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Bio mathematical Analysis on Impedance Measurement during COVID-19 Pandemic

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Abstract

The coating impedance size can reflect the aging degree of the coating to a certain extent; therefore, the measurement of the coating impedance size can monitor the aging degree of the coating in real time. Since the coating is traditionally considered as an insulating medium, its impedance value before aging is as high as 10^8 Ω or more, it is difficult to achieve accurate impedance measurement, and the current generated by loading by voltammetry at low voltage is very weak and easily affected by external electromagnetic interference noise, and the measurement accuracy is low. In this paper, by pluralizing the high impedance, establishing the mathematical model of differential amplification circuit, and then using sinusoidal fitting in which processing, so that the obtained signal is more accurate during COVID-19 pandemic.

Introduction

In the industrial field, impedance is an important parameter, and the measurement and analysis of impedance helps us to understand the changes of morphological characteristics of the object under test [1]. For example, in the oil and gas pipeline transmission system, the impedance of the pipeline corrosion protection layer needs to be measured to grasp its service life [2]; in the field of biomedicine, the clinical application of bio impedance technology has a great front [3]; in the field of corrosion monitoring, the monitoring of aircraft coatings, which is an effective means to prevent corrosion of the base metal [4], these belong to the category of high impedance measurement, with an impedance of up to $10^8\Omega$. Therefore, in the processing of these weak signals processing, the idea of sinusoidal fitting is used to process to obtain more information during COVID-19 pandemic [5].

Differential amplifier circuit mathematical model

The excitation signal is formed by bucking the sine signal generated by filtering, assuming that the bucking scale factor is k_1 and the amplitude of the sine signal before bucking is A, the excitation signal is expressed as:

$$(t) = k_1(\omega t) \qquad (1)$$

If the differential amplification is k_2, the output V_o of the differential amplifier circuit and the input V_i satisfy the following vector relationship:

$$V^{\cdot} = \frac{k2ZX}{ZX + ZO} V^{\cdot} \qquad (2)$$

Translated into a specific functional form of time it can be expressed as:

$$V(t) = \frac{k1k2|ZX|}{|ZX + ZO|}(\omega t + \varphi) \qquad (3)$$

Z_0: Reference impedance, standard resistance is generally used in measurement circuits.

φ: Difference between Z_x and the impedance angle of $Z_x + Z_o$.

If the presence of the input capacitance C_0 of the amplified input system is not considered, is the measured coating complex impedance Z_c, and if the presence of the input capacitance is considered, it is the combined impedance of the coating complex impedance in parallel with the capacitance, satisfying the following relationship [6, 7].

Understanding of sine fitting

Simple moving average method

First, we use the simple moving average method to feel the meaning of "moving".

There is a sequence as follows (Table 1).

If a moving average with a window of 5 is used, the element with a sequence of 11 and a value of 2 should be replaced with

$p11 = (8 + 5 + 2 + 1 + 3)/5$

Then the element with a sequence of 12 and a value of 1 should be replaced with

$p12 = (5 + 2 + 1 + 3 + 6)/5$

For fast calculation, the following formula can be used for recursion

$p12 = (5 * p11 + 6 - 8)/5$

Simple moving average is defined as: Simple moving average of data

$P1, P2, ..., PM$ with window n:

In MATLAB, there is a corresponding smooth function available.

Table 1: Sequence table.

Sequence	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Value	3	5	3	7	7	10	9	6	8	5	2	1	3	6	7

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We can use $matlab$ to verify smooth (y, span). The following figure shows the result of data (Figure 1).

Digital sine fitting

We can draw the following discrete curve by inputting the following commands in the $matlab$ command line window

>>$i = 0{:}\ 100$;

>>$y = 2 * (2 * pi * i./25 + pi/4) + 3$;

>> $plot(i, y)$;

(Figure 2, 3)

If each point of the above discrete curve is defined by

$x_i = A\ co(\theta + \Delta_i) + \varepsilon_i + C$

Since the known curve is drawn, the above parameters can be easily obtained, and the error of each point is 0. However, for a relatively disordered sequence, there will always be a certain deviation from the ideal curve, so the error will not be 0, but our purpose is to find a curve that is closest to it, and the evaluation standard is the sum of squares of errors, which is consistent with the least square method (Figure 4-6).

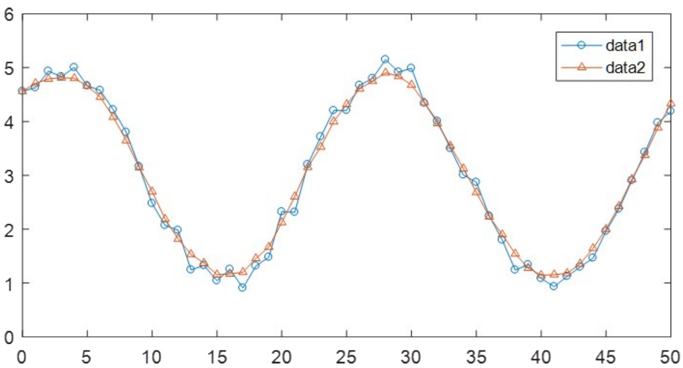

Figure 1: Smooth validation chart.

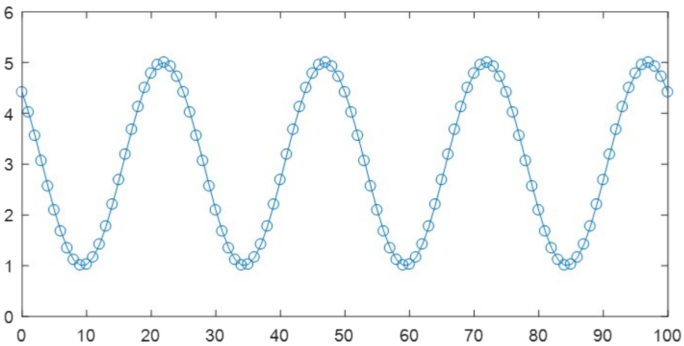

Figure 2: Discrete curve chart.

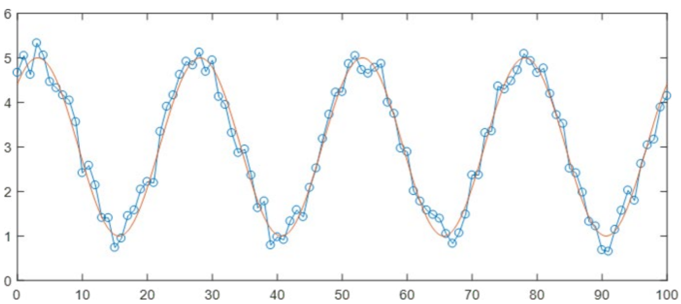

Figure 3: Discrete sequences.

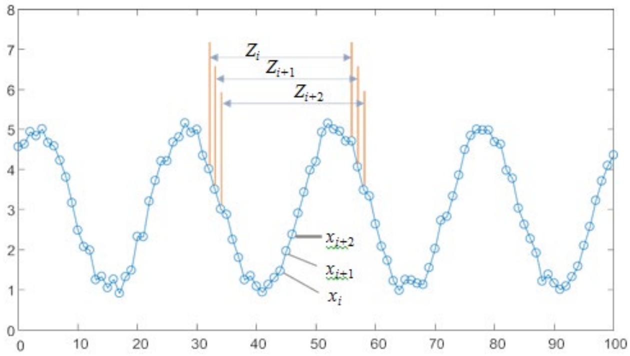

Figure 4: Four-period discrete series.

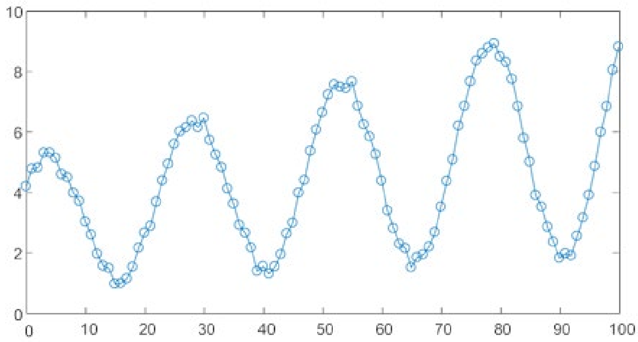

Figure 5: Ultrasonic signals.

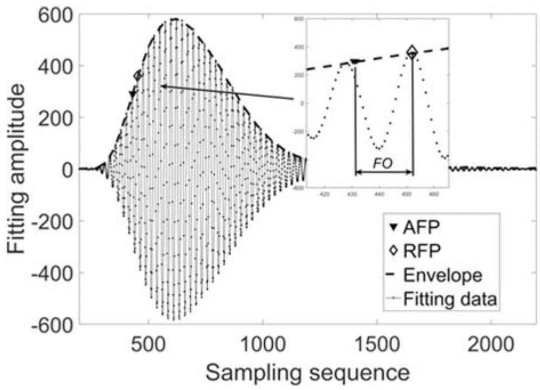

Figure 6: Ultrasound echo signal.

Similarly, we use the following expression

$x_i = A\ co(\theta + \Delta_i) + \varepsilon_i + c$

For subsequent operation processing, another form is used to express

$x_i = a\ cos\ \Delta_i + b\ sin\ \Delta_i + c + \varepsilon_i$

Results

In large impedance measurements, the signal is extremely weak, so a differential circuit is introduced to change it into complex impedance form and the simplicity of sine fitting in amplitude and phase calculation is used to assist in calculating the impedance magnitude, which plays an important role in subsequent large impedance measurements [8-10].

Conclusion

The technique of TRA is widely recognized for identifying the sources of air pollutants, but there is room for improvement in the current models. By incorporating time series data or advanced models, a clearer picture of the behavior of pollutants can be obtained. Although TRA is primarily used for PM, it can also be applied to other pollutants such as carbon black, ozone, and ammonium sulfate. More research is needed in regions outside of Europe, the US, and the Arctic, such as Latin America, Africa, and Asia.

CA and PCA are more commonly used techniques and have been applied in various ways in previous studies. This literature review aims to scrutinize and analyze a wide range of research studies that investigate the connection among meteorological parameters and pollutants. By combining TRA, CA, and PCA, a more comprehensive recognizing of the correlation between meteorological variables, emission sources and air pollutants can be obtained. Using TRA to determine emission sources, CA to group cities based on weather patterns and pollutant behavior, and PCA to quantify the relationships between variables, a spatial model between cities can be created. This review is a novel examination of studies that employs PRISMA guidelines in the analysis of meteorological variables and air pollutants, utilizing CA, PCA and TRA.

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Conflict of Interest

We have no conflict of interests to disclose and the manuscript has been read and approved by all named authors.

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