NEXT WEEK I PLAN TO THINK ABOUT THE OPTION OF USING TECHNOLOGY THAT ISN'T YET AVAILABLE.
VLBI Sampling Techniques

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and the
Electronics Division
Teledyne RAD004

- Teledyne purchased the Rockwell Sampler Division

- The RAD004 is used in the EVLA project
  - 3 bit sampler
  - 4.096 GHz clock

- Advertised small signal analog bandwidth - 10 GHz
6 Bit 4 GS/s Analog to Digital Converter

**Features**

- 6-Bit Resolution
- Up to 4 GS/s Sampling Rate
- Integrated Dual Track and Hold
- 0.5 Vpp Differential Full Scale Range
- 6 GHz Full Power Bandwidth (min)
- DNL: 0.5 LSB
- INL: 1 LSB
- ENOB: 4.5 Typical (DC to 4 GHz)
- No Missing Codes
- LVDS Compatible, Adjustable CML Output
- Grey Code Output
- Over-Range Indicator Output
- Integrated Pseudo Random Pattern Generator
- 2 Clock Cycles Latency
- 88 Pin QFP Package
- 7.5 W Power Dissipation
- 1 to 4 Demultiplexed Binary Output when Coupled with RDX004M4
- ROHS Compliant

**Figure 1 - Functional Block Diagram**
EVLA DTS Module

- 3-bit Teledyne Sampler
- 4 GHz Sampler Clock
- 2 GHz Digital Bandwidth
Sampling Concept

2\textsuperscript{nd} Nyquist zone  |  3\textsuperscript{rd} Nyquist zone  |  4\textsuperscript{th} Nyquist zone  |  5\textsuperscript{th} Nyquist zone

4.000 GHz
Sample Clock
Degradation of Signal to Noise

- $D_{SNR} = 10 \log \left( \frac{B_{EA}}{\text{Bandwidth}} \right)$
  
  $B_{EA} = \text{Equivalent noise bandwidth}$

  $D_{SNR} = 10 \log \left( \frac{10.5 \text{ GHz}}{2 \text{ GHz}} \right) = 7 \text{dB}$

- Anti-aliasing are required

* R. Vaughan – Theory of Band-pass Sampling
2.5 GHz Sine Wave
No anti-aliasing filter
11.7 GHz Sine wave
No anti-aliasing filter

18 dB Theoretical Limit
Sampler Characteristics

- Sample clock frequency can be constant
- One set of digital filters and processing firmware can be used for multiple nyquist zones
- Anti-aliasing filter design is challenging
- Nyquist boundary nulls
- Only one zone can be sampled at a time
ATA Wideband feed

- 32+ functional antennas
- 0.5-11 GHz
- Flat frequency response
- ATA uses traditional analog RF converters (4 each)

Credit David DeBoer
MaCOM Microwave Switch

- Band-pass filters
- 2-20 GHz
- 2” X 2.2”
- Advanced ceramics
- Good temperature stability
VDBE Compatible
Conclusion

- Reduce the LO system
  - Block conversions for higher frequencies
- May reduce analog noise
- Compatible with digital or analog transmission systems
- May be lower cost
Add anti-aliasing to Receiver