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Monitoring of AC Motors Parameters Using Industrial Internet of Things

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MONITORING OF AC MOTORS PARAMETERS USING INDUSTRIAL INTERNET OF THINGS

A Thesis

by

MOHAMMAD MUHEISEN

Submitted in Partial Fulfillment of the

Requirements for the Degree of

MASTER OF SCIENCE IN ENGINEERING

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May 2023

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Thesis
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May 2023

ABSTRACT

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In this thesis, the industrial internet of things has been introduced, as a very newborn research field. The suggested prototype has been assembled at the university laboratory to simulate the system conditions. Two three-phase induction motors have been utilized to perform this study, to monitor and gather data, regarding vibration and temperature. As a very newborn field, the data collected from the two motors can be analyzed to achieve a couple of goals, in energy consumption, to reduce the financial burden of the remedy works. A fast Fourier transformer has been applied to measure the motor's vibrations, and the current and the temperature of the proposed system have been monitored. The industrial internet of things is similar to the internet of things, in comparison to identifying the proper parameters in the system, depending on the principles used on the internet of things have been applied, to verify the performance of said systems.

DEDICATION

I must express my very profound gratitude to my parents and my friends for providing me with unfailing support and continuous encouragement throughout my years of study and through the process of researching and writing this thesis. This accomplishment would not have been possible without them. Thank you.

ACKNOWLEDGMENTS

It has been a pleasure working on this thesis and learning under Dr. Alexander Domijan, the chair of the thesis committee, the director of the south texas assessment industrial center (IAC), along with the two committee members Dr. Jaime Ramos and Dr. Maysam Pournik, team management of IAC. Being part of a professional team, working on a couple of assessment studies for industries, with the team sharing valuable expertise and experience, to guide me in the proper direction. The industrial internet of things research is a result of interacting with a great team. Although Covid diminished the initially proposed system, with the support of the UTRGV family and learners, the goal has been achieved, by performing engineering skills, and guidance to implement and test the modified model, to achieve the study research. I would like finally to thank the UTRGV, staff, and students, my greatest success is the memories that I made here.

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CHAPTER I

INTRODUCTION

As an inevitable result of the robust evolution in technologies, utilization to perform more human tasks has tremendously been acknowledged and used in different life aspects. Energy and electricity are one of the major fields that have been affected by this evolution, especially, how the production and consumption of energy interact with the earth's environment and eventually touch human life.

Supervisory Control and Data Acquisition systems are a great example of an energy control system, it is known as SCADA systems. Several fields utilize the supervisory control and data acquisition services in generating and distributing energy, and in industrial fields, it provides robust and reliable service, with the presence of an operator, this human factor assures sometimes the continuity of the product, in addition to the importance of supervising the system.

The Internet of things (IoT) can be considered the new research field or system, that has been developed to take over the old control way, with the help of new technologies, in not only energy control but in most life aspects. Medical and home services sectors started to test and use the internet of things earlier than the rest, due to the importance of medical research, and the availability of personal interest to upgrade the automated home systems.

The energy sector is getting more recognition, and more advanced systems emerged toexist.

Internet of things main concern is to provide the system. This system should provide real-time monitoring using a micro-computer (advanced controllers) and advanced technologies, and it gathers data for future processing purposes. It can also be upgraded to use machine learning methods, in order to design a system adaptable to the changing variables. The Internet of things has grown quickly in the last decade as the future of industries, as it proposes the principle of running a lone system, with a possible internet connection, moderated by security resilient countermeasures. Looking into other systems, and comparing them to the supervisory control and data systems, the internet of things might possibly replace the supervisor control and data system in the future. It could provide a cutting-edge set of data that can be analyzed to reduce energy costs in those systems In terms of variables like voltage fluctuations, surges in the system, temperature, and other parameters that can affect the outcome.

This research targeted an even new system called the industrial internet of things, which utilized the internet of things in industrial environments. To simulate the industry environment, the system will run motors and monitor their parameters. The proposed model can be deployed in industries, with the help of a drafted manual, to use the system, for studying industries purposes only. It can be more useful, to gather data and implement the energy assessment process following the industrial assessment center rules and regulations, and train the students in the university laboratory to be more familiar with using the Internet of things concept in industrial applications. The contribution of this work is twofold. In the first part, the performance of the proposed system under a similar industry environment, and comparing the required tasks on the system structure. In the second part, pave more roads toward future research in a very important field.

Alternating current motors (AC motors) are relied on considerably in the industrial field, for their reliability to provide the desired power to accomplish industry tasks. However, failures of AC motors are a huge issue in the industry, costly in both time and money. Traditional maintenance of AC motors previously used to be carried out upon failure, proves to be costing money and time with the machine being out of service. Preventative maintenance has been introduced to overcome unforeseen failures of AC motors, including periodic maintenance activities to prevent machines from future failures. Yet this method lacks real-time data on the machine can present a burden for the industry, on how many times to perform this kind of periodic maintenance and when both time and cost are considered by industries before deciding to follow this method.

Predictive maintenance techniques based on real-time data can without any doubt, give more clear information about the parameters of the machine, and how it can be analyzed to have clear information on when to carry out periodic maintenance. A real-time monitoring system can also be used to prevent unexpected failures or anomalies in the AC machines, but it has to be formulated to stand in the environment for enough time, to accomplish this task. The more tasks required by the system, the more design details shall be taken into account. By identifying the system parameters under normal conditions, and keep monitoring and comparing them, with calculated values. It is also important, to make it clear, designing and implementing systems, that have to have resembled inside harsh environments, should always consider extreme measures, to avoid possible unforeseen problems.

1.1 Literature Review

The industrial internet of things can be considered a very newborn field, that comes from the huge importance of controlling energy. Previously, and still, nowadays, the human presence in the energy systems is essential to assure the appliances' safety, system reliability, continuity, and avoidance of unforeseen defects or malfunctions. Due to that, two major research yet has been carried out in the industrial internt of things field [1], [2], even though both designs are simple, they provide real researched data about energy monitoring. The proposed system with this research can be considered as an addition, to the above-mentioned systems [1], [2], by executing the monitoring tasks, for motors parameters, in industrial conditions.

System [1] suggests two different scenarios, to compare the performance of the industrial internet of things, developed using testing-bed,.suggested structure and equipment, and part of the design is to choose the processor, in one suggested scenario in [1], in a laboratory environment, the gateway (processor) performance has been compared with advance sensor (multi-sensor model), and applying the same comparison principle in diary [1], to mimic the industrial environment. It is useful to get more knowledge on how different processors' mechanism works, based on performance, in this research, we will shed more light on structural comparison and processing performance comparison between suggested systems, based on monitoring output, using the industrial internet of things. In the second system [2], the system provided monitoring research data, and real-time monitoring for three phase induction motor, including voltages, temperature, and vibrations, along with the same principle in [1], of performing a couple of analyses for systems based on appliances performances [1], different environment [1], and [2], which can be more useful in picking appliances, that can be utilized to upgrade the system in this research, for more durable internet of things industry.

1.2 Thesis Content

In this work, monitoring of AC motors parameters using the industrial internet of things, where a new system for monitoring and future controlling energy purposes has been researched, due to the huge effect of energy on the environment, and greenhouse gas congestion in the atmosphere[3].

It will introduce a real system, using the industrial internet of things to monitor the parameters of AC motors, with real-time data (constant data stream) from the AC motors. Parameters will include the motor temperature, and the vibration of the motor. The proposed system had been assembled in the university laboratory, using the laboratory available motors, and appliances, to demonstrate the industry environment and running conditions for the AC motors. Also, the proposed system can be deployed in industries, to gather data and implement the energy assessment process, in accordance with the industrial assessment center rules and regulations, and train the students in the university laboratory to be more familiar with using the internet of things concept in the industrial applications. AC motors have huge concerns in the recent industry, as defects can put the machine out of service.

In chapter 1, the Industrial internet of things is discussed in brief. A literature review of two approaches for the system to monitor motor parameters has been studied. An overview of the work and a summary of the contributions are provided.

In chapter 2, the internet of things is presented. The major issues are provided. Utilizing the internet of things in industrial applications has been discussed.

In chapter 3, implemented systems designs are presented. Two systems, with details about each one.

In chapter 4, the outputs of the system are shown. Discussion, conclusions, and future work are also presented.

1.3 Thesis Contribution

The contribution of this work is the development of industrial internet of things system models, that can be utilized for advanced student research purposes, that are simple and convenient to apply at the student level, based on the result and conclusion [1], [2] to monitor 3-phase induction motor parameters, under simulated industrial environment, at the university laboratory. The special need to study this field, comes from the importance of climate change, due to greenhouse emissions [3]. Simulating the industry's environment is considered. For the research to continue, the output has been collected, while assuring the system running conditions safely. The contributions of this thesis are summarized as the following:

1. The industrial internet of things system model, tested at the university laboratory, has been introduced, in addition to the previous research, that concludes and compares, the specific proposed system, for comparison purposes.

2. Continuous analysis, and studies, to reach a stable system, that can monitor the proposed system parameters.

3. Two models of the proposed system, with distinguishing differences, as model one support the personal devices user type, and model two can be used for stationary devices users.

The proposed system has similarities to the internet of things systems, which come from the correlation and relatives, between the availability of new cutting-edge technologies, and the need for more adaptable systems, to promote human life.

CHAPTER II

INDUSTRIAL INTERNET OF THINGS

This chapter sheds light on the internet of things, the industrial internet of things, similarities, and differences between the two systems. System components, appliance interactions, and systems structure have been discussed in this chapter.

2.1 Internet of things

The internet of things, also known as IoT, is an interconnected system of various objects (things), along with sensors and other technologies, that use internet modeling methods, and techniques, to communicate and exchange data with one another and systems to accomplish a certain task or tasks.

The rapid development of the internet of things is made possible by the strong evolution of numerous technologies, including sensors, embedded systems, communication and internet protocols, wireless sensor networks, control systems, automation (including home and building automation), machine learning, and other technologies.

To make it simple, having a system with machines or equipment equipped with sensors or measuring equipment, connected via communication channels (wireless communication or wired channel) to send data to a processing device (has central processing unit) like the computer, microchips, and telephone for processing purposes and automated system controlling and enhancing, all or sub-system of them, can be called internet of things.

The data type is related to the function required to be carried out by the internet of things system. For instance, simple internet of things, contains 1 Motor to monitor, data can be the running time of the motor, the idle time, the motor speed, the motor temperature, and so on, this goes to applying the internet of things principle, over industries. The basic elements of internet of things are:

Connected devices: Most of the actual physical items linked to the system are devices. Sensors are the elements of the device connectivity layer for asset control systems. These intelligent sensors continuously gather environmental data and communicate it to the following layer. Modern semiconductor manufacturing techniques can provide tiny, intelligent sensors for a variety of uses.

Central control hardware: The two-way data traffic between various internet of things systems, and the devices used to construct them, along with the right communication protocol, can all be assembled at this part. The 's capacity of the central control hardware has to meet certain requirements, depending on the design criteria and the desired function of the system, to interpret various network protocols, and ensure compatibility of the linked devices and sensors.

Data cloud: the internet of things generates enormous amounts of data from devices, depending on the system specifications, applications, and users that must be effectively managed in both directions. Internet of things cloud provides capabilities to quickly gather, manage, process, and store massive amounts of data. These data are easily accessible remotely, allowing businesses and services to take important decisions as needed. Internet of things cloud is a sophisticated, high-performance network of servers designed to handle traffic management, high-speed data processing of numerous devices, and accurate data analysis. One of the essential elements of the internet of things cloud is distributed management database systems.

User interface: User interfaces are the audible, observable portion of the internet of things system that users can access. To foster more interactions, designers need to ensure that the user interface is properly thought out. In today's competitive market, user interface design is more important than ever because it frequently influences the user's decision to select a certain product or appliance. If a new device or smart gadget is very user-friendly and compatible with popular connectivity standards, users will be interested in purchasing it.

Network interconnection: the exponential rise in internet-connected devices is the most important trend on the internet of things during the past few years. Internet of things technologies have a wide variety of uses, and because of that, each device's specifications can vary greatly from one another, but most devices share several fundamental traits. The Internet of things is accomplished by a variety of technologies. The network that an internet of things installation uses to interact with its devices is essential to the field, and numerous wireless or wired technologies may fill this role. The communication protocol model, used in describing the internet data interaction (stack or layer) model, can be a clear analogy, to imagine similar models.

System security: Despite being a crucial component of internet of things implementation, security is far too frequently overlooked while creating new systems. Internet of things systems have proven to be susceptible to major attacks, because they can be used with the internet. The first step in creating a secure system is to eliminate internet of things device vulnerabilities, and provide them with the tools they need to defend against, detect, and recover from harmful attacks.

Figures 2.1 and 2.2, show a sample of the internet of things system, to carry out testing-bed tasks [4], [5], and [6] for a router, in an industrial application. To study the interaction of the internet of things node, and gateway, are using the same controller, but the function of each one is different, these designs were developed and studied to assure more understanding of the internet of things system. While all the nodes provide sensing services, and data exchange, the gateway provides data communication flow, between the nodes and the system. The router is needed to provide an access point to the internet, it will facilitate communication between nodes and gateways, by providing wireless communication coverage. The workplace can be as mentioned before, industrial, medical, or domestic. The internet of things designs share a lot of similarities.

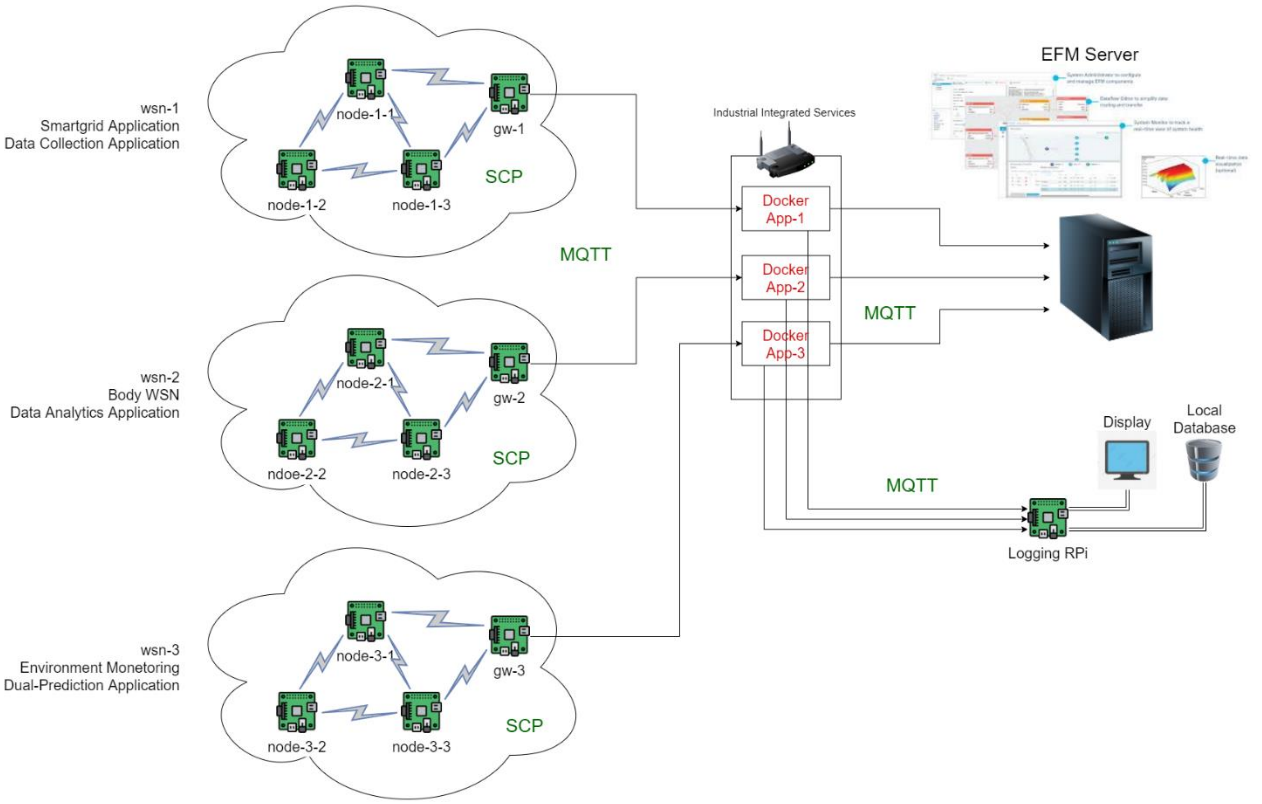


Figure 2.1: Logical-connections router test-bed

It is essential to understand the difference between internet of things systems, based on the environment or deployed place. The harshness of working spaces makes the internet of things' special system designs very unpredictable.

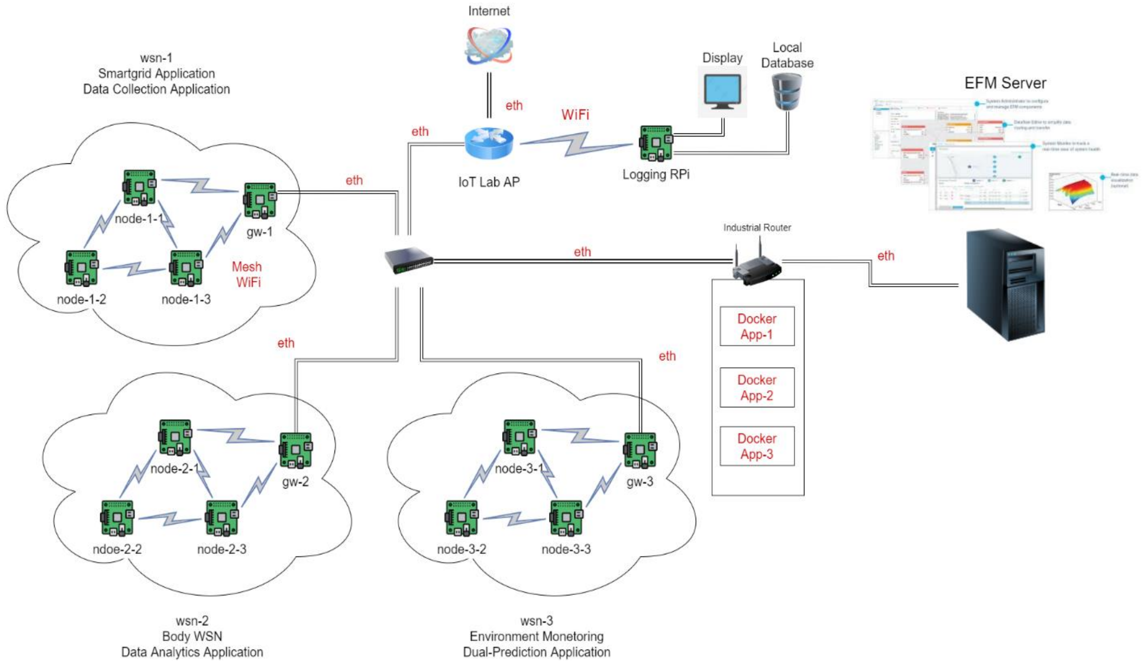


Figure 2.2: Physical-connections router test-bed

The suggested model above can be assembled, and used to test industrial routers, to understand more about performance, under system load [4],[5],[7].

2.2 Industrial Internet of things vs internet of things

The internet of things can be described as a paradigm, wherein any type of device with built-in networking and computational capabilities can interact to achieve a certain state. These abilities are used to check the object's state and, if possible, change it. The term "Internet of Things" describes a new type of environment where practically all the appliances and items we use are linked to a network. They can be used in concert to complete challenging tasks that call for high levels of intelligence [8].

While studies and research have grown rapidly in the internet of things field, it was inevitable to subject this pioneering concept to more effective fields, and one of the major ones is the medical internet of things (MIoT), which can be justified due to the importance of human life[9]. Other fields touch the same spot, but are more sensitive to deal with, in both time and money, to reach similar output, we can call it the engineering internet of things, or more formally the Industrial internet of things. The industrial internet of things shall connect large mobile digital devices, industrial equipment, manufacturing equipment, etc. Along with various internet of things connection protocols, to achieve industrial useful tasks [5]. The devices might use radio-frequency identification (RFID) tags and chip-less radio frequency identification (CRFID) tags[10]. These devices shall continue to produce enormous amounts of data and signals that are used for sensing, controlling, system upkeep, and data analysis [11]. To simplify, the industrial internet of things uses a lot of the original internet of things technologies, the idea self-started based on the internet of things concept. However, unlike the internet of things which is concentrating on human-centric consumer services, the Industrial internet of things is a production-oriented system, designed to reduce production cost and maintain production volume by reducing the energy used, which means it has very limited scientific recognition, due to the lack of research.

As aforementioned, we can consider the industrial internet of things as a subset of the industrial of things, figure 2.3 shows an industrial internet of things sample, the techniques itself used in implementing the industrial internet of things were derived from the suggested system in figure 2.1 and 2.2 while adding the motors to the nodes, shows that the system intention is to perform the industrial task. They can also share common technologies from data cloud to sensors, actuators, cloud connectivity, and analytics-designated testing beds. However, they both defer in working environments and applications, the internet of things is a human-centric base service application, used to elevate the basic life activities of the users during their daily life activities. While the industrial internet of things is a production-base-oriented application, designed to increase industry efficiency by increasing production and reducing cost.

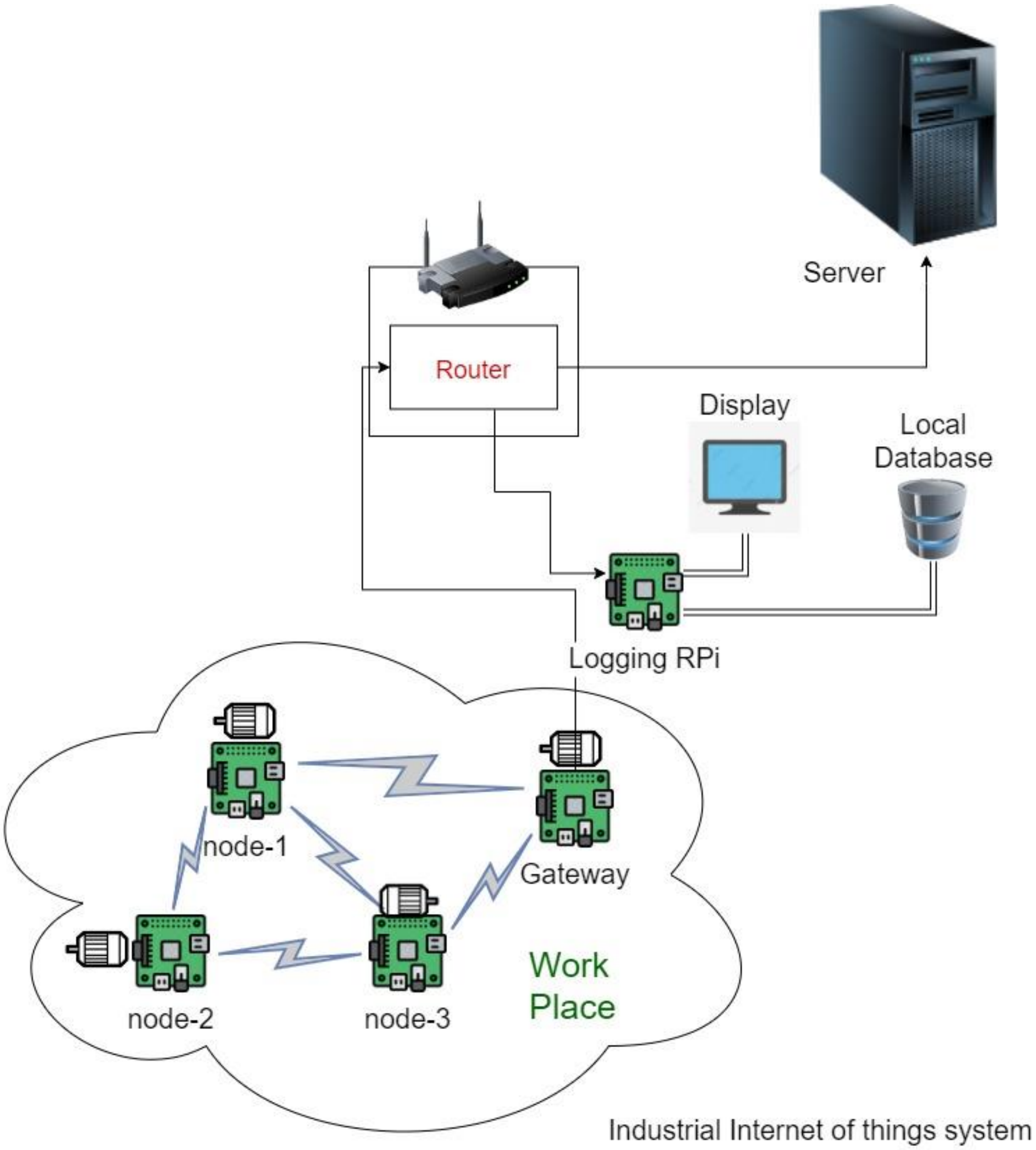


Figure 2.3: physical-connections for the industrial internet of things system

The industrial internet of things shall be normally deployed in an industrial environment. Required to be a rigid system, that works in harsh conditions, with a large number of interconnected devices (sensors, actuators, and controllers) connected to interact with other critical industrial components. The internet of things, on the other hand, is a system most likely deployed in a home or office environment, with a smaller number of interconnected devices (smartphones and smart switches) in a smart consumer environment.

2.3 Industrial internet of things cyber risk management

Cybersecurity concerns have grown exponentially, with the development of the internet of things, the most deployed system, whether it is an internet of things system or special internet of things system. By safeguarding internet of things assets and user privacy, internet of things cybersecurity management aims to lower cybersecurity risks for businesses and consumers [12].

Studies show venerability in some communication protocols, due to the similarity of the construction between the protocols and the Internet [12], that applied to the internet of things, while the industrial internet of things had not been researched at all, and it is also susceptible to cyberattacks. Isolation can be the answer, and the medical system always preferred to run in a closed-up environment, while having a backup server connected to the system, but still the system is monitored most of the time by operators.

Better internet of things security management may be possible with the help of new cybersecurity technology and techniques. Effective internet of things cyber risk management frameworks[13], however, are lacking for managers. This study examines frameworks for managing cyber risks and internet of things cybersecurity technologies, but it will be always safe, by using the stand-alone testing principle. Using a layered structure similar to the internet of things layer [14], to be the industrial internet of things communication protocols model.

The industrial internet of things can be isolated and monitored by less than what is needed, however, the same setup and connection to a cloud are needed, and doing that, it will make the system susceptible to cyberattacks. Scheduling safe backups for the data can be considered a way to be safe, but to monitor energy in real-time, a constant connection with the internet is needed. Needless to say, the advantages and benefits of the suggested system are far more crucial compared to the hazard of being hacked.

2.4 Previous research and works

After the background, it's needless to say that the industrial internet of things as a field is still a fresh one, it has not been addressed like the internet of things had, however, two remarkable starting work is worth the mention, the first research tackled the industrial internet of things directly, while the second one, using internet of things on motor applications.

low-cost real-time monitoring motors in the industry: The research focused on two system performances. The first system was suggested in a laboratory, with a single-phase induction motor being monitored by a program. The second system is a pump in a diary to mimic an industrial environment [1].

The findings of the research can be concluded with data processing comparison, based on time for two different systems, the idea is crucial in evaluating future industrial systems. In the proposed system, the comparison focused more on the industrial environment, and the motors are three-phase induction motors.

Monitoring parameters of three-phase induction motor using the internet of things: to sum up, the conclusion of analyzing the three-phase induction motor parameters can be affected by the sensors type, in general, the harshness of the system, current, and voltage, along with other parameters had been monitored in a laboratory [2].

2.5 Conclusion

This chapter considers the internet of things. The industrial internet of things is discussed, a suggested physical connection for the prospective industrial internet of things system has been shown, and details of comparison methods and criteria have been presented, for the internet of things possible utilizations, in the industrial internet of things. Cyber security concerns have been briefly discussed, and their correlation with the system's reliability. Related research works included two systems mentioned, with details regarding structure and conditions. with the notable understanding of testing devices' performance only, while this research looks into possible monitoring scenarios, in addition to comparing devices' performance.

CHAPTER III

SYSTEM IMPLEMENTATION

This chapter shows the implemented systems, as the prototype of the industrial internet of things. Similarities and differences between the two systems, system components, appliance interactions, and systems structure have been discussed in this chapter.

Facing obstacles during the implementation stage, produce a possible path, to discuss more details about future work, in the industrial internet of things field. Most of our systems designs challenges come from the many available sources, and many problems have to do with compatibility between different products. The chapter shows two systems, a planned one and implemented one and it shed more light on protocols and incompatibility issues.

To start identifying the system components, thrill research and studies over various systems took place, before drawing the systems' main components.

3.1 System One

The system mimics the experienced systems produced under the internet of things principle, with the necessary adjustment to be robust, and resilient to work in the industrial environment. The system was assembled at the laboratory. To briefly cover the description of the system, figure 4.1 shows a model of the system using robust control (Raspberry Pi), it can be considered as the original design, and the controller can act as a node, to carry out most of the interaction between the system component. Raspberry Pi is a microcomputer that was developed in the last two decades, to perform controlling tasks, in low and medium industrial conditions, it is widely used for personal internet of things applications. The suggested model uses the fourth-generation raspberry pi, the newest one, it can support pipelining, to achieve acceptable latency and throughput [15], compared to other microcomputer controllers.

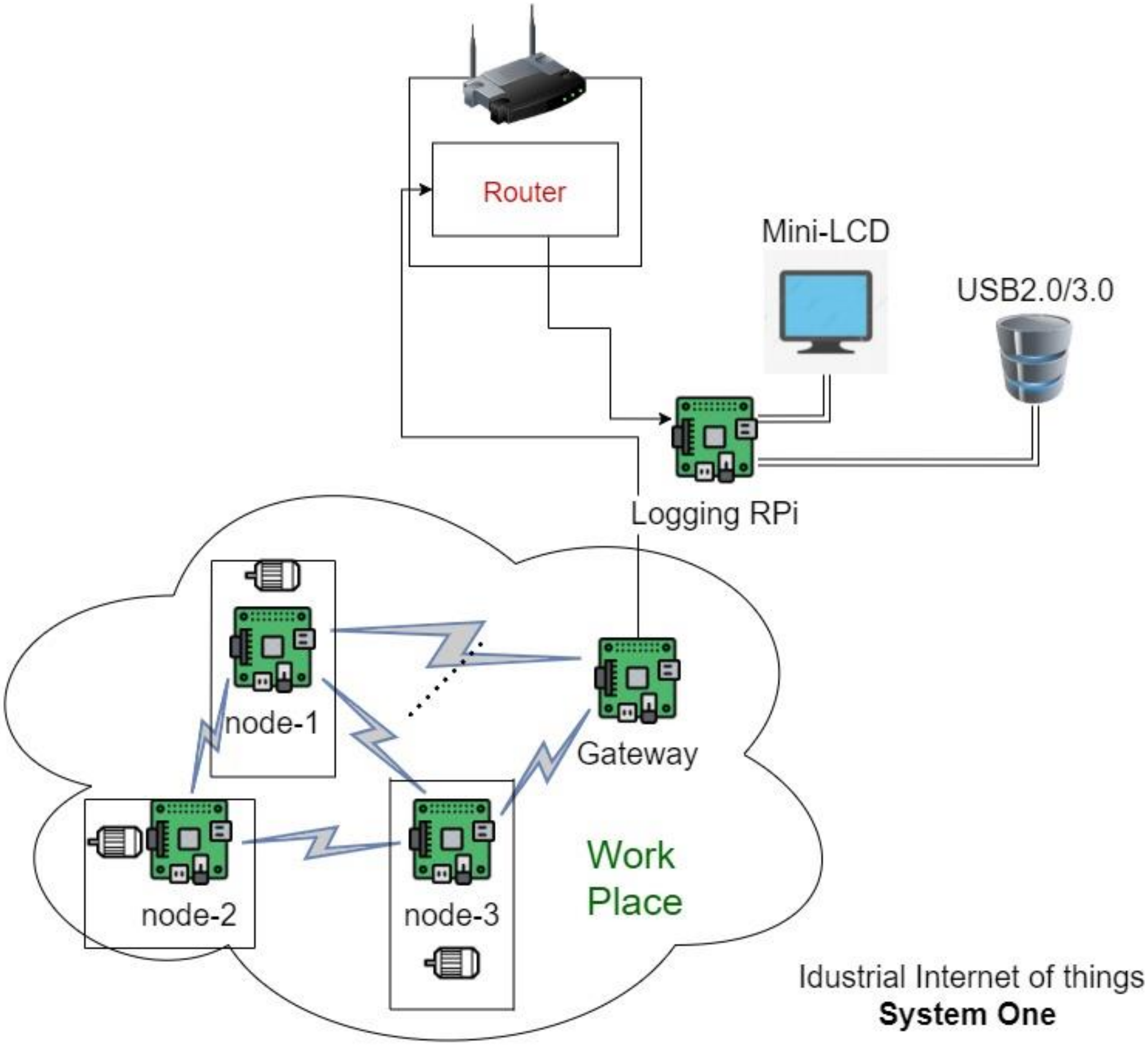
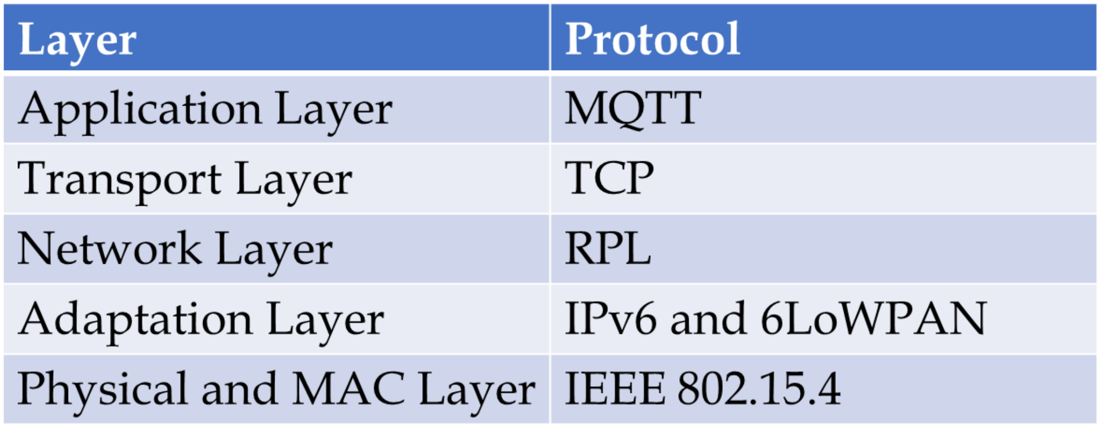


Figure 3.1:System one physical connection

Communication between various components is moderated using a protocol layer model similar to the internet layers model [14], but with a different protocol designed to work in more harmony with this type of component. The only notable thing is that for security reasons, transmission control protocol (TCP) is preferable, to make sure the connection is always monitored by two ends, and to maintain the system running with no congestion.

The following figure shows the protocol model, for system one.



Layer	Protocol
Application Layer	MQTT
Transport Layer	TCP
Network Layer	RPL
Adaptation Layer	IPv6 and 6LoWPAN
Physical and MAC Layer	IEEE 802.15.4

Figure 3.2: System one protocol model

The controller is running through a fixed energy supply. It will support the system's goal to carry out data processing and send it to the cloud. The server can act as a server in the stand-alone system, or it can be connected to a cloud over the extra connection to the internet. There are multiple possible ways to exchange and process data using this system, however, due to the limitation in funds because of Covid-19, assembling the system was not in reach.

Eventually, the system could not be assembled due to the unforeseen pandemic (covid-19). The second system has emerged to continue the design work in the industrial internet of things, to achieve the desired goal.

3.2 System Two

System two had been suggested to perform system one tasks. To have that accomplished a shift in the controller was needed to overcome this issue. A developed kit provided by one of the cutting-edge companies (Texas instrument) to be the cornerstone for system two design.

CC2650STK: can be described as several advanced integrated circuits that have been designed, fabricated, and assembled to achieve several tasks. The tasks include featuring CC2650 wireless master control units. It also contains several communication systems based on frequency range and more featuring circuits supplied by the battery.

System two relied on CC2650STK to achieve the necessary performance by system one. It has to gather and send data to the end-user interface. The kit provided wide possibilities for design ideas and models.

Model one: this model has to serve the end-user directly, and the model has to support using personal devices to monitor the motor's parameters. Figure 3.3 shows the model as assembled at the laboratory.

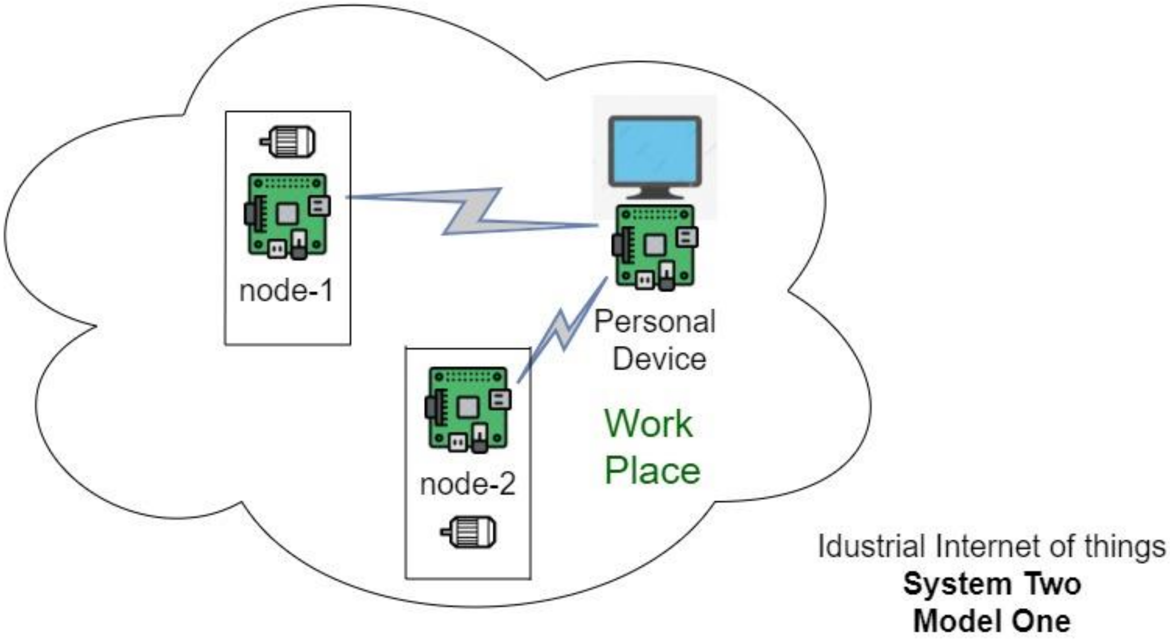


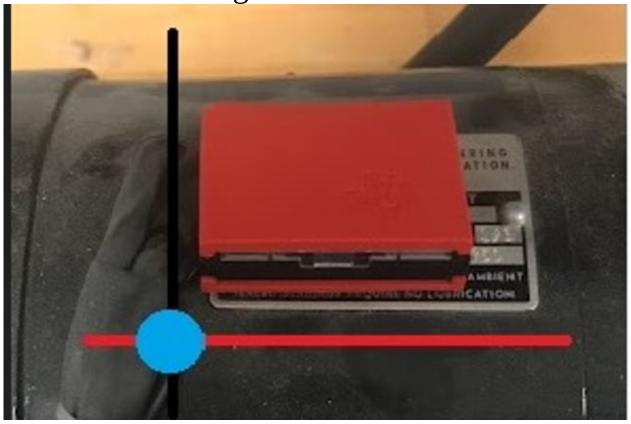
Figure 3.3: Model one physical connection

The following figure, shows the system component assembled and tested at the lab, including the two motors used, nameplates, and details.

Motor 1 nameplate

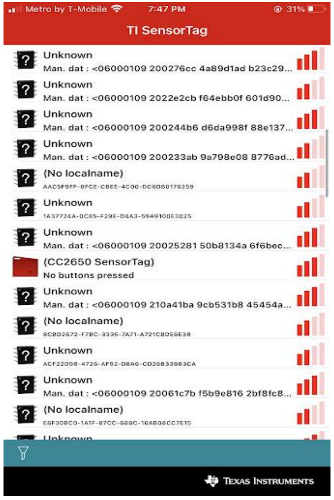
Sensor-Tag location over motor 1

Sensor-Tag location over motor 1



Sensor-Tag location over motor 1 with vibration axis’s, based on the manual location.

Motor one on the right, motor two to the left



Metro by T-Mobile 7:47 PM 31%

TI SensorTag

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(No localname)
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Unknown
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(No localname)
E8F30BC0-1A1F-87CC-688C-16AB08CC7E15

Unknown

Accessing the sensor tag for motor 1, using IOS system

Figure 3.4: Laboratory testing details

The communication and interaction, for model one of system two, are shown in the following flow chart, for only low-energy communication protocol.

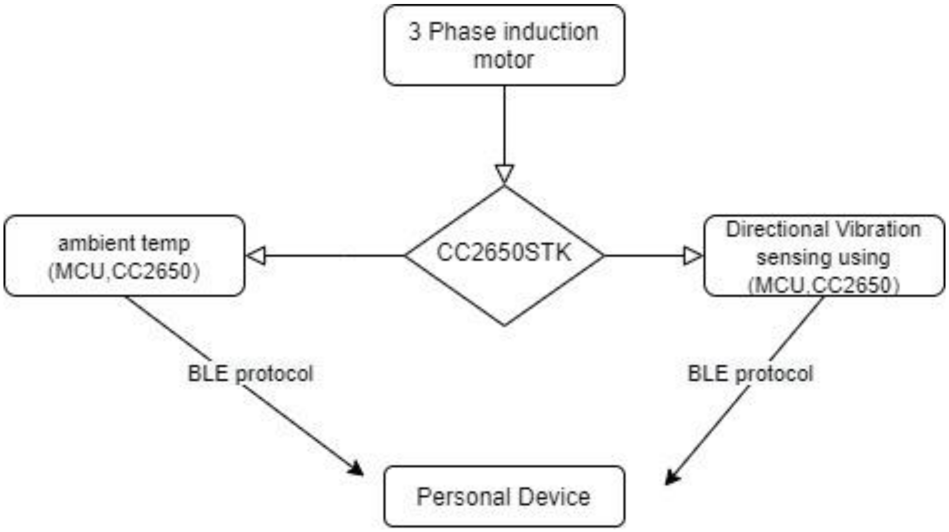

Figure 3.5: Simple BLE flow chart for model one, system two

High interference was noticed during the testing of the system model at the laboratory, we can notice that in the program interface photo, in figure 3.5, which affected the performance of the user's personal device. The data was gathered successfully. The master control (CC2650) unit, which is part of the sensor tag kit CC2650STK was utilized to gather the machine vibration and temperature, the details of using this master control unit, are provided by the manufacturer site.

Working description: once the accelerometer senses the vibration of the motor. Fast Fourier transform is applied inside the relevant part in providing different components to send the data via the selected wireless communication channel, and for this model, Bluetooth low energy 5.1 protocol stack (MCU), the connection was used to maintain the battery health at the beginning of testing.

Model two: As model one testing results were satisfactory, with the same set-up, shown in figure 3.4, the need for more possible models, that can provide more room for student research, was manageable. Moreover, possible future work has emerged, due to some system incompatibility problems, during design.

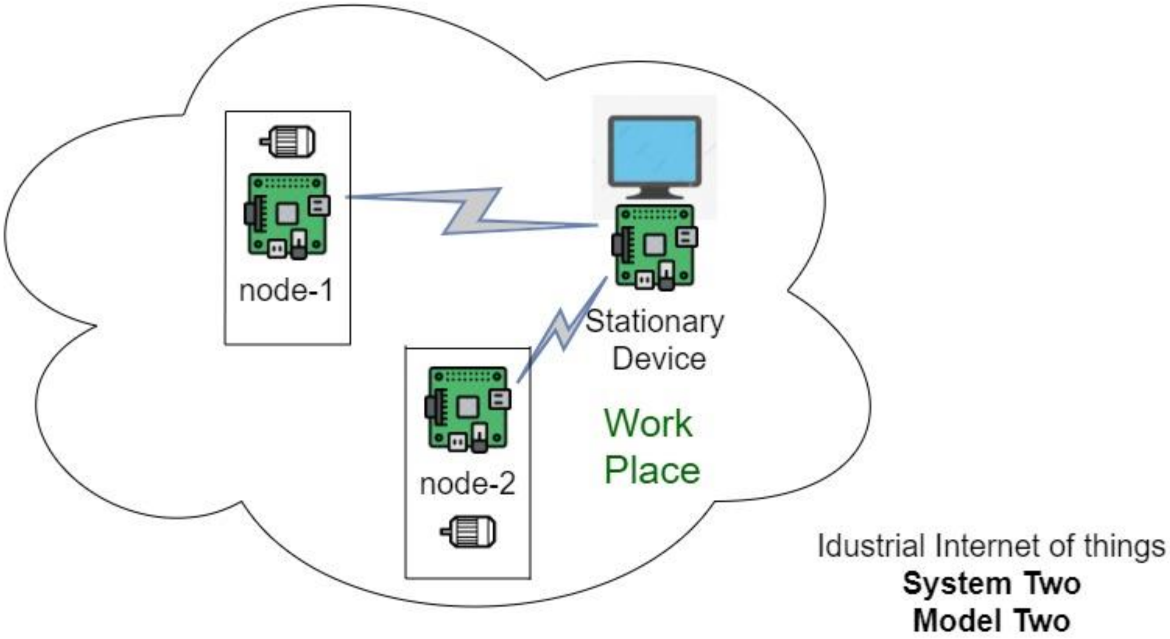

Figure 3.6: Model two physical connection

Emulators are programs, used to moderate between different computerized systems. In this research, the emulator has been utilized, to change the user interface, from a personal device, to a stationary device, this change can be considered an extra contribution to this research. It can be utilized, as a programmable solution designed to run different programs, over different operational systems. More specifically here in this model, the emulator is a program used to run android programs over popular operation systems, windows and IOS different platforms. Two emulators have been used,bluestack X, and nixplay. The following chart contains steps for getting system two to work, during the implementation stage.

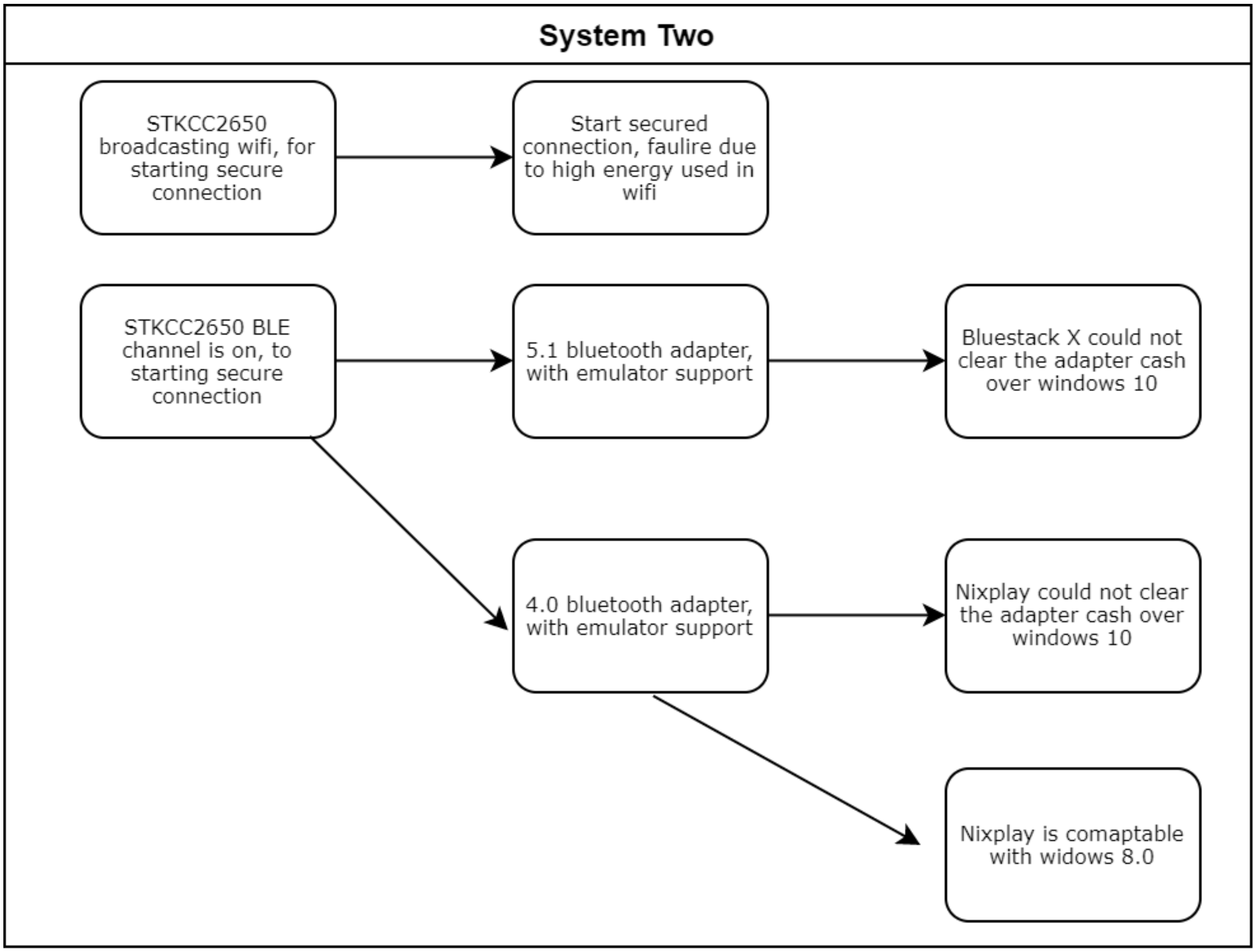

Figure 3.7: System two, implementation stage chart

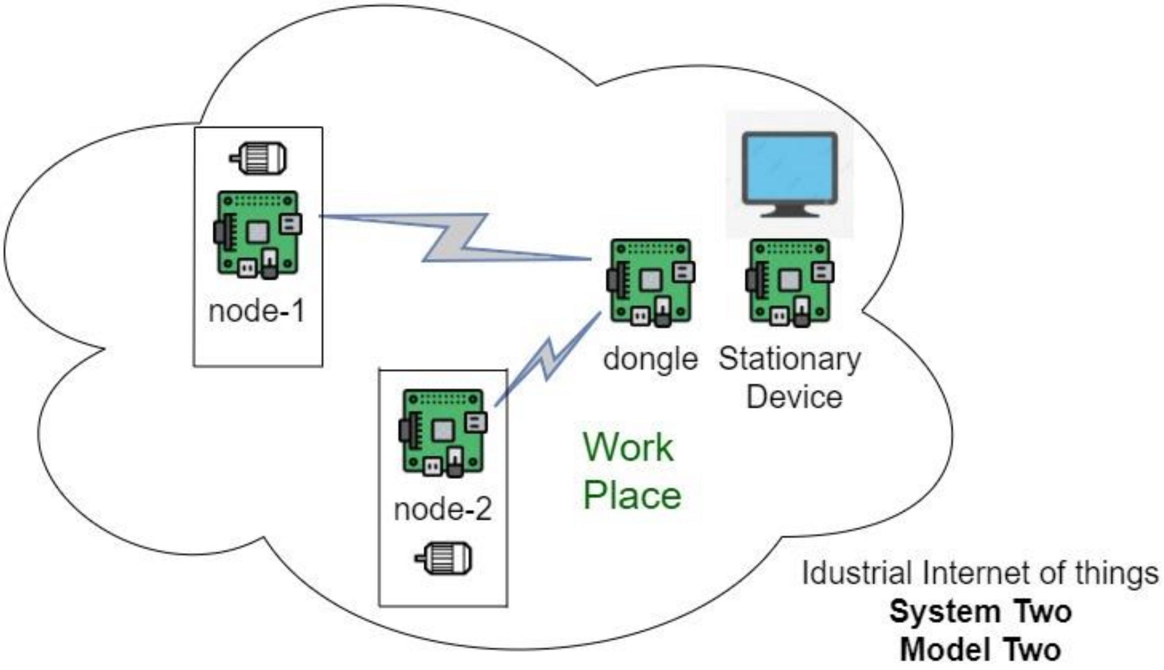

Figure 3.8: System two physical connection, with Bluetooth adapter

Figure 3.8 shows the physical connection for system two, using a Bluetooth dongle inserted into the system to support the running model using the emulator. IIano Bluetooth dongle is a fifth-generation Bluetooth dongle, that supports the latest Bluetooth protocol, it was proposed as a match for the low-energy Bluetooth system, operated by the master control unit. After trying to start the connection, the system failed to perform that, due to incompatibility with the used operating system.

Obstacle & solution: The emulator could not initiate the communication protocol with the kit. After looking into the problem, incompatibility between the operation system version and the Bluetooth protocol cluster provided by the third partner was found [15]. To solve this, degrading the Bluetooth version was suggested, which can make the emulator capable of starting the connection. TP-Link fourth generation was proposed to support the cash problem. The operating system still could not start the communicating with the kit.

Operation systems incompatibility: as both windows 10 and 11, could not perform the necessary tasks, widows 8.0 was the only way to verify the functionality of the system, this operating system was designed to work for screen touch devices, with the use of an older version of the emulator, the system worked satisfactorily.

3.2 Conclusion

This chapter covers the implementation of the industrial internet of things. Two different systems were suggested, discussed, assembled then tested successfully. A couple of obstacles had resin during testing.

CHAPTER IV

RESULT, CONCLUSION, AND FUTURE WORK

This chapter discuss the two systems output, and future research.

4.1 System One

This system can be described as an industrial internet of things model, that can be used to monitor motor parameters. Due to the unforeseen obstacles, the system could not be resembled.

4.2 System Two (Model One)

This system can be described as an industrial internet of things model used to monitor motor parameters, the vibration of the machine, and temperature. Figure 4.1 shows the vibration being monitored under normal operating conditions.

The vibration is being monitored directly by the system, and this graph can always be accessed using the user interface, this output was monitored for the system under normal conditions, the line current is 0.7A, was observed using laboratory equipment, as well as, shaft rotational speed, which was 1768rpm, the time interval for processing the vibration was 0.1 s.

The system supports the possibility of saving the data over the cloud, by enabling this for to the end user to decide, however, it is not available during system implementation and testing, due to the available devices.

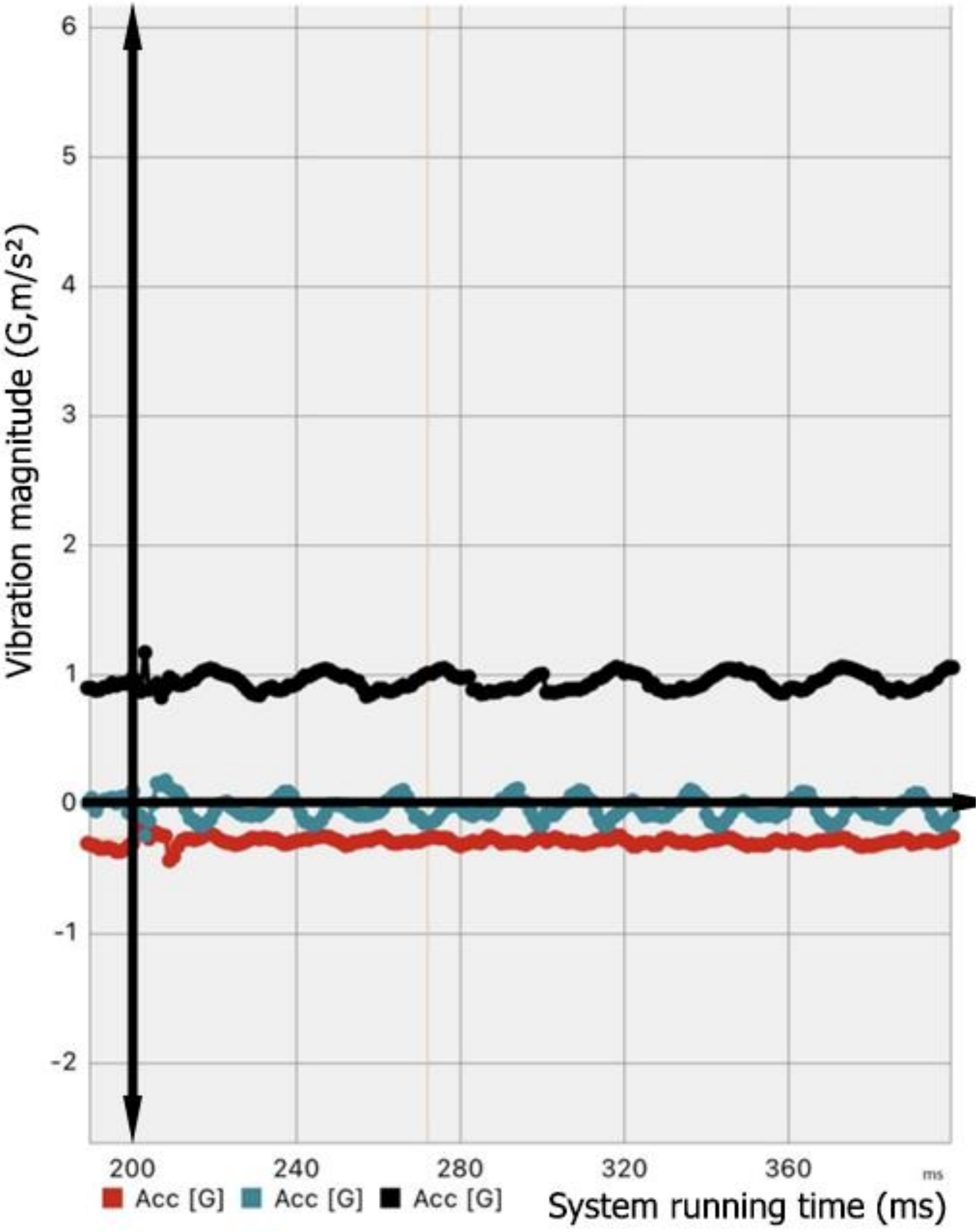

Figure 4.1: Monitored vibration, for model one, under normal condition

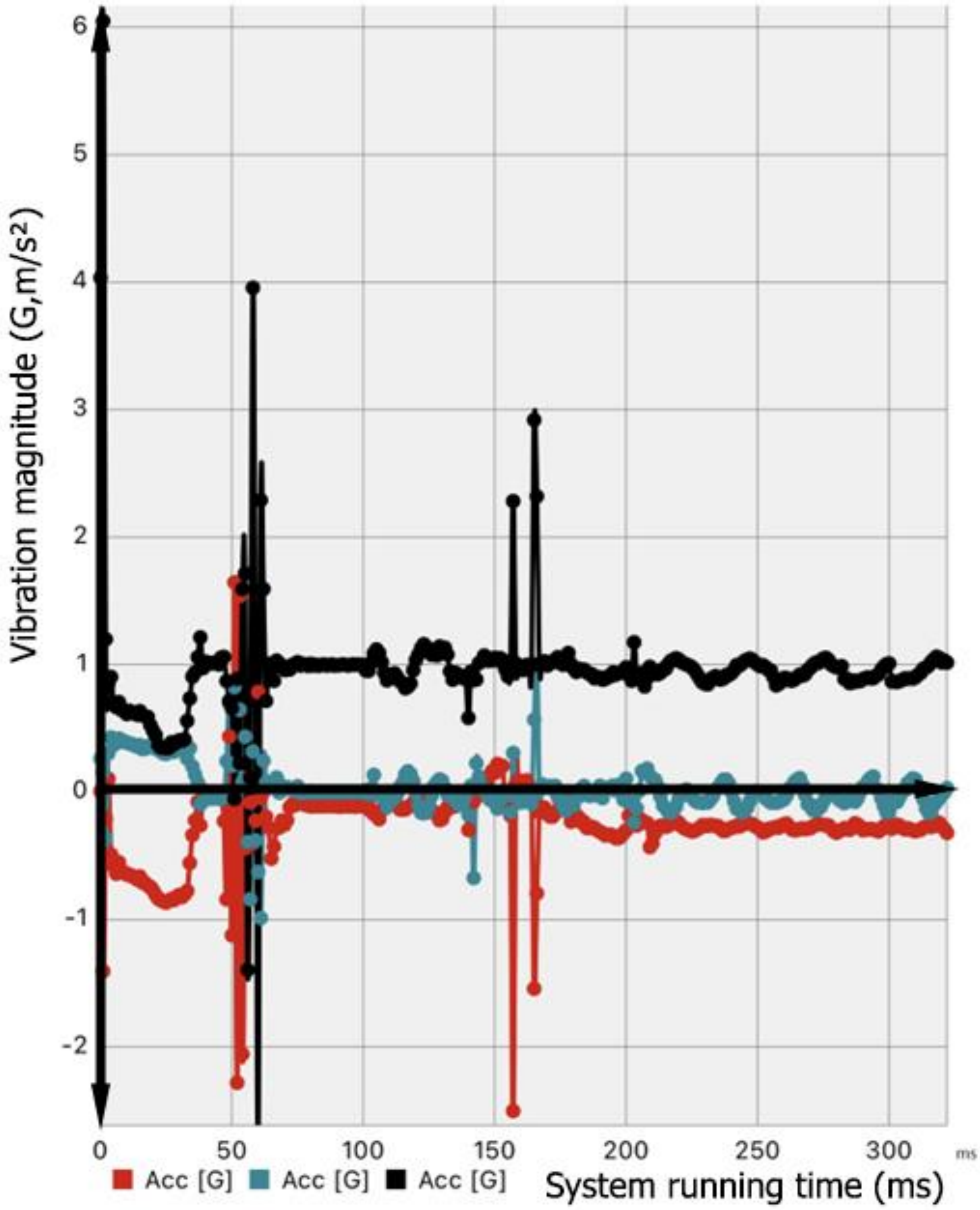

Figure 4.2: Monitored vibration, for model one, under the faulty condition

The figure shown above shows the system under fault condition, the three different colors express the vibration in three different directions, relevant to figure 3.4 (Sensor-

Tag location over motor 1 with vibration axis’s, based on the manual location). A designated break was used to simulate the fault condition, the line current of the machine increased to 0.9A, and the speed went down to 1760 rpm. We can notice that the machine vibration graph responded to the event. System one also supports monitoring the motor temperature, the following figure shows the monitored temperature under normal conditions only.

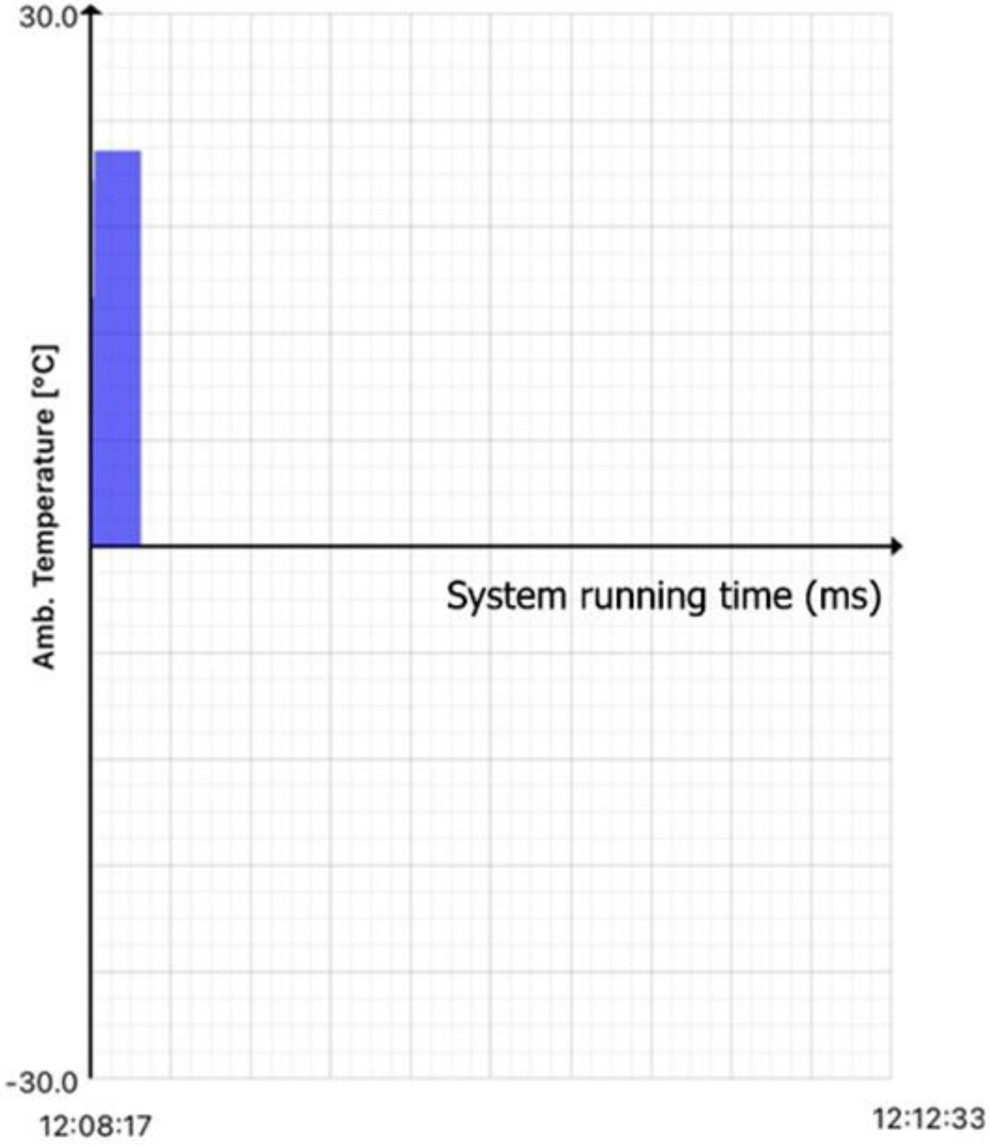

Figure 4.3: Monitored temperature, for model one, under normal operation

The temperature could only be monitored under normal operation mode, to avoid damaging the machine windings, as the temperature could increase in the event of an internal fault or short circuit, and harm the machine.

To sum up, system one output with two important parameters had been successfully monitored at the laboratory. The system can be used to detect system anomalies by monitoring the machine vibration, it can also take action in the fault event, based on the user specification, by adding a couple of design parameters, and devices.

4.3 System Two (Model Two)

System two output is shown for model two in the following figures () and (). The vibration shown in the first figure was taken for the machine under faulty operation mode, the modulation interval for the transformation is 1ms, and we can notice the changes between 30ms and 40ms as ten points. Directly after observing the output, the break was released, and the system returned to steady state operation mode, the monitored vibration for that was directly captured in the next figure

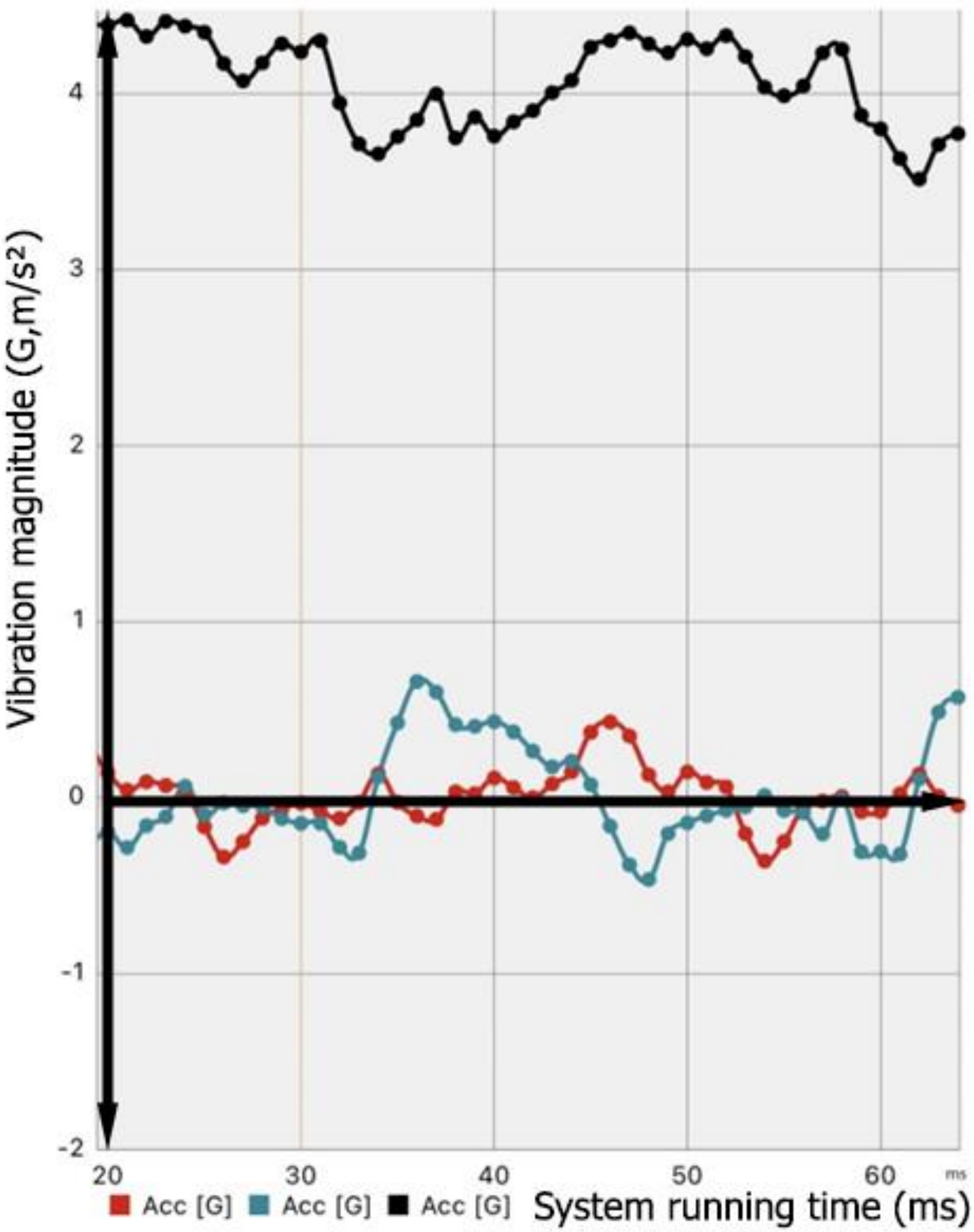

Figure 4.4: Monitored vibration, for model two, under fualty condition

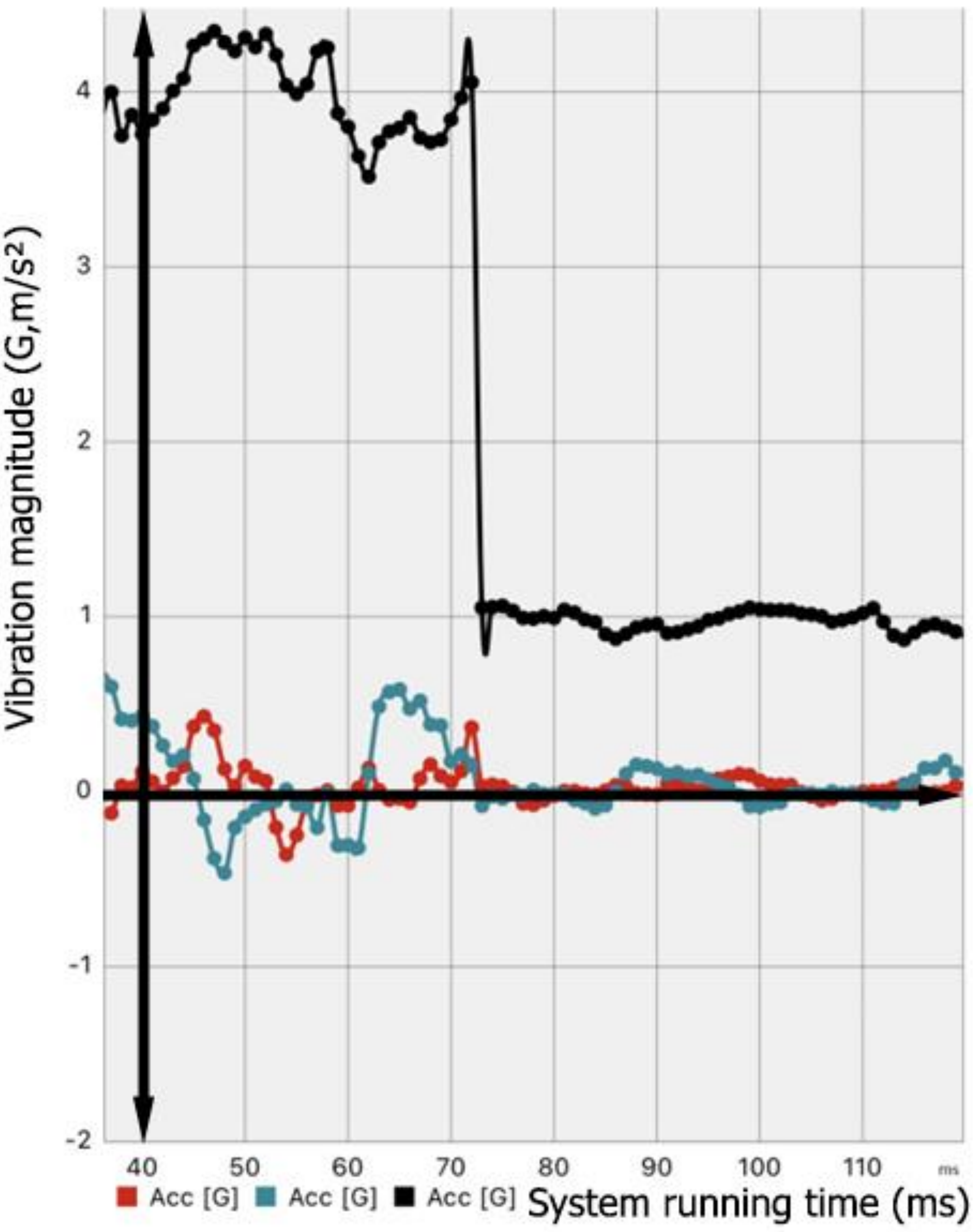

Figure 4.5: Vibration for system two, resting after faulty condition

The output was monitored using a middle interface program to support the different equipment, the original operation system (windows 10) failed to support the different appliances, and windows 8.0 with a proper emulator solve the issue.

The vibration is being monitored directly by the system, and this graph can always be accessed using the user interface, this output was taken for the system under faulty conditions, the line current is 0.8A, and the shaft rotational speed is 1762, the time interval for processing the vibration was 1ms.

4.4 Conclusion

The two systems resembled an industrial internet of things system, the incompatibility in low-energy communication protocol was detected during testing. The running system that can be assembled swiftly, with no physical difficulties can be achieved by using either of both systems.

Using interface middle programs made the interaction between the highly designed integrated circuit and widely used operating system possible.

While system one promises more future results, because it supports the self-device principle, and users would prefer in the future, a more mobilized system, which from the design perspective, only serves the benefits of the users. System two was added, to keep the door open for more possible research. This has been noticed after testing the models, using (pre-devices) in the proposed design testing. System two can be assembled at the relevant locations, and can run using the proposed devices, to carry out more monitoring purposes tasks, in the simulated industry environment.

4.5 Future Work

More research on the low-energy communication issue in the internet of things, was remarkably noticed after this research and could be a title for future research work.

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BIOGRAPHICAL SKETCH

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