

Parameters Quality Performance of Signal Fluctuation Based on Data Grouping

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Abstract— The study represents an analysis of several parameters of fluctuating signal quality, which has not been previously carried out. H₂O and H₂O materials mixed with NaOH have undergone the data acquisition process with a capacitive sensor and produced a high fluctuation signal. Next, the data grouping method for each material is created to obtain the standard deviation value. In addition, several signal quality parameters in the analysis process are calculated, such as power and signal-to-noise ratio (SNR). In the next stage, the results of the two materials based on their data grouping of three groups are compared: per 20, per 50, and 100 data groups. After that, the preprocessing stage calculates each data group's standard deviation value. Furthermore, the signal quality parameters in the signal processing process are gained, namely power and SNR. Here are some fruitful points: the group's highest power and SNR values per 20 data. So, this is because grouping into smaller groups will be better where the values are not that quite different.

Keywords—Signal fluctuation, High fluctuation, Data grouping, Signal quality, Analysis process.

I. INTRODUCTION

To determine whether a signal is or not, it is necessary to analyze the parameters of the signal quality. This parameter is in the form of signal-to-noise ratio (SNR) and the signal's power quality. SNR parameter analysis has been used to detect small amplitudes at pressure fluctuations caused by wind noise by processing using FFT. By using the pressure-sensitive paint (PSP) technique, the SNR value can be increased [1].

SNR calculations have also been performed for orthogonal frequency division multiplexing (OFDM) signals using the blind estimation method. This research can prove the accuracy of theoretical analysis with simulation [2]. Besides, SNR calculations are performed to analyze the hard disk drive's thermal stability (HDD) [3]. Likewise with research related to SNR that has been done previously [4], [5].

Furthermore, the quality parameter of the power has been used to analyze the signal using the detrended fluctuation analysis tool (DFA) technique approach. Also, signal power is

used for fast random fluctuations, where the test is performed effectively to detect dynamic errors [6]. Then, the signal power calculation is also used to evaluate traction substations. By calculating the power of the signal fluctuation, it is found that the impedance affects both large-scale fluctuations and jump currents [7].

Then, the research on the quality of a single or combined power was measured using fuzzy logic algorithms and particle swarm optimization (PSO) [8]. Also, power quality has been measured using discrete wavelet transform and wavelet network to see the interference. This technique can detect signal quality with a wide range of high accuracies, such as dc offset, flicker, and interference [9]. Here, the calculation of power quality is also used in this study [10]–[12].

To calculate the signal quality parameters, we try to calculate the standard deviation. Analyses of the standard deviation have been used to estimate noise in signals having unknown probabilities [13]. Moreover, standard deviation calculation has been used in previous studies to remove noise in wavelet images. Using this method could increase the value of SNR, and good visual quality is achieved [14]. The standard deviation has also been used to estimate the reliability of failure in selecting optimal data [15]. The research related to standard deviation was also carried out in this study [16]–[18].

This data grouping method or combination data has been used to combine infrasonic signals from fireball meteors [19]. Also, this data combination is used to improve reversible data concealment [20]. Data grouping is also used in dynamic workload analysis of online music portals and elastic web infrastructures that are dynamically scaled to servers [21]. Research related to grouping data has also been carried out by previous researchers at [22, 23].

Previous researchers have researched grouping data with capacitive sensor results to find the mean value and VMR of fluctuation patterns [24]. The difference between our proposed and previous research is that the previous calculations only used statistical calculations and did not analyze the signal quality parameters obtained from the material data grouping method. However, this study did not

analyze the signal quality obtained from the material grouping data method. In previous studies, data combining was used to obtain an algorithm that could reduce redundancies in the group data for health data [22].

This study is an Advance works of previous studies [24] that has used the fast Fourier transform (FFT) method to convert data from the time domain to the frequency domain [25]. Thus, the contribution of this study is to analyze the signal quality parameters based on the standard deviation, power, and SNR values of several groups of these material data. The selection of these parameters can represent the performance of the quality of a signal [26]. We try to obtain signal quality parameters based on the power value and SNR of several groups of these material data. Furthermore, this study is to determine the signal quality of H2O and H2O mixed with NaOH, which has not been calculated in previous studies. This is very important for signal processing at a later stage to be processed more comprehensively to become one of the multispectral signal identification parameters. Two materials are used; namely, H2O and H2O mixed with NaOH. Where the material has gone through the identification process in research [24, 25, 27, 28]. The results obtained from this study were in the form of signal fluctuations with the high fluctuation type (HF).

Moreover, the grouping the data from 100 data for each material are proposed. The data will then be divided into three groups: per 20, per 50, and 100 data groups. This data grouping process is needed to simplify the amount of data obtained from previous data grouping research [24]. Then the preprocessing stage will be carried out by calculating the standard deviation value of each data group. After that, we calculate the signal quality parameters in the signal processing process, namely power and SNR. Hopefully, we can see in more detail which data group has the best signal quality parameters based on STD, SNR, and signal power values.

II. METHODOLOGY

A. Method Proposed

The entire process in this study uses a simulation of the MATLAB R2018 software. We are starting from a combination of data, signal processing, and calculation of signal parameters. Fig. 1 shows the stages used in this study. Each stage will be explained further in the next section.

B. Data Acquisition

This study uses HF signal data from previous studies obtained from multispectral capacitive sensors [28]. The data goes through the pre-preprocessing stage using Fourier transformations to change the data from the time domain to the frequency domain so that 600 sets of data are generated [29].

TABLE I. DATA PARAMETERS

No	Parameter	Information
1	HF Signal Matrix Data H2O Material	Matrix Size 8192 × 31
2	HF Signal Matrix Data H2O mixed NaOH Material	Matrix Size 8192 × 31
3	Total data	200 Data, 100 data each material
4	Input Frequency (MHz)	31 Number of Frequencies: 0.001, 0.0015, 0.002, 0.003, 0.004, 0.005, 0.006, 0.007, 0.008, 0.009, 0.01, 0.015, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09, 0.1, 0.15, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1

This study only uses 200 data sets with details, as shown in Table 1. Table 1 shows the HF signal data for H2O and H2O materials mixed with NaOH is in the form of a matrix with a size of 8192 x 31. The value 8192 represents the spectral amount in the matrix, while 31 represents the input frequency. The total HF signal data used are 100 data for H2O material and 100 data for H2O material mixed with NaOH.

C. Equations

Based on Table 1, the total data we use is 200. Therefore, to simplify data processing and analyze the results, we grouped the data into several groups, namely: per 20 data, per 50 data per 100 data. This process is carried out by finding the average value of the data group using the following equation [23]:

$$\bar{x} = \sum_{i=1}^n \frac{x_i}{n} \quad (1)$$

Where, x is data mean, n is total data, and i is data for- i

For more details, here are the steps for combining data with as much as X data. First of all, the HF signal data in the form of a matrix with a size of 8192 x 31, which has been obtained in the previous study, used 100 data for H2O and H2O materials mixed with NaOH. Then, the data is divided into 3 data groups, namely per 20, per 50, and per 100 data. Furthermore, the data sharing is done using the following equations, which is simulated with the MATLAB:

$$\text{Matrix A1} = \begin{bmatrix} a1_{11} & \dots & a1_{1n} \\ \vdots & & \vdots \\ a1_{m1} & \dots & a1_{mn} \end{bmatrix} \quad (2)$$

$$\text{Matrix Ax} = \begin{bmatrix} ax_{11} & \dots & ax_{1n} \\ \vdots & & \vdots \\ ax_{m1} & \dots & ax_{mn} \end{bmatrix} \quad (3)$$

$$\text{Matrix } \mu\text{Ax}_y = \text{Matrix A1} + \text{Matrix A2} + \dots + \text{Matrix Ax} \quad (4)$$

$$\text{Matrix } \mu\text{Ax}_y = \begin{bmatrix} a1_{11} + \dots + ax_{11} & \dots & a1_{1n} + \dots + ax_{1n} \\ \vdots & & \vdots \\ a1_{m1} + \dots + ax_{m1} & \dots & a1_{mn} + \dots + ax_{mn} \end{bmatrix} \quad (5)$$

Matrix A1 expresses the first sequence of data while Ax expresses the sequence of data to the x -th.

In addition, after the HF signal data goes through a combination process using (5), then the data is divided by 20, 50, and 100 for each data group. This combination process is carried out for H2O and H2O materials mixed with NaOH separately. Lastly, this data combination process produces 5 data groups for data per 20 data, 2 data groups for data per 50 data, and 1 data group for data per 100 data groups for each material with a matrix still measuring 8192 x 31.

D. Signal Processing

At this stage, the combined HF signal data will be processed by looking for the standard deviation value. The standard deviation is an index of how closely individual data are clustered around the mean [16]. The following are the steps involved in signal processing.

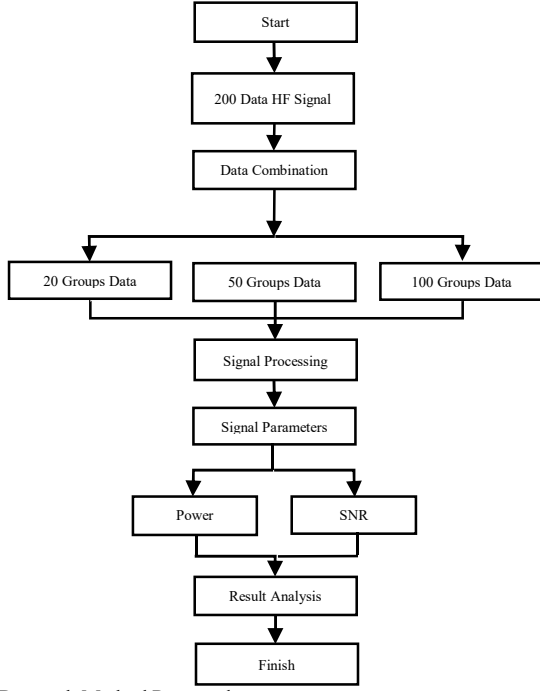


Fig.1. Research Method Proposed

To begin, the combined HF signal data is simulated again using MATLAB software with 16 data groups of data. The data's details are 5 data sequences per 20 data groups, 2 data sequences per 50 data groups, and 1 data sequence per 100 data groups for each material. Moreover, to find the standard deviation value, the (6) is simulated with MATLAB software [16].

$$STD = \sqrt{\frac{\sum_{i=1}^N (X_i - \bar{X})^2}{N - 1}} \quad (6)$$

Where, \bar{X} is mean, X_i is the x i -th value, N is sample size, and STD is Standard deviation. Furthermore, the results of the simulation of the calculation of Standard Deviation are 16 data that have been segmented into a matrix with a size of 1×31 .

The research that has been done using standard deviation is to calculate the frequency variation in the fuel deficiency condition [17]. Calculating the standard deviation of this study aims to measure the signal quality parameters using MATLAB software. Also, the standard deviation is used to weigh the output of the delay-and-sum (DAS) beamformer before image formation [18].

E. Signal Parameter

This study's signal quality parameters are signal power and signal to noise ratio (SNR). Signal power is the time average of energy (energy per unit time). Power has a non-zero and finite value [10]. Previous studies have used signal power calculations to compare leg muscles between healthy and stroke subjects based on electromyography (EMG). This power measurement is reliable because it shows logical behavior [11]. The following is an equation used to calculate the power of a signal [10].

$$P_f = \lim_{T \rightarrow \infty} \frac{1}{T} \int_{-\frac{T}{2}}^{\frac{T}{2}} (|f(t)|)^2 dt \quad (7)$$

Where, S is signal average power (Watt), and N is noise power (Watt). After the calculation of the signal power value and SNR is carried out for each group of HF signal data for H₂O and H₂O mixed with NaOH, an analysis will be carried out to see which HF signal data group has the best value.

III. RESULT AND DISCUSSION

Research on grouping data that has been done previously using the same material has not yet analyzed the signal quality parameters [24]. The parameters analyzed are the power value and SNR of the signal. This study's simulation uses Matlab 2018a for data processing and calculation of signal parameters from group data. The HF signal data used is 100 data divided into 3 data groups: per 20 data groups, per 50 data groups, and 100 data groups. The data group per 20 data groups produces 5 data sequences, while the data group per 50 data groups produces 2 data sequences, and the data group per 100 data groups produces 1 data sequence. This difference in data grouping aims to simplify the analysis process by looking at which data group has the best stability in signal quality. In addition, the selected data is a sequence in the data acquisition process with H₂O material and H₂O material mixed with NaOH. Where data A1 shows data taken earlier than A2 and B1 and B2. The following is a table of data sequences for each data group. In the signal processing process, the standard deviation value is calculated to facilitate signal quality parameters. The signal quality parameters used for the study are the signal-to-noise ratio and signal power. Then an analysis will be carried out on each SNR and the power of the data group by looking for the best value.

A. Analysis HF Signal Pattern of H₂O and H₂O Mixed with NaOH

HF signal fluctuation patterns were analyzed using 3D graphics through MATLAB simulation. The x-axis on the graph represents the input in MHz units. The y-axis represents the noise or spectral present in the matrix in units of MHz. While the z-axis represents the amplitude value of the signal.

Based on Fig. 2, it can be seen that the signal of the HF fluctuation pattern of H₂O material does not have a significant difference. As highlighted in Fig. 2 (a), where the highest amplitude is at the 6th sequence input frequency with a value of 290.5. Then, in Fig. 2 (b), the high amplitude value starts from the lower frequency input, namely the 6th sequence with a value of 277.6. Whereas in Fig. 2 (c), the highest amplitude value is also found at the 6th sequence frequency input with a value of 282.3. These high amplitude values are indicated in red on the chart.

Furthermore, Fig. 3 shows the HF signal fluctuation pattern for H₂O mixed with NaOH. As determined in Fig. 3 (a), reveals that the highest amplitude value is at the 6th sequence input frequency with a value of 269.4. Furthermore, Fig. 3 (b) shows the highest signal amplitude is found at the 6th sequence frequency input 266.2. Likewise, in Fig. 3 (c), the highest amplitude value is found at the 6th sequence frequency input and a value of 267.8. The entire signal fluctuation pattern of H₂O mixed with NaOH has the highest amplitude value at the 6th sequence input frequency.

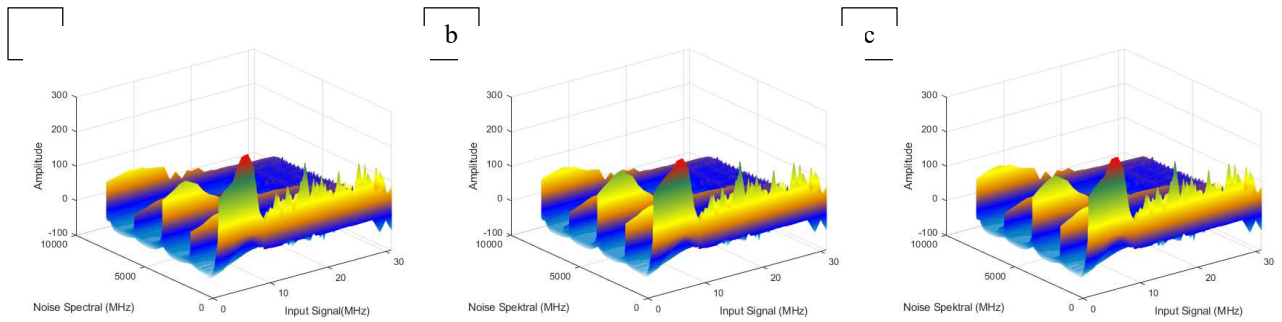


Fig. 2. Signal HF fluctuation pattern for H2O material (a) per 20 group data (b) per 50 group data (c) per 100 group data

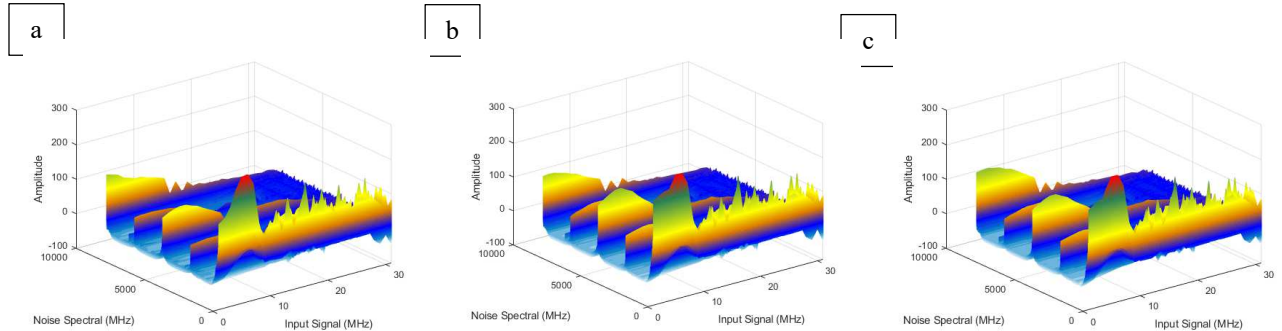


Fig. 3. Signal HF fluctuation pattern for H2O mixed with NaOH material (a) per 20 group data (b) per 50 group data (c) per 100 group data

This happens because at the input frequency, the reaction caused by the ARV method is very high [29].

B. Standard Deviation Analysis

HF signal data that has gone through a data combination process is processed using standard deviation to facilitate the analysis process. Fig. 4 shows the standard deviation value of the HF signal data per 20 groups of H2O and H2O material mixed with NaOH which is obtained by applying (6). Based on the graph, it is known that the value of The highest standard deviation is found at the 7th order frequency input, which is 0.006 MHz for both types of materials. The highest standard deviation values for H2O and H2O mixed with NaOH were 36.68 and 36.776 in A3 and A4 data. Meanwhile, the lowest standard deviation value is found on the 29th order frequency input, which is 0.6 MHz for both materials with data group A2 for H2O material with a value of 14,415 and group A1 data for H2O mixed with NaOH with a value of 13,366.

Furthermore, the value of the standard deviation of the HF signal data per 50 data groups obtained by equation (6) can be seen in Fig. 5 where the highest standard deviation value is also found in the 7th order frequency input. For the H2O material, the highest standard deviation value was 36,009 in the A1 data group, while for the H2O mixed NaOH material, the A1 data group also had a value of 36,686. The lowest standard deviation value is also found in the 29th order frequency input with 14,437 for the H2O material group A1 and 13,837 for the H2O material mixed with NaOH group A1.

Then, for the last data group, which is per 100 data groups, the highest standard deviation value is also found in the 7th order frequency input. Where in the H2O material, the highest standard deviation value is 35,727, while the H2O mixed with NaOH is 35,781. Meanwhile, the lowest standard deviation value is 14,453 for H2O and 14,293 for H2O mixed with NaOH. Based on the results of the standard deviation obtained

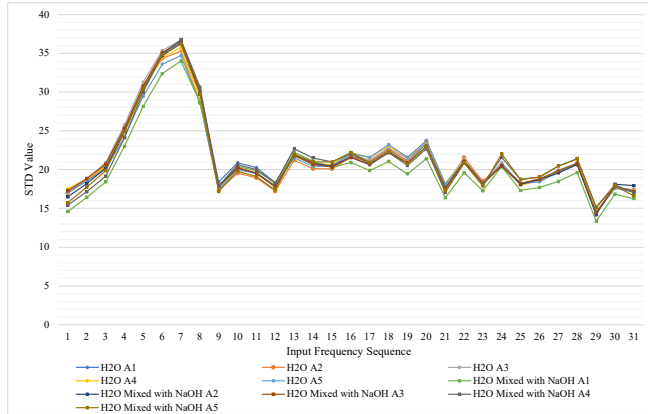
in the data group per 20, per 50 and per 100, it is known that the highest standard deviation value is found on the 7th order frequency input with a value of 0.006 MHz. This indicates that at the input frequency, the tested material (H2O and H2O mixed with NaOH) reacts to the Electrochemical Impedance Spectroscopy (EIS) technique used with the most consistent fluctuations and shows the best ARV [29, 30].

In addition, it can be seen that the resulting graphic pattern has the same trend for all data groups for both the H2O material and the H2O material mixed with NaOH. This is because the materials used are the same during the data acquisition process. The difference is only in the order of data collection, where A1 and B1 are data taken earlier than A2 and B2 .

C. Power Signal Analysis

After the HF signal fluctuation data group goes through the processing stage by calculating the standard deviation value, the power calculation is carried out first for each data group. Fig. 7 shows the power values of each group of HF material H2O signal data. Based on reference [12], the greater the power value than the better the signal quality is obtained. From this figure, we can notice that the data group per 20 groups of the 5th order has the highest power value equal to -1.065 dB. Meanwhile, the lowest power value is in the data group per 20 groups of the 3rd order, which is -3,652 dB. In this section, the 5th order signal fluctuates less or has a smaller std value than the 3rd order so that the power generated is greater. Like the material for the HF signal fluctuation data group for the H2O material, for the data group, the signal fluctuation for the H2O material mixed with NaOH, the power value was calculated. Based on the calculations obtained from figure 8, it can be seen that the data group per 20 data groups of the 5th order has the greatest power value, namely -2,621 dB. In contrast, the smallest power value is found in the data per 20 1st order data, which is -4.068 dB. The average value

of the power generated in the H₂O material fluctuation data group was more significant than the H₂O material mixed with NaOH. We can obtain this from the comparison between Fig. 7 and Fig. 8. This is influenced by the higher average standard



deviation of the H₂O material. In addition, the H₂O material does not react with other compounds to produce a better level of stability than the H₂O material mixed with NaOH.

Fig. 4. Comparison Standard Deviation value of 20 Groups Data of H₂O and H₂O mixed with NaOH

Fig. 5. Comparison Standard Deviation Value of 50 Groups Data of H₂O and H₂O mixed with NaOH

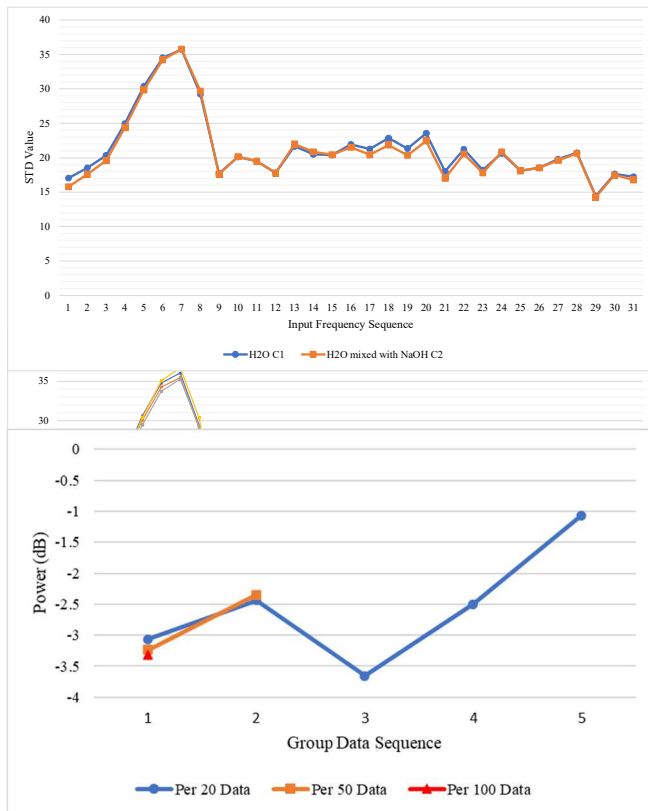


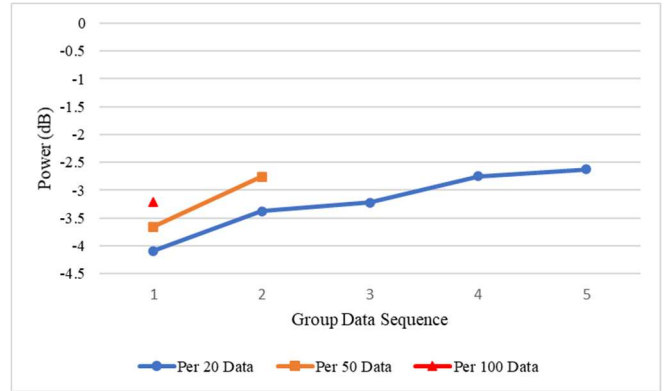
Fig. 6. Comparison Standard Deviation Value of 100 Groups Data of H₂O and H₂O mixed with NaOH

Fig. 7. Comparison Power Value of H₂O Data Groups

Fig. 8. Power Value of H₂O mixed with NaOH

D. SNR Analysis

The following calculation is the SNR value of each HF signal fluctuation data group. Fig. 9 shows the SNR values of each data set for the H₂O material. The greater the SNR value, the better the signal quality according to reference [2]. Based on Fig. 9, it is known that the greatest SNR value is found in the data per 20 data groups of the 1st order with a value of



0.331 dB. Meanwhile, the smallest SNR value is found in the data per 50 data groups of the 2nd order with a value of -2,327 dB.

In the HF signal group data for H₂O mixed with NaOH, the resulting SNR value is greater than that of H₂O alone, and this can be seen from Figure 9. Based on Figure 10, the most incredible SNR value is found in the data per 20 data groups of the 4th sequence with a value 3,593 dB. While the smallest SNR value is found in data per 20 data groups of the 1st order.

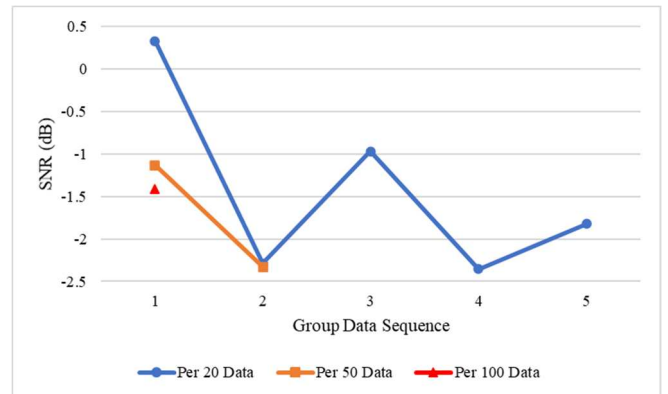


Fig. 9. Comparison SNR Value of H₂O Data Groups

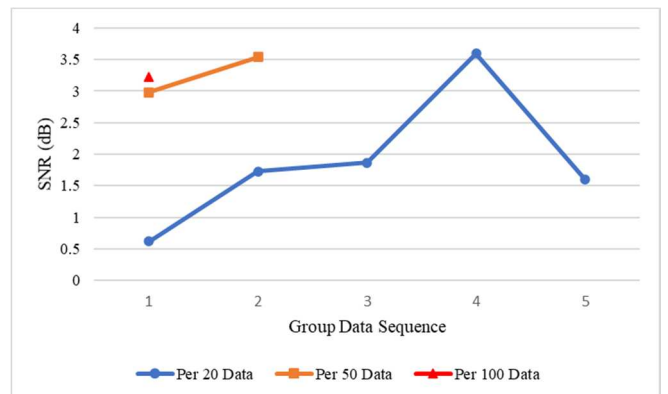


Fig. 10. Comparison SNR Value of H₂O mixed NaOH

Although the tremendous power value generated is found in the HF signal fluctuation data group per 20 data groups of the 5th order for H₂O material and H₂O material mixed with NaOH, this does not indicate that the resulting SNR value is good in the order of the data group. The reason is that the noise generated in the data group is more significant. This can be seen from Fig. 9 and Fig. 10, where the highest SNR value is not found in the data per 20 data groups of the 5th order.

IV. CONCLUSION

Based on the study that has been done, the data groups per 20, per 50, and per 100 data have almost the same fluctuation patterns from one another. Where the highest amplitude value is at the input frequency 4-7, this causes the need for analysis using SNR and signals power. Based on the calculation of signal power that has been carried out on H₂O and H₂O mixed with NaOH, the highest power value is found in the data group per 20 groups of the 5th order. As for the calculated SNR value for the data group, the highest value was found in the data per 20 groups of first-order data for H₂O and data per 20 groups of 4th data for H₂O mixed with NaOH. By using the data grouping method, analysis for large amounts of data is easier to do. This is because several data are combined into one, and the resulting SNR value will be better than the unit data.

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