DF Antenna Subsystem
Rev F

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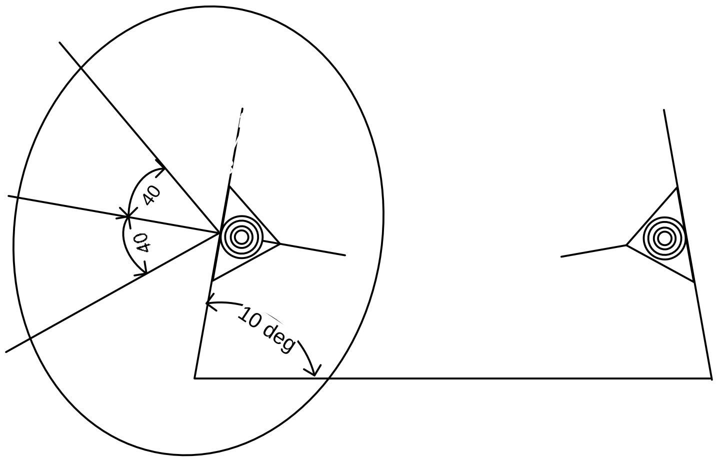
Brief Overview of DF Antenna Assembly

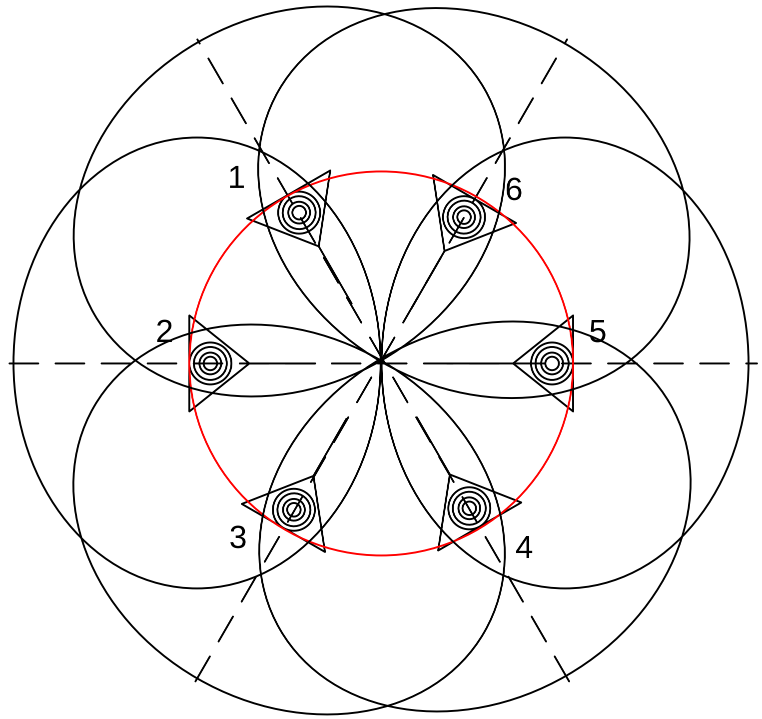
- **What we were asked to do:**
  - **R. A. Wood Associates was asked to design, build, test, and deliver a Direction Finding (DF) Antenna Assembly for one of our customers**
  - **The Assembly would be used in front of Commercial Off-The-Shelf (COTS) receiver boards**
  - **The Assembly needed to provide the RF front end to support:**
    - » **Angle of Arrival (AOA) determination for emitters in the environment**
    - » **Low noise figure for optimum system sensitivity**
    - » **High dynamic range to support high density emitter environments**
  - **The DF Antenna Assembly needed to provide calibration and Built-in-test (BIT) RF paths to calibrate the RF front end and the COTS receivers**
  - **The design needed to be very flexible to work with many different possible DF architectures**
    - » **One channel Amplitude DF (with sequential switching)**
    - » **Two channel Amplitude DF (with sequential switching of adjacent pairs)**
    - » **Two channel interferometer Phase DF (with sequential switching of adjacent pairs)**
  - **An internal digital compass was needed to provide the DF Antenna Assembly pointing reference**
  - **Delivery was needed in 6 months of contract award**

DF Subsystem Angular Coverage

- **Angular coverage: 360 degrees azimuth, -30 to +50 degrees elevation**

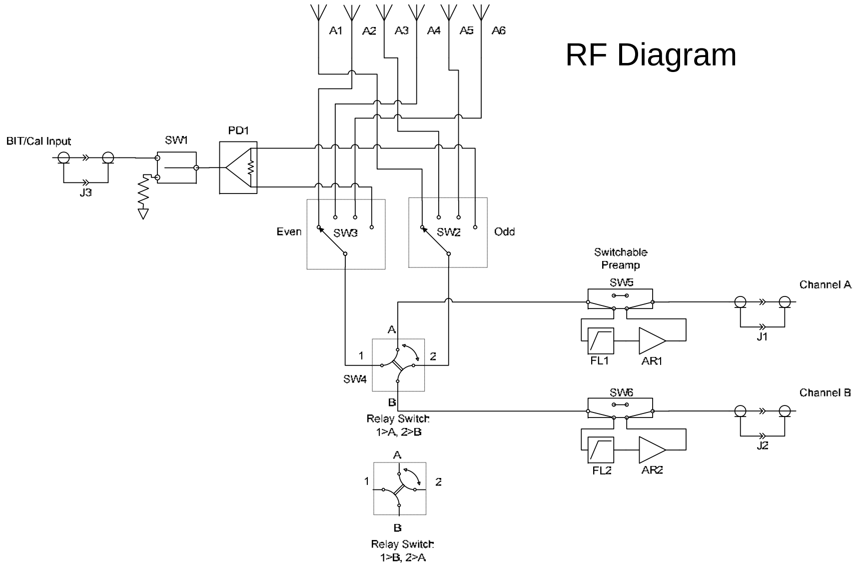


Proposed Elevation Orientation
Typical 3 dB BW ~80 degrees (+/-40)

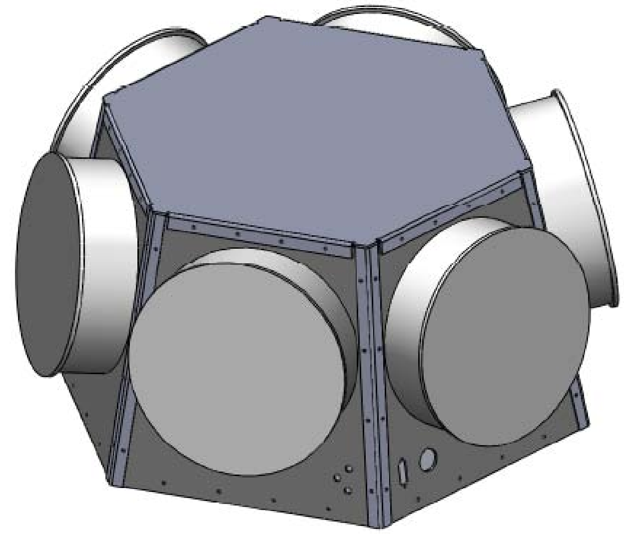


360 degrees coverage, two antennas at a time

DF Antenna Assembly Design Features



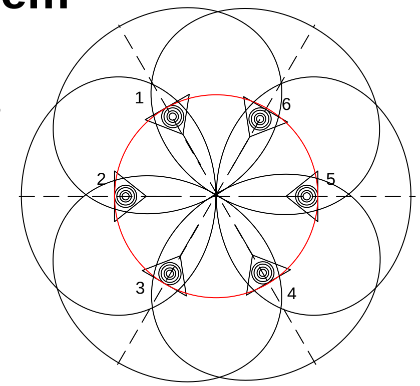
RF Diagram



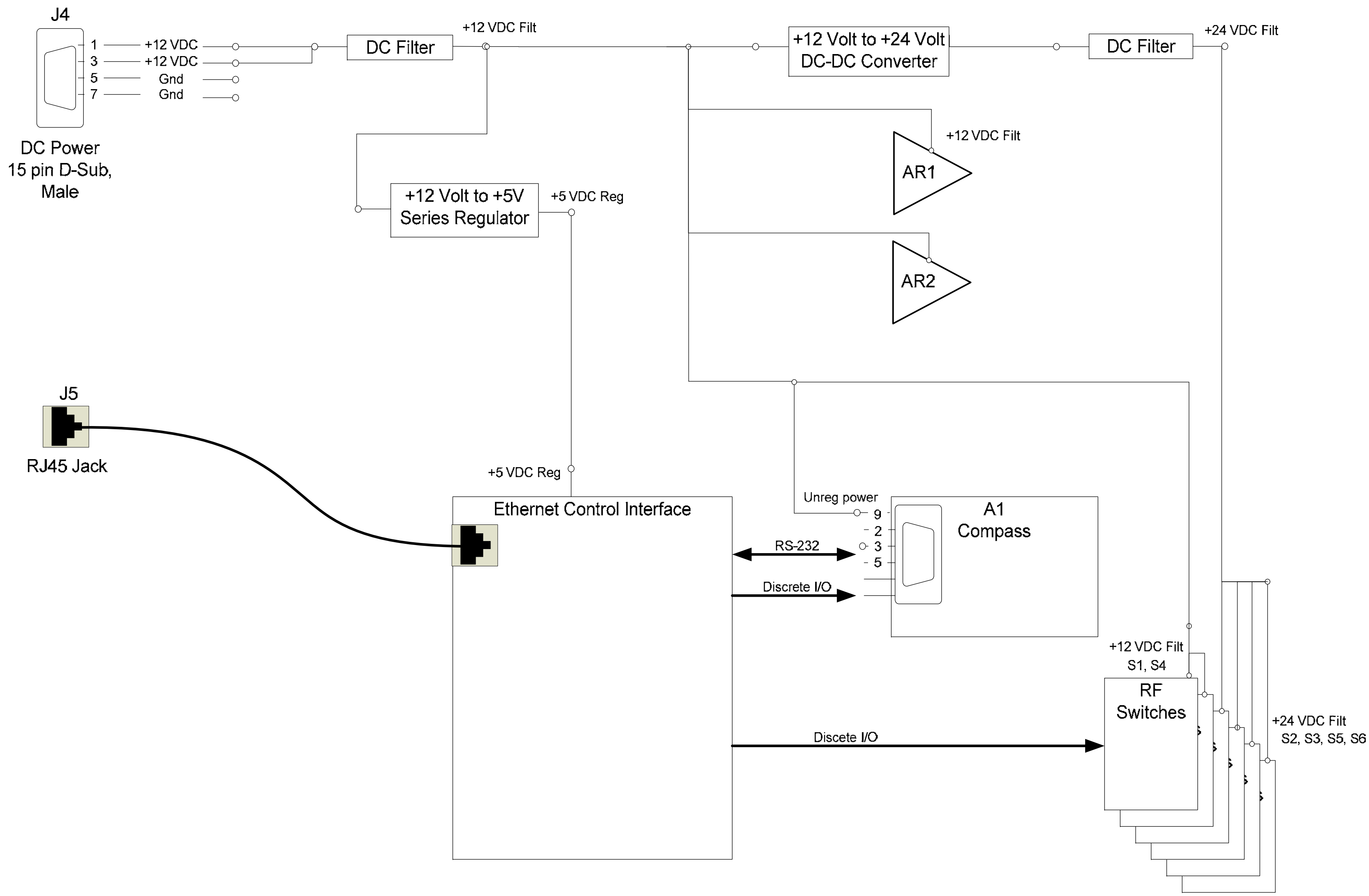
- **Antenna switching allows amplitude and phase measurements of adjacent antenna pairs for Angle of Arrival (AOA)**
  - **1 channel with sequential switching**
  - **2 channels for monopulse AOA**
- **Bit/Cal injection and transfer switch allows the receiver phase and amplitude to be calibrated out**
- **Low noise front end provides ~3.5 dB noise figure for enhanced sensitivity measurements, or bypass for pre-selection filtering**
- **Assembly can be used as a front end for many types of systems**

Additional Comments

- **Two output channels are available for amplitude and phase measurements**
- **Antennas can be selected in pairs (odds and evens) to the two output channels**
  - **Direction Finding: A1/A2, A2/A3, A3/A4, A4/A5, A5/A6, A6/A1**
  - **Acquisition: A1/A4, A2/A5, A3/A6**
- **A calibration input is supplied to support calibration (equal amplitude and phase signals applied to the 2 output channels)**
- **A relay switch is provided. This allows the capability to "self calibrate" the output channels using actual received signals**
  - **Make measurements in both positions to remove receiver phase and amplitude differences**
    - » **Take the average of the differences to cancel out receiver errors**
  - **The relay switch also allows the system to operate in signal channel mode**
- **A switch-able preamp is provided to improve receive system sensitivity**
- **Currently all switches are controlled by static TTL signals through an Ethernet interface**
- **Input DC Power is 12 VDC**

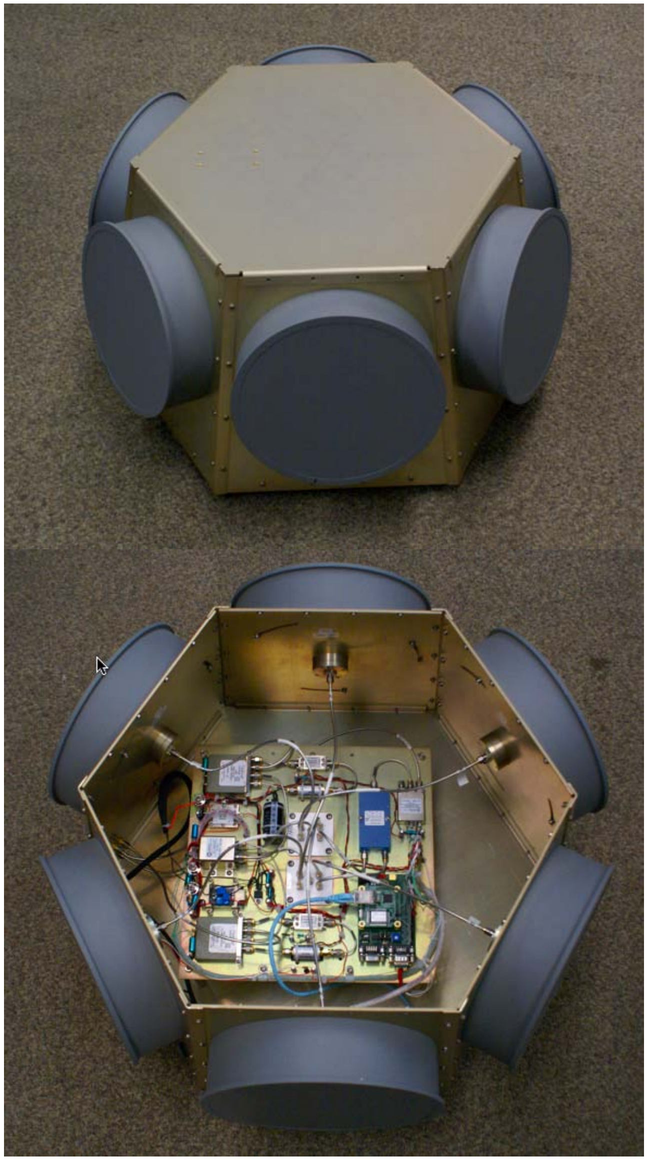


DF Assembly Internal Wiring

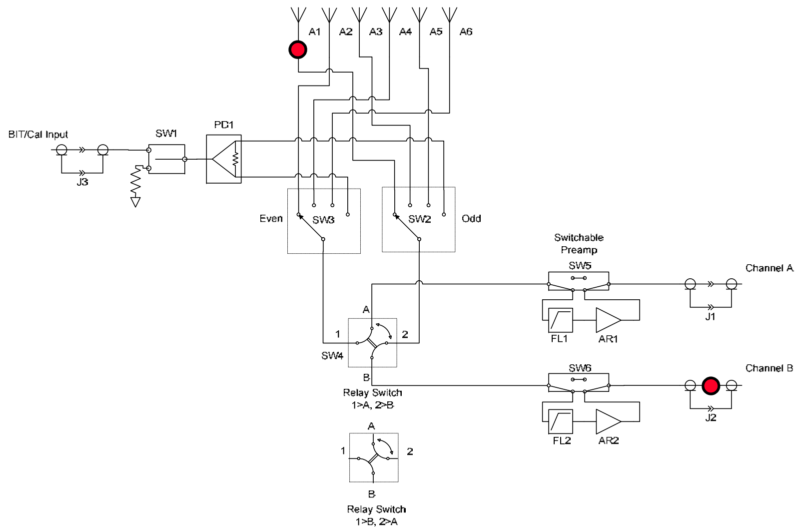


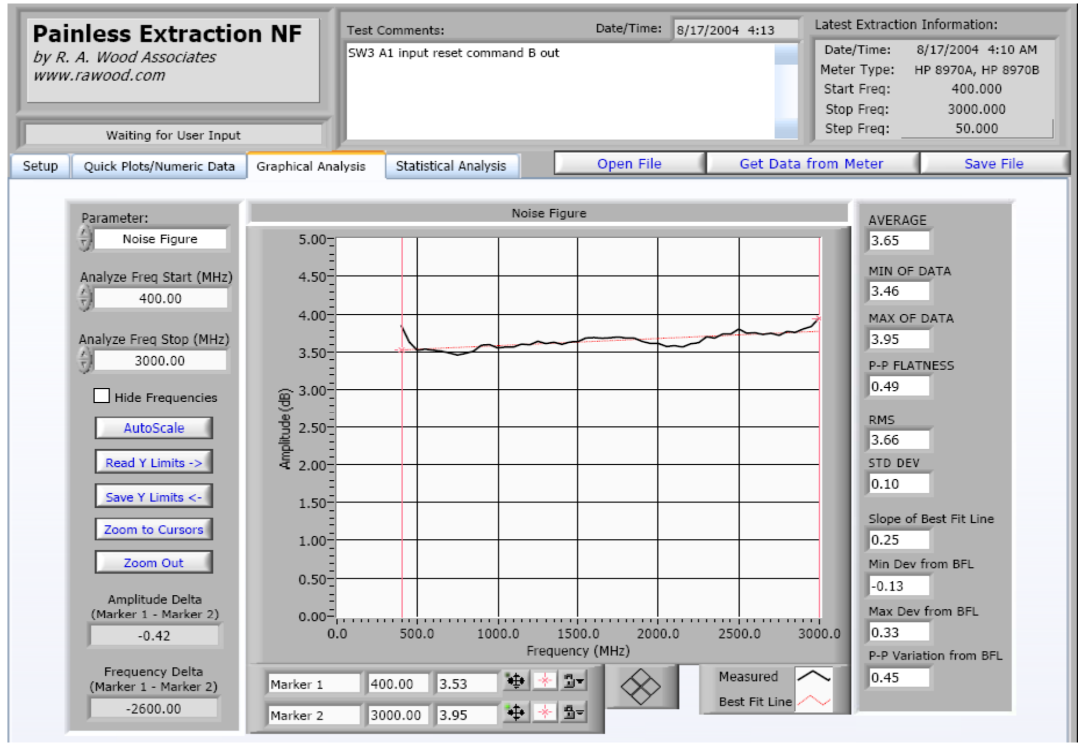
Antenna Assembly Test Results

- **The DF Antenna Assembly was built up and test data taken**
- **Performance was great (as good as could be hoped for)**
- **Noise Figure is around 3.5 dB, including the cable from the antenna, and 3 RF switches in front of the low noise amplifier**
- **The antenna paths (odd and even antennas) all match each other very well (within tenth's of a dB)**
- **The BIT/Cal injection removes the RF path differences between A and B outputs to less than tenth's of a dB**
- **This means with calibration, we should be able to remove nearly all amplitude errors in the receiver, and leave only the antenna differences to measure**

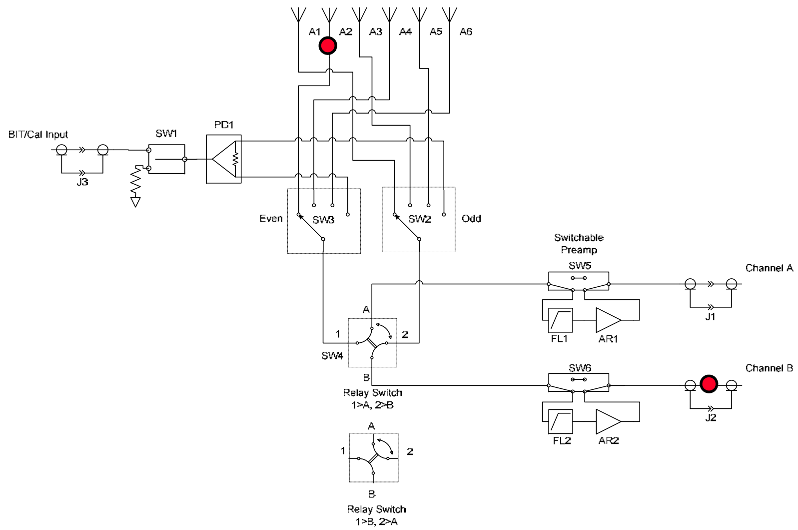


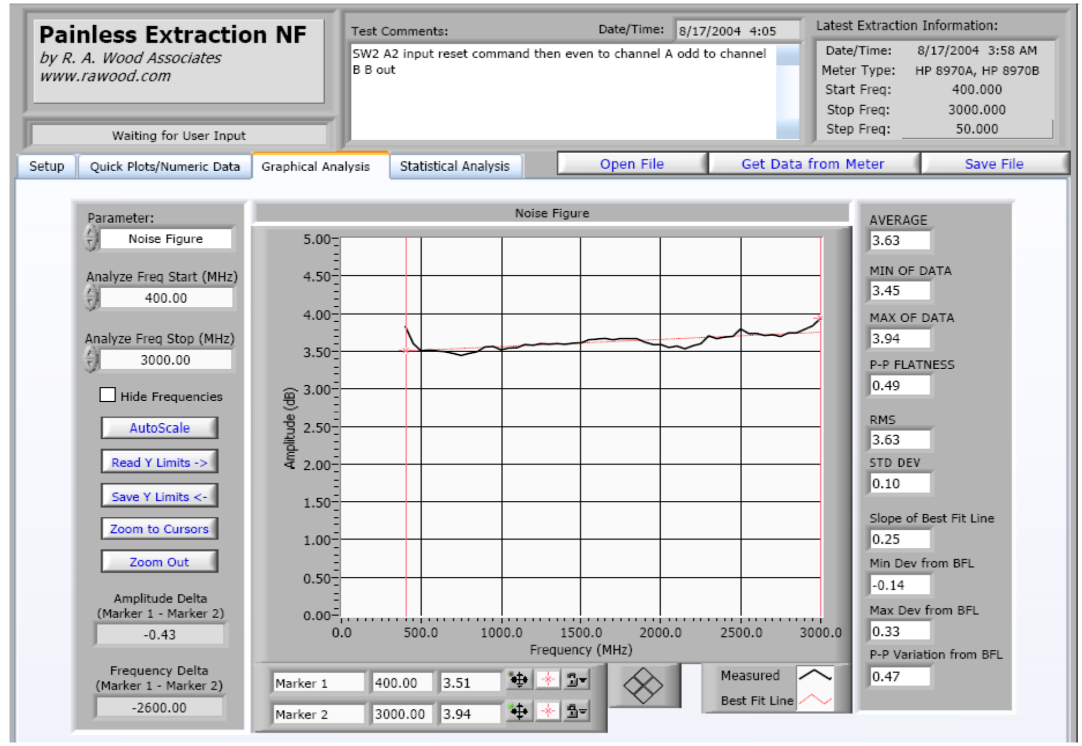
Noise Figure Results (A1 Input, B Output)



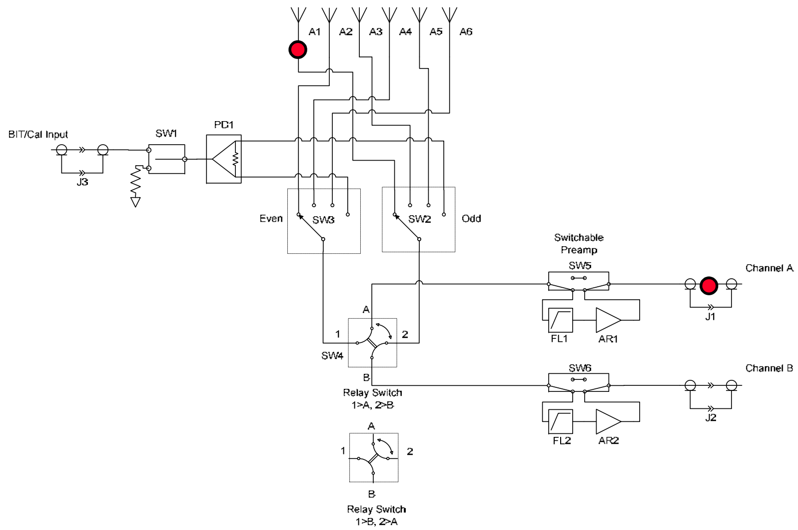


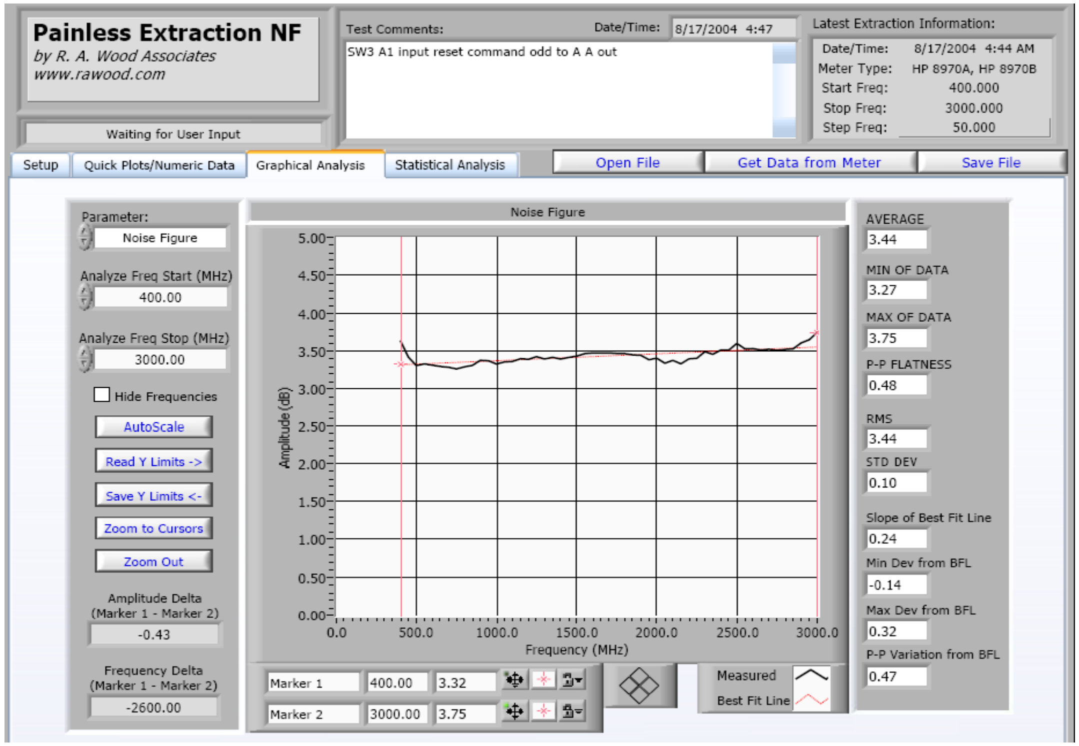
Noise Figure Results (A2 Input, B Output)



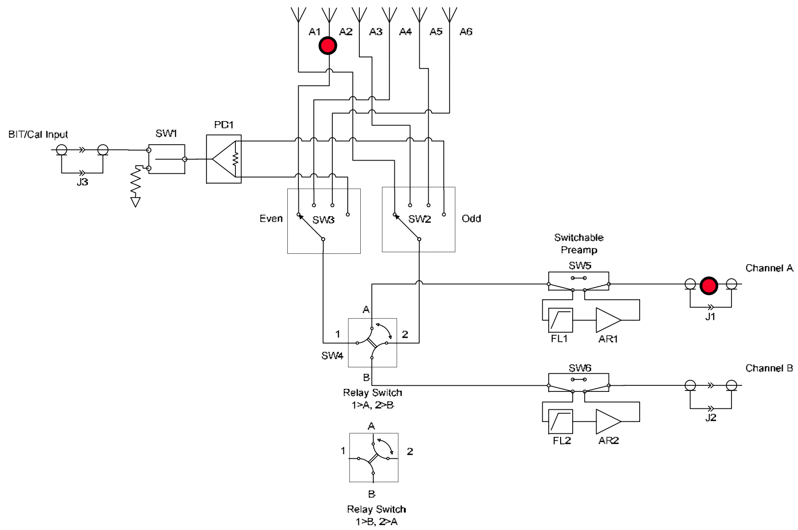


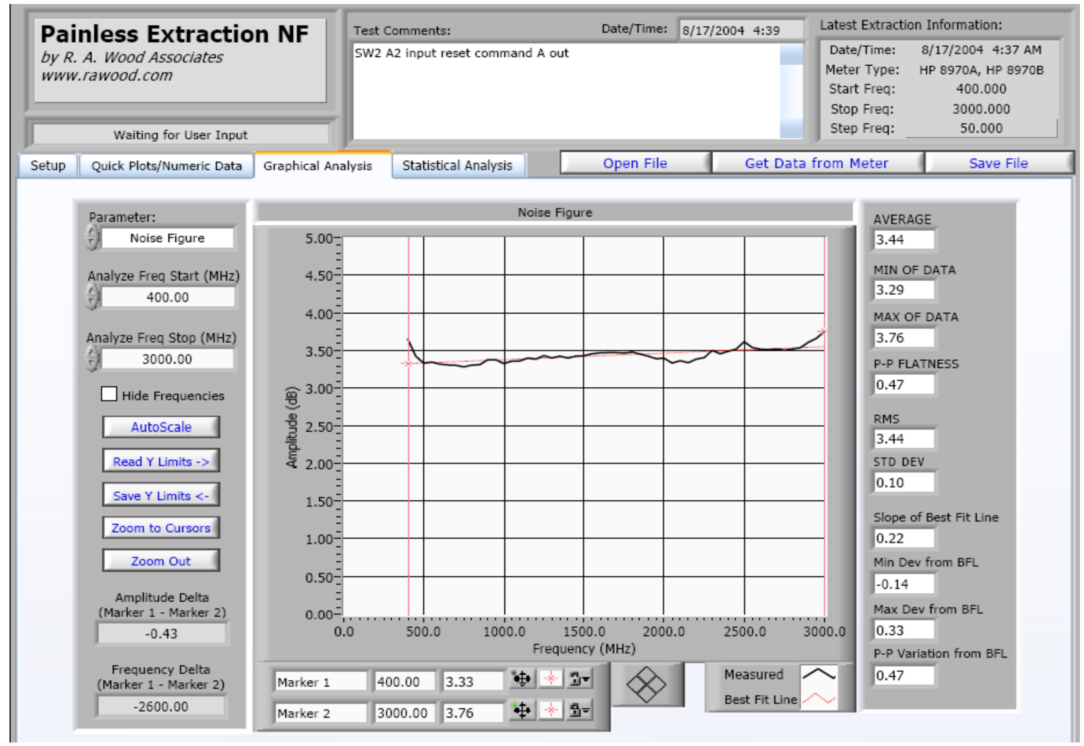
Noise Figure Results (A1 Input, A Output)



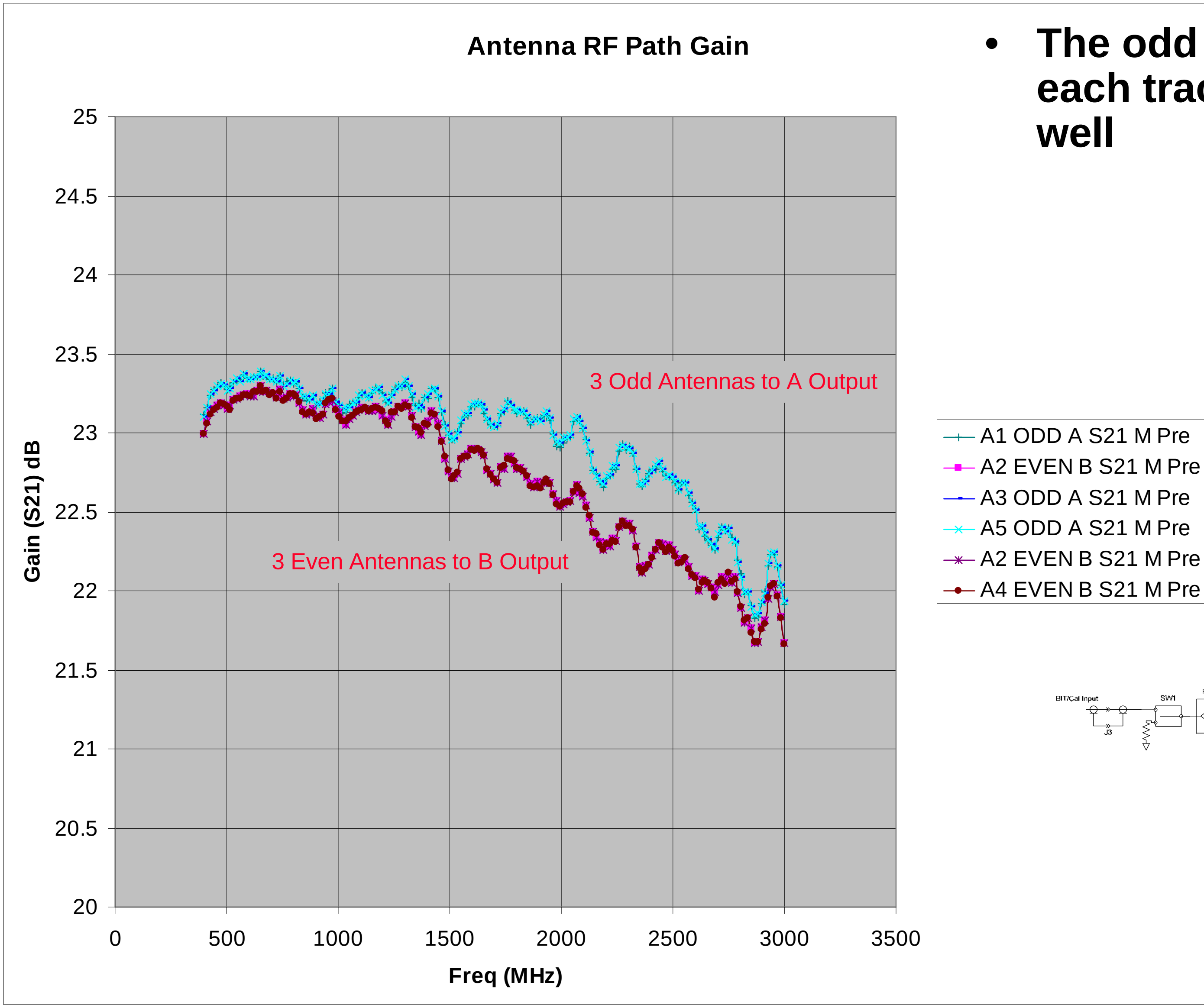


Noise Figure Results (A2 Input, A Output)

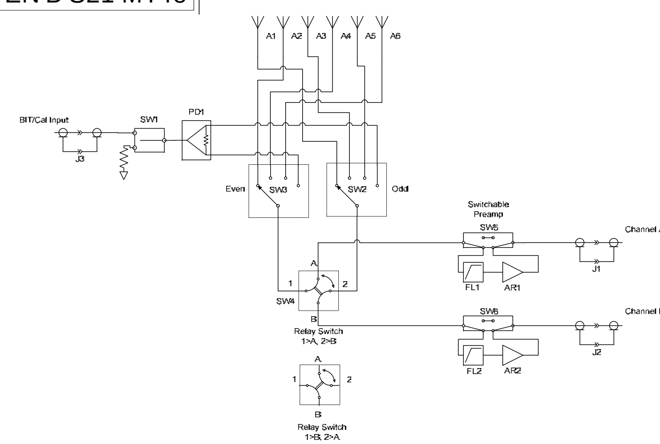




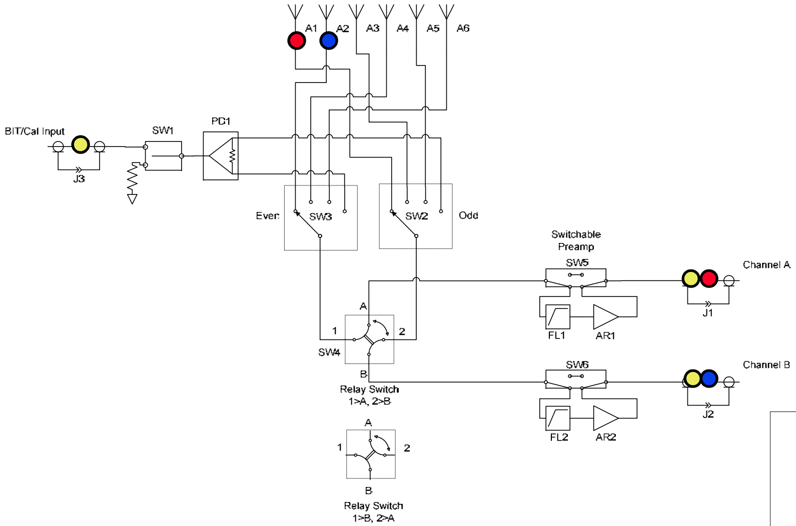
Antenna Path Gains



- **The odd and even antennas each track each other very well**



Calibration Performance



- **The BIT/Cal injection captures the Antenna Channels and calibrates the receiver chain after the antennas to within 0.1 dB!**

How well does the BIT/Cal calibrate the RF path after the antenna? The statistics on the residual error:

Ave	0.028 dB
Std Dev	0.030 dB
Min	-0.044 dB
Max	0.127 dB