A Fully Automated Scanning RFI Monitoring System for VGOS Site Surveys

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Radio Frequency Interference

- I initially had no idea.
  - Large learning curve
- **Definition**: any observed signal in a designated frequency band that is not being transmitted from the initially desired source.
My System’s Purpose

- **Primary purpose:**
  - System scans for RFI at sites
  - **VGOS**- VLBI Global Observing System
  - Broadband (2-14GHz) signal acquisition chain utilizing small, fast antennas
  - Haystack leading developer for VGOS
- **System Automation**
- **Portability**
How does it all work?

- System Layout
- Motional capabilities
- Data acquisition instrumentation
- Underlying software
Feed/RF Receiving End

• System operated at McDonald Observatory
• ETS-Lindgren model 3164-05
  • **Frequency range**: 2GHz-18GHz
  • Dual linear polarization
  • Small and lightweight
• Low Noise Amplifier
  • Minicircuits ZVA-183+ LNA
  • Ultra-wideband, 3dB noise figure
• RF Switch
  • Replacing with USB RF switch
Motional Instrumentation

• Class 5 IP65 Rated M-style SmartMotor
  • Functions in harsh/wet weather
  • Ideal operating temperature range: 0°C - 85°C
  • Small size
  • Two modes of functionality: relative and absolute position moves or velocity moves
  • SMI Software (SmartMotor Interface)
• Bill of Materials (BOM) Experience
  • ICD (Interface Control Document)
  • Parts list
• Mounting plan
  • 2 motors required

Image courtesy of Manufacturer’s specs
Feed facing head on.

Zeroed out at this position using limit switches.

90° elevational rotation

360° azimuthal rotation

SmartMotor Mounting Layout
Power and Communication Distribution

Limit
CANopen
(Controller Area Network)

I/O
COM
Power

Terminator

Limit
CANopen
(Controller Area Network)

I/O
COM
Power

Terminator

24-48V Driver Power
Separate 24V Control Power

Referenced SM23165MT Specification Sheet
Determining Increments of Motion

- Beam patterns
  - 3dB Half-Power Beamwidth with line of best fit
  - E-plane
  - H-plane
- 25° HPBW selected
  - Motor steps in increments of 12.5°

The step increments that the motor will be programmed to implement.

Image courtesy of manufacturer specs.
Selected HPBW: 25°
Step increment of motor: 12.5°

Antenna Sweep Demonstration

Point of overlap occurs at 350°
Evolution of Spectrum Analyzers

• Out with the old, in with the new

Hewlett Packard 8563A
MXA—Agilent
RTSA7500—Berkeley Nucleonics
BB60C—SignalHound

Not spectrum analyzer
Original Testing—My First Task

Feed directed ~North

Feed directed South

Observed RFI on spectrum
Peaks: ~5GHz and ~10GHz
Berkeley Nucleonics—RTSA7500

- Spectrum analyzer for system design
  - Frequency range: 100kHz-18GHz
  - Real-time Bandwidth: 100MHz
  - Good quality for price
  - Size: 10.58 x 6.81 x 2.15 inches

- Real-time Spectrum Analyzer Capabilities:
  - Discovery of rare, short duration events
  - Detection of transient/dynamic events
  - Weak signals masked by noise

- Testing for Berkeley Nucleonics
Underlying Software

- LabVIEW
  - Not too friendly
  - **Plan**: Morgan Goodrich’s code for VLBI system modified and simplified
  - Capable of controlling motors for system motion and USB RF switch for data acquisition
  - Leaving behind beneficial documentation

- Berkeley RTSA7500
  - GUI-Graphical User Interface 😊

- SmartMotor
  - Personal SMI software
  - Codes: hard stop, on/off command, and recording location
LabVIEW Code
Overview of System Improvements

• First and foremost, we needed a new radome
• Smarter motor
• Spectrum Analyzer
  • No longer using benchtop—more portable
  • More powerful
  • Real time capabilities
  • Capable of doing full sweep
  • *Frequency sweep band1*: 1-2.9 GHz; 601 points
  • *Frequency sweep band2*: 2.9-14 GHz; 601 points
• USB RF switch
  • LabVIEW compatible, eliminates use of Arduino
Future Work

• Continuing improvements to system design
• Minimizing cost
• Further modifications to LabVIEW code
• Refined understanding of motor control via SMI software
• Better means of system storage
• **Big Goal**: Deploying system to every VGOS site for continuous RFI scanning
Secondary Projects

• Hydrogen MASE (poster)
• VLBI work
• SRT Plans (Thanks Alan!)

Glow from the dissociator bulb

VLG-10 Hydrogen Maser

Small radio telescope

Testing Morgan’s system for VLBI

VLBI Mark 5 recording station
Thank you!

• Endless help, guidance, and advice from my mentors and everyone else here at Haystack

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• Mary Reynolds

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• Fellow REUs

• NASA Kentucky