mhz would multiply to 47088 at +10dBm, keying this oscillator on/off would supply the modulation. The second on 11664MHz would generate the LO at 46656MHz on receive allowing the use of a 432MHz IF. A power of around +19dBm would be needed at 12GHz to allow a safety margin to avoid overdriving the irreplaceable diode.

A few options were considered for the 11.7GHz oscillators. PLL bricks were too noisy, too big and consumed too much current from the voltage inverter. The DB6NT MK3 oscillator would be ideal on size and 12V operation grounds, but I had heard no successful reports of anyone moving them very far from their nominal 12.1GHz operating frequency. I therefore reverted to the G4DDK004 2.5GHz oscillator (1) and G3WDG009 times five multiplier (2) module combination, which had been used successfully in many applications before (3). These were fairly large but it was discovered that a G3WDG multiplier worked equally well on both 11664MHz (G4DDK004 on 2332.8MHz with 97.2MHz crystal) and 11772MHz (G4DDK004 on 2354.4MHz with 98.1MHz crystal) so a relay could select one of two

G4DDK004 oscillators to feed a single WDG multiplier saving some space; it was intended to use the original NEC housing for the new transceiver The WDG multiplier produced +14dBm, a little short of our requirements so a 12GHz amp was needed. The deficiency was solved by retuning a WDG006 10GHz MGF1801 Amplifier to 12GHz with copper foil, which produced an output of +20dBm. The final local oscillator configuration is shown in Fig 3

## Local Oscillator details

A G4DDK004 oscillator was modified as follows. For stability the entire G4DDK004 oscillator is run off a L4710 low volt drop regulator, the original 78L09 regulator being removed and replaced with a link. Do not omit a 100uF capacitor on the L4710 output or spurious signals will abound. All the Crystals were cut for operation at 50C, to cope with Texas summertime temperatures and are fitted with BG330N murata posistors run off a separate 7805 regulator to maintain 50C. For an excellent description of how to use these posistors effectively see the article by Doug Friend, VK4OE (4)

The oscillator circuit (TR1 and TR2) is left running all the time to maintain maximum frequency stability. On off keying is achieved by keying the supply to a multiplier stage. Initially R16 was disconnected from the 10V rail and a VFET (IFRD9020, –50V, 0.28ohm on resistance 1W dissipation) used to key the collector voltage. Unfortunately the “carrier suppression” was only 18dB. So it was decided to key the collector supply of TR4 and TR5 by switching R16 and R20 with a FET, this supplies some 50dB of “carrier suppression” and produces an acceptable T7 signal.

Note that a “keying” circuit is also fitted to the receive G4DDK004 unit disables the RX LO on transmit to prevent spurious signals. For the same reason the Transmit oscillator is disabled on receive. The relay switching receive and transmit oscillators to the G3WDG009 multiplier is an SMA unit requiring 28V drive. To avoid having to build a 28V 100mA inverter the Down East RVD-1 relay driver board (5) is used to “pulse and hold” the relay.

## Conversion Process

Before starting any conversions operation was verified. The output on 50GHz was measured on both units using an HP8563E analyser & HP11970K external mixer as being +10.6dBm. Communication between the two units was also confirmed. The opportunity was also taken (while it still worked!) to measure and record the DC Voltages feeding the RF unit and every DC connection point of the multiplier/receive mixer assembly. This would allow the power supply requirements of the modified units to be evaluated. It was found that the RX IF amp ran off +10V and that a negative bias of around –3.5V was applied to the multiplier diode to improve efficiency. These voltages could be supplied very easily off a 12V supply, allowing the existing volumous NEC PSU module to be discarded. The circuit of the PSU to generate the negative diode bias is shown in Fig 6. The WW2R014 PCB originally used for the Qualcom 10GHz PSU board (6) was modified for this application. The board is mounted on the inside of the front panel.

Remove and discard all the PSU and Demodulator PCBs, but keep all their associated mounting hardware, it will be used later. The 9 screws on the top and the 4 screws underneath the multiplier module are removed, allowing the innards to be modified. Firstly the DRO puck is smashed and the wires feeding the power oscillator are removed. NEC very conveniently has mounted an SMA connector on the module to allow the 12GHz DRO frequency to be measured and set. By application of a small piece of copper foil this connector can be connected to the input of the isolator instead of the output of the puck oscillator. The 20dBm of 12GHz is then fed to the multiplier through this point. The feedthrough nearest the multiplier output is the multiplier diode bias connection; the wires to the other 3 feedthroughs on the underside of the mixer are disconnected, as they are no longer needed.

The RX IF appears on a SMB connector on the output of the brass box containing the IF amplifier A lead was made to connect this to a BNC socket on the back panel for the 432MHz receiver. The receiver diode bias preset is accessible through a hole close to the output connector.

A piece of Aluminium, the same size as the discarded PSU module is attached where the PSU module used to be. On the side away from the front panel the two G4DDK004 oscillators are mounted on edge, they were fitted with right angled SMA female connectors. Each oscillator has an SMA male barrel and an SMA right angled SMA male to female adaptor allowing both oscillators to be connected directly to the SMA relay. On the other (front panel) side of the Aluminium is mounted the RVD-1 unit, the WDG009 multiplier and the WDG006 amplifier. The output from the G3WDG006 amp is connected to the input of the multiplier with a short piece of semi rigid coax with right angled sma connectors on each end; straight connectors cannot be used as the unit cannot be reassembled into the case.

Power supply switching between receive and transmit is accomplished with a 4pole 4way switch, as shown in Fig 5. This switch also routes the key jack into circuit on transmit. The key socket is a normally closed device obliviating the need for a key to test the transmitter. The fourth position is to allow fm transmission to be added at a later date. To allow easy disconnect of the switch assembly/back panel from the main assembly the 9 pin 0.1” header connectors were reused.

## Tune-up

Firstly make sure that the local oscillator chains are producing +19dBm at 11664MHz and 11772MHz respectively on receive and transmit. Next connect the local oscillator to the SMA port on the multiplier assembly. A power meter or sensitive detector is connected to the antenna port. With SW1 set to transmit the tuning screws on the multiplier up to the circulator, the circulator matching screws and the multiplier diode bias pot are adjusted for maximum output, typically 10mW on 47088MHz. Next connect a voltmeter across the bias pot at the input to the IF amp with the pot set to maximum resistance. Switch to receive and tune the screws between the circulator and the receive mixer for maximum voltage reading. It was found possible to adjust the circulator tuning screws to reduce the RX oscillator output to –32dBm without affecting performance.

The bias pot on the input to the IF amplifier is tuned for maximum receive sensitivity when receiving a weak signal. I used an 11.772GHz brick driving a WR18 waveguide detector at the bottom of the garden as a signal source.

## Results

Frequency stability is excellent. Measuring the 47GHz frequencies using the HP8563E analyser, HP11970K mixer and a GPS locked 10MHz frequency reference showed both oscillators to be within 5kHz after warmup, even when left for 24 hours in an un-airconditioned garage.

The second Pasolink was altered exactly as the first one. A pair of Pasolinks worked the 55km path between Sanger, TX (EM13II) and Gunter, TX (EM13PK) during the ARRL Jan 2000 contest on cw with ease. A DB6NT transverter using a 43dB gain ProComm dish to compare the receive signals at one end of the link was considerably down on receive sensitivity, indicating that all the extra work in bringing the project to fruition had been well spent.

## Conclusion

Hopefully the above will encourage anyone that comes across these units that they are worth the time and effort turning them into a useful receive system for 47088MHz.

## References


1. An Oscillator for 2.0 to 2.6GHz Sam Jewell G4DDK RSGB microwave handbook volume 2, pp 8.13 to 8.16
2. http://www.g3wdg.free-online.co.uk/product.htm
3. The Two FRE UK 142GHz Expedition 2000 www.mesh.net/~g4fre/142g.htm
4. Crystal Heaters, some useful observations. Doug Friend VK4OE. RSGB Microwave newsletter Jan 2000
5. www.downeastmicrowave.com
6. A Smaller Power Supply for the Qualcomm Omnitrak Amplifier Dave Robinson WW2R. http://www.mesh.net/~g4fre/10gpa.htm

Table 1. IF Amplifier gain characteristics

| Frequency/MHz | Gain/dB |
|---|---|
| 50 | 9 |
| 144 | 10 |
| 220 | 10 |
| 432 | 13 |
| 1296 | 8 |

Table 2. Components for Multiplier diode bias PSU

| Resistors | Value | Caps | Value | Semiconductor | Part |
|---|---|---|---|---|---|
| R1 | 100k | C1 | 10u 25V | IC1 | LT1054 |
| R2 | 20k | C2 | 10u 25V | IC2 | L4710 |
| R3 | 10k | C3 | 10u 25V | | |
| R4 | 820 | C4 | 100u 10V TANT | | |
| R5 | 120 | C5 | 2200pF | | |
| VR1 | 500 preset | C6 | 1u 25V TANT | | |

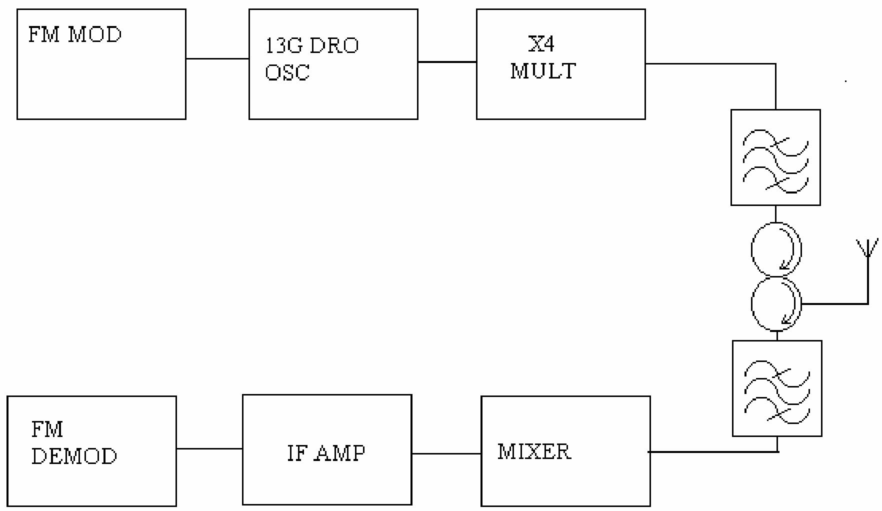


Fig 1:Original Pasolink Configuration

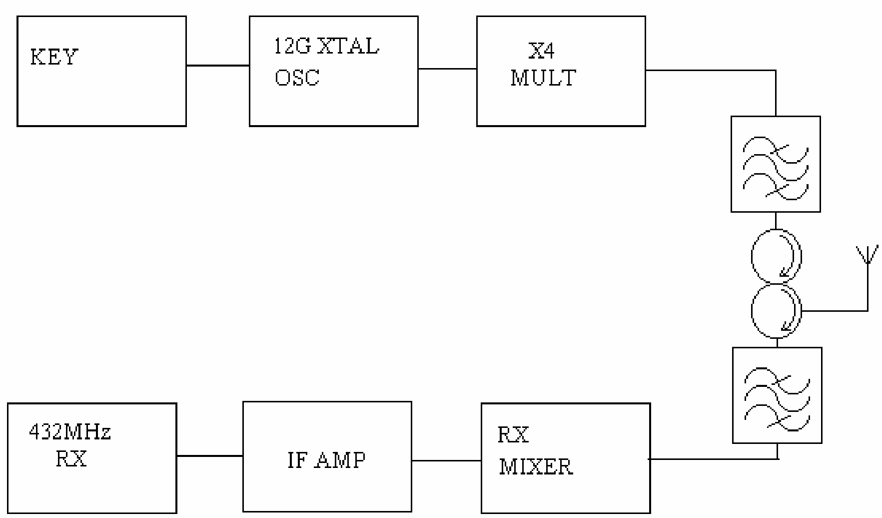


Fig 2. New configuration of Pasolink

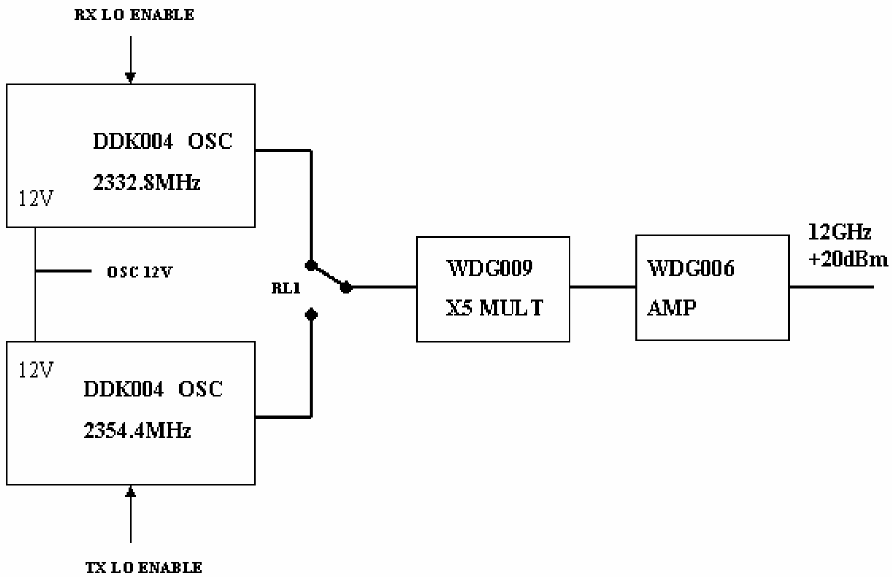


Fig 3: New 12GHz Local Oscillator for Pasolink

Fig 4. Modifications to G4DDK004 Local Oscillator

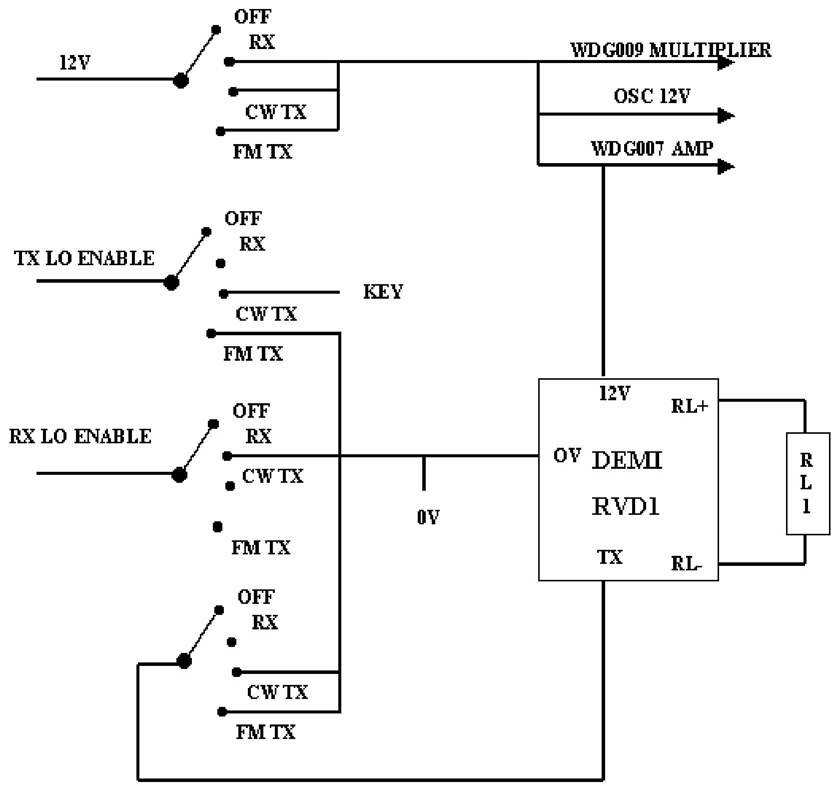


Fig 5: D.C. Switching circuit

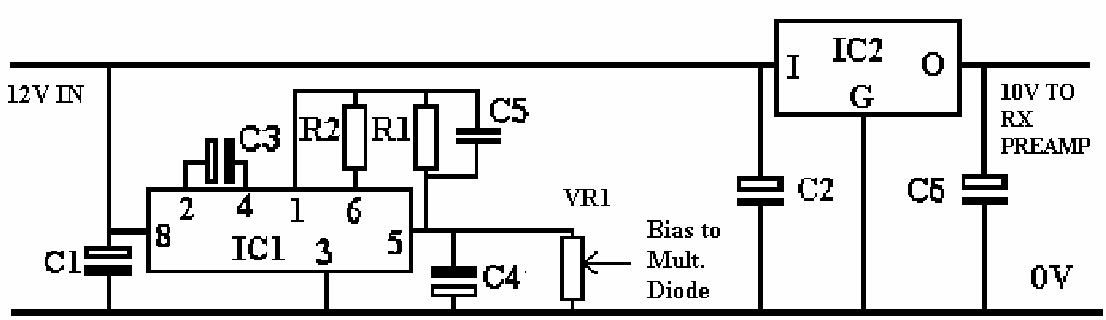


Fig 6. Mixer diode bias Circuit