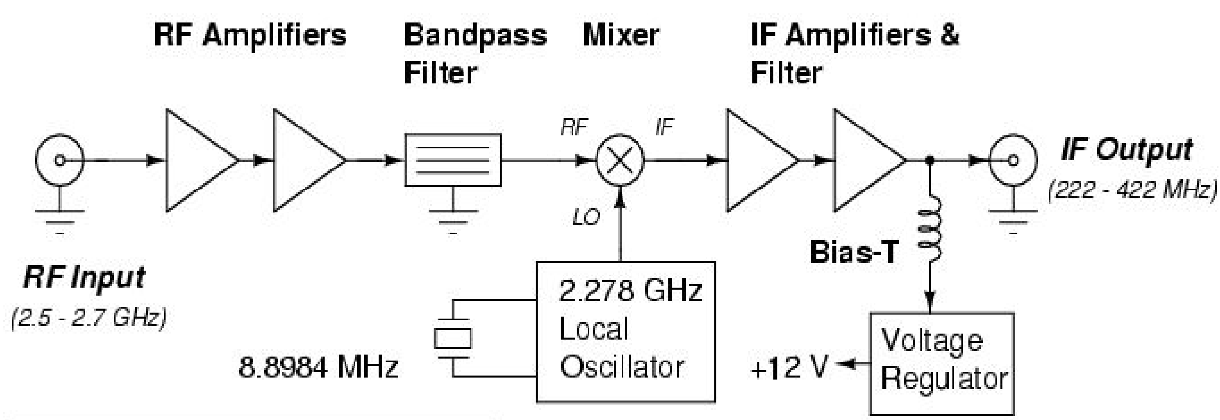
Converter for Monitoring 2.4 GHz Cordless Phones

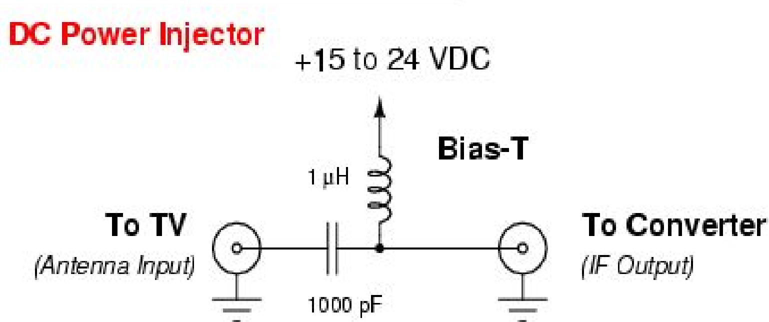
It is possible to receive conventional, Frequency Modulated (FM) 2.4 GHz cordless phones (the cheap kind) using a regular communications receiver (scanner) by *downconverting* their 2.4 GHz transmit frequencies to much lower ones.

This receiver converter is based around a surplus California Amplifier Multipoint Microwave Distribution Service (2.5 – 2.7 GHz) downconverter. These are the systems which are used to provide cable TV service to rural areas when running coaxial cable is not practical. The downconverter will remain mostly intact, with its current Local Oscillator (LO) of 2.278 GHz staying the same, but the Band Pass Filter (BPF) and mixer stages will be modified. It should be noted that the stock MMDS downconverter *will* receive the 2.402 – 2.483 GHz Part 15 band, but with about 20 dB of additional attenuation. These modifications will help improve that.

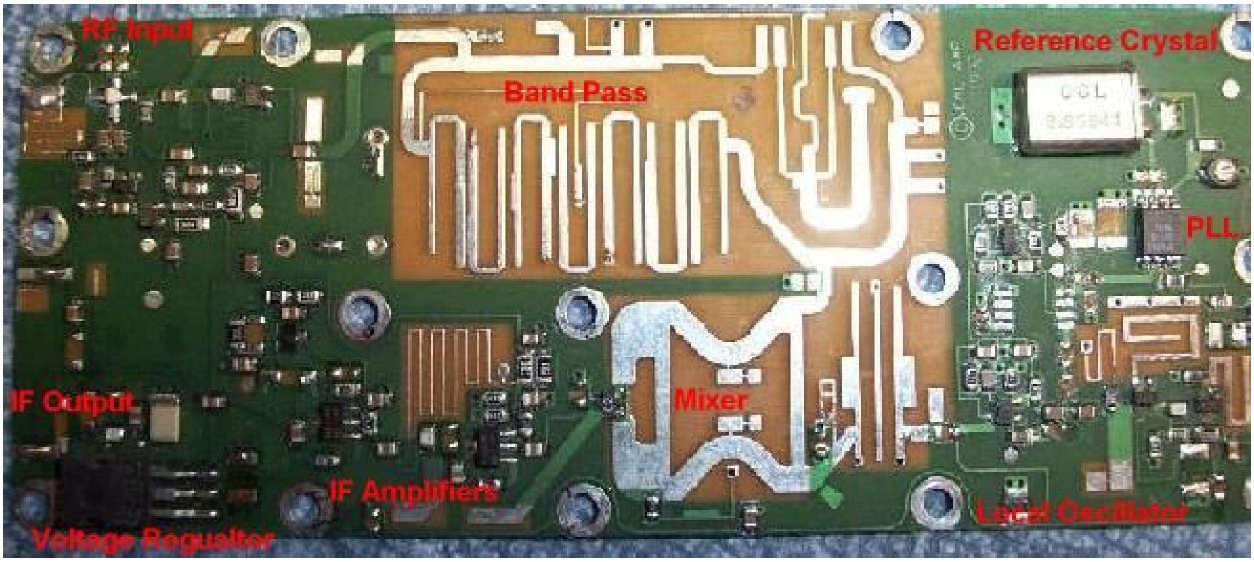
What this conversion does is to allow incoming RF signals (2.402 – 2.483 GHz, in this case) to be mixed with a LO frequency of 2.278 GHz and converted down to a much lower VHF frequency. *Example:* a 2.45 GHz signal will be output as a 172 MHz signal (`2.45 GHz - 2.278 GHz = 172 MHz`). This allows us to quickly scan the 2.4 GHz Part 15/ISM band using a conventional communications receiver to step through 124 – 205 MHz (wide or narrow FM). It is possible to receive 2.4 GHz cordless phones, 2.4 GHz baby monitors, WaveLAN transmitter audio, and even 2.4 GHz amateur radio transmissions using this setup.

<u>Original California Amplifier MMDS Downconverter Block Diagram</u>



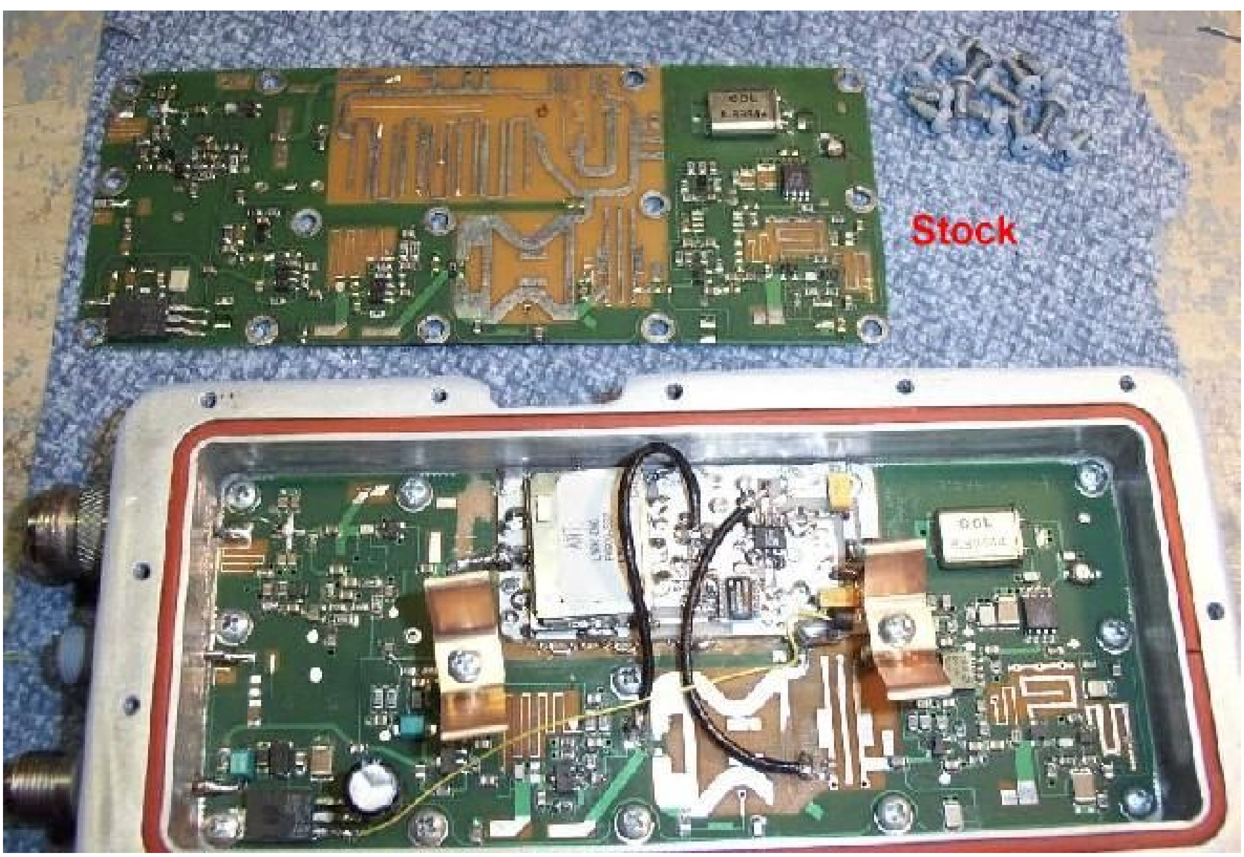


Original California Amplifier MMDS Downconverter PC Board



The original, stock MMDS downcoverter was used to receive cable TV signals that where broadcast in the 2.5 – 2.7 GHz band. These converters, when connected to a high–gain parabolic dish antenna, converted the 2.5 – 2.7 GHz MMDS signals down to VHF TV frequencies (222 – 422 MHz). You would then "tune" your TV to these standard TV channels (cable channels 24 – 57) and could view the TV signal which was transmitted in those microwave bands.

Comparison Picture – Stock & Modified Downconverters



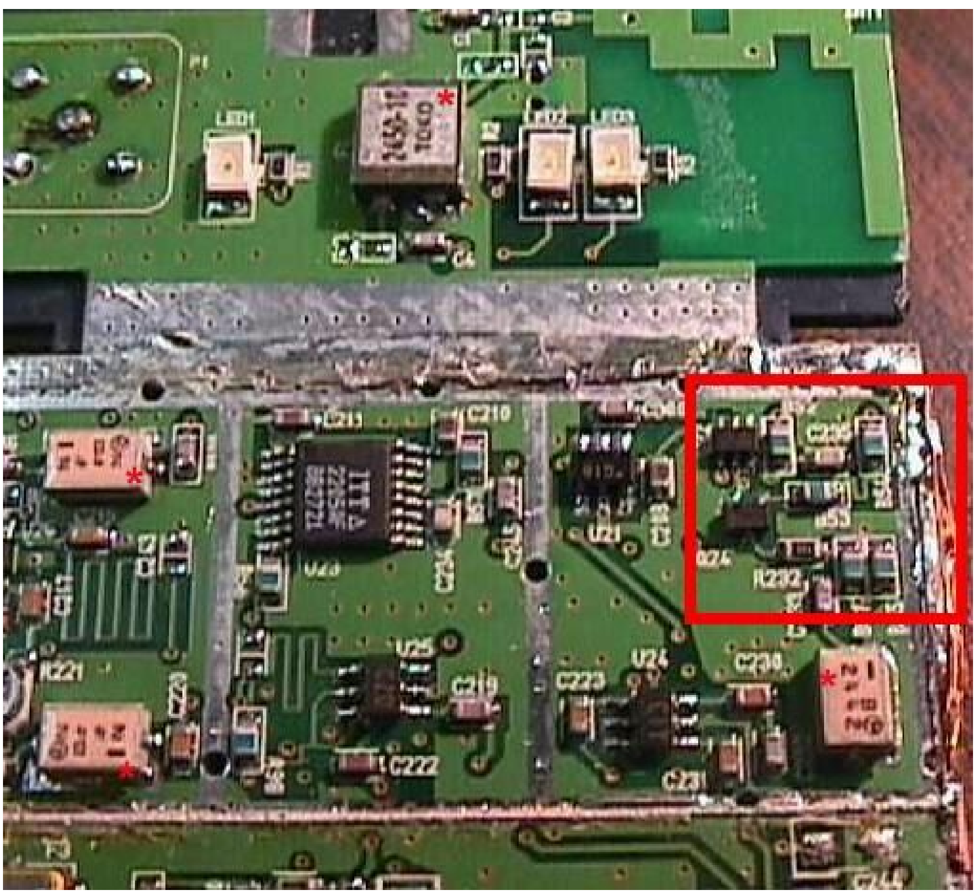
This modification will replace the converter's 2.5 – 2.7 GHz microstrip line BPF with a Toko 4DFA–2450T–10, 2–pole, 2.45 GHz BPF (Digi–Key Part No. TKS2610CT–ND, $24.06). The mixer stage is replaced with a Mini–Circuits MBL–25MH mixer. The 2.278 GHz LO signal will also be increased to +17 dBm for improved third–order intercept and signal linearity.

You'll note that the BPF shown in the above picture is *not* the Toko model in the schematic. It's actually a 2.45 GHz duplex filter from an old Metricom Ricochet radio. The Toko model will have the same performance and is alot easier to purchase. Another difference between the schematic and the picture is that I originally used the converter's stock Intermediate Frequency (IF) amplifier to "boost" the mixer's IF output. Though the results varied, I found the extra gain actually *decreased* the converter's performace. This is because the receiver connected to the IF output (a Radio Shack PRO–2042, AOR AR8000, and Standard CCR708 where tested in this case) contains the needed amplifiers and filtering. There is no need for additional IF amplification, unless you're using an old, deaf receiver for the IF rig.

The area where the microstrip line BPF was is isolated (using a Dremel tool) and the new PC board containing the BPF and mixer was added. The LO signal is tapped *after* the downconverter's microstrip line BPF and sent, via a small coax (RG–196) connection, to the VNA–25's RF input through a 6 dB resistive attenutation pad. The stock 2.278 GHz LO signal is increased to +17 dBm and applied directly to the mixer.

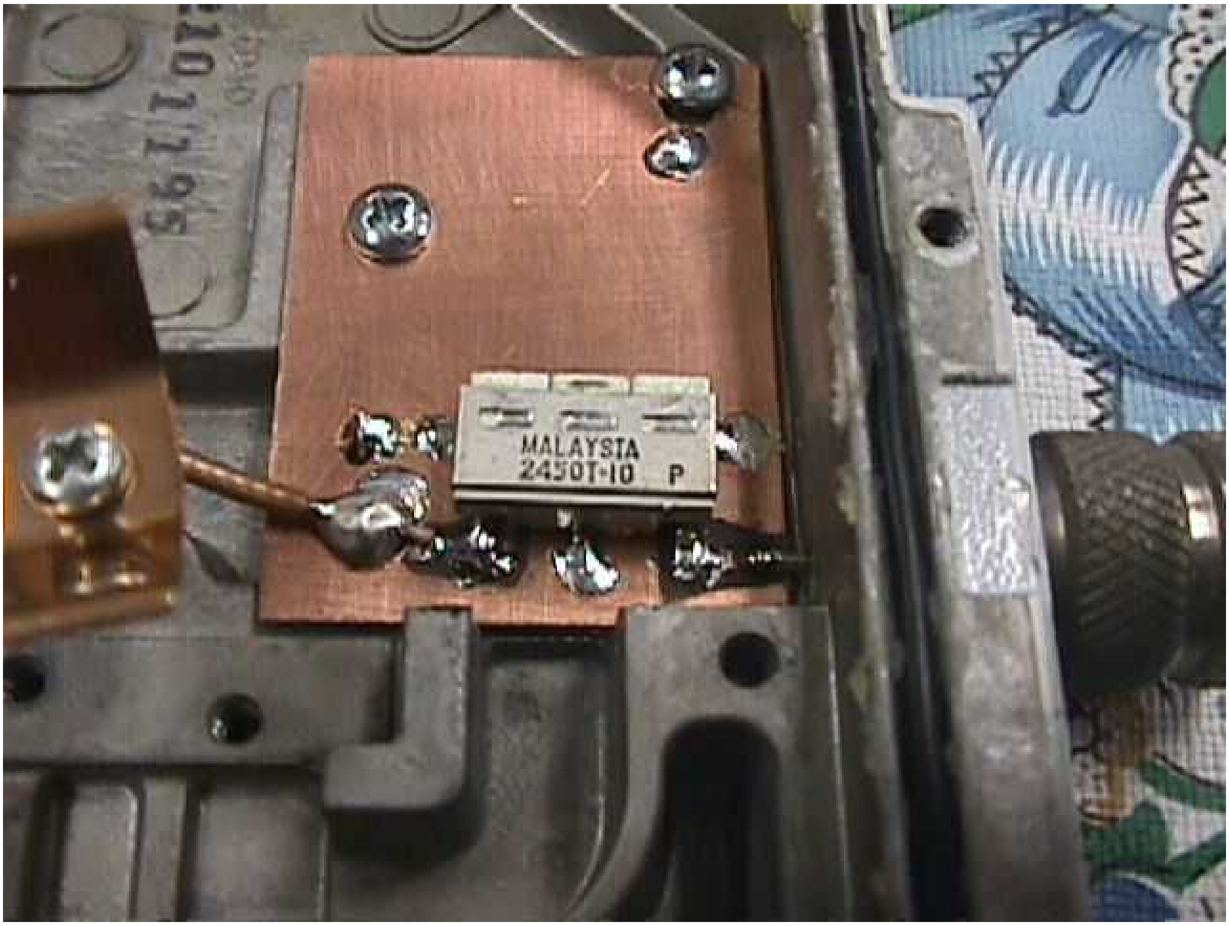
On the 2.4 – 2.5 GHz RF input side, the signal is tapped after the second RF amplifier and is connected via a *very* short coax cable to the BPF's RF input. In a pinch, 2.45 GHz band pass filters can be salvaged from old 802.11b wireless LAN hardware.

The PC board shown in the pictures also has a small 78L05 voltage regulator on it. Here is the downconverter's +12 VDC voltage regular output tap (yellow wire) to feed the 78L05's input.

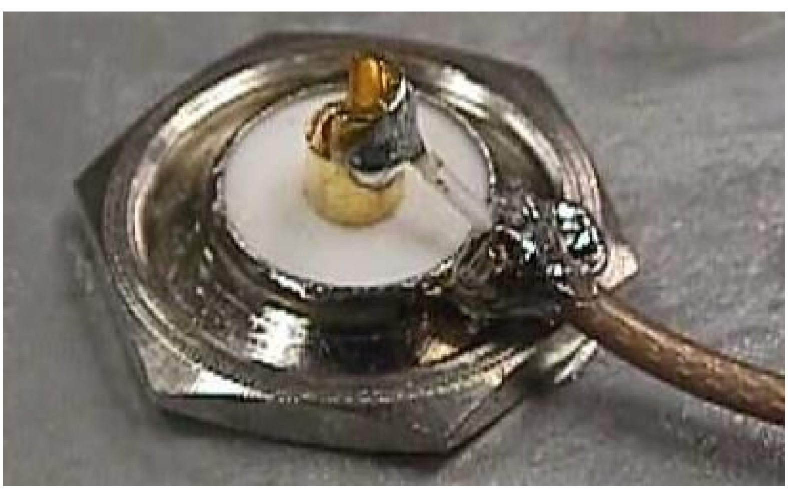


Picture of a dead 802.11b wireless LAN card. There are *four* (marked with little red stars) useable Murata 2.45 GHz band pass filters on this particular card. To remove them, heat the underside of the PC board quickly with a hot air gun and then pick them up with a tweezers. The area in the red square is an Agilent MGA–86563 receive pre–amplifier. This can be used as an (optional) stand–alone, external receive pre–amplifier.

Overview of an (optional) external 2.45 GHz band pass filter which can be placed ahead of the downconverter to reduce out−of−band interference and intermodulation products. The case is from another California Amplifier downcoverter.

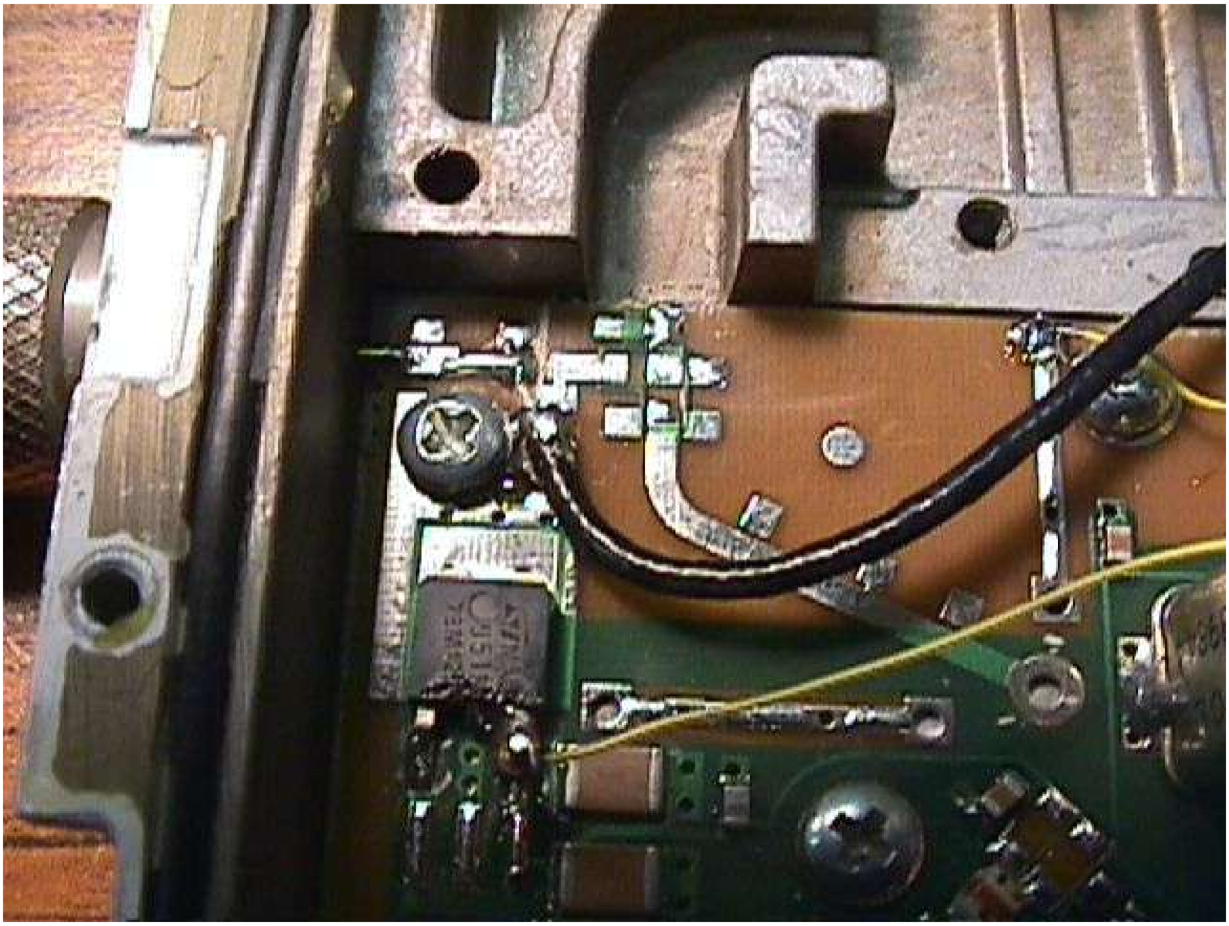


Band pass filter's internal view. RF input (antenna input) is on the right, RF output (to downconverer) is on the left. The filter shown is a Toko 4DFB−2450T−10, 3−pole, 2.45 GHz BPF (Digi−Key Part No. TKS2618CT−ND, $40.19).

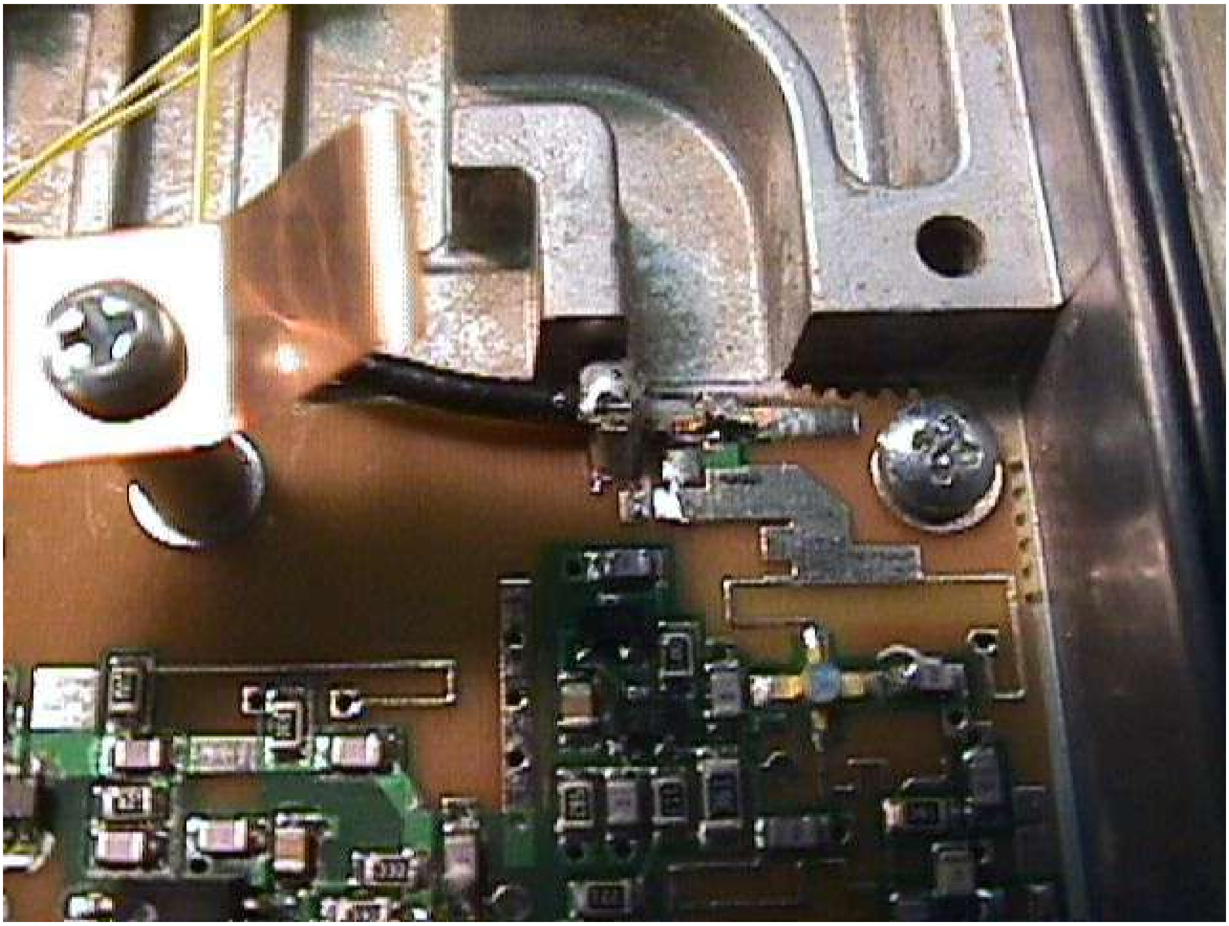


Filter's RF output N−connector. Yes, this is *incorrect* construction at those high microwave frequencies, but I didn't have a choice.

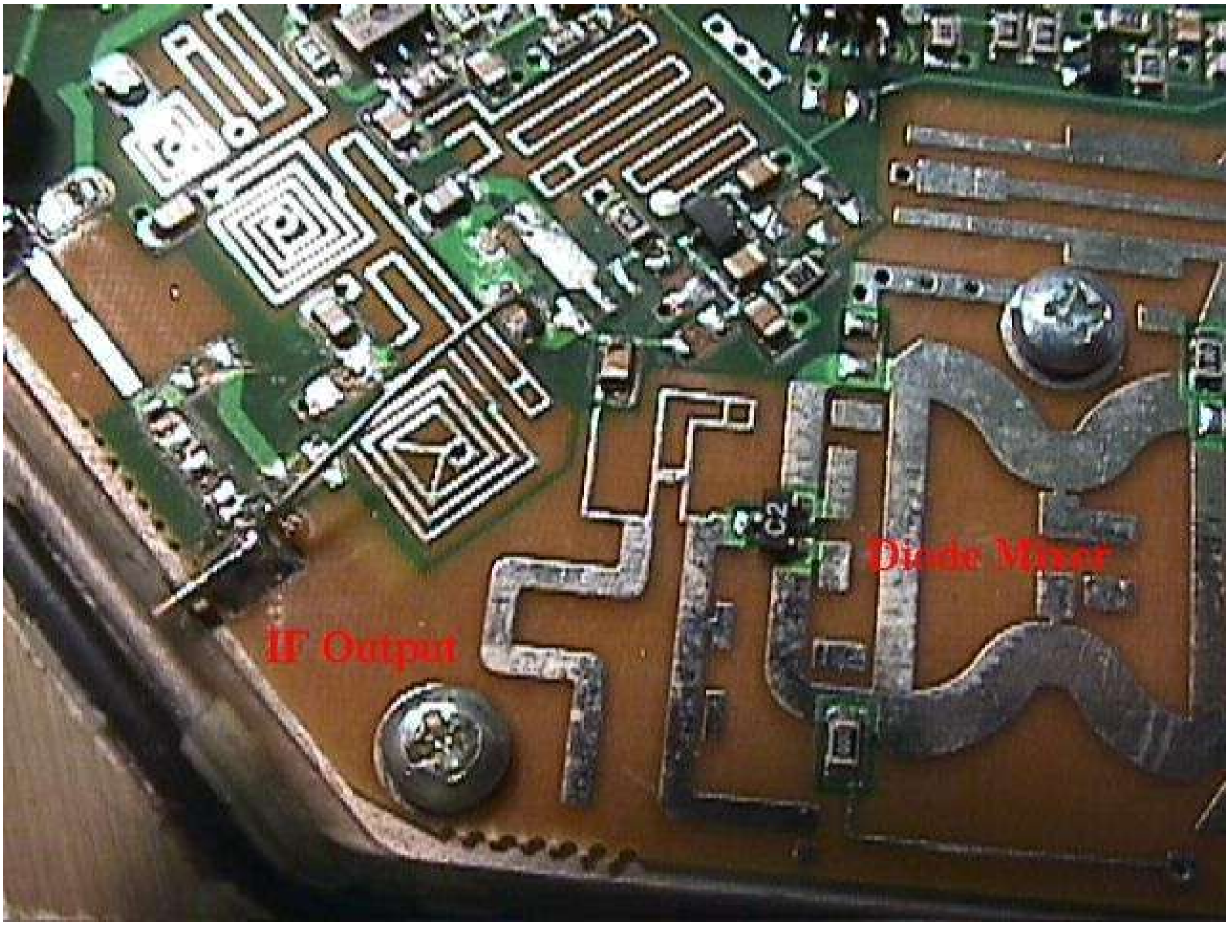
Here is a modified high−gain California Amplifier MMDS downconverter connected to an AOR−8000 receiver. The sharp, 2.5 – 2.7 GHz BPF on the converter's RF input was removed and at the IF output the amplifiers and filtering were bypassed.



Converter's RF input (2.402 – 2.483 GHz). The original MMDS−band filter was removed and a coax jumper is needed to "jump over" to the pre−amplifier section. Ignore the yellow wires.

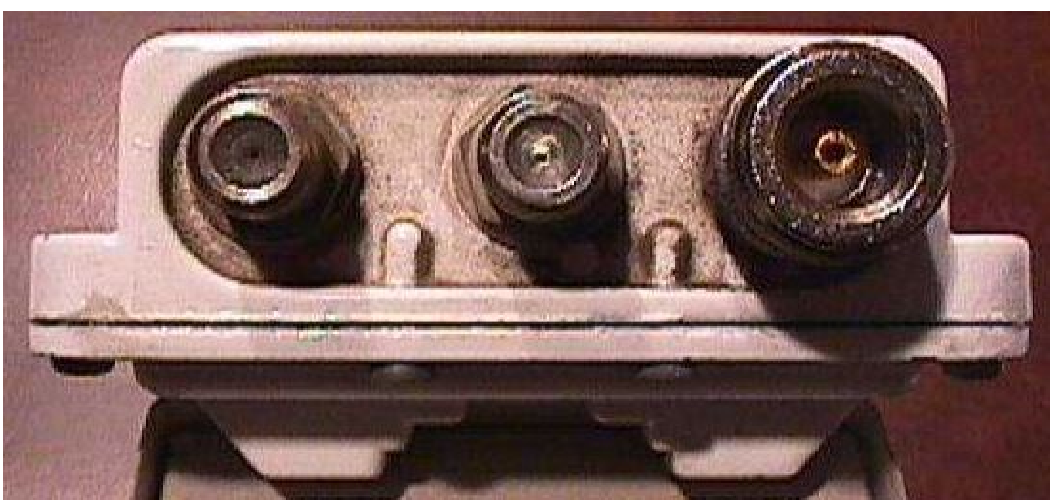


Coaxial input to the receive pre−amplifier.

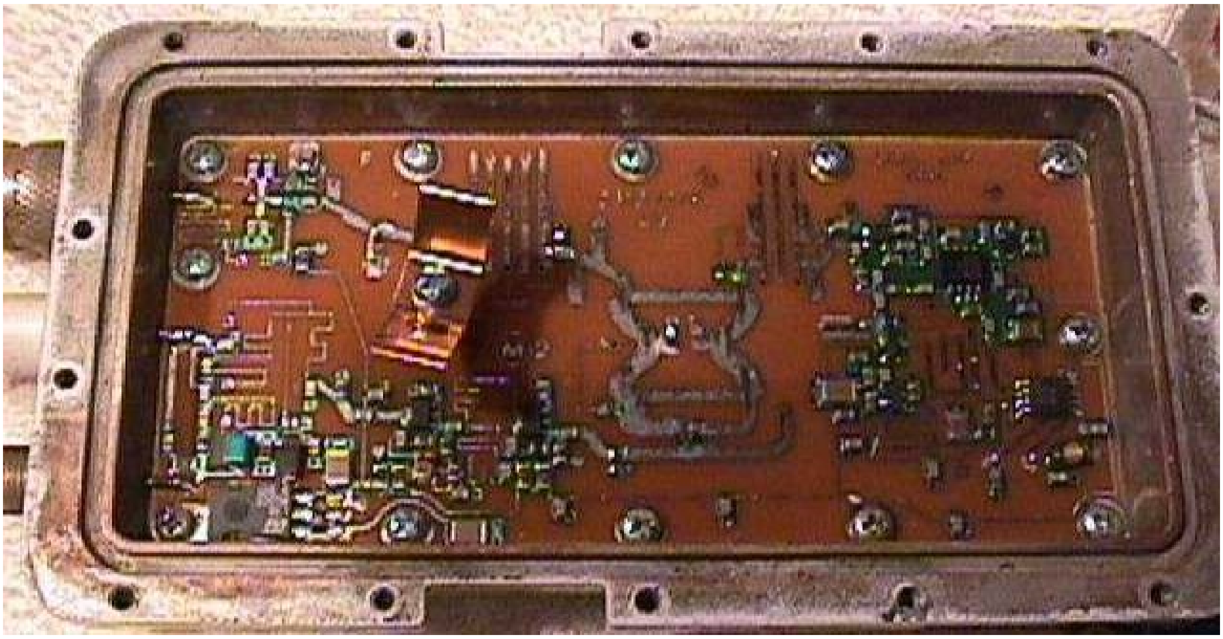


IF output (to the AOR−8000 receiver). The IF output is tapped after the diode mixer/DC blocking capacitor via a short wire loop and is sent straight to a F−connector. In this particular downconverter, I left the original, small 2.5 – 2.7 GHz microstrip line BPF filter (located above the screw on the right) and diode mixer sections intact. Performance was still very good.

Case label on a dumpster–dived CalAmp MMDS downconverter.



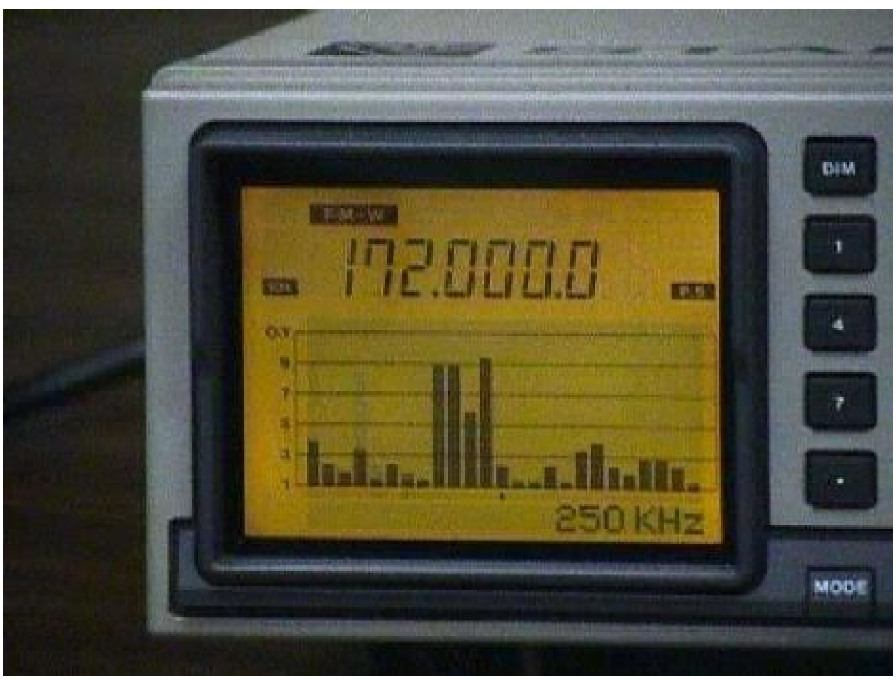
Downconveter's RF connectors. RF input (2.5 – 2.7 GHz) on the right, IF test (–20 dB) in the middle, and IF output/DC input (222 – 408 MHz) on the left. To clean them, use a good spurt of electronics cleaner and a Q–tip.



Internal view. This particular model is physically smaller than other models and the BPF doesn't have a sharp as roll−off either. This makes it ideal for receiving the 2.4 GHz band without the need for any internal modifications.

Here is an experiment using a CalAmp Yagi antenna with an integrated MMDS downcoverter to receive microwave oven radiation leakage (2.45 GHz). The IF receiver is a Standard CCR708 tuned to 172 MHz (in wideband FM mode) with the spectrum sweep 250 kHz wide.

Noise floor shown at 172 MHz while connected to the powered MMDS downconverter.



Microwave oven leakage is observed! The 2.45 GHz oven RF radiation is mixed with the downconverter's internal 2.278 GHz LO signal and then converted to 172 MHz. Microwave ovens tend to drift slightly in frequency, as the spectrum display shows.

2.4 GHz Cordless Phone Receive Converter