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Improving the Performance of Anti-GPS Signal

HESHAM N. ELMAHDY, MOHAMED L. RAMADAN
 Information technology Department
 Faculty of Computers and Information - Cairo University
 5 Dr. Ahmed Zwait Street, Orman
 Giza, Postal code 12613. EGYPT
 ehesham@mail.eun.eg
mohamedloey@gmail.com

Abstract: – This paper improves the performance of GPS jamming signal using new technology of jamming. We use new technology called multi-band limit white noise. We identify jamming design issues. How those issues may affect jamming system performance. It addresses fabrication issues, data requirements, error handling, local and remote operations, how to attain high accuracy, and repeatability during the generation and measurement of jamming. We simulate this GPS jamming signal using matlab, and jamming controlling system using fuzzy logic. Finally make comparisons between all jamming technologies that use in simulation.

Keywords: - Anti-GPS, auto tracker, jamming signal, anti-jamming signal, noise signal, jamming signal ratio(J/S), noise signal ratio (N/S),Multiband-Limited White Noise

1 INTRODUCTION

In recent years, GPS has rise as major application in military and civilian devices. The Global Positioning System (GPS) is a satellite-based navigation system made up of a network of 24 satellites. Those satellites placed into orbit by the U.S. Department of Defense. GPS was originally intended for military applications, but in the 1980s, the government made the system available for civilian use. GPS works in any weather conditions, anywhere in the world, 24 hours a day. This device helps people in many aspects like get location and make mapping also tracking something or someone and get exact time, finally GPS use in navigation.

But some of them misuse GPS and use this device to kill, spy and thief anyone. We ask ourselves why people make this to brothers. So jamming radio signal is not a new application ,but it has been use from world war two.GPS jamming [1,2,3] has raise as important application to prevent evil GPS , and how to generate those signal in a laboratory environment. So I write this article to see some advantage and disadvantage of using GPS. How to prevent those evil people misuse of GPS, and generate a simulation to make jamming signal that will block GPS receiver.

1.1 Misuse of GPS

“Kill, spy and thief ” are easy words that we could say today, by using cheap and small devices and tools to achieve what they want. First of all GPS was originally intended for military applications, to confuse the enemy on where their exact location is. Where are the enemies using GPS guided missiles [4]. GPS allows

just anyone to track anyone else, and know where and when, this technology is know as auto tracker [5]. Finally a GPS help thief, what’s happening lately is that the fascists and criminals are finding it much cheaper. So GPS Tracking is an important field in GPS application. We will discuss GPS tracking types.

1.2 GPS Tracking Detecting and Blocking

A GPS tracking [5,6,7,8] unit is a device that uses the Global Positioning System to determine the precise location of a vehicle, person, or other asset to which it is attached and to record the position of the asset at regular intervals. We will discuss Types of GPS tracking device technology available to the public.

1.2.1 Passive or Logger Tracking Device

Passive tracking is used to tell where a vehicle has been over a certain period of time. Passive tracking devices are so difficult to detect because they use different technologies to report the GPS locations. Probably the best defense against passive/logger tracking devices comes in the form of a GPS blocker. These units can range in price from \$200 to \$850 [9].

1.2.2 Real Time or Active Tracking Device

Active tracking is intended to show where a vehicle is now, usually real time tracking connect with wireless network using computer or phone to get tracking information. Real type of tracking device is relatively easy to detect with a combination cell phone/GPS blocking device or RF detectors/scanners. These units range in cost from \$300 to more than \$1000 [9].So the

best solution to block GPS receiver devices is generating jamming signal.

1.3 GPS Jamming Signal

Anti-GPS is advice prevent the GPS loggers, trackers and GPS/GSM devices to get positions from the Satellites. Figure 1, Show simply how to make Anti-GPS jamming signal [2]. First of all to make those jamming signal we must know GPS signal Structure.

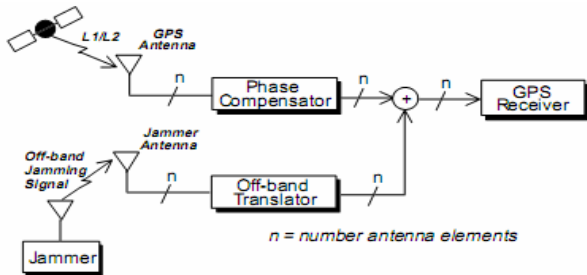


Figure 1: simple structure to Anti-GPS jamming signal

1.4 GPS Signal Structure

To design a simulation software-defined signal GPS receive. It is necessary to know the characteristics of the signal, data transmitted from the GPS satellites and received by the GPS receiver antenna.

The GPS signals are transmitted on two radio frequencies in the Ultra High Frequency (UHF) band. The UHF band covers the frequency band from 500MHz to 3GHz. These frequencies are referred to as L1 and L2 and are derived from a common frequency, L0 = 10.23MHz

$$L1 = 154 * L0 = 1575.42 \text{ MHz,}$$

$$L2 = 120 * L0 = 1227.60 \text{ MHz.}$$

Its Navigation data have a bit rate of 50 bps, the navigation data contain information regarding satellite orbits. Signals are modulated onto the carrier signal using the binary phase shift keying (BPSK), The GPS signal use two pseudorandom number (PRN) code, the first one is the Coarse / Acquisition (C/A) code and the other one is the Precision code (P(Y)) code, C/A code is only modulated onto the L1 carrier while the P(Y) code is modulated onto both the L1 and the L2 carrier [10, 11].

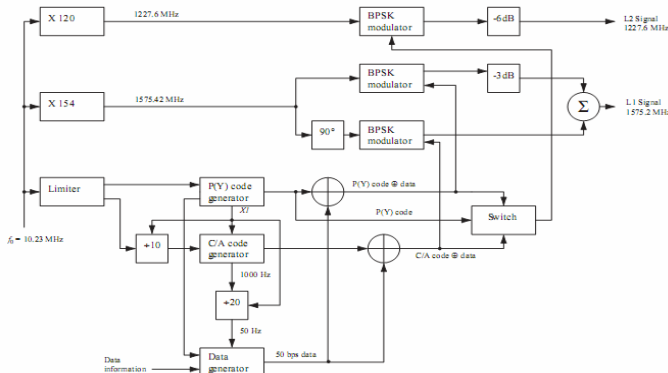


Figure 2: GPS Signal Structure block diagram

1.5 Drawback Of Using ANTI-GPS

It should be noted that most GPS jammers are illegal to build or use in many countries or localities. For instance, a GPS jammer can confuse aircraft and other vehicle instruments, possibly causing mishaps. Some GPS jammers state that they are only for civilian GPS jamming only; however some military equipment, must first sign onto the civilian GPS radio frequency in order to gain access to the military GPS frequency.

2 EXPERIMENT DESIGN

First of all we must know that to make radio jamming signal:

- The jamming signals have same frequency.
- The jamming signals have the same type of modulation.
- The jamming signals have enough power to override any signal at receiver.

Most jamming techniques fall into three major types usually based on bandwidth. Continuous wave, or CW jamming, Narrowband (NB) and Wideband (WB) jamming. All discussions of jamming signal ratio (J/S) will be related to dBm. J/S ratios are with respect to L1 or L2 P(Y) code only, where L1 = -133 dBm, L2 = -136 dBm, where there are three dB are added for C/A-code J/S comparisons between L2 and L1 [1, 2].

2.1 Jamming Design Issues

2.1.1 Accuracy

When measuring the GPS jamming signals, it is also important to note that the complete 20.46 MHz of signal bandwidth for L1 or L2 P(Y) code should be measured, to ensure that all the jamming energy is accounted. When performing the J/S calculations. GPS simulator signals must also have correct signal power levels. Adjusting the power output to correct for the testing system's losses or gains usually attains this. Incorrect GPS simulator output levels will cause J/S to be artificially high or low, nullifying test results, even if the GPS jamming levels are correct[2,3].

We need to be able to determine J/S as accurately as possible. Any error in determining this parameter can have a large impact on system performance. For example, suppose we wish to determine how a +1.0 dB error in measuring the amplitude of jamming would affect the overall accuracy of our J/S calculation. Assume there is no amplitude error in S, the GPS signal level, and that it is a constant value. Given in (1)

$$1 \text{ dB} = 10 \text{ Log } JM / JT \quad (1)$$

Where: JM = Measured jamming power

JT = True jamming power Then

JT = 1.26 JM or a positive 26% error in measurement

For a -1.0 dB error in measuring jamming amplitude, we have

$$-1 \text{ dB} = 10 \text{ Log } J_M / J_T \quad (2)$$

Or $J_T = 0.79 J_M$

This corresponds to a negative 21% error in our measurement [2].

2.1.2 Frequency

There are other important jamming parameters besides amplitude tolerances. Frequency is also an important issue. CW jammer or NB jammer center frequency location relative to the GPS signal is important, especially if testing a GPS receiver that can notch-out CW and NB jammers in the frequency domain. Too much drift from the commanded center frequency of the signal generators could nullify test results. We chose to limit the frequency offset to ± 9.0 MHz to avoid generating jamming outside the band, and to ensure that all the jamming energy enters the GPS receiver under test [1, 2].

2.1.3 Pulse

For pulse jamming (turning CW, NB, and WB jamming on and off at some rate), care should be taken to limit the two pulse description parameters, pulse repetition frequency (PRF) and duty cycle (DC). Large values for both PRF and DC will make the jamming look continuous, and very small values for both will not affect the GPS receiver noticeably [1,2].

Realistic values found through experimentation are:

Minimum PRF: 1 Hz, Maximum PRF: 20 kHz

Minimum DC: 10%, Maximum DC: 90%

Those values should only be considered as a starting point and are tailor able for specific requirements.

2.1.4 Modulation

The overriding goal of any GPS jamming modulation/mixing [1, 2, 3] scheme is to completely fill a given bandwidth of frequency with energy that will cause the GPS receiver to lose lock or never attain lock. There are many types of modulation options available. Some standard modulation types are amplitude modulation (AM), frequency modulation (FM), and biphase shift keying (BPSK). Mixing of noise with a carrier frequency to produce WB jamming is another common practice. Other options are as follows: sweeping the center frequency, summing two different kinds of modulation together (AM and FM, for instance), RF summation of multiple signal generator jamming signals, and others. The possibilities are almost endless.

2.1.5 J/S Range

Another design parameter not already addressed is the absolute limits placed upon the J/S values of the GPS jamming system. Low values of J/S will have little effect on receiver performance, and very high values provide little useful information because the GPS

receiver has lost lock since lost lock. Values chosen for the jamming system located inside the Navigation Laboratory were 7 to 80 dB J/S in 0.50 dB increments of precision. The minimum value of 7 dB J/S was chosen because C/A acquisition a 24 dB J/S is a common military requirement. The maximum value was chosen because no GPS receivers can track at 80 dB J/S against a WB jammer without employing beam steering, nulling, or some other multi-element antenna technique [1, 2, 3].

2.1.6 Setting of applied parameters

The system offers the following GPS jamming types [2]:

- CW: Successive oscillations those are identical under steady-state conditions.
- NB: Generated from a pseudorandom Gaussian distributed noise sequence. A 2MHz bandwidth contained within a 20.46 MHz band usually centered about the L1 or L2 frequency.
- WB: Generated from a pseudorandom Gaussian distributed noise sequence. A 20.46 MHz bandwidth centered on the L1 or L2 frequency.

The different jamming signals [1] used were:

- Non-Coherent Continuous Wave (NCW) Frequency: 1450~1600 MHz
- Coherent CW (CCW) Frequency: 1450~1600 MHz.
- Amplitude Modulation (AM): Carrier frequency: 1450~1600 MHz, Modulation waveform: Sine, Modulation frequency: 1 kHz, Modulation depth: 50.0 percent.
- Frequency Modulation (FM): Carrier frequency: 1450~1600 MHz, Modulation waveform: Sine, Modulation frequency: 1 kHz, Frequency deviation: [+ or -] 50 kHz.
- Band-limited White Noise (WB): Center frequency: 1450~1600 MHz, Bandwidth: 20 MHz.

Characteristics [2] common to all types of jamming are as follows:

- Pulsed NB, WB, and CW: each of the previously mentioned jamming types can be pulsed at a maximum pulse repetition frequency of 20 kHz. The minimum PRF is 10 Hz. Duty cycle can range from 10 to 90%.
- Jamming levels: Variable from 7 to 80 dB J/S with an accuracy of ± 0.5 dB in 0.5 dB increments of precision.
- Frequency offset: Allowable frequency offset of ± 9 MHz in 1 kHz increments for CW and NB jamming types. Only wideband noise may not be offset in frequency.

3 JAMMING SIGNAL SIMULATION

In this section we will explain how to make anti-GPS controller system using fuzzy logic. This controller will help laboratory to generate a perfect jamming signal, and how to simulate those jamming signal. There are many simulation tools to simulate jamming signal but the best tool is using matlab simulink, we use matlab V7.7.0 (R2008b) [12].

3.1 Jamming signal controller using fuzzy system

Fuzzy Logic Toolbox™ software is a collection of functions built on the MATLAB®. It provides tools for us to create and edit fuzzy inference systems within the framework of MATLAB. We can also integrate your fuzzy systems into simulations with Simulink® software. The GPS error signal and frequency and PRF and DC and J/S and frequency offset are used as input fuzzy variables. Fuzzy system output is defined as Jamming Signal. This fuzzy system need to define membership functions so figure 4. Show membership functions where fig.(a,b,c,d,e,f,g) are frequency ,PRF , , GPS error signal ,J/S , frequency offset ,Jamming Signal membership functions.

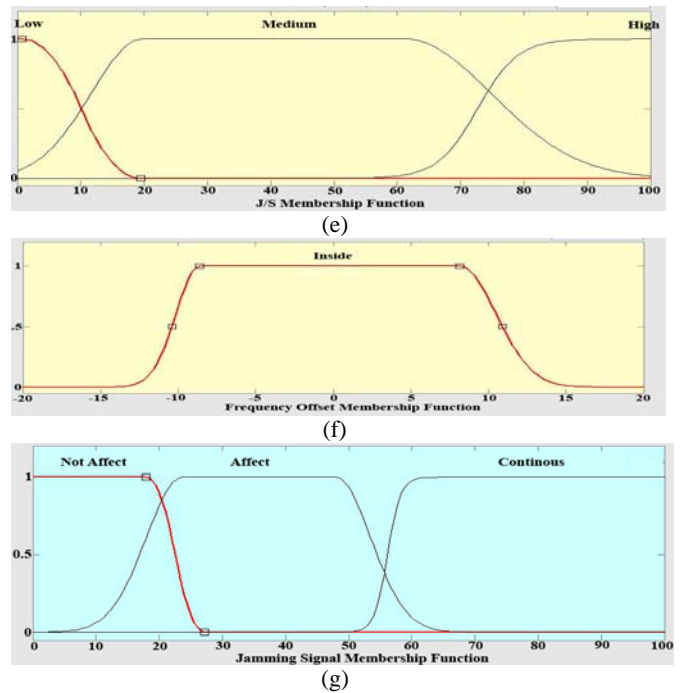
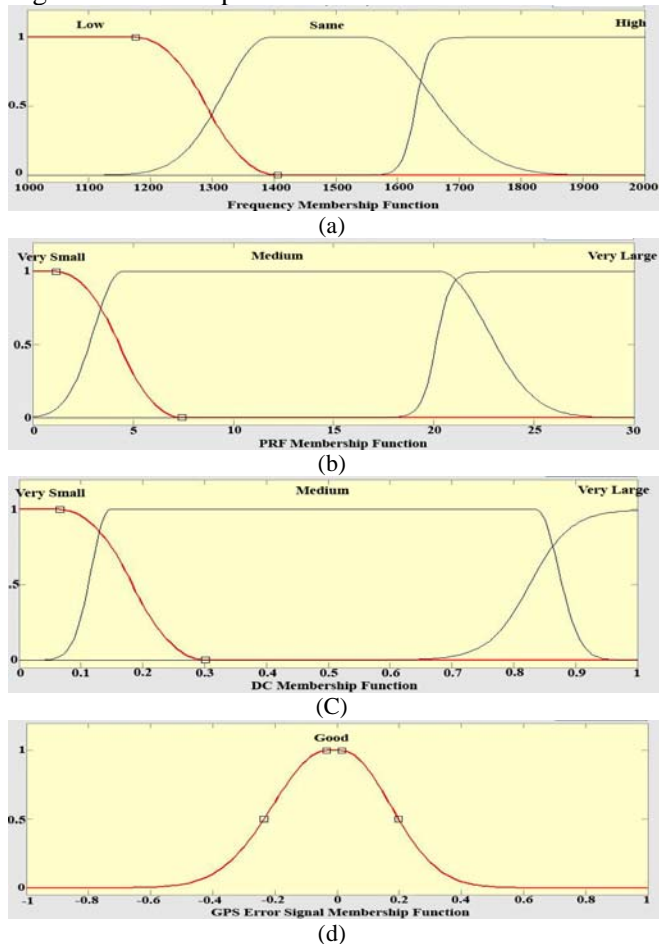


Figure 4: Anti-GPS fuzzy control membership functions

After define membership functions, now it is easy to define Anti-GPS fuzzy system control rules, it's illustrate in table 1.

1.If (GPSErrorSignal is not Good) then (JammingSignal is NotAffect)
2.If (GPSErrorSignal) and (Frequency is Same) and (pulseRepetitionFrequency is Medium) and (Duty is Medium) and (JammingSignalRatio is Medium) and FrequencyOffset is Inside) then (JammingSignal is Affect)
3.If (PulseRepetitionFrequency is VerySmall) or (DutyCycle is VerySmall) Then (JammingSignal is NotAffect)
4.If (PulseRepetitionFrequency is VeryLarge) or (DutyCycle is VeryLarge) Then (JammingSignal is Continues)
5.If (FrequencyOffset is not Inside) then (JammingSignal is NotAffect)
6.If (JammingSignalRatio is Low) then (JammingSignal is NotAffect)
7.If (JammingSignalRatio is High) then (JammingSignal is NotAffect)
8.If (Frequency is High) then (JammingSignal is NotAffect)
9.If (Frequency is Low) then (JammingSignal is NotAffect)

Table 1: Anti-GPS fuzzy control Rules

This Anti-GPS fuzzy jamming control make a perfect result to simulate jamming signal, so when the input define as [0 1500 15 .5 50 0], the output will be 35.7 dB jamming signal ratio.

3.2 Jamming Signal Simulation using Simulink

3.2.1 Band-limited white noise

First of all we simulate band-limited white noise. The band-limited white noise block generates normally distributed random numbers. White noise is suitable for

use in continuous or hybrid systems. The primary difference between this block and the random number block is that the band-limited white noise block produces output at a specific sample rate, which is related to the correlation time of the noise. We make a model using Band-Limited White Noise block and Scope block. Band-limited white noise block have three parameters noise power and sample time and seed. Figure 5 show band-limited white noise block diagram.

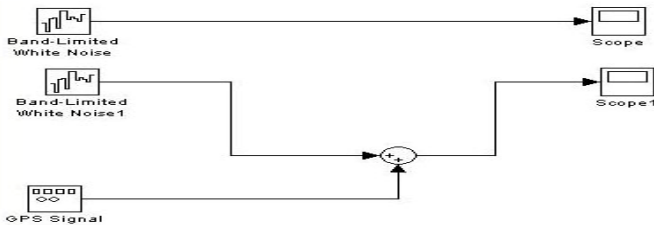


Figure 5: Band -Limited White Noise Block Diagram using simulink

3.2.2 Frequency modulation

Frequency modulations pass band simulation. The FM Pass band block modulates using frequency modulation see figure 6. The output is a pass band representation of the modulated signal. The output signal's frequency varies with the input signal's amplitude. Both the input and output signals are real sample-based scalar signals.

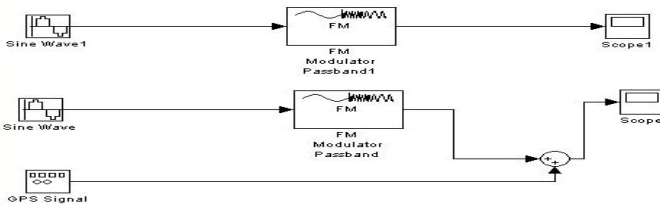


Figure 6: FM Jamming Signal block diagram

3.2.3 Multiband-limited white noise

Finally, multiband-limited white noise simulation block. This block models multiband noise using four different band limited white noise blocks, each one with its own power and time scale. A first order low pass filter with a selectable cut off frequency is applied to the last three noises (have look under the mask).The output sampling time has to be multiple of the first sample time. We make a model using Band-Limited White Noise block and Scope block to see result. Band-Limited White Noise block have three parameters noise power and sample time and seed as illustrate in figure 7.

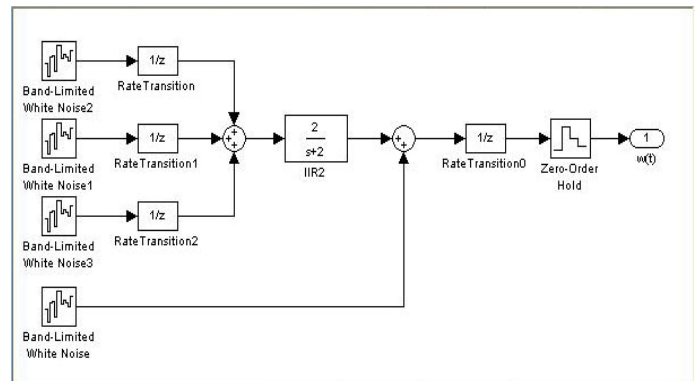
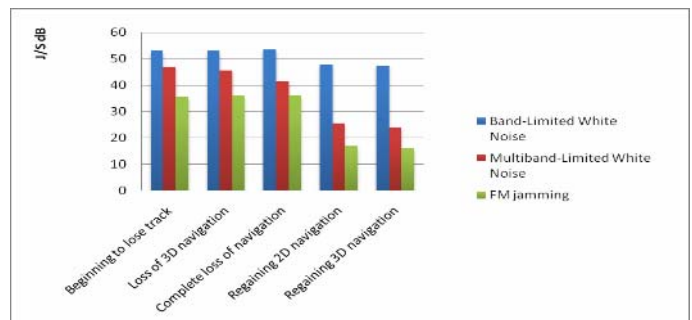


Figure 7: Multiband-Limited White Noise block diagram subsystem

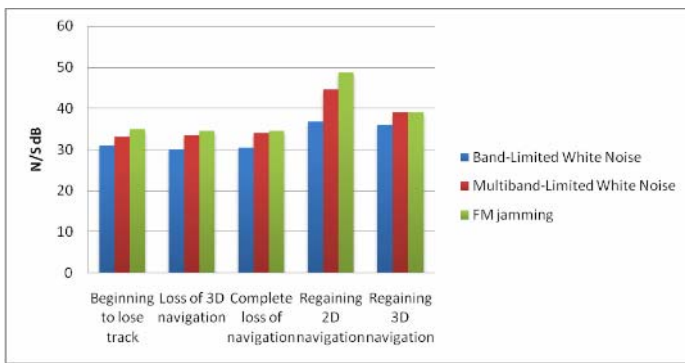
4 Comparisons between Results

As we mentioned above, Power received at L1 from each GPS satellite is -133 dBm, and Power received at L1 from each GPS satellite is -136. so to generate jamming signal we must generate jamming signal at range 1450-1600 and frequency offset is +- 9 MHz and PRF between 1HZ and 20 KHZ and DC is between 10% and 90% and J/S is between 7 dB and 80 dB.

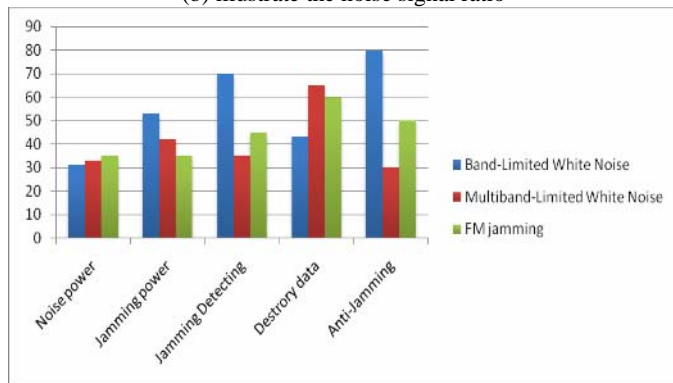
The problem is how to have enough power to override any signal at receiver and what is the range of jamming, so the comparison between all jamming GPS signal show in figure 8 where figure (a) illustrate the jamming signal ratio, it define when GPS receiver lose track and when to regaining, the FM jamming signal have the less jamming power and the most jamming GPS signal effect and band-limited white noise has a less jamming GPS signal effect. Figure (b) illustrate the noise signal ratio, it define when GPS receiver lose track and when to regaining. Finally figure (c) show the comparisons between all jamming GPS signal used in simulation. Where FM is the best jamming signal when use those signal in less jamming power and more noise and it is difficult to detect and Anti-Jamming [13, 14] but multi-band is more difficult to make Anti-Jamming on it, or to remove multi-band jam effect because its has been made with difficult technology and this technology has more data destroy effect on GPS signal.



(a) illustrate the jamming signal ratio



(b) illustrate the noise signal ratio



(c) comparisons between all jamming GPS signal used in simulation

Figure 8: comparisons between all Jamming GPS signal

5 CONCLUSIONS AND FUTURE WORK

GPS has rise as major application in military and civilian devices. GPS has been made too many applications like to get location and tracking, but some person’s misuse of using GPS. So Anti-GPS has rise as major application to prevent connection between satellites and GPS receiver. Most of GPS jammers are illegal to build or use in many countries or localities due to the potential for misuse. For instance, a GPS jammer can confuse aircraft and other vehicle instruments, possibly causing mishaps.

This paper has presented the major issues and problems associated with generating GPS jamming signal. We simulate jamming signal using matlab, and make Anti-GPS fuzzy controller. Then make comparisons between all jamming technologies that use in simulation. Our future work is to make our simulation result in laboratory test.

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