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## Comparative Analysis of Material Fluctuation Response based on Data Set Groups

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# Comparative Analysis of Material Fluctuation Response based on Data Set Groups

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**Abstract.** Multi spectral capacitive sensor (MSCS) is a sensor that is formed based on the concept of white noise impedance spectroscopy. This concept utilizes the spectral noise frequency approach of the frequency domain signal resulting from the field effect on the dielectric. As a sensor, the consistency results obtained is stable, so that it can facilitate analysis. In this study, we tried to compare data groups, starting with 100 data sets and 300 data sets from a total of 600 data sets for H<sub>2</sub>O and H<sub>2</sub>O mixed with NaOH materials and H<sub>2</sub>O mixed with HCl using a new transformation, namely Tamsir statistical transformation (TST). Furthermore, grouping data uses the total amplitude value of each data set obtained. We obtain the results in the form of differences between groups of data with fluctuations in response patterns that are close together which are shown in 2D graphics. Hence, we can implement the data groups as a reference pattern of fluctuations in a material.

## 2. Introduction

Multi spectral capacitive sensor (MSCS) is a tool that works based on the fluctuations observations. It is represented by the statistical magnitude that are the average and the standard deviation of the spectral noise observed in a large number of data sets. Some researchers have used sensors to obtain information signal characteristics from the measured material, such as for monitoring the equipment conditions and the equipment temperature during the data acquisition stage [1-2]. Also, the equipment can detect the noise contained in the signal and extract it in the process of getting the initial data [3-4].

The data acquisition process by utilizing the MSCS system has been carried out by previous researchers [5-6]. Here, data processing uses a quite new approach or Tamsir transformation statistics, which has been done previously by [7]. Furthermore, the stages of data grouping in this study, we refer to the previous research by utilizing the total value of the amplitude from each data set obtained from each material [8].

We conduct the research to determine the ability of these sensors by identifying the molecules in certain materials, such as pure water, mixtures of chemicals, oils and etc. Moreover, the final product expected is a device that can detect or identify the content of a substance without direct contact between the sensor and the substance being tested, so it does not have destructive the properties. Lastly, we expect to compare the data group, which groups can be used as references for fluctuations response in a material using MSCS.



## 2. New Method of Tamsir Statistical Transformation (TST) for Multi Spectral Fluctuation Signals

The Tamsir Statistical Transformation Method (TST) is a quite new method for processing the multi spectral signals. Signal processing of data acquisition from the MSCS system that is already in the frequency domain, and then is processed by the multilevel statistical processing. The data are still in the time domain and are converted into the frequency domain using FFT. Furthermore, we process those into several stages, known as STA-01, STA-02, STA-N. STA is a naming for a new statistical processing approach method that has been developed previously [7].

### 2.1 Data Processing at stage of STA-01

The initial data are saved into the results of STA-01, the formula is shown as follow:

$$MF_1 = \mu_1 \quad (1)$$

$$HF_1 = \mu_1 \cdot \sigma_1 \quad (2)$$

### 2.2 Data Processing at stage of STA-02

STA-02 is the next step after processing is done at STA-01. In stage of STA-02, the data produce the following values by applying this formula:

$$MF_2 = \mu_{MF_1} \quad (3)$$

$$HF_2 = \mu_{HF_1} \quad (4)$$

$$HHF_1 = \mu_{HF_2} \cdot \sigma_{HF_2} \quad (5)$$

## 3. Research Method

### 3.1 The Research Object

We use the liquid material as an object in this study, which are H<sub>2</sub>O, H<sub>2</sub>O mixed NaOH and H<sub>2</sub>O mixed with HCl.

### 3.2 system of multi spectral capacitive sensor

Data processing is carried out automatically via personal computer (PC) using Matlab software into 2D (dimensional) graphics. We implement the system of MSCS that is referring to the previous study [5].

### 3.3 Data Processing

Data processing is done through the Matlab program using different configurations and test materials. The grouping of data sets refers to previous research using the total amplitude value [8]. However, in this study, there are only two types of data sets were used, namely 100 data sets and 300 data sets for H<sub>2</sub>O and H<sub>2</sub>O mixed NaOH, while H<sub>2</sub>O mixed with HCl materials used grouping 100 data sets and 200 data sets only. The following is a concise process of grouping data by using the total amplitude value [8]:

$$\text{Amplitude - total} = \frac{\sum_{i=1}^m \sum_{j=1}^n A_{ij} \cdot f_i \cdot f_j}{\sum_{i=1}^m \sum_{j=1}^n 1 \cdot f_i \cdot f_j} \quad (6)$$

Where:  $A_1$  : Value of amplitude 1  
 $A_2$  : Value of amplitude 2  
 $m$  : matrix  $m$  (8192)  
 $n$  : matrix  $n$  (31)  
 $f_i$  : frequency for  $n$   
 $f_j$  : frequency for  $m$

The grouping process is done by applying equation (6) to all data sets. It starts from the data set from the 1st to the 600th data set. Furthermore, the set data that has a range of adjacent a total values are grouped separately in sequence from the beginning to the end.

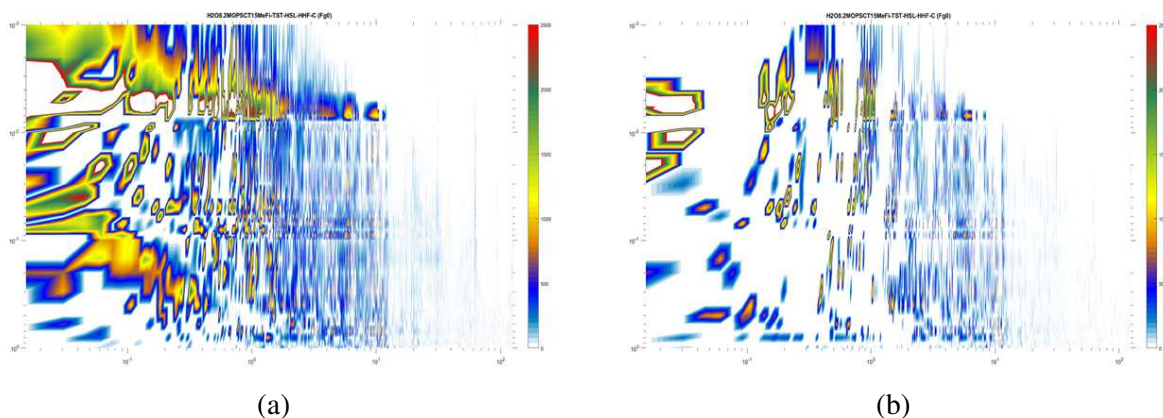
#### 4. Result and Discussion

Based on the methodology proposed, the results of this study show the fluctuations response represented in 2D graphics. It should be emphasized that from 600 data for  $\text{H}_2\text{O}$  and  $\text{H}_2\text{O}$  materials mixed with NaOH, the data comparison is only done for the first and second data groups, which is as much as 100 data sets and 300 data sets. As for  $\text{H}_2\text{O}$  material mixed with HCl, the comparison is only 100 data sets and 200 data sets, because the data for this material is only 300 data sets. Based on fluctuating patterns with clearer results, the results of fluctuations response from the HHF pattern are used. This is because this pattern gives a more significant picture for each ratio of fluctuating responsiveness for each ingredient when compared to MF and HF patterns.

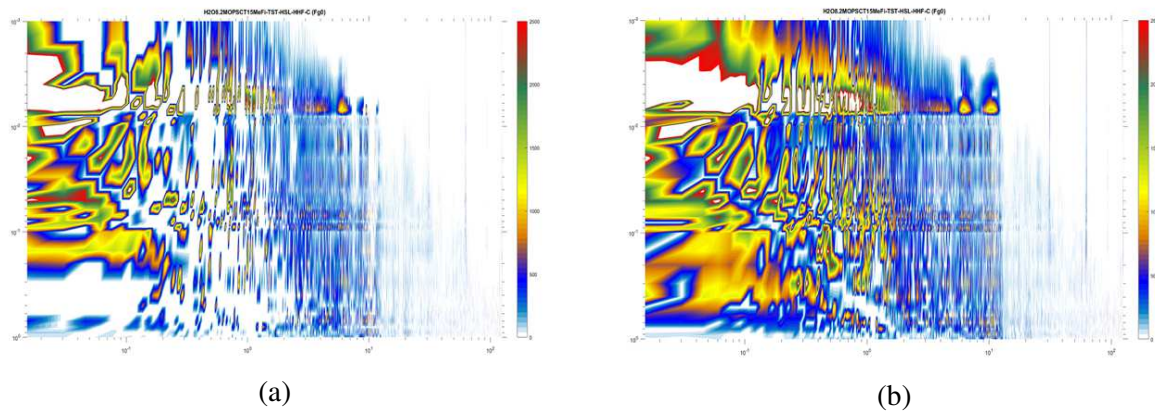
The X axis of the fluctuation response graph shows that the X axis is the spectral noise frequency in MHz, while the Y axis is the frequency input used in accordance with the initial data. In addition, this graph also presents several different colours that start from white, blue to red. So, it clearly shows the amplitude level, which starts from the smallest amplitude value to the highest amplitude value of the fluctuations occurred.

Furthermore, figures 1 and figure 2 show the results of the fluctuations response of  $\text{H}_2\text{O}$  with the HHF pattern. The differences of figure 1(a) and 1(b) are the result of the comparison of response fluctuations per 100 data sets for the first and the second, while figure 2(a) and figure 2(b) are the results of grouping per 300 data sets for the first and the second. Clearly, the grouping per 100 data sets in figure 1(a) and figure 1(b) show the fluctuations in the form of colours with the majority of white and blue. This phenomenon indicates the comparison of fluctuations that occur relatively small according to the HHF equation in (5). Then, the different things are shown in figure 2(a) and figure 2(b), the ratios of fluctuations response are more clearly seen with the appearance of a pattern that appears prominent and are followed by a higher amplitude value with increasing the numbers of yellow, green and red.

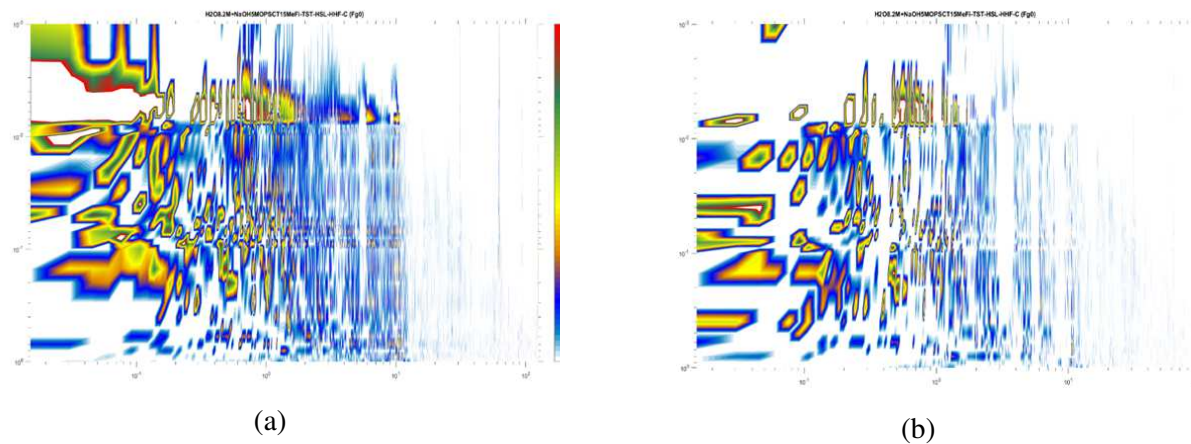
However, the striking views are revealed in figures 3(a) and 3(b). The graphs are the grouping of  $\text{H}_2\text{O}$  material data mixed with NaOH for per 100 data sets. Unlike the spread of fluctuations response of  $\text{H}_2\text{O}$ , the graphs of  $\text{H}_2\text{O}$  mixed with NaOH are more spread and less white are found. Then, slightly striking view are shown in figures 4(a) and 4(b) for grouping of  $\text{H}_2\text{O}$  mixed with HCl. Here, the results show clearer and more contrasting colours. It can be said that the fluctuation respiration has a higher amplitude value than those of the previous material.



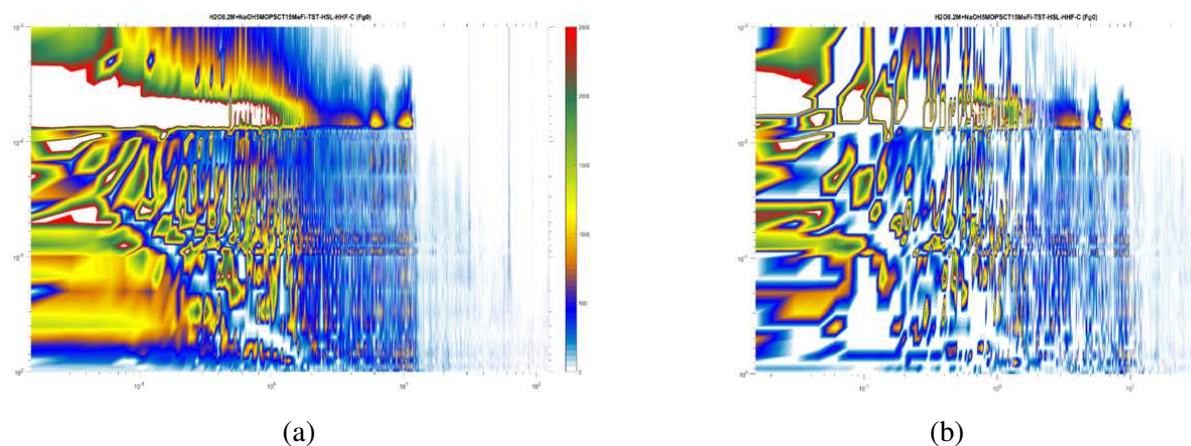
**Figure 1.** 3D HHF graph of  $\text{H}_2\text{O}$  for grouping per 100 Data Set (a) the First of 100 Data Set (b) the Second 100 Data Set



**Figure 2.** 3D HHF graph of  $H_2O$  for grouping per 300 Data Set (a) the First of 300 Data Set (b) The Second of 300 Data Set

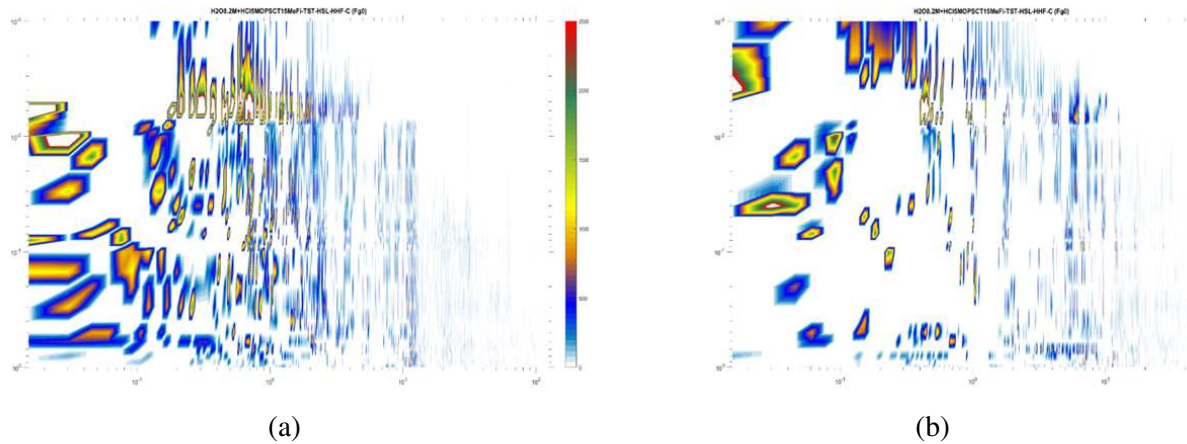


**Figure 3.** 3D HHF graph of  $H_2O$  mixed with  $NaOH$  for grouping per 100 Data Set (a) the First of 100 Data Set (b). The Second of 100 Data Set

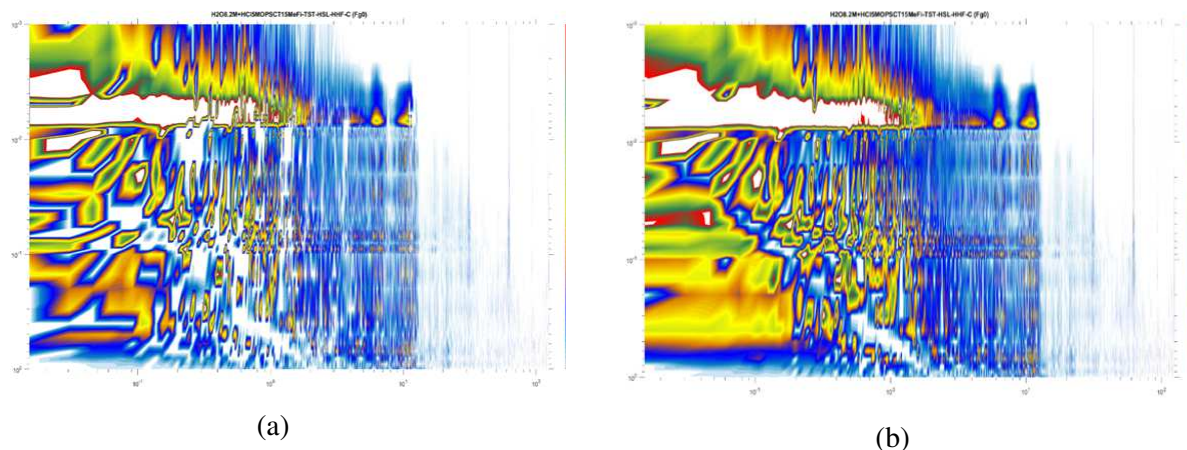


**Figure 4.** 3D HHF graph of  $H_2O$  mixed with  $NaOH$  for grouping per 300 Data Set (a) The First of 300 Data Set (b) The Second of 300 Data Set





**Figure 5.** 3D HHF graph of  $\text{H}_2\text{O}$  mixed with HCL for grouping per 100 Data Set (a) the First of 100 Data Set (b) The Second of 100 Data Set



**Figure 6.** 3D HHF graph of  $\text{H}_2\text{O}$  mixed with HCL for grouping per 200 Data Set (a) the First of 200 Data Set (b) The Second of 200 Data Set

Moving on to the results of the fluctuations response in  $\text{H}_2\text{O}$  mixed with HCL material in figure 4 and figure 6. We found that HHF fluctuations response show quite different view with the two previous ingredients. In addition, in the grouping per 100 data sets, in figure 5(a) and figure 5(b), there is a spread of the pattern form that is quite far different from the results of the response to previous pattern fluctuations. In addition, the fluctuations responses are also dominated by white, which indicates a low amplitude value. While figures 6(a) and figure 6(b) show a pattern that is slightly more similar to figure 4(a). However, at a greater frequency input value, the response of fluctuation pattern looks more clustered and fused compared to the two previous materials.

## 5. Conclusion

This research has obtained the results of fluctuations response. We apply a new approach method that is Tamsir transformation statistics. This is shown by grouping per 100 data set and 300 data set for  $\text{H}_2\text{O}$  and  $\text{H}_2\text{O}$  mixed with NaOH. In addition to  $\text{H}_2\text{O}$  mixed with HCL materials has the group of 100 data set and 200 data set. Particularly, the larger of data groupings show a clearer and more detailed response fluctuation pattern for each material compared to smaller data groupings. It is noticeable to

say that we can use the data groups as a potential reference of fluctuations pattern from the certain material in the subsequent studies.

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