

# Applications of Complex Function Analysis in Transmission, Physics, and Economy

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**Abstract.** The usage of complex functions is common in many professions. This study focuses on the usage of the complex function in physics, transmission, and economics. Among these, many research demonstrate the relationship between complex function and the disciplines of physics and transmission. This study demonstrates how the complex function has improved transmission accuracy and the measurement of the Fault Index in the transmission area. Furthermore, the research demonstrates how the complex function has aided the study of physics, such as investigating the usefulness of the complex function in wind generating. Finally, the research reveals that in the field of economics, the complex function improves calculating performance. The author has the potential to better help readers understand the usage of complex functions in real settings by demonstrating the relationship between the complex function and fields such as physics, transmission, and economics. As a result, it may give people with another important tool for future investigations. Meanwhile, it demonstrates the widespread use and importance of the complex function in specific areas, pushing individuals to consider whether they can apply the complex function in new domains or in a deeper way.

**Keywords:** Complex function; transmission; physics; economy.

## 1. Introduction

Complex functions were the first mathematical instruments to have significant success in the study of fluid mechanics, according to research into the topic's history. The integration, series, and mapping theories of complex variable functions were subsequently developed by Cauchy, Weierstrass, and Riemann, respectively. The use of complex functions is widespread in both technical applications and scientific research [1]. Complex variable functions can be transformed into matching matrix quaternion functions when they are extended to quaternions, hypercomplex numbers, etc. Complex numbers can be divided into different two-dimensional complex number systems, different quaternion number systems, different n-dimensional complex number systems, and numerous mixed complex number systems. Accordingly, the complex variable function makes a number of generalizations [2]. Therefore, the complex function can be used in many fields, such as physics, economy and computer science. Complex function is a fundamental mathematical course in engineering disciplines such as communication and automation [1]. Complex variable function theory is primarily utilized in communication systems for signal processing, communication channel modeling, channel equalization, signal identification, and other related tasks. The use of the complex function can improve the performance, accuracy, and reliability of signal transmission, and hence the overall effectiveness of communication systems [3].

As a result, it is evident that effectively using the complex function in real-world settings can assist people better run certain functions. The complex function can also be used in other fields such as economy. Economic mathematical modeling today includes econometrics as a component. It is challenging to employ econometric models to reflect all different kinds of economic processes, despite the fact that there are many of them in use. However, since they depict the relationship between economic variables in a different way than real variable models do, functions of complex variables can aid in overcoming this challenge. The ability to model nonlinear interrelationships that lack analogues in actual variable econometrics or are too complex for practical use is provided by a

variety of complex variable functions. Thus, the instrumental foundation of econometric research is substantially expanded by the use of complex variable models [4].

The application of complex functions finds extensive application in several domains, hence enhancing the caliber of individual inquiries and expanding their range. Consequently, comprehending the nuanced function of optimization in real contexts is undeniably crucial in scientific inquiry. In turn, participating in a discourse on the diverse uses of a complex function can facilitate individuals in acquiring a more profound understanding of its significance and fostering the requisite expertise to efficiently employ it in practical situations. In the subsequent section, the author will provide further elucidation on the notion of the complex function, along with the pertinent ideas that hold significance in its investigation. Subsequently, the author will illustrate the application of the complex function in three specific domains, namely physics, economics, and transmission, aiming to tackle various challenges and achieve conventional outcomes. In the concluding section, the author will present a generalization and assess the importance of implementing the complex function, along with its potential future implications.

## 2. Basic Descriptions

A function of a complex variable is one that is defined on the domain of complex numbers and uses complex numbers as inputs and function values. A complex number is one that has both real and imaginary components, as indicated by the formula  $z=x+iy$ , where  $x$  and  $y$  are real numbers and  $i$  is the imaginary unit. A complex function is one that accepts a complex integer as input and returns a function result with real and imaginary components represented by  $Re(f(z))$  and  $Im(f(z))$ , respectively. The inverse of a complex function, written as  $f^*(z)$ , can be utilized to produce a conjugate function [3]. Complex functions are associated with a range of theorems, including the Cauchy-Riemann Equations, Laurent series, isolated singularity, and Cauchy's residue theorem. The Cauchy-Riemann equations are defined as  $u/x = v/y$  and  $u/y = -v/x$ . The Cauchy-Riemann equations are required for  $f$  to have a derivative at a given position [5]. The point at infinity is an illustration to illustrate isolated singularity. It is acceptable to assume that a function  $f$  has a single isolated point at  $C_0$  if it is analytic on the complex plane excluding a finite disk [5].

**Table 1.** F-index peak magnitude[7].

case study	Peak Magnitude of the Fault Index		
	phase A	phase B	phase C
Reverse Power Flow	$9.5 \times 10^9$	96	95
Presence of Noise	$13.5 \times 10^9$	207	204
Hybrid Line	$7.1 \times 10^9$	71	70

## 3. Applications in Transmission

In contemporary times, the utilization of the intricate function has been prevalent within the domain of transmission. An analysis of radiation pulses in optics is done using the Wigner distribution function (WDF), a phase-space representation. It is employed in determining the initial design of a transmission line (TL) and in representing the dynamics of field evolution in future propagation. For the theoretical study of optical systems, acoustics, signal processing, radio waves utilized in wireless technologies, and radar emitters, the WDF is a helpful tool. For time-frequency analysis, the WDF is especially helpful, although spatial frequencies are more significant in this task [6]. Another use of WDF, the fault index, which is based on a mixture of properties taken from the current signal by using the Wigner distribution function (WDF) and Stockwell transform, is used to detect faults [7], demonstrating the use of the Wigner distribution function for current-based transmission line fault detection and classification [8]. The utilization of the Wigner distribution function (WDF) enables researchers to enhance the assessment of the peak magnitude of the Fault Index. According to the Table 1, it is evident that the peak magnitude of the Fault Index for A significantly exceeds the

predetermined threshold of  $5 \times 10^9$ . Conversely, the peak magnitudes of the Fault Index for B and C are found to be below the established threshold. Another noticeable aspect is that in the presence of noise, the peak magnitude of the Fault Index for phase A, B, and C all exhibit an increase. Thus, the modified test system's Phase A defect of an L-G character in the noisy environment is successfully detected [7]. By using the Wigner distribution function (WDF) to determine the magnitude of the Fault Index, the hybrid test PTL (overhead line and subterranean cable) Phase A fault of an LG character can be effectively discovered by the researcher [7].

#### 4. Applications in Physics

In the study of physics, the complex function has seen a great deal of application. People are able to express certain functions with the concept of an imaginary part working in conjunction with a real part. The formula for the electrochemical impedance  $Z$  is  $Z = Z_{re} + iZ_{im}$ , where  $Z_{re}$  and  $Z_{im}$  are the real and imaginary components of the complex impedance, respectively [9]. An essential component of the study of complex functions is the residue theorem, which has applications not just in the field of mathematics but also in the study of physics. The residue theorem is thought to be an effective method for estimating the area under a curve [10]. In the realm of physics, scholars have the potential to incorporate the residue theorem into the domain of wind generation, particularly when studying the mechanisms involved in harnessing wind energy for power generating purposes. A soft sliding mode control based on the residue theorem is presented. The residual value between the controlled variable and the set point is the new definition of the control strategy mistake [10]. The boundary limits softly move as a result of the residue equation's integration effect. According to the previous study (seen Fig. 1), it is easy to tell that the two curves have the roughly same trends, which shows that the rational speed changed with the estimated speed. Therefore, there is definitely a coincidence between the rational speed and the estimated speed. Hence, It shows that the calculated speed has smooth dynamics devoid of overshoots, precisely following its reference value from Maximum Power Point Tracking (MPPT) [10].

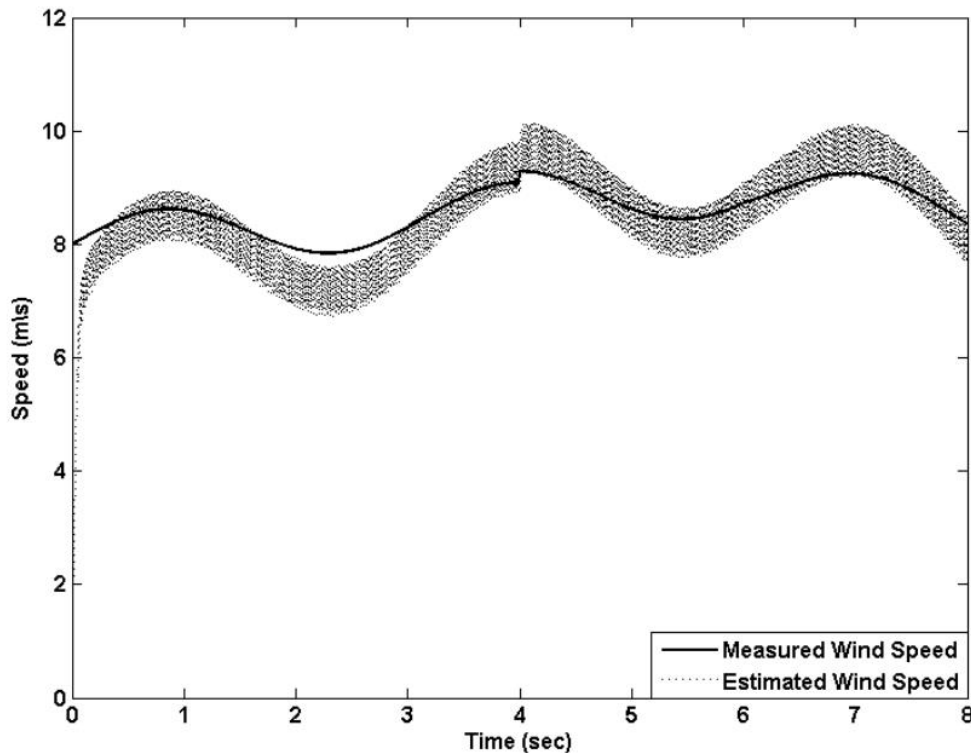


Fig. 1 Results of the speed.

## 5. Applications in Economics

In the field of economics, the complex function possesses the capacity to assume a fundamental role, namely improving the calculating procedures. With the same number of inputs and outputs, there is a need to develop a direct technique in this study to solve the linear nonhomogeneous time-invariant difference equation. The economic cybernetics statespace difference equation's z-transformation state is often a rational function with the same power for the denominator and numerator, followed by the tedious operations [11]. Therefore, the author need to get the result of the z-transformation state in this certain topic. During such a process, the author apply the Cauchy-Riemann residue to find the result of the z-transformation state. A rational function with one pole is  $G(z)=1/(z-p)$ . This yields  $g(k)= \text{Residues}[zk-1/(z-p)]$  using the inverse z-transformation theorem of Cauchy residue calculus. Through the use of the above equations, the author was able to determine  $F(z)$ 's inverse z-transformation [11]. Researchers can gain a better understanding of how the economy operates in a particular region by paying attention to the residue, which is another significant idea involved in the complex function. To determine the primary mode for capturing the intensity of the economic crisis on the carbon market, researchers conduct a multiscale study based on the composition of the low-frequency modes and residue (seen from Fig. 2) [12].

The main goal of another work is to look into how the statistical characteristics relate to the foundations of a complex-valued economy. In econometric models, the second way is based on substituting complex variables for real ones [13]. Given that oil and gas are the most widely used energy sources that are indicative of worldwide trends, they can be viewed as complex variables [13]. Then, the author can apply the complex function to this certain situation to determine the general trend. From this model, the author concluded that it is plausible that in econometrics of complex variables, dispersion must be complex above all other traits and measures of variability [13].

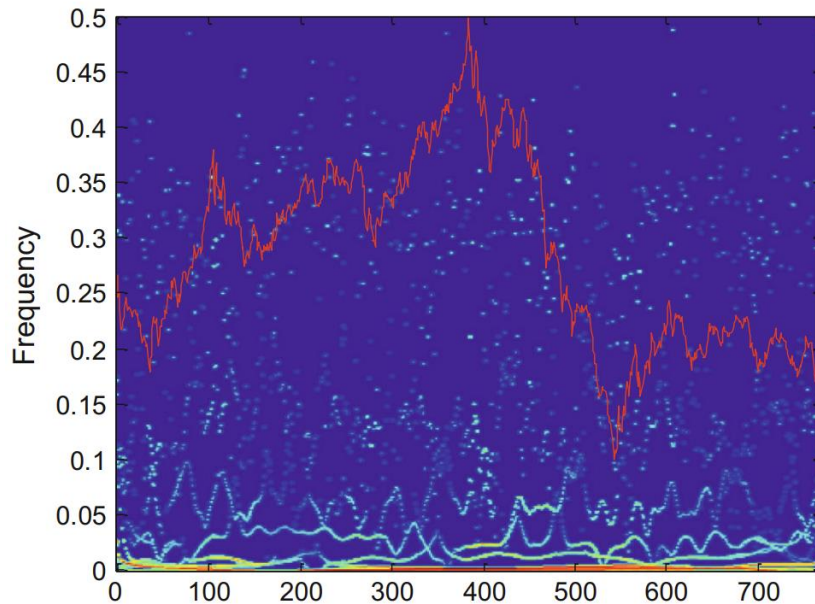


Fig. 2 Hilbert spectrum for the carbon price in the analysis window.

## 6. Conclusion

There is no doubt that the complex function plays a crucial part in the examination of specific disciplines. This phenomenon arises from the inherent capability of simplifying calculations and aiding scientists in devising more effective strategies to accomplish their objectives. The complex function has been extensively utilized in the domain of transmission, serving to improve transmission quality and identify potential faults that may have arisen during the transmission process. Furthermore, a substantial body of research has been dedicated to investigating the correlation between the intricate

function and the field of physics. Extensive research has been undertaken to investigate the integration of the intricate function with other domains of physics, including as analytical mechanics, fluid mechanics, and electromagnetism. The study's author presents an exemplification of the relationship between the residue theorem and the domain of wind production in order to showcase the incorporation of complex functions within the realm of physics research. Other disciplines, such as economics, have not been extensively examined in the realm of research. The utilization of the complex function is predominantly employed by scholars in this particular domain as a mechanism that aids them in either streamlining or enhancing the representation of the computational process. Rather than merely focusing on the surface-level calculations, the author argues that there are undoubtedly further possibilities in this field that include a deeper integration of the economy and complex functions. This research may potentially enhance individuals' motivation to explore intricate relationships between complex functions and other domains. Consequently, it may also lead to increased focus on the practical application of complex functions across a broader range of domains.

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