Acoustic Monitoring System and Data Analysis For Steerable Radar Antennas

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Why an acoustic monitoring system?

- Regular maintenance of Millstone Steerable Antenna (MISA) is necessary
- Problems with ice slippage, drive failure, metal fatigue, etc.
- Difficult to catch problems in advance
- Acoustic monitoring system could detect problems before they are too serious
The Antenna

- Used for incoherent scatter radar system
- Features
  - 46 meter diameter
  - 120 ton
  - Operates in UHF frequency range
- Fully steerable in both azimuth and elevation
The Sensors

- Accelerometers, ultrasonic sensors, acoustic microphones, and a tilt sensor
- Used to measure vibrations and sounds due to movement of antenna, rotation of motors and gears, application of brakes, and response to wind loading as well as tilt of antenna
- Signal needs to be amplified and filtered
- Signal conditioning circuit is designed
Designing The Circuit

- Power supply circuit
  - Contains voltage regulator to produce constant voltage of -5V, 5V, and 9V
- Input connectors
- Amplifiers
  - 1X, 10X, 100X, and 10X AC
- Filters
  - 50kHz and 500kHz
  - 4th order Buttersworth low pass filter
Using Software for Circuit Design

- Entered components onto schematic
- Simulated the filter circuits
- Designed footprints
- Designed the Printed Circuit Board (PCB)
  - Transferred the design
  - Routed the board
    - Manufactured output files
Example of Protel PCB
Antenna Sensor Board Under Test
Getting Ready For Data Taking

- Tested the circuit board and sensors
- Corrected necessary parts of board
- Made an experimental plan
  - set of movements for the antenna
  - variables implemented: where to place sensors, what sensors, etc.
  - data taking information and times
Taking the Data

- Used National Instruments 5102 USB based two channel oscilloscope
- Oscilloscope was connected to a laptop
- Laptop, board, sensors, cables, etc. were taken to antenna
- Took a sample set of data the first day
- Made necessary corrections for the second set of data
Ready To Take Data: Day 2
THE RESULTS....

- Acoustigram of accelerometer while azimuth brakes are released
- Acoustigram of accelerometer during start of azimuth motion
- Acoustigram of accelerometer during end of azimuth motion
- Acoustigram of ultrasonic as during braking
- Acoustigram of tilt sensor during start of azimuth motion
Y-axis Accelerometer: Brakes Being Taken Off
Z-axis Accelerometer:
Beginning Movement
Z-axis Accelerometer: Ending Movement
Ultrasonic: Brakes Being Applied
Tilt Sensor: Beginning Movement
What Was Learned?

- AC amplifiers are more appropriate for some of the sensors
- The 0-5KHz range contains more information than higher frequencies
- Accelerometers show a better response than ultrasonic sensors
- Check footprints many times!
- “Experimental things are never as easy as they seem” - Frank
Acoustic monitoring system for antenna is definitely feasible. More data needs to be taken to learn more about the structure and to identify the signals. Eventually a system can be engineered that will enable real time monitoring of the antenna.
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