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INTERFERENCE SOURCES IDENTIFICATION FOR ETHERNET CABLE IN ELECTROMAGNETICALLY NOISY ENVIRONMENTS BASED ON BLIND SOURCE SEPARATION TECHNIQUES

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(M. Sc. In Communications Techniques Eng.)

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THESIS

SUBMITTED TO THE (COMMENICATION TECHNIQUES ENGINEERING DEPARTMENT) IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF (MASTER DEGREE)

BY

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Supervised by

Prof. Dr. Ali Abdulabbas Albakry

December /2021

بسم الله الرحمن الرحيم

وَمَن يَتَّقِ اللَّهَ يَجْعَل لَّهُ مَخْرَجًا ﴿ 2 ﴾ وَيَرْزُقْهُ مِنْ حَيْثُ لَا
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صَدَقَ اللهُ العليُّ العَظِيم

سورة الطلاق

الآيات (2 ، 3)

Supervisor Certification

I certify that this thesis titled **" Interference Sources Identification for Ethernet Cable in Electromagnetically Noisy Environments based on Blind Source Separation Techniques”** which is being submitted by **Ameer Thabit Rasheed Hadi** was prepared under my supervision at the Communication Techniques Engineering Department, Engineering Technical College-Najaf, AL-Furat Al-Awsat Technical University, as a partial fulfillment of the requirements for the degree of Master of Technical in Communication Engineering.

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Committee Report

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Linguistic Certification

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Abstract

When text, audio, graphics, or any other type of data is transmitted via a carrier media, the transmission process is impacted by the environment, and the delivered signals may be distorted as a result. Blind Source Separation (BSS) algorithms are employed to address the distortion problem. (BSS) , on the other hand, is a common approach for recovering signals from observed signals . Noise and distortions across Ethernet connections are one of the practical issues. The Ethernet cable is the model of choice in this thesis for testing the suggested method. Blind Source Separation algorithms STONE Algorithm, Joint Approximate Diagonalization of Eigen(JADE) Algorithm, and Efficient Fast-Independent Component Analysis (EFICA) were used in this thesis to seperate the source signal from the observed signal . Electric Magnetic Field noise Electromagnetic Interference (EMI) and Crosstalk noise are two type of noises added to three types of data: text data, audio data, and image data. The Signal to Noise Ratio(SNR) was used to compare the outcomes of three Blind Source Separation(BSS) algorithms.

Based on the three types of data sent via the Ethernet cable: audio, text, and picture data, the results were split into three groups. To compare all algorithms , the average Signal to Noise Ratio obtained by each algorithm is utilized. According to the data, the STONE algorithm have the Signal to Noise Ratio value with the highest estimated value. Despite having a lower Signal to Noise Ratio than STONE, the Joint Approximate Diagonalization of Eigen method beats the Efficient Fast-Independent Component Analysis algorithm. Each algorithm's reported Signal to Noise Ratio in decibels.

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I cannot fail to extend my thanks to everyone who contributed and helped directly or indirectly to the success of this effort, and I forgot to mention his name. And may God reward me with the best reward, everyone who raised his hands to pray for me success in my studies from near or far.

Dedication

To the one who delivered the message and fulfilled the trust.. and advised the nation.. to the prophet of mercy and the light of the worlds.Our Master Muhammad, may God bless him and grant him peace.

To my master and master, **Imam Al-Mahdi**, the master of the age and time (peace be upon him).

To my dear **father** and my tender-hearted **mother**.

To my **brother**, the martyr (**Akram Thabit Rasheed**), whose departure is not measured by any pain.

To the pleasures of my liver, my dear **brothers** and **sisters**, my companions in my path, you are an incomparable blessing.

To my dear **wife** and **children**.

To all who supported and encouraged me to achieve my success.To all the Iraqi martyrs, wherever they go and no matter who they are.

To my first and everlasting love.......to the great homeland........**Iraq.**......land.......and people......

Declaration

I hereby declare that the work in this thesis my own except for quotations and summaries which have been duly acknowledged.

30 December 2021 Ameer Thabit Rasheed Hadi

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List of Abbreviations/ Nomenclature

Abbreviation	Description
ARCNET	Attached Resource Computer NETwork
BSS	Blind Source Separation technique
BCI	Brain Computer Interfaces
dB	Decibel
DSL	digital subscriber line
EFICA	Efficient Fast-ICA
eig	Eigen Value
ECG	Electrocardiogram
EM	Electromagnetic
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EMR	Electromagnetic Radiation
EMG	Electromyogram
FICA	Fast-Independent Component Analysis
FDDI	Fiber Distributed Data Interface
F	foil shielded
GEVD	Generalized Eigen Value Decomposition
ICA	Independent Component Analysis
IoT	Internet of Things
JADE	Joint Approximate Diagonalization of Eigen
LAN	Local Area Networks
M2M	Machine -to- Machine
MAN	Metropolitan Area Networks
PSO	ParticleSwarmOptimization technique
PLI	Power Line Interference
PSD	Power Spectral Density
RF	Radio Frequency
RF	Radio Frequency
STP	Shielded Twisted Pair
S	shielded.
SNR	Signal to Noise Ratio
SVD	Singular Value Decomposition
SVD	Singular Value Decomposition

TIA	Telecommunications Industries Association
TL	Transmission Line
TP	Twisted Pair
TPE	Twisted pair Ethernet
U	unshielded
UTP	Unshielded Twisted Pair
WGN	White Gaussian Noise
WAN	Wide Area Networks

List of symbols

Symbol	Definition
V	Eigenvector matrix
w	Inertial coefficient
Bl	Long-term constant value
C_(x_i x_j)^long	Long-term covariance matrix
Hlong	long-term half parameter
A	Mixing matrix
X(t)	Observed signal
S(t)	Original signal sources
W	Separation Matrix
βS	Short-term constant value
hshort	Short-term half parameter
F(y)	Temporal predictability of signal y(k)

Chapter 1: Introduction and Literatures Review

1.1 Introduction

The Internet of Things (IOT) has gained traction in government, academia, and businesses. Because (IOT) tools are extensively distributed, they require infrastructure to store and process massive amounts of data in order to make intelligent decisions without the need for human involvement. (IoT) encompasses a wide range of applications, including Smart homes, Smart classrooms, Smart cities, and others [1]. The world is heading towards an automated future where more gadgets are equipped with sensors that have connectivity capabilities, transforming the Internet of people into an Internet of things model. Wired channels, including optic fiber for platforms, are required for (IOT) infrastructure. Copper-based cabling (Ethernet) has become the dominant technology due to rising network needs and higher bandwidth requirements inside (IOT) applications. Ethernet began as a single connection and has evolved into a worldwide system of wires and cables that can link many devices and equipment. Today, Ethernet networks may be expanded to include as many devices as are required, and it is the most widely used network technology [2]. Furthermore, with the advent of smart technologies in energy distribution, transportation, and automotive applications, Ethernet has the potential to develop. Crosstalk and environmental noise coupling to nearby wire pairs are disadvantages of wired Ethernet in the industrial context [3]. For the following reasons, Ethernet cabling (the twisted 4-wire pair) is organized in pairs to propagate electrical signals along the transmission line:

a) Rather than employing several signal wires and a single common ground, signals are propagated through a single twisted pair. At higher frequencies, this produces less distortion than the single common ground connection.

b) The twists reduce cross-talk and other types of interference between signals within and across cables.

Twisting, on the other hand, can significantly diminish the Twisted Pair cables (TWP) immunity to outside fields. Shielded Twisted Pair cables (STP) or Unshielded Twisted Pair cables (UTP). In (STP) a conductive layer surrounds each pair and, in certain circumstances, the whole cable (usually aluminum metal foil). This shielding method decreases interference caused by either coupling to or radiating from the cable. Crosstalk is reduced when individual pairs are shielded. (UTP) does not have any shielding. It is less expensive, more flexible, and far more commonly used than the (STP), particularly in new installations. (STP) on the other hand, has a better ability to reject interference, particularly when the shield casing of the (STP) cable is adequately grounded [4] . (TWP) are inexpensive and are used in structured cabling for data transmission (for example, Digital Subscriber Line (DSL), Wide Area Networks (WAN), and Local Area Networks (LAN)), which are in charge of supplying telecommunication, wireless, and internet signals). TWP cables are also used in avionics for differential dc buses for power distribution, where the TWP cables are meant to run atop a metallic ground plane [5].

The TWP cable has also acquired appeal in many new applications, such as video transmission, and is expected to play a significant part in the growing (IOT).

According to the most significant function will be Machine-to-Machine (M2M) connections, which will enhance manufacturing, agriculture, healthcare, industrial processing, and other professional services [6]. Wires, on the other hand, act as antennas, broadcasting and receiving electromagnetic waves. The conductors of twisted pair cables are typically operated in differential mode, which means that the signal at any point along the circuit is equal in amplitude and phase to that at the opposite point to ground. As a result, outside electromagnetic fields (noise) coupling into the cable may generate the same interference voltage (magnitude and phase) — common mode coupling. Overall, noise coupling to the wires of a cable has the potential to interfere with data conveyed by the cable, leading the connection to act more like an unintended radiator/antenna [7].

Twisted pair Ethernet cables (TPE) is the following stage in the advancement of copper contorted pair information link and it is proposed for use in car, mechanical control and computerized constructing applications. One potential restricting element is commotion coupling, especially in electromagnetically boisterous conditions, for example, the vehicular and modern applications being tended to. For clamor relief reasons, distinguishing likely wellsprings of this commotion is profoundly alluring: such data can advise the advancement regarding establishment and utilization suggestions just as the improvement of remuneration programming to be installed in the interchanges innovation. The proposed system will research Blind Source Separation (BSS) .

1.2 Problem Statement

When an Ethernet cable (a metal conductor) passes through a magnetic field (for example, close to an electrical load with a large electromagnetic field), an excited electromagnetic field with an excited current is generated in the cable, causing the Ethernet signal (which is also an electric current) to be distorted. What does this signify for data transmission? The integrity of the packets has been compromised, which may result in intermittent communications. In an office, this generally implies a retransmission of the packet, which the user is unlikely to notice. In an industrial context, when time is crucial due to mechanical operations, this might result in liquid squirting on the floor, a botched weld, or even a line stoppage. As a result, reducing noise concerns is plainly vital in Industrial Automation.

1.3 The Scope of Work

Single The scope of this proposed system is to develop a system to suppress the electromagnetic noise or distortion in the Ethernet cable caused by electromagnetic interference (EMI) using the Blind Source Separation (BSS) techniques. MATLAB ver. R2021a Software will be used to build the proposed system, while the input data set or measurements will be taken from a specialist institute reliable college to test the system efficiency or simply generated in the lab.

1.4 Objectives

1. One of Suppressing the electromagnetic noise and crosstalk interference caused due to moving signals throughout the Ethernet cable.
2. develop different types of Blind Source Separation (BSS) techniques (such as Fast-Independent Component Analysis (EFICA) algorithm, Joint Approximate Diagonalization of Eigen (JADE) algorithm, and STONE algorithm) to assess types and sources of interference in an (EMI) environment for Ethernet cable.

1.5 Thesis Contribution

Most computer and communication networks operate in different environments, and that environment varies according to the type and function of the network. Each environment has a different effect that affects the process of sending and receiving data. In this thesis, the electromagnetic environment will be focused on and its impact on those networks in which it operates. This thesis will contribute to discovering the negative effects resulting from the electromagnetic environment and how to reduce that impact.

1.6 Literatures Review

Many academics have published papers and created algorithms to identify electromagnetic interference in computer networks and the Internet in general, and specifically in Ethernet cables. The most important prior studies in this field will be examined in this section of the research, and our work in this present study will be stated at the conclusion for comparison.

In 2010, David Bowen, Isaak Mayergoyz, and Charles Krafft presented new distributed Ethernet switch models. Their research focused on the characterization, testing, and modeling of Ethernet switches. First, the combined equivalent circuit of Ethernet converters for differential mode signals was investigated, and then unique test techniques for experimental parameter definitions of this equivalent circuit were presented. Traditional test methodologies for power (low frequency) transformers (such as open and short circuit testing) have not been applicable to Ethernet transformers since winding currents and alternating current forces are difficult to detect. Special versions of these approaches that depend exclusively on peak voltage measurements were proposed in the study. Because the main and secondary windings of the Ethernet transformers were densely intertwined, the cross and bypass capacitances were dispersed in nature [8]. Characterizing, testing, and modeling Ethernet switches and cables were among the tasks undertaken by the researchers. They didn't apply any algorithms to enhance the signals, instead recommending modified versions of frequency measurement techniques. Our system will use BSS algorithms to optimize the signal that flows over Ethernet cables when it is in use.

In 2015, Pulses from a PD source were hypothesized by researchers C. Boya, MV Rojas-Moreno, M. Ruiz-Llata, and G. To test the performance of the proposed approach, the research focuses on implementing the algorithm and detailing the experimental setup of controlled generation and PD detection [9].To check the performance of data transmission via Ethernet cables, the researchers settled on an algorithm based on pulses from a PD source, while data will be created from voice, image, and text, along with noise, to check the usefulness of our suggested algorithms.

In 2015, Harbin Engineering University researcher Ahmed Karim Abdullah published two blind source separation algorithms, Evolutionary Stone BSS (ESBSS) and Evolutionary Multi-BSS (EMBSS). These algorithms are based on a hybridization of soft computing with classic BSS approaches in order to enhance separation and overcome current difficulties in non-invasive brain signal analysis. Furthermore, using a mix of filtering and wave noise reduction techniques, a new method for obtaining a clean synthetic reference from residual neural signals is suggested [10].

In 2018, To increase the spectrum efficiency of the future generation of wireless communication systems, Xiaogang Tang, Sun'an Wang, and Jiong Li introduced a new, sophisticated technique to blind source separation based on generalized automated source correlations. The suggested algorithm improves the de-mixing matrix by taking into consideration the temporal patterns of the communication signals and using the natural gradient method. Furthermore, local stability has been established. Simulation results demonstrating the suggested algorithm's improved performance in the inter-symbol interference of approximated signals were given [11]. Blind source separation algorithms will be utilized to separate the data created with noise, such as Electromagnatic noise and Crosstalk noise, in our research.

In 2018, Edwin Chukwuemeka Arihilam suggested a first-step approximate symbolic method to determine EM radiation and, as a result, convert DM to CM and vice versa in data cable, and conducted experiments with a four-port vector network analyzer in 2018. In the lack of specialized/dedicated measurement instruments, the use of four VNA ports has a broad applicability in cable parameter measurement. The mechanisms of signal mode conversion may be recognized using certain assumptions of transmission line on the basis of the Telegraph equation and the modular decomposition idea, which lowers mode conversion in the transmission line to reduce the bit error rate [7]. The researcher Edwin Chukwuemeka Arihilam relied on determining the EM radiation by suggesting an approximate symbolic defect using a four-port vector network analyzer, whereas in our work, we will use Stone Algorithm, JADE- Algorithm, and EFICA- Algorithm to separate electromagnetic noise and crosstalk noise from the original data.

In 2019 , The researcher Mushtaq Taleb Mazal presented an algorithm consisting of two parts: In the first part of the proposed algorithm, the electrocardiogram of single and twin fetuses was extracted based on the separation of the blind source of the stone. The results obtained by Stone's algorithm were compared with two other BSS algorithms (EFICA and JADE). In the second part, the algorithm separated the source from the Modified Blocking Stone (MSBSS). A combination of conventional Stone BSS and particle packing optimization (PSO) was used to produce MSBSS. The results obtained using two other BSS algorithms (EFICA and JADE) were compared in addition to the results obtained using traditional Stone BSS in the first part. The MSBSS method revealed better performance compared to other BSS techniques, including Stone BSS [12]., where we both used blind source separation algorithms, and the results obtained by Stone's algorithm were compared with two other BSS algorithms (EFICA and JADE). However, researcher Mushtaq Taleb Mazal worked on extracting the electrocardiogram of the individual and twin fetus based on the separation of the blind source of the stone, while our work was on the separation of three types of original data.

In 2020, This study was carried out by researchers I N B Hartawan, P P Santika, I B A I Iswara, and I G M N Desnanjaya to see how electromagnetic waves created by electrical wires affect the quality of network services on cable transmission medium. The power cable utilized in their research was NYYHY and NYM electrical cables, which are often used in electrical installations in buildings. They employed an unshielded Category 5e (Cat 5e) and a shielded twisted pair (STP) network cable in their research. The experiment was carried out in the lab by merging power and network cables into a single cable and transmitting data packets [13] .The researchers utilized an unshielded Cat 5e twisted pair and a shielded twisted pair (STP) network cable to minimize noise in this article. This research is one of the closest to our work, whereas a single ethernet cable was used to reduce noise and segregate the signals using BSS algorithms.

In 2020, Apena Waliu Olalekan, Olasunkanmi Omowumi Grace, and Salako Anuoluwapo presented a study comparing the performance of Pulse Amplitude Modulation (PAM) and Multi-level Modulation (PAM-16) technology with other PAM versions in order to verify high-speed copper Ethernet network characteristics and fault performance. The research was carried out in a MATLAB R2017b simulation environment, which gave the computed bit-error rates (BER) for the modulation schemes under consideration under various channel circumstances. The bit error rate for PAM-16 is 10-12, which is significantly lower than the bit error rates for PAM-2 and PAM-4. The Hamming code was also utilized to discover and remedy design flaws, as well as the efficacy of each PAM level [14].The researchers compared the performance of pulse amplitude modulation (PAM) technology and multi-level technology (PAM-16) with other versions of PAM to verify the high speed of Ethernet networks and error rates, but they did not address the techniques of blind source separation algorithms, unlike our work, which relied on those algorithms.

In 2020, To reduce false arrhythmia alarms and improve the classification accuracy of artificial neural networks, Krzysztof Gagoniček, Ega Grzegorczyk, Misha Gustkowski, and Tomas Zabkowski employed the blind source separation approach. The research focused on an unique prototype aggregation method for coping with arrhythmias that are difficult to foresee. The data was analyzed using five-minute physiological signals (ECG, BP, and PLETH) obtained for people with arrhythmias. The arrhythmia alert was triggered at the end of each patient's indication. The data raises the question of whether the alarm was genuine and warranted action, or if it was a hoax and a different notice should have been sent. When compared to measurement models such as ANN, random forest, segmentation trees, and recursive regression, the capacity of BSS ANNs to identify four arrhythmias—systole, ventricular tachycardia, ventricular fibrillation, and tachycardia—has been proven with better classification accuracy. The scores for the challenge varied from 63.2 to 90.7 [15].

The researchers proved that BSS can identify four types of arrhythmia — asystole, ventricular tachycardia, ventricular fibrillation, and tachycardia — with higher classification accuracy than measurement models like ANN, random forests, and segmentation and regression trees. Iterative, while our research demonstrated BSS's capacity to extract data that is extremely comparable to the original data received from the source after removing electromagnetic and crosstalk noise.

An algorithm based completely on BSS blind source separation techniques will be created in our current research to identify sources of interference in an electromagnetic environment. Where three forms of data, text, speech, and pictures, will be utilized to transport them across networks with interference and noise, where the original data was created using two types of electromagnetic noise, and Crosstalk noise, and then merged and delivered over a network through Ethernet cable. The stone algorithm, the JADE algorithm, and the EFICA algorithm were employed as BSS algorithms, exposing the information and data passing through the cable to the harmful impacts of the electromagnetic environment and determining one of these algorithms is better than the other.

1.7 Thesis Layout

- **Chapter 2** It gives a general background about the applications of the Ethernet and the noise, benefits of the Ethernet cabling architecture applications, general introduction to the technique (BSS).
- **Chapter 3** It tackles the general description of the methodology and the proposed System and our proposed method of the (BSS) technique for suppressing electromagnetic noise in the Ethernet cable.
- **Chapter 4** It highlights the obtained results for the different cases.
- **Chapter 5** Conclusion and suggestions for future work are presented in this chapter.

Chapter 2: Theoretical Background

2.1 Introduction

Each network or connection must have a transmission to transfer data or access network resources; this transmission might be wired or wireless. This section of the research will discuss wired transmission, namely Ethernet cables. Every electronic device, whether computer, tablet, gaming console, or other, is frequently linked to a network through an Ethernet cable, which enables you to access the Internet and interact with shared network resources. Earthnet is a wired computer networking protocol that is frequently used in Local Area Networks (LANs), Metropolitan Area Networks (MANs), and Wide Area Networks (WANs) (WAN). The cable was commercially available in 1980 and was standardized as IEEE 802.3 in 1983. Ethernet has been enhanced since then to enable faster bit rates, a greater number of nodes, and longer link distances, while retaining a high degree of backward compatibility. Ethernet has generally supplanted wired LAN systems such as Token Ring, FDDI, and ARCNET over time [16,17]. Ethernet cables are used because wireless connections are not always reliable. You may have noticed that your Wi-Fi becomes stuck or damaged as a result of certain interfering elements; this might be due to the distance between you and the network, anything interfering with the connection speed, an interfering item such as a brick wall, or a variety of other issues [18,19]. An Ethernet cable ensures your network connection (no internal cables). Direct connection delivers a more dependable and faster service experience [20,21]. It also provides a convenient backup alternative when the Wi-Fi connection is idle. Certain networks allow users to join wirelessly or using an Ethernet cable. Other networks, such as local area networks (LANs), need the use of this cable in order to connect to the router [22].

2.1.1 Ethernet Cable Basics

Ethernet cables used in the majority of residential and business environments are twisted pair cables within a single universal cable: Cat 5, Cat 6, and Cat 7. Winding the wires together allows the currents to balance; that is, the current flows in one direction in one wire and in the opposite direction in the other wire of the pair, canceling out the total fields around the twisted pair. This enables the transfer of data over vast distances without the need for excessive precautions[23]. Due to the fact that a network cable contains several twisted pairs, the number of turns per unit length is ordered in such a way that each pair is unique; because speed is determined by prime numbers, two turns will never line up. This minimizes inter-cable crosstalk[24]. Ethernet cables are available in a variety of lengths as patch cables or as the cable itself for integration into systems, buildings, and other environments. After that, the ends may be crimped to the chosen connection with a crimp tool. These network cables are available in a range of lengths; some are as long as 75 meters [25] . Earlier network cables were unshielded, but shielded cables improved performance. For example, while an unshielded twisted pair (UTP) cable may be appropriate for a short distance between a computer and a router, shielded FTP is preferable when the cable goes through locations with significant electrical noise[23,25]. Ethernet cables can be protected in a variety of ways. The most frequent method is to surround each twisted pair with a shield. This not only shields the cable from the elements, but also minimizes interference between the inside twisted pairs. Manufacturers can enhance performance even more by wrapping a shield over all cables within the cable immediately below the jacket. Different symbols are used to denote various forms of shielding [25,26]:

- U / UTP: Unshielded cable, unshielded twisted pairs
- F / UTP - Foil shielded cable, unshielded twisted pairs
- U / FTP - Unshielded cable, foil shielded twisted pairs
- S / FTP - Shielded twisted cable, foil shielded twisted pairs

Where: TP = twisted pair, U = unshielded, F = foil shielded, S = twisted shield.

Another distinction among Ethernet cables is whether they are Cat 5, Cat 5e, Cat 6, Cat 6e, or Cat 7 and if they have solid or stranded cables. As the name implies, solid wire use a single piece of copper as the electrical conductor within each wire in the cable, whereas stranded wire utilizes a series of copper wires that have been twisted together. While purchasing a patch cord is not essential for this knowledge, installing a long-range cord is, as each kind is better suited for certain purposes [26,27].

- Stranded cable: This type of cable is more flexible and is more suited to Ethernet cables that can be moved, which is commonly the case when connecting wires in offices or making general connections to computers, etc., where movement is expected.
- Solid Cable: Steel cable is less flexible than braided cable, but it lasts longer. As a result, it's ideal for long-term installations such underground cable runs, walls, and the like.

2.1.2 Ethernet Cables Types

For Ethernet and other networking and communication applications, a number of cables are available. Telecommunications Industries Association (TIA) recognizes network cables in several categories, such as Cat 5 cable, Cat-6 cable, and so on, which are detailed below [27,28,29].

a) **Cat-1:** It is not recognized by TIA/EIA. It's a type of cable that may be used for traditional telephone wire (POTS) or ISDN.

b) **Cat-2:** It is not recognized by TIA/EIA. For token ring networks, the type of cable utilized was 4 Mbit / s.

c) **Cat-3 -** TIA / EIA-568-B is the standard for this cable. It's utilized in data networks that operate at frequencies of up to 16 MHz. It was once popular for usage with 10 Mbps Ethernet (100Base-T), but Cat-5 cable has since supplanted it.

d) **Cat-4:** This cable is not recognized by the TIA/EIA. It may, however, be utilized for networks with frequencies as low as 20 MHz. It was mostly utilized in token ring networks with a data rate of 16 Mbps.

e) **Cat-5** - TIA / EIA does not recognize this. Because it delivers performance that permits data at 100Mbps and somewhat higher (125MHz for 1000Base-T) Ethernet, this is the most frequently used network cable for 100Base-T and 1000Base-T networks. Cat 5 cable superseded Cat 3 and became the industry standard for Ethernet cables for several years. Cat 5 cable has reached the end of its useful life and is no longer recommended for new installations. Twisted pairs are used in Cat 5 cable to minimize interference from internal cables (XT) and exterior cables (AXT). Cat 5 cable utilizes 1.5 to 2 twists per centimeter, however this is not standardized. A Cat 5 Ethernet cable is seen in Figure 2-1, and it is utilized in LAN networks.

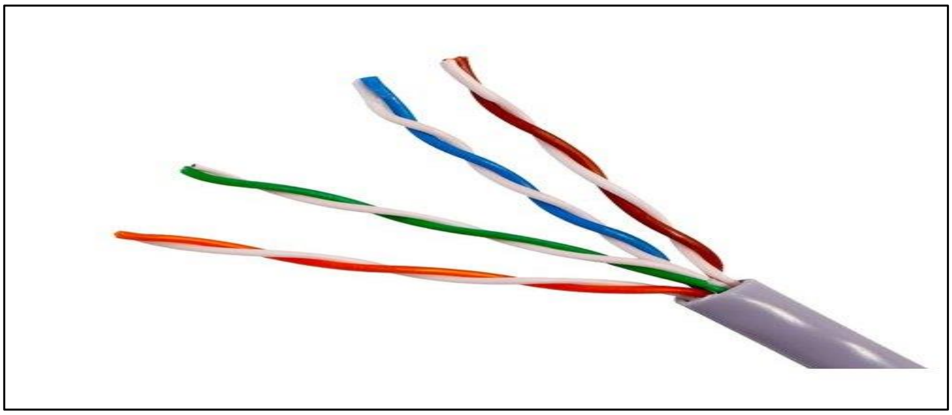

Figure 2-1 Cat-5 LAN cable[27].

f) **Cat-5e**: TIA / EIA recognizes this type of cable, which is described in TIA / EIA-568, which was recently updated in 2001. Cat-5 cable provides performance up to 125 Mbps per second, which is a slightly higher frequency standard. Cat-5e is compatible with both 100Base-T and 1000Base-T networks (Gigabit Ethernet). The Cat 5e standard refers to Enhanced Cat 5, which is a type of Cat 5 cable that is built to a higher quality yet is almost equivalent to Cat 5. It has been put through more rigorous testing to guarantee that it can handle greater data rates. Twisted pairs in network cable are usually twisted to the same degree as Cat 5 cabling.

g) **Cat-6 -** This cable meets TIA / EIA-568-B specifications and outperforms Cat5 and Cat 5e in terms of performance. Cat 6 cables are more coiled during manufacture than Cat 5 or Cat 5e cables, and they frequently include an outer jacket or braided jacket. The shield helps to avoid interference and noise by protecting the twisted pairs of cables within an Ethernet cable. Although Cat-6 cables may theoretically handle rates of up to 10 Gbps, they are only capable of doing so over distances of up to 55 meters, making them rather lengthy Ethernet cables. Cat 6 Ethernet cables often have more than 2 twists per centimeter, and some may include a nylon backing to prevent interference, while the specification does not mandate it.

h) **Cat-6a:** The standard was updated in 2008, and the letter "a" in Cat 6a stands for "Augmented." Cat 6a cables can carry double the amount of data and sustain faster transmission rates over longer network cable lengths. To minimize crosstalk, use enough shielded Cat 6a cables. However, it is less flexible than Cat 6 cable as a result of this. In terms of construction and form, Figure 2-2 depicts the differences between CAT-5E, CAT-6, and CAT-6A Ethernet cables.

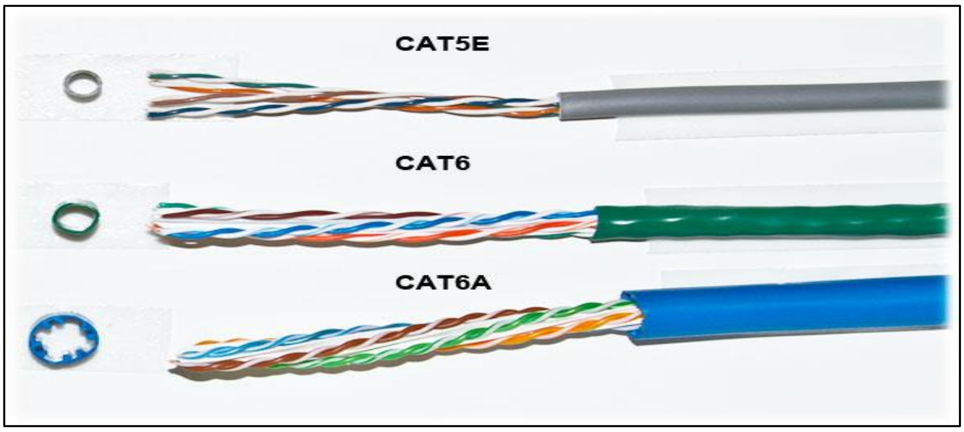

Figure 2-2 Category Cable Types, CAT-5E VS. CAT-6 and CAT-6A[27].

i) **Cat-7:** For ISO / IEC 11801 Category F cables, this is an unofficial number. Within a general shield, they are made up of four separately protected pairs. It's designed for applications that demand transmission speeds of up to 600 megabits per second. Figure 2-3 demonstrates how to protect a CAT-7 Ethernet cable with an outer cover.

Figure 2-3 CAT-7 cable[29].

j) **Cat-8:** Cat 8 cables are now available, offering a considerable boost in data speed and bandwidth. As a result, Cat 8 cables are far more costly than prior versions such as Cat 6 or even Cat 7 . More information on Ethernet cables, as they are often used in today's Ethernet networking applications, may be found below.

Table 2-1 Summary of Ethernet cable performance [28].

CATEGORY	SHIELDING	MAX TRANSMISSION SPEED (AT 100 METERS)	MAX BANDWIDTH	COST
Cat 3	Unshielded	10 Mbps	16 MHz	low
Cat 5	Unshielded	10/100 Mbps	100 MHz	low
Cat 5e	Unshielded	1000 Mbps / 1 Gbps	100 MHz	medium
Cat 6	Shielded or Unshielded	1000 Mbps / 1 Gbps	>250 MHz	medium
Cat 6a	Shielded	10000 Mbps / 10 Gbps	500 MHz	high
Cat 7	Shielded	10000 Mbps / 10 Gbps	600 MHz	high
Cat 8	Shielded	25 Gbps or 40Gbps *	2000 MHz	high

* 25 Gbps for Cat 8.1 and 40 Gbps for Cat 8.2.

The table above provides a comparison of Ethernet cables in terms of shielding, maximum transmission speed, and maximum bandwidth, with the transmission speed and bandwidth gradually increasing.

2.1.3 Advantages of Ethernet cable

a) Speed

When compared to a distant connection, the speed provided by an Ethernet connection is significantly higher. With the most modern turned sets, you can easily get a speed of 10Gbps via Ethernet. Some can reach speeds of up to 100 Gigabits per second. The balanced association found in them is the explanation for this. Fiber optic cables provide a substantially increased reach. Instead of using traditional data transmission methods, these connections use light.

b) Security

Unlike WiFi, which is vulnerable to attacks, an Ethernet connection provides higher levels of security. When it comes to Ethernet connections, you often have control over who uses the network. When using an Ethernet, programmers will not be able to access your data properly. As a result, this may be used to prevent security breaches[30].

c) Reliability

The consistent quality of Ethernet connections is unmatched. This is due to the fact that the radio frequencies do not have any breaks. As a result, there are fewer detachments and lulls in Ethernet over time. Furthermore, because the transmission capacity is not shared among the linked devices, there are no transfer speed issues.

d) Efficiency

There are some Ethernet links, such as Cat6, that burn through at a much lower strain level. Significantly less than a WiFi connection. As a result, these kinds of links are thought to be the most force-producing[31].

2.1.4 Disadvantages of Ethernet cable

a) Mobility

Ethernet has more practical limitations in terms of flexibility. When connected through Ethernet, unlike when connected via WiFi, you can't roam about freely. The device must be placed in a specified location. As a result, these sorts of relationships must be beneficial to devices such as workstations. Ethernet connections aren't appropriate for those who have cell phones.

b) Expandability

If you need to expand your organization, there will be more charges and it will be time-consuming in Ethernet. This is due to the fact that additional switches, switches, and, in particular, many meters of wires are required. In addition, all of the devices should be redesigned[32].

c) Installation

Without the assistance of a professional, Ethernet connections are often more difficult to set up. Especially in areas where they must cross between barriers and various levels. These areas should be penetrated separately. Furthermore, different PCs and switches should be connected with distinct links.

d) Connections

In contrast to a WiFi network, where you can connect to several devices at once, you can't do so with a wired association. With a single Ethernet connection, you can only connect to one PC at a time. If you want to make additional connections, you'll need to use more links[33].

2.2 Noise Coupling for Ethernet cable

The Cables and wires have been known to be the most vulnerable parts of electrical and electronic equipment. Noise can be described as anunwanted signal which interferes with a desired signal. A noise signal can be transient or constant. Constant noise (e.g. electric/power line hum) can emanate from the predictable 50 Hz AC "hum" power line or from harmonic multiples of it and is capable of coupling to data communication cable when in close contact with it. Electrical noise coupling can take any of the following forms[7]:

a) **Galvanic Noise** source can occur in data cabling when two signal channels in a signal data cable share the same reference conductor as common return path. In this way, the voltage drop across one channel appears as noise in the other channel and gives rise to interference. This form of noise coupling is often referred to as conductive common

   impedance coupling.

b) **Electrostatic Coupling** occurs through various capacitances present in a network or circuit, between wires in a cable, between wires and ground, etc. The capacitances offer low impedance paths as noise voltages of high frequency are presented. This type is also referred to as capacitive coupling.

c) **Electromagnetic Induction** expressed in terms of noise coupling is a course of action where a current carrying element located within a changing magnetic field creates a voltage across the current carrying conductor. As a result, this causes an induced current in the conductor.

d) **Radio Frequency Interference(RFI**) is the emission of RF energy from most electrical and electronic devices which can couple to adjacent circuits and are capable to impair or degrade the performance of such systems. The interfering signals can be emitted from devices such as switching power relays, personal computers, electronic printers, computing devices and laptops, etc.Noise coupling to twisted pair cabling has been a growing concern to communication networks. This is so as communication speed continues to grow.

2.2.1 electromagnetic interference (EMI)

When detected in the frequency spectrum, electromagnetic interference (EMI) is a disturbance generated by an external source that affects an electrical circuit by electromagnetic induction, coupling, or electrostatic conduction. The disturbance might impair the circuit's performance or possibly prohibit it from functioning. As both man-made and natural sources generate alternating electrical currents and voltages that can cause electromagnetic interference, these effects can range from a higher error rate to total data loss in the data path: ignition systems, cell phones from the cellular network, rays, solar energy, flares, polar auroras (northern / southern lights). AM radios are frequently affected by electromagnetic interference. Cell phones, FM radios, and televisions can all be affected, as well as radio astronomy and atmospheric science observations [34,35].

Electromagnetic interference is divided into two categories [36]:

a) Narrowband EMI, also known as RFI, is broadcast by radio and television stations, as well as mobile phones.

b) RFI (radio frequency interference), which is unintentional radiation from sources such as power lines.

Physical contact between conductors causes electromagnetic interference rather than transmitted electromagnetic interference, which is generated by induction (no physical contact of conductors). Electromagnetic disturbances in a conductor's electromagnetic field will no longer be restricted to the conductor's surface, but instead radiate out from it. This happens in all conductors, and mutual induction between two radiating electromagnetic fields causes EMI [37]. In other terms, EMI (electromagnetic interference) is the disturbance of an electronic device's functioning produced by another electronic device's electromagnetic field (EM field) in the radio frequency (RF) spectrum[35,37]. Personal computers' internal circuits produce electromagnetic fields in the radio frequency band. Furthermore, cathode ray tube (CRT) displays emit electromagnetic radiation at a variety of frequencies. The performance of adjacent sensitive radio receivers may be harmed as a result of these emissions. If you use a wireless receiver of any sort at the same time that you switch on your PC, the receiver is likely to pick up RF noise from the computer system[37]. Wireless transmitters with medium or high power can generate electromagnetic fields powerful enough to destroy neighboring electronic devices. You've probably encountered EMI from radio or television transmitters if you reside near a broadcast station or in the heart of a big city. In the presence of powerful radio frequency fields, cordless phones, home entertainment systems, laptops, and various medical devices may cease operating properly[33,37,38].

2.2.2 Crosstalk Phenomenon

Any phenomenon in which a signal delivered via one circuit or channel of a transmission system has an undesirable influence on another circuit or channel is known as crosstalk. Unwanted capacitive, inductive, or conductive coupling from one circuit or channel to another is the most common source of crosstalk. In structured cabling, audio electronics, integrated circuit design, wireless communications, and other communication systems, crosstalk is a serious issue[39]. A changing field, whether electrical, magnetic, or movement, is linked with each signal. When these fields collide, their signals interfere with one another. Crosstalk is caused by electromagnetic interference. If two cables carrying different signals are placed near to one other, the currents in them will produce magnetic fields, resulting in a reduced signal on the next cable [40].The impedance of the return path generates a common impedance coupling between the signals in electrical circuits that share a common signal return channel, resulting in crosstalk[39].

2.3Blind Source Separation (BSS)

Blind source separation is the separation of a group of source signals from a group of mixed signals with no (or very little) knowledge of the source signals or mixing mechanism. It is a technique used in digital signal processing to restore a mixture of signals with the objective of restoring the signals to their original components. The cocktail party problem is a typical example of a source separation problem, in which multiple individuals are talking at the same time in a room (for example, during a cocktail party) and the listener tries to follow up on a conversation. This type of auditory source separation difficulty can be handled by the human brain, but it is a difficult challenge to solve in digital signal processing[41]. Although the problem is not extremely specific, helpful solutions may be discovered in a surprising number of situations. Much of the early research in this field has focused on the separation of temporal signals like sound. Blind signals, on the other hand, are now regularly split into multidimensional data like pictures and tensors, which may or may not include any temporal dimensions at all[42]. Various ways to solving this problem have been presented, but work is currently ongoing. Principal component analysis and independent component analysis are two of the most effective techniques. They work well when there are no delays or echoes, which means the problem is significantly simplified. Sound source separation is attempted using a method based on human hearing in the field of computational sound scene analysis[43]. Blind source separation approaches usually aim to narrow down the set of possible solutions in a way that is unlikely to exclude the desired answer, because the fundamental challenge of the problem is its lack of definition. Source signals that are least linked or maximum independent in the probabilistic or theoretical meaning of the information are sought in one technique, independent principal component analysis. Nonnegative matrix factorization is the second approach, which involves putting structural restrictions on the source signals. These structural constraints can be generated from a signal's generative model, but they're more often justified by excellent experimental results. The application of some type of low complexity limitation on the signal, such as the variance in an exponent of the signal space, is a recurrent motif in the second method. This method is very useful when just the most important features of a signal are required[41,43].

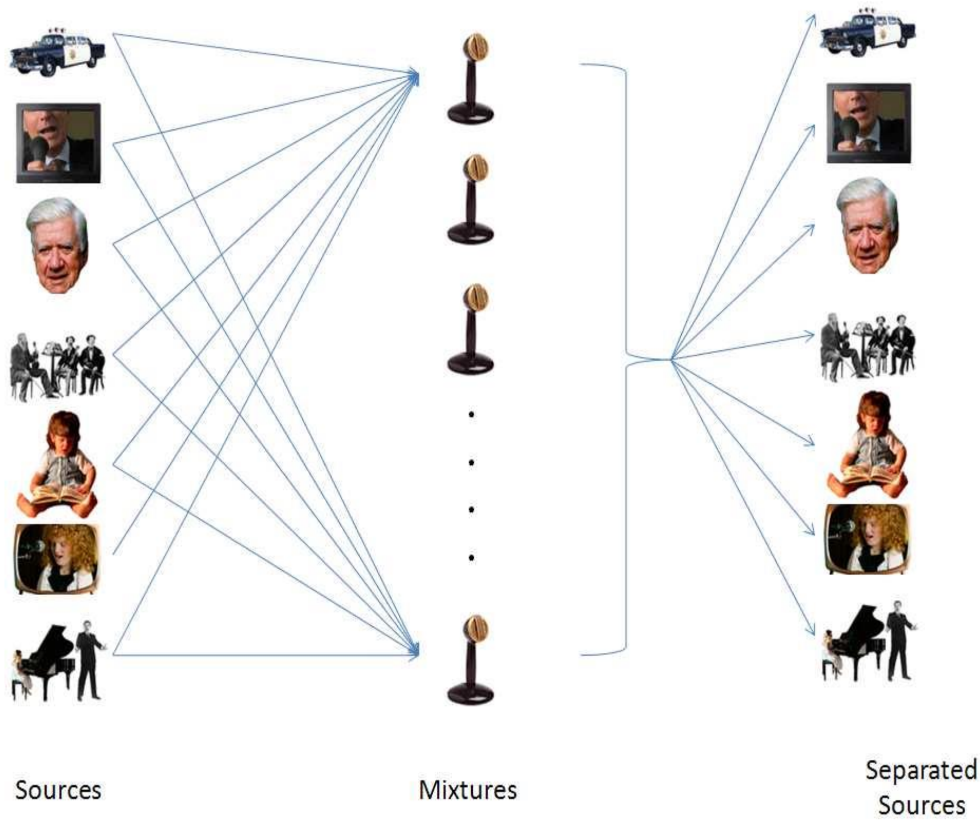

Figure 2-4 A blind source separation example at a cocktail party[44].

2.3.1 Classification of BSS

There are three basic categories of BSS, according to a study from the current research. There are several types of BSS, including linear and nonlinear BSS, instantaneous and convolutive BSS, and overcomplete and underdetermined BSS. Linear algorithms dominate the BSS research field in the first category because of their simplicity of analysis and clear separability[45]. BSS has also been improved to tackle nonlinear mixtures. This model, which takes into account nonlinear distorted signals, depicts reality more accurately. Finally, when the number of detected signals exceeds the number of independent sources (No ×Ns), the system is said to be over complete. The BSS, on the other hand, is underdetermined when the number of detected signals is lower than the number of independent sources (No×Ns)[46].

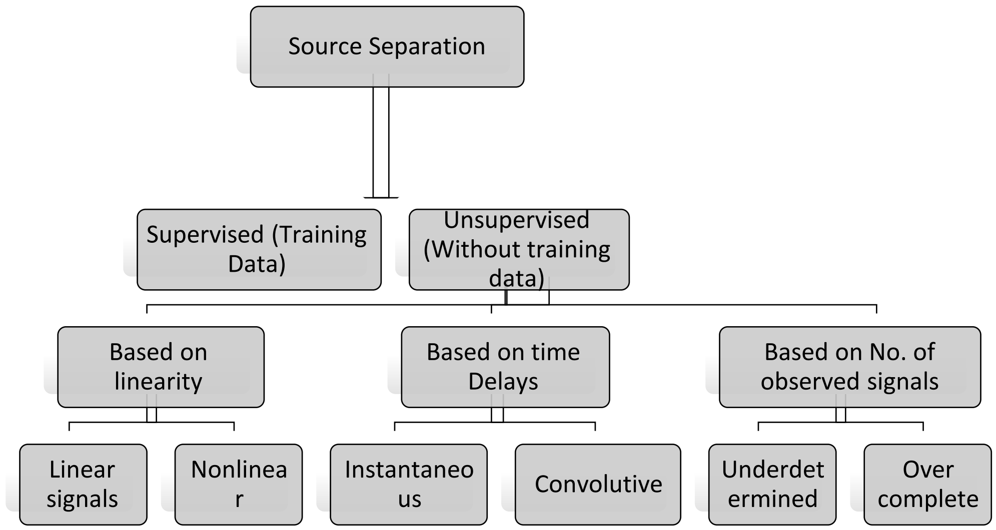

Figure 2-5 The classification of Blind Source Separation[47].

2.3.2 Applications of BSS

Because of its wide variety of prospective and fascinating uses, BSS has sparked a lot of attention in both academia and industry. In the recent decade, BSS has made significant advances in wireless communication, medical signal processing, geophysical research, and picture enhancement/recognition [47]. In the context of BSS, the phenomenon of recovering original speech signals of speakers from mixed signals collected from many microphones is referred to as the "cocktail party" problem. In the field of radio communication [48], observations that correspond to the outputs of multiple antenna elements in response to various transmitters that represent the original signals are comparable examples. Electroencephalography

(EEG), magnetoencephalography (MEG), and electrocardiogram (ECG) are utilized as observations in the study of medical signals, whereas BSS is employed as a signal processing technique to aid noninvasive medical diagnosis. BSS has also been used to analyze data in the domains of finance and seismology [49]. In chemometrics, BSS has been used to determine the spectra and concentration profiles of chemical components in an unresolved mixture, for example. Separating signals by applying basic processing to a single source inside a polyphonic combination is nearly impossible in most audio applications. This necessitates source separation methods that first split the mixture into sources before separating the sources. Audio coding, analysis, and modification are among these applications [50,51].

2.3.3 BSS problem formulation

The blind separation of signals presupposes that a set of signals is produced by distinct sources and subsequently mixed in a specific system. Both the source signals as well as the mixing system are presumed to be unknown. Both significant and unwanted components may be included in source signals (e.g., noise as well as interference). The replication of source signals based solely on observed signals is referred to as "blind signal separation." The most straightforward method involves a linear model (system) of signal mixing, as defined by the formula:

$$X(t) = A\,S(t) \qquad 2.1$$

where t is an observation number or time index, S(t) = [s1 (t), …. , sn (t)] T is a vector of source (unknown) signals, X(t) = [x1 (t), …. , xm (t)]T is a vector of the observed signals, as well as A ϵ Rm*n is an unknown nonsingular matrix representing the mixing system. To solve the above solution, many assumptions are generally made, including the characteristics of the source signals, the fact that the columns of the A matrix are linearly independent, and the fact that the number of source signals matches the number of observed signals, m = n. Figure 2-6 illustrates a block diagram of a conventional BSS design[52,53]

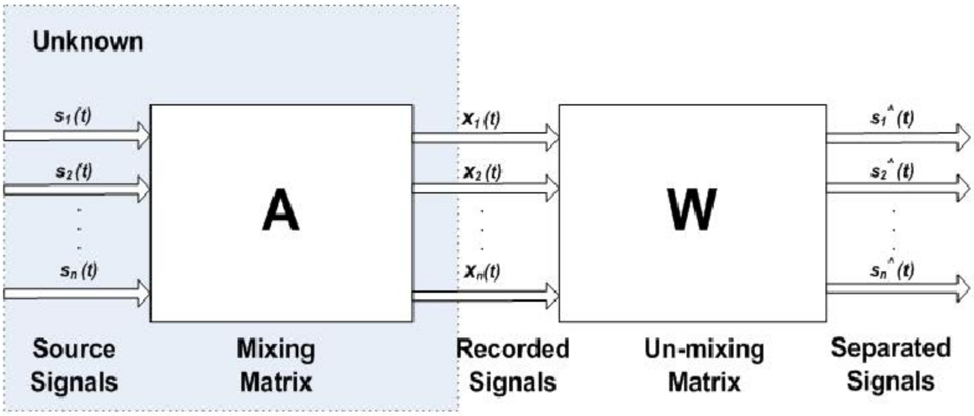

Figure 2-6 A block diagram illustrating a typical BSS design [54].

Without a priori knowledge of A and s, getting a perfect solution is difficult due to the aforementioned assumptions and uncertainties (t). As a result, the objective of blind signal separation is to identify (both estimate and reconstruct) a separation matrix W that enables the identification of the source[53].The formula for signals is as follows:

$$Y(t) = W. X(t) = PD\ S(t) \qquad 2.2$$

P is a permutation matrix that specifies the order of the estimated signals, D is a diagonal scaling matrix, and Y(t) is a vector of estimated signals. As a result, while doing blind signal separation, the correct solution is to recreate original signals that have been scaled and appear in a different order than the source signals.Indeed, the way BSS is produced depends on the true and underlying features of the source signals, including smoothness, decorrelation, statistical independence, non-negative, sparseness and non-stationary nature. Numerous analytical features are used to examine various data properties, and the method chosen is influenced by both the nature of the specific problem and the data characteristics.

The source vector S(t) in a model (Equation 2.1) is assumed to have mutually independent components in the independent component analysis (ICA) for BSS. As a result, the mixing matrix A in (Equation 2.1) is not well-defined, and some additional assumptions must be made [53]: the source components are mutually independent, E(s(t)) = 0, E(s(t)T s(t))= I, at most one of the components is Gaussian, and each source component is independent and identically distributed[55].

The diagonalization of Eigen matrices by means of joint approximation is one of the most well-known ICA techniques (JADE). It employs joint diagonalization for estimating the matrix W and fourth-order moments.Although Gaussian distributions contain no extra kurtosis, ICA's usual assumption is non-Gaussianity. JADE seeks an orthogonal rotation of observed mixed vectors in order to estimate source vectors due to their high kurtosis[56].

2.4 BSS Algorithms

BSS is a technique for extracting underlying sources blindly from their mixes (i.e.,Without original source knowledge or process mixing) [57].The BSS algorithms will be explained in our present suggested system in this section of the chapter.

2.4.1 STONE’S BSS Algorithm

Stone's BSS is a second-order statistic method introduced by Stone [52], a low-complexity batch approach that outperforms independent component analysis (ICA) techniques [57]. Numerous researchers created and discussed Stone's BSS [58]. For linear mixtures, convolutive mixtures, and nonlinear mixtures, Stone's BSS is used [60]. While the foundation of BSS should be ignorance of sources, STONE'S BSS and ICA are prone to the local minima problem [53] since they are based on source dispersion. STONE'S BSS employs the temporal predictability metric in order to separate the mixture (TP). STONE'S conjecture (that the TP of every signal mixture is the same as that of any of its components) is utilized to discover the weight vector that produces an orthogonal projection of signals mixtures [62]. The BSS model is illustrated in Figure 2.7 .

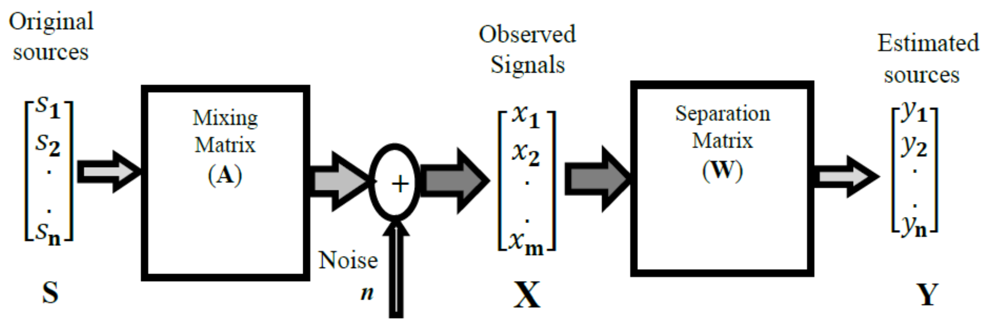

Figure 2-7 STONNE'S BSS model[12].

The noise-free (without noise) mixing system is:

$$X(k) = A\ S(k) \qquad 2.3$$

Where X(k) represents the mixed signals from known sensors, as $X(k)=[x_1(k)x_2(k)\ldots x_n(k)]^t$, and $\mathbf{S(k)}=[s_1(k)s_2(k)\ldots s_n(k)]^t$ are the unknown sources, The transpose operator is denoted by the superscript T, $A\in R^{n\times n}$ is a mixing matrix (unknown), Time or sample index is represented by the symbol **k**. The goal is to retrieve S from X without knowing A; to do so, the Y separation matrix W should be established, which in the ideal scenario is $W=A^{-1}$. The separation model calculates the recovered signals as follows[63,64]:

$$Y(k) = W\ X(k) \qquad 2.4$$

The permutation of **S** up to the scaling factor is Y, Stone's measure of signal Y(k) temporal predictability is defined as:

$$F(y) = \log\frac{V_y}{U_y} = \log\frac{\sum_{k=1}^{N}(y_{long}(k)-y(k))^2}{\sum_{k=1}^{N}(y_{short}(k)-y(k))^2} \qquad 2.5$$

$$y_{short}(k) = \beta_s\, y_{short}(k-1) + (1-\beta_s)y(k-1): 0 \le \beta_s \le 1, \qquad 2.6$$

$$y_{long}(k) = \beta_L\, y_{long}(k-1) + (1-\beta_L)y(k-1): 0 \le \beta_L \le 1, \qquad 2.7$$

N is the number of y(k) samples, $\beta_s = 2^{-1/h_{short}}$, $\beta_L = 2^{-1/h_{Long}}$, and $h_{short,}$ h_{Long} as a half-life parameters, where the half-life h_{short} of β_s is 100 time shorter than half-life h_{Long} of β_L.

When y(k) = $w_i^T x(k)$, and W = [w_1, w_2, …, w_n], then 2.5 can rewritten as:

$$F(y_i) = \log \frac{w_i C_{xx}^{long} w_i^T}{w_i C_{xx}^{short} w_i^T} \quad 2.8$$

Where C_{xx}^{long} is a long-term covariance matrix (N×N), between signal mixtures, and Where C_{xx}^{short} is a short-term covariance matrix (N×N), between signal mixtures, so $C_{x_i x_j}^{long}$ and $C_{x_i x_j}^{short}$ between i_{th} and j_{th} mixtures defined as:

$$C_{x_i x_j}^{short} = \sum_r (x_{ir} - x_{ir}^{short})(x_{jr} - x_{jr}^{short}) \quad 2.9$$

$$C_{x_i x_j}^{long} = \sum_r (x_{ir} - x_{ir}^{long})(x_{jr} - x_{jr}^{long}) \quad 2.10$$

STONE'S BSS aims to maximize Rayleigh's quotient in order to provide unmixing vectors. In order to address this problem, generalized eigenvectors of $C_{xx}^{long}[C_{xx}^{sort}]^{-1}$ are studied. to find the orthogonal eigenvectors (W_1,W_2,W_3,....,W_M) of matrix ($C_{xx}^{sort\ -1}$ C_{xx}^{long}) in the covariance matrices:

$$W_i C^{short} W_i^t = 0 \quad 2.11$$

$$W_i C^{long} W_i^t = 0 \quad 2.12$$

Where :

$$W_i C^{short} W_i^t = \sum_r (y_{ir} - y_{ir}^{short})(y_{jr} - y_{jr}^{short}) \quad 2.13$$

$$W_i C^{short} W_i^t = \sum_r (y_{ir} - y_{ir}^{long})(y_{jr} - y_{jr}^{long}) \quad 2.14$$

When the short-term half-life parameter h_{short} toward zero value ($h_{short} = 0$) then the short-term mean is:

$$y_r^{short} \approx y_{r-1} \quad 2.15$$

$$(y_r - y_r^{short}) \approx d_{yr}/dr = y'_r \quad 2.16$$

Also, when the long-term half-life parameter h_{long} toward zero value ($h_{long} = \infty$) then the long-term mean is:

$$y^{long} \approx 0 \quad 2.17$$

$$(y_r - y_r^{long}) \approx y_r \quad 2.18$$

The expected values for y_i and y_j are now equal to zeros under these conditions:

$$E[y_i y_j] = 0 \quad 2.19$$

Hence, since y_i and y_j are independent, each of the recovered signals can be expressed as $y_i=W_ix$, and $y_j=W_jx$, and the expected value for these variables is zero. This method is beneficial for any mixture of linear signals, which is regardless of whether they are statistically independent. It assures that the independent components are always separated. The temporal derivatives of each recovered signal are uncorrelated, and their average is zero:

$$E[y'_i y'_j] = 0 \quad 2.20$$

Finally, to compute the separation matrix W, which is used in several applications in the theory of elliptic equations, one may use Matlab's eigenvalue function as follows:

$$W = eig(C^{long} C^{short}) \quad 2.21$$

One of STONE'S BSS's advantages is that it simplifies the BSS problem to a general eigen problem.STONE'S BSS offers several benefits over independent component analysis (ICA) methods. Although it is susceptible to the local minima problem, STONE'S BSS simplifies the BSS problem to generalized eigenvalue decomposition (GEVD).Figure 2-8 Summarizes the outline of the recommended algorithm for easy reference.

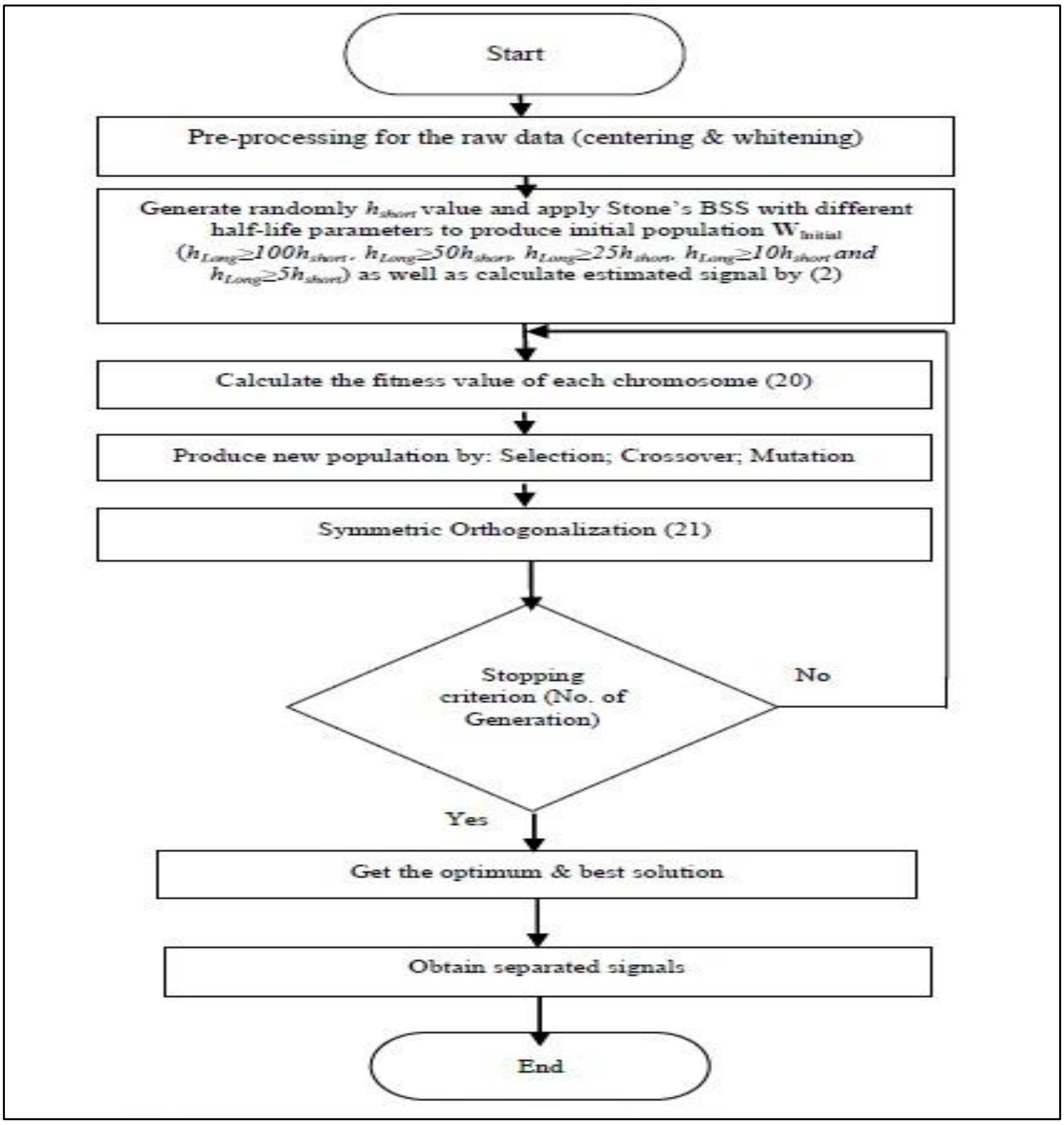

Figure 2-8 Flowchart of the Proposed STONE (BSS) Algorithm[64].

2.4.2 Joint Approximate Diagonalization Of Eigenmatrices (JADE) Algorithm

The JADE (joint approximate diagonalization of eigenmatrices) approach might employ fourth moments. JADE does not require unique kurtosis values[65].

$$C(M) = E[(x_{st} M x_{st}^T)\, x_{st}^T x_{st}] - M - M^T - tr(M) I_p \qquad 2.22$$

x_{st} stands for standardized variable. Then write $E^{ij} = e_i^T e_j$, i, j = 1,.., p, where ei is a p-vector with the i^{th} element one and the rest zero. The matrices $C(E^{ij})$, i, j = 1,..., p are approximately jointly diagonalized by an orthogonal matrix in JADE (after the whitening)[66]. The rotation matrix U maximizes the approximation joint diagonalization criteria.JADE is affine equivariant even though the matrices $C(E^{ij})$, I, j = 1,..., p are not orthogonal equivariant. If the independent components' eighth moments are finite, the vectorized JADE unmixing matrix estimate has a limiting multivariate normal distribution. The JADE algorithm diagonalizes p2 matrices at the same time. When a result, as the number of components grows, the computational burden grows rapidly [67].A well-parallelized JADE method would yield a quicker implementation with improved accuracy and reduced memory use. This is especially useful when embedded systems are expected to be memory limited.

2.4.3 Enhanced Fast Independent Component Analysis (EFICA) algorithm

Using Independent Component Analysis, EFICA is a common method for isolating linearly mixed independent sources. The separation is done by optimizing a contrast function based on kurtosis or other entropy approximations with a nonlinear function[65]. EFICA is a three-phased extended version of FastICA [64]. The original FastICA (the symmetric approach) is applied to the preprocessed data in the first phase, with sample mean and correlations removed. The nonlinearity of this step guarantees convergence for a large number of variables. When it comes to calculating the spectrum of distributions, hyperbolic tangent is a popular choice. The saddle point test wraps up the first stage, guaranteeing FastICA's global convergence. The tentative estimations of the original signals from the previous stage are used in the second phase of EFICA. This is used for adaptive nonlinear function selection, which is done for each signal to be estimated separately. Based on the sample fourth moment of the signal, the original EFICA detects the nonlinearity that is suitable for GGD signals. In the third phase, a few fine-tuning rounds of one-unit FastICA using the specified nonlinearities are conducted based on the preliminary estimation of the sources (obtained in the first step). As a consequence, individual signal estimations improve. The method is tweaked in the end to remove any leftover inter-signal interference[64,66]. Independent Component Analysis (ICA) [65,66] uses the following basic model:

$$X = \mathrm{AS} \qquad 2.23$$

where **S** equals $[s_1 ; . . . ; s_d]^T$ is a is a vector of independent RAM Variables (RVs), each of which represents one of the unidentified initial signals. In actuality, there exist N independent realizations of x, which are mixes of the signals s via an unknown d*d regular mixing matrix A. The objective is to estimate the de-mixing transform A^{-1} up to an indeterminable order, scales, and sign of its rows using the assumption of independence of s_1 ; . . . ; s_d,. Numerous separation methods for ***N*** i.i.d. signals have been suggested [64,67,68]; some recent algorithms have been developed to attain accuracy close to the corresponding Cram´er-Rao Lower Bound (CRLB) [69]. For an unbiased estimate the $\hat{W}$ of A^{-1}, the bound is as follows:

$$\mathrm{CRLB}[\mathrm{G}_{kl}] = \frac{1}{N}\frac{K_t}{K_l K_t - 1} \qquad k \neq l \qquad 2.24$$

The FastICA algorithm [68] is based on a contrast function optimization.Means of a sample The one-unit FastICA completes each iteration by normalizing the vector w^{+}_{k}, whereas the symmetric FastICA computes d iterations (3.4) in parallel as well as a symmetric orthogonalization of $[w^{+}_{1}, \ldots, w^{+}_{2}]^{T}$ to estimate all rows of the de-mixing matrix.

Many engineering applications, such as electroencephalographic (EEG) signal separation for artifact removal in Brain Computer Interfaces, suffer from the Blind Source Separation (BSS) problem (BCI). Despite its high computational cost, Independent Component Analysis (ICA) is a widely used approach for this purpose. As a result, when'real-time' operation on (BCI) systems is required.

Chapter 3: Methodology and The Proposed System

3.1 Introduction

When transmitting data over carrier medium, whether it's text, audio, graphics, or any other type of data, the transmission process is impacted by the environment in which it's delivered, and the sent signals are distorted as a result. Blind source separation (BSS) is a common approach for recovering signals from distinct sources that are isolated from the environment. This chapter will address the general explanation of BSS technology as well as our suggested approach for using BSS technology to decrease electromagnetic noise in an Ethernet connection. Figure 3-1 depicts the primary noise coupled with the Ethernet wire.

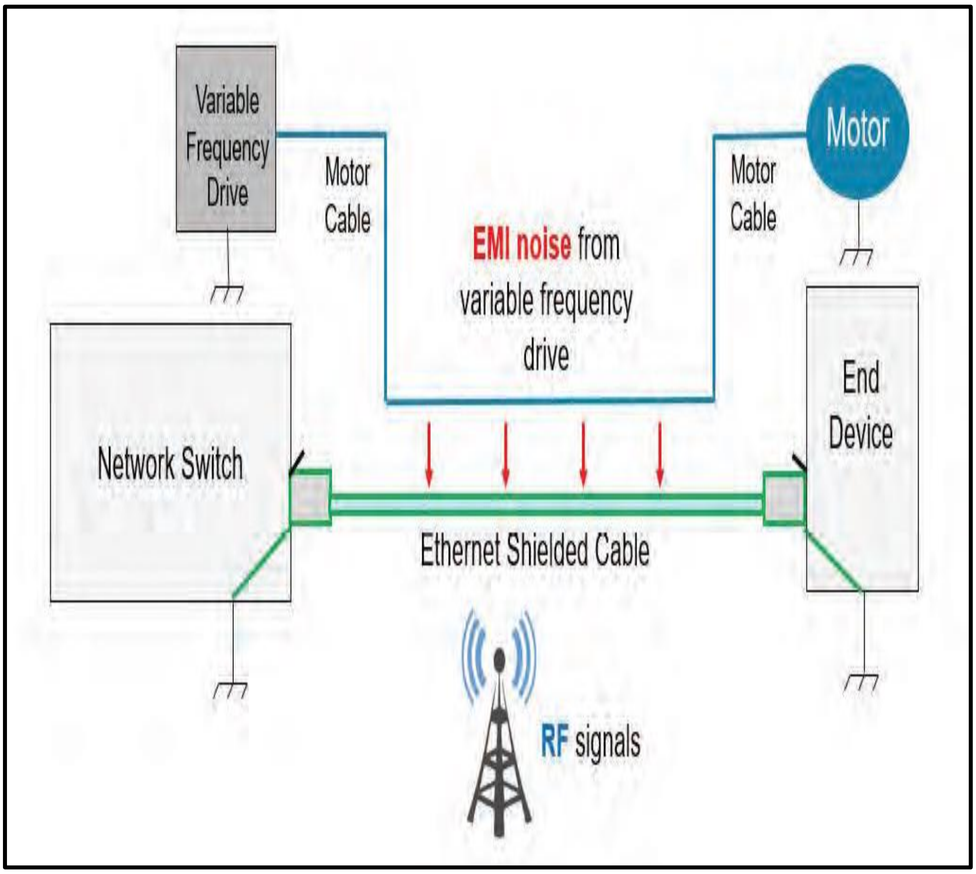

Figure 3-1 Electric noise (EMI or RF) can be coupled to the Ethernet connection to disrupt the transmission signal.

3.1.1 Methodology

As previously said, transmitting data, whether it is text data, pictures, or video, over networks using Ethernet cable exposes it to a great deal of noise and distortion, which degrades such signals. In our present study, it is employed(BSS) algorithms to decouple the data source from the data. EMI and crosstalk are examples of noise and distortions that impact data. The figure below depicts the key operations of our methodology.

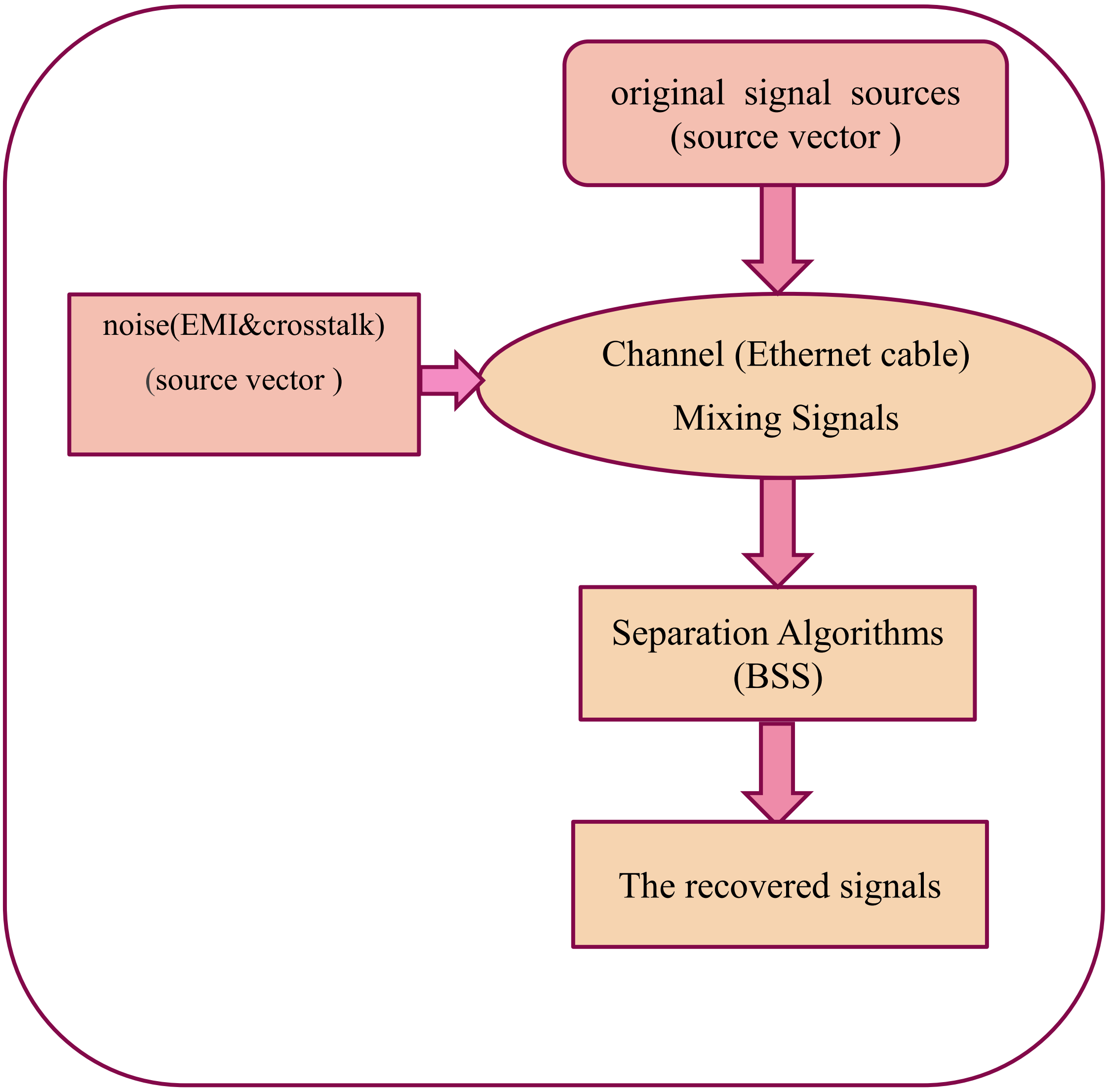

Figure 3-2 Methodology

3.1.2 Input Data

In our current system, three types of data are used: Text data, audio data, and image data. The input data have collected using the following methodology:

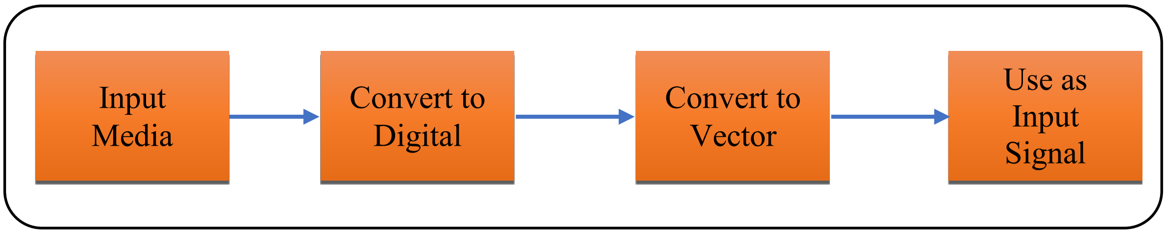

Figure 3-3 The Input data methodology.

a) Input Media

In our current system, three types of data, text, voice, and images, with two types of noise, electromagnetic noise, and crosstalk noise are entered, to make sure the system works and is effective.

b) Convert to Digital

Digitization is the process of converting information into a digital (i.e. computer-readable) format. As a result, a sequence of numbers are generated that define a discrete set of points or samples used to represent an object, picture, sound, text, or signal (typically an analog signal). This is referred to as digital representation for the object, and digital form for the signal. Digitized data in current practice is in the form of binary digits, which simplifies processing by digital computers and other activities, although digitizing technically refers to the conversion of analog source material into a numerical format. Digitization is essential to data processing, storage, and transmission because it "allows information of all sorts in all forms to be transferred with the same efficiency and also intermingled. Though analog data is more stable, digital data is easier to share and retrieve, and it may potentially be propagated forever without loss of generation if it is converted to new, stable forms as needed. This is why many organizations all around the globe embrace it as a data preservation strategy.

c) Convert to Vectors

Data transmitted over cables can be transmitted in its natural form (frame), but it also contains feature-based data that you may find more helpful in its original form,When converting a data frame to a vector [54].

d) Use as Input Signal

After converting the data entered into the system into digital data and converting it to vectors, that data is used as input for the next stage, which is the BSS algorithm, to mix it with the input noise, which is electromagnetic noise and crosstalk noise, so that the program separates it using BSS algorithms and compares the results with the original data via the BSS algorithms.

3.1.3 Transmission line model CAT5

The perplexing electromagnetic field in and around the area regulates every twisted pair's conduct. It is need a more detailed portrayal of the link that can be completed within the project timeline and is computationally viable. Nonetheless, the model must properly address important link barriers such as deferral, end-to-end cross-talk, and link disasters. A single transmission line pair is seen in Figure (3- 4).

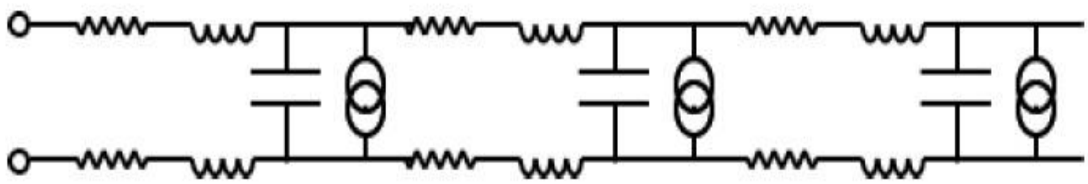

Figure 3- 4 Transmission line pair CAT5

To equalize the impedance, the transmission lines are partitioned into equal length components. The voltage and current of the base wire perfectly describe the voltage and current of the top wire in a fully differential representation . The voltage and current in every component are defined in this case as:

$$-dV = R\,dxI + Ldx\frac{dI}{dx} \quad 3.1$$

where dx is the component's length, R=40 represents resistance per unit length, L=40e.6 represents inductance per unit length, C=40e.12 represents capacitance per unit length, and Io represents (voltage regulated) current per unit length. G is a recurrent subordinate conductance, and Io is usually expressed in the structure GV. The accompanying condition for the voltage at each location along the line as a component of time is obtained by combining the above two conditions and removing I.

$$-dI = I_o dxI + Cdx\frac{dV}{dx} \quad 3.2$$

3.1.4 Types of Ethernet Cable Modeling

Here, MATLAB ver. R2021a Software will be use to as a possible showing portrayal because of its capacity to socially depict complicated analog circuits and frameworks. To deal with the uncoupled transmission line situation accepting Io=0, the transmission line module employs a limited distinction technique. Figure 3-5 illustrates the behavior of the CppSim module.

$$\frac{\partial V}{\partial x^2} = LC\frac{\partial^2}{\partial t^2} + RC\frac{\partial V}{\partial t} + \frac{\partial I_o}{\partial t} + RI \quad 3.3$$

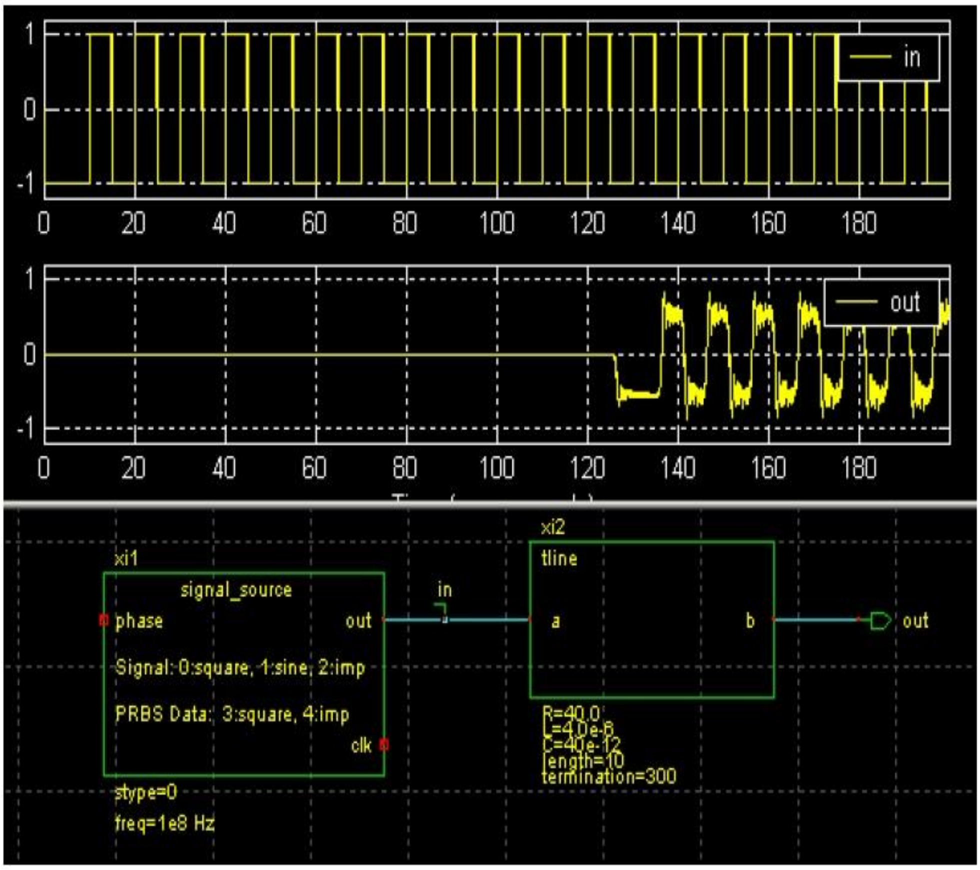

Figure 3-5 Module and results of CppSim transmission lineCAT5

The deferral and static resistive loss of a single wire pair may be evaluated using this simple social model. In any case, it provides no information on end-to-end cross-talk or recurrent subordinate decreasing. Other simulation environments, such as MatLab™, might be used to create the aforementioned module, but it would need to be expanded to show up to eight linked transmission lines.To uncouple the transmission line conduct and ensure combination and strength, these requirements, which are handled in vector structure, need network control (change of premise) and advanced mathematical techniques.

- The model addresses intra-pair and inter-pair coupling, as well as the associated resistance and X-talk, as essential interconnection variance elements.
- The consequences of resistance loss in the wire and dielectric.

This basic computer model allows the modelling of whole transceiver lines in a single validation environment. Intra-pair skew and inter-pair skew caused by torsion variation, as well as progressive impedance discontinuities caused by in-pair separation along the cable or at the conductors, have all been shown to be too difficult to model. At the system level, these must be represented in a model.

3.2 Data Generation

Using Matlab, we generated three types of data, which are text data, audio data, and image data, through three algorithms. The following figure shows the original data of the sound type with two types of noise.

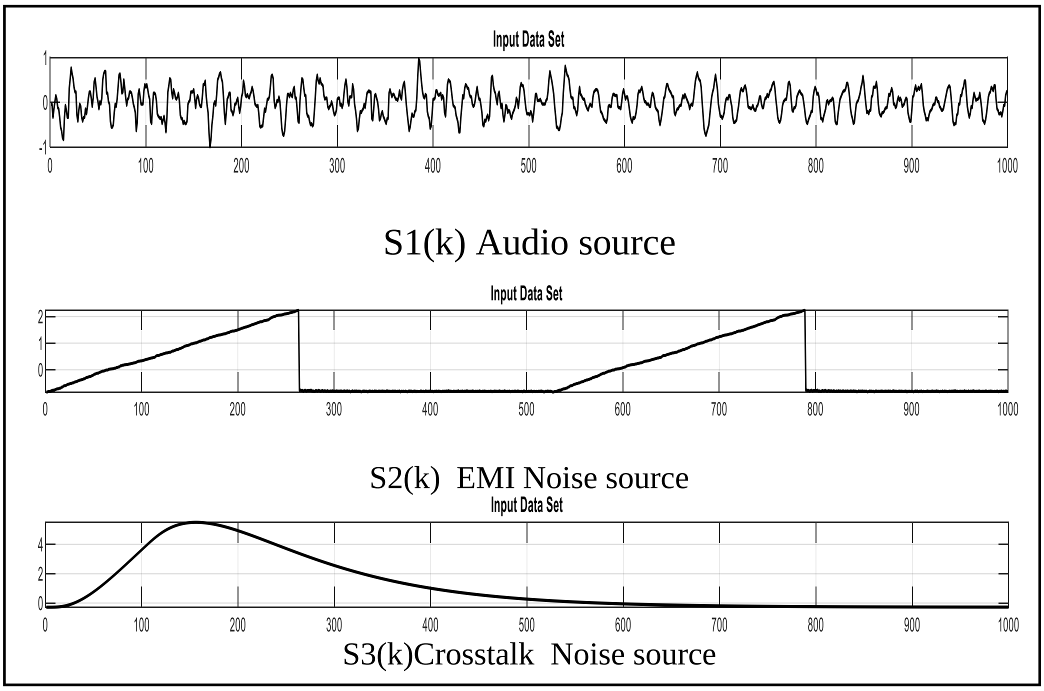

Figure 3-6 Audio with noise source.

The following figure shows the original data of text type with two types of noise.

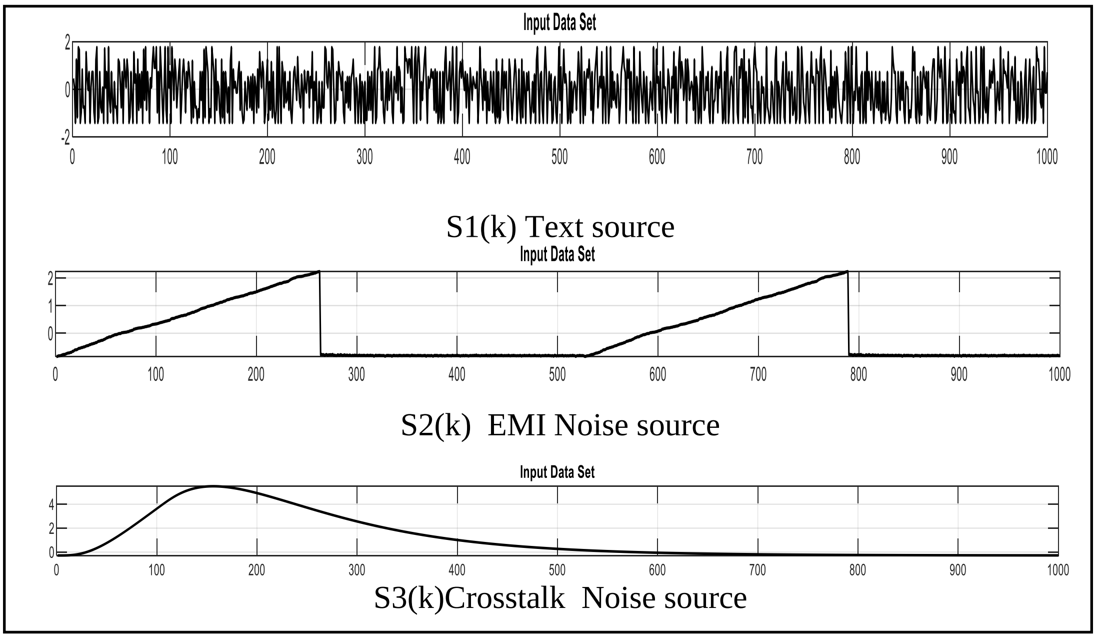

Figure 3-7 Text with noise source.

The figure 3-8 shows the original data of image type with two types of noise.

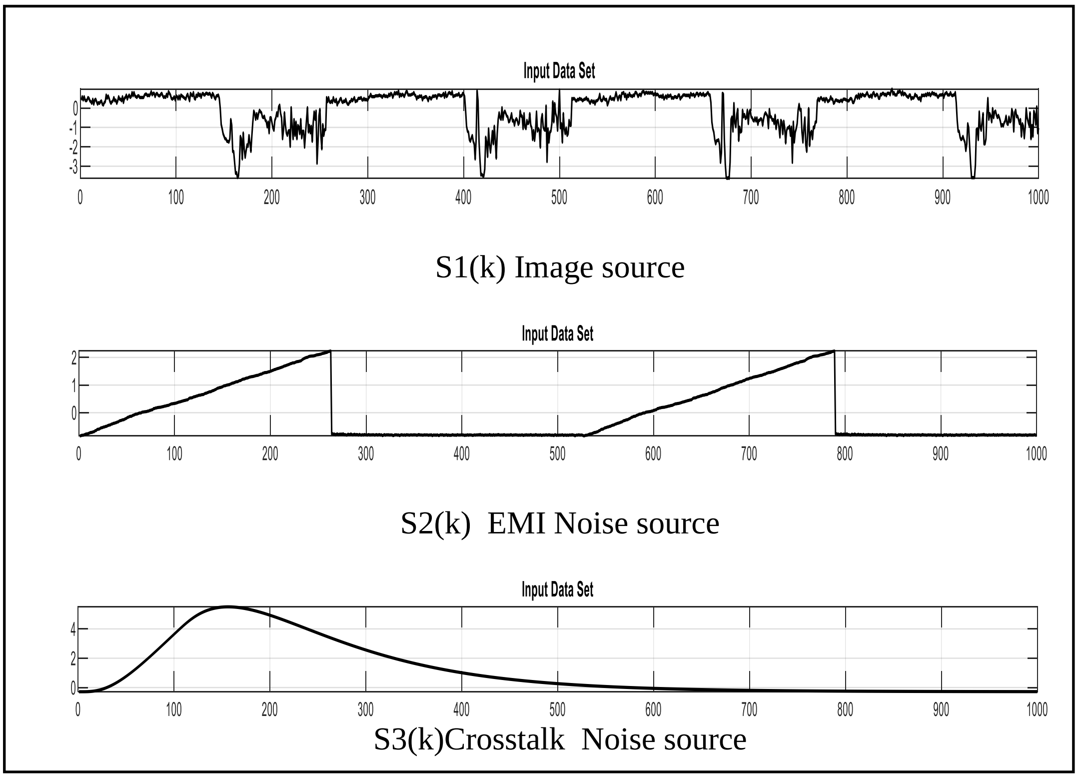

Figure 3-8 Image with noise source.

3.2.1 Preprocessing

Preprocessing is the process of preparing data before entering it into the BSS data. There are three different approaches:

a) Centering process

It simply implies that after recovering the original signal, the received vectors' sample mean will be removed and added to the original signal.

b) Whitening process

It is the process of changing the shape of a vector. This transformation occurs in a linear manner. All whitened components will have the same variance and will be uncorrelated. The whitening matrix is then restored using the Eigen value decomposition covariance matrix.

c) Principle component analysis

Dimensionality is introduced by carefully selecting the components that must be used and in which circumstances they must be used. This process is tasked with the responsibility of avoiding "overlearning."

The steps below can be used to summarize the general work of BSS algorithms [9].

- Set the data to a zero-mean value;
- Whitening the data
- At random, select W as the first vector. In the inverse matrix W, the chosen vector represents the anticipated column.
- stage of "fixed-point iteration";
- equalization;
- check convergence; if it is satisfactory, proceed; otherwise, revert to step 4.

3.2.2 The Proposed System

The suggested system's approach is as follows the noise-free mixing system is as follows from (Eq. 3.4) Where **x(k)** = [x1(k),...., xn (k)]T. **S(k**)=[s1(k),..., sn(k)]T. X(t) is the mixing vector of the received signal. The unknown source vector is denoted by **S(k)**, whereas the unknown destination vector is denoted by:

$$X(k) = A\ S(k) \qquad 3.4$$

Is the known received signal mixture vector, T denotes the transpose operator, AϵRn*n denotes an unknown mixing matrix, and k denotes the time or sample index. The suggested system will employ the following approach, based on the STONE (BSS) Algorithm, in the system depicted in Figure 3-9 The objective is to recover S from X without knowing A. To do this, a separation matrix W should be built, with W equal to A in the ideal scenario $W=A^{-1}$. To illustrate further, the matrix form of Eq. 3.4 may be transformed into linear equations as follows:

$$X_1(k) = a11\ S_1(k) + a12\ S2(k) + \ldots \ldots + a1n\ Sn(k)$$

$$X2(k) = a21\ S_1(k) + a22\ S2(k) + \ldots \ldots + a2n\ Sn(k)$$

…..

$$Xn(k) = an1\ S_1(k) + an2\ S2(k) + \ldots \ldots + ann\ Sn(k)$$

The above equations illustrate the broad mathematical model for proposed blind source separation algorithm.S denotes the original signal sources (k). Following that, matrix A will combine all of the inputs to form the mixture matrix X(k) .

The noise-generating system is as follows:

$$X(k)=A\ S(k)+n(k) \qquad 3.5$$

n(k) = [n1(k), n2(k), n3(k),..., nn(k)]T, where n(k) denotes additive noise, with each source having a zero-mean and unit variance.

The Eq. (3.6) show the separation model calculates the recovered signals:

$$Y(k) = W\ \ X(k) \qquad 3.6$$

The permutation of **S** up to the scaling factor is Y.S up to the scaling factor has a permutation of Y.A denotes an unidentified mixing matrix with unidentified mixing weights an ij, x(k) denotes a known observation matrix, and s(k) denotes unidentified original sources.Our objective is to deconstruct the resultant mixtures and separate the primary sources. If A is a full rank matrix, the formula Y(k) = W X(k) may be expressed as follows:

$$s_1(k) = w_{11}x_1(k) + w_{12}x_2(k) + \cdots \ldots + w_{1n}\, x_n(k)$$

$$s_2(k) = w_{21}x1(k) + w_{22}x_2(k) + \cdots \ldots + w_{2n}\, x_n(k)$$

……………………………………………………………

$$s_n(k) = w_{n1}x_1(k) + w_{n2}x_2(k) + \cdots \ldots + w_{nn}x_n(k)$$

As mentioned earlier, the sending data (audio, text, images or video) over networks through the Ethernet cable exposes it to a lot of noise and distortion which negatively affects those signals. The proposed system represented by three stages, the first stage is for signal preparing and generation. The second stage is for mixing the three types of signals based on the used Ethernet cable. The Final stage is for applying the BSS algorithms to separate the original data from the noise and distortions sources. Figure 3-9 show the general diagram of the proposed system with its main stages.

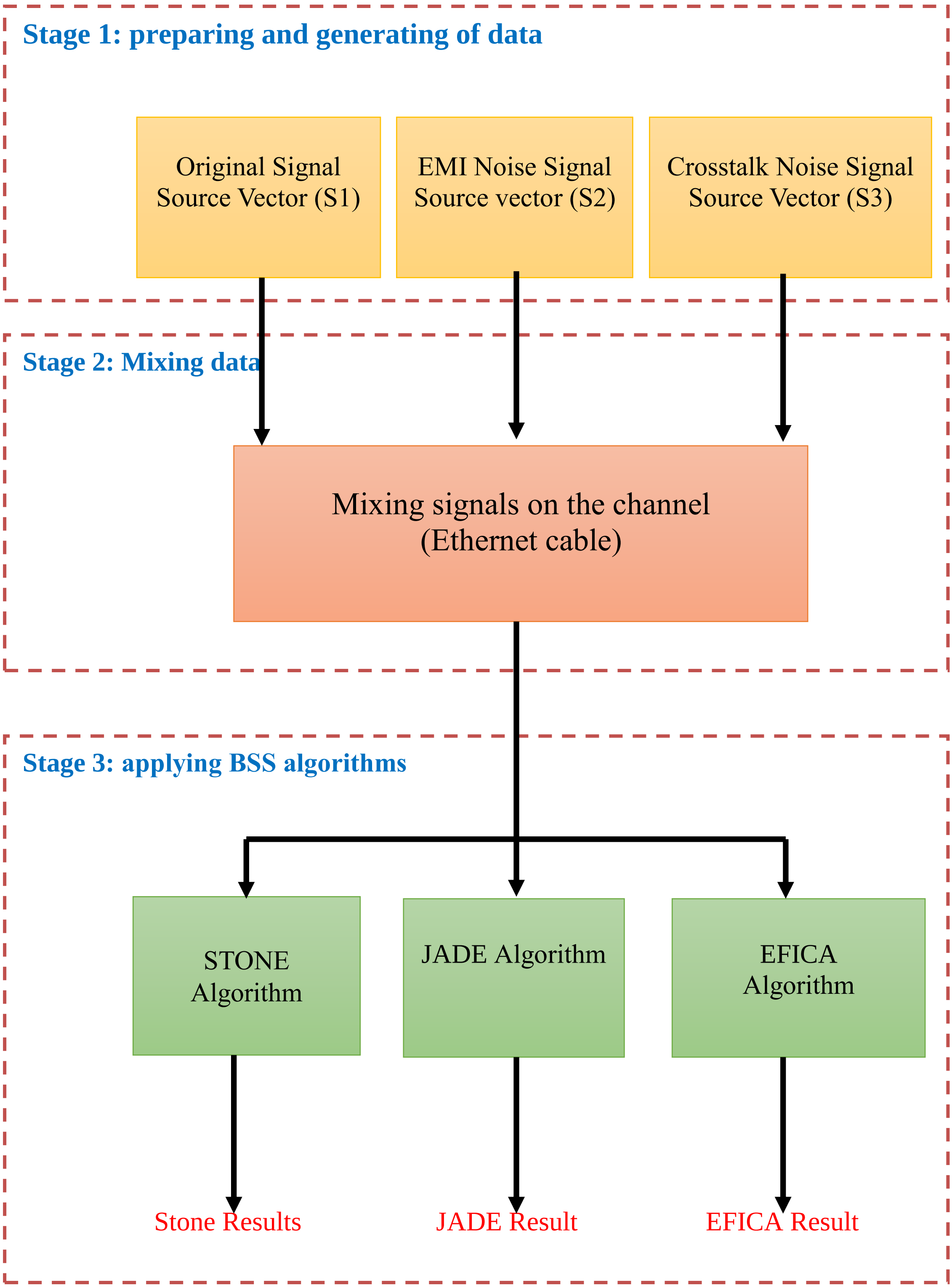

Figure 3-9 The proposed system stages.

Chapter 4: Results and Discussion

4.1 Introduction

In this chapter of the thesis, It is discussed about the results obtained after applying the blind signal separation algorithms, where the results were divided into three cases in relation to the three types of data sent via the Ethernet cable, which are audio data, text data, and image data. Three BSS algorithms, the Stone Algorithm, the JADE-Algorithm, and the EFICA-Algorithm, were used, and their outcomes were compared using the Signal Noise Ratio (SNR) and Root Meen Sequre Errer (RMSE)

4.2 Results and Discussion

4.2.1 Case1 Results

In the first case, the three algorithms of BSS were applied to the first type of data, which is the sound, where the sound data was generated using Matlab program with the generation of two types of the noises, electromagnetic noise and crosstalk noise. The following figure shows the original data for audio with noises.

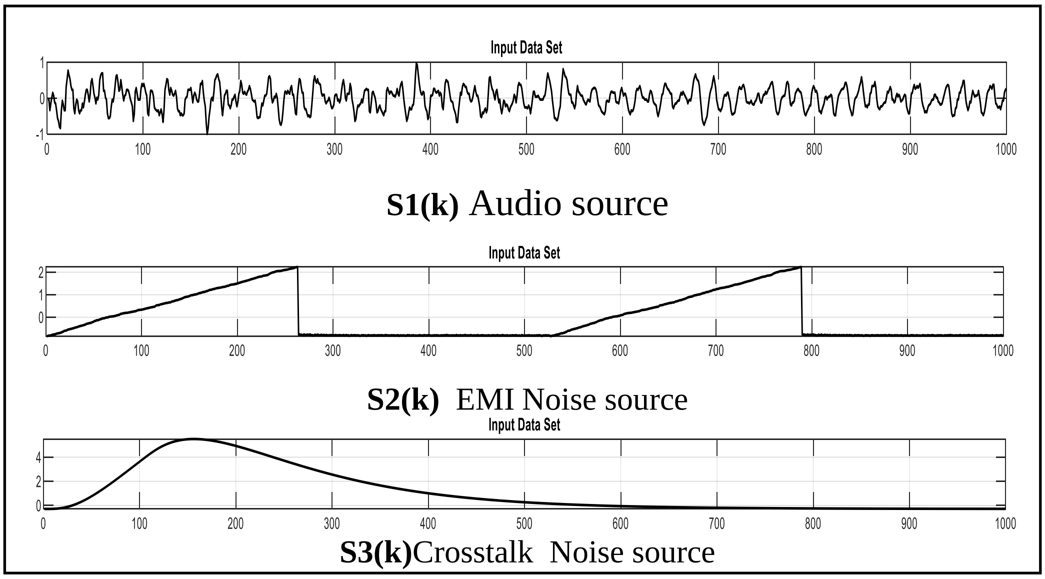

Figure 4-1 Audio with noise sources.

After the data and noise are entered into the system, a preprocessing of the input data and mixing will take place, so that the system evaluation is accurate. The mixing process is very important in our current work, as it is not possible to measure and evaluate the efficiency and performance of the system without testing data with signals containing noise. The following figure shows the signals of the first case after the mixing process.

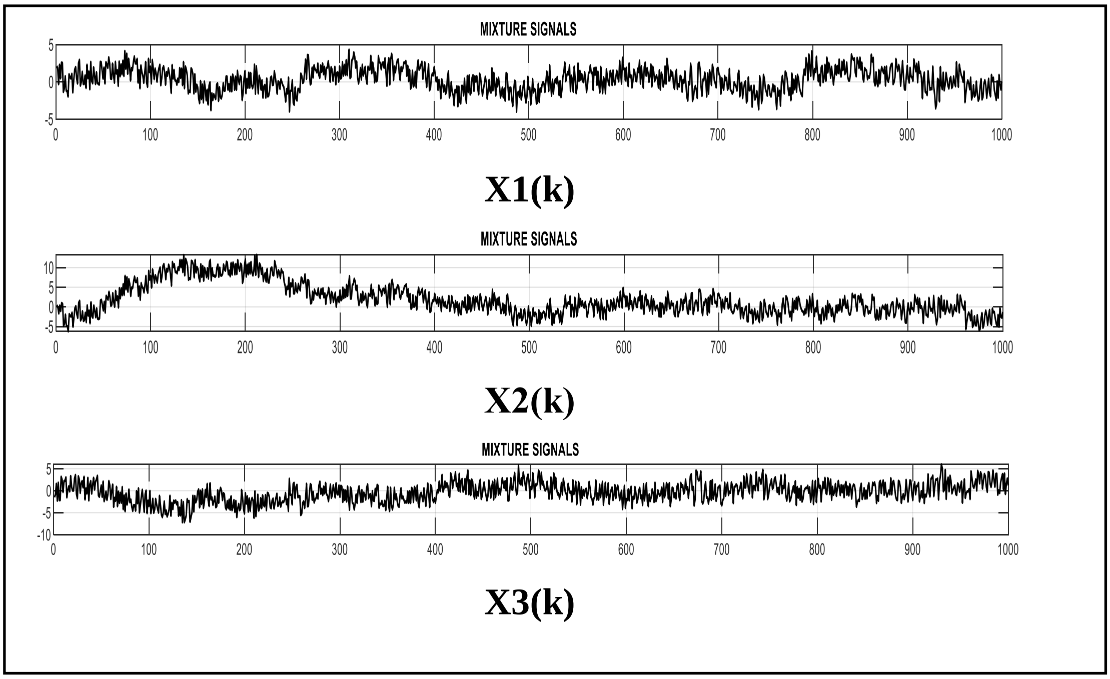

Figure 4-2 Audio with noise sources after mixing.

After the mixing process, three BSS algorithms will be applied to it, STONE Algorithm, JADE-Algorithm, and EFICA-Algorithm, where some mathematical equations are applied to them to get new signals, and they are compared with the original signals to see the accuracy and effectiveness of the results of the algorithm used. The BSS algorithms will be started with Stone's algorithm, which is the most powerful among the algorithms used, because a great similarity is found to the resulting signals and the original signals used. Figure 4-3 shows the results of Stone's algorithm on the signals of the first case (audio signals and noise).

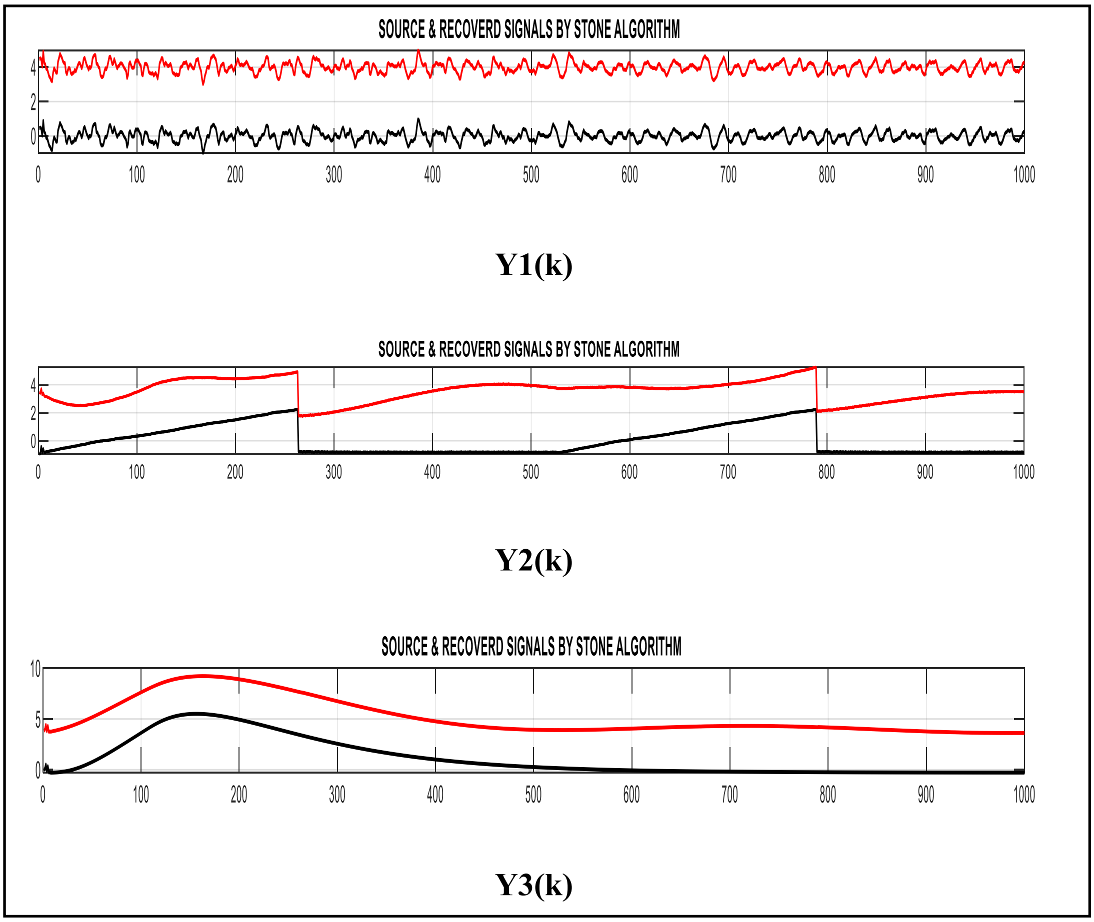

Figure 4-3 The results of STONE'S algorithm on the signals of the case1

In the above figure, the original signals were represented in black, while the resulting signals from Stone's algorithm were represented in red. A very large similarity will be noticed between the original sound signal and the sound signals generated by the algorithm, as well as the case with noise, there is a great similarity in electromagnetic noise and crosstalk noise.

When applying the JADE-Algorithm to the same signals that Stone's algorithm is applied to got lower results than the accuracy of Stone's algorithm results. Figure 4-4 shows the results of the JADE-Algorithm on the signals of the first case (audio signals and noise). The original signals entering the algorithm were also represented in black, while the resulting signals were represented in red in order to distinguish them and facilitate comparison of the shape of the signals.

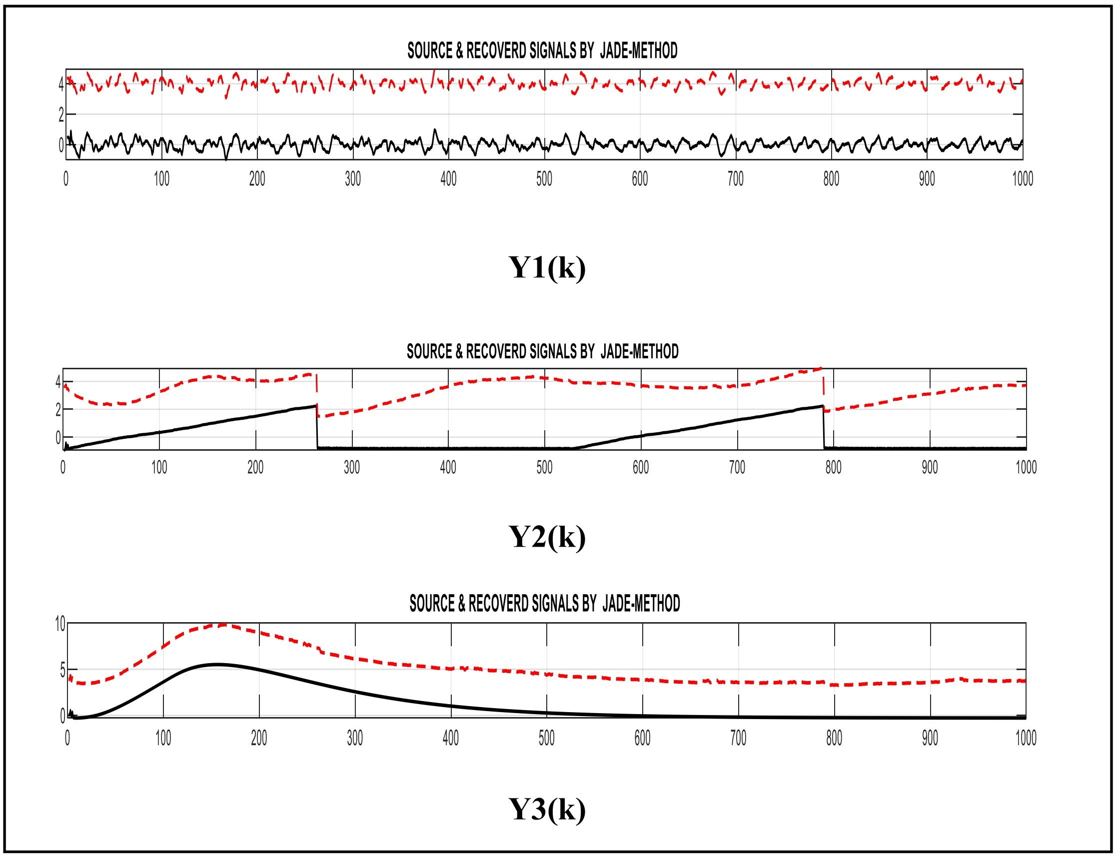

Figure 4-4 The results of JADE-Algorithm on the signals of the case1.

Finally, when applying the EFICA algorithm to the original signals, much lower results will be got than the JADE algorithm. Figure 4-5 shows the results of the EFICA-Algorithm algorithm on the signals of the first case (audio signals and noise).

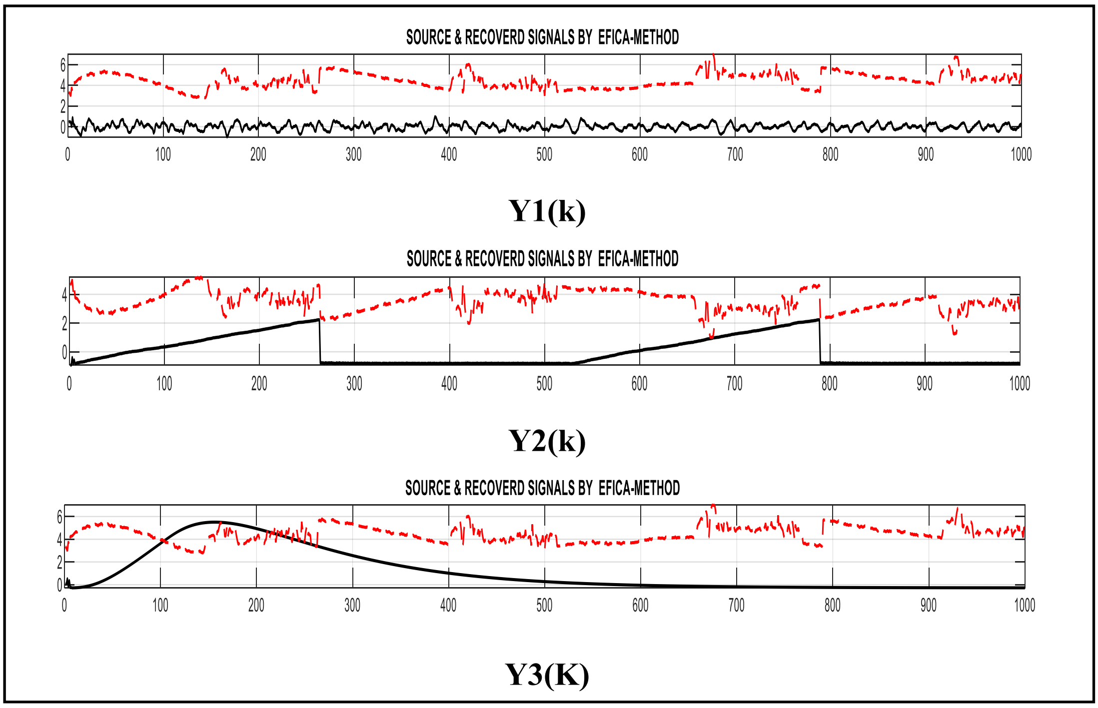

Figure 4-5 The results of EFICA-Algorithm on the signals of the case1.

After using the three BSS algorithms, STONE Algorithm, JADE-Algorithm, and EFICA-Algorithm, and comparing the BSS algorithms via signal noise ratio (SNR), as discussed in detail later, the following findings are obtained:

Table 4-1 SNR for case1.

Input data source	BSS Algorithm STONE	BSS Algorithm JADE	BSS Algorithm EFICA
Audio source	32.0282	22.8581	2.9389

According to the data in the preceding table, the SNR obtained by calculating the signal-to-noise ratio varies from one algorithm to another, and this indicates the accuracy of the signal generated by the algorithm, as well as the high similarity between the produced signal and the original signal. The SNR of the Stone-algorithm reached 32.0282, which is the highest value among the rest algorithms, and it was followed by the SNR of the JADE- algorithm, which reached 22.8581, which was the second highest value.

4.2.2 Case 2 Results

In the case 2, the three algorithms of BSS were applied to the second type of data, which is the text, where the text data was generated using Matlab program with the generation of two types of the noises, electromagnetic noise and crosstalk noise. The following figure shows the original data for text with noises.

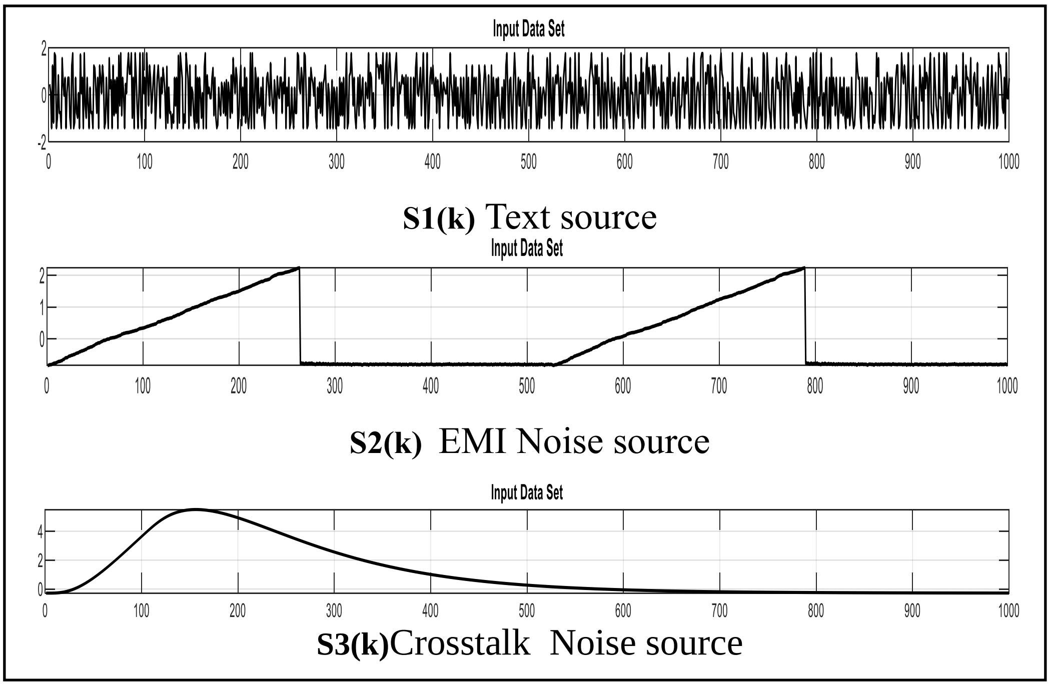

Figure 4-6 Text with noise sources.

After the text signal and noise are entered into the system, the input data will be preprocessed and mixed to ensure that the system evaluation is accurate. The mixing procedure is critical in our current work because it is impossible to monitor and evaluate the system's efficiency and performance without testing data with noisy signals. The following figure shows the signals of the second case after the mixing process.

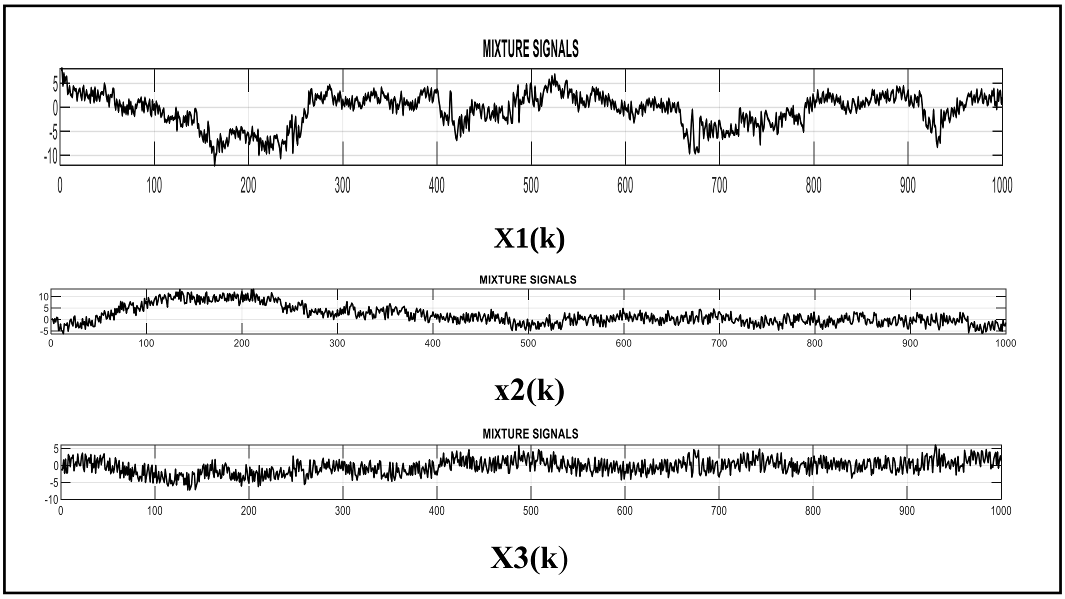

Figure 4-7 Text with noise sources after mixing.

Following the mixing process, three BSS algorithms, namely Stone Algorithm, JADE-Algorithm, and EFICA-Algorithm will be applied to it, as previously mentioned, where some mathematical equations are applied to them to obtain new signals, which will then be compared to the original signals to determine the accuracy and effectiveness of the algorithm used . The BSS algorithms will be started with Stone's method, which is the most powerful of the algorithms utilized, because the generated signals and the original signals are very similar. The results of Stone's method on the signals in the second case (text signals and noise) are shown in Figure 4-8.

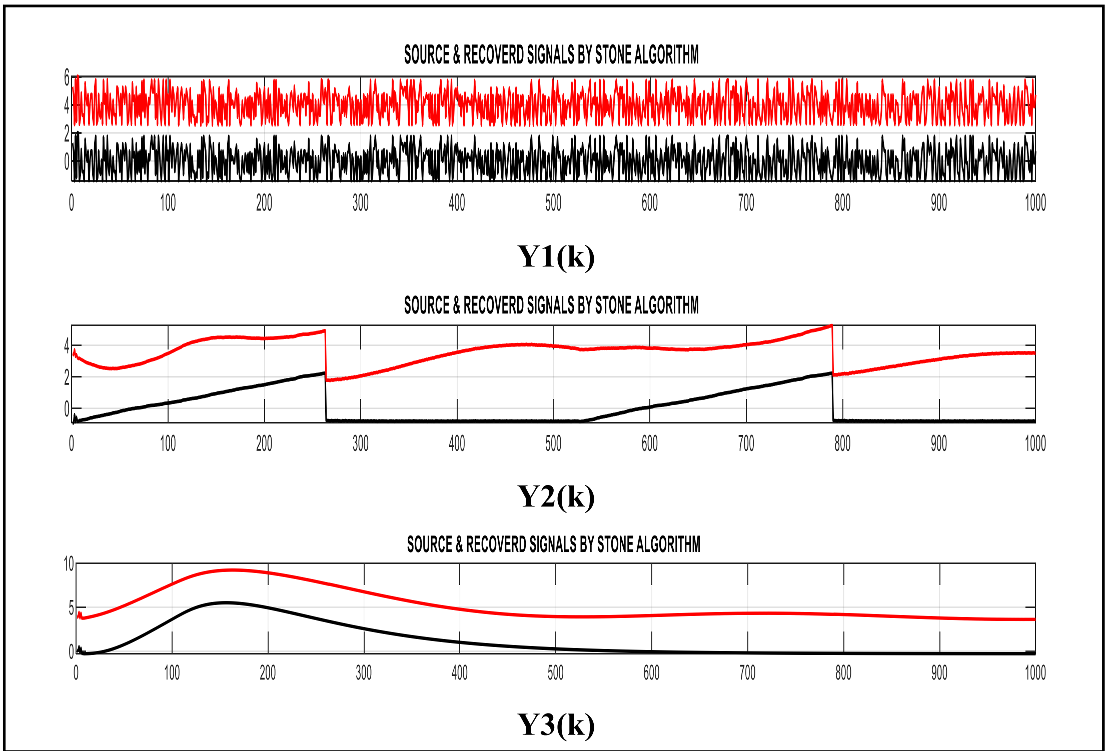

Figure 4-8 The results of STONE'S algorithm on the signals of the case2

The original signals are shown in black, while the resulting signals from Stone's technique are shown in red in the figure above. a significant similarity will be noticed between the original text signal and the text signals created by the algorithm, much as there is a significant similarity between electromagnetic noise and crosstalk noise with original noise.

When it is applied the JADE-Algorithm to the same signals that we used for Stone's algorithm, the accuracy of the JADE-Algorithm results was worse than Stone's algorithm results. The findings of the JADE-Algorithm on the signals in the second case (text signals and noise) are shown in Figure 4-9. In the following figure, to identify them and make signal comparison easier, the original signals entering the algorithm were also shown in black, while the generated signals were represented in red.

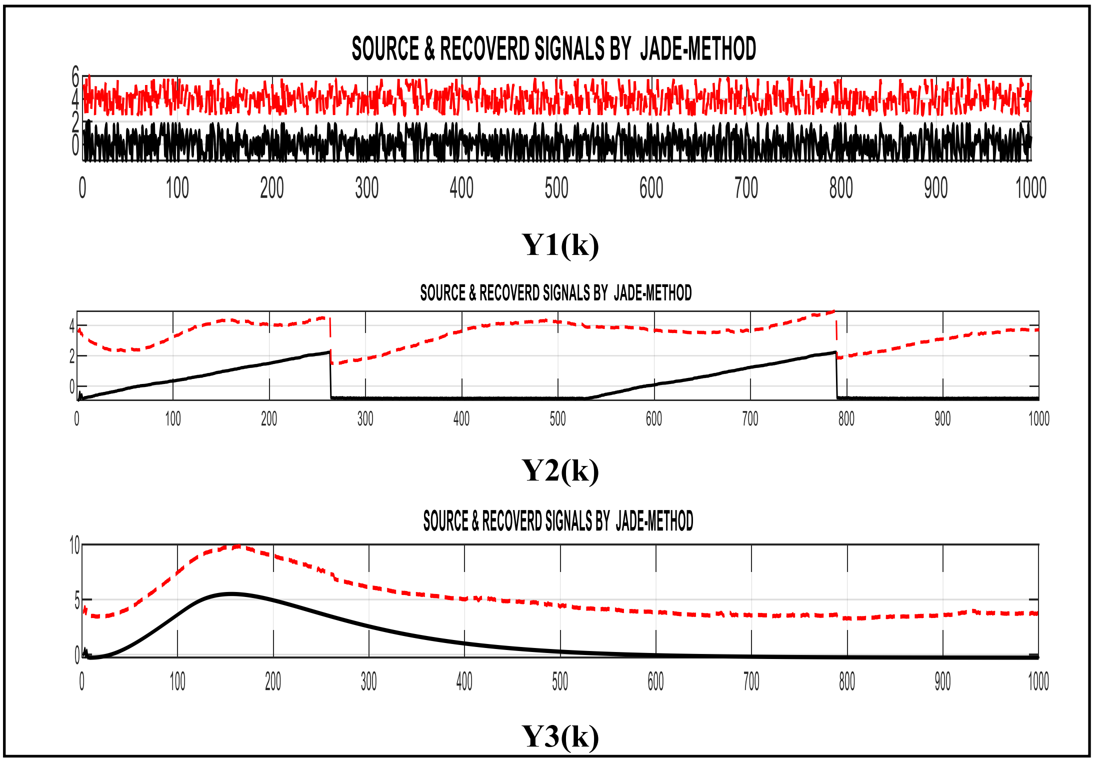

Figure 4-9 The results of JADE-Algorithm on the signals of the case2.

Finally, the EFICA method produced significantly poorer results than the JADE algorithm when applied to the original signals. The findings of the EFICA-Algorithm algorithm on the signals in the second case (text signals and noise) are shown in Figure 4-10.

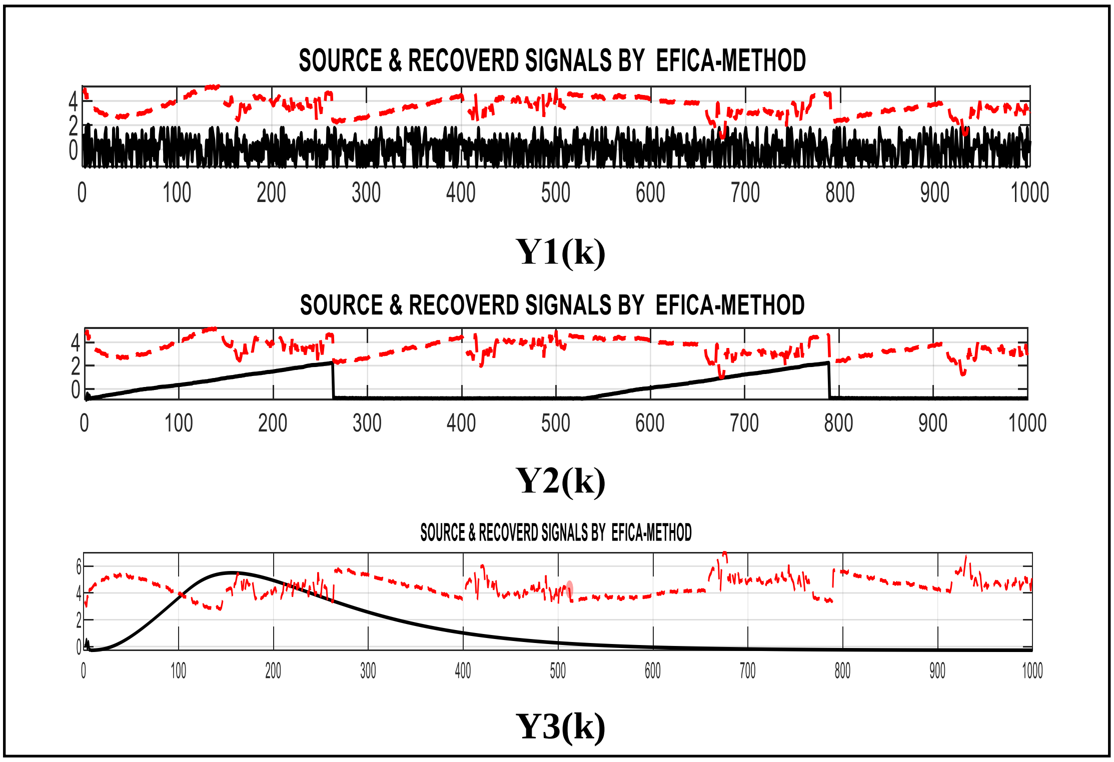

Figure 4-10 The results of EFICA-Algorithm on the signals of the case2

The three BSS algorithms, Stone Algorithm, JADE-Algorithm, and EFICA-Algorithm, will be compared using signal noise ratio (SNR), and came up with the following results:

Table 4-2 SNR for case2.

Input data sources	BSS Algorithm STONE	BSS Algorithm JADE	BSS Algorithm EFICA
Text source	34.4000	27.3116	2.9801

The SNR obtained by calculating the signal-to-noise ratio varies from algorithm to algorithm, indicating the accuracy of the signal generated by the algorithm and the high similarity between it and the original signal, where the SNR of the STONE algorithm reached 34.4000, the highest value among the rest algorithms. The JADE-Method algorithm came in second with a rate of 27.3116, and the EFICA-Algorithm algorithm had the lowest SNR with 2.9801.

4.2.3 Case 3 Results

After the signals of the first and second states (sound and text) are tested, the test of the signals of the third state will be came, which is the image data. The three BSS algorithms were used to the third type of data, the image, in case 3, where the text data was generated using the Matlab program with the development of two types of noises, electromagnetic noise and crosstalk noise. The original data for the image with noise is shown in the figure below.

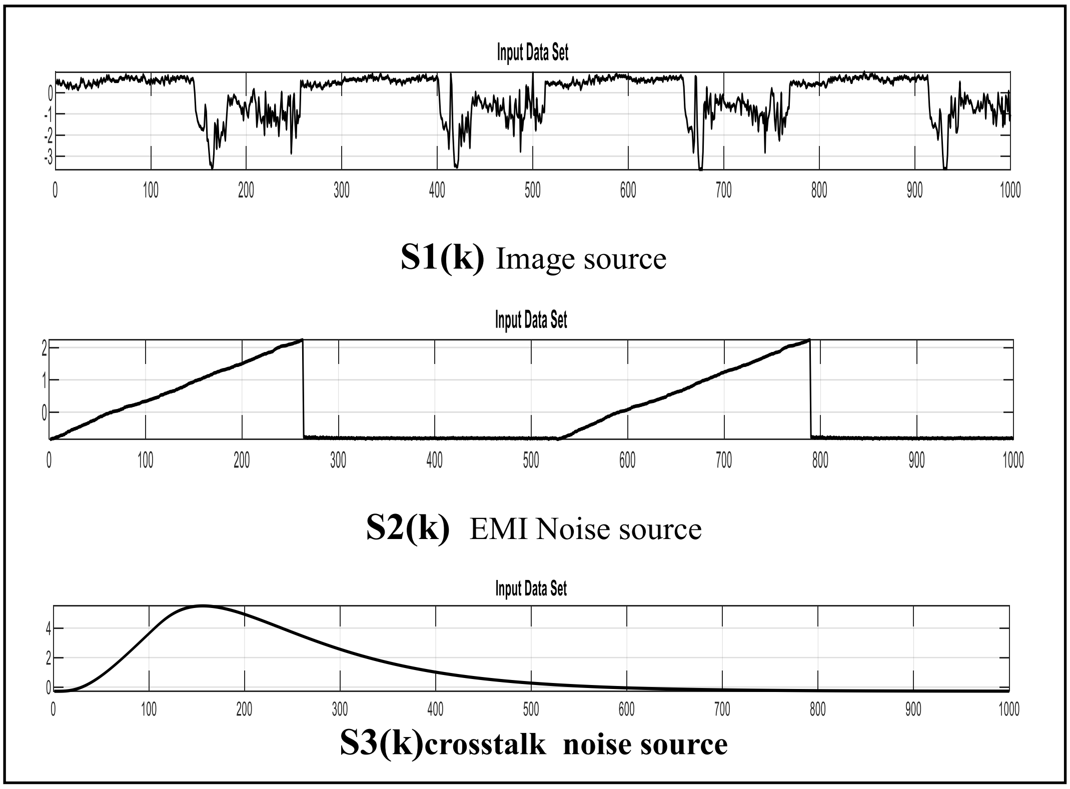

Figure 4-11 Image with noise sources.

The input data will be preprocessed and mixed after the image signal and noise are entered into the system to ensure that the system evaluation is correct. Because it is impossible to monitor and evaluate the system's efficiency and performance without testing data with noisy signals, the mixing technique is crucial in our current work.

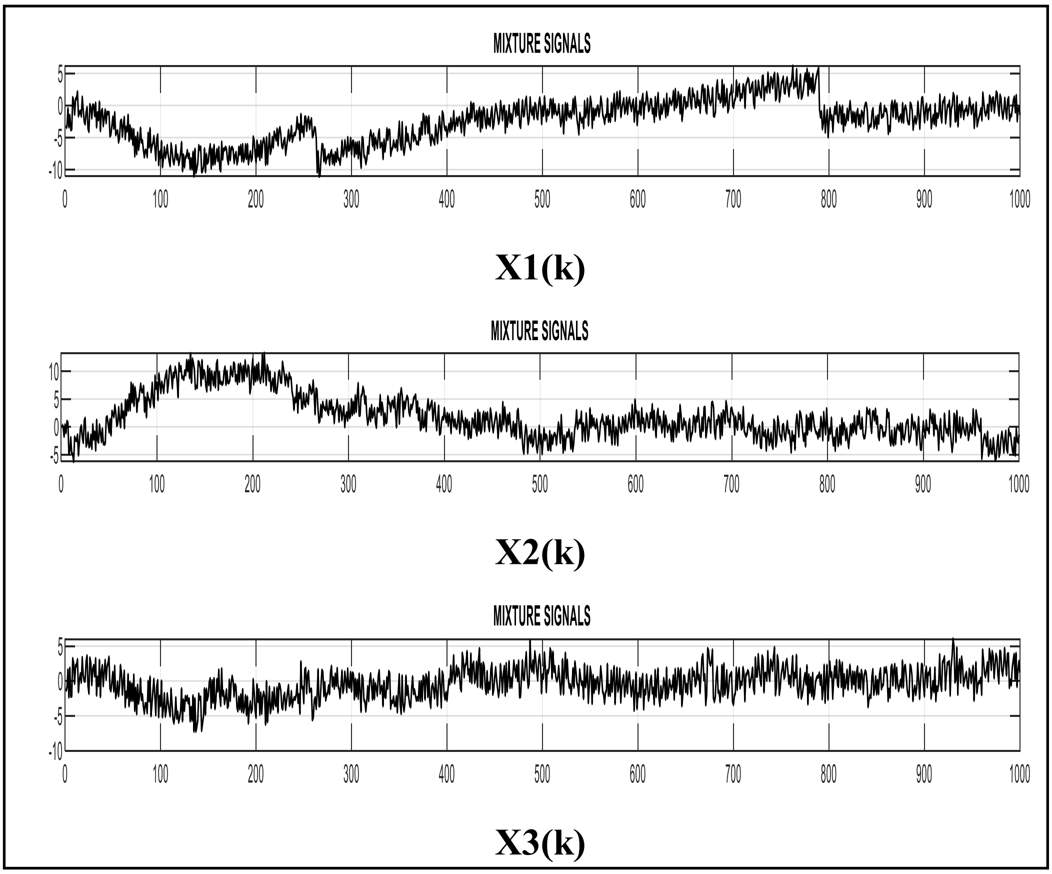

Figure 4-12 Image with noise source after mixing.

Following the mixing process, three BSS algorithms will be applied to it, namely Stone Algorithm, JADE-Algorithm, and EFICA-Algorithm, as previously mentioned, where some mathematical equations are applied to obtain new signals, which will then be compared to the original signals to determine the accuracy and effectiveness of the algorithm used.

Because the generated signals and the original signals are quite similar, the BSS algorithms will be start with Stone's approach, which is the most powerful of the algorithms used. Figure 4-13 shows the results of Stone's approach on the signals in the third case (image signals and noise).

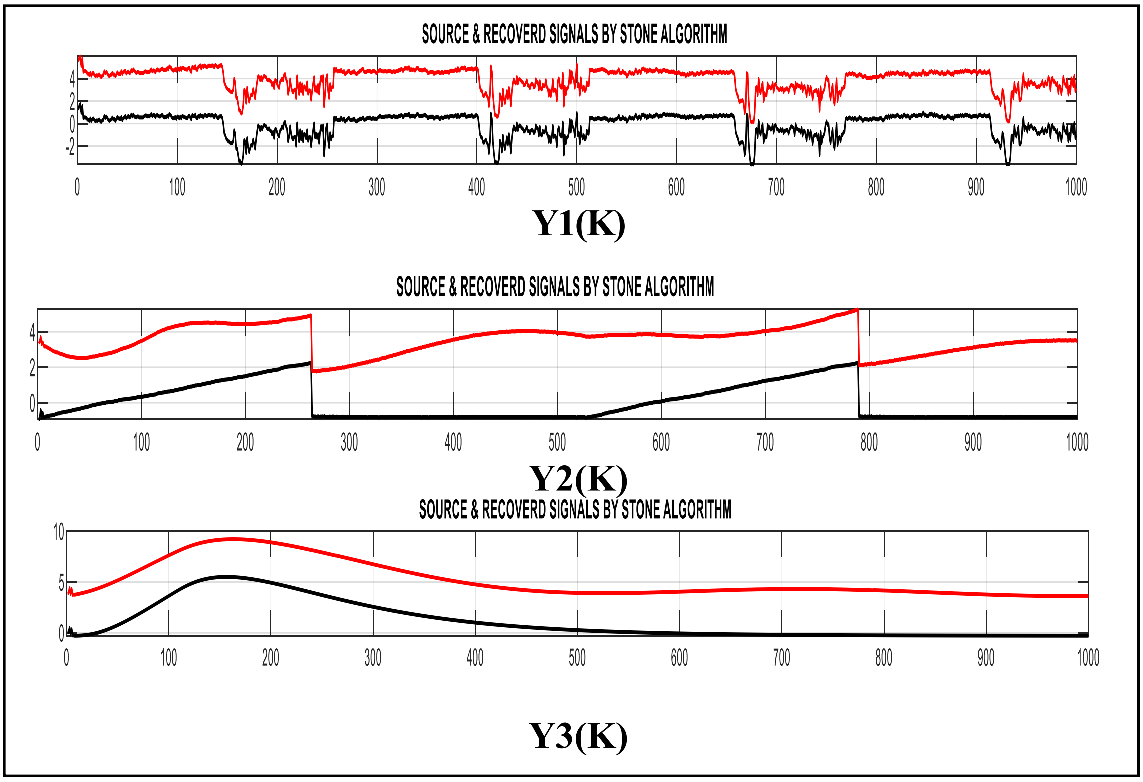

Figure 4-13 The results of STONE'S algorithm on the signals of the case3.

In the figure above, the original signals are shown in black, while the resulting signals from Stone's approach are shown in red. The original image signal and the text signals generated by the algorithm are strikingly similar, much as electromagnetic noise and crosstalk noise are strikingly similar to the original noise.

When the JADE-Algorithm is utilized on the same signals as Stone's algorithm, the JADE-Algorithm results were less accurate than Stone's algorithm results. Figure 4-14 shows the results of the JADE-Algorithm on the signals in the third case (image signals and noise).

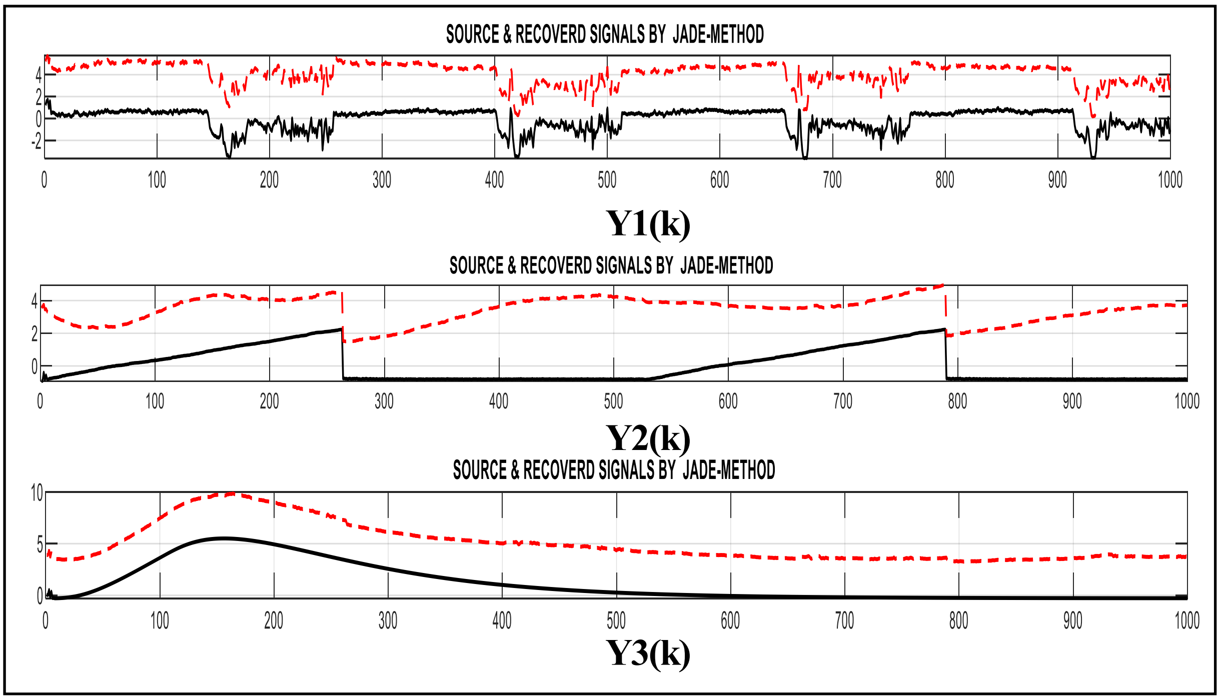

Figure 4-14 The results of JADE-Algorithm on the signals of the case3

The original signals entering the algorithm were also shown in black in the above figure to make signal comparison easier, while the created signals were shown in red.

When applied to the original signals after Stone Algorithm and JADE-Algorithm, the EFICA approach gave much worse results than the JADE algorithm. Figure 4-15 shows the results of the EFICA-Algorithm algorithm on the signals in the third case (image signals and noise).

Signal noise ratio (SNR) is used to compare the three BSS algorithms, STONE Algorithm, JADE-Algorithm, and EFICA-Algorithm. Table 4-3 displays the SNR for BSS algorithm on the case3 signals.

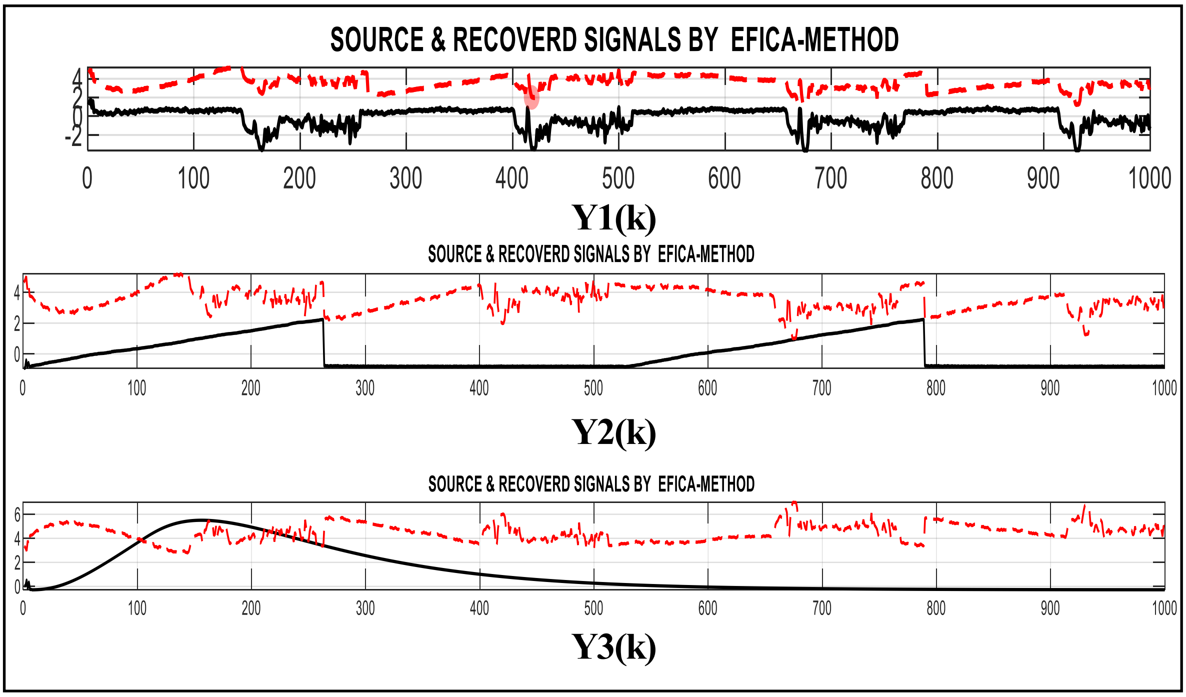

Figure 4-15 The results of EFICA-Algorithm on the signals of the case3

Table 4-3 SNR for case3.

Input data sources	BSS Algorithm STONE	BSS Algorithm JADE	BSS Algorithm EFICA
Image source	15.8072	6.4311	1.9968

The signal-to-noise ratio (SNR) obtained by calculating the signal varies from algorithm to algorithm, indicating the accuracy of the signal generated by the algorithm and the high similarity between it and the original signal, with the SNR of the STONE algorithm reaching 15.8072, the highest value among the other algorithms.The JADE-Method algorithm came in second with a rate of 6.4311, and the EFICA-Algorithm had the lowest SNR with 1.9968.

All of the algorithms were successful in recovering all of the signals, so comparing them becomes very necessary based on the achieved signal to noise ratio (SNR) to see which one has the best performance.

Table 4-4 SNR BSS algorithms.

Input data sources	BSS Algorithm STONE	BSS Algorithm JADE	BSS Algorithm EFICA
Audio source	32.0282	22.8581	2.9421
Text source	34.4000	27.3116	2.9790
Image source	15.8072	12.1180	1.3173
Recorded Average SNR	31	23	7

Note in the above table that all algorithms showed good results, where Stone's algorithm excelled with the highest result because the resulting signals are very similar to the original signals, followed by JADE-Algorithm, which came with fewer results, and finally EFICA-Algorithm.

SNR is a comparison of all methods based on the average signal to noise ratio (SNR) produced for each approach. The STONE algorithm saves the highest estimated SNR value. The JADE method has a lower SNR than STONE, but it outperforms the EFICA algorithm. For each algorithm, the recorded SNR in decibels. To facilitate the reading of the data clearly for the viewer, a data diagram was made, where the columns of the chart represent the SNR of each of the BSS algorithms.

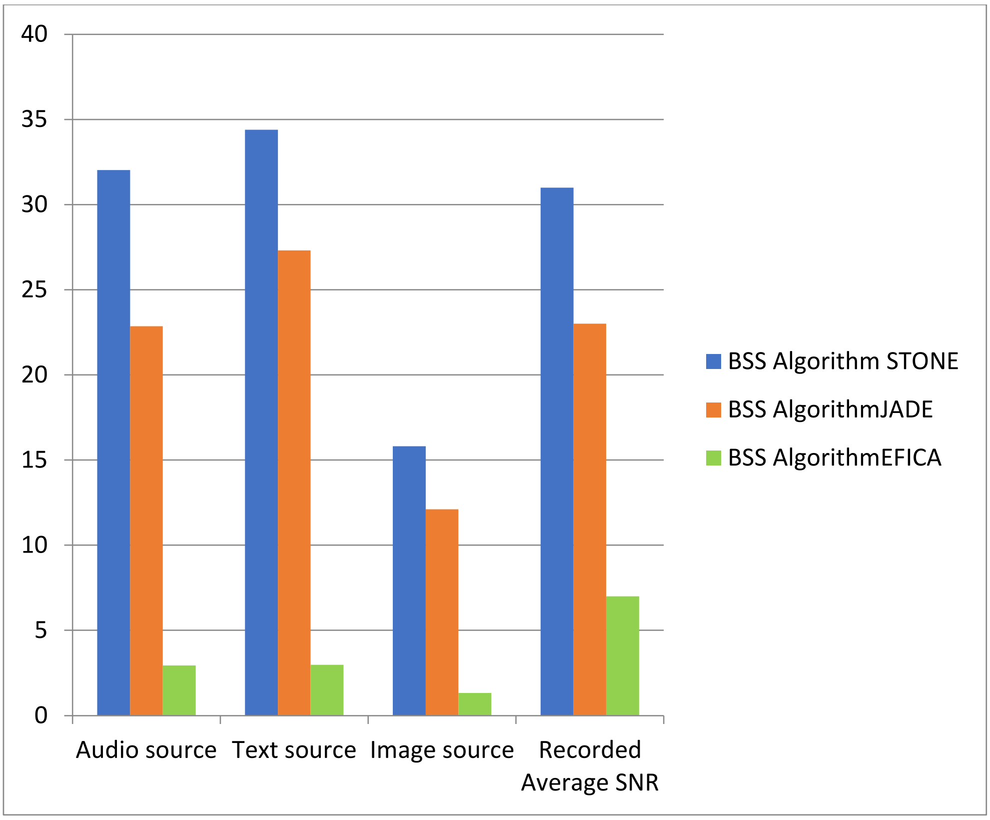

Figure 4-16 SNR BSS algorithms diagram.

In the above graph, the three data sources (audio, text, and image) were represented on the x-axis of the plot, as well as the signal-to-noise ratio (SNR), while the BSS algorithms were represented on the y-axis in the graph. In the x-axis there are four groups, three of which represent the data sources, and the fourth group represents the noise rate of the signal, rising from each group are three columns representing the three algorithms used, where it is noticeable that the first column, which represents STONE'S algorithm, is superior to the JADE and EFICA algorithms, which It indicates the accuracy of the results of the Stone algorithm, followed by the JADE algorithm in the accuracy of the results.

Root Mean Square Error (RMSE) is a standard way to measure the error of a model in predicting quantitative data. RMSE represents a comparison between all algorithms depending on the obtained Recorded Average RMSE for each algorithm.

All of the algorithms were successful in recovering all of the signals, so comparing them becomes very necessary based on the achieved RMSE to see which one has the best performance.

Table 4-5 RMSE BSS algorithms.

Input data sources	BSS Algorithm STONE	BSS Algorithm JADE	BSS Algorithm EFICA
Audio source	0.025	0.072	1.4032
Text source	0.0191	0.0431	1.4098
Image source	0.1622	0.248	0.86
Recorded Average RMSE	0.0687	0.1977	1.2243

STONE algorithm record the less value of calculated RMSE. JADE algorithm records higher RMSE than STONE but is lower than EFICA algorithm. Note in the above table 4-5 that some algorithms showed good results, where STONE'S algorithm excelled with the fewer result because the resulting signals are very similar to the original signals, followed by JADE-Algorithm, which came with higher results, and finally EFICA-Algorithm.

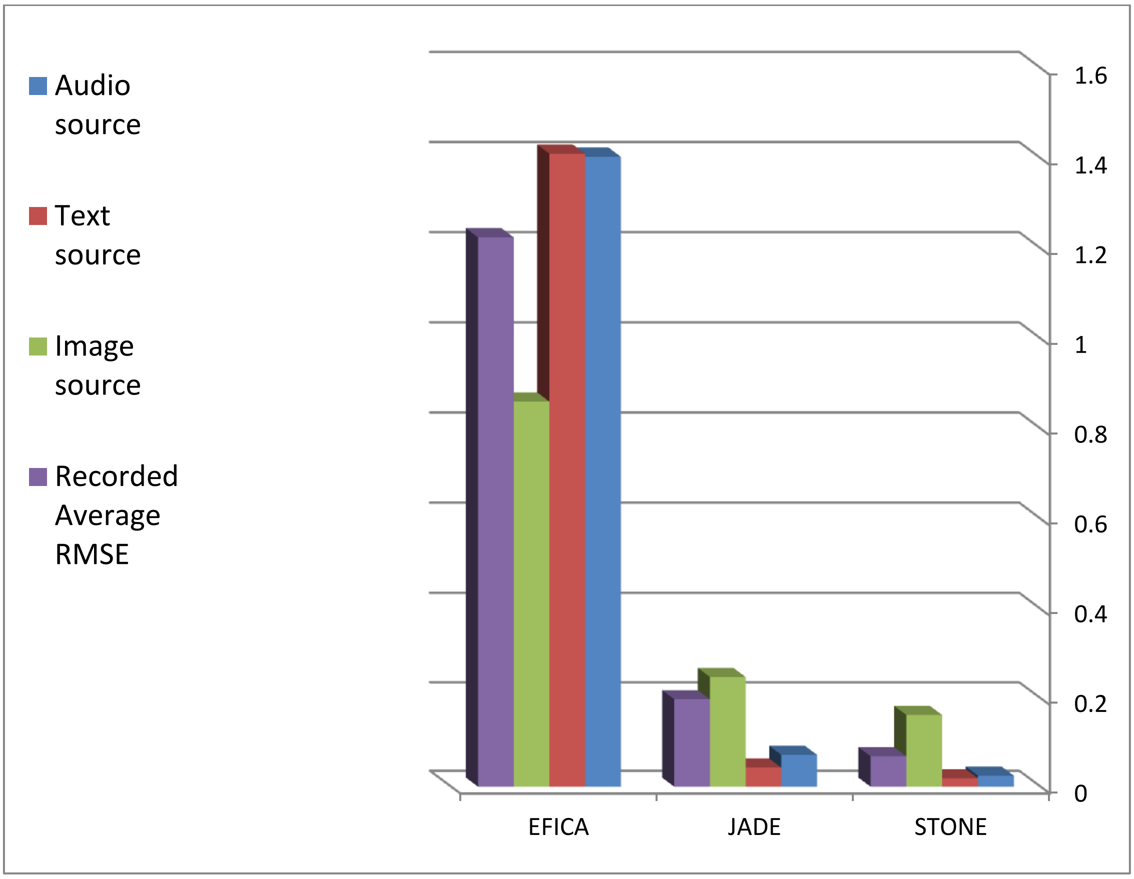

Figure 4-17 RMSE BSS algorithms diagram.

In the x-axis there are three groups, three of which represent the BSS algorithm. Rising from each group four columns representing the three algorithms used and recorded average RMSA, where it is noticeable that the first column, which represents Stone's algorithm, is better than the JADE and EFICA algorithms because it is the least possible.

Chapter 5: Conclusions and Suggestions for Future Work

After designing and implementing our proposed system, and presenting the results and evaluation of the system in the fourth chapter of this thesis, the most important conclusions and future work will be reviewed in this chapter. The conclusion is intended to extract through the concepts to clarify the results of the system or to confirm a theory that was deduced from the thesis. As for the future works, they are the procedures and procedures that can be done in the future or that researchers in the same specialty carry out to develop the current work and come up with results that are much better than what was obtained in this thesis.

5.1 Conclusions

In this part of the chapter, the most important conclusions obtained from the design and implementation of the system will be illustrated in the form of the following points:

There are distortions of the transmitted signals in any data transmission process, whether via wired networks, and these distortions have a negative process on the data received on the opposite side of the network (the receiver).Signal distortions come in many forms, they may be noise or interference between the transmitted signals themselves . noise has many types, What concerns us in this work are two types: electromagnetic noise and crosstalk noise.Electrical noise (EMI or RF) can be coupled onto Ethernet communications cables, causing the signal to be disrupted.

Blind Source Separation (BSS) approaches are successful in recovering the source signal from cross talk and EMI noise. However, not all BSS algorithms have the same level of robustness as the data show.It is noticed a strong similarity between the actual signals and the signals created by the algorithm . The STONE algorithm saves the highest estimated SNR value(Recorded Average SNR=27db)and less (Recorded Average RMSE =0.0687). The JADE algorithm has a lower SNR than STONE (Recorded Average SNR=21db) and(Recorded Average RMSE =0.1977).The EFICA algorithm fails because it achieves lower (Recorded Average SNR=2db) and higher and (Recorded Average RMSE =1.2243).

5.2 Suggestions for Future Work

The proposed system to three types of data: voice data, text data, and image, in this paragraph some suggestions and future work will be presented, which, if applied in future work, would improve and raise the effectiveness and achievement of our proposed system, and the following is an explanation of the most important suggestions and future work:

In the future, it will be useful to develop hybrid algorithm that combines BSS algorithms, so as to take advantage of the strengths of each algorithm, and thus obtain an integrated algorithm through which strong results will be obtained.It is very useful to use artificial intelligence techniques and combine them with BSS algorithms, to become powerful enough to separate the original signals of the data and distinguish the noise signals.The obtained results by STONE algorithm are very encouraging to design and implement hardware equipment in future for recording and processing STONE algorithm as an operating system by using the BSS chip is implemented using TSMC 90nm technology .

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List of Publications

1. Rasheed, A. T., & Al-bakri, A. A. (2021). Enhancing of Ethernet Cable Performance under Effect of Noise & Interferences. *Solid State Technology*, *64*(2), 6990-6999.
2. Study the electromagnetic environment and its impact on Ethernet networks to discover the negative effects resulting from the electromagnetic environment Based On Blind Source Separation Techniques.

   "Accepted in AIP Conference Proceedings (2021) “ .
3. Blind Source Separation Techniques for Interference Sources Detection in Electromagnetic Environments of Ethernet Networks.

   "Accepted in AIP Conference Proceedings (2021). "

الخلاصة

عندما يتم إرسال نص أو صوت أو رسومات أو أي نوع آخر من البيانات عبر وسيط ناقل ، تتأثر عملية الإرسال بالبيئة ، وقد تتشوه الإشارات المرسلة نتيجة لذلك. يتم استخدام تقنيات فصل المصدر الأعمى لمعالجة مشكلة التشويه. من ناحية أخرى ، يعد فصل المصادر العمياء طريقة شائعة لاستعادة الإشارات من المصادر المعزولة. تعد الضوضاء والتشوهات عبر اتصالات الايثرنت إحدى المشكلات العملية.كابل الايثرنت هو النموذج المفضل في هذه الأطروحة لاختبار الطريقة المقترحة. تم استخدام خوارزميات فصل المصادر العمياء ، خوارزمية الحجر ، وخوارزمية التقطير التقريبي المشترك ، وخوارزمية تحليل المكونات المستقلة السريعة الفعالة في هذه الأطروحة لعزل مصدر البيانات الاصلية من البيانات المستلمة. ضوضاء المجال المغناطيسي الكهربائي التداخل الكهرومغناطيسي وضوضاء الحديث المتبادل نوعان من الضوضاء المضافة إلى ثلاثة أنواع من البيانات: البيانات النصية والبيانات الصوتية وبيانات الصورة. تم استخدام نسبة ضوضاء الإشارة لمقارنة نتائج ثلاث خوارزميات لفصل المصدر الأعمى.

بناءً على الأنواع الثلاثة من البيانات المرسلة عبر كبل الايثرنت: بيانات الصوت والنص والصورة ، تم تقسيم النتائج إلى ثلاث مجموعات. لمقارنة جميع التقنيات ، يتم استخدام متوسط نسبة الإشارة إلى الضوضاء التي تم الحصول عليها بواسطة كل طريقة. وفقًا للبيانات ، تحفظ خوارزمية الحجر قيمة الإشارة إلى نسبة الضوضاء بأعلى قيمة مقدرة. على الرغم من وجود نسبة إشارة إلى ضوضاء أقل من خوارزمية الحجر ، فإن طريقة التقريب التقريبي المشترك تتفوق على خوارزمية تحليل المكون المستقل السريع الفعال. تم الإبلاغ عن نسبة الإشارة إلى الضوضاء لكل خوارزمية بالديسيبل.

تحديد مصادر التداخل لكابل الأيثرنت في بيئات الضوضاء الكهرومغناطيسية بالاعتماد على تقنيات فصل المصادر العمياء

الرسالة

مقدمة الى قسم هندسة تقنيات الاتصالات كجزء من متطلبات نيل درجة

الماجستير

تقدم بها

أمير ثابت رشيد هادي

إشراف

أ.د علي عبد العباس عبد الله البكري

كانون الاول /2021

جمهورية العراق

وزارة التعليم العالي والبحث العلمي

جامعة الفرات الاوسط التقنية

الكلية التقنية الهندسية- نجف

تحديد مصادر التداخل لكابل الأيثرنت في بيئات الضوضاءالكهرومغناطيسية بالاعتماد على تقنيات فصل المصادر العمياء

أمير ثابت رشيد هادي

ماجستير هندسة تقنيات الاتصالات

2021