# Amateur DSN - Early Days

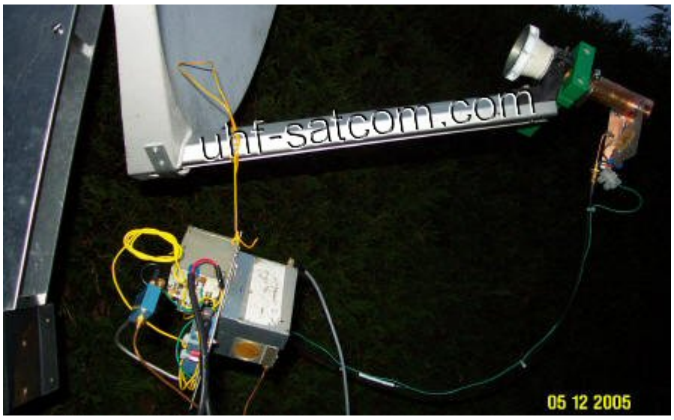
**Introduction**.

The inspiration for building a down converter for 8.4GHz came from a demonstration that was given by **James Miller G3RUH** and **Freddy de Guchteneire ON6UG** at the UK Microwave Group microwave meeting in November 2005. James and Freddy have had a fair amount of experience in receiving these deep-space-probes, and there is a nice page of useful information at the Amsat-DL site.


The photograph above shows the experts, James and Freddy, using a home made 1 metre mesh dish, an off-the-shelf DB6NT 8.4GHz LNA and down converter. In the photo, Freddy is listening directly to Venus Express shortly after it was launched just with open waveguide! The DB6NT DSN converter provides an IF output in the 23cms band. The signals during the demonstration were consistent and copyable in SSB audio bandwidth, with Venus Express being a lot stronger than the Mars Reconnaissance Orbiter, also en-route to its destination planet. The feed used on the 1m dish is a dual circular polarisation waveguide with a septum plate in it. The DB6NT LNA shown in the picture has a waveguide input and is coupled off of the relevant port in order to achieve reception of RHCP signals from the Orbiter.

Shortly after watching the demo and chatting about the topic, a visit was made to the junk-sale at the microwave meeting, where a few important parts were found to build an 8.4GHz down converter.

hugh from the feed-arm of a 1.05M offset dish (below right). The brick oscillator in the down converter runs at 8GHz and is fed with an 80MHz reference from a GPS locked source / frequency synthesiser ensuring frequency accuracy and high stability.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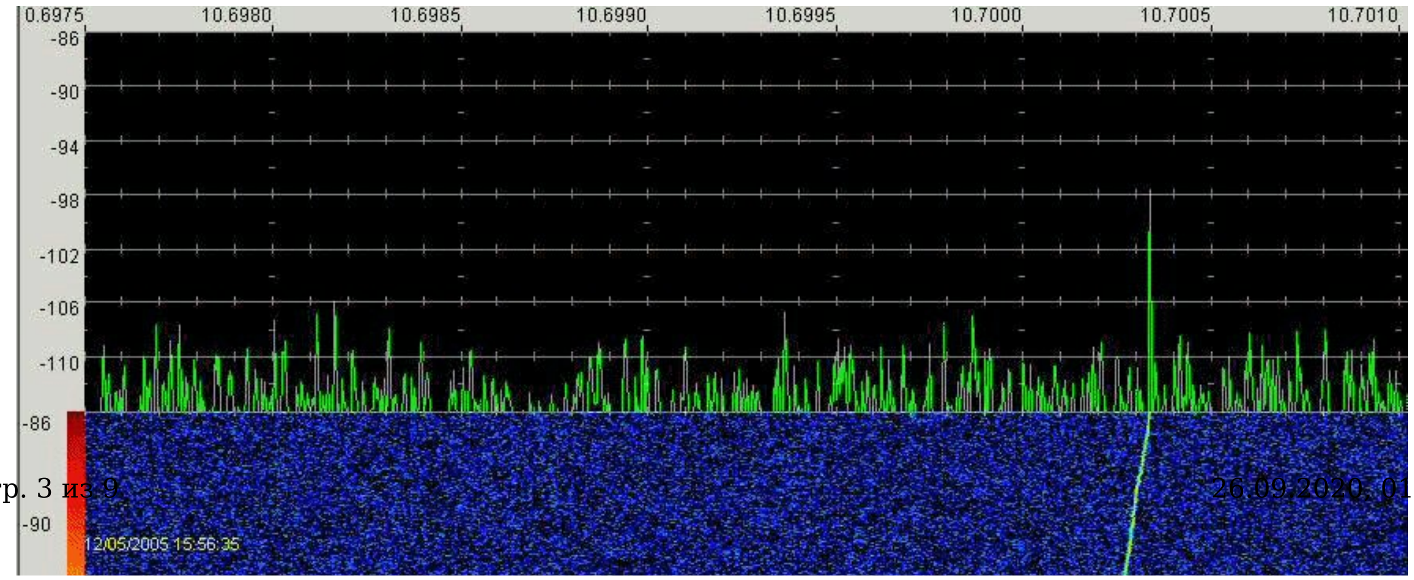
The frequency at the time (15:30 UTC 5/12/2005) of reception was 8419.0010 MHz. The JPL horizons website was used to calculate the azimuth / elevation of the space craft, then using a reference from an X-band communications satellite, the appropriate azimuth / elevation was calculated.

Signals received from Venus Express on the 5th December 2005:

0:00

The spectrum plot below clearly shows the carrier drifting in frequency as the relative position / motion of the Earth and the Venus Express probe changes. The FFT image was captured using an RFSpace SDR14 Software radio. The FFT was taken in a 5KHz span. The great thing about using the SDR is that your actual receiver doesn't have to be spot on frequency, yet you can still see the signal in the FFT display and peak up the dish etc, then when satisfied that everything is aligned, tune the receiver to hear the carrier.



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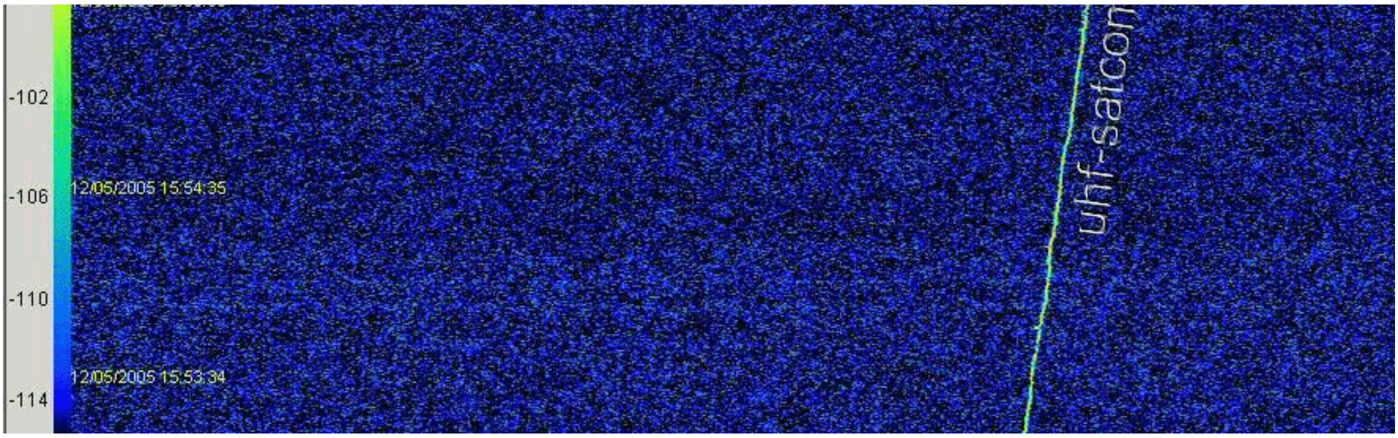


**Results after adding the 8.4GHz band pass filter.**

The two pictures below show the band pass filter that was designed with the G3JVL filter software. It is a 2 cavity filter built in WG16. Once the filter had been roughly tuned up, it had 0.5dB through loss at 8420MHz, with a bandwidth of about 50MHz. The plot on the right shows a sweep of the filter - the peaks can clearly be seen. Checks on the image frequency of 7580MHz showed that the filter has over 50dB of rejection - this should solve the image noise problem, and make the receive signal a lot better.



The waveguide filter described above has made about a 4 to 5 dB improvement in the received signal, presumably due to the removal of the image noise. The two images below show the down converter with added filter, and the improvement in received signal. The probe is further away today, at 4.17 million miles.

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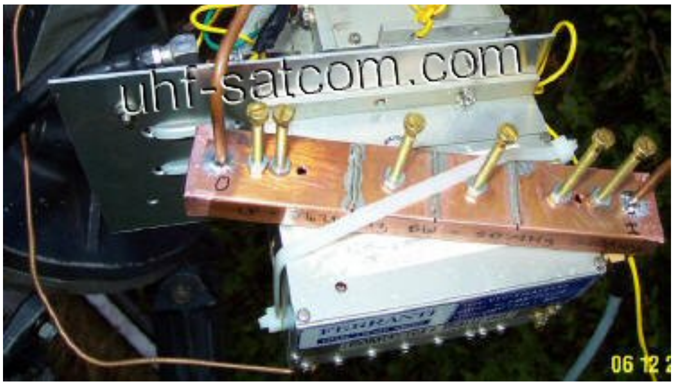
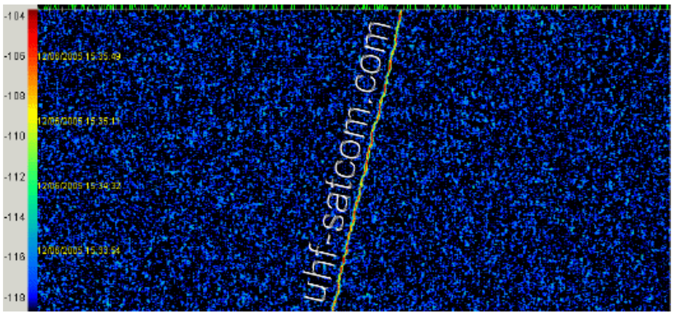
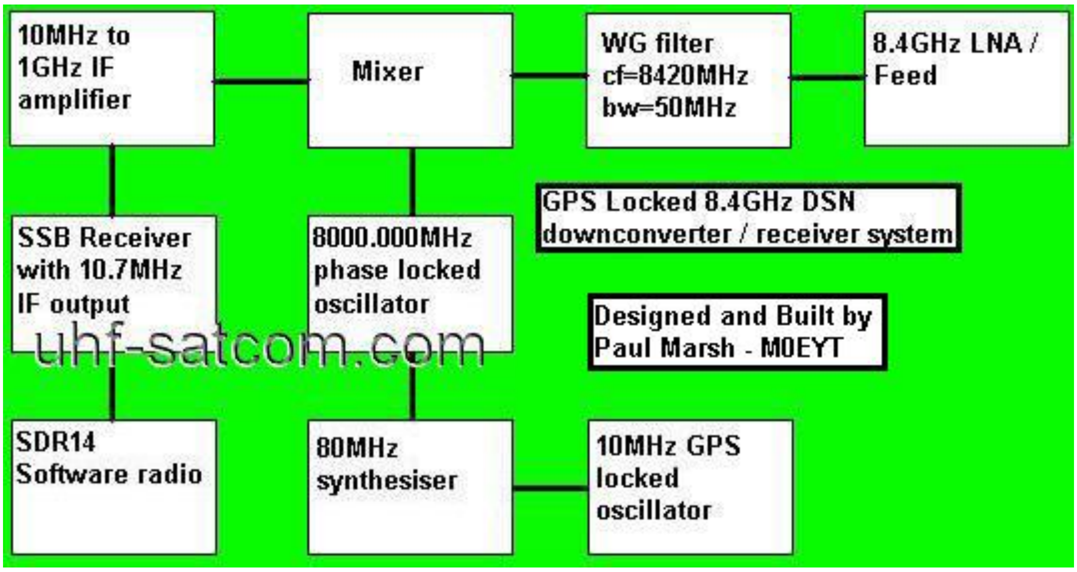



The picture below is the block diagram of the down-converter used to convert the 8.4GHz signal down to a suitable IF frequency, in this case the IF is around 400MHz.

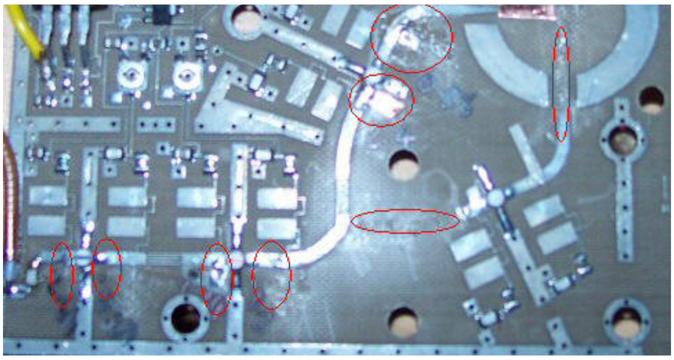


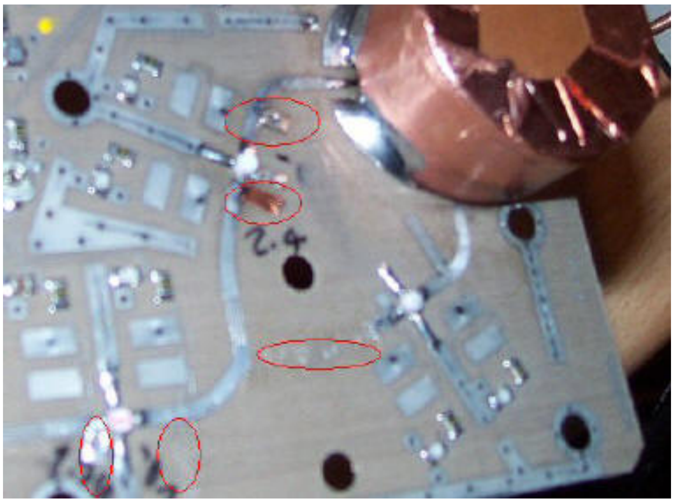

Signal received from Venus Express on the 21st December 2005 after adding the band pass filter:

0:00

**LNA modification details.**

The LNA is made by modifying a Marconi Ku band LNB. Basically the modifications involve chopping out the DRO, IF amplifier, 11GHz filter and the mixer assembly, removing the tuning tabs around each Gaasfet, and replacing the waveguide / antenna assembly with one more suitable for 8GHz. For the new waveguide, I used 28mm copper water pipe couplers soldered together. The LNA is tuned up on a weak signal by experimenting with the positioning of the tabbing around the active devices, whilst monitoring the output on a receiver or spectrum analyser. The red circles in the photos below indicate where a modification needs to take place, by adding tuning tabs or removing tracks. The output of the 3 stage LNA is coupled to coax using a suitable DC blocking SMD capacitor - in this case it was from the same board, located next to the mixer. The 1/4 wave probe also has to be lengthened due to the slightly lower frequency. The photos below show the modifications performed.





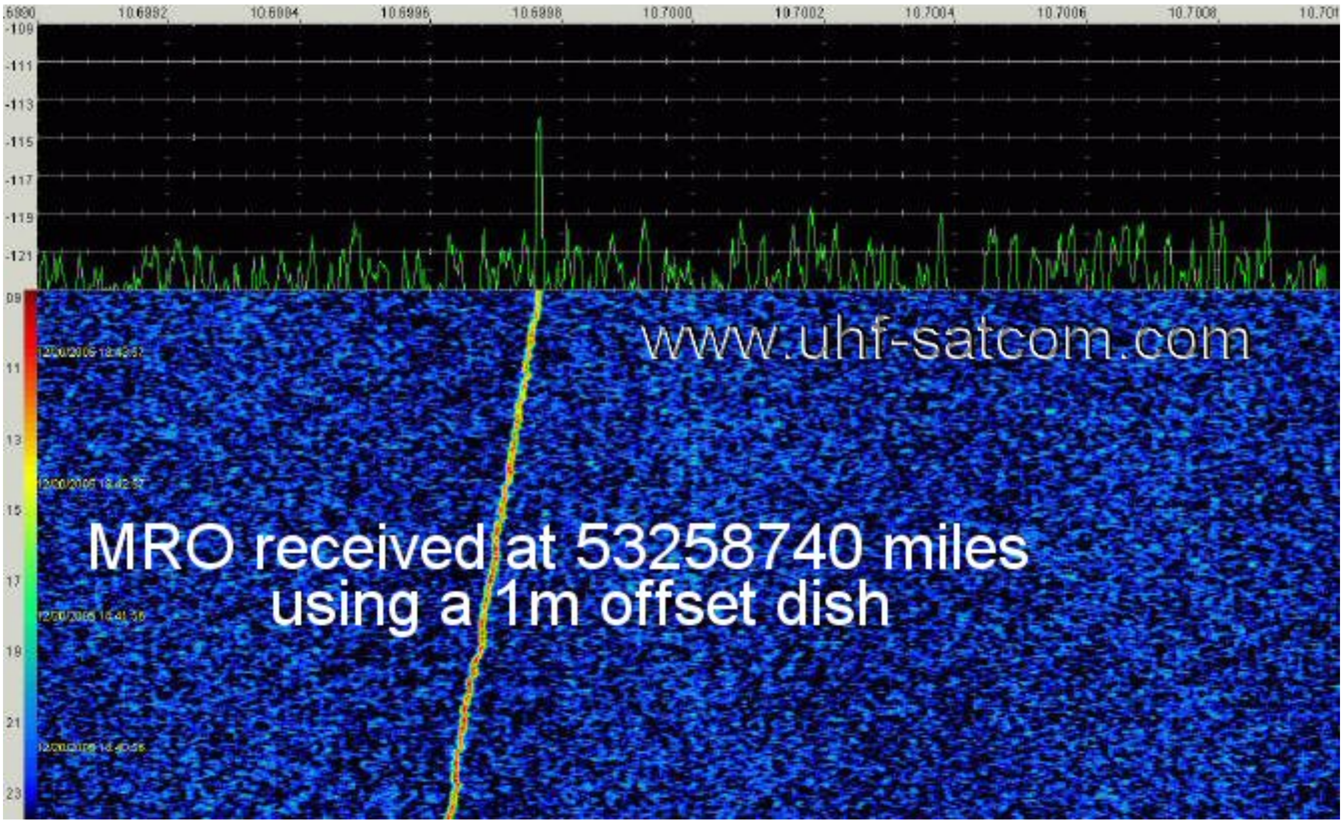
The photos below show some close-ups of the LHC feed horn with depolarising screws, and the feed horn mounted on the feed arm of the 1.05M dish.



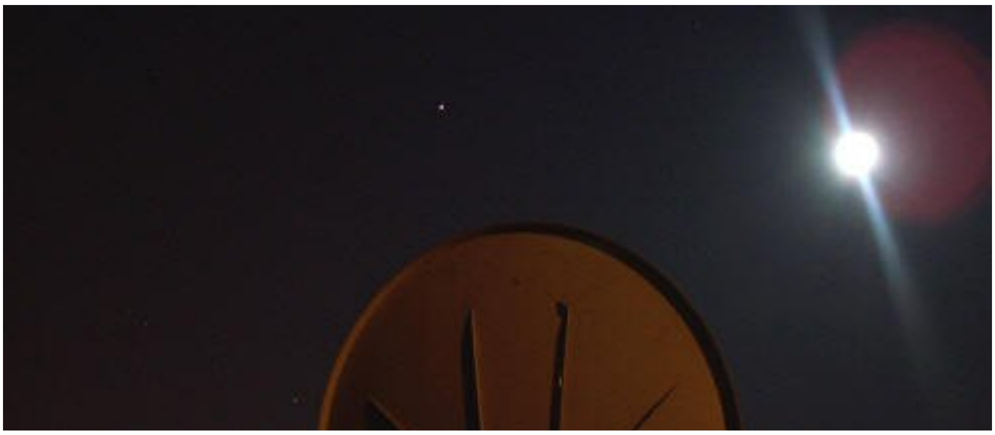



Following some further work on the LNA, a new feed was added that came from Bertrand Pinel's more than 3 or 4 dB higher than the above examples.

**First Signals from MRO!** The Mars Reconnaissance Orbiter (MRO) was launched on August the 12th, 2005 from the Kennedy Space Centre in Florida. At the time of the first signal reception, the one way light time was 4.045806 minutes, making the Orbiter 45,151,194 miles away from Earth. Once MRO reaches Mars, it will orbit the planet taking photos and performing other science experiments. MRO transmits on DSN channel 32 which is 8439.444444 MHz - by the time that reaches Earth, due to Doppler the frequency has dropped to around 8439.031 MHz. MRO has a 3 meter diameter dish antenna driven by a 100 Watt TWTA to transmit signals to Earth, this means that the signal coming in our direction is of the order of 4.2 mega watts of RF.




Using the same receive system as used for Venus Express, the Doppler was first calculated and the receiver was tuned - the dish was adjusted as per the az/el generated by the JPL Horizons software. The picture below shows the MRO receive setup, with Mars and the Moon being visible above the dish.



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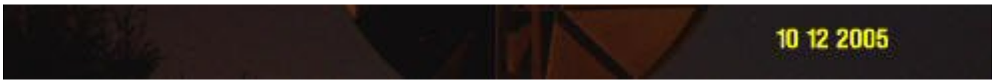
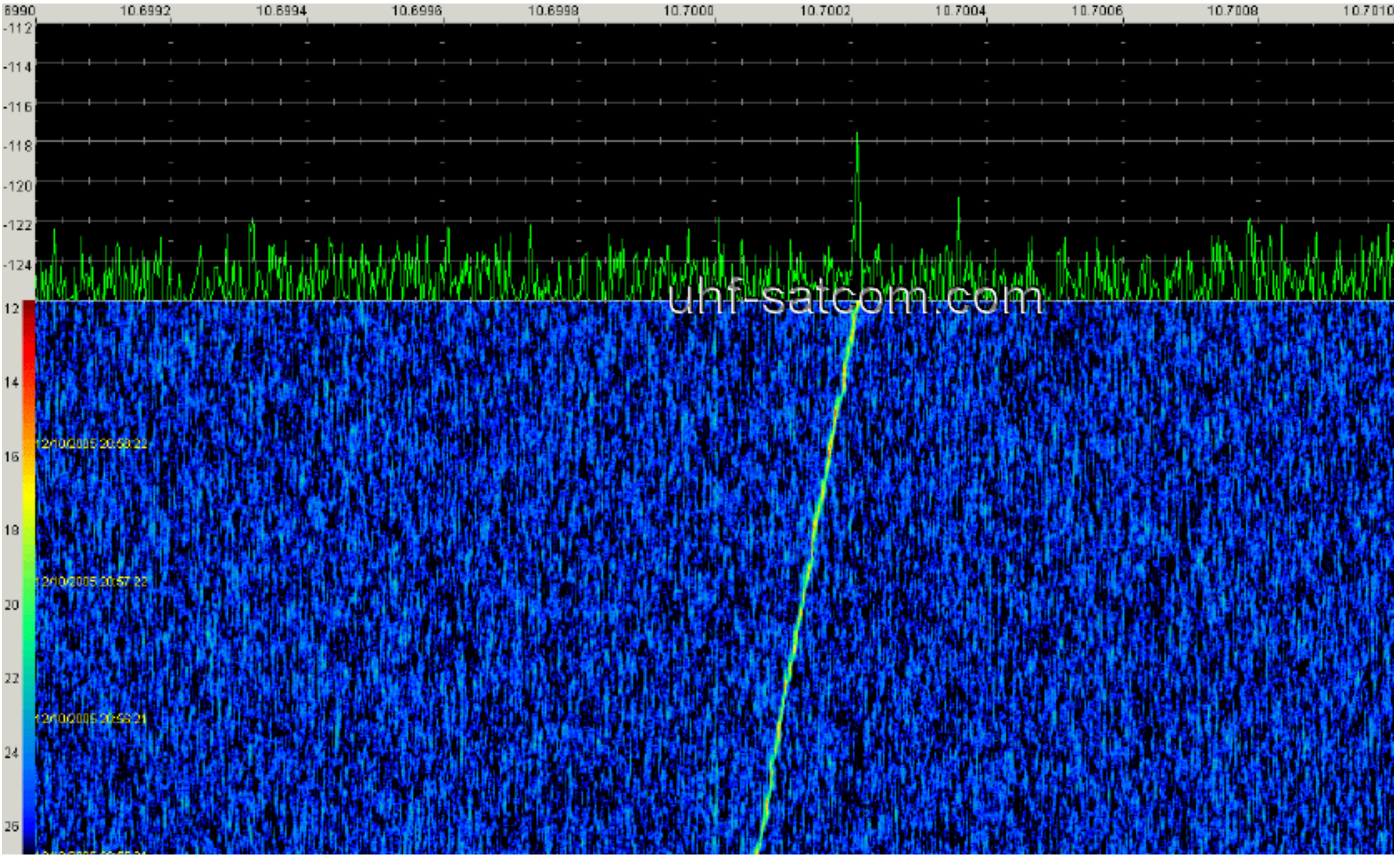


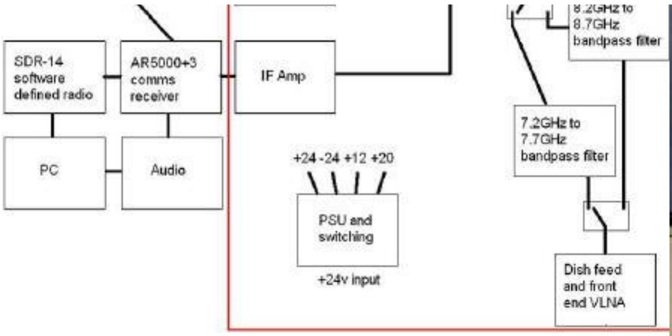

The signal was clearly visible in the FFT display of the SDR-14 software radio, and just audible in SSB bandwidth of a communications receiver. The signal was consistently about 6 to 8 dB above the noise floor. The FFT picture below was taken in a 2KHz bandwidth centred on 10.7MHz which is the IF of the receiver used. All oscillators are locked to GPS.




0:00 This is a rather large WAV file of the signal (1.6Mb); it is best to download the file, then process it in your favourite FFT software in order to see the carrier, as it is weak and may not be audible to the untrained ear. For processing the WAV file, it is worth checking out WaveVue, Spectran and Spectrum Lab.

A block diagram and photo of the integrated X-Band converter is shown below. All items within the red box on the block diagram are located in the outdoor unit.

A test was made on X-Band DSN with the FRARS 3.7M antenna on the 26th February 2006.






**Links**

#Hearsat IRC chat details

Amateur DSN group.io

UHF-satcom group.io

Hearsat mail list

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with the help of a lot of caffeine