ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
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International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)Vol. 10, Issue 10, October 2023

# Computer Controlled Automatic Closed loop Anesthesia Control for Surgery Applications with Vital Parameter information System

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**Abstract**: Anesthesia plays vital role in any type of surgery, infusing of perfect Anesthesia rate is most important to keep all essential parameter in perfect wellness during surgery. In current situation, based on the experience of the medical professional's Anesthesia is infused and all the time it cannot be perfect, because of human errors which often leads to improper dosage. At the same time anatomical structure of all human's is not same, different blood group, tissues variation in haemoglobin, heart rate, blood pressure,Lung volume, PhotoPlethysmoGraph(PPG) and Galvanic Skin Resistance(GSR) will change human-to-human. In this case it is essential to examine the requirement of anesthesia and it must be infused with proper feedback mechanism to ensure safest surgery process. The Market available solutions exists over three decades for anesthesia infusion based on open loop method with manual feedback. Later many advancements introduced in drug delivery and made significant improvement, but doesn't solve the requirement completely because of the more vital signal essentiality in surgery process. The proposed research deals with real-time application of infusion model with bio-signal feedback. The vital parameter to be maintained during entire surgery period is respiration rate of 12-17 per minute. In this research feedback signals received from various sensors like Heart rate,PPG,GSR and the main signal called respiratory temperature will be received using thin film Resistance Temperature Detector(RTD PT-100) . A closed loop pump using PID controller is employed to maintain the set anesthesia value throughout the surgery process, the whole system utilizes the state of art embedded system technology with appropriate electronic circuits.

**Keywords**: Photo Plethysmo Graph(PPG), Galvanic Skin Resistance(GSR), Resistance Temperature Detector (RTD PT-100), Embedded Micro Controller(EMC),Proportional Integral Derivative (PID)

## I. Introduction

Anesthesia is a drug given by a physician or surgeon to patient which induces lack of consciousness for prevention of pain during or after surgery which is literally acts as sedative with unconscious. Anesthesia can also be infused in the form of injection, inhalation, topical lotion, spray, eye drops, or skin patch, this kind of medicines are called as anesthetics. There are several kinds of anesthesia have been utilized by surgeons over many years are include: General, Local, Regional anesthesia.

### GENERAL ANESTHESIA

General anesthesia is usually used for long operations or results in unbearable pain over long period local anesthesia which blocks signals in the nervous system Messages from the body travel through the nerves and spinal cord to the brain. Anesthesia blocks pain messages from getting to the brain Patients can get general anesthesia through an IV (into a vein) or inhale it through their nose and mouth. A tube placed in their throat helps the person breathe while they are under general anesthesia.

### REGIONAL ANESTHESIA

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This type of infusion become more economical, decreased blood loss, high level of patient satisfaction, maintain airways of the patient and selective muscle relaxation have been make advantages in this process. There are three types of regional anesthesia methods available in practices are Neuraxial anesthesia (spinal anesthesia and epidural anesthesia) ,Peripheral nerve blocks and Intravenous regional anesthesia. It requires the professionals must have deeper knowledge in science of anatomy, this become the widely implemented for the patients by anesthesiologists.

## LOCAL ANESTHESIA

There is two class or type of local anesthetics namely amides and esters. In general Amide class are common in dentistry includes lidocaine, prilocaine, mepivacaine, and reactions to anesthesia. The above mentioned parameters has to be examined by surgeons or medical professionals based on that the amount of anesthesia to be administered. The figure 1 and 1a are some of the commercially available devices in the market used in the hospital inside and figure 2, 2a are the devices used in the ambulatory systems. The pump models are open loop, need to be monitored periodically throughout the surgery process, but bio feedback called respiration is essential for anesthesia infusion.

The infusion pumps have been deployed in the hospitals over 20 years with computer interface ports, but rare incidence it is interfaced with computing software. Most of the cases it is bupivacaine. Ester anesthetics are less utilized in dentistry and allied activities, but benzocaine may be used for topical anesthesia in practice. Three different local anesthetic drugs are used in the hospital practices namely local application, local application and nerve blocks. Two local anesthetics drugs commonly used by anesthesiologists are amides like lignocaine, prilocaine, and bupivacaine esters like cocaine, procaine, and amethocaine.

## INTRODUCTION–EXISTING SYSTEM

The infusion of anesthesia is based on the body parameters of the patient such as Age,Medical Condition, kind of surgery or procedure, current and past health, including any breathing problems like asthma, Intake of supplements, or herbal medicines, any allergies and past determined with ECG, pulse oxymeters and capnopathy is used to understand oxygen saturation level, cardiac activity and carbon dioxide level of the patient using appropriate devices while and before surgery to monitor and intervene if necessary. The market available anesthesia pumps are very expensive and affordable by only big hospital setups, more over it needs high skill set in instrumentation, mechanical and bio medical. A low cost, simple in construction, highly informative, state of art Computer controlled Embedded Controller system, changeable setting throughout the surgery process and fully automatic based on the bio feedback is essential to meet present need of surgeons.


Figure 1


Figure 1a

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Figure 2

Figure 2a

The above mentioned instruments (Figure 1,1a, & 2,2a) and similarly available such instruments are stand alone, settings of infusion, loading of drugs are automatic. These complex instruments are costly because, possess lot of electrical, electronic and mechanical parts apart from the syringe pump mechanism. These pumps are target controlled infusion pumps developed before two decades with less bio feedback mechanism. The drawbacks like calculation of drug quantity using mathematical model found in this system makes limited in, more over it doesn't consider drug interaction or concurrent drug therapy. Though it fulfills the need of drug delivery it must have connectivity with computer for online setting based on the anesthesia requirement to the patient, remote monitoring ,controlling , data logger for the complete infusion management for post surgery analysis and ensures safe surgery.

INTRODUCTION-PROPOSED RESEARCH

When considering all the above the proposed research has numerous built in features with vital parameter feed backs to provide effective solution for closed loop anesthesia delivery system. The proposed system collects respiration rate as input using inhalation exhalation temperature variation methods using RTD PT100 sensor instead of the conventional chest expansion and contraction resistance. The system also has PPG sensor built in to collect single point ECG, Heart rate and of course respiration also can be arrived from PPG sensing. Galvanic Skin Resistance(GSR) is employed to collect the emotional feedback from the patient during pre and postsurgery process and makes the observation much easier. The proposed research block diagram shown below figure number 3 details the complete process and execution.

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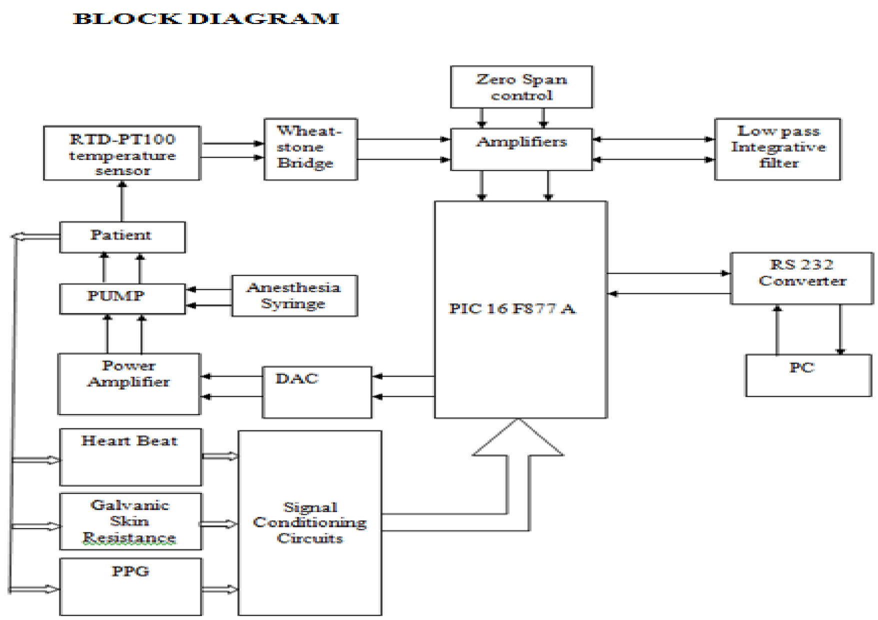


Figure 3 over all concept block Diagram

Explanation of the Complete block Diagram

The proposed block diagram figure no 3 illustrates complete closed loop concept of the proposed research. From the patient feedback input respiration taken using RTD PT 100 temperature sensor connected to the wheat stone bridge to convert unknown resistance in to voltage and further given to bridge amplifier , appropriate filters before interface with Embedded Micro controller. Similarly Heart Beat , GSR and PPG sensors coupled to the Embedded controller with signal conditioners. Though all the parameters are connected to the embedded controller ,only respiration rate will be the decision making input. Based on the baseline anesthesia flow setting the computer delivers 0 – 255 data (8 bit) to the DAC to convert logical signal in to linear signal to drive non – contact syringe pump motor.

The DAC circuit contains all associated circuitries like I/V convertor, voltage follower to increase the output current for better impedance matching with MOSFET motor driver. The motor coupled with lead screw to convert rotary to linear motion conversion, a pusher connected with the lead screw will change rotary to linear syringe push operation to deliver anesthesia as per the requirement. Computer initiate baseline setting only, the complete system then follows only respiration managed anesthesia flow control by delivering 0 – 255 to the DAC circuit from the computer with the help of embedded controller.

Explanation of the PPGBlock Diagram

The PPG circuit Sensor contains one Laser or infrared emitter, Infrared detector arranged between fingers or both the emitter and detector on one side using proper housing as mentioned in the figure 4a , The detector output pulses will change in accordance with the PPG, then the output will be connected to an amplifier and Schmitt trigger ,both logical and linear profile variation are possible in this process. The final output can be connected to the embedded controller for getting the output on the computer screen.

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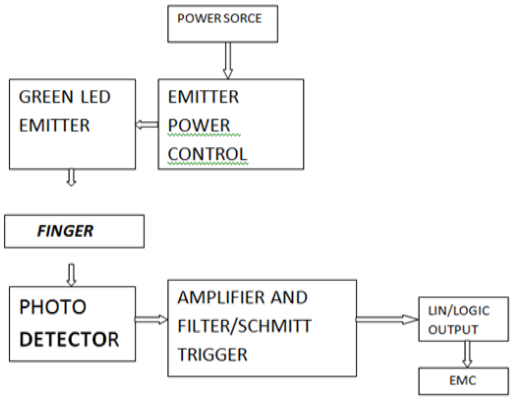


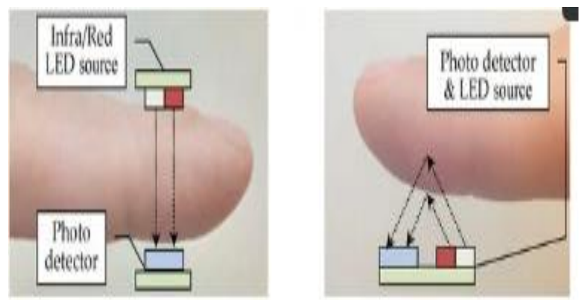


Figure 4 a Block diagram of PPG Figure 4a Sensor Arrangements

Explanation of the GSR Block Diagram

Galvanic Skin Resistance or Conductivity is a Electro Dermal Activity (EDA) is a essential device in the hospitals to calculate stress level of a patient undergo surgery. The pre and post surgery stress level to be monitored to analyze the magnitude of pain for the concern patient and treat accordingly. The sensors have to be arranged as per the figure 4c to get proper value from the sweat glands, the block diagram mentioned figure 4d clarifies in detail of construction of GSR sensor. The Conductivity change can be observed by applying small voltage between the sensors and acquiring the change in conductivity. If the patient feel more pain the sweat gland opens to deliver sweat, if in case of no pain least sweat will be delivered . As per the sweat level the conductivity changes will occur, these signals can be processed using operational amplifiers with associated circuitries like filters before applied to embedded micro controller.

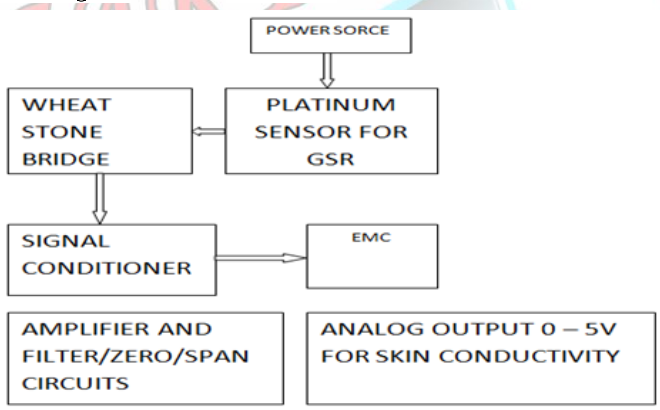


Figure 4 c Block diagram of GSR Figure 4 d Blocks of GSR sensor

Details of bio feedback – Respiration Temperature sensing

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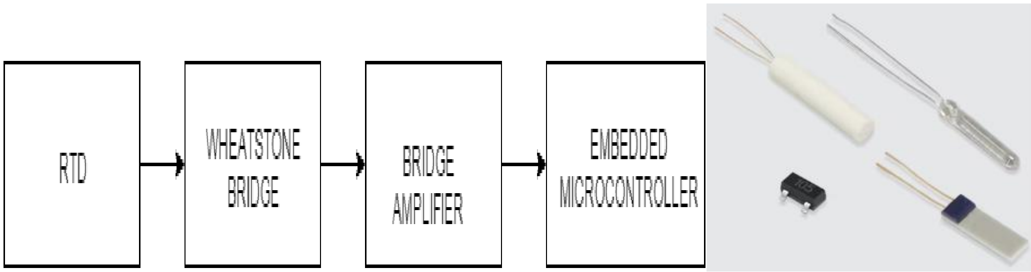


**Figure 5 Block diagram of Respiration sensing**

RTD PT 100 is used, whose resistance at 0 $^{o}$Cis 100Ω.It has a temperature range of 0-50 $^{o}$C which can be convertible in to $^{o}$F. It requires an external excitation voltage for its operation. RTD is connected across one of the arms of a Wheatstone bridge like Figure no 6. It is attached to the patient whose respiratory temperature has to be measured, which changes the resistance value and thus corresponding change in the temperature is displayed on the monitor.

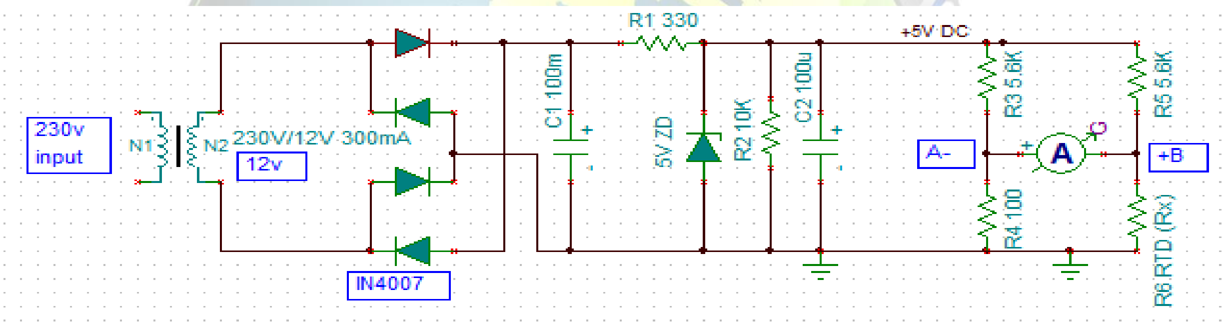


Figure 6 Circuit diagram of Respiration sensing Wheat Stone Bridge

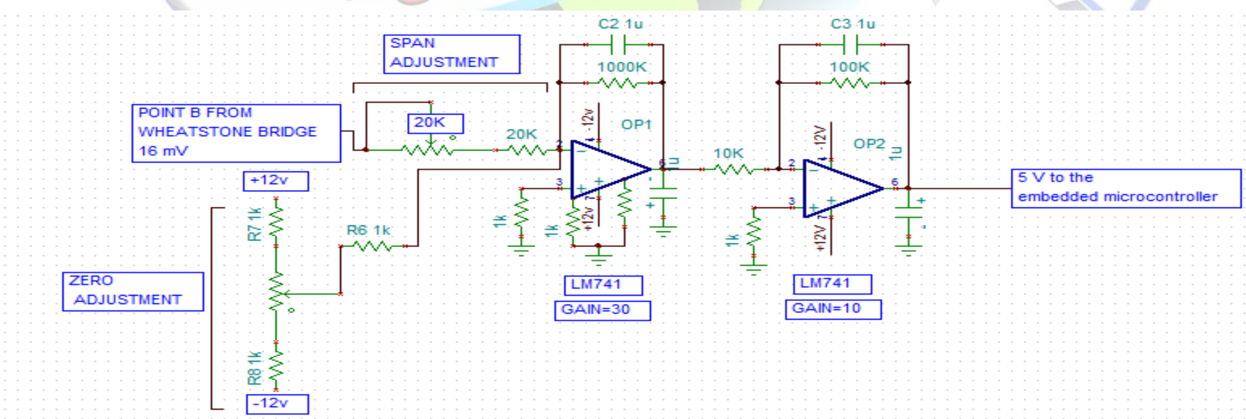


Figure 6 a Circuit diagram of Respiration sensing Wheat Stone Bridge Amplifier

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**Wheatstone Bridge Design Considerations:**

1.Requirement of balanced output.
2.Low current consumption to avoid thermal problems.

AC – BC = AB

where AC is potential divider 1 & BC is potential divider 2

Maximum current flow = 5V / 5.7K < 1 mA
Reason to select $R_2$ as 100Ω is to balance the bridge at 100 Ω at 0 $^o$C.

**2) BC = 5V * 0.1K / (5.6K + 0.1K) = 87.71 mV**

AC at 0 $^o$C.
AC = 5V *0.1K / (5.6K+0.1K) = 87.71 mV
AB = AC – BC = 87.71 - 87.71 = 0V (balanced bridge)

AC at 50 $^o$C
AC = 5V *0.1194K / (5.6K+0.1194K) = 104.38 mV.

Voltage developed at Wheatstone bridge at 50 $^o$C is
AC – BC = 104.38 - 87.71 = 16.67 Mv

Voltage across $R_4$ = V* $R_4$ / ($R_3$+$R_4$)

BC = V *$R_2$ / ($R_1$+$R_2$)

**1) $R_1$ = 5.6K, $R_2$ = 100 , $R_3$ = 5.6K, $R_4$ = RTD**

Reason to select $R_1$ and $R_3$ as 5.6 K is to consume very low current to avoid heating of resistance.

The output of the wheat stone bridge 16.67 mV will be further amplified using Op Amp base signal conditioner Figure 6 a before entering in to the RA port of the embedded controller.
Now, all the parameters like Respiration, PPG, GSR will be connected to RA port of the Embedded Microcontroller (figure no 7 )for analog to digital , digital to serial . The serial USART output of the controller connected to a RS232 convertor for computer interface type serial communication. RS232 is a process that amplifies the microcontroller signal of 5V in to 20V(+ 10 V to – 10 V) without change in signal frequency. All the signals will go as serial and decoded to deliver perfect user interface using Visual basic 6.0 software specially developed for this application

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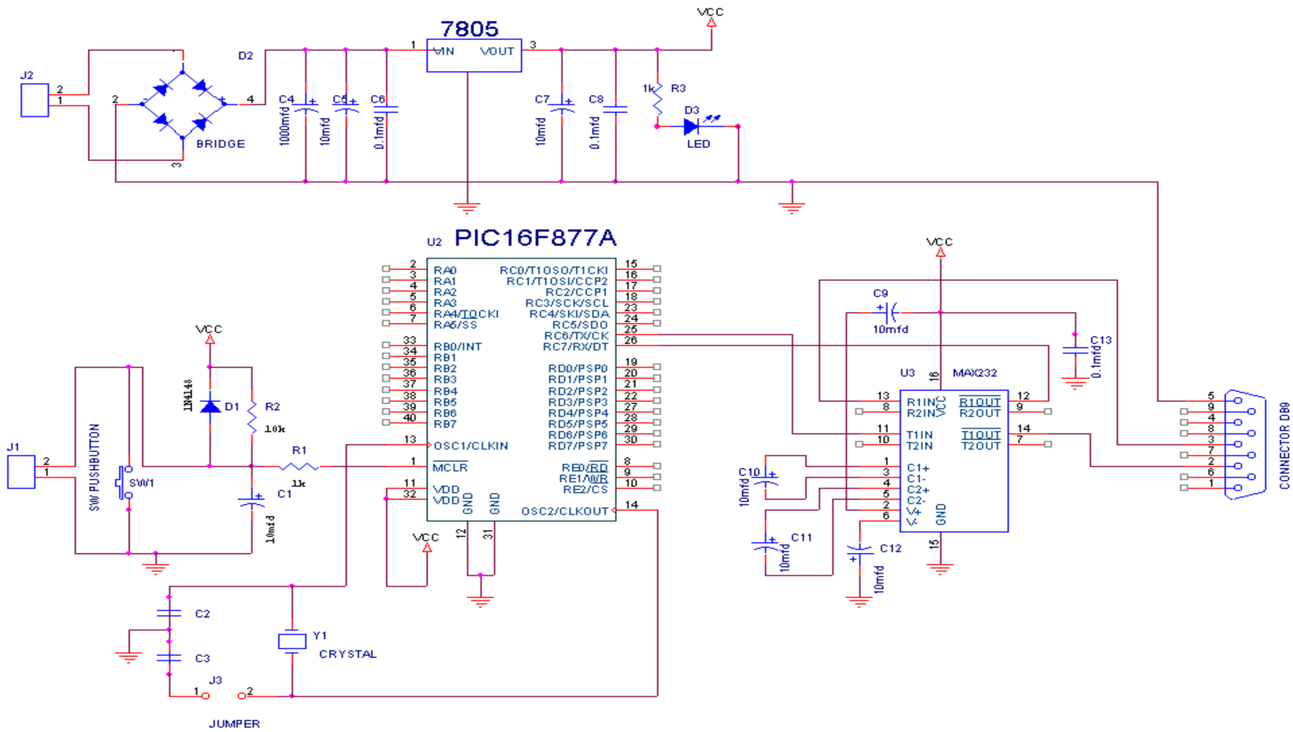


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Figure no 7 Embedded Micro Controller With RS232 interface

Now based on the breath rate, infusion will be carried out by mechanical system specifically developed for this application. Before starting the surgery predefined % of anesthesia flow will be set and can constantly infused by our system.

Once if the respiration rate goes down, anesthesia flow will be reduced to maintain respiration rate using PID controller circuit (Figure 7a) connected on the embedded controller and controlled by computer using feedback loop. If respiration rate goes up, the patients will not be co-operating for surgery because of the pain. So flow of anesthesia must be increased to maintain the constant breath rate as we described earlier using computer. The PID controller system using DAC 0808 is achieved using a software on VB6.0 and a DAC circuit and motor driver using MOSFET(Q 4) as mentioned like (figure 7c) ,and final the motor will be connected to the mechanical syringe pusher model

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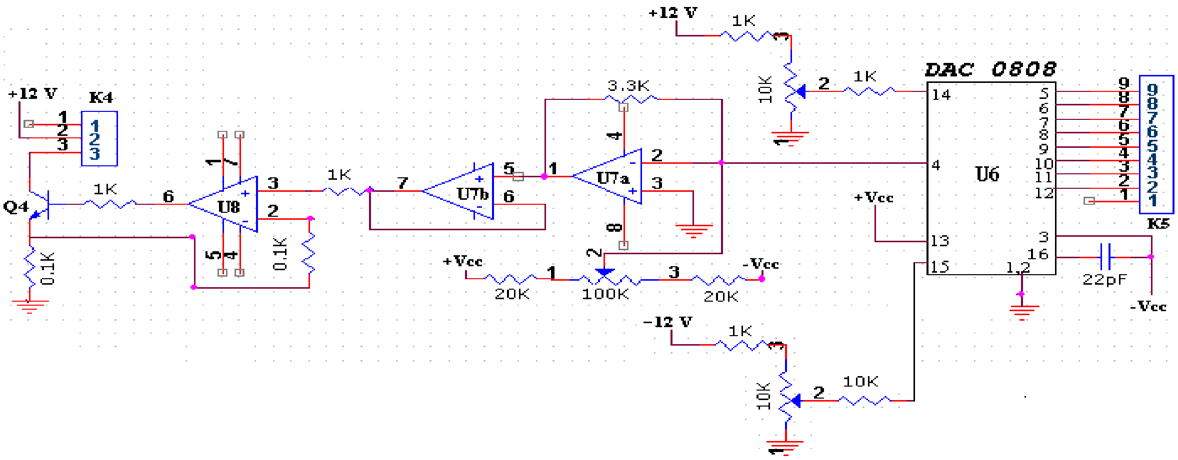

Figure no 7 a PID external hardware interface to motor

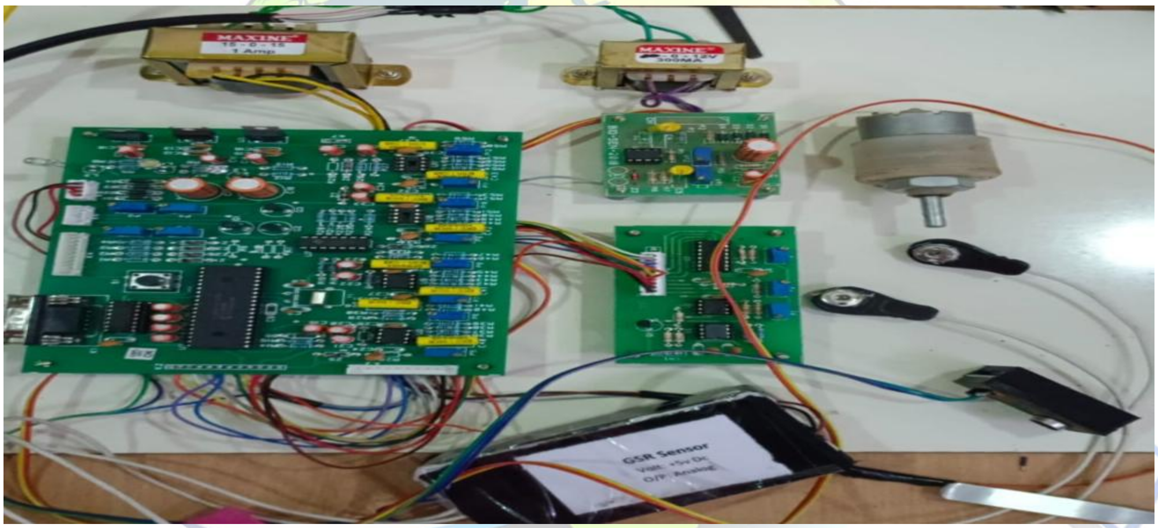

Figure 7 b Picture of Hardware prototype Model

The infusion mechanical model will be made up of lightweight non-corrosive fabric Hylam(Figure 7c). For perfect infusion control, DC motor-based rotary to linear motion mechanical model will be developed for real time application.

Figure no 7 c Mechanical model with syringe Interface

The proposed research outcome will be perfectly suits for the medical professionals to analyze pre surgery data from the patient using an excellent graphical representation of the variables in different graphs as like (figure 8). Anesthesia flow control display, providing set point ,baseline setting with continuous flow control output shown in (figure 8 a) numerical and graphical represented.

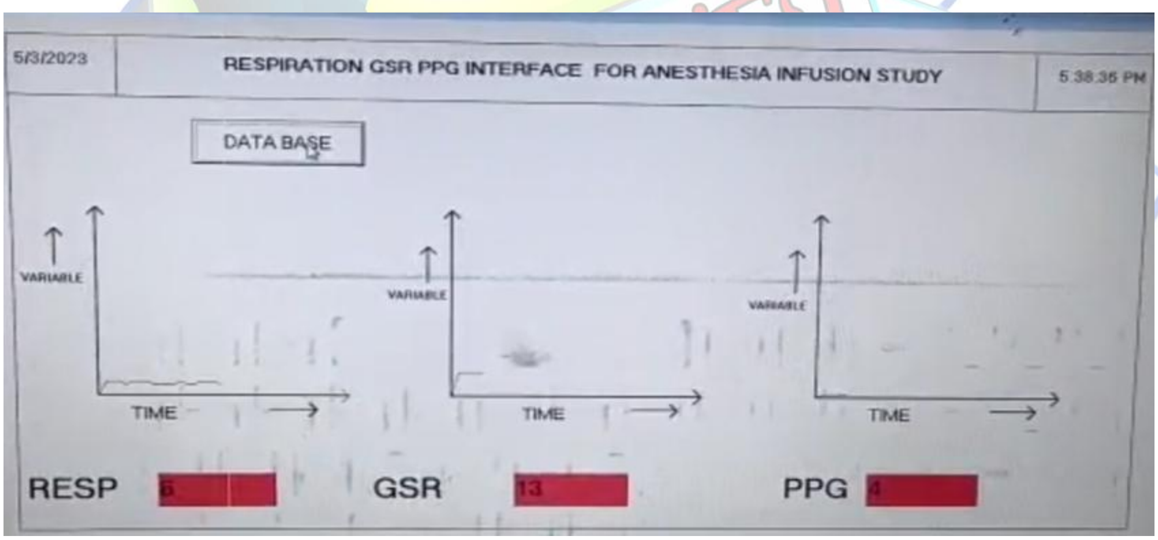


Figure no 8 Pre surgery Support system Output screen

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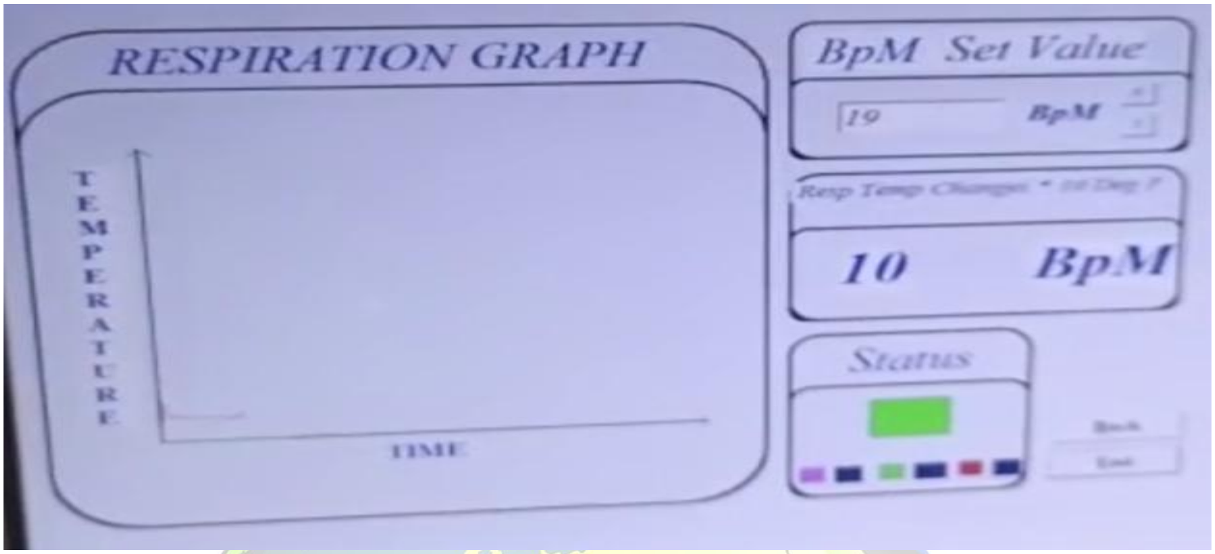


Figure no 8a Surgery Support system Output screen

CONCLUSION

This device determines the anesthesia by maintaining the range of respiration between 12-17 beats per minute using PID controller with appropriate sensing system. A compact temperature sensor PPG ,GSR is used for accuracy and easy detection. PID acts as a vital component as feedback mechanism to control process variables and are the most accurate and stable controller. The anesthesiologist who acts like an air-traffic controller closely monitors vital parameters, gives instructions and takes action when necessary for safe surgery. The proposed research based on the breath rate, infusion will be carried out automatically by electro mechanical system specifically developed for this application. Before starting the surgery predefined base line % of anesthesia flow will be set and can constantly infused by our system. Once if the respiration rate goes down, anesthesia flow will be reduced to maintain respiration rate. If respiration rate goes up, the patients will not be co-operating for surgery because of the pain. So flow of anesthesia must be increased to maintain the constant breath rate. The infusion mechanical model will be made up of lightweight non-corrosive fabric Hylam. For perfect infusion control, DC motor-based rotary to linear motion mechanical model developed for real time application.

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