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MONITORING INFUSEOF MONITORED PATIENTS USING MICROCONTROLLER IN NURSE ROOM

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Abstract
Monitoring system on the number of drip drops during this time is still done manually, both in terms of use and recording. This condition causes paramedics to pay attention longer to the infusion condition periodically. To avoid such mistakes have been designed and made a device used to regulate and monitor the rate of infusion in the patient. The device is a liquid infusion connected to the sensor, in this case a strain gauge installed over the infusion fluid. Any change in the infusion condition is transformed by the sensor to become a comparable electrical signal. With the existence of tools and the systems, the problems that arise due to negligence of employee can be minimized, is also expected to facilitate the nurses in monitoring intravenous fluid replacement, and lower the risk of delay in intravenous fluid replacement for patients.

KeyWords : Strain gauge; Microcontroller; Infusion.

Introduction
As technology improvement, hospitals still rely on paramedics to record and regulate the number of drip drops in patients. Monitoring system on the number of drip drops during this time is still done manually, both in terms of use and recording. This condition will certainly take a lot of time by paramedics to pay attention periodically to infusion conditions (Okstein, 1984). In addition, there may be errors that are common at the administrator level frequently. Administrator errors can cause harm to the patient and increase health costs (Han, 2005). The clinical condition of complex ICU patients leads to the use of many drugs that lead to potential drug interactions.To avoid such mistakes have been designed and made a device used to regulate and monitor the rate of infusion in the patient. This device can be an attractive option in monitoring infusion flow rates with limited medical resources (paramedics), thereby reducing the chapter of the paramedic (Prerana, 2007).

Every hospitalized patient in the mostly need of intravenous fluids, where this infusion fluid functioned as a medium of drug delivery and intake of food that can not be leased through the patient's mouth. This intravenous fluid is inside a special plastic bag or glass bottle. The most general method that used is intravenous infusion, and to check the infusion with the simplest way is with the nurse injecting to patient and monitoring it with several time that has been determined, but this method has several deficiencies. Drip speed and temperature of liquid can not be controlled certainly. There are many devices that have been developed to access venous, but almost all of that devices are not advanced yet. The main unit of that devices is 8 bit and 16 bit MCU mostly, even though this makes many deficiencies such as, complex external circuit, complex external contruction, bad anti-interface capability, and the ability to only can get few parameters (Yang, 2009). The nurse have to change the infusion with the new one, when there is no intravenous liquid left. But the patients in many cases do not know the condision or the time when the liquid exhausted. Not only that but also the patients in many cases hardly press the button that connect to the guard room to inform that they run out of liquid. Because of that the nurse need to check the condition of the infusion several times that has been determined, And this can also cause other complications such as blood can be sucked up into the infusion tube and can be frozen on the infusion hose so that interfere with fluid flow fluid flow. In addition, if the pressure on the infusion is not stable, the blood is frozen the intravenous tube can be sucked back into the blood vessels. The blood clot can circulate throughout the body and can clog blood capillaries in the lung causing embolism in the lungs (Waitt et al., 2004). If these things happen then the place of intravenous infusion should be removed and install to the other venous blood vessels, which is possible to cause complications that are much more dangerous due to the installation is not done properly.

The Proposed System

The sensor part consists of a strain gauge placed over the infusion fluid. Changes in the infusion condition are transformed into a comparable electrical signal by sensor. RPS (signal conditioning unit) is an ang circuit consist of several componets such as multivibrator and resistor circuit. It has function to change the value of the resistance of strain gauge into analog voltage in between 0-2.65V range. This value is adjusted to the maskan range of ADC. Then the analaog signal is converted by the internal internal ADC in the microcontroller chip, the output is a digital value with a range of 0 to 512 decimal. This data stored in the register and processed mathematically to determine the condition and identification of the infusion problem. Conditions detected include intravenous fluid levels, fluid rates calculated in units of ml per minute, and blockage of infusions etc. The output from the microcontroller is a hexa decimal code which is then sent to the receiver via wireless transmitter module. The data sent is a power pack consisting of the sender address, condition data, marker. The form of data packets is a 3 byte hexadecimal code.In the receiveng end, the wireless receiver module receive the data, the data is serial data with ADDRESS format-DATA-END, this data is parsed in microcontroller to be separated, ADDRESS information is used for determine sender address in which will be translated in room viewer. The status data of the infusion is translared by microcontroller to buzzer. All data is displayed in a boar containing the LED and placed in the nurses' room or nurse's guard room.

The Methodology

Electrical Planning

In the electrical design section there are two module design, the sender and signal module. The signal sending module is placed in the patient room while the signal receiving module is placed in the nursing room. Electric design scheme can be seen in **Figure 1.**

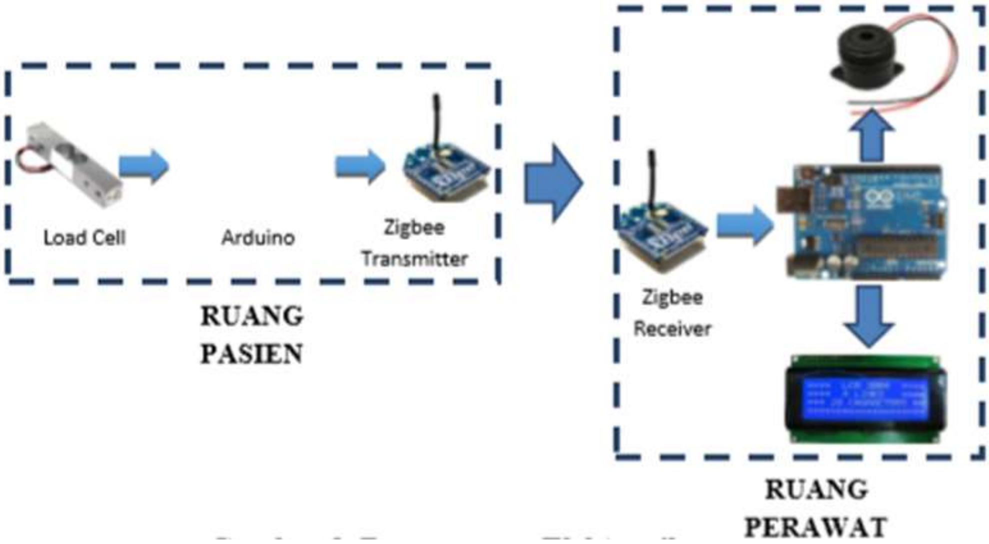

Figure 1 Electrical Planning

Ogawa et al, in his research entitled A New Drip Infusion Solution Monitoring System With A Free-Flow Detection Function found a new solution for infusion monitoring system solution for hospitals and care facilities(Ogawa, 2010).In the signal sender module consists of several components, among others, Strain gauge used for intravenous heavy sensor sensor, Arduino as a sensor reader, and Zigbee Transmitter used to transmit data to the Nurse Room. While the receiver signal module consists of Zigbee Receiver which serves as a signal receiver from zigbee transmitter. Then the signal is processed using arduino and the readout is displayed through the LCD and if the sensor readings have reached the minimum limit specified will make the buzzer sounds.

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Mechanical Design

In the mechanical design of this tool, that is by modifying the standard pole of intravenous fluids by replacing the intravenous fluid hook with a module consisting of Strain gauge, Arduino and Zigbee Transmitter. The mechanical design can be seen in **Figure 2.**

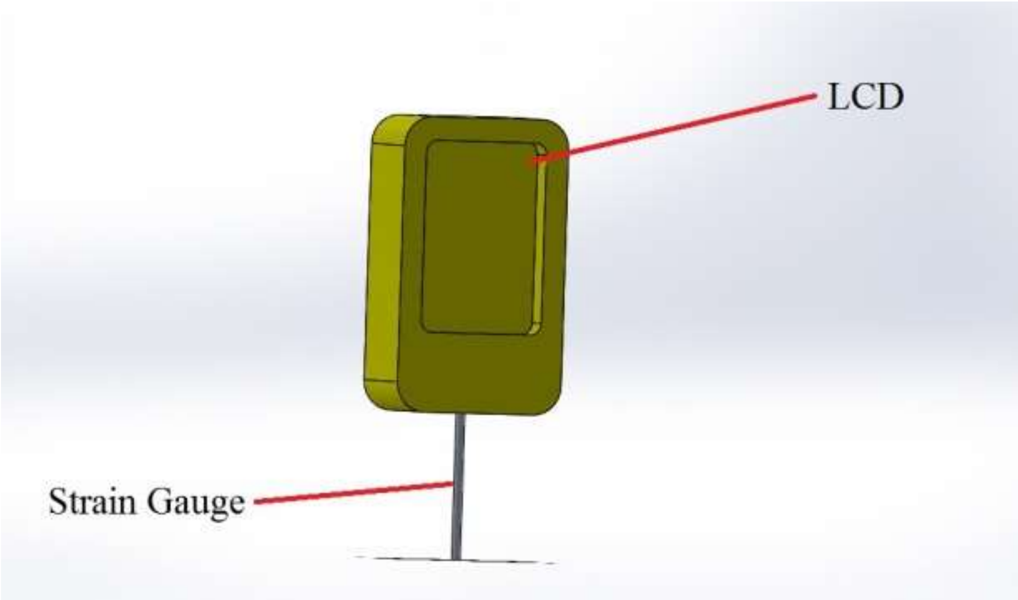

Figure 2 Mechanical Design

Infusion

The infusion is entering a certain amount of fluid through the patient's vein continuously over a long period of time. The use of intravenous fluid infusion requires proper prescribing and close monitoring. The infusion can be seen in **Figure 3.**

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Figure 3 Infusion

Complications caused by incorrect installation of infusion:

a. Hematoma, the blood rests in the tissues of the body due to rupture of the arterial venous or capillary veins. Occurs due to the correct exposure when inserting a needle, or puncture repeatedly on a blood vessel
b. Infiltration, namely the entry of blood into the intravenous ducts, occurred due to infusion fluids have been exhausted and there is a vacuum in the bottle so that draw blood into the hose.
c. Tromofeblitis or swelling (inflammation) in the veins, occurs due to infusion that is installed is not monitored closely and correctly.
d. When air enters blood vessels and cause blockage of the blood flow can create condition known as air embolism. While the air enters the blood vessels, it will follow the blood circulation into brain, heart, lungs causing serious illness 3.4 Operational Amplifier (Op-amp) The Operational Amplifier is an instant booster which can be used for many reinforcement applications.

Operational Amplifier (Op-amp)
The Operational Amplifier is an instant booster which can be used for many reinforcement applications.The op-amp is an IC (Intergrated Circuit). Packaging Op-amps in ICs vary, some contain op-amps (eg 741), two op-amps (4558, LF356), four op-amps (eg = LM324, TL084), etc.

Microcontroler ATMEGA8535
Microcontroller is a family of microprocessors which is a chip that can perform data processing digitally in accordance with assembly language command given by the manufacturer. Control device is the most important component in a system where all process control, data processing and settings centered on one device.ACR microcontrollers are formed from 8 bit RISC (Reduced Instruction Set Computing) architecture. Where all the

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information is in 16-bit code and mostly done in 1 (one) clock cycle, in contrast to MC51 instruction which takes 12 clock cycles. AVR RISC technology, while MCS51 series tech CISC (Computing Instruction Set Complex). The microcontroler ATMEGA8535 can be seen in **Figure 5.**

Figure 5 MicroControler ATMEGA8535

Strain Gauge

Strain gauge is an electronic component used to measure pressure (deformation or strain). This sensor was first discovered by Edward E. Simmons in 1938, in the form of insulative metal foil (insulation) attached there is an object to be measured pressure. If the pressure on the object changes, the foil will be deformed, and the electrical device will change. This change of electrical resistance is inserted into the Wheatstone Bridge circuit. The strain gauge can be seen in **Figure 6.**

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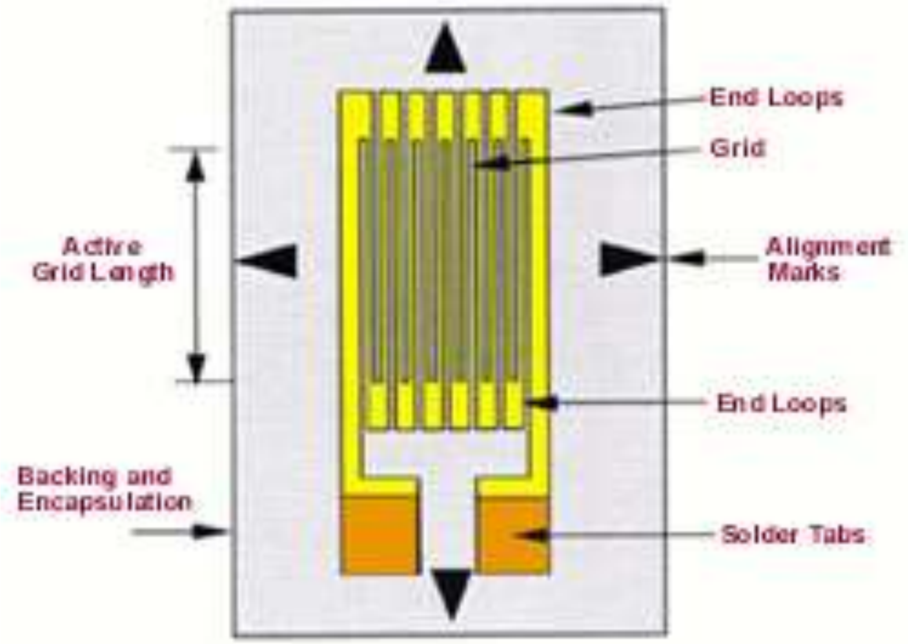

Figure 6 Strain Gauge

ZigBee Topology

Zigbee Topology is a standard that have been made as communication protocols for low-data-rate short-range wireless networks. This wireless dvices operate at 868 MHz, 915MHz, and 2.4 GHz band. Maximum data is 250 Kbps (Shanin, 2008). Rahman et all in 2010 in his journal entitled Development of Prototype Infusion Control and Monitoring System for Wireless Network Based (ZigBee) in star topology or known ad point-to-point, all devices are in direct communication to the coordinator, where all messages are directed.

a. ADevice sends a message to the PAN coordinator then shared on the destination device which shown in **Figure 7**, where each devise within the network able able to communicate by using PAN coordinator (Personal Area Network). For enabling and starting to bulid the network in PAN coordinator, Full Function Devices (FFD) are programmed in such scenario.

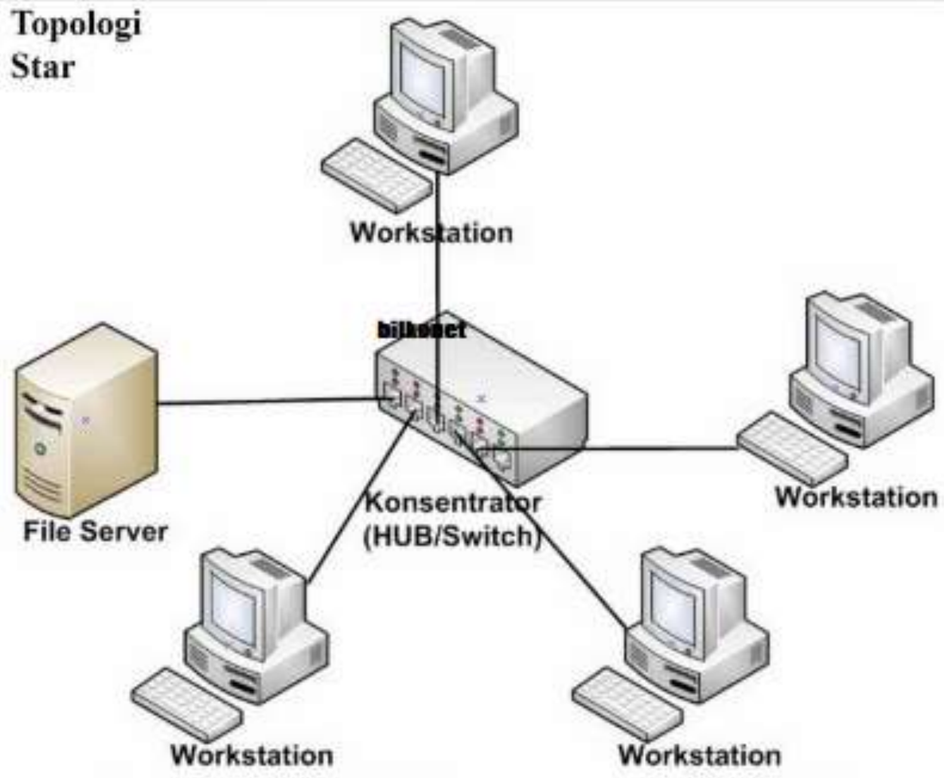

Figure 7 Star Topology

b. The first thing is the PAN coordinator conducts the selector of a unique PAN identifier that is not used by another network within the radio sphere of influence area, where inside that region these devices can communicate with each other. It means that, it makes sure to that this PAN identifier cannot be used by any other network nearby.
c. Based on the **Figure 8**, peer-to-peer topology is known as mesh topology that being made of interconnected routers and devices. Where each router was connected by two lines and can relay messages from each other. The mesh topology supporting “multi-hop” communications, this make data jump form one to another device is possible to be achieved. It makes the mesh topology be realible and effective to communicate. In a peer-to-peer network, all devices participating in conveying messages are FFDs, because RFDs are unable to convey messages. But RFD communicate with one particular device and can be part of a network . A peer-to-peer network can be a different forms depends restrictions that exist within the devices that can communicate with each other. If there are no restrictions, the peer-to-peer network topology can be called by mesh topology. There is a support form of peer-to-peer called Tree ZigBee topology (see **Figure9**). In this case, the coordinator of ZigBee (PAN coordinator) forms the initial network. ZigBee routers are used to form a branch and message relay. The ZigBee end device acts like a tree leaf parable and does not participate in routing messages. ZigBee routers can grow networks outside the initial network set by the ZigBee coordinator.

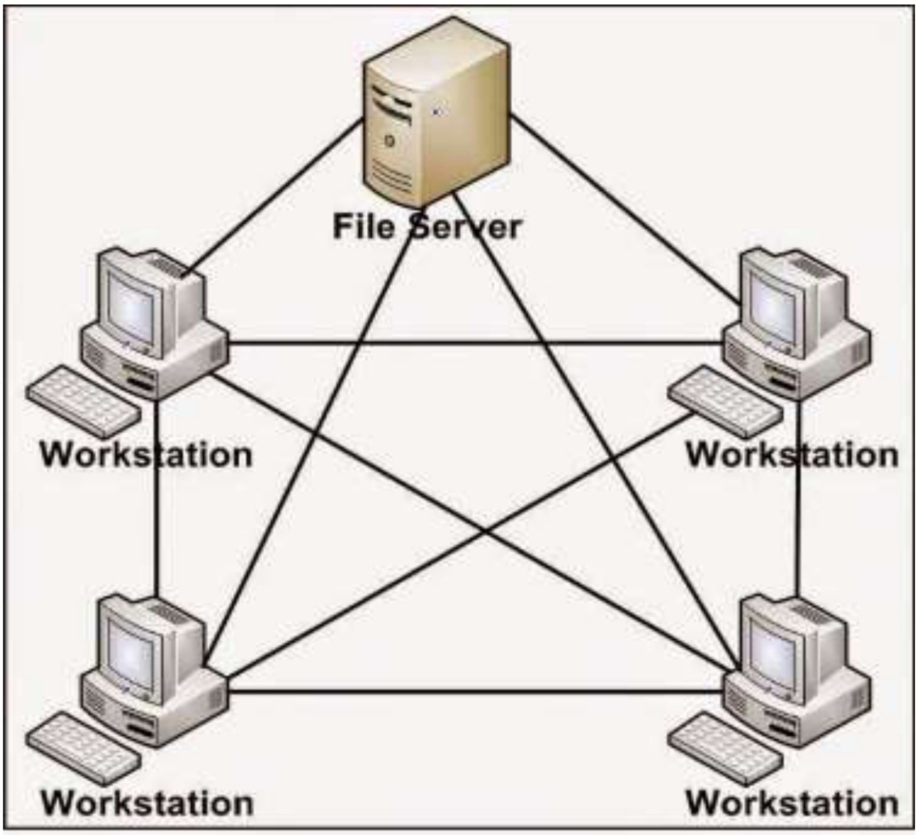

Figure 8 Mesh Topology

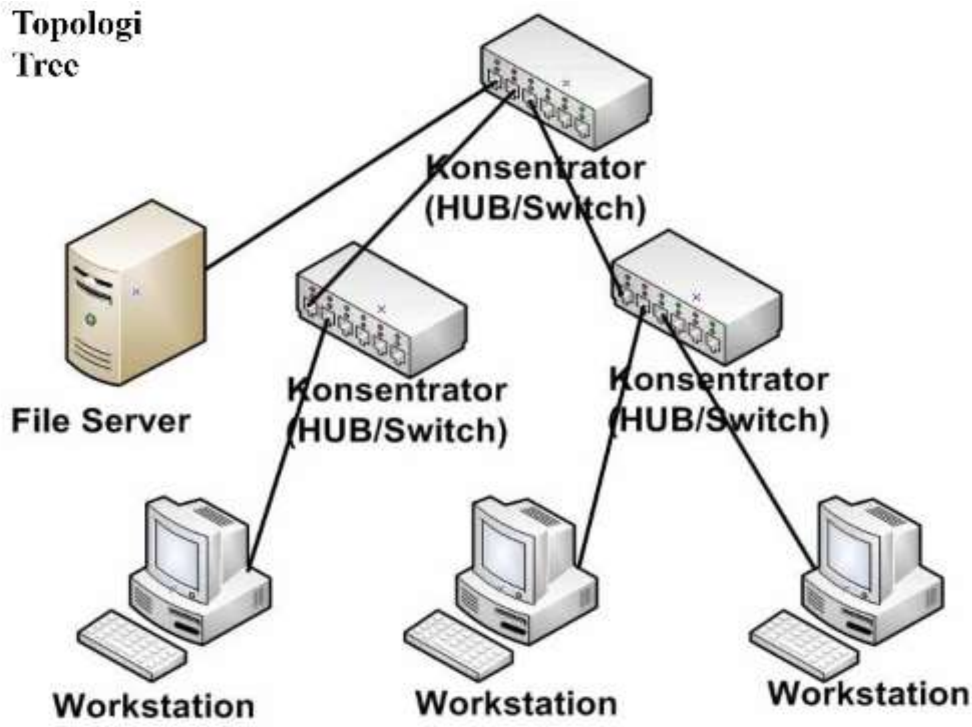

Figure 9 Tree Topology

Flowchart

Generally the system to be made consists of 2 blocks of the sender block (transmitter) and block receiver (receiver). The sending block is composed of a strain gauge sensor, signal conditioning circuit (RPS), microcontroller and wireless transmitter module. The receiver section is composed of wireless secuiver module, microcontroller and display unit. The workings of the tool are outlined in the block diagrams as shown in the **Figure 10** and **Figure 11**.

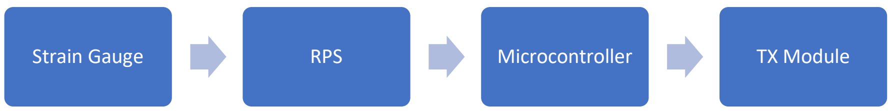

Figure 10 Transmitter System Block Diagram

Figure 11 Receiver Block Diagram

Results and Discussion

Testing of this infusion detection system consists of several tests, namely: testing the sensor and RPS signal conditioning circuit, ADC testing, testing infusion disorder. Sensor and RPS testing is done by assembling the sensor and RPS in the infusion, the output from the sensor is connected to the multimeter and microcontroller in the settings as data logger and transmitter serial data to the computer UART. The test chart is shown in **Figure 12.**

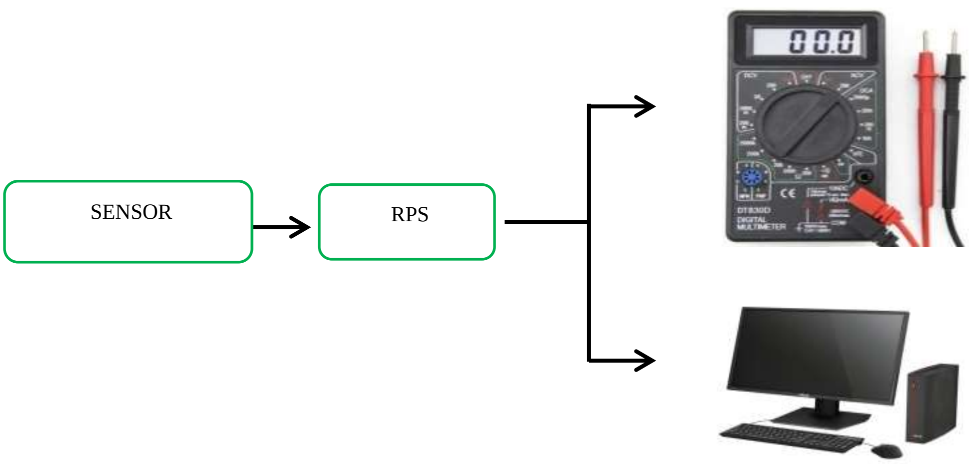

Figure 12 Sensor Testing and RPS

From the reading of the data from the sensors recorded in the computer in the form of tabulation data. The first test is performed by measuring the response of the sensor to the infusion rate without interruption. Data output from RPS and microcontroller sent to PC via serial communication. The data below based on the data of the

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research that has been done by Zainuri at 2012. The sample of the recording is shown in Table 1. The next test is done by flowing the infusion normally and then on a certain tumble, this procedure is simulated when the infusion of the patient is pinched so that the infusion fluid does not flow into the patient's body. The read result data is sent to the computer via serial port and recorded in txt and xls files. The test results data are shown in **Table 2**.

Table 2 Test results when infussions is clogged

NUMBER OF SAMPLING	ADC OUTPUT	NUMBER OF SAMPLING	ADC OUTPUT
1	695	598	461
12	695	608	442
52	690	607	376
305	624	701	309
318	655	710	291
319	692	762	283
320	651	786	260
321	624	826	154
322	642	874	149
351	632	1008	129
449	584	1033	102
582	516	1151	88

The test data in **Table 1**is represented in Graph shown in **Figure 13**. When sampling time 0 to 27 the infusion locking conditions are locked so that the ADC output is relatively flat. From sampling to 28 to 225 the locks are opened so that the graph appears with a decrease in the volume of liquid close to linear. Detection of infusion level when critical condition / close to programmable during infusion output below 70 value. From the graph in **Figure 13**. we can get the infusion fluid degradation rate approach: y = $-3.10^{-10}x^4 + 2.10^{-6}x^3 - 0.001x^2 + 0.290x + 363.4$.

Table 1 Data of sensor readings with normal speed

NUMBER OF SAMPLING	ADC OUTPUT	NUMBER OF SAMPLING	ADC OUTPUT
1	653	487	210
21	652	489	208
34	550	530	191
45	450	547	188
56	455	699	182
76	443	1162	108
193	445	1202	96
246	448	1243	86
458	325	1269	59
483	220	1330	48

: clogged infusion
: normal infusion

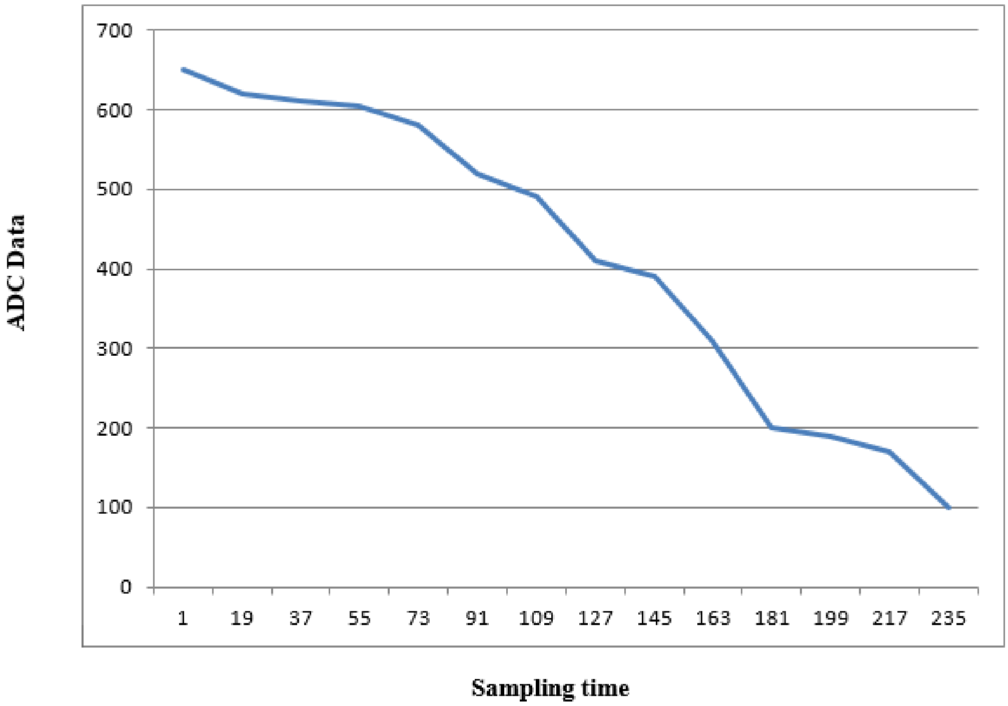

Figure 13 The rate of decrease in normal intravenous fluids

The data on the measurement of the volume of the infusion fluid and the ADC reading results are shown in **Table 3**. The graphs in **Figure14** and the data in **Table 2** show the condition when blockage occurs, the average ADC output value is relatively stable at 430. When this condition occurs the ADC output value relatively fixed while the sampling time continues to run then the program will detect the condition of the blockage, the method of detection of the occurrence of blockage is to calculate the change of ADC data to the sampling time. If within a certain time the ADC is fixed and still above the level of the lower level setpoin while the sampling time continues to run then the program will indicate the occurrence of blockage, then will provide a warning of sending the code to the viewer in the nurse room. Code data is then displayed through the LEDs arranged in order and number of rooms, so that the infusion position is known to experience interference.

Table 3 ADC Output against infusion liquid volume

NO	ADC OUTPUT	VOLUME
1	374	500 ml
2	355	400 ml
3	246	300 ml
4	182	200 ml
5	122	100 ml

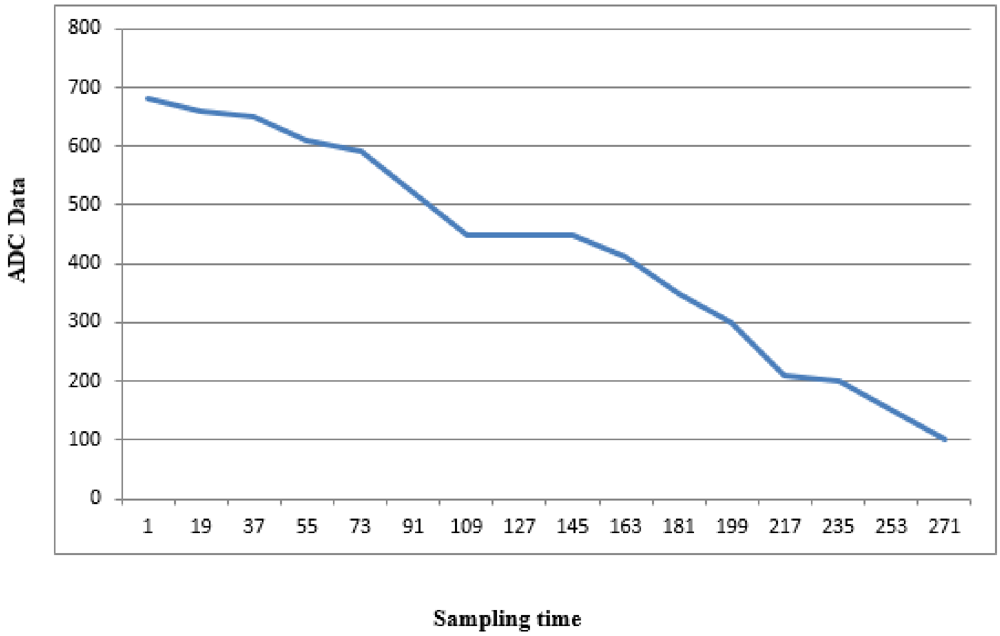

Figure 14 Rate of decrease in intravenous fluid during blockage

Conclusion

The intravenous fluid monitoring system that has been designed successfully detects intravenous fluid use in patients using Strain gauge, the sensor readings are transmitted via a zigbee transmitter to the zigbee receiver. An intravenous fluid monitoring system can help monitor the use of intravenous fluid in patients using LCDs and buzzers. Data delivery of infusion conditions has been successfully worked by wireless communication with a serial communication baudrate of 4800bps. From the results of testing and analysis obtained the rate of infusion fluid drops to the volume of $y = -3.10^{-10}x^4 + 2.10^{-6}x^3 - 0.001x^2 + 0.290x + 363.4$.By the existence of these tools and systems then the problems arising from negligence officers can be minimized, is also expected can facilitate the nurse in monitoring intravenous fluid replacement, and reduce the risk of delayed intravenous fluid replacement for the patient.

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