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AMQP Based Patient Monitoring System

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Abstract -The PMS is based on latest buses connectivity, especially by using the AMQP protocol suite as an internal bus instead of the traditional design like HPIB, Profibus and CAN bus, TCP/IP protocol etc. The AMQP is currently existing efficient protocol so it is good approach to use AMQP suite as internal bus for also reducing the cost effectiveness. The AMQP protocol suite based architecture systems are capable to upgrade the PMS's firmware and software through dedicated AMQP suite via open communication network. The patient monitoring is a very critical monitoring system, it can monitor physiological signals including electrocardiograph (ECG), Respiration Rate, Invasive and Non-Invasive Blood Pressure, Oxygen Saturation in Human Blood (SpO2), Body Temperature and other Gases etc. During patient treatment, the PMS is to monitor continuously vital physiological signs of the patient. It is quite hard job for medical personnel to monitor each patient for 24 hours. In centralized patient monitoring systems all patient monitors connected with a single server based patient monitor system. The use of networks in medical field has become a core component for any hospital system especially regarding critical issues, like data overflow and security issue etc. So introducing different type of networks topology will make the life easier for hospital management. The peer to peer networking is better than client-server topology. Here using p2p topology doctors and other paramedical staff can able view and will receive all physiological measurement sign of patients on his personal tablet computer or in other communication devices like cell phone etc. accessed anywhere from the world.

I. INTRODUCTION OF PATIENT MONITORING SYSTEMS (PMS)

The Patient Monitoring System (PMS) is a very critical monitoring systems, it is used for monitoring physiological signals including Electrocardiograph (ECG), Respiration, Invasive and Non-Invasive Blood Pressure, Oxygen Saturation in Human Blood (SpO2), Body Temperature and other Gases etc. In PMS, the multiple sensor and electrodes is used for receiving physiological signals like as ECG Electrodes, SpO2 Finger Sensor, Blood Pressure Cuff and Temperature Probe to measure the physiological signals. During treatment, it is highly important to continuously monitor the vital physiological signs of the patient. Therefore, patient monitoring systems has always been occupying a very important position in the field of medical devices. The continuous improvement of technologies not only helps us transmit the vital physiological signs to the medical personnel but also simplifies the measurement and as a result raises the monitoring efficiency of patients.

A. Classes Of Patient Monitoring System In Industry

In recent years, the technological improvements pertaining to measurement and information transmission has led to more comprehensive performance and stable quality of the patient monitoring products. In the past, the dominant products manufactured by medical device manufacturers are mainly those for single parameter measurement. Nowadays however, a multi-parameter patient monitor is commonly used. Now in current industry the patient monitoring systems is available in two classes.

1) *Single-Parameters Monitoring Systems:* Single parameters monitoring systems are capable for measuring only single physiological sign. It is quite old technology but nowadays, it is continue to be used in developing countries like in India, Pakistan, Bangladesh, etc. The single parameter monitoring systems is available in very low cost and it is very easy to manufacturer and maintain. The single parameter monitoring system is available for measuring blood pressure of a human body, ECG (Electrocardiograph) monitor, SpO2 (Oxygen Saturation in Blood) monitor etc.
2) *Multi-Parameter Patient Monitoring Systems:* A multi-parameter Patient Monitoring System (PMS) is used for multiple critical physiological signs of the patient to transmit the vital information like Electrocardiograph, Respiration Rate, Blood pressure etc. Therefore, multi parameter PMS has always been occupying a very significant position in the field of medical devices. Due to continuous improvement of technologies in PMS help to put out the vital multiple physiological measurements signs to the medical personnel. The latest PMS simplifies the measurement of physiological sign and increases the monitoring effectiveness. So nowadays PMS is very flexible and it can monitor multiple physiological signals in a single monitoring

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system.

B. Clinical used in hospital

The PMS commonly used in some clinical areas such as Intensive Care Unit (ICU), Critical Care Unit (CCU), operation room and emergency room because, the monitor can provide multiple physiological parameters of the patient to medical personnel.

FIGURE 1.
MULTI PARAMETER PATIENT MONITORING SYSTEM (PMS)

II. OPEN ARCHITECTURE APPROACH IN PATIENT MONITORING SYSTEM (PMS):

Since last couple of decades the engineers and scientist widely used an old traditional bus communication systems in medical industries like HPIB or some serial bus systems like Profibus, CAN bus systems etc. [2] In current age, the technology is evolved especially for open communication source in the medical industry. The trend is developed to switch over to AMQP as an internal bus instead of the traditional design like HPIB, Profibus, CAN bus and TCP/IP. The open architecture approach is increasing popularity in medical industry. Almost medical equipment's entire manufacturer is using latest bus systems for open communication networks interface in medical device manufacturing.5

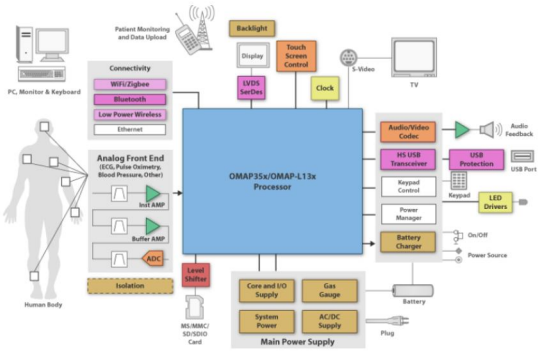

FIGURE 2.
TEXAS INSTRUMENTS INTERNAL CIRCUIT BLOCK DIAGRAM OF PATIENT MONITOR

A. New Adoption Of Buses In Current Industry

Since last 10 years, the adoption of latest buses was very slow in industry as compare to traditional bus system. Universal Serial Bus (USB) is used in large scale. Universal Serial Bus (USB) used as standard interface bus for test and measurement application in the industry. However, as we know the technology is increased and evolved day by day so it is quite good opportunity to use those kinds of devices, which support the future buses and it could be used as for instrument test and measurement control applications for longer period. The new technology in bus systems of hardware is quite a good reason for using GPIB (General Purpose Interface Bus) in current industry as a bus for instrument control and for network connectivity. The GPIB is designed for instrument control and hopefully it will continue for many years for testing and measurement application in industry. As for patient monitoring industry, the large number of old patient monitoring system having traditional buses system. Therefore, the manufacturer like

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National Instrument is offering the bridge products and with the help of GPIB, the users are able to connect the latest bus system with the old bus technology systems. The bridge products, offered to the user, can easily connect latest technology buses in old systems after that the instrument are able for plug and play capabilities, availability of a new bus technology and it is also used for controlling the equipment for test and measurement system in the industry. These bridge products help to connect the old patient monitoring systems to the current hospital network system. There are some bridge products which is available in industry for test and measurement of the equipments.

1) *GPIB (General Purpose Interface Bus) External Controller:* Characteristics of General Purpose Interface Bus:
a) Compatible software for Windows
b) GPIB control from RS232, RS422, RS485, and latest bus port Universal Serial Bus (USB).
c) Industrial standard NI 488.2 for software reduces development time.

2) *Hi-speed usb to gpib controller:* Characteristics of USB to GPIB Controller:
a) The transfer rates up to around 1.8 Mb/Sec.
b) Hi-Speed USB compatible with USB 1.x.
c) No requirement for GPIB cable for connection of instruments and plug-and-play property is available.
d) Windows, Mac OS X complete compatibility.

B. Flexible Software Approach In Open Architecture System:

The software compatibility is always a key issue in industry especially when introducing latest buses in device manufacturing industry. In medical industry, multi vendors interface system approach is increasingly popular in current days. The software are maintaining the new buses compatibility as well as old buses compatibility, so far as concern to medical industry, it is quite better thinking for using industry standard software in medical device manufacturing. Currently such standards offered by Interchangeable Virtual Instrument (IVI) Foundation and Virtual Instrument Software Architecture (VISA). The Interchangeable Virtual Instrument (IVI) foundation was developed in 2001. They offered a membership to vendors for software, hardware, instruments and multi system suppliers for common compatibility level. So now in industry most of vendors use Interchangeable Virtual Instrument (IVI) Foundation and VISA for helping to prevent software investment of end user especially when user migrated towards the new buses system compatibility.

The main purpose of software standardization is to maintain the product presence and availability as long as possible. The main goal of software standardization is:

1) Easy use of device with optimal performance.
2) Increase and maintain long term compatibility of multiple vendors' devices.
3) Software support for open architecture system for multiple vendors.
4) Reuse for old and new software with multiple vendors.
5) Provide surety of system software standards.

III. STATE OF PATIENT MONITORING SYSTEM (PMS) IN CURRENT INDUSTRY

In terms of functionality, the Patient Monitoring System (PMS) made up by the following modules.

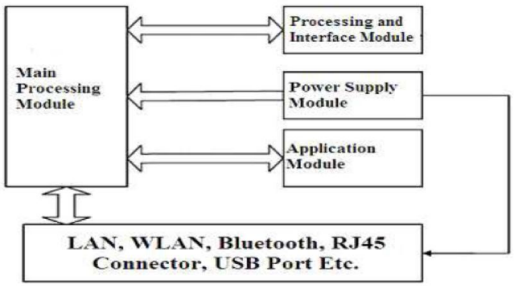

FIGURE 3. SCHEMATIC DIAGRAM OF PATIENT MONITORING SYSTEM (PMS).

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A. *Application module*

The Application parameters module of Patient Monitoring System (PMS) is made up by following physiological measurements.[3]

1) *Electro Cardio Graph (ECG) Module:* Electrocardiography (ECG) is a non-invasive technique based on interpretation of the electrical activity of the heart over time. These signals or activities recorded by using skin electrodes, which is known as ECG Cable lead for PMS. The ECG module in PMS has three or five leads. Theses three or five electrodes leads arranged in standard configurations are placed on the skin to sense the physiological signals. Two methods is available for selection of ECG cable lead, the one of European style lead configuration and the other is American style lead configuration. In PMS leads are differentiate by means of colors of the wires and each leads will differ from others as shown in below.

Monitoring cable connections		
Europe	**Position**	**U.S.A.**
Red	Right Arm(RA)	Black
Yellow	Left Arm(LA)	Red
Green	Left Leg(LL)	Green
Black	Right Leg(RL)	Brown
White		

FIGURE 4.
ALL REFERENCES ARE FROM EUROPEAN
INTERNATIONAL ELECTRO-TECHNICAL COMMISSION (IEC) CABLE COLORS.

In PMS, the two electrodes are required for getting an ECG signals and using third electrode for as a reference to eliminate the electrical interference or noise.

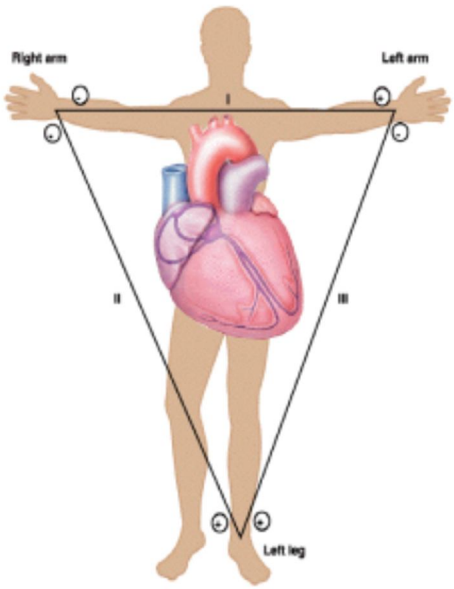

FIGURE 5.
STANDARD LEADS CONFIGURATION OF PATIENT MONITORING SYSTEM (PMS).

The ECG module of PMS gets small voltages around about 1mV that normally appears on the skin that may helps to monitor the cardiac activity in human body. The signals from the different leads provide helps to cardiologist for diagnosing with a complete

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representation of the electrical activity of the heart, including the heart rate (HR), which interpreted as the R-to-R Interval.

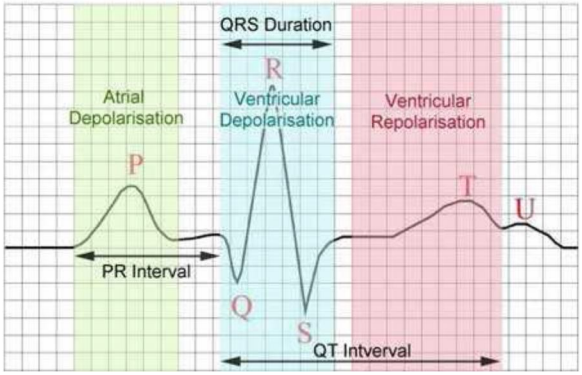

FIGURE 6. GRAPHICAL REPRESENTATION OF ELECTROCARDIOGRAPH SIGNALS.

The main functions shown in below is fulfilling concerning ECG task in multi parameter Patient Monitoring System (PMS).
The PMS having electrocardiograph leads (3 or 5).
The ECG module of PMS should be monitor seven electrocardiograph channels leads by using five leads cable.
Standard lead method: I, II, III, AVR, AVL, AVF, V.
Based on right-leg drives circuit.
PMS should have lead-off detection circuit.
The PMS have dual-channel ECG amplification, simultaneously processing ECG signals of any two. The ECG circuit is responsible for processing the ECG signals of human body.

a) *Input Circuit:* The ECG electrodes connected into the circuit through the cables. This circuit is mainly used to protect ECG input phase, filter the signals to remove the outside interface noisy signals.
b) *Buffer Amplifying Circuit:* This circuit is to converting the impedance of ECG signals, so it should be ensure that the ECG signals has very high input impedance and very low output impedance.
c) *Right-Leg Drive Circuit:* The middle output point of the buffer amplifying circuit reversely amplified and then fed to the Right Leg (RL) of the 3-lead ECG to maintain the human body is an equal-potential state. This method can reduce the interference and raise the common-mode rejection ratio of the circuit.
d) *Lead Connection Circuit:* This circuit can connect different lead electrodes into the main amplifying circuit for amplification. This module also recognized the information of missing electrodes if the interface b/w patient and ECG lead get error in connection.
e) *Amplifying Circuit And Processing Circuit:* A measurement amplifier constructed by three standard operation amplifiers. Next phase of processing circuit is used mainly to couple ECG signals, program-control the magnitude of the gain, filter the waveform and move the level, amplify the signal and send it to the Analogue-to-Digital converter for further displaying.

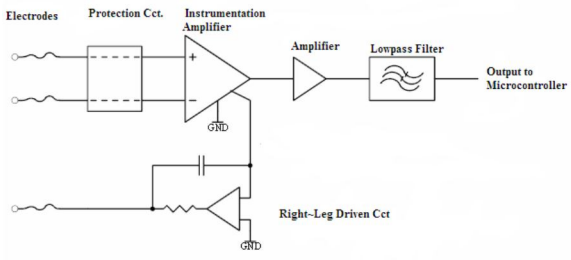

FIGURE 7.
AMPLIFYING CIRCUIT BLOCK DIAGRAM OF ECG PROCESSING CIRCUIT.

2) *Respiration rate module:* During respirations, a person chest goes up and down. This movement equals to the impedance changes between electrodes of Right Arm (RA) and Left Arm (LA) leads.

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Volume 3 Issue III, March 2015
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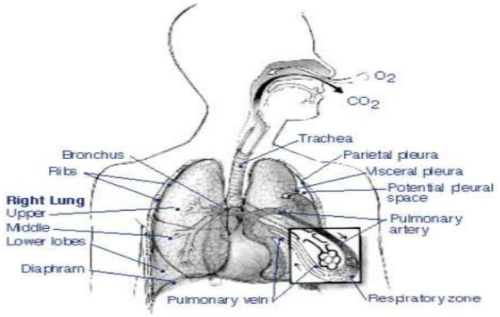

FIGURE 8. RESPIRATION SYSTEM OF A HUMAN BODY.

Respiration module made up of a respiration circuit board and a coupling transformer. The circuit includes such parts as oscillation, coupling, demodulation, preliminary amplification, and high gain amplification etc. The respiration module converts the high-frequency signals passing through Right Arm and Left Arm into amplitude modulated high frequency signals, which demodulated and amplified into electric signals varying with the respiration changes and then transmitted to Analogue-to-Digital converter.

3) *Non-Invasive Blood Pressure (Nibp) Module:* Blood pressure monitors measure arterial pressure, which is produced by the contractions of the heart and constantly changes over the course of cardiac cycle in a human body.

Three blood pressure values calculated in PMS are as follows.

The systolic pressure is the maximum cycle pressure in which when ventricular contraction is occur.

The diastolic pressure is the minimum cycle pressure, occurring during the ventricle's filling stage between contractions.

The means arterial pressure is the mean value of the blood pressure over the cardiac cycle.

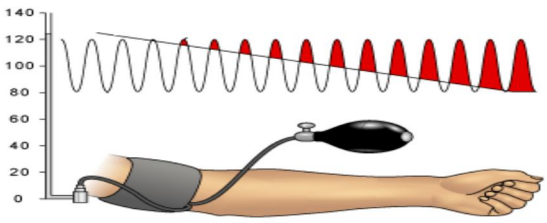

FIGURE 9. (NIBP) NON-INVASIVE BLOOD PRESSURE APPARATUS.

Nowadays a method is used to calculate or monitor non-invasive blood pressure by using the oscillometric method.

a) *Oscillometric Method*: In this method, inflate the cuff surrounded the upper arm until the pressure in the cuff block the blood flow in the artery of the upper arm. Then deflate the cuff gradually according to the requirement of certain arithmetic. With the decrease of the pressure in the cuff, the artery blood will beat with the pulse, which results in palpitation in the cuff. Through the pressure sensor connected with the inflating pipe of the cuff, a palpitation signal palpitating with the pulse will generated. After filtered by a high-pass filter about 1Hz, this signal becomes pulsating signal and amplified. Then the amplified signal converted into digital signal by Analogue-to-Digital converter. After using digital signal, we may obtain systolic, diastolic and mean pressure of human body.

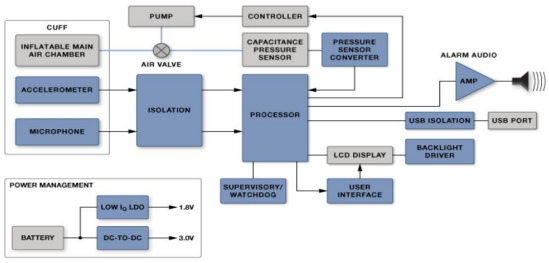

FIGURE 10. CIRCUIT BLOCK DIAGRAM OF NIBP MODULE.

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Volume 3 Issue III, March 2015
ISSN: 2321-9653
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4) *Invasive Blood Pressure (IBP) Module:* Invasive Blood Pressure (IBP) can monitor Arterial Blood Pressure (ABP), Central Venous Pressure (CVP) and Pulmonary Arterial Pressure (PAP). The IBP method is established and implants the catheter into blood vessel of part to be measure in human body. A Catheter's port connects outside of body directly with pressure transducer. Inject saline into catheter because the liquid can transfer pressure, so the blood pressure inside blood vessel can transfer to exterior pressure transducer via inner catheter liquid. A pressure transducer connected to the catheter converts the mechanical force exerted by the blood into an electrical signal, which displayed graphically as pressure versus time on a monitor screen. Therefore, through specified calculation method, we can achieve systolic, diastolic, mean arterial pressure from a person via IBP method.

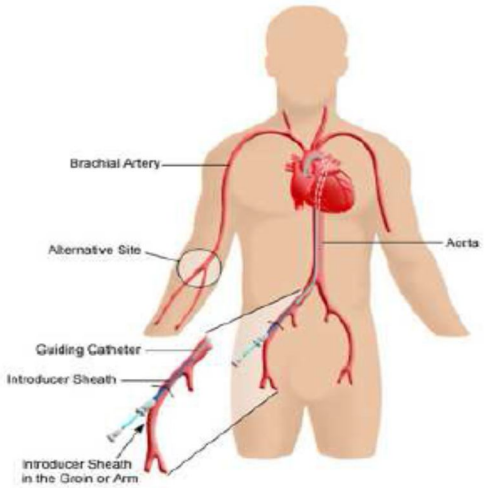

FIGURE 11. SCHEMATIC DIAGRAM FOR USING CATHETER IN BLOOD CIRCULATORY SYSTEM.

5) *Oxygen Saturation In Blood (Spo2) Module:* Oxygen Saturation in a Blood (SpO2) calculation method is based on the absorption of blood oxygen into red and infrared light by means of finger sensor and (SpO2) measuring unit. The light-electronic transducer is used to measure the blood oxygen. [4]

FIGURE 12. SPO2 DEVICE FOR MEASURING OXYGEN SATURATION IN BLOOD.

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a) *Spo2 Sensor:* The SpO2 sensor consists of two LED and a photo detector. The two LED are respectively red diode and infrared diode, which lighted on according to certain time sequence. When the capillary vessel of the fingertip congests or fill up repeatedly, the light of the LED are absorbed by blood vessels and then projected onto the photo-detector. The photo-detector can detect the light intensity varying with pulse changes and display the changing light intensity in the form of changing electronic signals. The ratio between the DC and AC of the two types of signals for light is the require percentage (percentage) of oxygen in the blood. Then we can calculate correct SpO2 value by using specified arithmetic and calculate pulse rate according to the SpO2 waveform.

The SpO2 module mainly consists of following parts.

Sensor.

Signal processing.

Control unit of LED driving sequence.

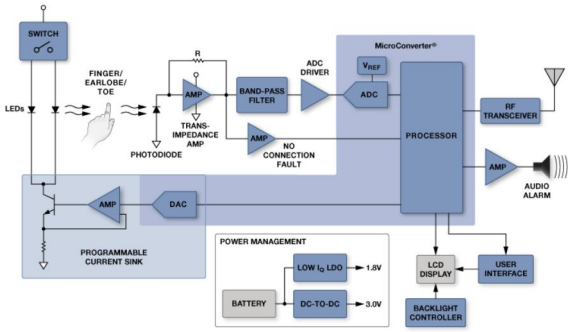

FIGURE 13. SPO2 BLOCK DIAGRAM WITH SENSOR CIRCUIT FOR MEASURING OXYGEN SATURATION IN BLOOD. [5]

6) *Temperature module:*

Body temperature is measured by means of a thermistor probe.

FIGURE 14 TEMPERATURE PROBE FOR PATIENT MONITORING SYSTEM. [6]

7) *Carbon Monoxide (Co) Measuring Module:* In patient monitoring system, the method is used for measuring of CO is by the Thermal dilution method. In this method, insert the catheter into the pulmonary artery by passing the right atrium. Then we use catheter to inject saline liquid into the right atrium, a temperature sensor installed at the front side of the catheter. When the cold liquid of normal saline mix-up with the blood, temperature will change and the mix-up liquid enters the pulmonary artery. Then temperature sensor can detect the change in temperature. The time of infusing normal saline and temperature changes after mixing up, the CO monitoring system can calculate CO and cardiac stroke index of both left and right ventricles, and resistance in pulmonary blood vessels etc.

8) *Carbon dioxide module (co2) measuring module:* The measure of CO2 is based on infrared absorption and characteristic of CO2 molecules. These molecules can absorb infrared rays. The absorption intensity is proportional to CO2 concentration of patient sample, the CO2 concentration will compute from the detecting CO2 absorption intensity of patient sample. The relation between partial pressure and percentage of CO2 concentration given below:

P (mmHg) = Percentage (%) × (pressure)

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9) *Gas Measuring Module:*Concentration of GAS (Anesthetic gas) is measured by its characteristic of absorbing infrared rays. All of the anesthetics gases have their own absorption characteristics. For measuring gases, use optic infrared filter and selects the infrared rays with special wavelength to penetrate this gas. For a given volume, the higher gas concentrations of the infrared rays are absorbed. It means the higher the concentration of the absorbed infrared gas is the fewer infrared rays penetrated the gas. First measure the quantity of infrared rays that have penetrated the gas and then calculate the gas concentration via specialized formula. For measuring oxygen (O2) we apply galvanic oxygen sensor. Through the oxidation and de-oxidation reaction, the sensor can produce current, so we can measure the current to calculate the oxygen (O2).

B. Central processing and interface module:

In PMS, the central processing module has interface board and central processing module. The central processing module has a system memory, display, network circuit, I/O interface and USB.

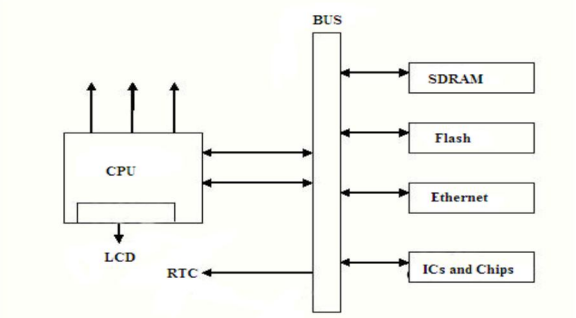

FIGURE 15. INTERNAL CONNECTION B/W BUSES AND MODULES.

1) *Central Processing Unit (CPU):* Central Processing Unit (CPU) is the core part of the main board. CPU connects with other periphery modules via bus and I/O cables. It can realize data communication, data processing, logical control and other functions. The CPU system is equipped with speaker (it is using for heart beat sound), data recorder and printer, real time clock and keyboard etc.

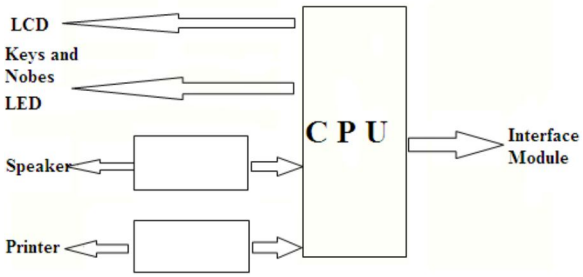

FIGURE 16. BLOCK DIAGARAM OF CENTRAL PRCESSING UNIT OF PATIENT MONITORING SYSTEM (PMS).

2) *Ethernet Network Controller Module:* Ethernet controller was developed in 1972. After the long time being researched, the Ethernet technology has been evolved and getting more matured in the field of communication networking. Ethernet is a set of frames, which based on networks technology for Local Area Networks (LAN). It is used for common addressing for cabling and signaling to Physical Layer by means of network access at the Data Link layer in the Open System Interconnection Reference Model (OSI) model. Ethernet controller is used for very quick data communication transferring in local area networks and it has proved itself as a relatively inexpensive. Ethernet controller attachment in medical devices is to link all kind of medical equipments via Ethernet LAN. Nowadays 10 Mbps and 100 Mbps standard controllers becomes more widely used in medical industry. In PMS, Ethernet controller of 10 Mbps, 100 Mbps and 1000 Mbps are commonly used by manufacturers.

a) *Standards:* In medical industries, the standards of Ethernet devices are as same as for computer networks. Ethernet technology was standardized by the standard committee of Local Area Networks (LAN). The Institute of Electrical and Electronics Engineers (IEEE) was first published in 1985, with the title of IEEE 802.3 then after that, the International Organization has adopted standard for Standardization (ISO). Now IEEE 802.3 standard used as worldwide networking standard. In patient

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monitor, Ethernet controller 10 Mbps, 100 Mbps and 1000 Mbps supports and fulfils the standards requirements of IEEE 802.3, IEEE 802.3u and IEEE 802.3z.

b) *Ethernet on open system interconnection (osi) module:* Ethernet operates on physical and data link layer of Open System Interconnection Reference Model (OSI) module. Ethernet technology supports all higher level of protocol and all popular networks like TCP/IP , AMQP etc.

The relationship between OSI model reference and physical and data link layers of Ethernet.

The relationship is define in IEEE 802.3 is below picture.

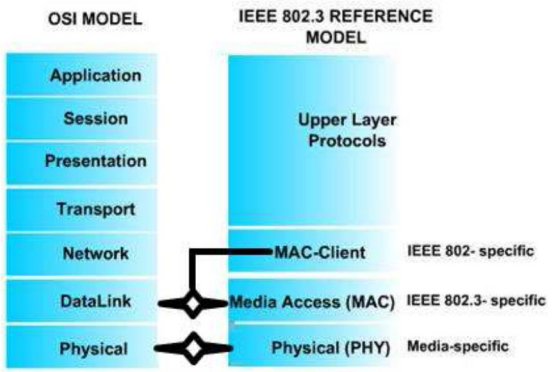

FIGURE 17. RELATIONSHIP TO THE OSI REFERENCE MODEL.

c) *Ethernet on physical layer:*Physical layer is the 1st layer of OSI model and it defines the physical connection of networks. This layer helps to send data over networks by means of interfaces between devices and networks application. It also defines the electrical, mechanical and optical characteristics of the system.

d) *Physical signaling sub-layer:* The physical layer interface with the Medium Access Control (MAC) in the Open System Interconnection architecture (OSI) and it is a part of the data link layer. The physical signaling layer performs data reception, character encoding/decoding and transmission.

e) *Ethernet on data link layer:* Data link layer is the 2nd layer OSI model and it is define the procedure of communication links and frames packets and also help to detects the correctness and transmit errors of the data or frame. The OSI data link layer is divided into two sub layers as regarding of IEEE- 802.3 protocols.

f) *Media access control (mac) sub layer:* The Media Access Control (MAC) Sub layer controls the nodes of the network. The only requirement for basic communication between two nodes of network is only for the MAC area and it supports the same rate of transmission without any help of extra communication protocols. The Media Access Control (MAC) sub layer has two basic functions: Data encapsulation with frame packets before transmission and give frame error detection during sending and after reception of the frame. Media Access Control (MAC) including start of frame transmission and recovery from transmission failure. In IEEE 802.3, the physical layer has a specific data transmission rate, signal encoding and the media for connecting of two nodes.

g) *Mac-client sub layer:* The MAC-client sub-layer focusing on Logical Link Control (LLC). This layer providing the interface between Ethernet Media Access Control and the upper layers in the protocol stack of the end network station. The Logical Link Control (LLC) sub layer is defined in IEEE 802.2 standards. The Media Access Control MAC client sub layer may fulfill one of the following requirements

A layer which provides the interface between the MAC address of Ethernet and the upper layers in the protocol of stack end network station. That is called Logic Link Layer (LLC).

If the network unit is Data Communication Equipment (DCE) then bridge entities present interface of LAN to LAN interface and it also same as for different protocol.

IEEE 802.3 Standards Local Area Network (LAN) Protocols: Local Area Network (LAN) protocols standardized by IEEE 802.3, which is based on two

3) *Working modes:*

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a) *Half Duplex Mode:* In a half-duplex system, the communication of data transmitted in both sides. The only one side transmit the data at a time, like receiver is waiting until for other transmitter stop transmitting before reply. In this mode, data can transfer using CSMA/CD (Carrier Sense Multiple Access /Collision Detection) protocol on a shared medium.

b) *Carrier Senses Multiple Access With Collision Detection Protocol:* Carrier Sense Multiple Access with Collision Detection protocols does the following important things: If we want to transmit the data at any time there is no notion for time slots. Ethernet controller never transmits the same data frame if it senses that other controller already transmitted the same data frame. A transmitting controller aborts its transmission as soon as it detects that another adapter already transmits the same data frame. For attempting to retransmission adapter controller wait for very small time as compared to transmitting the frame again. In system network each Ethernet equipped devices can operate alone for all stations. The Ethernet devices are connected to a shared signaling system, which is used as a network medium for transmit the data frame onto network station. The signaling system has an ability to check the channel if channel is ready to send or receive data, then network station sends the data frame in form of a frame or packet. After each frame delivered on the channel, the network device must compete equally for the next frame send opportunity. The shared channel is determined by the Medium Access Control (MAC) which is implanted in the Ethernet interface at each station. This Medium Access Control mechanism is based on CSMA/CD (Carrier Sense Multiple Access with Collision Detection) protocol. When the Ethernet controller sends the data frames onto the shared signal network channel, all Ethernet interfaces links look for the targeted address. If the targeted address of the frames matches with the Ethernet controller interface address, the frame is read the complete frames and delivered to the networks server software, which is running on the server system. During this moment, all other network system interfaces will stop to sense the frame when they find out that the targeted address does not match their own address.

c) *Full duplex ethernet for fast data transmission:* A full duplex or double duplex system allows networks to communicate in both directions at the same time. In this operation, the Media Access Control (MAC) has an optional capability for allowing data in two-way direction over point-to-point links. Full duplex transmission is very simple and it has many benefits for using full duplex technology in new Ethernet systems.

Time secure as compare to half wave duplex.

No need for retransmitting the frame.

No collisions occur.

Full data capacity is available in both directions of network link.

Network station does not have to wait for other stations before transmitting the data.

The data transmission usually starts when frames are ready to send. There is only one restriction, it must be a minimum inter frame gap between two successive frames, and each frame must fulfill Ethernet frame format standards.33

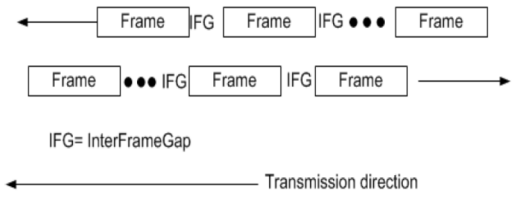

FIGURE 18.TWO WAY DATA TRANSMISSION ON THE SAME LINK.

C. Power supply module:

The power supply module converts the AC voltage main near around 220-230V into +5v and +12V and -12V to other internal modules of patient monitor. If main AC power supplies cutoff the system should automatically run on a reserved battery. The system should have a battery backup for continuous patient monitoring against power failures or power breakdowns. According to medical standards in a patient monitor system the rechargeable backup battery has a backup of at least l4 hours.

D. Block diagram of state of patient monitoring system (PMS):

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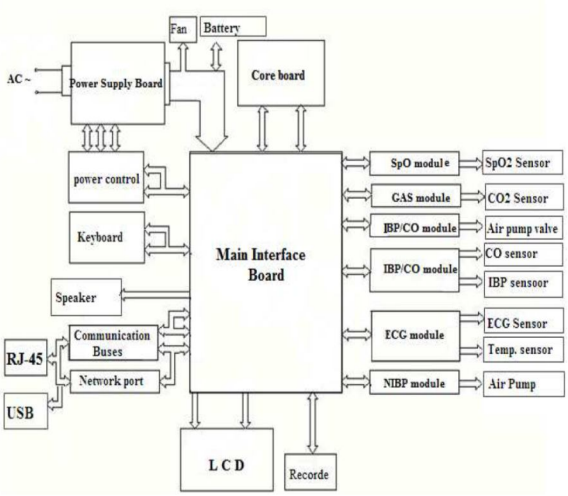

FIGURE 19.
BLOCK DIAGRAM OF STATE OF THE ART PATIENT MONITORING SYSTEM (PMS).

IV. CENTRAL PATIENT MONITORING SYSTEM (CMS)

Multi-Parameter Central Monitoring System (CMS) is a kind of medical information equipment widely applied in clinical monitoring field. This system consists generally of CMS software and a high performance computer. It constructs a monitoring network system by connecting multiple bedside monitors.

The Central Monitoring System (CMS) is controlled on a desktop PC which is equipped with latest connectivity and buses system. It should perform the following things:
The system should have a capability of real time monitoring of at least 16 or 24 patient at a time.
Monitor and display the real time physiological sign for 16 or 24 patients for 24 hours.
Counter signal interpretation and alarm beep with event mark up.
Store physiological monitoring data automatically in Central Monitoring System (CMS).
The data transfer between Central Monitoring System (CMS) to bed side monitors in Extensible Mark-up Language (XML) format.
The Central Monitoring System (CMS) should have wireless applications for remote monitoring or to connect Central Monitoring System (CMS) with Hospital Networks
System.

A. Introduction of networks in patient monitoring systems:

In the Central Patient Monitoring System (CMS), the network performs a very important role and with the help of communication networks in hospital, the doctors are able to treat patients all over the world.

B. Single Computer Server Based Patient Monitoring (CMS):

In Patient Monitoring Systems (PMS) the networks usually are server based. The patient monitoring server connected with client patient monitors through the network device and it has access to all other client patient monitoring systems. The Central Patient Monitoring System (CMS) server is responsible to managing real time data and maintains the record of client patient monitoring data. The patient monitoring server equipped with a dedicated operating system like Windows NT server, Windows 2008, Linux etc.

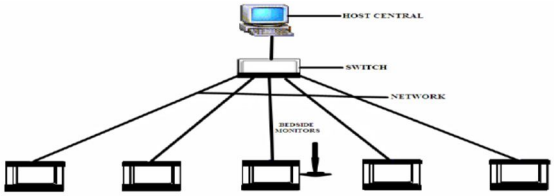

FIGURE 20 SINGLE SERVER BASED CENTRALIZED PATIENT MONITORING SYSTEM (CMS).
In single server based central patient monitoring networks, the three kinds of servers normally works:

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The file servers manage the real time record of multiple physiological signals from different bedside patient monitoring system.
The application server is used as database server. The application server is also used for programming and upgrading the bedside patient monitors.
The print server is used to take printout for all PMS clients of CMS networks.

1) *Issues In Single Server Based Patient Monitoring Systems:* Now in new era of technology the Tele-monitoring is set to become a common monitoring. The big issue in Tele-monitoring is data storing and overloading with a centralized computer. Nowadays in hospitals all networks are centralized by a single network called Hospital Information System (HIS). Normally the server has one or more hard disks for data storage for the networks clients' patient monitoring system. This is quite dangerous, when server system crash down or may have a hard disk failure, then all of client patient monitoring system feels the problem for data sharing and other major communication effects. Due to this major problem of data overload in hospital server system, the researchers are very much convinced on to decentralize the system to avoid medical data overload. So it is good approach to introduce a peer to peer networking to solve the data overload issue in Hospital Information System (HIS).The Peer-to-Peer approach is very old in computer networking technology. The concept of Peer-to-Peer networks is to share and store data on each connected system on the network. It helps to avoid the data overload on server system. In Peer-to-Peer network the peer are known as nodes, peer nodes are a basic entity of any Peer-to-Peer networks. It gives help to provide the possible task for executing data on any Peer-to-Peer network to another Peer-to-Peer network directly and indirectly. The nodes of Peer-to-Peer network has no server point and it uses as their ideal processing cycles, data storage and bandwidth via the internet. The introduction of Physically Aware Reference Model (PARM) monitoring application, it would be developed into E-health system soon and after that, it is helpful to reduce the cost of patient expenses and definitely by using Peer-to-Peer, it is become more cheaper.
2) *Peer-To-Peer Networking With Computer Server Based Patient Monitoring System:* Peer-to-Peer networks are very simple to connect, easy data sharing and most important it is quite cheap as compare to single server based patient monitoring networks. By using Peer-to-Peer networks in healthcare environment gives more efficient tasks, like improve the patient care and maintain overhead cost and also reduce the manually perform application like patients are able to store data through hospital Peer-to-Peer networks infrastructure.

Some salient features of Peer-to-Peer networks in hospital environments are:
Maintain electronic patient record instead of traditional paper file system.
The patient has access to register his information by using Peer-to-Peer hospital website.
Patient information is available for any time in Peer-to-Peer networks.
The Central Patient Monitoring database is sharing all information in real time with peer to peer hospital information system, and furthermore the authorized central patient monitoring database is accessible in real time from anywhere in the world.
It is possible to make an appointment with physicians with video conferencing, and physician is able to diagnose the problem.

C. Peer-to-peer network performance

The performance is the core issue in every Peer-to-Peer network and regarding CMS, we need to share or exchange large number of data files in real time. In CMS, the network server and client system uses the same standards of data transferring and data sharing. [7]
The Peer-to-Peer network is established by connecting the patient monitoring systems via hubs or switches with the computer-based patient monitoring server. The main purpose for using Peer-to-Peer server based networks, if there is any breakdown or failure of a server, it does not make any effect on other patient monitoring systems and all other clients patient monitoring communicating each other freely.

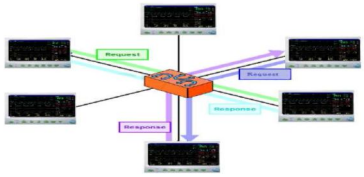

FIGURE 21. CENTRALIZED MULTI-PARAMETER PATIENT MONITORING SYSTEM BASED ON PEER-TO-PEER NETWORKS.

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In Peer-to-Peer networks, the multiple clients of Patient Monitoring System are setup by means of equal sharing. Each client works as a peer in the centralized patient system and these clients or devices has the same software operating system. The PMS, clients and server both has equal rights to send/receive the data, storing data and file sharing etc. The network interface card transmits the data in Extensible Mark-up Language (XML) format from clients to server in CMS networks. Each system has its on Internet Protocol (IP) addresses, which helps to identify the each patient monitoring systems.[7]

D. Advantages of peer-to-peer patient monitoring networks

The advantages of Peer-to-Peer networks are very specific. The advantage of the Peer-to-Peer system networks are as follows in below:

1) *Availability of Data:* The basic and important advantage is permanent data availability on networks because the data content is distributed at each peers of the Peer-to-Peer system.
2) *Durability of a Network:* The data can store for long period on the network.
3) *Data Security on Peer-To-Peer Networks:* The security of any network is always a big issue for network management. The most important factor in Peer-to-Peer networks is who the authorized part of network system. The system should be secure from unauthorized user. The main common issue in networks is denial of service (DOS). In a DOS attack, the network has received many unknown additional requests. Due to this effect the regular traffic is either slowed or completely interrupted like as if virus or worm attack on network. The DOS also damage the databases and also interrupts the network service for some period. In Peer-to-Peer networks, the denial of service (DOS) issue is minimum due to there is no centre of point for single administration. There is some another important security protocol also working for data management and security like, Internet Protocol Security (IP-Sec), Secure Socket Layer (SSL), Virtual Private Network (VPN) etc.

V. AMQP BASED PATIENT MONITORING SYSTEM:

The AMQP is an open standard application layer protocol for message-oriented middleware. The defining feature of AMQP is message orientation, queuing, routing, reliability and security. AMQP mandates the behavior of the messaging provider and client to the extent that implementation from different vendors is interoperable, in same way as SMTP, HTTP, FTP etc.

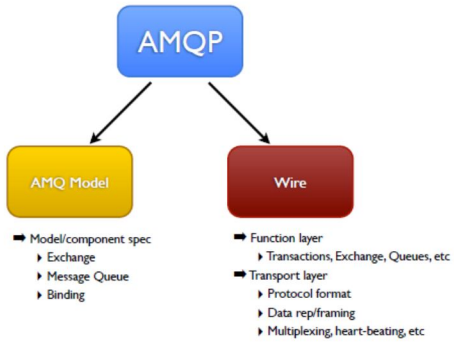

FIGURE 22
AMQP MODEL LAYER

AMQP is a binary, application layer protocol, designed to efficiently support a wide variety of messaging application and communication patterns. It provides flow controlled message-oriented communication with message delivery guarantees such as at-most-once (where each message is delivered once or never) at-least-once(where each message is certain to be delivered, but may do so multiple times) and exactly-once (where the message will always certain arrive and do so only once) and authentication and/or encryption based on SASL and TLS. It assumes an underlying reliable transport layer protocol such as Transmission Control protocol (TCP).The AMQP specification is defined in several layers

A type system

Symmetric, asynchronous protocol for transfer of message from one process to another

A standard extensible message format

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A set of standardizes but extensible messaging capabilities

A. AMQP Performatives & The Link Protocol

The basic unit of data in AQMP is a frame. There are nine AMQP frame bodies defined that are used to initiate, control and tear down the transfer of message between two peers. These are

Open, Begin, Attach, Transfer, Flow, Disposition, End, Close

The link protocol is at the heart of AMQP. An attach frame body is send to initiate a new link. A detach to tear down a link. Links may be established in order to receive or send messages. Messages are sent over an established link using the transfer frame. Messages on link flow in only one direction.

Transfers are subject to create based flow control scheme, managed using flow control schme, manage using flow frame. Multiple links, in both direction, can be grouped together in a section. A session is a bidirctional, sequential conversation between two peers that is initiated with an end frame. A connection betwwen two peers can have multiplexed over it, each logically independent. And terminated with a close frame

B. AMQP Message Format: AMQP defines as bare message that part of the message that created by the sending appliction. This is considered immutable as the message is transferred between one or more processes. The headeris satandared set of delivering related annotations that can be requested or indicated for a message and include time to live, durability , priority.

C. Message capabilities:

The link protocol transfer message between two nodes but assume very little as to what those nodes are or how they are implemented the AMQP specification calls such nodes distribution nodes and codifies some common behaviours. Though AMQP can be used simple peer-to-peer systems defining this framework for messaging capabilities additionally enables interoperability with messaging intermediaries in larger, richer messaging networks.

VI. CONCLUSIONS

The medical field is growing up on daily basis, the new development introduce for patient care and safety. The Patient Monitoring System (PMS) is a very critical monitoring system, it can monitor physiological signals including Electrocardiograph (ECG), Respiration Rate, Invasive and Non-Invasive Blood Pressure, Oxygen Saturation in Blood (SpO2), Body Temperature and other Gases etc. Therefore, patient monitor has always been occupying a very important position in the field of medical devices. The latest development in patient monitoring system, the system has multiple physiological measurement tools and it can used in Intensive Care Unit (ICU), Critical Care Unit (CCU), Operation Rooms and Emergency Rooms of hospital. The AMQP based Patient Monitoring System (PMS) with an open architecture approach theory is very popular and almost all vendors are using new bus system for open communication interfaces networks in the current industry. The PMS has its own database and analysis tools and after the introducing of latest buses like AMQP, TCP/IP, Ethernet, plug and play devices, USB module, the PMS are able to provide multitasking open communication ability for hospital management system. The use of the AMQP protocol suite as an internal bus instead of the traditional design like HPIB, Profibus and CAN bus is very popular in current industry TCP/IP. The AMQP based architecture of PMS is capable for upgrading the system's firmware and software with dedicated AMQP protocols via open communication network. The AMQP protocol suite is easily available in a very cheap price, so it is a good approach to use AMQP protocol suite as internal bus for reducing the cost effectiveness. During treatment, the patient monitor is continuously monitoring the vital physiological signs of the patient to transmit the important information. It is tough job for medical personnel to monitor each patient for 24 hours. So due to importance of patient monitoring system, the medical manufacturer are introducing centralized patient monitoring since last couple of years before. In centralized patient monitoring system all patient monitors are connected with a single server based patient monitor. The use of networks in medical field has become a core component for any hospital system especially regarding critical issues like data overflow and security issue etc. Introducing a Peer-to-Peer type of network topology will make the life easier for hospital management. Nowadays many medical IT companies implementing the Peer-to-Peer approach in medical networks infrastructure. The continuous improvement of technologies not only helps us transmit the vital physiological signs to the medical personnel but also simplifies the measurement and as a result raises the monitoring efficiency of patients

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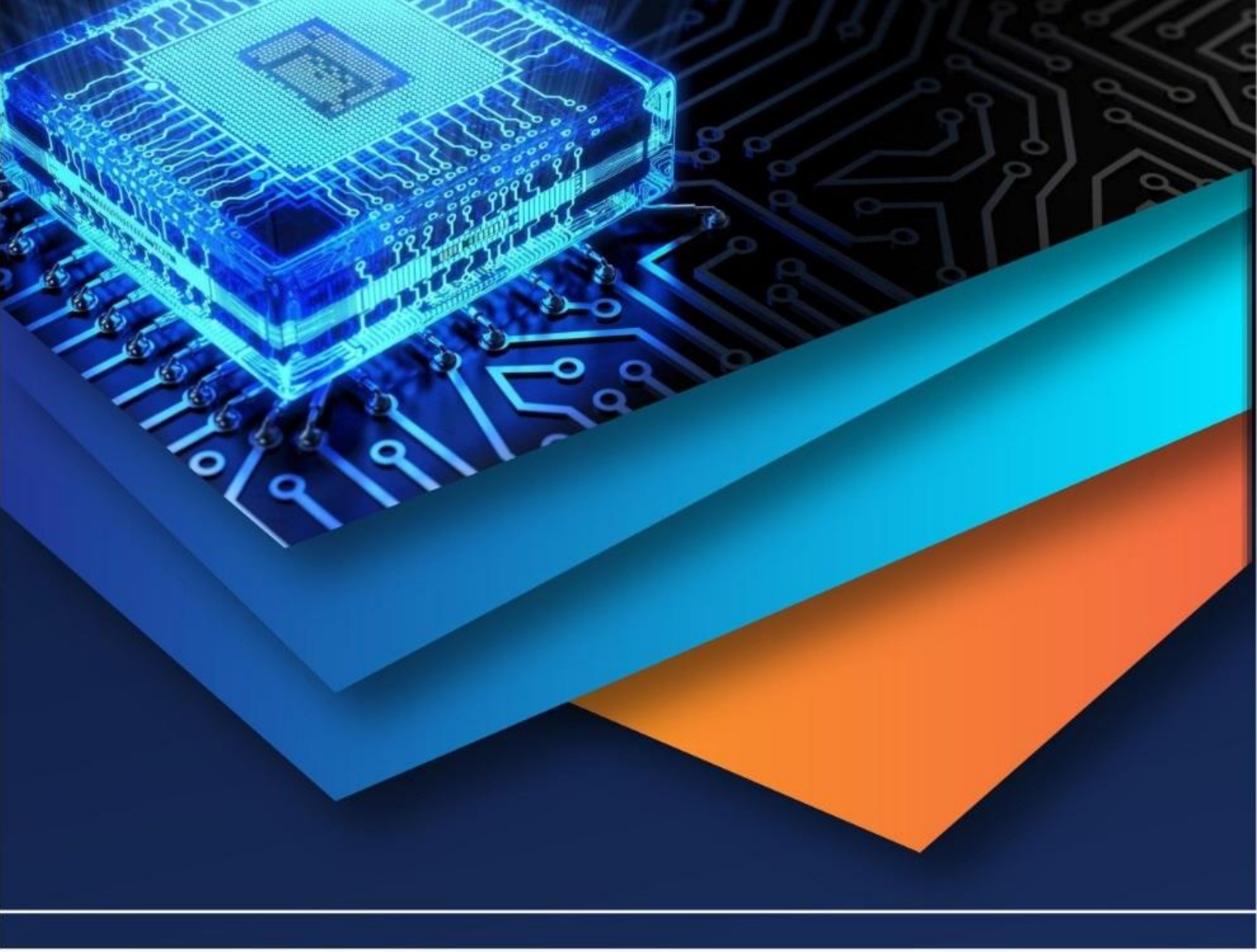

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