Spectrum Alerting System Based on Software Defined Radio and Raspberry Pi

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Outline

- Motivation
- Proposed Design of Spectrum Alerting System (SAS) based on RTL-SDR and Raspberry Pi
- Experimental Results of the proposed SAS
- Conclusion and Future Work

Motivation

- Traditionally the analyst would manually tune a radio receiver across the frequency band to identify unusual or ‘rogue’ signals.
- This was very time consuming and expensive in terms of resources.
- With the advent of digital radio, the ‘sweep’ of the frequency band could be programmed into the radio receiver which automatically highlighted frequencies of interest.
- If a difference is detected, according to pre-set thresholds, an alert is generated and analysed accordingly.

Motivation..

- However, signals intelligence operations can be inhibited by

1. High cost digital radio receivers and processors.
2. Paucity of expensively trained Signals Intelligence Analysts (SIA).

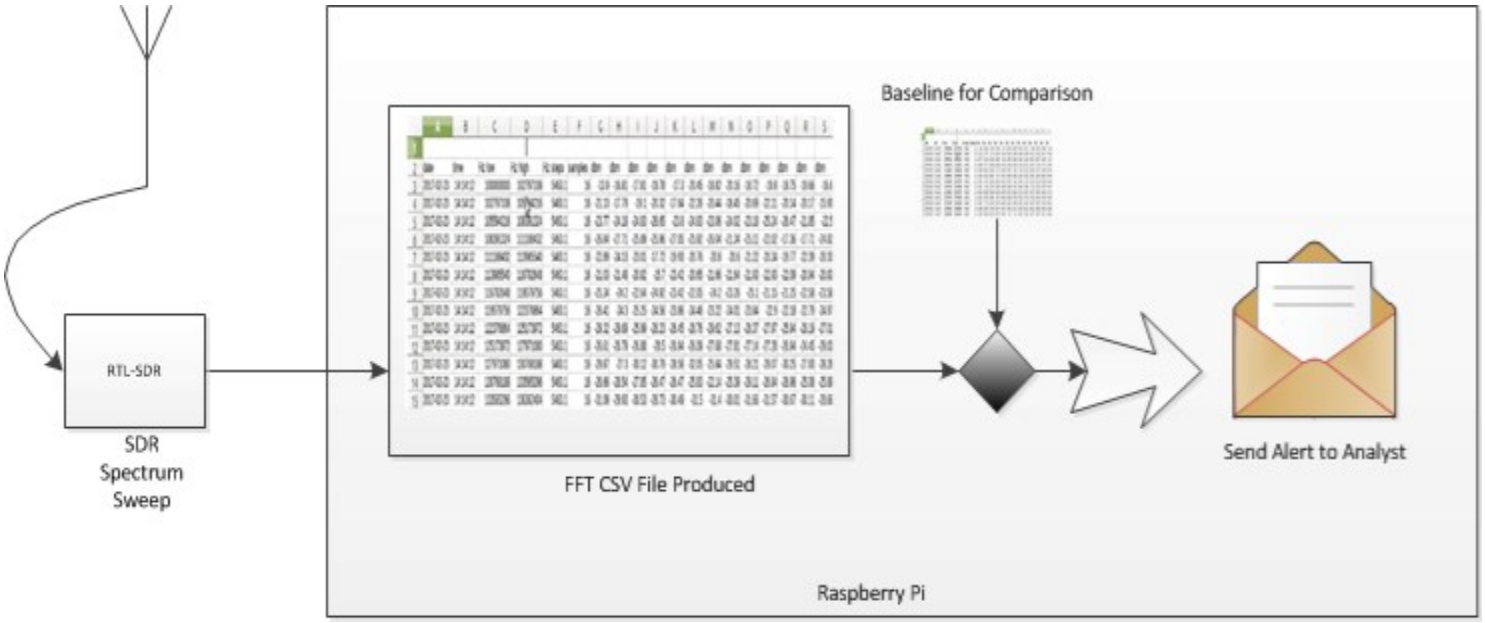
- The use of lightweight, cost-effective, low-cost SDR and low-power microprocessors can significantly reduce the cost.
- Several low-cost SDR devices are available in the market and RTL-SDR USB device is one of the cheapest SDR.
- Similarly, Raspberry Pi is one of the low-cost and low-power microprocessor devices available.

Motivation..

- Automatically generating and sending an alert message to Signals Intelligence Analysts (SIA) can save both time and money.
- SIA may decide to use the information to re-baseline the system, or they may decide that the frequency is of interest and take further intelligence action.
- Therefore, this paper presents the design and implementation of an inexpensive and generic Spectrum Alerting System (SAS), based on RTL-SDR USB device and a Raspberry Pi that can send an alert to SIA.

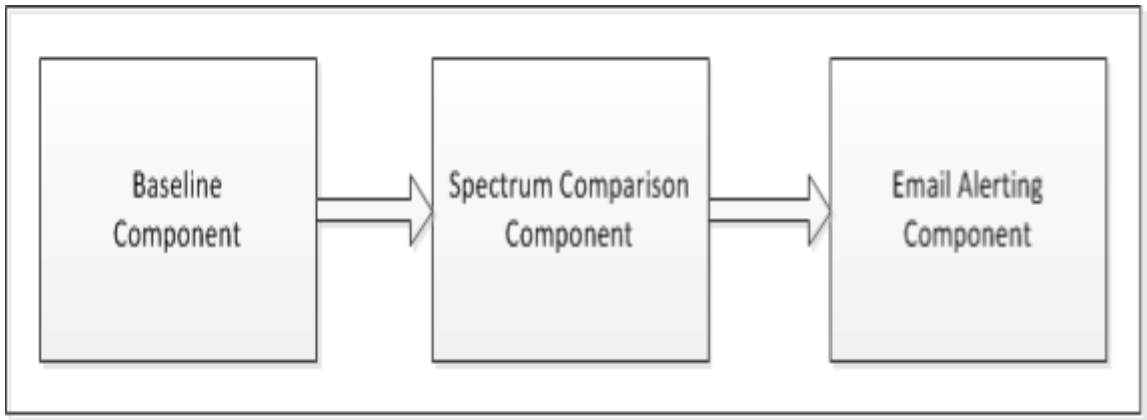
Proposed Design of SAS

- Figure shows the proposed design model of Spectrum Alerting System (SAS) and its operational flow.
- In which, RTL-SDR USB device, Python and Raspberry Pi are utilised.
- RTL-SDR USB device acquires signals, presenting them to the Raspberry Pi. The signal is sampled and passed to a Fast Fourier Transform block.
- The software module of the SAS performs the baselining, signal comparison and alerting via email.



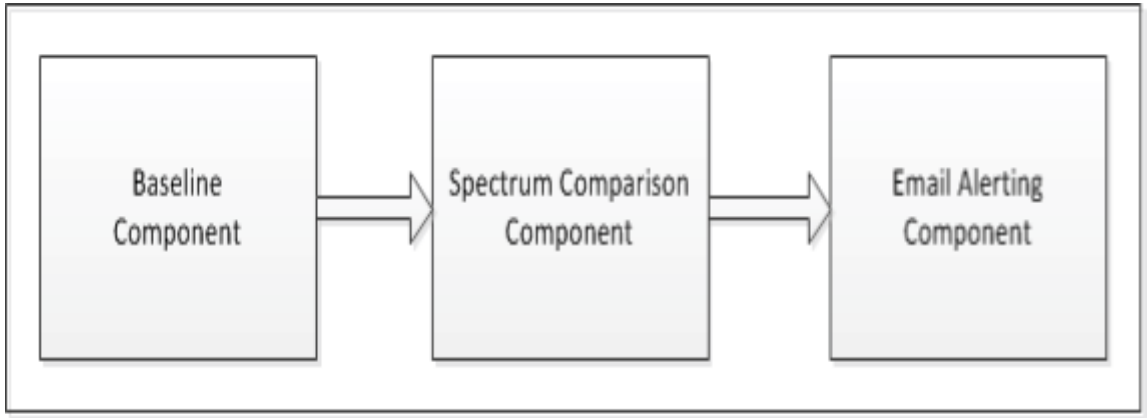
Proposed Design of SAS (1)

- The software module of the SAS is written in Python and developed in three stages: baseline component, spectrum comparison component and email alerting component.
- The first stage is a baseline component to capture a sample of the EM spectrum and record it in the CSV file format.
- The design of this baseline component requires following operations:
- Sets the frequency range, i.e., lower limit and upper limit (in MHz).
- Sets the FFT bin size (in Hz).
- Sets the gain (in dB).
- Sets the length of the capture (in seconds).
- Assigns the output filename for the CSV file.



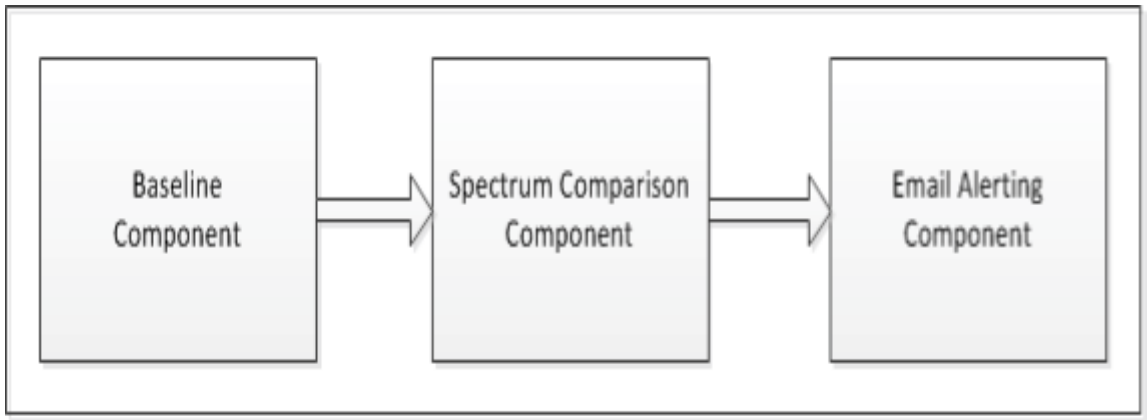
Proposed Design of SAS (2)

- The second stage of the SAS software module is to continuously sample the spectrum of interest, at specified intervals recording the readings, comparing the reading with the baseline.
- Both baseline and the new reading are stored on the system as CSV files.
- It subtracts the baseline from the new reading and records the result; any differences between the two, are subsequently compared with the threshold, if the threshold is breached, the program automatically proceeds to issue an email alert.
- If the threshold is not breached, the program returns to its sampling mode, collecting another sample reading and the whole process repeats.



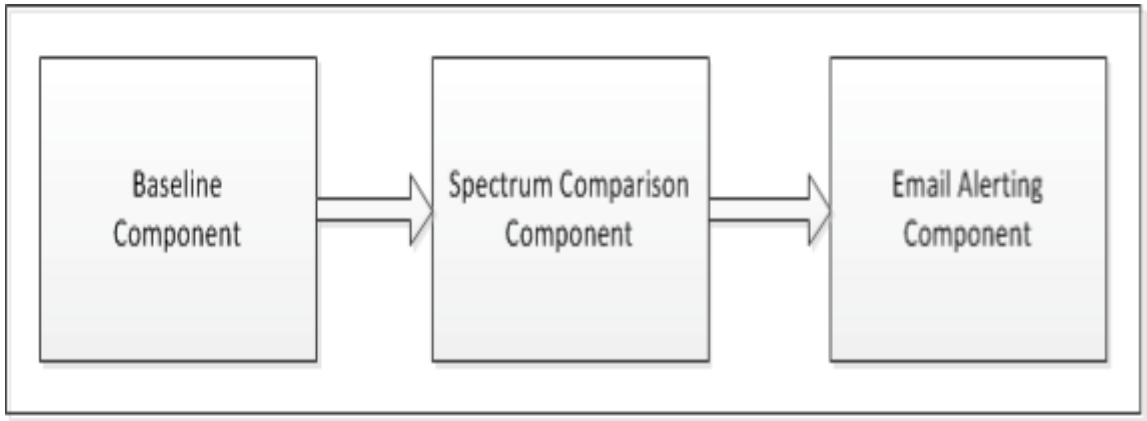
Proposed Design of SAS (3)

- The design of this spectrum comparison component requires following operations:
- Use the same spectrum parameters as the baseline.
- Assign the output filename for the CSV file (on the initial comparison capture).
- Capture the spectrum data and append the comparison CSV file.
- Subtract the Baseline from the comparison spectrum.
- Test the result against the thresholds.
- Step on to stage three to send email alert if the threshold is breached, otherwise return for the next comparison capture.



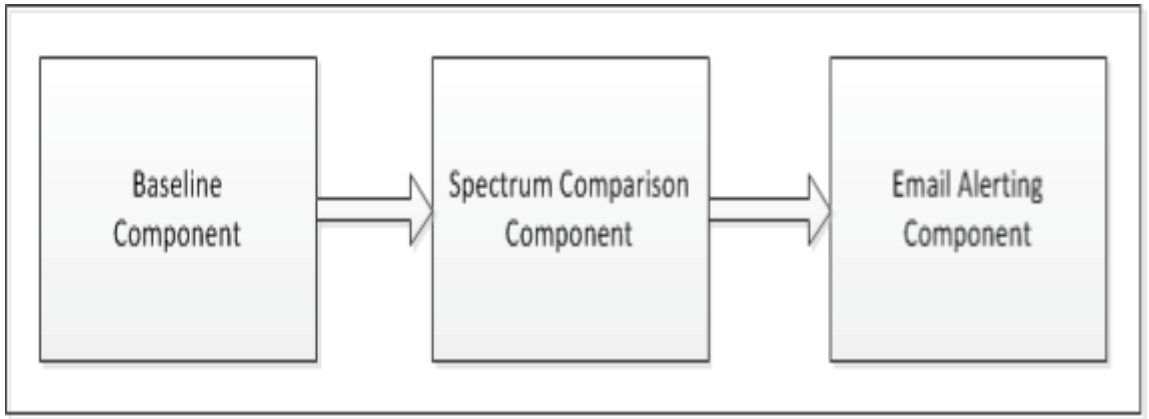
Proposed Design of SAS (4)

- The final third stage of the software module of the SAS is an email alerting component to trigger an email alert on an occurrence of a specified event.
- The conditions were identified which would prevent the remote signals intelligence analyst from being bombarded with emails.
- Firstly, an email would only be sent if a specified event occurred; the specified event being the breach of the threshold value in the comparison results.
- Secondly, an email would only be sent if 300 seconds have elapsed since the last email.
- This would prevent the continuous sending of emails in the event of the first condition being continually met.
- These conditions are set for this particular implementation, however, these conditions can be easily adjusted by the user depending on their requirements.



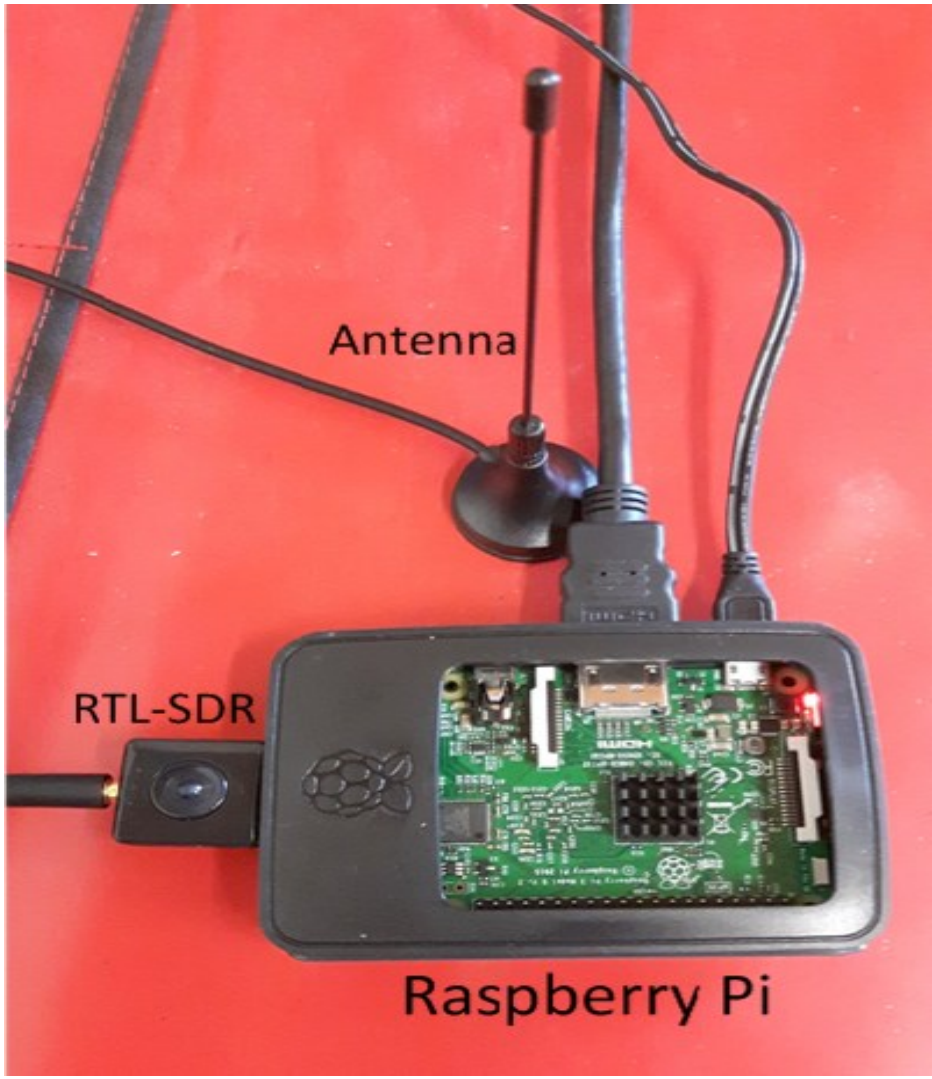
Proposed Design of SAS (5)

- The design of the email alerting component requires following operations:
- Importing the Simple Message Transfer Protocol (SMTP) and Email Python modules.
- Configuring the desired email format and specifying the email account, subject and body along with any documents to be attached.
- Configuring the SMTP server including login details of the internet-based email account.
- Instructing the email program to send an email if the event is True.
- Updating ‘time since last transmission’ CSV file with ‘time now’, if email is sent.



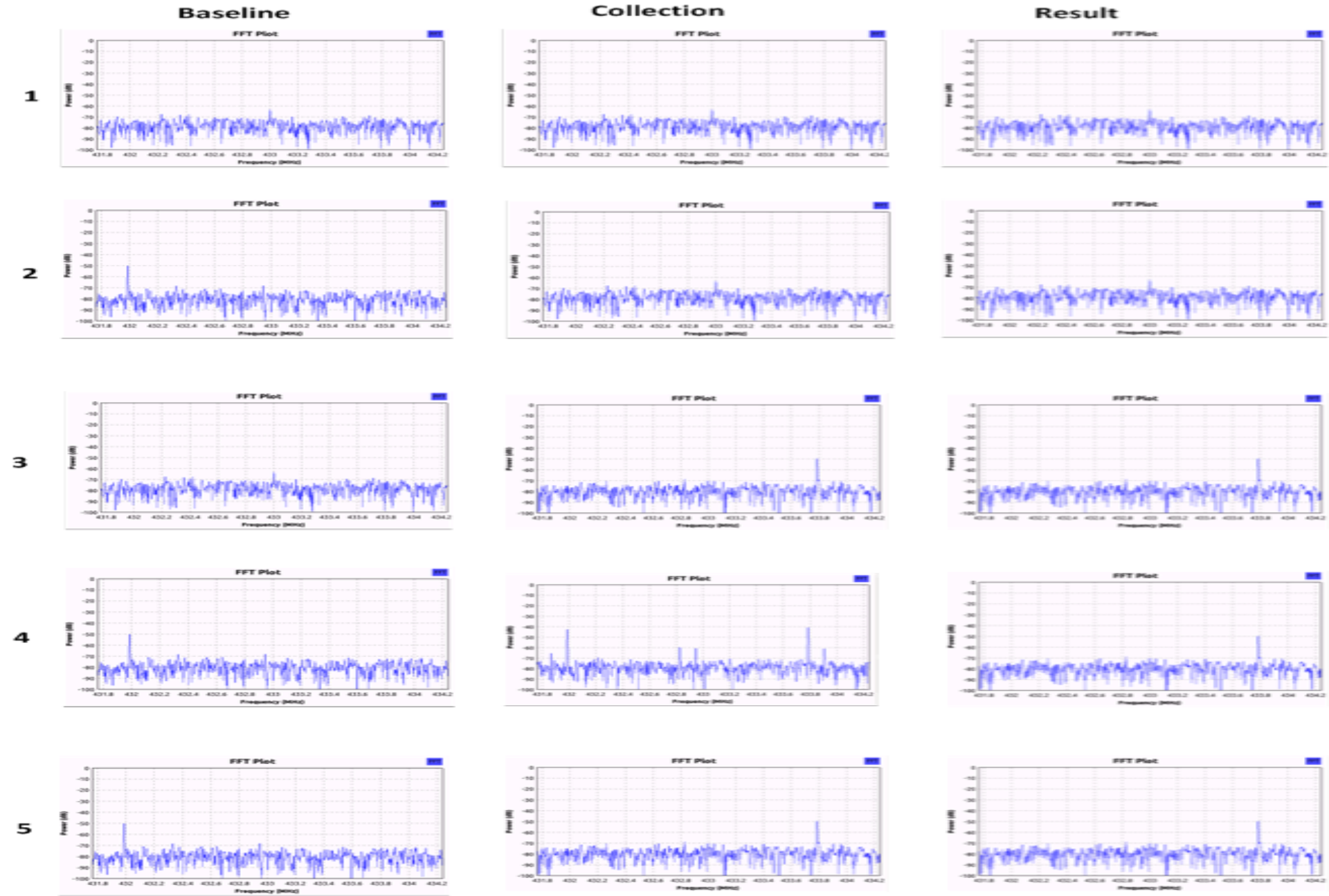
Proposed Design of SAS (6)

- The output CSV file was designed to be appended to, rather than written over.
- This would allow a history of new signals to be recorded within the output file.
- However, to produce the graph to attach to the email, only the most recent line in the CSV file would be required.



SAS Built using RTL-SDR and Raspberry Pi (ARM Cortex)

Experimental Results of the proposed SAS



Conclusion and Future Work

- This paper has presented the design and successful implementation of an inexpensive and generic Spectrum Alerting System (SAS) based on Software Defined Radio (SDR) by using the RTL-SDR USB device and a low-power microprocessor Raspberry Pi.
- The system captured an instance of the baseline spectrum and stored it in the CSV file for comparison.
- On subsequent spectrum sweeps the code compared the newly capture spectrum CSV file with the baseline CSV file.
- If the threshold is breached, the SAS generates an email alert of the spectrum differences to a remote signals intelligence analyst.
- The signals intelligence analyst has the option to remotely access the SAS to reset threshold or re-baseline the spectrum captured depending on their analysis.

Conclusion and Future Work..

- The implementation and experimental results demonstrate the success of the proposed SAS in the particular scenario.
- It shows the potential of SAS as an inexpensive and generic choice for an intelligence surveillance system in both a benign and hostile environment.
- Although the RTL- SDR works well for scanning a small frequency range for this particular experiment, if more complex waveforms are to be successfully decoded then a more complex SDR receiver is required.
- In the future, it is important to examine this spectrum alerting system for other real-time applications and compare its results with the established radio system to determine its real success and suitability for specific projects.

Thank You
&
Questions ?

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