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DESIGNE OF COMMUNICATION SYSTEM FOR SMART FACTORY CONTROLLED BY PLC BASED ON IOT TECHNOLOGY

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Master Thesis

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Hussein Tiarah Abd Ali Gharbawee

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ABSTRACT

DESIGNE OF COMMUNICATION SYSTEM FOR SMART FACTORY CONTROLLED BY PLC BASED ON IOT TECHNOLOGY

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A smart factory is an extremely digitalized and associated fabrication capability that depends on smart industrialized. The model of the smart factory is considered as new idea for the 4^{th} manufacturing revolution. The major features for smart factory are perceptibility, communication and independence. Industrial unit has extended trusted on robotics. On the other hand, the smart factory produces that notion significantly extra. Also, this smart factory was capable to product devoid of more human interference. In this thesis a new method for mixing the idea of the smart factory with the idea of the internet of things. This mixing provides extra benefit for controlling the smart factory without attending to the factory and know the state of the production and the amount of industry. The GLOVA G7-DR20U is used as a programmable logic controller, PLC to control the action on smart factory while using the NodeMCU esp8266 as the IOT board for communication between owner and the factory using the smart phone programming. The software programming in the mobile phone was written in MQTT program. The program which written inside the PLC by using ladder language for controlling the work of the PLC. The prototype of smart factory was containing from two motor one for horizontal movement while the other for vertical movement. The scheme, moreover, has six sensors. Every motor attaches with double sensors to bind its movement. The other two sensors are one for detecting the exist of production while the other for count the production on the output side. When running the system, it is shown that the system is working very well and the response to

the communication system via IOT is very good also receiving and sending the information to the mobile phone without errors.

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LIST OF ABBREVIATIONS

EPROM	:	Erasable Programmable Read Only Memory
FBD	:	Function Block Diagram
IDC	:	International Data Corporation
IL	:	Instruction List
IoT	:	Internet of Things
LD	:	Ladder Diagram
OSLC	:	Open Services for Lifecycle Collaboration
PLC	:	Programming Logic Controller
RAM	:	Read Access Memory
RFID	:	Radio Frequency Identification
SF	:	Smart Factory
SFC	:	Sequential Function Chart
SMOs	:	Smart Manufacturing Objects
ST	:	Structured Text

1. INTRODUCTION

1.1 MOTIVATION

In current time, the industry has been hypothesized by way of a structure that moves outside the industrial unit ground, and patterns of "manufacturing as an ecosystem" have developed. The word "smart" comprehends creativities that generate and usage information rate the produce life span sequence by the aim of making elastic industrialized procedures that react quickly to alterations within the request at small rate to the fixed devoid of destruction to the situation. The idea needs a lifespan sequence vision, wherever produces are considered to effectual construction and recycle ability. Clever Industrial permits entirely data around the industrial procedure to become obtainable once it is wanted, anywhere wanted. Also, within method that desirable crosswise total industrial source restraints, comprehensive creation life-cycles, numerous productions, with minor, middle and great creativities. That notion was characterized via a “Smart Factory or notation by SF” that trusts on interoperable structures. This is a multistate active forming with imitation; smart computerization; climbable, multi-level replicated safety; and interacted devices [1]. That initiative employs facts and data through the whole creation lifetime round through the aim of making elastic industrial procedures that reply quickly to alterations in request at little rate for stable, in addition to the situation. Those procedures enable the movement of info crossways entirely commercial roles private the initiative and accomplish the networks of providers, clienteles, also extra investor's external the initiative.

1.2 SMART FACTORY

Smart factory is a comprehensive group of developed for aiming of enhancing idea cohort, manufacture, and produce contract. Though industrial could define as poly-phase procedure for generating invention beyond basic resources, clever industrial is a subset that employments processer governor and great stages of adapts. Clever industrial goals to the revenue benefit of progressive info and developed skills to permit elasticity in corporal procedures to report an active and international fair. It is improved personnel preparation to like plasticity and usage for skill somewhat than exact responsibilities same usual for outdated developed [2]. This idea is demonstrated in figure 1. Progressive automata, likewise, identified as clever machineries work separately and could join straight with industrial schemes. For approximately progressive industrial frameworks, it could effort through persons aimed at meeting responsibilities. Through estimating corporeal effort and unique among diverse creation formations, that machineries were capable to resolve difficulties and make choices self-governing of persons. That automata were capable to comprehensive effort yonder that primarily automatic to do and has simulated cleverness that permits them to study after involvement [3]. Those machineries take the elasticity to be re-configured. This contributes them the capability to reply quickly to enterprise alterations and invention, that is a modest benefit above extra outdated industrial procedures.

1.2.1 Benefits and Aims

Smart factory goals to become a perfect repetition in industrial. It includes the combination in totally stages of the product construction method. The goal actuality extra melodious expansion procedure using information to progress clever skill to advance novel and advanced superiority belongings.

A. Emerging business practices

When it is accepted, smart nets of industrial will understand outcomes in manipulating commercial together nationally and universal. Commercial simulations will extra simply conceptualize round the incorporation of each stage of the growth procedure; creation, industrial, transference and vending [4]. The ultimate objective is extra elastic, compatibility, and sensitive method for contributing in modest marketplaces.

B. Removing workplace incompetence and vulnerabilities

SF could moreover become accredited to charting workplace disorganizations also supplementary in employee protection. Effectively optimize is a vast emphasis for adopters of SF. That is complete over information investigation and smart education computerization. For example, workers may be assumed private entree card by inherent Wi-Fi or Bluetooth. That means attaches through mechanisms with a Cloud stage to control that the worker is functioning that is instrumented within an actual period [5]. Smart, unified scheme will have established for setting an activity aim, define when the aim was available, and classify disorganizations over disastrous and late activity objectives.

1.2.2 Exploit and Properties

The foundation to one important positioning of replicated corporal schemes was unified information joining crossways each period for assessment addition procedure. For to each produce, together per his real corporeal representation, a simulated representation remains endure additional expansion. Thus, Clever Industrial expansion with employment concentration for best incorporation among actual and the simulated domain.

An important element for the clever industrial unit was rationalizing governor: Brainy modules work within every step of the association scheme over portion changes. That kind of assemblage procedure, announcement happens in every stage toward concluding whatever parts toward improve and assemblage stages to appliance [6]. Regionalized governor styles at ease toward improving and altered portions when wanted. That creates it flatter to run into growing request in frame customization.

Further $4 billion was participated for software corporations meanwhile 2007. This is for aiming for allowing numeral representation for worth restraint. That individual done whole incorporation for separate, assessment addition stages makes conceivable for realizing entirely believable advances within production.

It is known that there are triple central features for that advanced:

1. **Industrial implementation**. It is representing a uniform extra significant part. The step of connecting among the mechanization step with the industrial implementation scheme that determination growth meaningfully. Similarly, crossways the limitations of corporations and places. The incorporation of Initiative Supply Preparation stages leads to development for attain comprehensive transparent in addition to connective for commercial information. This can be saying completely essential data was obtainable within actual period.

2. **The merger of the creation and construction lifecycle**. The additional central component was the assimilation of produce and manufacture lifespan rely on communal information ideal. These lead to permit producers happens the tests the effect over eternally littler creation lifespan [7].

3. **Virtual corporeal schemes**. It is a base to growth in industrial elasticity that outcomes in smaller period to marketplace. That construction part could be malleable combined to present construction procedures. Virtual corporeal schemes combine transportations, information technology, with corporeal components by means of essential knowledge, with device meets; Internet communicates substructure, actual period treating with occasion managing, huge information and information provision; with automatic processes with supervision for universal actions through creativities.

Figure 1.1: Motorized manufacture as smart factory.

1.3 INTERNET OF THINGS (IOT)

The meaning of the IOT has grown because of merging of numerous tools, actual time analytic, mechanism education, producing instruments, and surrounded schemes. Outdated grounds of entrenched schemes, robotics (containing home-based and construction robotics). Also entirely donate for allowing the IOT.

The idea of a system for clever plans is deliberated as initial in 1982. This an adapted Coke instrument at “Carnegie Mellon University”. This is a primary Internet linked application, capable to account its record and if a new encumbered drink was icy. The IOT is the net of plans, automobiles and home-based applications which comprise microchip technology, software, sensor, and connective that permits these effects toward attaching, interrelate and conversation information.

The internet of things includes covering the net. Connection outside typical strategies. This is similar to desktop, laptops and smart-phones. For a somewhat kind of conventionally *dumbing* or never-internet-enable corporeal equipment with everyday items. Implanted with knowledge, these strategies can interconnect and interrelate ended the Internet, It could distantly have observed and organized [8].

1.3.1 The Working of IOT

The IOT contains of web permitted clever equipment that usage entrenched processor, actuators and communicate among hardware, transmit and performance of information they obtain for the surroundings. The internet of things equipment segment the instrument information that assemble via joining through internet of things entry or additional advantage maneuver anywhere information was both directed to the cloud in order to evaluate or examined in the same places. Occasionally, that equipment connects within extra connected plans and performance for data they acquire after any an additional device. The equipment did the greatest effort deprived of mortal interference, though persons can interrelate within strategies. The connective, interacting and communicate procedures use within that web- allowed strategies mostly rely on detailed IOT submissions organized.

1.3.2 The IOT Applications

The widespread established uses for the internet of things equipment is regularly separated to customer, marketing, manufacturing, and substructure places. This can be shown in figure 2.

A. Customer application

An increasing share of the internet of things equipment is formed to customer usage, counting linked automobiles, home-based robotics, wearable knowledge, associated healthiness, with applications for distant observing abilities.

1. Smart home-based

The internet of things equipment is a portion from greater idea of home-based robotics that contains illumination, warming and air conditioning. Also containing broadcasting with safety schemes [9].

2. Senior carefulness

Some vital use for clever home-based was for providing help to people that incapacities or aging persons. That home-based schemes usage assist skill in providing lodgings proprietor's precise incapacities.

B. Marketable applications

1. Medicinal and health-care

The Medical Things runs by the Internet used for the internet of things for medicinal with fitness connected devotions, information group with an inquiry to the investigation also for observing. That Clever Healthcare headed to making a digital healthcare scheme, joining obtainable medicinal incomes with healthcare facilities.

2. Transportation

The internet of things is able to contribute within the incorporation of transportations, governor, and info treating through numerous transport schemes. The field of internet of things spreads to entirely feature of transport schemes. Forceful contact among these mechanisms of a transportation scheme allows put in the ground and intra-vehicular communicative, clever road-traffic governor, clever car-parks, and protection highway assists.

3. Construction and home-based robotics

Internet of things equipment is able to observe and governor the automatic, electric schemes use within numerous kinds of structures within home-based robotics and construction robotics schemes.

C. Manufacturing applications

1. Developed

The internet of things is able to understand the unified incorporation of numerous developmental equipment by detecting, sympathy, treating, communicates, actuality, and network abilities. They open the gate to generate entire novel commercial and marketplace chances for industrial.

2. Farming

There exist many internet of things uses in agricultural like gathering information on hotness, drizzle, moisture, airstream haste, bothers plague, and mud gratified. That information may use for mechanizing agricultural methods, revenue knowledgeable choices for advance feature and the amount, minimize danger and leftover, and decrease exertion obligatory to achieve harvests. For instance, agriculturalists were able to observe earth heat with dampness remotely.

D. Substructure places

Observing with governing processes of maintainable city and countryside substructures similar channels, railway track and was a fundamental request for an internet of things. Internet of things substructure use of observing somewhat actions or variations within organizational situations which cooperation security and growth hazard. Internet of things profits the structure manufacturing using charge redeemable, period saving, improved feature workday.

1. Urban rule distributions

Numerous deliberate or continuing extensive placements for internet of things. This is for assisting a superior organization for towns with structures. For instance, “Songdo within South Korea”, the earliest that completely fortified and underwired clever town, was regularly existence constructed, through about 70% for commercial region finished at 2018.

2. Power organization

Important quantities of power consuming procedures like switch, TV, now incorporate Internet connection, that permit it toward interconnect through functions toward equilibrium energy generated by power treatment and improve power ingesting.

3. **Environment observing**

Environment observing application for the internet of things naturally uses sensors for contribution within an environment guard for observing air and liquid feature, atmosphere with earthly circumstances. It contains zones similar observing the actions of nature with its habitations. Expansion of supply inhibited plans linked through net similarly income additional presentations comparable earthquake or tidal wave primary cautioning schemes and also for spare facilities for delivering extra actual assistance.

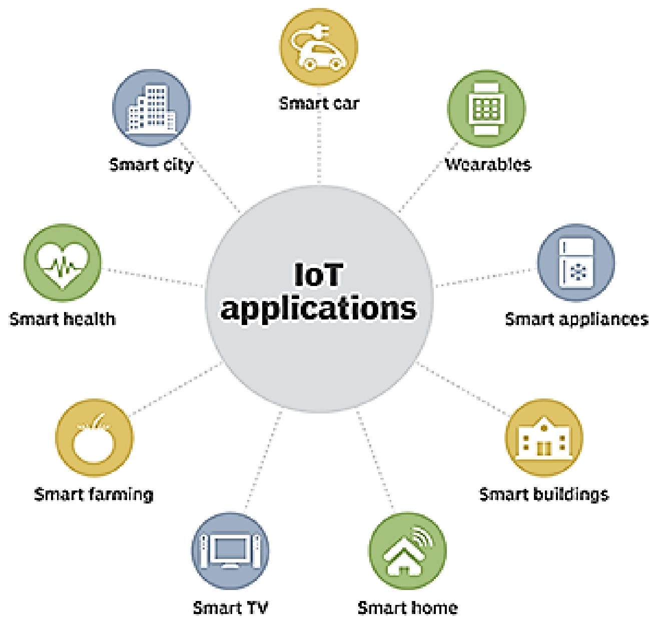


Figure 1.2: The description of IOT application

1.4 THE PROGRAMMING LOGIC CONTROLLER (PLC)

Within 1968 General Motors Hydromantic delivered an appeal for suggestions to electric spare to solid bound relay schemes. This is grounds for a manuscript printed by an. E. R. Clark. Charming suggestion derived as of Bedford Connections from Bedford, Massachusetts. The primary programmable logic controller, selected the 084 since they are Bedford Companions' 84 mission, is the product. Bedford Acquaintances ongoing an original corporation devoted to emerging, industrial, vending, and repairing that novel invention: “**Modicon”**. That product erected to segmental numerical control. Some persons that operated within the mission is “Dick Morley”. This person was regarded as the "father" for programmable logic controller [10].

Contemporary PLC could program within a diversity of methods, beginning with relay derived hierarchy logic reach to another language like specially modified for “BASIC and C”. Additional technique was national logic. This is an exact great level software design language considered for software package PLC rely on state changeover figures. The widely held for PLC schemes nowadays follow of “IEC 61131/3” governor schemes software design normal, which describes a five-languages: “Ladder Diagram (LD), Structured Text (ST), Function Block Diagram (FBD), Instruction List (IL) and sequential function chart (SFC)”.

Several primaries PLC never contain supplementary software design stations which accomplished graphic demonstration for sense. Also sense in its place characterized like a sequence for sense terminologies within around form of Boolean arrangement. This is alike to Boolean algebra. The prime aim of that was the PLC resolve sense within a foreseeable and reiterating order. Also, the ladder sequence permits the computer operator to understand some matters within the skill for logic arrangement extra simply more than further format [11].

1.4.1 Programming of PLC

PLC programming is classically inscribed in a superior presentation in a private PC. The transferred by a direct connect tow and above net through a programmable logic controller. The program-sequence was stored inside a programmable logic controller. This is done in two methods the first one was within battery-RAM or extra never volatile flash memorial.

Additional lately, PLC was programmed by means of request software on private PCs. It represents logic within an explicit shape in its place for characters’ symbol. A PC was linked via a programmable logic controller over USB, Ether-net and other methods connections. A program of the software permits entrance with excision for ladder system sense. Also can likely to sight with editing a programming in meaning block-diagrams, flowcharts or structured-text. Usually, a software delivers roles for repairing and troubleshooting the programmable logic controller software. For instance, for important parts for logic in showing the present state through a process and by simulations. A software then uploads or transfer a programmable logic controller driver, aimed at back-up and rebuilding devotions. Within other simulations in programming governor, the programs are transfer beginning from a PC to a programmable logic controller over a programmed board that inscribes a driver to a transferable chip like EPROM [12].

1.4.2 Basic Functions

The greatest simple purpose of the PLC was to match the meanings of electronic-mechanical relay. Distinct input has assumed a single position. Also, a programmable logic controller orders will check whether I/P condition was 1 or 0. Impartial by way of a sequence of relays associates do a rational AND purpose. Also, never allow electricity to permit except entirely contact was close. Consequently, a sequence of orders, then invigorates its O/P loading bit in case of entirely the I/P bits are 1. Correspondingly, a matching established of orders, then does a rational OR. Within electric-mechanic relays cabling graph, a collection of connections governing single coil was named a "rung" for "ladder diagram ". That idea was similarly used for describing programmable logic controller logic. Few models of programmable logic controller bounded an amount of sequence with parallel orders within single "rung" for logic. The O/P for every step set or evaporates a storing bit that possibly will associate within corporeal O/P addresses and might "internal coil" through the never corporeal link. Those inner coils will work. It can be said that mutual portion within numerous distinct rungs. Dissimilar corporal relay, typically never boundary for amount of periods I/P, O/P and interior coil will reference within a programmable logic controller driver.

There is a programmable logic controller that imposes types of orders or instruction to assessing rung logic. That was dissimilar shape of electric-mechanic relay connections. That is adequately compounding circuits that might permit electricity left to right or right to left, which depend upon the configure of nearby links. Removal of that "snitch paths" was both an infection and a piece, contingent on software design.

Additional progressive commands for programmable logic controller might do by way of useful chunks that perform approximately process once allowed via a rational contribution and that produce production to indication.

1.5 CONTRIBUTION AND ARRANGEMENT OF THE THESIS

Digitalizing the corporeal domain, The IOT was receiving massive devotion. It is shown in what way looks outside the publicity with understanding applied conducts internet of things skill will produce an actual financial rate on behalf of professional. A capability for automatically observing and achieves kits and produces within corporeal domain, marks that conceivable for bringing information ambitious choice creation to novel dominions in mortal action with optimizing the presentation of schemes and procedures.

The developing of explanation to seizure, investigate and imagine important action pointers by the industrial, logistic with usefulness parts. All this is done via "smart factory" tools. Our clever results decrease the quantity of interval with possessions obligatory to detention and connect serious data crossways the industrial unit and animatedly interpret that information to criminal cleverness. That is authorizing workers for taking suitable remedial act to assistance eliminates loss and indorses an intelligence of possession and teamwork. In our thesis the new design of smart factory will be designed and implement as a prototype of part from smart factory. The design of the prototype will be controlled using the PLC (in this thesis the GLOFA GM7U PLC type will be used as a controller in the process of prototype of the smart factory as shown in figure 3). The second component that will be used in the smart factory is the communication system for the internet of things IOT which is the NODEMCU 8266 board as shown in figure 4 which enable the system to communicate with the manager from anywhere. The prototype will be explained in detail in chapter four from the theses. The chapter two will take in details the literature review of the researcher that dealing previously with the smart factory in another method and will talking about this idea. The chapter three will deal with the principle of IOT and the PLC in the side of programming and how to connect and make the communication channel. Finally, the discussion, conclusion and future work will be discussed in detail in chapter five. After adding the references of the thesis, the two appendixes will be added to describe in detail with all necessary information about the component that is used in this thesis that means one appendix for the PLC, which is GLOFA GM7U PLC and the second appendix will take in details all the information about NODEMCU 8266 board.

Figure 1.3: The GLOFA GM7U PLC

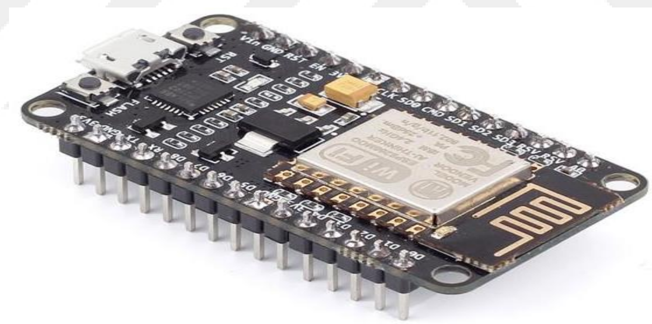


Figure 1.4: The NODEMCU 8266 board

2. LITERATURE REVIEW

A- Hae Kyung Lee and Taioun Kim design a new idea of the smart factory environs, greatest micro-processors are entrenched and linked through the connection of using "wireless and wired" which is depend on corporal system. A corporation making manufacturing "vinyl film" which has great faulty relation is chosen to satisfy the IOT allowed clever factory. Through using accepted wireless equipment, the suggested IOT idea is applied within workroom. The authors conclude that the internet of things is a bell term never just for knowledge, but similarly within the commercial use. The authors show that the Internet with wireless communicate together to transform the dream of a real world in all feature of manufacturing and life smartness. This paper was written to investigate the great role of the internet of things in the field of the "smart factory". The internet of things participates a main part for the understanding of "smart factory". Finally, the authors can conclude that the results show the viability of the internet of things that is applicable in the new version of the factory which is called smart factory [13].

B. Md. Faisal and Vinodini Katiyar study how to understand the want and meaning of security views in industrial mechanization and how this is needed the new idea which is the internet of things which represent the core of the new generation of factory which is called smart factory. The primary stage is to identify the sensor precondition which is inserted inside the engine portions in which actual period analysis results getting the information. In this case, incessant heat alteration from heater sensors or enumerate the velocity for the selected movable part inside an engine. The utilization of the connection of sensors leads to generate the information for rapid gauges. In the same manner collection of actuators are reachable that lead to use in relation to the requirement. The other stages were taking this information for the examination side therefore the need of internet thing is necessary. The third stage was to get nonstop information via a little prevalent program same as "Flume or Kafka". After that the fourth stage was doing the true period examination in order to provide true period imagining distantly that is greatly achieved using cloud computing. Therefore, receiving the program as a facility within the cloud was a major defy to information technology security providers.

Therefore, it actually needs a great security phase to replace our private information for computer operator detached in which this manuscript needs of security. The secure formation in keen factory and the finale to the finale guard of information has been speaking around. The authors conclude that, which depends on the discussion within this manuscript, that vital of secure information within the smart factory is considered as core which can't unnoticed to the strong clever factory without the problem that is occurring during the work. Also study the coherent stages and topics that careful within internet of things that built Smart factory [14].

C. Jean Jung and Kym Watson show that the "Industrial Internet of Things (IIoT)" was mentioned as newest resources to creation industrial extra elastic, price operative, and receptive to vicissitudes in client stresses. Though, a chief anxiety nearby "IIOT" was interoperability among equipment and machineries that meaning in altered procedures and constructions. The authors on that paper demonstrate the "Smart Factory Web (SFW)". This feature was built on the "IIoT" idea of upgrading "factory-to-factory" interoperability. The suggested Smart Factory Web permits security of information and work addition in a cross-site programing scenario like "plug & work" tasks for equipment's and information analysis program by relating manufacturing criteria, "Open Platform Communications Unified Architecture (OPC UA)", and "Automation Markup Language (Automation ML)". In order to touch this, aim or target, experiment factory which contains various industrial arrangements that related and Smart Factory Web was executed within four parts. The practice scenario which is named as "order-driven adaptive production". This is arranged to support ability through manufacturing works which was legalized within the actual placement [15].

D. Hyunjeong Lee et.al. Show that the power organization for "smart factory SF" is demonstrated which is rely on situation- consciousness. The SF is collected from three parts. The internet of things actuators is organized within SF. Also, it is used to assemble numerous types of information containing stuff, tools, and situation. At first one, the information gathering and controller level, gathers and transmit conservation and governor information to the second level. The second level, power managing relies on setting consciousness level, examines the information then concludes the setting from it. Lastly, the power facility level delivers power controlling facilities to operators over observing and governing the situation of power ingesting.

By means of the planned arrangement, operators will control their power ingesting, and governed their values and tools to prevent a power leak. The authors conclude that Because of the universal roasting and the rise of power used, effective power feasting was the chief study subjects at this time. So, numerous types of power organization skills for workshops, constructions, and households are deliberate and positioned to decrease carbon emanation and power rate. The suggested power administration basis for SF delivers power bosses and CEOs of SF with observing facilities for power ingesting and governing facilities for tools. Power leak will decrease, and power ingesting is professionally achieved within SF [16].

E. R.Anita and Bodla. Abhinav demonstrates that Companies are touching to influence internet of things skills and information analysis to continue and vacation modest. The IOT is altering industrial through becoming the flowers more effectual, useful and cleverer. The current studies address the sympathetic to the idea of the internet of things and smart factory. To instruction to continue, be viable in the marketplace and improvement modest benefit the producers are starting to device are internet of things skills and information analysis. International reasonable burdens are stimulating manufacturing businesses to achieve staff abilities holes, oust disorganizations from those schemes. Also discover commercial chances. The world is dashing within the time of bottomless information bury connective and corporations are capable to twice their preceding manufacture quantity, once connecting novel skills. "International Data Corporation (IDC)" predictions the international internet of things marketplace will develop from $1.25 T in 2013 to $3.03 T in 2020. However, Cisco forecasts the international internet of things marketplace will be $14.3T by 2022. The secondary study is assumed to comprehend how IOT will be working within industrial. A small number of forecasters are predicting that "25 billion" IOT equipment within 2020. With extra and extra corporations participating and production an influence in SF. Therefore, the study concentrations on IOTs, its significance and influence on industrial procedure. The authors conclude that the internet of things was slowly transporting a marine of technical changes within our everyday survives. This is to assistances to creation our life humbler and more relaxed. Also, numerous tools and requests. The IOT has a memorable circle in it. For numerous the possibilities are almost too far-reaching to imagine. For manufacturers the likely influence of the internet of things within SF appearances exacts big certainly. In upcoming constructers will depend on associated crops to deliver produce as a facility. It is exploring the feasibility of micro logistics nets to become improved commercial choices via reserves in active aptitude and permit the potential of quicker provision for choice crops and clienteles [17].

F. Navid Shariatzadeh et.al. Show that the IOT in industrial is well-defined as an upcoming of knowledge which daily carnal things in the workshop ground, persons and organizations that linked via net to construct facilities grave for industrial. The SF was a method to "a factory-of-things". This was actually associated through internet of things. This is never just contracts with keen influences among corporal items nonetheless similarly, by the contact through altered information technology device usage inside the numerical works. The datum derives via mixed information technology schemes for altered fields, belvederes, stages of division and lifetime series stages producing probable discrepancies within information distribution, avoiding corporation. Therefore, the objective was to explore methods and ethics after incorporating the numerical factory. The information technology devices and internet of things in industrial in a mixed information technology situation toward guarantee information constancy. Particularly, that manuscript submits a method toward recognizing all the method of integrating the data. Also, this paper proposes incorporation among internet of things and "PLM platforms" by means of semantic web tools and "Open Services for Lifecycle Collaboration (OSLC)" regular on instrument interoperability. The authors conclude that in the direction of realizing interoperability among a SF with a numerical corporation three points need to measure. Firstly, information transmission procedures. Secondly, information demonstration and arrangement. The third one is semantics and appreciative of the information. More than one method, tools and information simulations toward achieving interoperability for every layer. On the other hand, with the purpose of choice the greatest appropriate ones giving the wanted aims, here was a want used for strategies to display the dissimilar stages that consider toward recognizing the finest result for combination [18].

G. Ray Y Zhong et.al. Explain that the SF is solitary of the serious modules within "Industry 4.0" that represents the following manufacturing generation. That manuscript presents IOT that allowed SF "Visibility and Traceability Platform iVTP" toward eventually realize real-time fabrication conception inside SF. Visibility and Traceability Platform usages internet of things skill to recognize numerous industrial items. Precisely, “radio frequency identification (RFID)” tools were used for altering numerous incomes to “smart manufacturing objects (SMOs)” with those relations consequently it is capable toward real time replicate the manufacture processes with performances. Through creatively by means of a “laser-scanner” in the shop-floor, Visibility and Traceability Platform was capable toward real time exhibition the actions of numerous smart manufacturing objects and matching the real time radio frequency identification information toward demonstration their situations. The Cloud-based structure construction that allows totally the facilities packed and organized in a Cloud permits classic end users to simply describe their manufacture senses, move valuable facilities, and progress their modified facilities. Numerous affectionate situations are obtainable to display in what way Visibility and Traceability Platform could enable the distinctive choice, creation, manufacture and logistic processes in a SF. The authors conclude that the Actual period perceptibility and trace-ability shows significant part within SF wherever distinctive industrial properties are changed to keen industrial items by means of several internet of things equipment like “RFID readers and tags”. The “laser-scanner” was arranged in SF wherever classic actions of “SMOs” would detect and caught. Within “image and video processing algorithms”, a 3-D actual conception prototype was accessible toward attaining the actual period perceptibility and trace-ability. Numerous influences are existing in this manuscript. Initially, internet of things knowledge same as “RFID” were used toward classifying numerous industrial possessions with the purpose of capable to actual period interrelate and connect to all accompanied by manufacture manners. Therefore, classic manufacture actions like mechanical processes and logistic actions become enabled. Lastly, this manuscript offering relaxed and elastic key that reasonable to “SMEs” which anticipating to usage the progressive tools to advancement their industrial plants [19].

H. D.Gowtham chitha et.al. Demonstrate the works education for IOT which grounded industrial and preparation procedure within keen businesses. The manuscript offers the broad education on cloud governor organization in businesses, fast model, and objective in period industrial by means of IOT. That manuscript moreover offers approximately item for training for the present method tracked within productions. This review manuscript provides a comprehensive explanation for monitors of sensors with period redeemable systems in IOT technology. After that the authors recognize the numerous current methods usages within current businesses to grow the assembly level. The author concludes that this manuscript provides the comprehensive review for clever industrial with the internet of things in current industrial part on behalf of development manufacture. That provides a broad comprehensive revision in the numerous methods and procedure trailed within current clever businesses. The authors show that the manuscript presents training for IOT that supported actual period mechanism station observing method in Cloud Industrial. Mechanism implements, as any of the crucial communal funds in industrial could be an actual period observed. When constructing filled usage in the internet of things knowledge, numerous industrial funds were recognized, and their positions may take [20].

I. **Mohammed M. Mabkhot et.al.** Explain that through the growth of “Industry 4.0” with appearance of SF idea, the outmoded attitude of industrial structures was altered. SF presents alterations to elements for outdated industrial schemes and joins the present necessities for keen schemes that make it possible to contend for coming. A growing quantity of study together academe and manufacturing was devoted to move the idea of SF from philosophy to training. The aim of the present study was to hyphenate the viewpoints that figure the SF also to propose methods with practical provision to permit the understanding for these standpoints. That manuscript clears the cavity through classifying and investigating investigation in SF. The propose a basis to investigate present study and examine the features and structures of SF structures. Within the manuscript, the author's emphasis on novel tendencies within industrial side, mainly the idea of I4.0, in this will transform industrial schemes. The authors concentrated on SF structures and considered present effort that is important to that a structure. SF structure was regarded lone an idea, with never the perfect vision of the necessities, the components with structures for basics that support to understand the structure. That conclusion, interested in effort to detail the necessities for SF structure, study these necessities beside strategy values, and analysis and categorize connected prose in SF structures. The investigation accessible within manuscript caused in numerous respected assumptions. More about current methods usage their viewpoint and estimation to form an idea of upcoming industry. More about methods located superior accent in an overall idea of I4.0, nonetheless rare of them dedicated in SF. They clarified an overall summary of scheme values, then never define the features with structures within SF structure. Governor structures and communicate concerned round about consideration. Investigators clarified the manners and performances within structures, also proposed situation trainings to understand and organize that concept, however, stay a want for extra application to understand that concept within manufacturing. Furthermore, current effort located actual slight stress for practical enabler and corporal modules wanted to SF structure. Lastly, the authors deliberated the greatest significant subjects resulting via the manuscript and advised numerous instructions to upcoming study [21].

J. F. Shrouf et.al. Show that the actual and the simulated creations are rising quickly and strictly to usage the IOT. Actually, internet of things has enthused the industrial unit with the supervisions to presentation development trip to the 4th industrialized revolt named "Industry 4.0". Manufacturing, manufacture of the novel time lead to extremely elastic within construction capacity, wide incorporation among clients, corporations, and providers, with entirely maintainable. Revising and investigating the present creativities and linked trainings for SF. Within that manuscript the authors demonstrate a situation construction to the internet of things that dealing with the SF. This paper describes the chief features of that industrial unit. After that the authors suggest a method to power supervision within SF rely on the internet of things model. The authors offered advice and predictable profits and discuss all the related idea about the smart factory that is depends on the internet of things. The authors conclude that the manuscript offerings summary for SF or it is named "Industry 4.0". Also, the construction of the internet of things and its relation to smart factory is explained. Also, the features of that industrial unit with an emphasis on the sustainable features are demonstrated. Overall, the authors present a method to implement internet of things pattern in manufacture stage so that sustenance power supervision and growth power effectiveness of construction schemes in that industrial unit. Through gathering power ingestion information from factory ground. Also, it can be said through provided that choice creators within the actual period for some residence. Also ultimately incorporating power information within manufacture administration performs power effectiveness will have enhanced. This is done over discovery and decreases the trashes and permit the power mindful choice creating within construction administration stage [22].

K. Arshdeep Bahga and Vijay K. Madisetti explain that the IOT is approved for manufacturing and industrial uses. This application can be regarded as industrial mechanization, far away mechanism diagnostic, predictive healthiness administration for developed technologies and source series managing. The Cloud Created Developed is a current with order typical of industrial that is leverage internet of things equipment. Though Cloud Founded Industrial allows order admission for industrial incomes, a main intermediate is compulsory for connections among the operators that request to benefit industrial facilities. The authors provide a dispersed, point-to-point stage entitled "BPIIOT" for Manufacturing IOT founded with Chunk sequence machinery. Through the usage of Chunk sequence skill, the "BPIIOT" stage allows aristocracies in a regionalized, trust-less, point-to-point net to interrelate together deprived of the requirement for a reliable intermediate. The authors conclude that a Block-chain Stage for Manufacturing IOT-(BPIIOT). BPIIOT stage enables a bazaar of industrial facilities anywhere the machineries which has Block-chain explanations and the customers are capable of delivery and manage within machineries straight into an advantage industrial facility. The profits of consuming Block-chain that made it appropriate to Manufacturing IOT which are as follows: "Decentralized & Trustless, Resilient, Scalable, Secure & Auditable, Autonomous, CAP & Block chain, Smart Contract Vulnerabilities, Awareness, Regulation, Privacy and Efficiency" [23].

3. MATERIALS AND METHODS

3.1 MOTIVATION

In this chapter the demonstration of the parts of this thesis will be taken in the details. All this part will be studied, and the construction of these parts will be explained with the aid of graphs and tables. In this chapter, two main parts will be taken which are: PLC and NODEMCU board will be taken. Also, there are supplementary parts like micro-switches, motors, batteries, and so on. In this chapter only the hardware details will be taken and leave the software programming and the procedure of connecting in chapter four.

3.2 PROGRAMMING LOGIC CONTROLLER (PLC)

The power station was run for governor and initial power control is based on relays. Those relays permit current to switch “on and off” deprived of a machine-driven switch. There was a public to usages relay to create easy real control choices. The growth of little price PC was carrying the greatest current revolution. This new technique was called the (PLC). The beginning of “PLC” was in 1970. The PLC comes to be the supreme public choice for industrial control. The programmable logic controllers gain acceptance in factories and expected that it maybe continues principal in the future. Greatest of that has been since of the benefits they submit which are: “Cost effective for controlling complex systems, Flexible and can be applied to control other systems quickly and easily, Computational abilities allow more sophisticated control, troubleshooting aids make programming easier and reduce downtime, Reliable components make these likely to operate for years before failure”. The PLC was an essential portion of industrial unit mechanization and manufacturing procedure control for years. The PLC governor an extensive collection of uses as of modest lights purposes of conservation schemes to chemical treating plant. Those schemes achieve numerous purposes, given that a diversity of I/P and O/P interface. The Wholly PLC parts with jobs are arranged about the organizer that was programmed for a particular job [24].

3.2.1 Ladder Logic

The Ladder logic was the chief software design technique works for PLC. This language was established in impersonator relay design. The choice for usage the relay drawings is a planned unique. By choosing a ladder design as chief software design, the quantity of reeducation wanted for designer and trades people are significantly reduced.

Current control schemes remain includes relay nevertheless that is infrequently used in logic. The relay was easy equipment which uses a magnetic-field for governor a button. Once a power is practical to the I/P loop, the subsequent current generates a magnetic-field. The magnetic-field jerks a metallic switch (or cane) to it and associates trace, close the switch. The connection which closes once the loop is thrilled was named “normally open”. The other case which is called “normally closed” associates touch once the “input coil” was never thrilled. The relay is usually pinched in diagram procedure by means of a circle to signify the “effort coil”. The O/P contract contains two parallel lines. General open links are presented as double lines. Also, will open (“non-conducting”) once I/P was never energizing. Generally close contacts were presented through dual lines through a crosswise link from side to side. After I/P coil was never energizing the generally close contacts was closed [25].

3.2.2 The PLC Configuration

In this thesis the GLOFA-G7DR- PLC will be taken. In this part most of the specification and details. The GLOFA-GM7U series contain the subsequent specification.

1) The GLOFA-GM sequence specification

(A) They are considered with a foundation of “international standard specifications (IEC61131-3)”

* Provisions relaxed software design

* Delivers “IEC61131-3 Language (IL / LD / SFC)”

(B) Provisions open networks through the “international standard communication protocol”

(C) Great quickness treating through embedded operation-dedicated processor.

(D) Numerous singular units which increase the PLC usage variety

2) GM7U sequence was exceedingly compacted for fitting an extensive scope of uses.

(A) Great quickness treating (“0.1to 0.9 µs/step”)

(B) Numerous integral jobs

Just through the ignoble part, the operator could have configured numerous structures since contain numerous integral jobs.

• Rapid Treating Uses

- Permits the improper part to recite a pulse firmly as small as 10µs
- Support very-speed calculating till 1 pH. 100 kHz also 2 pH. 50kHz
- Exterior connection interrupts: allows the uses which need instant replies by means of integral eight-point interrupts I/P.

• I/P filter role benefits to decrease probability of wrong I/P situations from outside noise, like signal chatter.

• Integral setting control job permits to govern a walking motorized or a servo-motor deprived of an isolated placing unit.

• By means of RS-232C with RS-485 integral ports, GM7U could associate to outside plans. This is like a computer or observing devices.

• Via integral PID governor job, the PID governor scheme will configure simply devoid of consuming distinct PID unit.

(3) Users be able to simply go On/Off the scheme through RUN/STOP change.

(4) Users be able to configure numerous schemes via a distinct Cent I/F unit.

(5) Users package be able to easily keep within the EEPROM via humble operation through GMWIN devoid of consuming outside memories.

(6) Progressive self-indicative jobs GLOFA-GM7U sequence is able to discover the mistakes exactly.

(7) Inadvertent interpretation and inscription be able to stop via using a secret code.

(8) Resume style situation. Users are able to choose Cold/Warm pick up the style.

(9) A reduced amount of Battery-operated - Through the EEPROM, user's package and factor be able to keep forever deprived of using batteries.

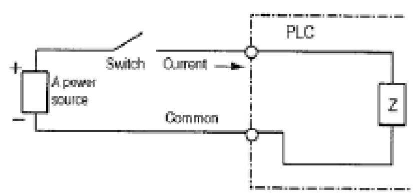
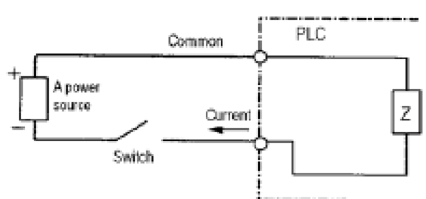
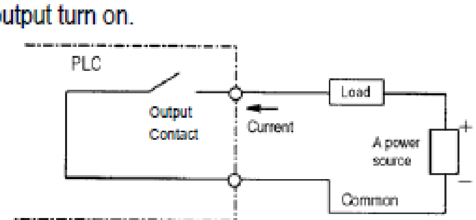
(10) Correcting job On-line correcting was obtainable at the time when PLC Process style was fixed to correct kind.

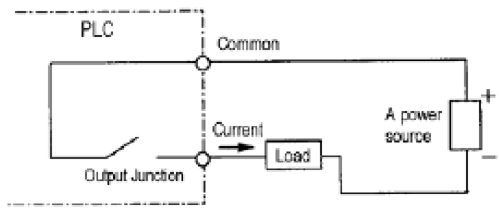
(11) Numerous software package implementation role Period ambitious interrupt, outside and interior interject program in addition to test program be able to execute through set the implementation state [26].

The next table provides a meaning of terms used in this thesis. These terms are explained in detail in table 3.1 as shown below.

Table 3.1: The terms used in simulation

Terms	Definition	Remarks
Module	A standard element that has a specified function which configures the system. The devices such as I/O board, which inserted onto the mother board or base unit.	Example) CPU module, Power supply module, I/O module
Unit	A single module or group of modules that perform an independent Operation as a part of PLC system.	Example) Main unit
PLC System	A system which consists of the PLC and peripheral devices. A user program can control the system.	
Cold Restart	To restart the PLC system and user programs after all of the data (variables and programs of I/O image area, of internal register, of timer of counter) were set to the specified conditions automatically or manually.	
Warm Restart	In the warm restart mode, the power supply Off occurrence will be informed to the user program and the PLC system restarts with the previous user-defined data and user program after the power supply Off.	
Hot Restart	After the power went off, the PLC system restores the data to the previous conditions and restarts in the maximum allowed time.	
I/O Image Area	Internal memory area of the CPU module which used to hold I/O statuses.	
Watch Dog Timer	Supervisors the pre-set execution times of programs and warns if a program is not completed within the pre-set time.	
Function	Operation Unit which outputs immediately its operation result of an input, while four arithmetic operations comparison operation store their results in the inside of instructions.	
Function Block	Operation Units which store operation result in the inside of instruction such as timer and counter and use the operation results which have been stored through many scans.	
Direct Variable	Variables used without the definition of their names and types. There are I, Q, M areas.	Example) •%IX0.0.2 •%QW1.2.1 •%MD1234 etc.

Terms	Definition	Remarks
Symbolic Variable	Variables used after the user's definition of their names and types. Declarations as 'INPUT_0' = %IX0.0.2, 'RESULT = %MD1234' makes INPUT_0 and RESULT be able to used instead of %IX0.0.2 and %MD123 in programming.	
GMWIN	A peripheral device for the GLOFA-GM series. It executes program creation, edit, compile and debugging.	
FAM	Abbreviation of the word 'Factory Automation Monitoring S/W'. It is used to call S/W packages for process supervision.	
Task	It means startup conditions for a program. There are three types of periodic task, internal contact task and external contact task which starts by the input signals of external input modules.	
RTC	Abbreviation of 'Real Time Clock'. It is used to call general IC that contains clock function.	
Sink Input	Current flows from the switch to the PLC input terminal if a input signal turns on. 	
Source Input	Current flows from the PLC input terminal to the switch after an input signal turns on. 	
Sink Output	Current flows from the load to the output terminal and the PLC output turn on. 	

Terms	Definition	Remarks
Source Output	Current flows from the output terminal to the load and the PLC output turn on. 	
Fnet	Fieldbus Network	
Cnet	Computer Network	
Dnet	DeviceNet Network	

3.2.3 Basic System Configuration

The table 3.2 explains the basic configuration and the types of components that is connected to the main part of the PLC. All the type of main and expansion modules is demonstrated.

3.2.4 Cnet I/F System

The Cnet I/F Scheme is designed for communicating among the central part with exterior components via “RS-232C/RS-422” Line. GM7U series contains an integral RS-232C port, RS-485 port. Also, the PLC contains “G7L-CUEBfor RS-232C”, “G7L-CUEC forRS-422”.

1) One to one Communication organization

(A) Communicate among computer and GM7U-PLC through RS-232C connection

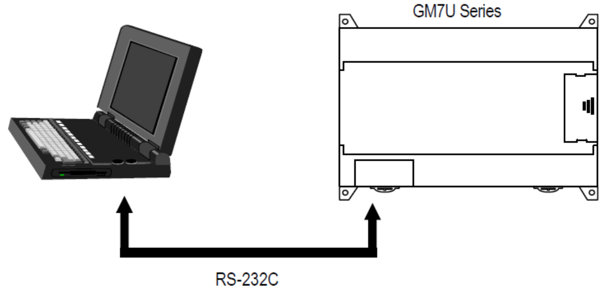
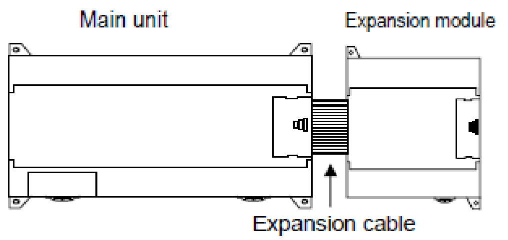


Figure 3.1: One to one communication organization

Table 3.2: The Basic configuration and modules connected to the PLC



Total I/O points			20 ~ 120 points	
Maximum number of expansion modules	Digital I/O module		3	Total 3 modules (External Memory and RTC modules can be connected as a 4th expansion module)
	A/D-D/A module		3	
	Analog timer		3	
	Cnet I/F module		1	
Item	Main unit		• G7M-DR20,30,40,60U	• G7M-DR20,30,40,60U/DC
			• G7M-DRT20,30,40,60U(N)	• G7M-DRT20,30,40,60U(N)/DC
			• G7M-DT20,30,40,60U(N)	• G7M-DRT20,30,40,60U(N)/DC
			• G7M-DT20,30,40,60U(P)	• G7M-DRT20,30,40,60U(P)/DC
	Expansion module	Digital I/O	G7E-DR10A/G7E-DR20A/G7E-TR10A/G7E-DC08A/G7E-RY08A/G7E-DR08A G7E-RY16A	
		A/D,D/A	G7F-ADHA/G7F-AD2A/G7F-DA2I/G7F-ADHB/G7F-DA2V/G7F-AD2B /G7F-ADHC	
		RTD Input	G7F-RD2A	
		Analog Timer	G7F-AT2A	
	Communication I/F module	Cnet I/F	G7L-CUEB,G7L-CUEC	
		DeviceNet I/F	G7L-DBEA	
		Fnet I/F	G7L-FUEA	
		Pnet I/F	G7L-PBEA	
		Rnet I/F	G7L-RUEA	
	Option module	RTC	G7E-RTCA	
		Memory	G7M-M256B (*1)	

(B) Communicate through modem joining job of "Cnet I/F module" in the direction of the interface within extensive space equipment.

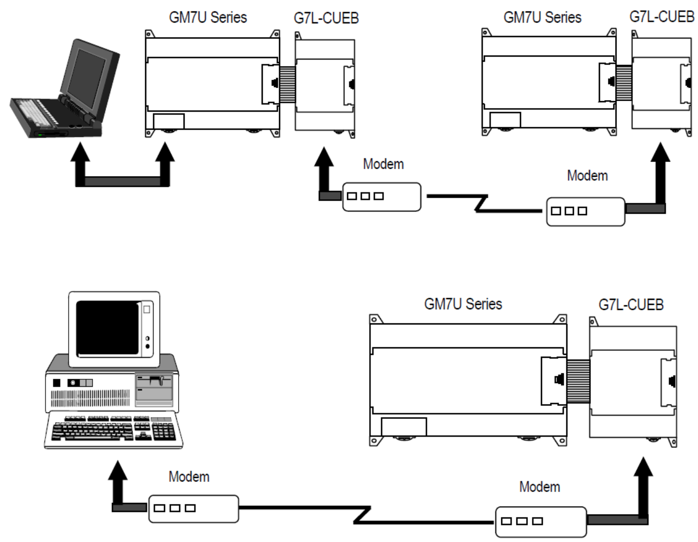


Figure 3.2: Communicate through modem joining job of "cnet i/f module"

(C) Communicate among HMI with GM7U-PLC through RS-485 port

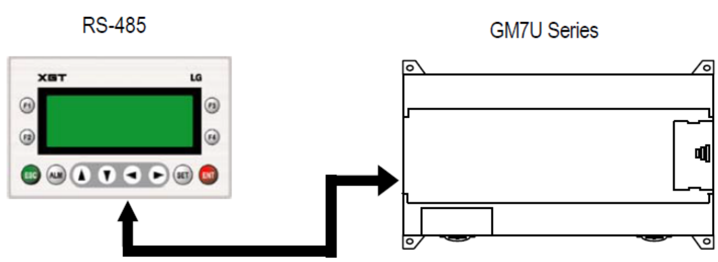


Figure 3:3: Communicate among HMI

2) One to N communicate organization

That technique connects a PC with numerous chief parts till 32 parts.

(A) Through RS-422-Cnet I/F unit

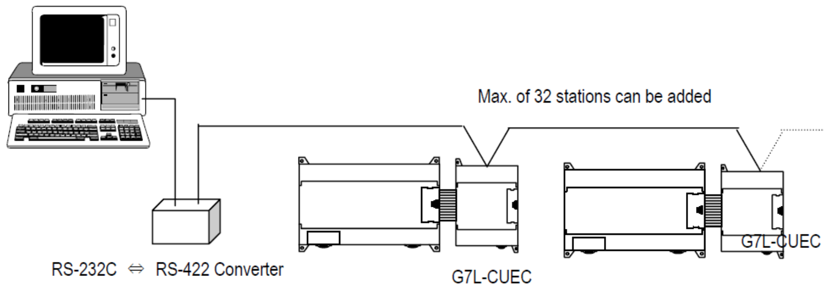


Figure 3.4: Connects a PC with numerous chief parts through RS-422-Cnet I/F

(B) Through RS-485-Cnet I/F unit

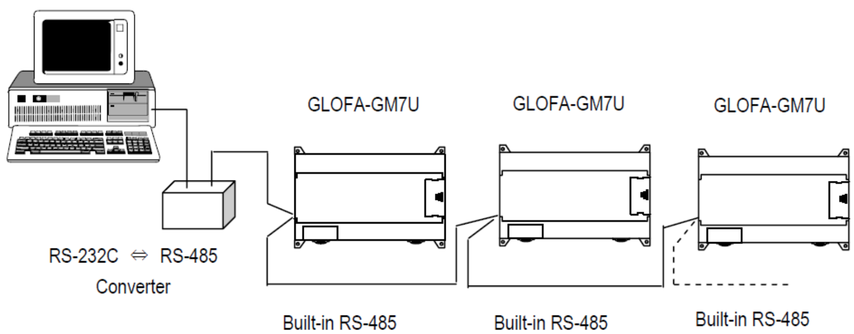


Figure 3.5: Connects a PC with numerous chief parts through RS-485-Cnet I/F

3.2.5 PLC Functional Block

Invention conformation chunk for GM7U-PLC sequence was shown. Also, it is shown from table 3.3 that each part has a special function that is designed for it such as CPU, I/P, O/P, power supply and so on

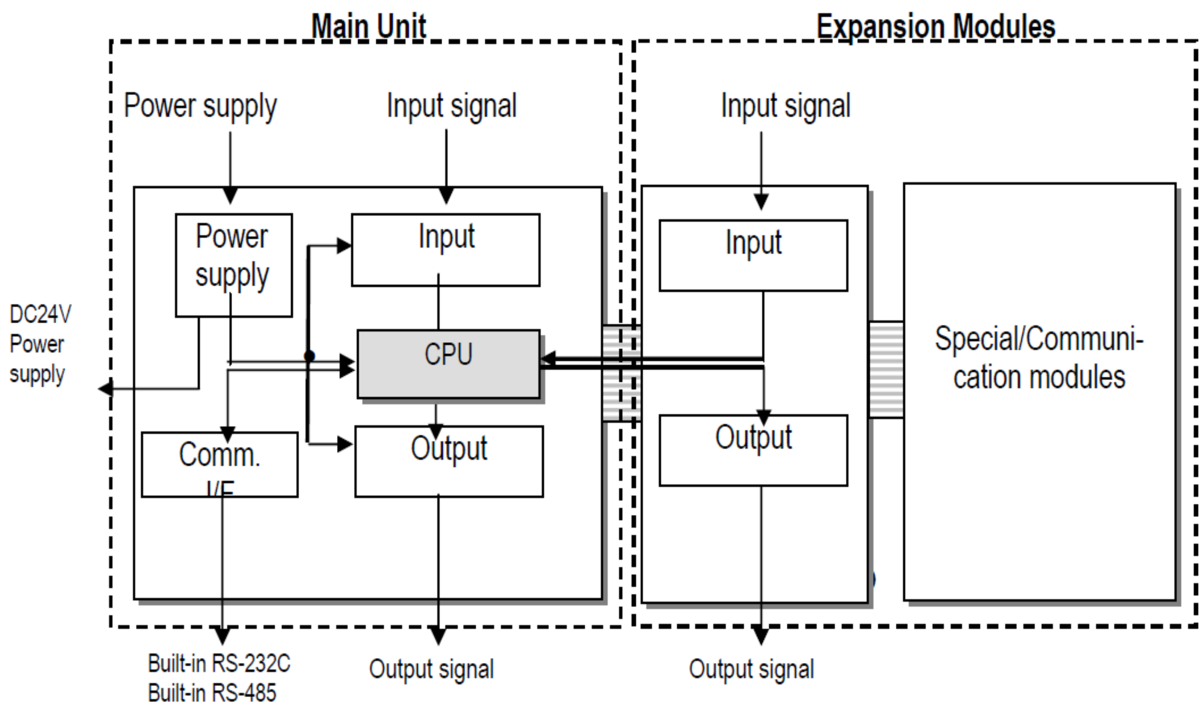


Figure 3.6: The main components and function block of PLC

Table 3.3: The function of the main parts

Sub-system	Description
CPU	• Signal processing function - Operating system function - Application program storage / memory function - Data storage / memory function - Application program execution function
Input	The input signals obtained from the machine/process to appropriate signal levels for processing
Output	The output signals obtained from the signal processing function to appropriate signal levels to drive actuators and/or displays
Power Supply	Provides for conversion and isolation of the PLC system power from the main supply
Communication Interface	Supports 1:1 or 1:N communication system using built-in communication I/F function or GMWIN

3.2.6 General Specifications

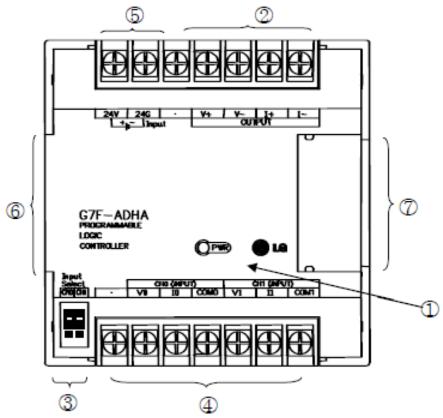
The table 3.4 demonstrates the overall specification for GLOFA-GM7U-PLC sequence.in this table most of the specification for the PLC was displayed to understand how this type of PLC was works [26].

Table 3.4: The specification of glofa-PLC

No.	Item	Specifications					References
1	Operating ambient temperature	0 ~ 55 °C					
2	Storage ambient temperature	−25 ~ +70 °C					
3	Operating ambient humidity	5 ~ 95%RH, non-condensing					
4	Storage ambient humidity	5 ~ 95%RH, non-condensing					
5	Vibrations	Occasional vibration			-		
		Frequency	Acceleration	Amplitude	Sweep count		IEC 61131-2
		$10 \leq f < 57$Hz	–	0.075mm	10 times for each X, Y, Z axis		
		$57 \leq f \leq 150$Hz	9.8m/s^2 {1G}	–			
		Continuous vibration					
		Frequency	Acceleration	Amplitude			
		$10 \leq f < 57$Hz	–	0.0375mm			
		$57 \leq f \leq 150$Hz	4.9m/s^2 {0.5G}	–			
6	Shocks	• Maximum shock acceleration: 147 m/s^2 {15G} • Duration time: 11ms • Pulse wave: half sine pulse (3 shocks per axis, on X, Y, Z axis)					IEC 61131-2
7	Noise immunity	Square wave Impulse noise	± 1,500 V				LSIS' Standard
		Electronic discharge	Voltage: 4 kV (Discharge by contact)				IEC 61131-2, IEC 1000-1-2
		Radiated electromagnetic field noise	27 ~ 500 MHz, 10 V/m				IEC 61131-2, IEC 1000-1-3
		Fast transient /burst noise	Item	Power supply	Digital I/O (>24V)	Digital I/O (<24V) Analog I/O Interface	IEC 61131-2 IEC 1000-1-4
			Voltage	2kV	1kV	0.25kV	
8	Atmosphere	Free of corrosive gases and excessive dust					
9	Altitude	Up to 2,000m					
10	Pollution degree	Below 2					
11	Cooling method	Air-cooling					

3.2.7 Special Units

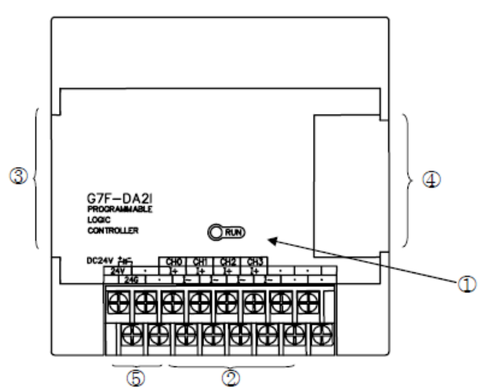
(A) Analog to digital and digital to analog arrangement unit (G7F-ADHA-module) [27].



No.	Names
①	RUN LED
②	Analog Output Terminal
③	Analog Input (Voltage/current) selecting jumper pin
④	Analog Input Terminal
⑤	External Power Supply Terminal (DC24V)
⑥	Expansion Cable
⑦	Expansion Cable Connecting Terminal

Figure 3.7: The A-D and D-A convertor.

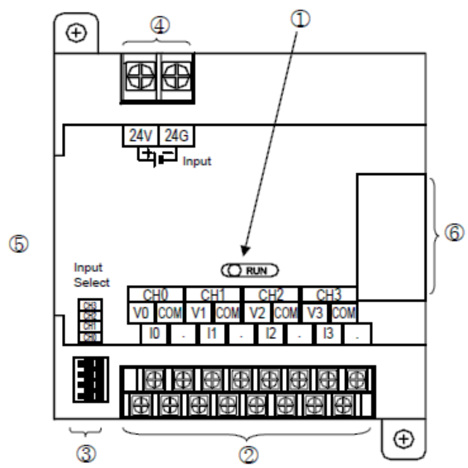
(B) Digital to analog alteration modules (G7F-DA2I)



No.	Names
①	RUN LED
②	D/A Output Channel
③	Expansion Cable
④	Expansion Cable Connecting Terminal
⑤	External Power Supply Terminal (DC24V)

Figure 3.8: The digital to analog modules.

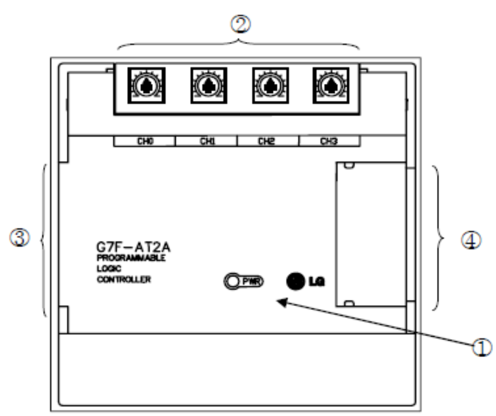
(C) Analog to digital conversion module alteration modules (G7F-AD2A)



No.	Names
①	RUN LED
②	Analog Input Terminal
③	Analog Input (Voltage/current) Selecting Jumper Pin
④	External Power Supply Terminal (DC24V)
⑤	Expansion Cable
⑥	Expansion Cable Connecting Terminal

Figure 3.9: The A-D conversion module

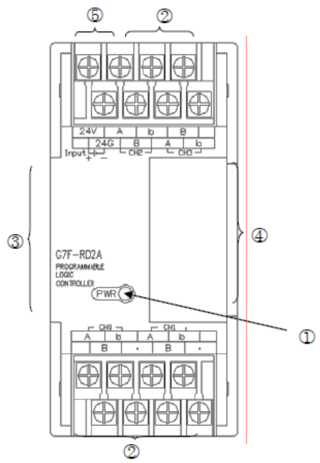
(D) Analog timer unit.



No.	Names
①	RUN LED
②	Analog Timer Volume Control Resistor
③	Expansion Cable
④	Expansion Cable Connecting Terminal

Figure 3.10: The analog timer unit

(E) RTD I/P unit.



No.	Names
①	RUN LED
②	RTD Input Channel
③	Expansion Cable
④	Expansion Cable Connecting Terminal
⑤	External Power Supply Terminal (DC24V)

Figure 3.11: The RTD I/P unit.

3.2.8 Programming Structure

The software package contains entirely of the functional features which wanted to perform a specific control. This program was stored within interior RAM in CPU portion or within EEPROM memories [28]. The task fundamentals are categorized as shown in table 3.5.

Table 3.5: The fundamental of tasks and function elements of programming.

Function elements	Processing Operation
Initialization program	• Executes when the power is applied or the CPU operation is transited to the RUN mode. • Executes the initial/fixes data setting for execution of scan program and the initialization of peripheral devices on special modules.
Scan program	• Processes the constantly repeated signals that are executed every scan.
Time driven task Program	• When the following time conditional processing is required the program is executed complying with the time interval setting. - In case of the processing need a shorter interval than that of average scan processing time. - In case of the processing needs a longer interval than that of average scan processing time. - In case that the processing should be executed by the specified time interval.
Interrupt program	• A fast processing is executed for internal or external interrupt.
HSC interrupt program	• Executes when HSC Comparison Output occurs.

(A) Software package implementation process

Figure 3.11 gives details of the software package implementation process once the voltage was appear or in case the mode setting button on CPU portion within RUN position.

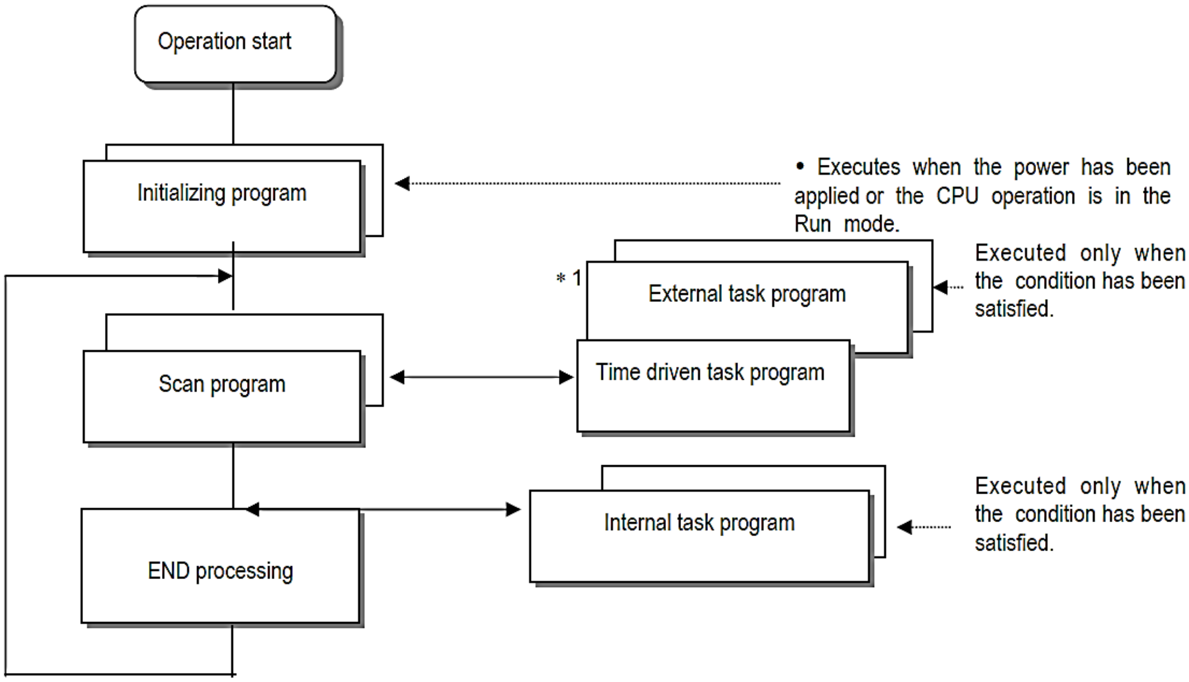


Figure 3.12: The implementation of software package.

3.2.9 Action Styles of Working

A CPU unit works within single from four styles - the "RUN, STOP, PAUSE and DEBUG" style. The subsequent defines the PLC process within every process style.

(A) RUN style

Within that style, programs were usually activated as shown in figure 3.12.

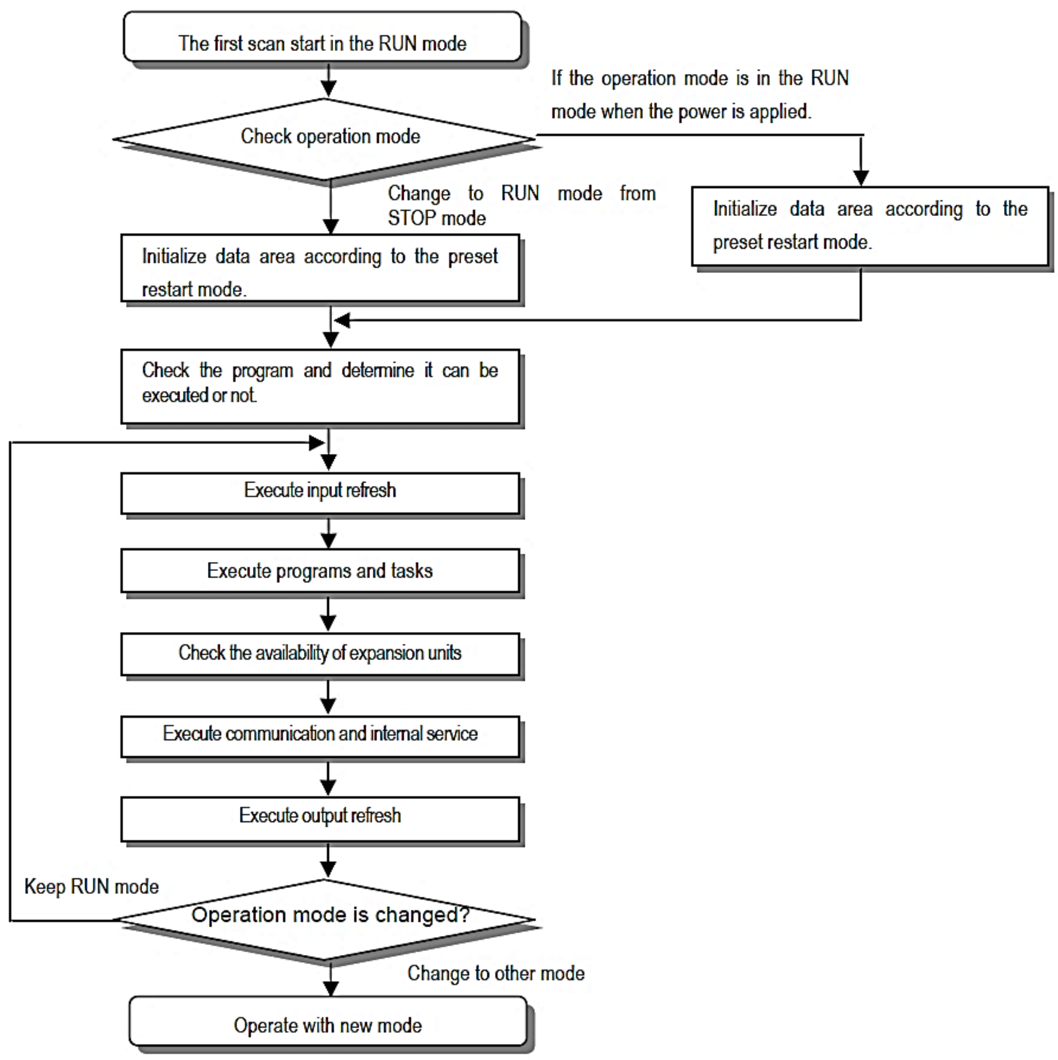


Figure 3.13: The run mode for implementation

(B) STOP style

Within that style, the program was never run.

(C) PAUSE style

Within that style, the programs process was momentarily stopped. When it back towards RUN style, the process remains as of the formal earlier the stop.

(D) DEBUG style

Within that style, mistakes within a software package were investigated with the process order was drawn. Altering to that style was merely probable within STOP style. Within that style, a software package is able to check within the investigation for its implementation formal and insides for every information.

3.2.10 Memories Structure

A central processing unit contains dual kinds of memories which obtainable for users. First types are programmed memories that work to keep a user's program stores to complete a scheme by the users. Second one for data memory. This type keeps information through the process.

1. Program memory structure

The table 3.6 demonstrates the data to that kept with storing size for program memories.

Table 3.6: The types of memory for programing

Item	Memory Capacity
Overall program memory area	132 kbyte
Parameter area • Basic parameter area • High speed link parameter area • interrupt setting information area	7.8 kbyte
Program area • Scan program area • Task program area • User defined function/function block area • Standard library area • Variable initialization information area • Protective variable specification information area	124.2 kbyte

2. Data memory structure

The table 3.7 explains the specification and the size of memory that is used with all details for those types of memory.

Table 3.7: The structure of data memory

Item	Memory Capacity
Overall data memory area	44 kbyte
System area • I/O information table • Force I/O table	1 kbyte
System flag area	2 kbyte
Input image area (%IX)	128 byte
Output image area (%QX)	128 byte
Direct variable area (%M)	10 kbyte
Symbolic variable area	30 kbyte

3.3 NODEMCU8266 FOR COMMUNICATION

3.3.1 General Description

Node-MCU was generated just next ESP-8266 came-out. In Dec. 2013, "Espressif Systems" started manufacture of ESP-8266. ESP-8266 was a Wi-Fi device which integrates through a "Tensilica Xtensa LX106 core". This kit was broadly working within internet of things application. Node-MCU ongoing in Oct 2014, after Hong dedicated the primary folder of Node-MCU firmware to Git-Hub. Double months far along, this development extended to contain open hardware design once designer "Huang, R." Dedicated Gerber folder for the ESP-8266 kit, called "devkit v0. 9". After this time, "Tuan PM" invented MQTT customer library from "Contiki" for the ESP-8266 kit, and dedicated for Node-MCU development. After that Node-MCU is capable to sustenance "MQTT IOT protocol". By use Lua to entree MQTT broker. Additional significant bring up to date is complete in Jan. 2015. This time Devsaurus invented u8glib for Node-MCU development, enable Node-MCU to effortlessly "drive, LCD, Screen, OLED, even VGA displays" [29].

Within 2015 the inventors uncontrolled the firmware development and a collection of self-governing funders took-over. In 2016 Node-MCU comprised over forty dissimilar units. Because of reserve restraints user essential for selecting units pertinent in their scheme and form a firmware custom-made for their wants.

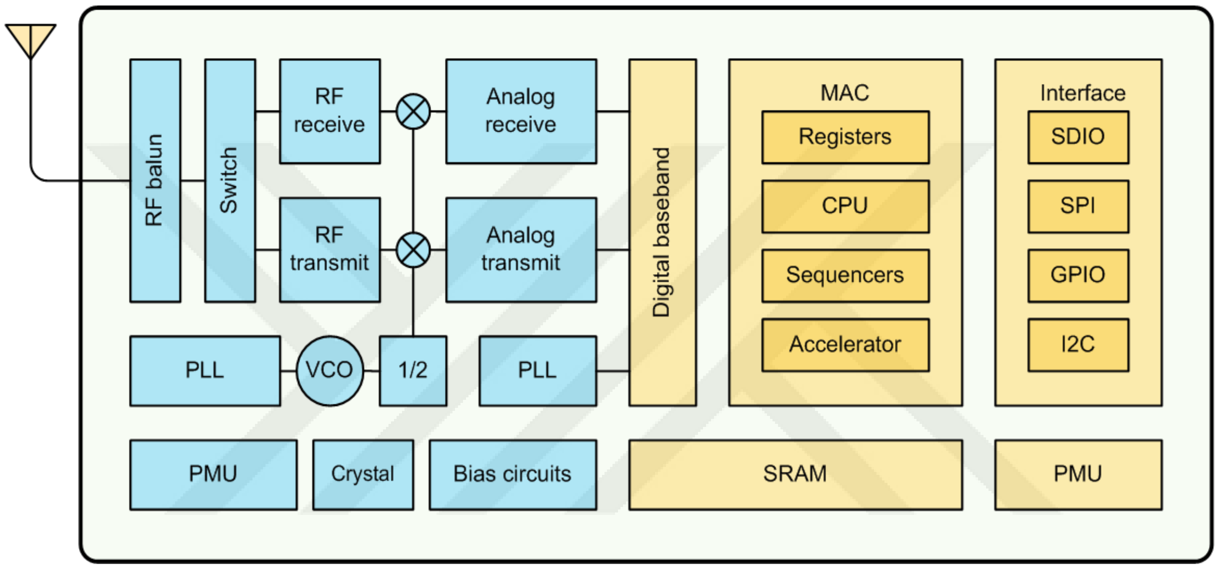
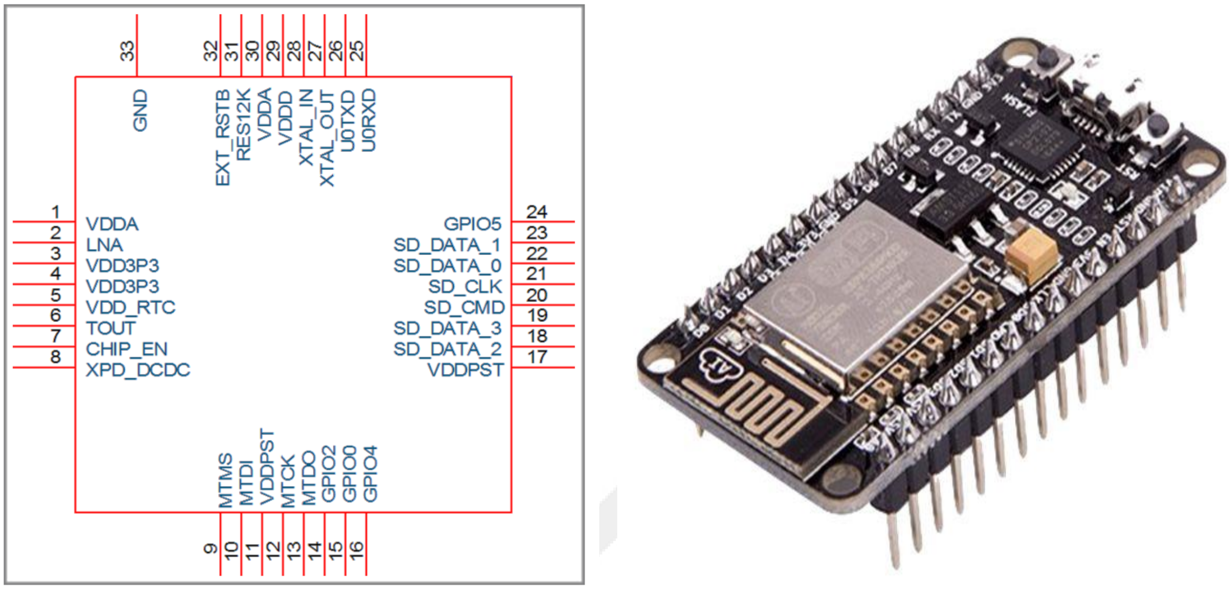


Figure 3.14: ESP8266EX block diagram

3.3.2 Pin Definations

The pin assignment for NodeMCU is illustrated in Fig.3.14



(A) (B)

Figure 3.15: Pins configuration for the NodeMCU

Table 3.8: Pin definitions for NodeMCU

Pin	Name	Type	Function
1	VDDA	P	Analog Power 3.0 ~3.6V
2	LNA	I/O	RF Antenna Interface. Chip Output Impedance=50Ω No matching required but we recommend that the π-type matching network is retained.
3	VDD3P3	P	Amplifier Power 3.0~3.6V
4	VDD3P3	P	Amplifier Power 3.0~3.6V
5	VDD_RTC	P	NC (1.1V)

6	TOUT	I	ADC Pin (note: an internal pin of the chip) can be used to check the power voltage of VDD3P3 (Pin 3 and Pin4) or the input voltage of TOUT (Pin 6). These two functions cannot be used simultaneously.
7	CHIP_EN	I	Chip Enable. High: On, chip works properly; Low: Off, small current
8	XPD_DCDC	I/O	Deep-Sleep Wakeup；GPIO16
9	MTMS	I/O	GPIO14; HSPI_CLK
10	MTDI	I/O	GPIO12; HSPI_MISO
11	VDDPST	P	Digital/IO Power Supply (1.8V~3.3V)
12	MTCK	I/O	GPIO13; HSPI_MOSI; UART0_CTS
13	MTDO	I/O	GPIO15; HSPI_CS; UART0_RTS
14	GPIO2	I/O	UART Tx during flash programming; GPIO2
15	GPIO0	I/O	GPIO0; SPI_CS2
16	GPIO4	I/O	GPIO4
17	VDDPST	P	Digital/IO Power Supply (1.8V~3.3V)
18	SDIO_DATA_2	I/O	Connect to SD_D2 (Series R: 200Ω); SPIHD; HSPIHD; GPIO9
19	SDIO_DATA_3	I/O	Connect to SD_D3 (Series R: 200Ω); SPIWP; HSPIWP; GPIO10
20	SDIO_CMD	I/O	Connect to SD_CMD (Series R: 200Ω); SPI_CS0; GPIO11
21	SDIO_CLK	I/O	Connect to SD_CLK (Series R: 200Ω); SPI_CLK; GPIO6
22	SDIO_DATA_0	I/O	Connect to SD_D0 (Series R: 200Ω); SPI_MSIO; GPIO7
23	SDIO_DATA_1	I/O	Connect to SD_D1 (Series R: 200Ω); SPI_MOSI; GPIO8
24	GPIO5	I/O	GPIO5
25	U0RXD	I/O	UART Rx during flash programming; GPIO3
26	U0TXD	I/O	UART Tx during flash progamming; GPIO1; SPI_CS1
27	XTAL_OUT	I/O	Connect to crystal oscillator output, can be used to provide BT clock input
28	XTAL_IN	I/O	Connect to crystal oscillator input
29	VDDD	P	Analog Power 3.0V~3.6V
30	VDDA	P	Analog Power 3.0V~3.6V
31	RES12K	I	Serial connection with a 12 kΩ resistor and connect to the ground
32	EXT_RSTB	I	External reset signal (Low voltage level: Active)

3.3.3 Features of The NodeMCU Board

The Node-MCU has more than one specification and this can be written as [30]:

- 802.11 b/g/n
- Integrated low power 32-bit MCU
- Integrated 10-bit ADC
- Integrated TCP/IP protocol stack
- Integrated TR switch, balun, LNA, power amplifier and matching network
- Integrated PLL, regulators, and power management units
- Supports antenna diversity
- WiFi 2.4 GHz, support WPA/WPA2
- Support STA/AP/STA+AP operation modes
- Support Smart Link Function for both Android and iOS devices
- SDIO 2.0, (H) SPI, UART, I2C, I2S, IR Remote Control, PWM, GPIO
- STBC, 1x1 MIMO, 2x1 MIMO
- A-MPDU & A-MSDU aggregation & 0.4s guard interval
- Deep sleep power <10uA, Power down leakage current < 5uA
- Wake up and transmit packets in < 2ms
- Standby power consumption of < 1.0mW (DTIM3)
- +20 dBm output power in 802.11b mode
- Operating temperature range -40C ~ 125C
- FCC, CE, TELEC, WiFi Alliance, and SRRC certified

3.3.4 Parameters

The parameters of the NodeMCU board can be divided into three parts which are: The Wi-Fi parameters and hardware parameters and software parameters. And these parameters can be shown in table 3.9

Table 3.9: The three types of NodeMcu parameters

WiFi Paramters	Certificates	FCC/CE/TELEC/SRRC
	WiFi Protocles	802.11 b/g/n
	Frequency Range	2.4G-2.5G (2400M-2483.5M)
	Tx Power	802.11 b: +20 dBm
		802.11 g: +17 dBm
		802.11 n: +14 dBm
	Rx Sensitivity	802.11 b: -91 dbm (11 Mbps)
		802.11 g: -75 dbm (54 Mbps)
		802.11 n: -72 dbm (MCS7)
	Types of Antenna	PCB Trace, External, IPEX Connector, Ceramic Chip
Hardware Paramaters	Peripheral Bus	UART/SDIO/SPI/I2C/I2S/IR Remote Control
		GPIO/PWM
	Operating Voltage	3.0~3.6V
	Operating Current	Average value: 80mA
	Operating Temperature Range	-40°~125°
	Ambient Temperature Range	Normal temperature
	Package Size	5x5mm
	External Interface	N/A
Software Parameters	WiFi mode	station/softAP/SoftAP+station
	Security	WPA/WPA2
	Encryption	WEP/TKIP/AES
	Firmware Upgrade	UART Download / OTA (via network)
	Ssoftware Development	Supports Cloud Server Development / SDK for custom firmware development
	Network Protocols	IPv4, TCP/UDP/HTTP/FTP

3.3.5 Main Applications

There are miscellaneous field that the NodeMCU can do it and can be demonstrated as [31]:

- Home Appliances
- Home Automation
- Smart Plug and lights
- Mesh Network
- Industrial Wireless Control
- Baby Monitors
- IP Cameras
- Sensor Networks
- Wearable Electronics

3.3.6 Power Consumption

The subsequent current ingesting was grounded on 3.3Volt source by means of interior devices. Measurement was complete with probe port deprived of SAW filter. The Total spreader's quantities were depending on "90% duty cycle".

Table 3.10: Description on power consumption

Parameters	Min	Typical	Max	Unit
Tx802.11b, CCK 11Mbps, P OUT=+17dBm		170		mA
Tx 802.11g, OFDM 54Mbps, P OUT =+15dBm		140		mA
Tx 802.11n, MCS7, P OUT =+13dBm		120		mA
Rx 802.11b, 1024 bytes packet length , -80dBm		50		mA
Rx 802.11g, 1024 bytes packet length, -70dBm		56		mA
Rx 802.11n, 1024 bytes packet length, -65dBm		56		mA
Modem-Sleep①		15		mA
Light-Sleep②		0.9		mA
Deep-Sleep③		10		uA
Power Off		0.5		uA

①: Modem-Sleep requires the CPU to be working, as in PWM or I2S applications. According to 802.11 standards (like U-APSD), it saves power to shut down the WiFi Modem circuit while maintaining a WiFi connection with no data transmission. E.g. in DTIM3, to maintain a sleep 300mswake 3ms cycle to receive AP's Beacon packages, the current is about 15mA

②: During Light-Sleep, the CPU may be suspended in applications like WiFi switch. Without data transmission, the WiFi Modem circuit can be turned off and CPU suspended to save power according to the 802.11 standard (U-APSD). E.g. in DTIM3, to maintain a sleep 300ms-wake 3ms cycle to receive AP's Beacon packages, the current is about 0.9mA.

③: Deep-Sleep does not require WiFi connection to be maintained. For application with long time lags between data transmission, e.g. a temperature sensor that checks the temperature every 100s, sleep 300s and waking up to connect to the AP (taking about 0.3~1s), the overall average current is less than 1mA.

3.3.7 Channel Frequencies

The radio frequency transceiver delivers the following channels according to the IEEE802.11b/g/n standards [32].

Table 3.11: The frequency channel for NodeMCU

Channel No	Frequency (MHz)	Channel No	Frequency (MHz)
1	2412	8	2447
2	2417	9	2452
3	2422	10	2457
4	2427	11	2462
5	2432	12	2467
6	2437	13	2472
7	2442	14	2484

4. RESULTS AND DISCUSSION

4.1 GENERAL DESCRIPTION

The term smart factory is the new term in the field of manufacturing and the world of new techniques because this term is begun at the same time when the application of the internet starts to enter in all the field of manufacturing and works at the core of the factories. The researcher, begun to mix between the old procedure of manufacturing in traditional factory with the new techniques which depends on the computer and the internet which make the process of making things more easily. In this thesis the new idea of mixing the smart factory with the idea of the internet of things was mixed that means the smart factory will work automatically without need of a person that monitors the factory or manages the factory. At the same time the owner of the smart factory can monitor and govern all the parts of his factory and know how the factory work also the owner can calculate the production of the factory remotely without the need of attending to the position of his factory.

4.2 THE PROPOSED SMART FACTORY

In this part the demonstration of this proposed idea was done. In the first the reader must know that in this thesis the mixing of IOT principle with the smart factory was done. As shown in figure 1 the two motors or compressor was existing in order to push the product part into a new position for putting the trade mark on the cover of the product or put the expiration date on over the side. Also, there is five sensors (in this thesis the micro-switch was taken). These sensors were put in order to determine the position of the two arms to take the right position for the arm that connected to the motor. These sensors are S (for indicating that there is produced over the sensor S in order to transfer to the next movement. The other sensors s1 and s2, which is a micro - switch, we're putting in this position in order to determine the exact position of the arm for putting the trademark or expiry date over the box of product in the right position. In the first the switch s1 is ON while switch s2 is off position. That position means the arm, which is work for pushing the box to the right position, was in first position or named starting position in order to be ready for the next position. The switch s3 stay in ON position and s4 stay in OFF position.

The sensor C3 (which is the count sensor) is the counter the calculate the amount of the product and send the final number to the owner in order to have a full monitor and control on the factory. Now begun with the next step which depends on the position of arm 1. In this position the arm will be moved to leave. The switch s1 return to OFF position and s2 also stay in the OFF position. The arm continues to move until the switch s2 turn its state to ON position. In this case the arm will suddenly stop and in this case the box of the product will in a position outside the queue of product and be ready. The sensor s3 will stay in ON position and s4 stay in OFF position. In this case the switch S return to OFF position that means the box is moved to a new position and ready to receive the new box product. Now in the third position the arm1 begun to return to the first position to let the arm 2 to begin moving to a new position. In this third position the arm begun to move to the left side and the micro switch s2, return to OFF position until the switch s1 return to ON position. The sensor S return to ON position that indicate the new box production was existing in the right position and ready to push under the arm 2.

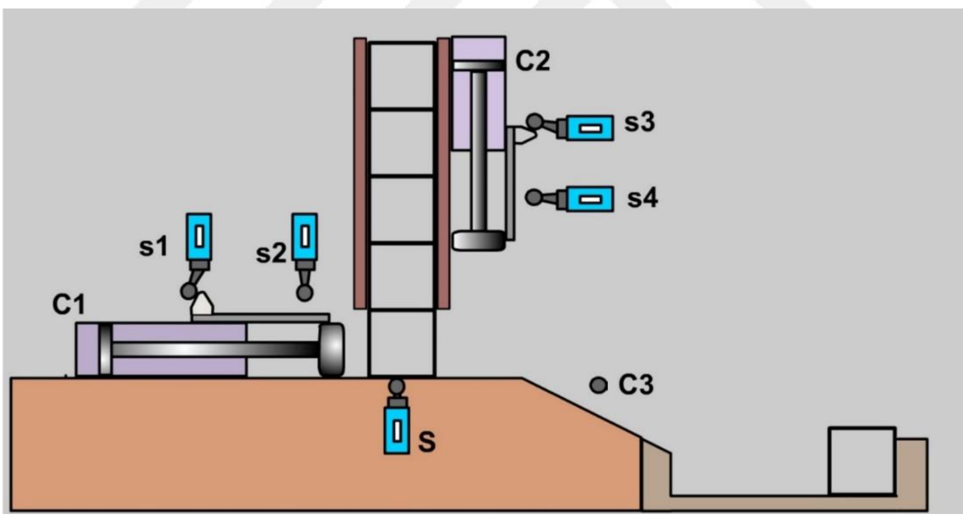


Figure 4.1: The first position of the arm 1 (begun position)

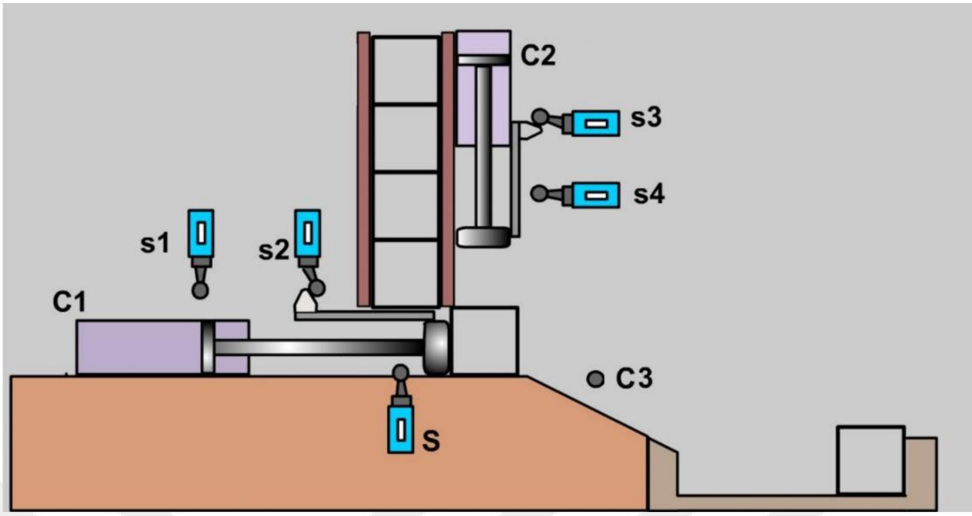


Figure 4.2: The second position of the arm 1.

The fourth position was shown in figure 4.4. In this figure it can be noticed that the arm 1 stayed in the same position and never moved that means the s1 stay ON state and s2 stay on OFF state. The arm 2 changes its state and move from up to down that means the sensor s3 changed his state from ON state to OFF state and the arm continue move to reach the right position then the sensor s4 changed its state from OFF state to ON state. At this moment the arm will stopped and press the box of product and put the trademark or expiry date on a production box.

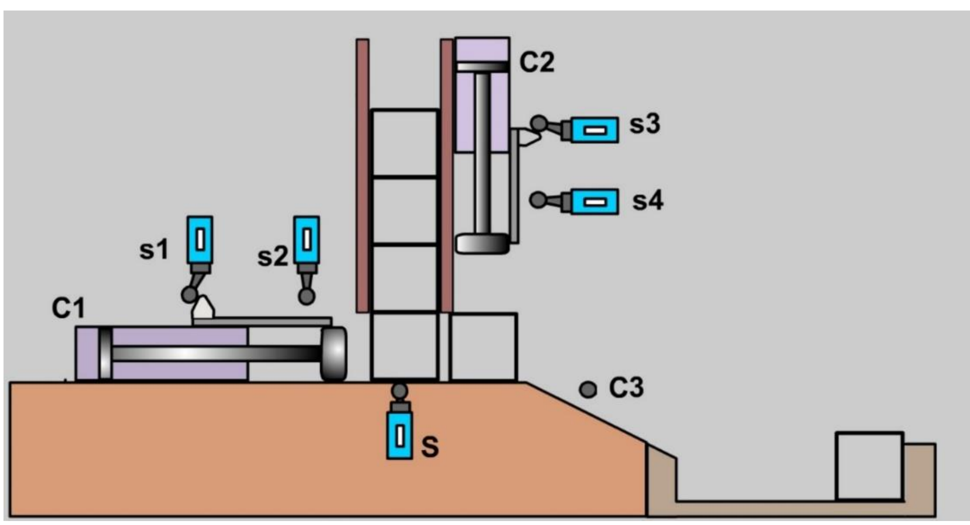


Figure 4.3: The third position of the arm1**.**

After that, the cycle will be returned as in the first position in order to be ready to begin the new cycle (that means the new box enter and take its mark). In this last position the arm 2 will be moved to up (as shown in figure 4.5). In this case the sensor s4 will change its position from ON state to OFF state and the arm will move from down to up state until reaches the desire position, then the sensor s3 will change its position from OFF state to ON state and the arm will be directly stop. In this case the shape of the machine was like the machine in figure 4.1. That means the machine will ready to begin a new cycle of putting the trade mark on the boxes for production. After this cycle the box will be sliding down and pass through the sensor C3 and this lead to increase the amount of counter by one and send this information to the owner.

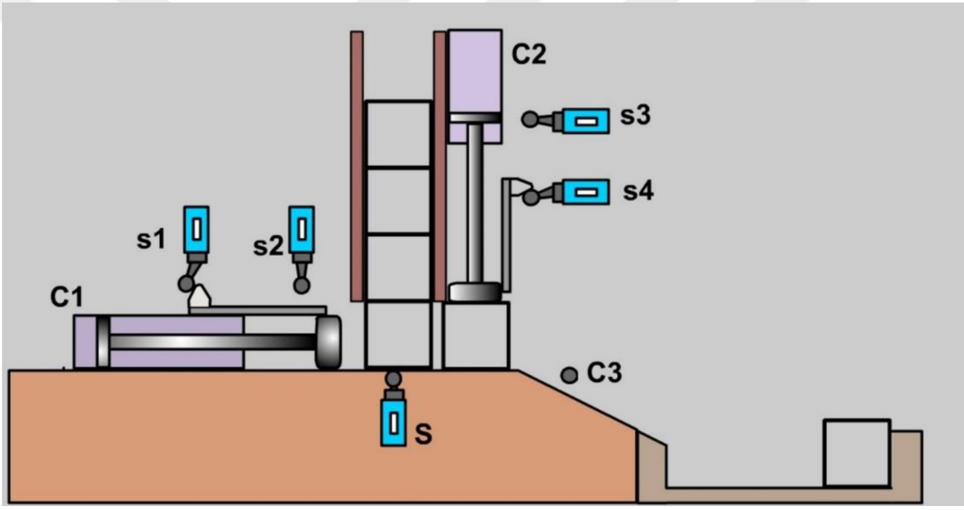


Figure 4.4: The second position of the arm 2.

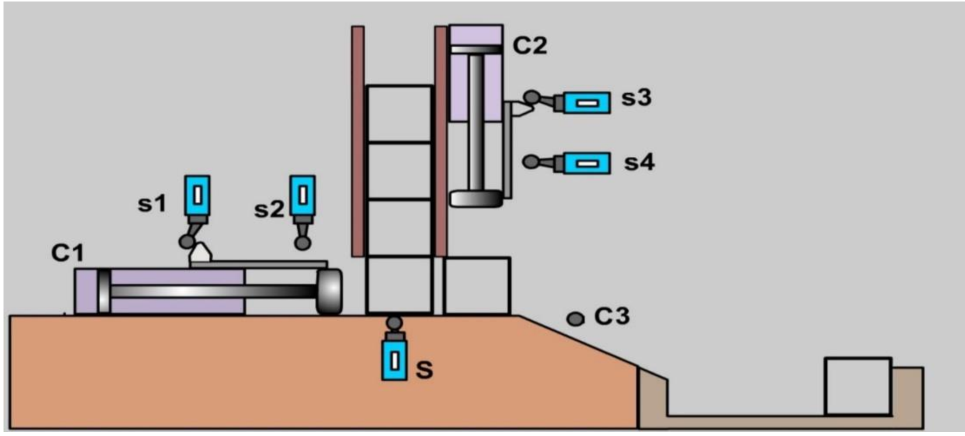


Figure 4.5: The final position of the machine for arm1 and arm 2.

4.3 THE CONNECTION OF PLC WITH SMART FACTORY

The connection of the programmable logic controller (PLC) with the smart factory was shown in figure 4.6. In this figure it can be noticed the symbols S, S1, S2, S3, S4, start and stop switches. These switches are governing the work of the smart factory. It can be shown that these switches are connected to input side and the inputs to these switches are the positive side of the DC power supply while the other side of the switches is connected to the input side of the PLC at the point numbers I00, I01, I02, I03, I04, I05 and I06 respectively. The PLC needed two types of inputs which are D.C. And A.C. The AC was entering to PLC via N and R. Also, it can be noticed that the PLC was connected to the internet of thinks using the NodeMCU board by controlling the start switch of the PLC. That means the starting of the PLC working was controlled by two methods which are manually by pressing stat bottom and the other method using the internet of thing via the NodeMCU board. Also, the IR sensor was connected to NodeMCU that is used to calculate the number of the production boxes when the factory was running.

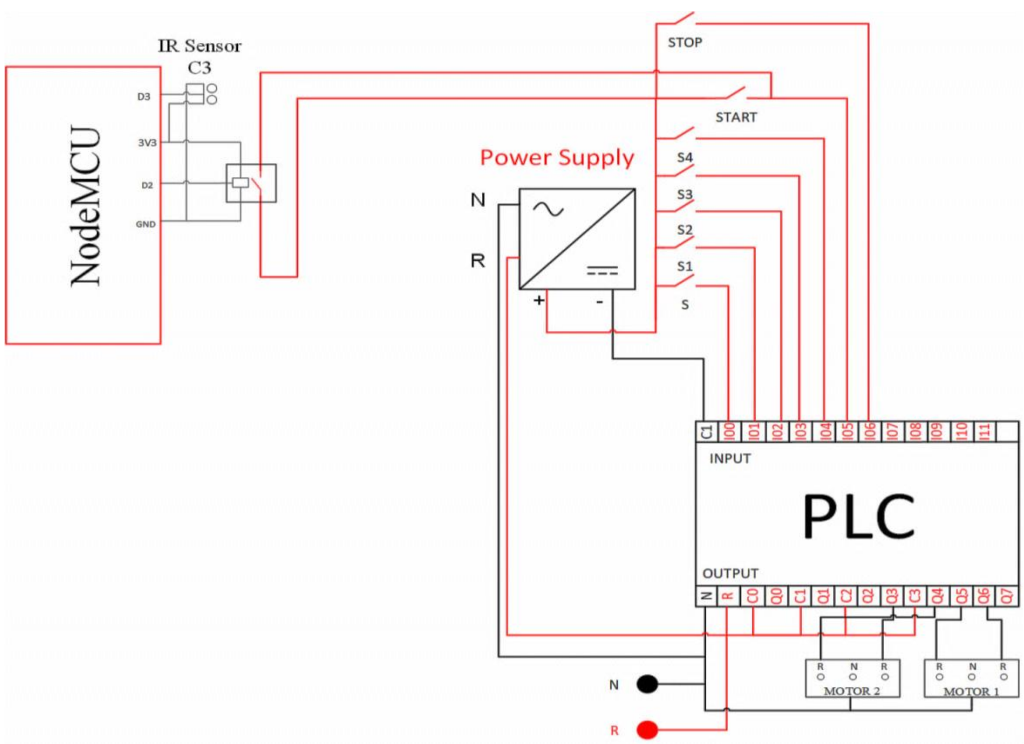
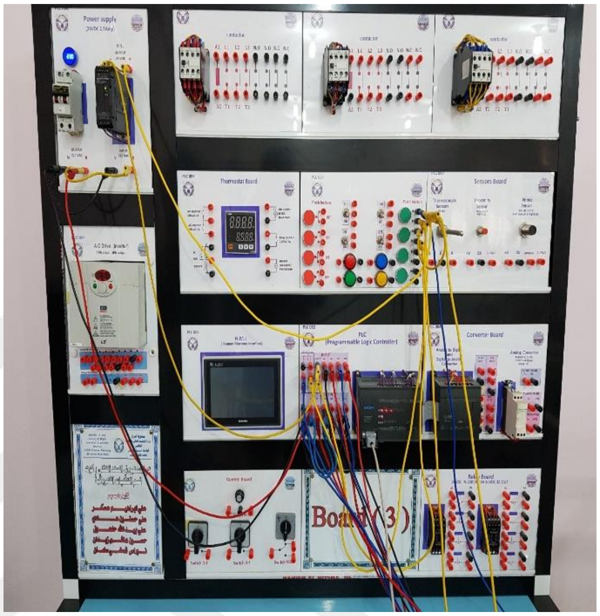


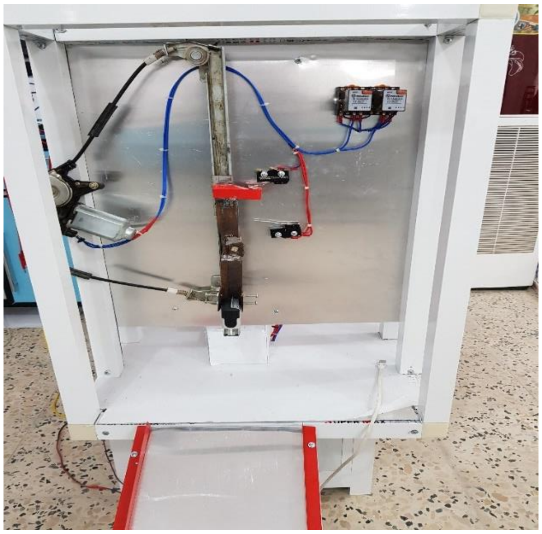
Figure 4.6: The wiring diagram of the PLC with the input and output.

The figure 4.7 (a, b, c and d) demonstrates the real connection of the PLC with the prototype of smart factory that is containing the two motors with sensors for position detection and for counting the product

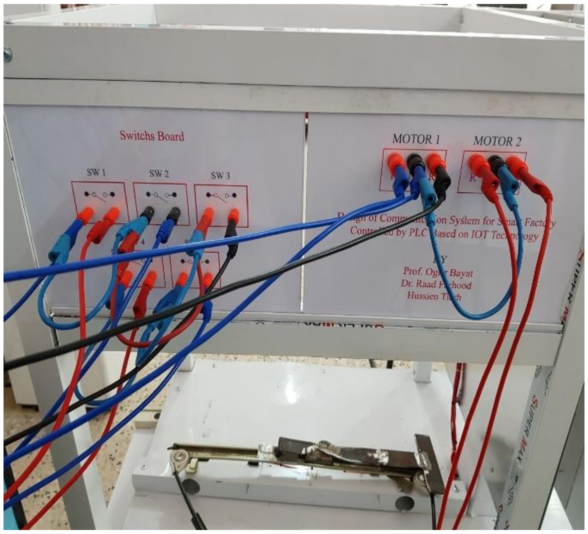
A



B



C



D

Figure 4.7: The practical connection of the smart factory using PLC and NodeMCU

4.4 THE LADDER PROGRAMMING

In this part the discussion of the ladder program is done. All the variable which used in the simulation are demonstrated. Below the variable were defined in the program and can see how they deal with that variable is affected on the run the program. The variable which is used in the program and its notation inside the program are:

MOTOR_OUT === QX0.0.6

MOTOR_IN ===== QX0.0.5

C2_IN ========= QX0.0.3

C2_OUT ======= QX0.0.4

COIL1 ========= Auto

S =========== IX0.0.0

S1 ========== IX0.0.1

S2 ========== IX0.0.2

S3 ========== IX0.0.3

S4 ========== IX0.0.4

START ====== IX0.0.5

STOP ======== IX0.0.7

OFF ========= Auto

The shape of ladder language or the diagram that explain the program (simulation) that govern the process of smart factory that is connected to the internet was shown in figure 4.8. The ladder language which can be drawn in figure 4.8 is divided to six lines and each one is used for special purpose and does the specific job in the smart factory. The first line was used to control the working of the horizontal motor which is used to push the box to the right side in order to prepare the box to be exactly lower the vertical motor. This line is regarded the core of the process overall because it is the first step to begin the work of the PLC. It depends on different factor or switches that must be closed to connect the line of electricity to the horizontal motor like **START** button must be open then changed to close and **OFF** must be closed and so on as shown in figure 4.8. The second line which is used to return the horizontal motor to normal place and move it to the left side and this also depends on some parameter of switches like **S2, S1,** and so on. The third line was used as a counter and auxiliary for preparing to the vertical motor and contain the present value and current value and compare between them and other parameter that assists the vertical motor to do its job. The fourth line is used to move the vertical motor to the down side. This line contains five parameters that control the activity of the motor such as **S1, S, and S4** and so on. When all this parameter is closed, then the motor is down to reach the specific point and the switch S4 is touch and become open then the vertical motor is stopped. The fifth line is used to up the vertical motor to the first or up position and this line depends on six parameters which are S4, S, and S1 and so on as shown in figure 4.8. When the motor begun to up position it continue up until the arm of the motor touch the switch S3 then it became open and the motor stop. The last line or sixth line was used to turn off the PLC and end the process and this line depends on the switch **S** which is related to the boxes in the production line. When the boxes are finished, then the switch **S** becomes OFF or open then this line is open and the PLC will be turned off.

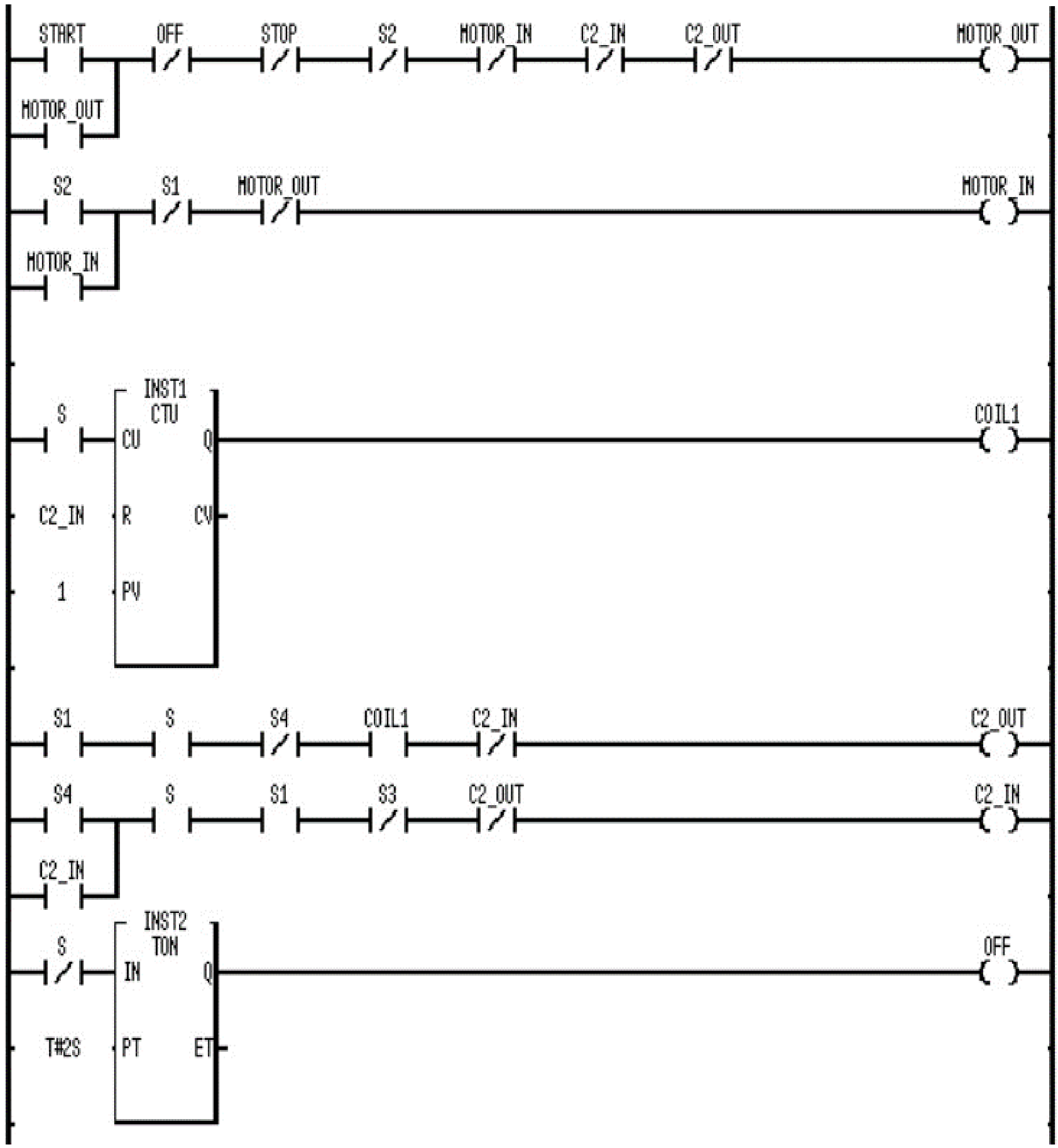
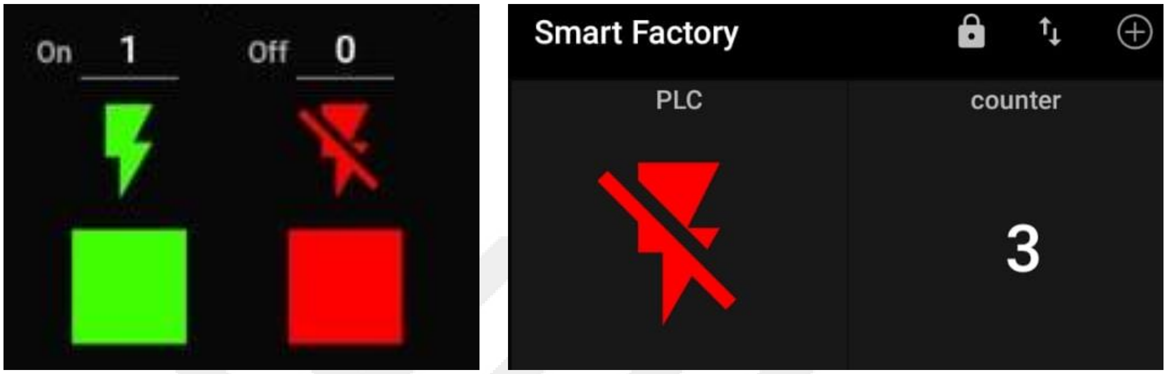


Figure 4.8: The simulation program written in ladder language

4.5 Codes for NodeMCU

In this part the codes for programing the wireless board (NodeMCU board) are written here. This program is saved in the memory of NodeMCU and this program is used to control the running and stopping the work of smart factory and also used to calculate the amount of production for that factory. The shape of the program that is appearing in mobile phones can be shown in figure 4.9. In figure 4.9 as it can be notice how can monitor the activity of rain or stop the PLC that is govern the all process of the smart factory while the figure 4.9 b demonstrate how the counter of production are appearing in the mobile phone.



a b

Figure 4.9: The program for mobile phone for control

This program that is written in NodeMCU is:

```
#include <ESP8266WiFi.h>

#include <PubSubClient.h>

// define NodeMCU D2 pin connect to Piezo Buzzer

#define BUZZER_PIN D2

// Update these with values suitable for your network.

const char* ssid = "******";

Const char* password = "******";

WiFiClient espClient;

PubSubClient client (espClient);

Long lastMsg = 0;

Char msg [50];
```

```
Int value = 0;
Void setup_wifi () {
  Delay (100);
 // we start by connecting to a WiFi network
   Serial.print ("Connecting to ");
   Serial.println (ssid);
   WiFi.begin (ssid, password);
   While (WiFi.status ()! = WL_CONNECTED)
   {
     Delay (500);
     Serial.print (".");
   }
 RandomSeed (micros ());
 Serial.println ("");
 Serial.println ("WiFi connected");
 Serial.println ("IP address: ");
 Serial.println (WiFi.localIP());
}
Void callback (char* topic, byte* payload, unsigned int length)
{
 Serial.print ("Command from MQTT broker is: [");
 Serial.print (topic);
 Int p = (char)payload[]-'0';
```

```
  // if MQTT comes a 0 turn off LED on D2
  If (p==0)
  {
    digitalWrite(BUZZER_PIN, LOW);
    Serial.println(" Turn Off BUZZER! ");
  }
  // if MQTT comes a 1, turn on BUZZER on pin D2
  if(p==1)
  {
    digitalWrite(BUZZER_PIN, HIGH);
    Serial.println(" Turn On BUZZER! ");
  }
  Serial.println();
} //end callback
void reconnect() {
  // Loop until we're reconnected
  while (!client.connected())
  {
    Serial.print("Attempting MQTT connection...");
    // Create a random client ID
    String clientId = "ESP8266Client-";
    clientId += String(random(0xffff), HEX);
    // Attempt to connect
```

```
    //if you MQTT broker has clientID,username and password
    //please change following line to    if (client.connect(clientId,userName,passWord))
    if (client.connect(clientId.c_str()))
    {
      Serial.println("connected");
     //once connected to MQTT broker, subscribe command if any
      client.subscribe("OsoyooCommand");
    } else {
      Serial.print("failed, rc=");
      Serial.print(client.state());
      Serial.println(" try again in 5 seconds");
      // Wait 6 seconds before retrying
      delay(6000);
    }
  }
} //end reconnect()
void setup() {
  Serial.begin(115200);
  setup_wifi();
  client.setServer(mqtt_server, 1883);
    pinMode(BUZZER_PIN, OUTPUT);
  digitalWrite(BUZZER_PIN, LOW);
}
```

```
void loop() {
  if (!client.connected()) {
    reconnect();
  }
  client.setCallback(callback);
  client.loop();
}
```

5. CONCLUSION AND SUGGESTIONS OF FUTURE WORK

5.1 CONCLUSION

Previously, the idea of smart factory was regarded as the dream of manufacturers and owner of factories because the management of the factory has been never an easy thing. Also, the amount of error that may be occurs during the hours of works is very high. Now, and exactly when the principle of smart factory is spread and become more common the management of the factory become easier and the number of workers that exist in the smart factory is near to zero persons. Therefore, the smart factory reduces the effort that the owner gives and reduce the problems that may be occurring during the work and also reduce the risks that may the workers face it. The major benefit from the smart factory was that this era of factories reduces the money spent as salary for workers, especially if we imagine that the number of workers that this factory will reduce. This leads to major and great benefit to the owner of the factory which is the cost of producing. This means that the principle of champion between the different products is very high and the customers will get a good chance to take high quality with lower price products. In this thesis an additional benefit was added to the principle of the smart factory which is the internet of things. This means that the owner can manage his factory remotely without need to come and see his factory and also the owner can know everything about the amount of product that the factory produces and also if the factory faces some problem. Therefore, this facility gives the owner the possibility of turning off his factory before crises occur. Therefore, these additional facilities added more benefit for the owner which is he safe the waste time for monitoring and reduces the cost of product because no need for persons that must exist in factory for monitoring the product and can monitor the factory from any position in the world. Finally, the owner has the major benefit over reduce the effort and money that he makes his factory safer and the thief cannot try to take anything from factory if we added some sensor for movement to detect thief and can call the police without coming to the factory.

5.2 SUGGESTIONS FUTURE WORKS

In order to improve this work, the author suggests some things in order to improve the work to get more benefit which are:

1. Add extra sensors to make the work more accurate
2. In order to make the factory safer suggest adding an IOT camera to take the photo to thief if the problem occurred
3. Changing the design to more line of production at the same time and the compressor will put the label on more than one box at the same time and then increase the productivity and reduce time
4. Add the technique of image processing in order to detect the bad box or Industrial defect and exclusion that box to give highest quality.

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