Implementation of a Total Power Radiometer in Software Defined Radios

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Introduction

Presentation Goals

The goal of this thesis and presentation is to explore other methods that could be used for a remote sensing radiometer and specifically the implementation of a software defined radio as a total power radiometer. The end goal is to develop a radiometer that is more flexible than most radiometers and still maintain the accuracy and stability of a traditional radiometers if not exceed these specifications.

Secondary goal

A secondary goal was to use off the shelf components and components that are generally more accessible. This would allow radiometers to be more accessible to a wider scope of researchers in this field.

Tertiary goal

And finally a tertiary goal was to ensure that the system as a whole is fairly easy to use. This ties to our secondary goal of making radiometers more accessible to a wider range of researchers and research topics.

Thesis Goals

This thesis looks to explore the following questions: (1) Can we use a SDR along with GNURadio to recreate a radiometer in software? (2) If so, what performance can we get from the system? (3) What benefits do we gain (if any) from using a SDR from a more traditional radiometer? The results of this research and experimentation are the subject of this thesis.

Background

Background

ISU currently owns a total power radiometer centered at 1.4 GHz with a fixed bandwidth of 20 MHz. This radiometer is unique in that it does a total power evaluation by undersampling the A/D converter. This current radiometer however has experienced a number of issues that hindered its performance.

Thesis Questions

This thesis looks to explore the following questions:

1. Can we use a SDR along with GNURadio to recreate a radiometer in software?
2. If so, what performance can we get from the system?
3. What benefits do we gain (if any) from using a SDR from a more traditional radiometer?

The results of this research and experimentation are the subject of this thesis.

Radiometer

The primary goal of a radiometer is to measure power. While that statement sounds easy, there are in fact many factors that go in to how well a radiometer can measure the power it sees. A better statement would be that a radiometer's primary goal is to accurately measure power within a certain degree of accuracy. In order to accurately and within a high degree of precision measure power, a radiometer must take into account various factors such as the system noise, the bandwidth of the signal and the stability of the system as a whole.

Measuring power

To measure power in a radiometer, several factors are taken into consideration. To begin with we have the noise signal coming from the antenna. Our antenna is assumed to be looking at our target of interest and it is assumed that we can relate the antenna noise to the noise from the source. It is often easier to refer to this noise as the brightness temperature. Therefore the brightness temperature of the source can be related to the brightness temperature at the antenna. We will refer to this brightness temperature as T_A.

Ideal Radiometer

Figure on slide 10 shows us an ideal radiometer. That is a radiometer that has an input from the antenna, T_A, a known bandwidth denoted as B and a known gain denoted as G. At the end of the block is the detector, which measures the power from the radiometer.

Bandwidth

Only a certain selection of the radio spectrum is observed by the radiometer. This is referred to as the bandwidth of the radiometer and is denoted as B or as β. This bandwidth is then centered around a center frequency. In our case, we center around 1.405 GHz as this falls in a protected frequency range often used for radiometry.

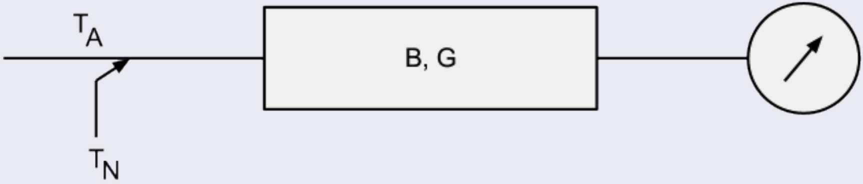
Power

The power coming from the antenna is amplified so it is easier to determine changes in the brightness temperature. The overall gain of the radiometer system is referred to as G in this case. Finally, we need to apply Boltzmann's constant, referred to as k. With these values, we can now compute the power the radiometer will see for an ideal radiometer. This can be shown in equation 1

$$P = k * \beta * G * (T_A) \tag{1}$$

Noise

However, since we do not have an ideal radiometer, we have another key component that needs to be addressed and that is the noise added to the system from the radiometer itself. Most of the additional noise is from the Low Noise Amplifiers (LNA) that are used to increase the signal while attempting to keep the noise added to a minimum. The Figure below shows the additional noise that is injected into the system.



Bullet Points

- Lorem ipsum dolor sit amet, consectetur adipiscing elit
- Aliquam blandit faucibus nisi, sit amet dapibus enim tempus eu
- Nulla commodo, erat quis gravida posuere, elit lacus lobortis est, quis porttitor odio mauris at libero
- Nam cursus est eget velit posuere pellentesque
- Vestibulum faucibus velit a augue condimentum quis convallis nulla gravida

Multiple Columns

Heading

1. Statement
2. Explanation
3. Example

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Integer lectus nisl, ultricies in feugiat rutrum, porttitor sit amet augue. Aliquam ut tortor mauris. Sed volutpat ante purus, quis accumsan dolor.

Table

Treatments	Response 1	Response 2
Treatment 1	0.0003262	0.562
Treatment 2	0.0015681	0.910
Treatment 3	0.0009271	0.296

Table : Table caption

Theorem

Theorem (Mass–energy equivalence)

$E = mc^2$

Verbatim

Example (Theorem Slide Code)

```
\begin{frame}
\frametitle{Theorem}
\begin{theorem}[Mass--energy equivalence]
$E = mc^2$
\end{theorem}
\end{frame}
```

Figure

Uncomment the code on this slide to include your own image from the same directory as the template .TeX file.

Citation

An example of the `\cite` command to cite within the presentation:

This statement requires citation [Smith, 2012].

References

John Smith (2012)
Title of the publication
Journal Name 12(3), 45 – 678.

The End