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Optimum Work Frequency for Marine Monitoring Based on Genetic Algorithm

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Abstract

The communication using of HF (High Frequency) is a system that depends on wave propagation using sky waves reflected by the earth's ionosphere layer so that it is highly effective for long distance communication, but highly dependent on varying ionospheric conditions from day and night (time after time) as well as the location of the transmitter and receiver radio. Currently, there is only one main frequency channel and one reserve frequency channel so that there are frequency constraints unable to communicate due to ionosphere changes. This research will predicted allocation of HF frequency to support long distance communication for marine monitoring using Genetic Algorithm method. Output or prediction results in the form of Optimum Work Frequency (OWF) for 24 hours and frequency graph.

Keywords*: Frequency prediction; Genetic algoritm; OWF; MUF*

1. Introduction

Indonesia's marine wealth is very vulnerable to the theft of sea resource so there are several technological innovations aimed at keeping the Indonesian sea from illegal fishing, crime in the border region or who use the border crossing. The surveillance of illegal fishing activities is a critical issue for the management of marine resources [1]. Border areas, both on land and at sea is one of the locations prone to crime. Measures that have been taken by the government, among others through the social-economic approach and security [2].

Many efforts have been made to secure Indonesia's marine territory, especially in border areas, but it requires a considerable amount of funding. One of those is in [2] which consist of three subsystems monitoring. Expected Integrated Surveillance System is able to improve the performance of agency-related agencies, which are replied the border of the region and this technology use cellular provider (GSM). The VMS (Vessel Monitoring System) collects global positioning system (GPS) positions of the fishing vessels that are transmitted typically hourly to the Fisheries Monitoring Centre by satellite communication (Argos, Inmarsat, Iridium, and Garuda-1). The use of satellite technology is certainly costly.

Therefore, it is proposed that the use of HF frequency in communicating between several elements in the field to monitor of Indonesian marine areas. The utilization of this HF frequency has been performed on [3] where it can predict the frequency of HF radio communications for frequency management. The utilization of these frequency predictions is also used in [4] for remote communications for monitoring Indonesian marine territories. The system that used uses a tool that is named ASAPS and not depends on the service provider and satellite technology. In this paper, it will propose the use of genetic algorithm method in optimizing the use of HF frequency in making frequency prediction.

The frequency range of HF (High Frequency) is not very wide only in the range 3-30 MHz. Optimization of frequency usage in this range has been done in previous research studies conducted in the form of prediction between fixed places with a predetermined area. Predictions are performed to be able to choose the Best Usable Frequency (BUF) between the available set of frequencies for communication from one station fixed to a location where the mobile station is located. This research will investigate about the allocation of frequencies of HF that will be predicted to be used in long distance communication using Genetic Algorithm method. Genetic algorithm (GA) simulates the reproduction, crossover and genetic mutation in natural selection and natural inheritance and it is a randomized search algorithm by referring to the natural selection and genetic mechanism in the biological world. [5]. Genetic algorithm is a useful way

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for complicated optimization [6]. GA is a population based algorithm that generates multiple solutions each iteration. The number of solutions per iteration is called population size. Each solution is represented as a chromosome and each chromosome is built up from genes. For a genetic algorithm of population size n, it starts with n random solutions. Then it chooses the best member solutions for mating to generate new solutions.

HF frequency uses the highest atmospheric layer of the ionosphere. The ionosphere is a layer of air that is part of the upper atmosphere of the earth located at an altitude of 60 km - 600 km above the earth's surface. The Ionospheric layer has the ability to reflect high-frequency radio waves. The frequency of the reflected radio waves depends on the electron density, the higher the electron density of the layer the higher the reflected frequency.

Communication systems using HF radio wave transmission technology is a self-contained communication system in which is not dependent on the service provider. HF communication works on frequencies between 3 - 30 MHz. The wave propagation properties with the HF frequency using sky waves reflected by the earth's ionosphere layer are highly effective for long-distance communication but are highly dependent on varying ionospheric conditions from day and night (time to time) and the location of transmitter and receiver radios [7].

Communication using High Frequency is not only for users between two different places but also for mobile communication both for land, sea and air. The dependence of the use of HF frequency (3-30 MHz) under natural conditions leads to the need for frequency prediction, to get a good reference frequency used to communicate at a time. Predictions are performed to be able to select the Best Usable Frequency (BUF) between sets of frequencies available for communication from a fixed station to a location where the station moves. The frequency prediction programming package that will be used for frequency management and channel evaluation can be selected according to the needs of regulatory agencies. Output or prediction results are Optimum Work frequency (OWF) for 24 hours, frequency graph. This research will use genetic algorithm method to optimize frequency selection by using OWF parameters to obtain optimum frequency value.

2. Determination of Optimum Work Frequency (OWF)

2.1 OWF using foF2 maps dan M (3000) F2

The optimal use of working frequency or OWF (Optimum Work Frequency) is equal to 15% from MUF (Maximum Usable Frequecy) value. The communication between Jakarta and Tanjung Pinang in January 2016 at 00.00 WIB, use frequency 6 MHz and 7 MHz as depicted in Figure 1. M index (3000) F2 on the Jakarta-Tanjung Pinang track of 3.1 as depicted in Figure 2. The OWF Jakarta-Tanjung Pinang is between 8.13 MHz and 9.48 MHz, the average frequency is 8.8 MHz.

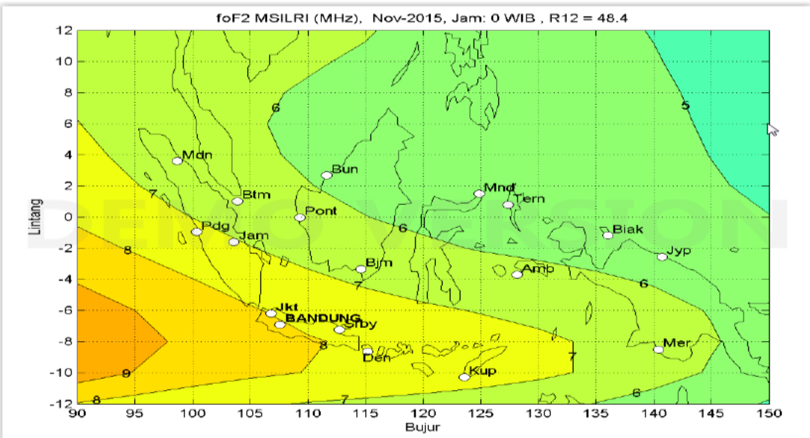

Figure 1. Map of foF2 in January 2016, hour: 00.00 [1]

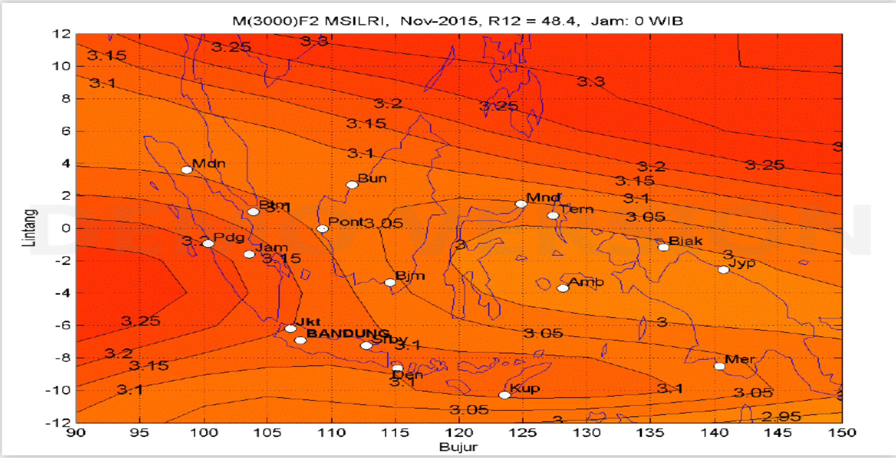

Figure 2. Map M Index (3000) F2 hour: 00.00

2.2 OWF using the Highest of Ionosphere Layer

Assuming the height of the ionosphere h_v=300 meters (night), while the critical frequency value (fc) using the foF2 value. The Optimum Work Frequncy (OWF) for communication from Jakarta to Tanjung Pinang is between the frequency of 8.83 MHz and the frequency of 10.3 MHz. The average frequency is 9.57 MHz. The difference in OWF values in the two calculation models is due to the height of the ionosphere and fc/foF2 layers. To obtain the height of the ionosphere layer and the critical frequency (fc/ foF2), it is necessary to observe by the ionosonda method by emitting HF frequency signal from the transmitting station (Sta. A) each hour to the emission received by the ionosonda equipment at the receiving station (Sta B) continuously for 24 hours. Ionosoda will calculate the results of signal reception and present the results of the ionosphere layer and critical frequency at each hour for 24 hours.

3. OWF using Genetic Algoritm

3.1. Decoding

The MUF and OWF values use the frequency variables. The HF frequency range is 3-30 MHz so the encryption of this critical frequency value uses using 8 bits starting with the smallest 3 MHz range value coded to 0000 0000 and the largest range of 30 MHz with code 1111 1111 as shown in Table 1.

Table 1. Decoding of Frequency

No	Individual	Frequncy (MHz)
1	0000 0000	3
2	0000 0001	3.10
3	0000 0010	3.21
4	0000 0011	3.31
5	0000 0100	3.41
6	0000 0101	3.52
7	0000 0110	3.63
8	0000 0111	3.73
9	0000 1000	3.84
10	0000 1001	3.95
11	0000 1010	4.05
….	……………….	……………….
….	……………….	……………….
….	……………….	……………….
250	1111 1101	29.68
251	1111 1110	29.79
252	1111 1111	29.89

By using a certain interval, the lower limit of r_b and the upper limit of r_a, the coding can be done in the formula as follow:

$$x = r_b + (r_a - r_b)g \text{ [8]} \quad (6)$$

Example:

x_1 = 0111 1111

Decoding into decimal numbers so that it becomes:

$$\begin{aligned} x_1 &= 3 + (30-3)((0x2^{-1}) + (1x2^{-2}) + (1x2^{-3}) + (1x2^{-4}) + (1x2^{-5}) + (1x2^{-6}) + (1x2^{-7}) + (1x2^{-8}) \\ &= 3 + 27(0 + 0.25 + 0.125 + +0.0624 + 0.03125 + 0.015625 + 0.0078125 + 0.00390625 \\ &= 16.39 \end{aligned}$$

The value of 0111 1111 equals 16.39 MHz

3.2. Fitness Function

In general, the choice of a fitness function is one of the more difficult steps in constructing an optimal GA, as the decision is not only problem specific but inherently dependent upon the genotype representation used [9]. The fitness function for determining the OWF is shown in this formula:

$$Fitness = \frac{\left(\frac{f_A+f_B}{2}\right)}{\left(\frac{f_A+f_B}{2}\right)+\left(f_x-\left(\frac{f_A+f_B}{2}\right)\right)^2} \quad (7)$$

Where:
f_A=The upper limit of frequency
f_B=The Lower limit of frequency
f_x=Selected frequnecy

3.3. Population Initialization

Population Initialization is the proposed solution that forms individual and the selected frequency is 8.835 MHz up to the frequency of 10.308 MHz, then for the initial population is raised between the frequencies of 8.6 MHz to 10.5 MHz as shown in Table 2.

Table 2. Population Initialization

No	Individual	Frequency (MHz)	Fitness
1	0011 0101	8.6	0.177
2	0011 0110	8.7	0.9296
3	00110111	8.8	0.9443
4	00111000	8.9	0.9576
5	00111001	9	0.9692
6	00111010	9.1	0.9792
7	00111011	9.2	0.9873
8	00111100	9.3	0.9934
9	00111101	9.4	0.9976
10	00111110	9.5	0.9997
11	00111111	9.6	0.9997
12	01000000	9.7	0.9976
13	01000001	9.8	0.9934
14	01000010	9.9	0.9873
15	01000011	10	0.9792
16	01000100	10.1	0.9692
17	01000101	10.2	0.9576
18	01000110	10.3	0.9443
19	01000111	10.4	0.9296
20	01001000	10.5	0.9177

3.4. Selection

The selection method used for this research is roulette-wheel and this is a commonly used method. The chromosomes that occupy the greatest fitness value occupy larger circle cuts with chromosomes that have low fitness values as in Table 3.

Table 3. Fitness Value Rank

No	Individual	Frequency (MHz)	Fitness
1	00111111	9.6	0.9997
2	00111110	9.5	0.9997
3	01000000	9.7	0.9976
4	00111101	9.4	0.9976
5	01000001	9.8	0.9934
6	00111100	9.3	0.9934
7	01000010	9.9	0.9873
8	00111011	9.2	0.9873
9	01000011	10	0.9792
10	00111010	9.1	0.9792
11	01000100	10.1	0.9692
12	00111001	9	0.9692
13	01000101	10.2	0.9576
14	00111000	8.9	0.9576
15	01000110	10.3	0.9443
16	00110111	8.8	0.9443
17	01000111	10.4	0.9296
18	0011 0110	8.7	0.9296
19	01001000	10.5	0.9177
20	0011 0101	8.6	0.9177

The selection process with the roulette wheel, go through the following steps:

1. Calculating the fitness value of each individual. The fitness formula has been previously formulated in equation 7 as shown in Table 4.
2. Calculating the total fitness value of all frequencies.
   Total Fitness=19.35
3. Calculating the probability of each individual. The following is the probability value of each individual in Table 4:

Table 4. Probability of individual

No	Individual	Frequncy (MHz)	Fitness	Probbaility Value
1	0011 0101	8.6	0.9177	0.0474
2	0011 0110	8.7	0.9296	0.0480
3	00110111	8.8	0.9443	0.0488
4	00111000	8.9	0.9576	0.0495
5	00111001	9	0.9692	0.0501
6	00111010	9.1	0.9792	0.0506
7	00111011	9.2	0.9873	0.0510
8	00111100	9.3	0.9934	0.0513
9	00111101	9.4	0.9976	0.0516
10	00111110	9.5	0.9997	0.0517
11	00111111	9.6	0.9997	0.0517
12	01000000	9.7	0.9976	0.0516
13	01000001	9.8	0.9934	0.0513
14	01000010	9.9	0.9873	0.0510
15	01000011	10	0.9792	0.0506
16	01000100	10.1	0.9692	0.0501
17	01000101	10.2	0.9576	0.0495
18	01000110	10.3	0.9443	0.0488
19	01000111	10.4	0.9296	0.0480
20	01001000	10.5	0.9177	0.0474
	Total		19.3521839914	1

4. Calculating the quota of each individual between 1 to 100

For the first individual to be assigned a value of rations from 1 to 4.74 then the next sequence increases in value from from 4.74 to 4.75 for the second individual in section 4, 75 to 9.54. It will continue until to 20th individual and ends up to a value of 100 (1) as shown in Table 5.

Table 5. Allocation for each individual

No	Individual	Frequency (MHz)	Fitness	Probabilty	Prosentase	Allocation
1	0011 0101	8.6	0.9177	0.0474	4.74	1 – 4.74
2	0011 0110	8.7	0.9296	0.0480	4.80	4.75 – 9.54
3	00110111	8.8	0.9443	0.0488	4.88	9.55 – 14.43
4	00111000	8.9	0.9576	0.0495	4.95	14.44 – 19.39
5	00111001	9	0.9692	0.0501	5.01	19.40 – 24.41
6	00111010	9.1	0.9792	0.0506	5.06	24.42 – 29.48
7	00111011	9.2	0.9873	0.0510	5.10	29.49 – 34.59
8	00111100	9.3	0.9934	0.0513	5.13	34.60 – 39.73
9	00111101	9.4	0.9976	0.0516	5.16	39.74 – 44.90
10	00111110	9.5	0.9997	0.0517	5.17	44.91 – 50.08
11	00111111	9.6	0.9997	0.0517	5.17	50.09 – 55.26
12	01000000	9.7	0.9976	0.0516	5.16	55.27 – 60.43
13	01000001	9.8	0.9934	0.0513	5.13	60.44 – 65.57
14	01000010	9.9	0.9873	0.0510	5.10	65.58 – 70.68
15	01000011	10	0.9792	0.0506	5.06	70.69 – 75.75
16	01000100	10.1	0.9692	0.0501	5.01	75.76 – 80.77
17	01000101	10.2	0.9576	0.0495	4.95	80.76 – 85.71
18	01000110	10.3	0.9443	0.0488	4.88	85.72 – 90.6
19	01000111	10.4	0.9296	0.0480	4.80	90.61 – 95.41
20	01001000	10.5	0.9177	0.0474	4.74	95.42 - 100
	Total		19.352	1		

From Table 5 above, we can transform in pie diagram as shown di Figure 3.

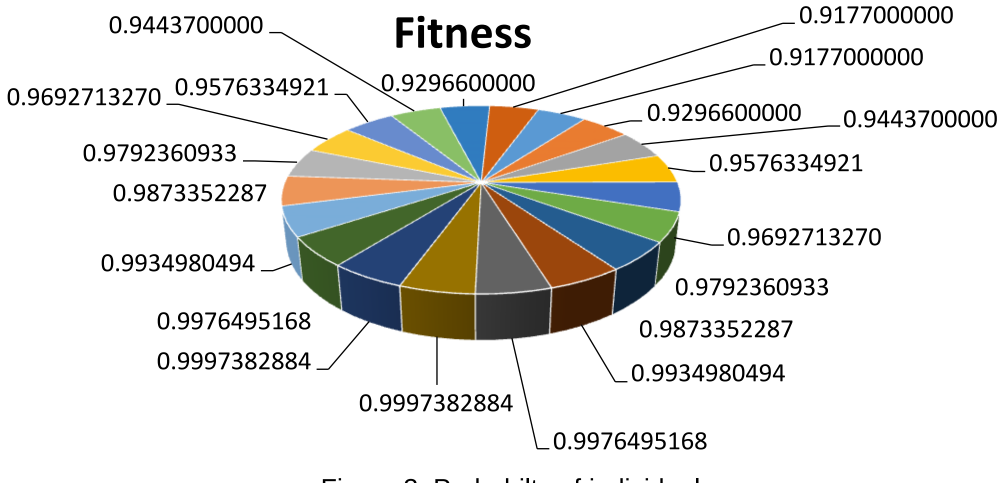

Figure 3. Probabilty of individual

The selection method used here is with the roulette wheel. It aims to select individuals who will experience crossovers and mutations.

3.5 Crossover and mutation

Crossover when done only if a random number 0 s / d 1 is generated less than the specified Pc. The value is set at 0.8. In the selection process that has been done before, based on the fitness value that has been set. The process that plays a role in replacing the missing genes of the population due to the selection process that allows the re-emergence of genes that do not appear in the initial population is determined at a value of 0.05.

3.6 Result

The following is the comparative result of calculations based on foF2 maps, ionosphere height, ASAP software and Genetic Algorithm (GA) in Table 6 with first mode. The antenna elevation angle is set at 28 to 44 degrees for first mode and the distance from Jakarta Tanjung Pinang is 845 km. From table above, it can be concluded that frequency based on GA method daytime is higher than nighttime because in daytime density electron is larger than in nigh time. The frequency of the reflected radio waves depends on the electron density, the higher the electron density of the layer the higher the reflected frequency. If it compare with another method (foF2, Fc and ASAP), it tend to have the same pattern with GA. The graph of these methods is shown in Figure 4.

Table 6 The OWF frequency with first mode

WIB	foF2	Fc	ASAP	GA
1	9.3	9.9	6.5	8.6
2	10	10.6	7.3	9
3	10.3	10.9	7.8	9.7
4	10.8	11.4	8	10.1
5	11	11.6	8.3	11
6	11.1	11.7	8.7	11.1
7	11.2	11.8	9.1	11.2
8	11.1	11.8	9.2	11.2
9	11.2	11.9	9	11.3
10	11.1	11.8	9	11.2
11	10.4	11.1	9	10.5
12	9.8	10.5	8.4	8.6
13	9.7	10.4	7.7	9.8
14	9.8	10.5	7.2	9.9
15	9.7	10.4	7.2	9.8
16	8.6	9.3	7	8.7
17	7.7	8.4	6	8.7
18	7.2	7.9	5.3	9.9
19	6.5	7.2	5	8.7
20	5.7	6.4	4.4	8.9
21	5.2	5.9	3.7	8.8
22	4.8	5.5	3.4	8.6
23	6.4	7.1	3.2	8.9
24	8.8	9.5	4	9.6

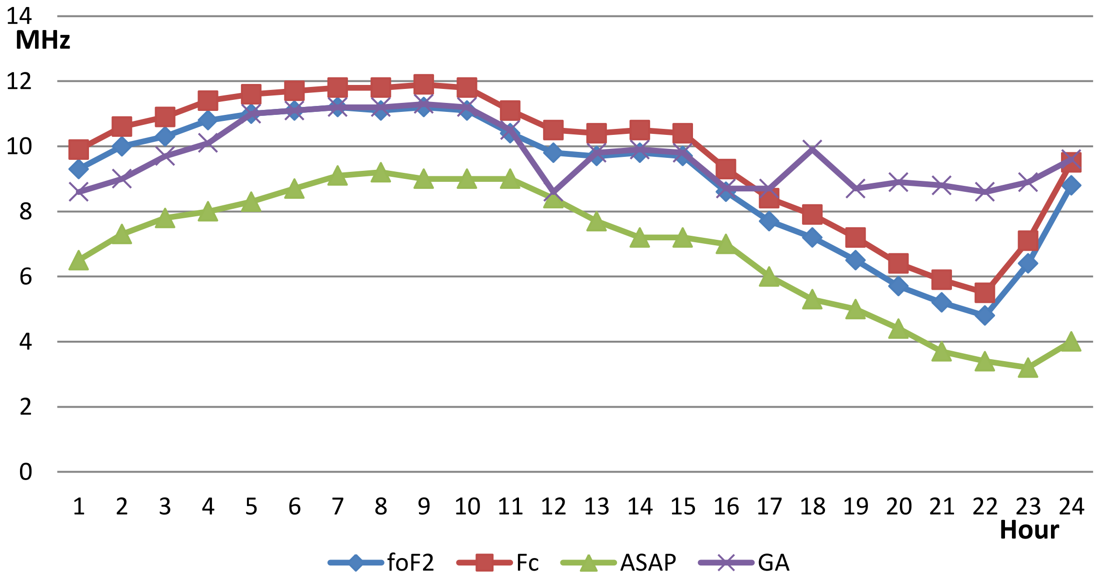

Figure 4 Frequency Graph of JKT-TPI In January 2016 (1F dand1E)

In second mode, the antenna elevation angle is set at 48 to 63 degrees. If we compare with first mode, the resulted frequency is higher than first mode because elevation antenna depends on the location of transmitter and receiver radios. The OWF frequency with second mode is shown in Table 7 and the frequency graph in Figure 5

Table 7 The OWF frequency with first mode

WIB	foF2	Fc	ASAP	GA
1	12.1	12.7	9	11
2	12.3	13	9.2	12.7
3	12.9	13.5	9.4	9.1
4	14.1	14.7	9.9	9.6
5	15.1	15.7	10.6	10.3
6	16.1	16.7	11.3	11
7	16.5	17.1	11.5	11.2
8	16.4	17	11.1	10.8
9	16.2	16.8	11	10.2
10	16.2	16.8	11	10.7
11	15.6	16.2	10.1	9.8
12	14.9	15.5	9.1	11
13	14.3	14.9	8.8	10.8
14	14.4	15	8.8	8.6
15	14.5	15.1	8.9	9.1
16	12.7	13.3	7.8	8.9
17	11.2	11.8	6.8	9.6
18	10.3	10.9	6.3	8.7
19	10.3	10.9	5.5	8.9
20	9.8	10.4	4.6	8.6
21	9.1	9.7	4.3	10.8
22	8.6	9.2	4	9
23	8.9	9.5	5.2	8.6
24	11.2	11.8	8.3	11

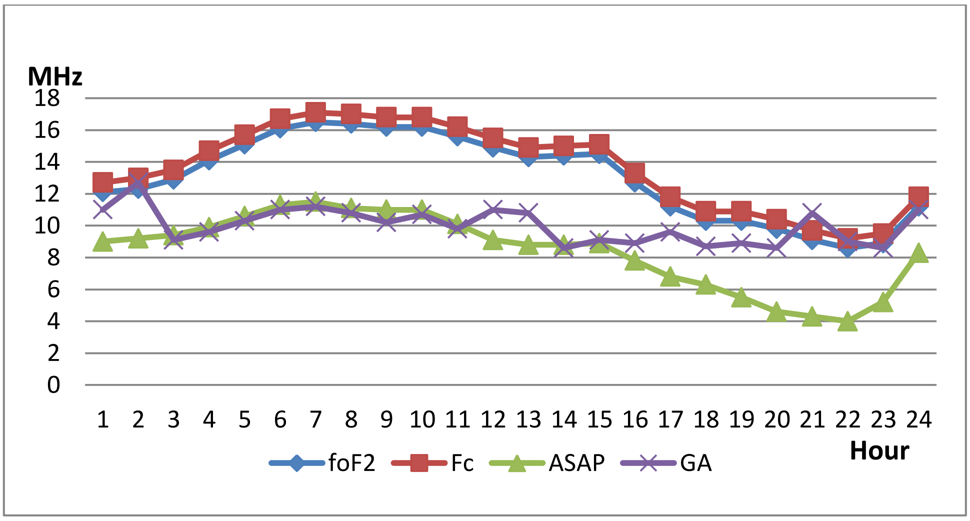

Figure 5. Frequency Graph of KT-TPI in January 2016 (2F and 2E)

4. Conclusion

The parameter used in frequency determination is OWF values that calculation results obtained the greatest fitness value is the frequency 9.5 and 9.6 MHz obtained on the fitness value 0.9997. Frequency prediction using genetic algorithm OWF parameters for communication from Jakarta to Tanjung Pinang using using two modes. The modes are 1F, 2E mode and 2F, 2E mode with different antenna elevation.The resulted frequency depends on the density electron in daytime or night and antenna elevation. The higher the electron density of the layer the higher the reflected frequency.

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