Modern & New Spectrum Analyzers for the Mk-5/VLBI2010 World

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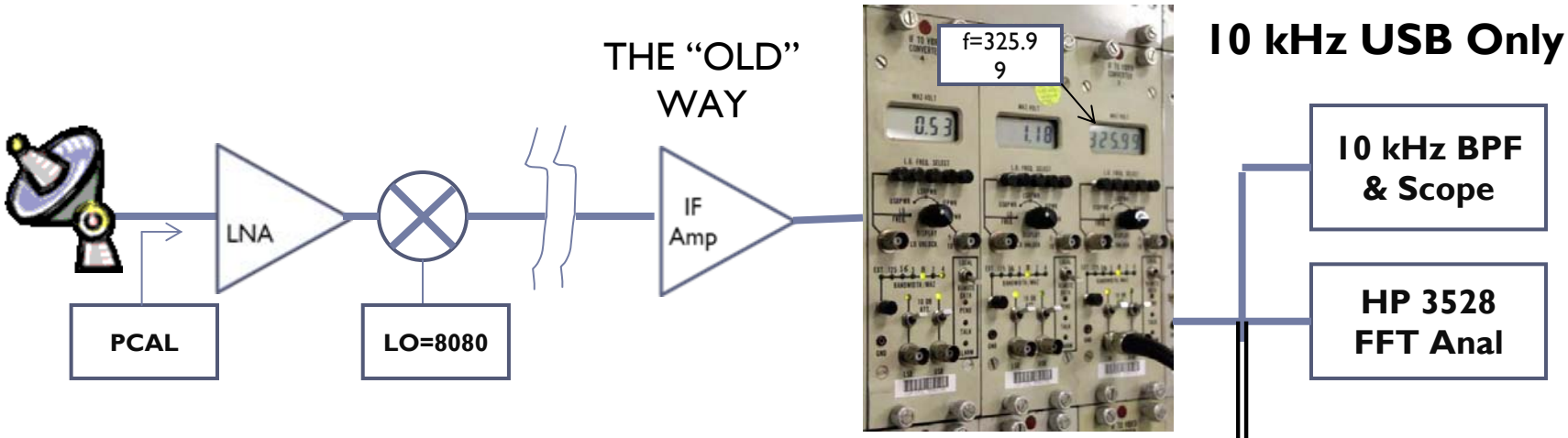
Thanks to Brian Corey & Rick Hambly for helping in my absence.

In VLBI, Spectrum Analyzers are used to:

- Detect & Identify external sources of RFI
  - Commercial Microwave RF Analyzers (1-20 GHz)
    - often cost $5000 - $30,000
- Detect & Identify local sources of RFI
  - Most often at IF frequencies (DC-3 GHz)
  - Well matched to a new generation of SDRs (Software Defined Radios) being developed by the Intelligence Community and by Radio Amateurs
    - A major part of the SDR is implemented for cheap PCs
    - Several low cost ($500 - $2000) hardware platforms are available
    - Much Software comes from the Open Source, Public Domain world

This contribution will report on some of the low cost SDR options that are now available.

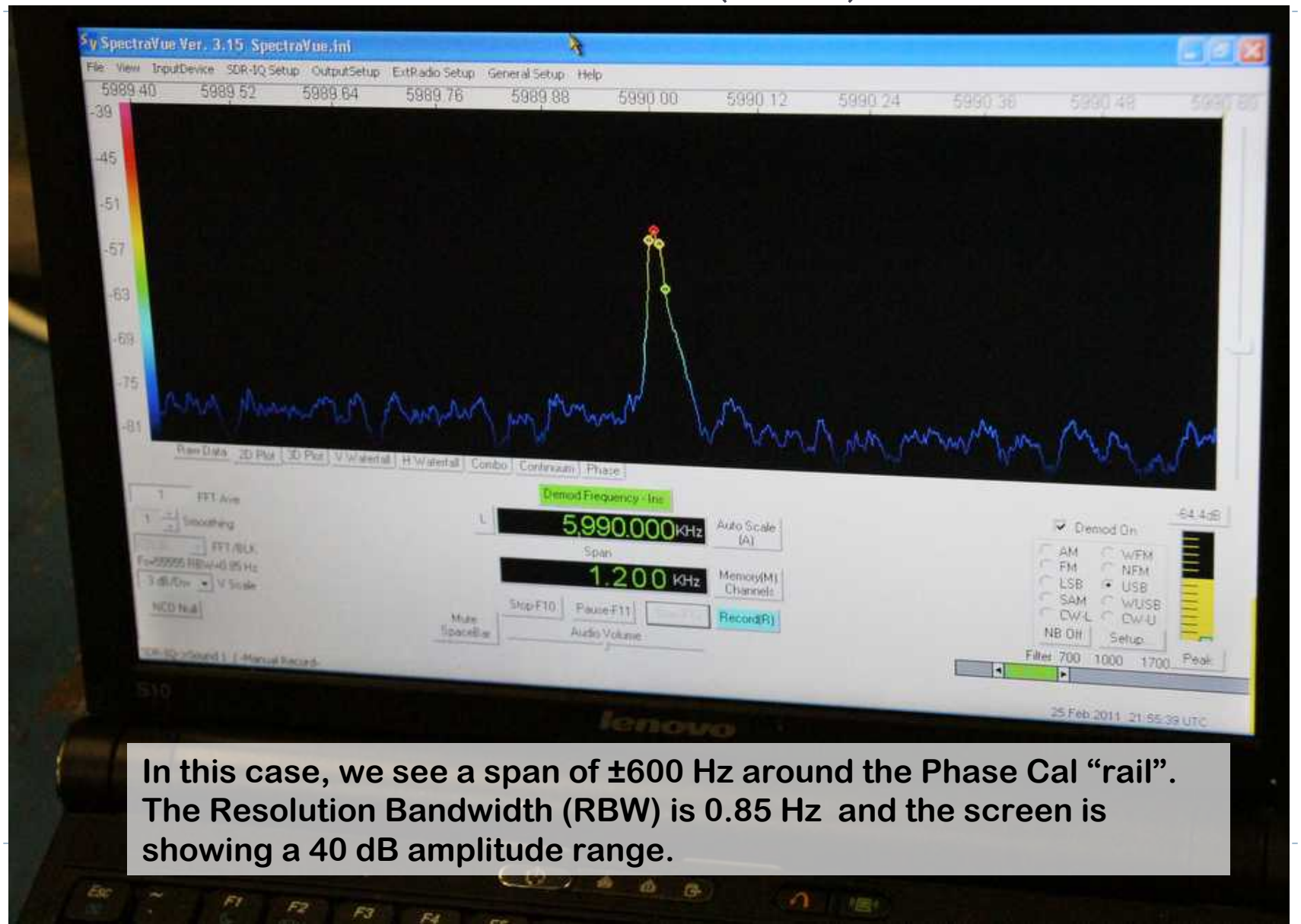
In the Mark-3 world we monitor Phase Cal Signals in the final baseband ("video") IF



THE "NEW" WAY with $500 SDR and a small Netbook PC

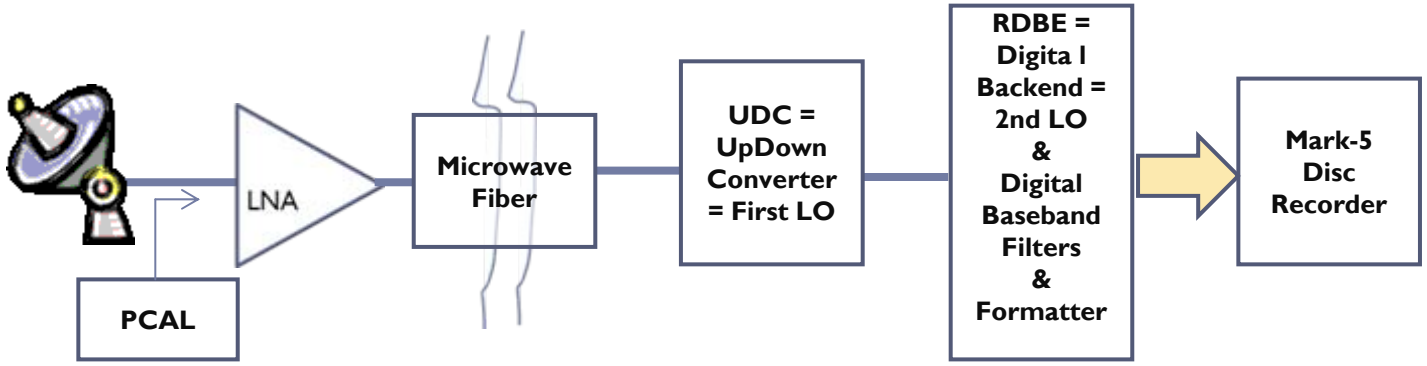
10, 1010,2010…. kHz USB
or
990,1990, 2990….kHz LSB
with
50+ dB Dynamic Range

In this case, we look at the Phase Cal signal at 8080 + 325.99 – 5.990(LSB) = 8400.000

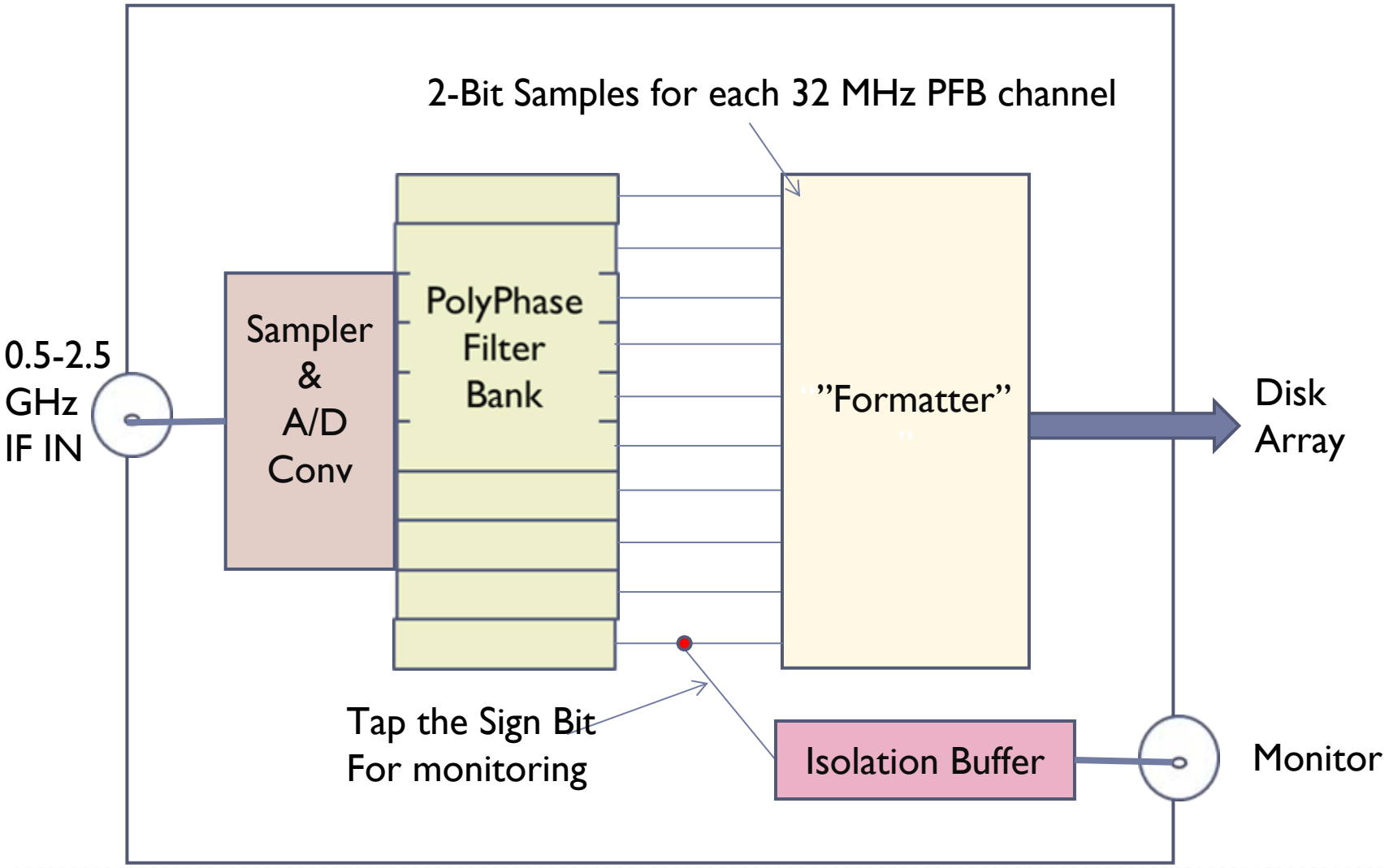


In this case, we see a span of ±600 Hz around the Phase Cal "rail". The Resolution Bandwidth (RBW) is 0.85 Hz and the screen is showing a 40 dB amplitude range.

In the new Mark-5 Digital Backend, the analog Video Converter function becomes Digital. The equivalent of the VC's USB/LSB BNC jacks exist only inside a Xilinx FPGA.



Real Soon Now, the RDBE Firmware will provide a digital monitor output:



Will we be able to monitor using just the Sign Bit ?

The answer is yes!

- For a "weak" signal, the S/N is degraded by a factor of $\pi/2 = 1.57 \approx 2\text{dB}$.
  - This is known as the van Vleck correction
  - The use of one-bit sampled data has been very common in Radio Astronomy

- For a strong signal, any amplitude modulation on the signal will be very distorted. An FM signal will sound perfectly normal (FM radios normally limit the signal).

Some Commercial SDRs

RF Space (http://www.rfspace.com) in Atlanta GA makes several SDR's:

- The $500 SDR-IQ (used in the previous example) covers the DC-30 MHz range with up to 192 kHz bandwidth. Interface is USB. This is competent small, cheap SDR that is a very useful piece of test equipment
- The new $3700 SDR-IP looks like a perfect VLBI Phase Cal monitor. It's internal clocks can be locked to the Maser for fully coherent system monitoring. It interfaces via Ethernet and TCP/IP packet covering up to 2 MHz bandwidth in the 0-34 MHz frequency range. I hope to be able to try one soon.

Some (sort of) Commercial SDRs

The Funcube Dongle (http://www.funcubedongle.com) was developed by AMSAT-UK members to support their educational Funcube cubesat. The FCD is very interesting in that it covers the 65-1700 MHz frequency range with spans ~80 kHz wide. It is self-contained in a USB plug and costs < $200. The FCD has (so far) been available in only limited quantities, but the ~800 users around the world have managed to make it usable on Windows, Linux and Mac compiuter

Some Commercial SDRs

The $700 “Quicksilver” QS1R (http://qs1r.wikispaces.com or http://www.srl-llc.com/ or http://groups.yahoo.com/group/qs1r/) by Software Radio Laboratory in Columbus OH shows much promise. It covers DC-62 MHz (or up to ~500 MHz when oversampled) with up to 2 MHz bandwidth. The QS1R interfaces to its PC by USB. The entire design and all its support software is “open” licensed.

Some Commercial SDRs

The Italian Pegasus SDR is available for $1000 in the US (http://www.universal-radio.com/catalog/commrxvr/0122.html) is quite similar to the QS1R but only covers 40 MHz.

Some Commercial SDRs

Flex Radio (http://www.flex-radio.com/) instrumental in introducing amateur radio to the SDR world. Most of Flex's efforts have been targeted towards full (receive + transmit) radios. Shown is their low-end Flex-1500, a $650 DC to 54 MHz SDR that can be locked to a phase-stable external frequency standard. Flex also makes a SDR system (http://www.flex-radio.com/Products.aspx?topic=CDRX-3200) for the surveillance community that might be adapted to VLBI's needs.

Non-commercial SDR that may be relevant

GNU Radio (http://gnuradio.org/redmine/wiki/gnuradio) represents a major collaborative effort from a number of sources.

All the GNU software is supported on the USRP hardware available from Matt Ettus (http://www.ettus.com/). FYI – Ettus was recently acquired by National Instruments and I anticipate NI will be making a splash in the SDR world soon.

Non-commercial SDR that may be relevant

HPSDR – the High Performance SDR is an all-amateur, open- source effort (http://openhpsdr.org/, http://tapr.org and http://iquadlabs.com/) that has produced some **very** impressive hardware.

Rick Hambly (W2GPS) has been very active in HPSDR and can answer questions.

HPSDR Rx FPGA Implementation