Development of a Low Cost Spectrometer for the Small Radio Telescope (SRT), Very Small Radio Telescope (VSRT), and Ozone Spectrometer

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Outline

- Introduction and Motivation
- System Overview
- Challenges
  - Gain and Saturation
  - RFI (Radio Frequency Interference)
  - Frequency Drifting
  - Frequency Offset
- Astronomical Observations
- Conclusion
Introduction and Motivation

• The SRT (Small Radio Telescope) was developed by Haystack Observatory as an educational tool for universities and colleges to teach astronomy and radio technology.

• Still in demand and used by academic institutions.

• Development of a low cost alternative to the current SRT system could be widely beneficial.

[1] Old SRT
System Overview

- Tuner: Rafael Microelectronics, Inc. R820T
- ADC/Demodulator Chip: Realtek, Inc. RTL2832U
- Superheterodyne receiver
- I/Q Demodulation
- Frequency Range: 24-1766 MHz
- Max Sample Rate: 2.4 MS/s (3.2 MS/s)
- Cost: ~$12-22
Previous SRT
Dongle-Based SRT Schematic
Gain and Saturation

- Expected power level from Hydrogen Line -125 dBm
- LNA provides +26 dBm
- Internal amplifiers of the USB Dongle aren’t enough!
RFI

- Replaced high pass filter with a 1420-1470 MHz band pass filter.
Frequency Drifting

- Vast temperature changes (≥20°C)
Frequency Offset

- Offset at 1420.4 MHz = ~44.4 kHz
- 31.3 ppm frequency error (Expected is 30-50 ppm)
- Offset can be easily corrected!
Astronomical Observations: Source S8

Previous SRT

Dongle Based SRT
Astronomical Observations: Galactic Rotation Curve

Previous SRT

Dongle Based SRT
Conclusion

- Using the TV USB Dongles as a replacement is feasible:
  - Huge savings
  - Off the shelf device
  - Easier integration, over-head is all in software
  - Able to make astronomical observations

<table>
<thead>
<tr>
<th></th>
<th>Previous SRT</th>
<th>Dongle Based SRT</th>
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</thead>
<tbody>
<tr>
<td>Y-Factor</td>
<td>2.71</td>
<td>2.82</td>
</tr>
<tr>
<td>System Temp.</td>
<td>170.9 K</td>
<td>160.2 K</td>
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<tr>
<td>Sample Rate</td>
<td>20 MS/s</td>
<td>2.4 MS/s (3.2 MS/s)</td>
</tr>
<tr>
<td>Resolution</td>
<td>12 bit</td>
<td>8 bit</td>
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<tr>
<td>Cost (No Dish/Motor Controller/Pier)</td>
<td>$3845</td>
<td>$691</td>
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</tbody>
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Questions?

Acknowledgements:

• MIT Haystack Observatory:
  • Dr. Alan Rogers
  • Timothy Morin
  • Dr. Juha Vierinen
  • Mark Derome
  • Dr. Vincent Fish, Dr. Phil Erickson, K.T. Paul, Heidi Johnson
  • Everyone else at Haystack!

• NSF

8/8/13 MIT Haystack Observatory
References

  <http://www.haystack.mit.edu/edu/undergrad/srt/oldsrts.html>

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