DVB-T and FM Channels in Enschede

ET4394 GNU Radio Project Report

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Introduction

1.1. DVB-T and FM Channels in Enschede

DVB-T is an abbreviation for ”Digital Video Broadcasting — Terrestrial”; it is the DVB European-based consortium standard for the broadcast transmission of digital terrestrial television.[1] Based on ITU Radio Regulation, television frequency band lies from 478 MHz to 862 MHz. FM broadcasting is radio broadcasting using frequency modulation (FM) technology. FM broadcasting is capable of better sound quality so it is used for most music broadcasts.[2] In Netherlands, 87.6 MHz - 104.8 MHz is used for FM broadcasting.

From Nederland Radio and TV database, the information for DVB-T television and FM listed in Table 1 and Table 2.

Table 1. DVB-T Channels in Enschede.[3]

	RTS5 Bouquet1	NTS1 Bouquet2	NTS2 Bouquet3	NTS3 Bouquet4	NTS4 Bouquet5
Channel	22	36	23	47	28
Frequency	482 MHz	594 MHz	490 MHz	682 MHz	530 MHz
Bandwidth	8 MHz	8 MHz	8 MHz	8 MHz	8 MHz

Table 2. FM Channels in Enschede.[3]

	Radio 8FMNoord&Oost	SubLime FM	100%NL	Radio 10	RADIONL Twente
Frequency	87.6 MHz	90.7 MHz	99.1 MHz	103.9 MHz	93.3 MHz

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1.2. White Spaces and Enegry Detection Approach

Cognitive radio (CR) enables spectrum sharing by allowing new unlicensed services from secondary users to operate in pre-allocated bands in an opportunistic manner. TV white space (TVWS) is a portion of the spectrum in ultra-high frequency (UHF) and very-high frequency bands, which is not utilised by primary users in specific time and location. The more white space frequencies exist in particular band, the less efficient the utilization of that band.

Currently, cognitive radio (CR) is great interest to technologists because of significantly increasing the overall utilization of spectrum efficiency. Spectrum sensing is the basic and essential mechanisms of Cognitive Radio (CR) to find the unused spectrum. Energy detection is the signal detection mechanism using an energy detector to specify the presence or absence of signal in the band. Energy detection based spectrum sensing has been proposed and used widely because it doesn't require transmitted signal properties, channel information, or even the type of modulation.

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Project Description

2.1. Objective

The objective of this project is to test a signal detector under varying channel condition. The presence of signals of FM and DVB-T in Enschede will be detected. Moreover, since theoretically there maybe white spaces frequencies utilized by unknown users, these kind of signals. The bandwidth and average power level of signals can also be captured by the detector.
The probablitlity of detection and the probability of false alarm will also be evaluated.

2.2. Hypothesis

Since white spaces usually occur in high frequency bands, it is expected to be found in DVB-T band and not in FM band which is much more crowded. Moreover, the bandwidth of FM signals will be smaller than that of DVB-T channels. The probability of detecting noises by mistake will be larger in FM band because of the small bandwidth and crowded frequency band.

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Implementation

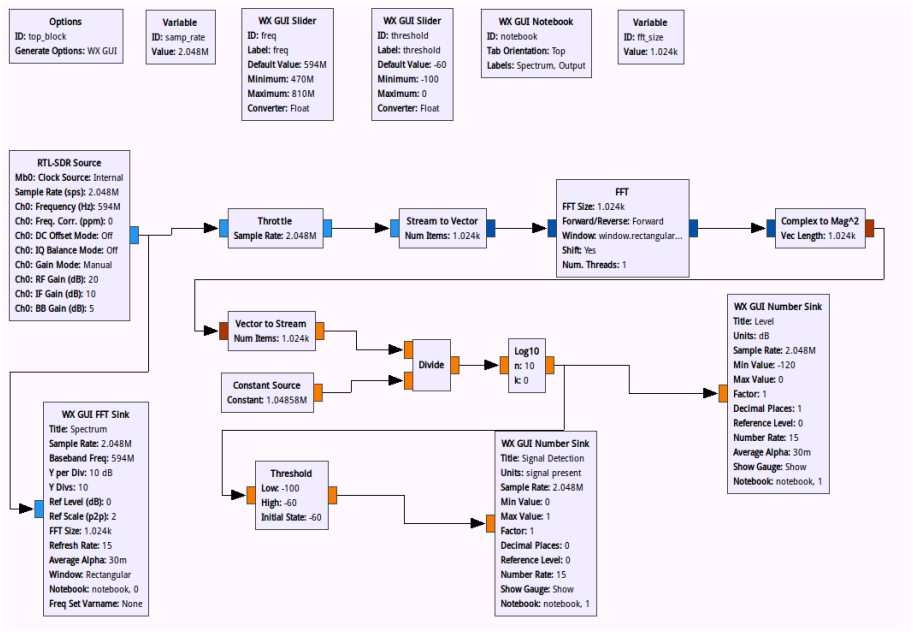

Figure 3.1: Block Diagram in GNU Radio of Energy Detection

In this project, NESDR Mini 2 by NooElec company is used to capture signals with Realtek RTL2832 and R820T2 as the receiver system. After the attaced antenna received signals, the dongle filters the received signal and performs converse them into digital signals. After that, signals will be conveyed to GNU Radio for following processing.

GNU radio is an open source software development toolkit that provides the signal processing runtime and processing blocks.Figure 3.1 is the energy detector developed by Rizqi Hersyandika. It contains the source block for inputting signals from the dongle, the throttle, stream to vector, FFT blocks for signal processing and power level threshold block for achieving energy detection.

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Result and Analysis

4.1. Signal Detection

4.1.1. DVB-T signals

Figure 4.1 is the power wafeform of DVB-T signal at NTS1 Bouquet2 channel with the frequency of 594MHz (left) and the power measurement result at the same time (right). It shows that the average power level at this point is -57dB which is higher than the threshold -60dB. Therefore, the signal is detected.

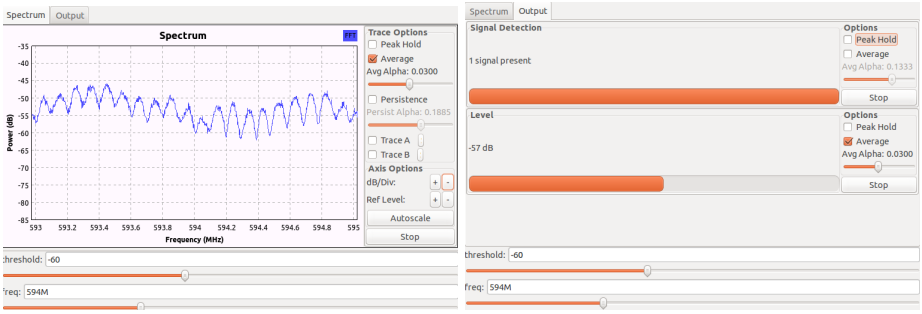

Figure 4.1: Detection of Signals of NTS1 Bouquet2

Figure 4.2 shows the edge condition of NTS1 Bouquet2 channel. Since the waveform window is in 2MHz range, it cannot show all the range of NTS1 Bouquet2 at the same time. So the range is divided into two pictures with the left and the right edge respectively. Since the bandwidth of NTS1 Bouquet2 is 8 MHz and the central frequency is 594 MHz, the left and the right edge should occur at 590 MHz and 598 MHz. From Figure 4.2, the detected left edge is at 590.16 MHz and the right edge is at 597.77 MHz, representing the bandwidth is 7.61 MHz because the noises are affecting the waveform and making the signal foot invisible.

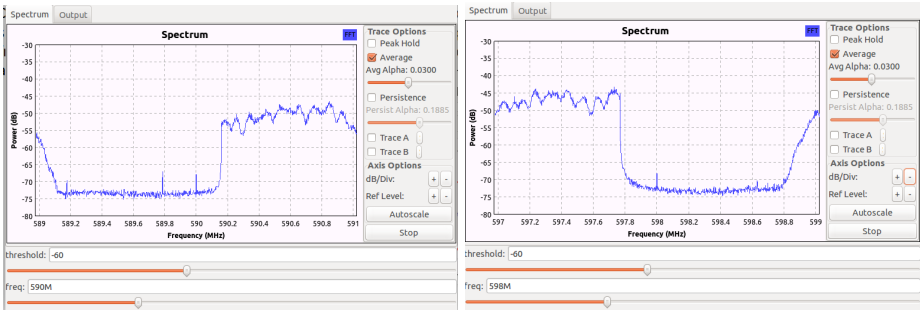

Figure 4.2: Edge detection of NTS1 Bouquet2

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One interesting thing is that the range of NTS5 Bouquet1 and NTS2 Bouquet3 is very close to each other. 486 MHz frequency is the boundary of these two channel. From figure 4.3, it is shown that there is a small interval between 485.8 MHz and 486.15 MHz to separate these two different channels. Because of the high sampling frequency, this detector successfully captured this interval.

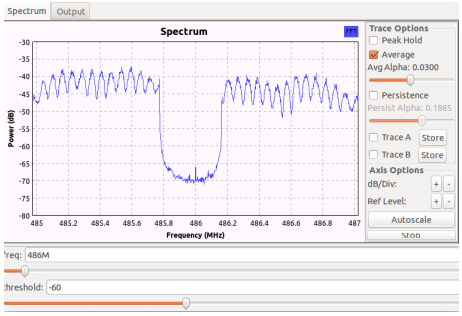

Figure 4.3: Waveform around 486 MHz

Besides the known channel for televisions, some un known signals are captured. There is a signal at the range from 801.4 MHz to 820.4 MHz like Figure 4.4 shows. The upper left picture of Figure 4.4 shows the loft edge of one channel around 801.4 MHz while the upper right picture is a right edge around 802.4 MHz. But it cannot be concluded that there is only one channel since there is an interval around 811 MHz like the lower picture of Figure 4.4 shows. This interval occurs between 801.4 MHz and 820.4 MHz, hence it may be the boundary of two signals. This two detected signals have an average power level of -69.9 dB which is quite different from DVB-T signals.

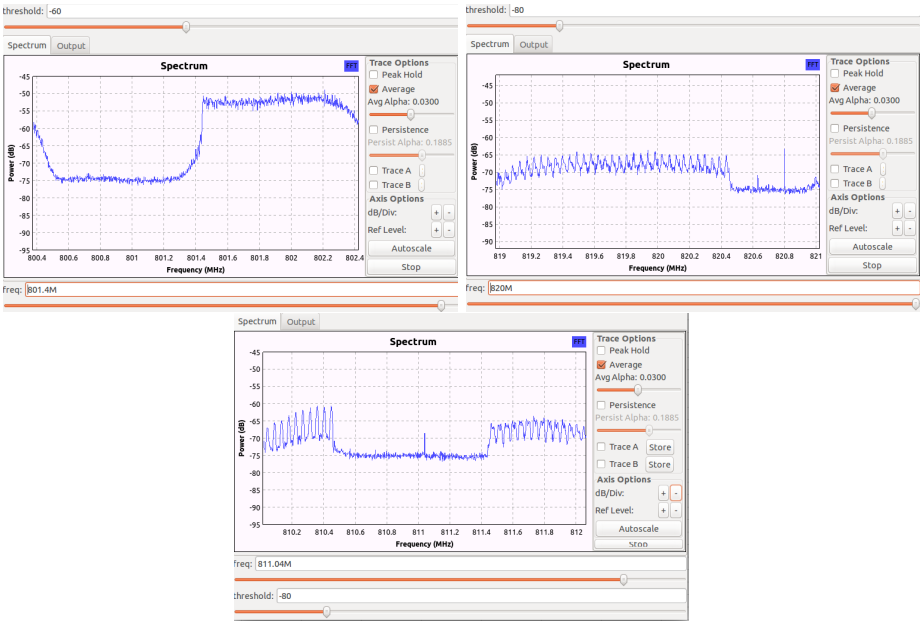

Figure 4.4: Unknown signal around 802.11 MHz

4.1.2. FM signals

Unlike DVB-T signals with bandwidth, FM signals usually work only in one fixed frequency. Figure 4.5 shows the waveform and signal detection of the FM signal at 87.6 MHz. The average power level of this signal is -72.5 dB which is relatively small when compared to the power of DVB-T signals. One problem for applying energy

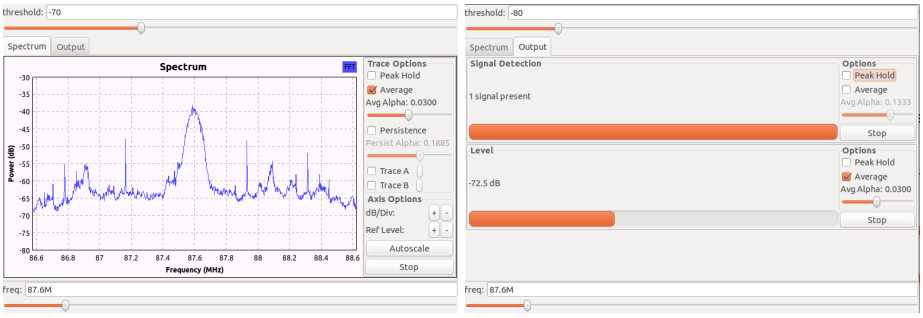

Figure 4.5: Detection of FM 87.6 MHz signal

detection approach in FM band is that the empty frequency will also be regarded as a signal like Figure 4.6 shows. The waveform(left) suggests there is no such a signal, but the detector regard it as a captured signal even though the threshold is -60 dB that is higher than the current power. This wrong capture disappears when the threshold is increased to -30 dB, which can also block the actually existing signal

at 87.6 MHz.

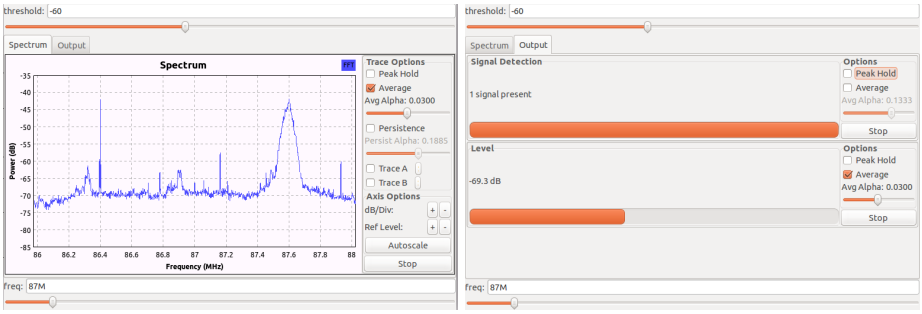

Figure 4.6: Wrong detection of FM 87 MHz signal

Table 2 lists only part of the used frequencies in FM band. Many unknown signals are captured in the waveform like Figure 4.7 shows. This happens at many point in the FM band and suggests it is not as empty as DVB-T band which has large white spaces.

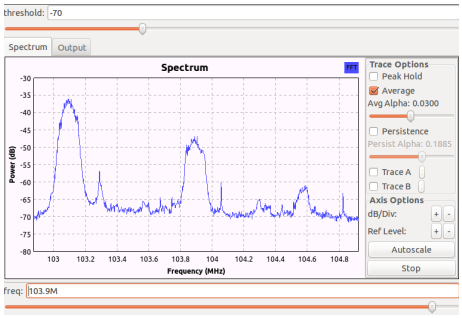

Figure 4.7: Detection of FM 87.6 MHz signal

4.2. Result and Analysis

Table 3 is the detection results for DVB-T band. When the power threshold is set to be -60 dB. All signal listed can be captured by signal detection except those empty frequencies. Table 4 is the detection results of FM band. However, almost every frequency will be regarded as a signal regardless of the current power.

Table 3. DVB-T Detection Results

	Center Freq (MHz)	Freq. Range (MHz)	Average Level (dB)
RTS5 Bouquet1	482	478 - 486	-52.9
NTS1 Bouquet2	594	590 - 598	-50.2
NTS2 Bouquet3	490	486 - 494	-46.4
NTS3 Bouquet4	682	678 - 686	-48.6
NTS4 Bouquet5	530	526 - 534	-43.5
Unknown Signal 1	807	801.4 - 811	-69.9
Unknown Signal 2	816	811 - 820.4	-70.1
Unknown Signal 3	749	-	-77.3
Unknown Signal 4	748.8	-	-77.5
Empty Frequency 1	524.88	-	-76.6
Empty Frequency 2	615	-	-77.2
Empty Frequency 3	626	-	-78
Empty Frequency 4	646	-	-76.3
Empty Frequency 5	505	-	-76.4
Empty Frequency 6	577	-	-77.5
Empty Frequency 7	713	-	-77.8
Empty Frequency 8	767.92	-	-77.2
Empty Frequency 9	752.24	-	-76.3

Figure 4.8: Detection results of DVB-T signals

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Table 4. FM Detection Results

	Center Freq (MHz)	Average Level (dB)
Radio 8FMNoord&Oost	87.6	-65.3
SubLime FM	90.7	-65.9
100%NL	99.1	-65.9
Radio 10	103.9	-64.5
RADIONL Twente	93.3	-66.5

Figure 4.9: Detection results of DVB-T signals

Conclusion

When the sensing band is DVB-T with relatively high frequency and large power, energy detection approach performs well for signal sensing. However, when it is applied on the FM band, empty frequencies will also be regarded as existing signals regardless of the power threshold.
I think the problem lays in the wrong blocks of the GNU Radio file however I failed to improve it to be capable for FM band.

References

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