BIO-MEDICAL ENGINEERING
PROJECT REPORT

MULTI-USER OXIMETER
AND
PATIENT DATA ENTRY SYSTEM

PREPARED BY:
MOHD NAZRULLAH BIN MUSTAFA (03DEU00F522)
SHAZRIL ASRUL BIN SUHAIMI (03DEU00F523)
KATHIRESH A/L RAJAGOBAL (03DEU00F515)

BIO-MEDICAL ENGINEERING

PROJECT REPORT

MULTI-USER OXIMETER
AND
PATIENT DATA ENTRY SYSTEM

Prepared By:

Mohd Nazrullah Bin Mustafa

(08DEU00F522)

Shazril Asrul Bin Suhaimi

(08DEU00F523)

Kathiresh A/L Rajagobal

(08DEU00F519)

This Report is Reresented to :

ELECTRICAL ENGINEERING DEPARTMENT

POLITEKNIK SULTAN SALAHUDDIN ABDUL AZIZ SHAH

To fulfil the requirement of

Diploma Medical Electronic Engineering

JUNE 2003

TESTIMONIAL

Hereby, we would like to declare that this project was developed and produced based on our own effort and work expect, some references and appendix that are attached together with this report.

Prepared By,

.....

Mohd Nazrullah Bin Mustafa

08DEU00F522

.....

Shazril Asrul Bin Suhaimi

08DEU00F523

.....

Kathiresh A/L Rajagobal

08DEU00F515

Certified by:-

.....

Mr Zunuwanas Mohamad

(Physiology Lecturer)

.....

Ms Wee Soo Lee

(Medical Clinical Lecturer)

.....

Mr Abu Bakar Hafiz

(Project / Physiology Lecturer)

ACKNOWLEDGEMENT

In developing this final project, we as a group have been developed by many individuals to whom we owe a dept of gratitude

No book is the work only by its author. We sincerely appreciate the cooperation of our lecturers Mr Zunuwanas bin Mohamad, Mr Abu Bakar Hafiz and Ms Wee Soo Lee.

Besides that, our gracefully thanks to the Bio-Medical Engineer of Healhcare Kumpulan Perubatan Johor, Mr Hanizan (Ampang Puteri Specialist), Mr Azhar Abu Bakar (Johor Specialist Hospital),Mr Elman El-Bakri (HTSSB HQ) and Dr Abd Razak Mohamad (Hospital Kota Tinggi) that willing help us for this project.

Lastly, we would like to take this oppornity to both of our parents. To Them we dedicated this project.

Thank you again to all who help us.

CHAPTER LIST

FIGURE LIST

CHAPTER 1
(Introduction)

INTRODUCTION

1.0 Bio-medical Engineering Project Introduction

In between to identify the bio-medical project, a lot of work we must do to make all the procedure progress and succeed. This project also to help students learn in a systematic fashion. Explanations are based on a conceptual framework that allows student to tie together individual pieces of information. Simple facts are presented first, and explanations are developed in a logical sequence. To further explain and visually supplement the project discussion, we carefully incorporate clear. Finally, to reinforce the project, clear and relevant examples are presented to helps student understand how structures function under a verity of common conditions.

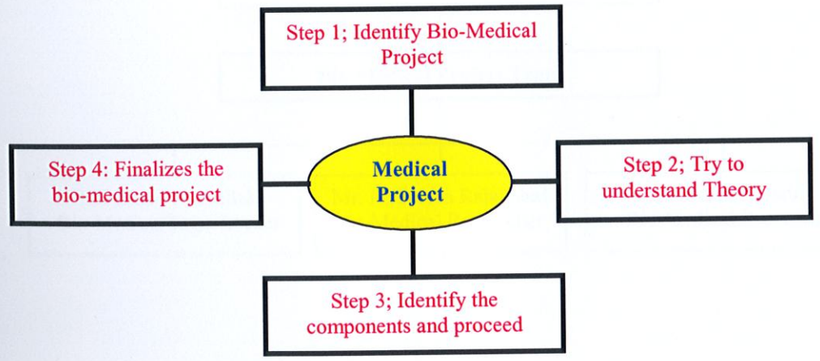


Figure 1;Project Identification Procedures

1.2 Project Team Members

Although the project build on one another, and can be though effectively in the sequence in which there are presented, care has been taken to make this bio-medical project to make this project sufficiently complete to allow them to be covered in a different as well.

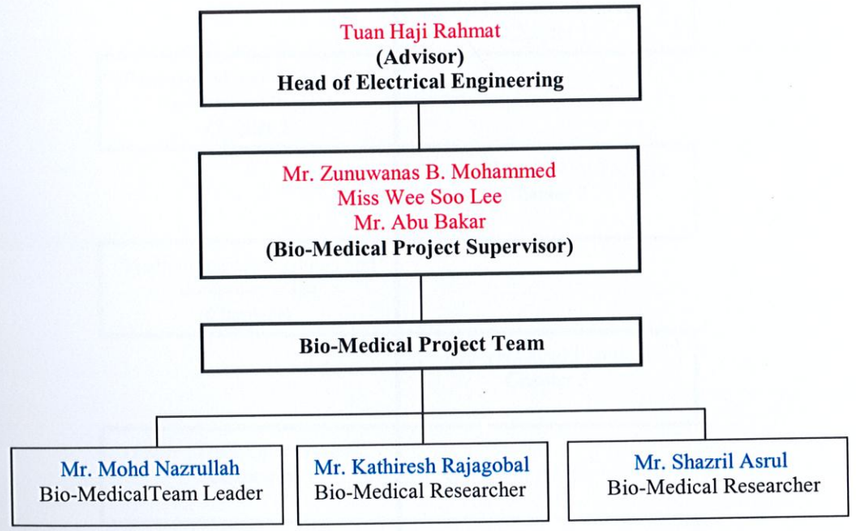


Figure 1.2(a); Team Members Chart

The order of chapters in the text is fairly traditional and is similar to that found in many order texts at this level. However, the content of the chapter and the organization of the information within each chapter are, in many ways, unique. The content in this project report is organized in what we feel is the best framework about this project.

Project Content

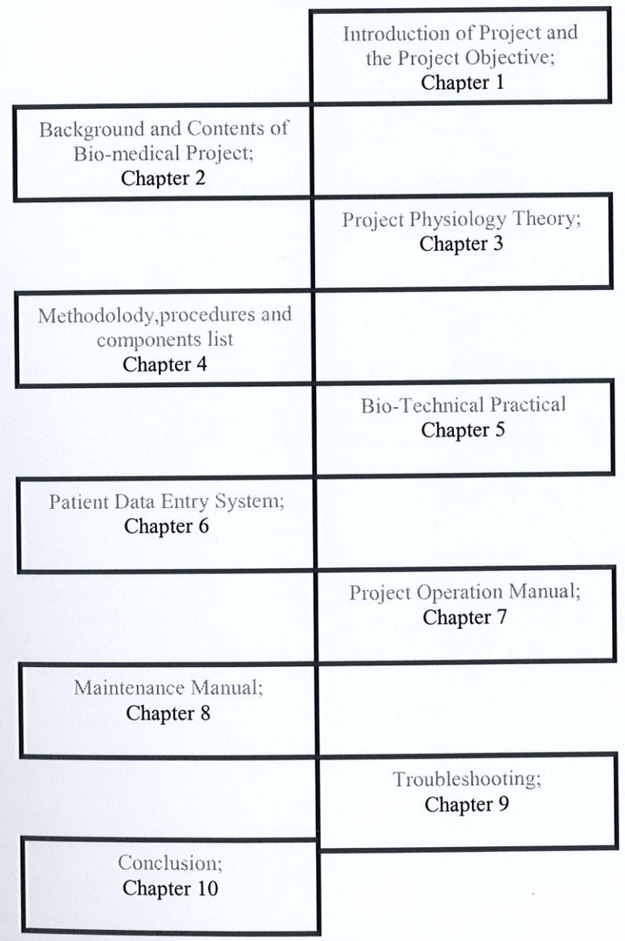


Figure 1.2(b) : Project Chapter Overview

CHAPTER 2
(Project Background)

PROJECT BACKGROUND

2.0 Project Background (Multi-oximeter)

Multi user oximetry and human body temperature is a useful method of monitoring patients in many circumstances, and in the face of limited resources, the pulse oximeter may represent a wise choice of monitor, as with training it allows for the assessment of several different patient parameters.

Oximeters are now a standard part of perioperative monitoring which give the operator a non-invasive indication of the patient's cardio-respiratory status. Having been successfully used in intensive care, the recovery room and during anaesthesia, they have been introduced in other areas of medicine such as general wards apparently without staff undergoing adequate training in their use [(1)]. The technique of project does have pitfalls and limitations and it is possible that patient safety may be compromised with untrained staff. This article is therefore intended for the 'occasional' user of this design.

This instrument measures the pulse rate, heart rate and human body temperature. The technology involved [(2)] is complicated but there are two basic physical principles. First, the absorption of light at two different wavelengths by heart beat differs depending on the degree of pulse beat per minute. Second, the light signal following transmission through the tissues has a pulsatile component, resulting from the changing volume of arterial blood with each pulse beat. This can be distinguished by the microprocessor from the non-pulsatile component resulting from venous, capillary and tissue light absorption.

What does a multi user measure?

1. The human body temperature- which is a measure of the average amount human body temperature is given as a digital readout together with an audible signal varying in pitch depending on the temperature saturation.
2. The pulse rate - in beats per minute, averaged over 5 to 20 seconds.

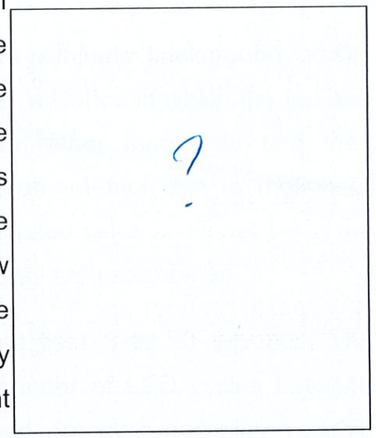
A multi user gives no information on any of these other variables:

- The amount of human body temperature
- The respiratory rate or tidal volume i.e. ventilation
- The cardiac beat per minute and pulse rate per minute

Principles of multi user isntrument

Oxygen is carried in the bloodstream mainly bound to haemoglobin. One molecule of haemoglobin can carry up to four molecules of oxygen, which is then 100% saturated with oxygen. The average percentage saturation of a population of haemoglobin molecules in a blood sample is the oxygen saturation of the blood. In addition, a very small quantity of oxygen is carried dissolved in the blood, which can become important if the haemoglobin levels are extremely low. The latter, however, is not measured bymulti user instrument.

The relationship between the arterial partial pressure of oxygen (PaO2) and the oxygen saturation is described by the haemoglobin-oxygen dissociation curve (see figure 1). The sigmoid shape of this curve facilitates unloading of oxygen in the peripheral tissues where the PaO2 is low and oxygen is required for respiration. The curve may be shifted to the left or right by various patient characteristics e.g. recent blood transfusion, pyrexia.



A multi user instrument consists of a peripheral probe, together with a microprocessor unit, displaying a beat per minute, the human body temperature and the pulse rate. Most multi user instrument (oximetery) also have an audible pulse tone, the pitch of which is proportional to the oxygen saturation - useful when one cannot see the oximeter display. The probe is placed on a peripheral part of the body such as a digit, ear lobe or the nose. Within the probe are two light emitting diodes (LED's), one in the visible red spectrum (660nm) and the other in the infrared spectrum (940nm). The beams of light pass through the tissues to a photodetector. During passage through the tissues, blood and soft tissues depending on the concentration of haemoglobin absorb some light.

The microprocessor can select out the absorbance of the pulsatile fraction of blood, i.e. that due to arterial blood, from constant absorbance due to non-pulsatile venous or capillary blood and other tissue pigments. Several recent advances in microprocessor technology have reduced the effects of interference on pulse oximeter function. Time division multiplexing, whereby the LED's are cycled: red on, then infrared on, then

both off, many times per second, helps to eliminate background 'noise'. Quadrature division multiplexing is a further advance in which the red and infrared signals are separated in phase rather than time and then recombined in phase later. In this way, an artefact due to motion or electromagnetic interference may be eliminated since it will not be in the same phase of the two LED signals once they are recombined.

Saturation values are averaged out over 5 to 20 seconds. The pulse rate is also calculated from the number of LED cycles between successive pulsatile signals and averaged out over a similar variable period of time, depending on the particular monitor.

From the proportions of light absorbed at each light frequency, the microprocessor calculates the ratio of the two. Within the oximeter memory is a series of oxygen saturation values obtained from experiments performed in which human volunteers were given increasingly hypoxic mixtures of gases to breath. The microprocessor compares the ratio of absorption at the two light wavelengths measured with these stored values, and then displays the oxygen saturation digitally as a percentage and audibly as a tone of varying pitch. As it is unethical to desaturate human volunteers below 70%, it is vital to appreciate that oxygen saturation values below 70% obtained by pulse oximetry are unreliable.

Reflection pulse oximetry uses reflected rather than transmitted light on a single-sided monitor. It can therefore be used more proximally anatomically e.g. forehead, bowel, although it may be difficult to secure. Other than using specific reflection spectra, the principles are the same as for transmission oximetry.

Practical tips to the successful use of multi user unit:

- Plug the multi user instrument in to an electrical socket, if available, to recharge the batteries.
- Turn the multi user instrument on and wait for it to go through its calibration and check tests.
- Select the probe you require with particular attention to correct sizing and where it is going to go. The digit should be clean (remove nail varnish).
- Position the probe on the chosen digit, avoiding excess force.
- Read off the displayed human body temperature and pulse rate. ** Be cautious interpreting figures where there has been an instantaneous change in saturation - for example 99% falling suddenly to 85%. This is physiologically not possible.*
- If in doubt, rely on your clinical judgement, rather than the value the machine gives.

Uses of pulse oximetry

- Simple, portable "all-in-one" monitor of oxygenation, pulse rate and rhythm regularity, suitable for "field" use.
- As a safe, non-invasive monitor of the cardio-respiratory status of high-dependency patients - in the emergency department, during general and regional anaesthesia, postoperatively and in intensive care. This includes procedures such as endoscopy, where often-frail patients are given sedative drugs such as midazolam. Pulse oximeters detect the presence of cyanosis more reliably than even the best doctors do when using their clinical judgement.

- During the transport of patients - especially when this is noisy - for example in aircraft, helicopters or ambulances. The audible tone and alarms may not be heard, but if a waveform can be seen together with an acceptable oxygen saturation, this gives a global indication of a patient's cardio-respiratory status.

- To assess the viability of limbs after plastic and orthopaedic surgery and, for example, following vascular grafting, or where there is soft tissue swelling or aortic dissection. As a pulse oximeter requires a pulsatile signal under the sensor, it can detect whether a limb is getting a blood supply.

- As a means of reducing the frequency of blood gas analysis in intensive care patients- especially in paediatric practice where vascular (arterial) access may be more difficult.

- To limit oxygen toxicity in premature neonates' supplemental oxygen can be tapered to maintain an oxygen saturation of 90% - thus avoiding the damage to the lungs and retinas of neonates. Although pulse oximeters are calibrated for adult haemoglobin, HbA, the absorption spectra of HbA and HbF are almost identical over the range used in pulse oximetry, so the technique remains reliable in neonates.

- During thoracic anaesthesia - when one lung is being collapsed down - to determine whether oxygenation via the remaining lung is adequate or whether increased concentrations of oxygen must be given.

- Fetal oximetry- a developing technique that uses reflectance oximetry, using LEDs of 735nm and 900nm. The probe is placed

over the temple or cheek of the fetus, and needs to be sterile and sterilisable. They are difficult to secure and the readings are variable, for physiological and technical reasons. Hence the trend is more useful than the absolute value.

Limitations of pulse oximetry

1. **Not a monitor of ventilation** A recent case report [3,4] highlighted the false sense of security provided by pulse oximetry. An elderly woman postoperatively in the recovery room was receiving oxygen by facemask. She became increasingly drowsy, despite having an oxygen saturation of 96%. The reason was that her respiratory rate and minute volume were low due to residual neuromuscular block and sedation, yet she was receiving high concentrations of inspired oxygen, so her oxygen saturation was maintained. She ended up with an arterial carbon dioxide concentration of 280 mmHg (normal 40 mmHg) and was ventilated for 24 hours on intensive care. Thus oximetry gives a good estimation of adequate oxygenation, but no direct information about ventilation, particularly as in this case, when supplemental oxygen is being administered.
2. **Critically ill patients** It may be less effective in very sick patients, because tissue perfusion may be poor and thus the oximeter probe may not detect a pulsatile signal.
3. **Waveform presence** If there is no waveform visible on a pulse oximeter, any percentage saturation values obtained are meaningless.

4. **Inaccuracies** Bright overhead lighting, shivering and motion artefact may give pulsatile waveforms and saturation values when there is no pulse.

5. Abnormal haemoglobins such as methaemoglobinaemia, for example following overdose of prilocaine, cause readings to tend towards 85%.

6. Carboxyhaemoglobin caused by carbon monoxide poisoning, causes saturation values to tend towards 100%. A pulse oximeter is extremely misleading in cases of carbon monoxide poisoning for this reason and should not be used. CO-oximetry is the only available method of estimating the severity of carbon monoxide poisoning.

7. Dyes and pigments, including nail varnish, may give artificially low values.

8. Vasoconstriction and hypothermia cause reduced tissue perfusion and failure to register a signal.

9. Rare cardiac valvular defects such as tricuspid regurgitation cause venous pulsation and therefore venous oxygen saturation is recorded by the oximeter.

10. Oxygen saturation values less than 70% are inaccurate as there are no control values to compare them to.

11. Cardiac arrhythmias may interfere with the oximeter picking up the pulsatile signal properly and with calculation of the pulse rate.

NB. Age, sex, anaemia, jaundice and dark-skin have little or no effects on oximeter function.

12. **Lag monitor** this means that the partial pressure of oxygen can have fallen a great deal before the oxygen saturation starts to fall. If a healthy adult patient is given 100% oxygen to breathe for a few minutes and then ventilation ceases for any reason, several minutes may elapse before the oxygen saturation starts to fall. A pulse oximeter in these circumstances warns of a potentially fatal complication several minutes after it has happened. The pulse oximeter has been described as "a sentry standing at the edge of the cliff of desaturation." because of this fact. The explanation of this lies in the sigmoid shape of the haemoglobin / oxygen dissociation curve (figure 1).

13. **Response delay** due to signal averaging. This means that there is a delay after the actual oxygen saturation starts to drop because the signal is averaged out over 5 to 20 seconds.

14. **Patient safety** there have been one or two case reports of skin burns or pressure damage under the probe because some early probes had a heater unit to ensure adequate skin perfusion. The probe should be correctly sized, and should not exert excessive pressure. Special probes are now available for paediatric use. The penumbra effect re-emphasises the importance of correct probe positioning. This effect causes falsely low readings and occurs when the probe is not symmetrically placed, such that the pathlength between the two LEDs and the photodetector is unequal, causing one wavelength to be "overloaded". Repositioning of the probe often leads to sudden improvement in saturation readings. The penumbra effect may be compounded by the presence of variable blood flow through cutaneous pulsatile

venules. Note that the waveform may appear normal despite the penumbra effect as it measures predominantly one wavelength only.

Alternatives to multi user instrument?

- Bench CO-oximetry is the gold standard - and is the classic method by which a pulse oximeter is calibrated. The CO-oximeter calculates the actual concentrations of haemoglobin, deoxyhaemoglobin, carboxyhaemoglobin and methaemoglobin in the sample and hence calculates the actual oxygen saturation. CO-oximeters are much more accurate than pulse oximeters - to within 1%, but they give a 'snapshot' of oxygen saturation, are bulky, expensive and require constant maintenance as well as requiring a sample of arterial blood to be taken.

- Blood gas analysis - requires an invasive sample of arterial blood. It gives the 'full picture', including arterial partial pressure of oxygen and carbon dioxide, arterial pH, actual and standardised base excess and actual and standardised bicarbonate concentrations. Many blood gas analysers report a calculated saturation, which is less accurate than that provided by the pulse oximeter.

Summary Points

1. Pulse oximeters give non-invasive estimation of the arterial haemoglobin oxygen saturation.
2. Useful in: anaesthesia, recovery, intensive care (including neonatal), and patient transport.

3. 2 principles involved: a) Pulse rate and haert rate

   b) Human Body Temperature

4. Differential light absorption by haemoglobin and oxyhaemoglobin.
5. Identification of pulsatile component of signal.
6. No direct indication of a patient's ventilation, only of their oxygenation.
7. Lag monitor - time delay between potentially hypoxic event such as respiratory obstruction and a pulse oximeter detecting low oxygen saturation.
8. Inaccuracies: ambient light; shivering and vasoconstriction; abnormal haemoglobins; and alterations in pulse rate and rhythm.
9. Advances in microprocessor have led to improved signal processing.

2.1 Project View/illustration

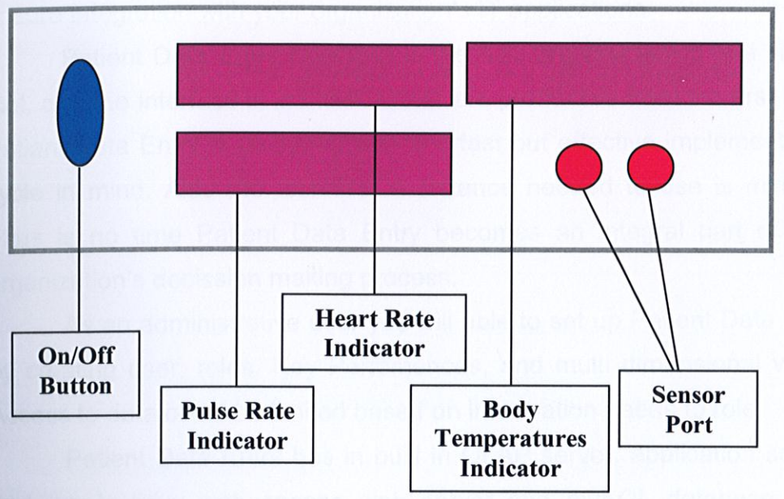


Figure 2.1(a); Project Front View

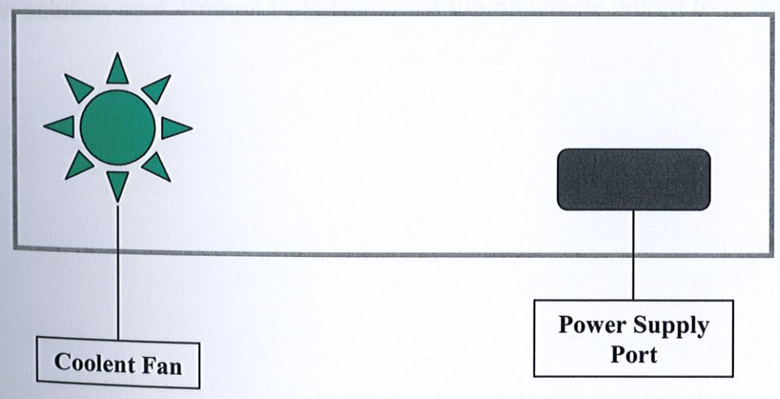


Figure 2.1 (b); Project Back View

2.1 Project Background (Patient Data Entry System)

Patient Data Entry System is a web based decision support Application that combines the power of data warehousing and Business Intelligent Technology. Patient Data Entry is built on open systems to ensure integration with your organization's IT applications.

Patient Data Entry front end is the web browser which is a similar tool, and the interface is intuitive. Users are produvtive from the first hour. Patient Data Entry is designed with shortest but effective implementation cycle in mind. Also the technical assistance needed to use is minimal. Thus is no time Patient Data Entry becomes an integral part of your organization's decission making process.

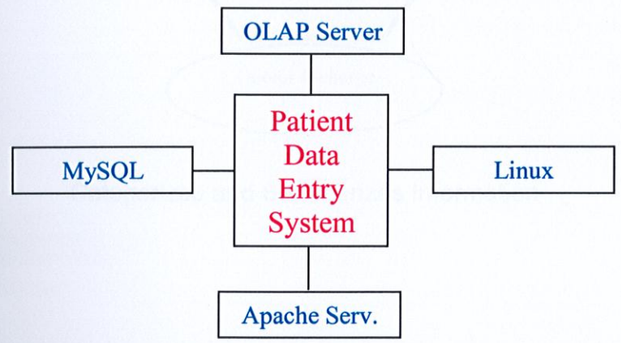
As an administrative user you will able to set up Patient Data Entry by creating user, roles, Key Perfomences, and multi dimensional views. Access to data could be limited based on information needs to role.

Patient Data Entry has in built in OLAP server, application server, and run in linux with apache web server and mySQL database. This means no other component is required for implementation and hence the low solution cost. Patient Data Entry can run on Oracle where required.

2.1.1 Patient Data Entry (PDS System) Keeps You Connected

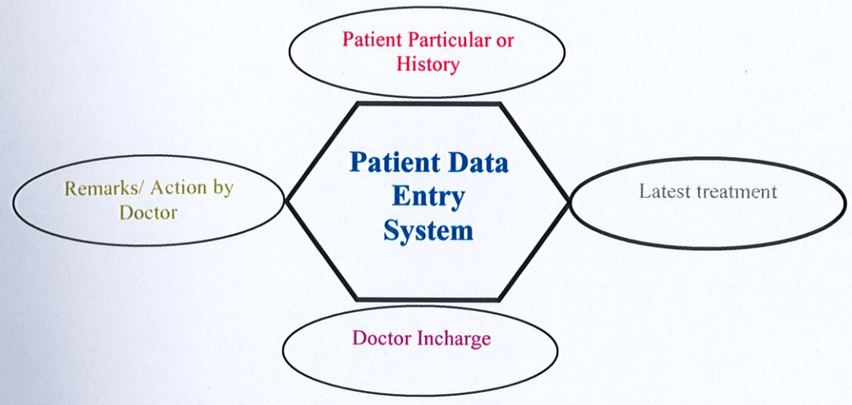
Patient Data Entry (PDS System) helps by collecting patient data from your exisiting systems and data bases, and tranforming them into the various management dashboard and alerts for you and your key managers.

It also categorizes and summarizes information, and prepare graphical views and multi-dimensial reports. Its easy to use drill-down feature lets you zoom in on any aspect of your business instantly.



Patient Data Entry (PDS System) Interface Framework

2.1.2 Patient Data Entry (PDS System) Format



Categorizes and Summarizes Information

CHAPTER 3
(Physiology Theory)

HUMAN BODY TEMPERATURE

3.0 Body temperature and sensation.

Heat kills by taxing the human body beyond its abilities. In a normal year, about 175 Americans succumb to the demands of summer heat. Among the large continental family of natural hazards, only the cold of not lightning, hurricanes, tornadoes, floods, or earthquakes - takes a greater toll. In the 40-year period from 1936 through 1975, nearly 20,000 people were killed in the United States by the effects of heat and solar radiation. In the disastrous heat wave of 1980, more than 1,250 people died.

And these are the direct casualties. No one can know how many more deaths are advanced by heat wave weather - how many diseased or aging hearts surrender that under better conditions would have continued functioning.

North American summers are hot; most summers see heat waves in one section or another of the United States. East of the Rockies, they tend to combine both high temperature and high humidity although some of the worst have been catastrophically dry.

National Weather Service Heat Index

Considering this tragic death toll, the National Weather Service (NWS) has stepped up its efforts to alert more effectively the general public and appropriate authorities to the hazards of heat waves - those prolonged excessive heat/humidity episodes.

Based on the latest research findings, the NWS has devised the "Heat Index" (HI), (sometimes referred to as the "Apparent Temperature"). The HI, given in degrees F, is an accurate measure of how hot it really feels when effects of the relative humidity (RH) is added to the actual air temperature.

HEAT INDEX °F (°C)													
	RELATIVE HUMIDITY (%)												
Temp.	40	45	50	55	60	65	70	75	80	85	90	95	100
110	136												
(47)	(58)												
108	130	137											
(43)	(54)	(58)											
106	124	130	137										
(41)	(51)	(54)	(58)										
104	119	124	131	137									
(40)	(48)	(51)	(55)	(58)									
102	114	119	124	130	137								
(39)	(46)	(48)	(51)	(54)	(58)								
100	109	114	118	124	129	136							
(38)	(43)	(46)	(48)	(51)	(54)	(58)							
98	105	109	113	117	123	128	134						
(37)	(41)	(43)	(45)	(47)	(51)	(53)	(57)						
96	101	104	108	112	116	121	126	132					
(36)	(38)	(40)	(42)	(44)	(47)	(49)	(52)	(56)					
94	97	100	103	106	110	114	119	124	129	135			
(34)	(36)	(38)	(39)	(41)	(43)	(46)	(48)	(51)	(54)	(57)			
92	94	96	99	101	105	108	112	116	121	126	131		
(33)	(34)	(36)	(37)	(38)	(41)	(42)	(44)	(47)	(49)	(52)	(55)		
90	91	93	95	97	100	103	106	109	113	117	122	127	132
(32)	(33)	(34)	(35)	(36)	(38)	(39)	(41)	(43)	(45)	(47)	(50)	(53)	(56)
88	88	89	91	93	95	98	100	103	106	110	113	117	121
(31)	(31)	(32)	(33)	(34)	(35)	(37)	(38)	(39)	(41)	(43)	(45)	(47)	(49)
86	85	87	88	89	91	93	95	97	100	102	105	108	112
(30)	(29)	(31)	(31)	(32)	(33)	(34)	(35)	(36)	(38)	(39)	(41)	(42)	(44)
84	83	84	85	86	88	89	90	92	94	96	98	100	103
(29)	(28)	(29)	(29)	(30)	(31)	(32)	(32)	(33)	(34)	(36)	(37)	(38)	(39)
82	81	82	83	84	84	85	86	88	89	90	91	93	95
(28)	(27)	(28)	(28)	(29)	(29)	(29)	(30)	(31)	(32)	(32)	(33)	(34)	(35)
80	80	80	81	81	82	82	83	84	84	85	86	86	87
(27)	(27)	(27)	(27)	(27)	(28)	(28)	(28)	(29)	(29)	(29)	(30)	(30)	(31)

To determine the Heat Index, look at the Heat Index Chart above. As an example, if the air temperature is 96 degrees F (found on the left side of the table) and the RH is 55% (found at the top of the table), the HI - or how hot it really feels - is 112 degrees F. This is at the intersection of the 96 degree row and the 55% column.

IMPORTANT...Since HI values were devised for shady, light wind conditions, EXPOSURE TO FULL SUNSHINE CAN INCREASE HI VALUES BY UP TO 15 degrees F. Also, STRONG WINDS, PARTICULARLY WITH VERY HOT, DRY AIR, CAN BE EXTREMELY HAZARDOUS.

Heat Index/Heat Disorders

Category	Heat Index	Possible heat disorders for people in high risk groups
Extreme Danger	130°F or higher (54°C or higher)	Heat stroke or sunstroke likely.
Danger	105 - 129°F (41 – 54°C)	Sunstroke, muscle cramps, and/or heat exhaustion likely. Heatstroke possible with prolonged exposure and/or physical activity.
Extreme Caution	90 – 105°F (32 – 41°C)	Sunstroke, muscle cramps, and/or heat exhaustion possible with prolonged exposure and/or physical activity.
Caution	80 - 90°F (27 – 32°C)	Fatigue possible with prolonged exposure and/or physical activity.

Summary of Alert Procedures

The NWS will initiate alert procedures when the HI is expected to exceed 105 degrees to 110 degrees F (depending on local climate) for at least two consecutive days. The procedures are:

- Include HI values in zone and city forecasts.
- Issue Special Weather Statements and/or Public Information Statements presenting a detailed discussion of
    - the extent of the hazard including HI values,
    - who is most at risk,
    - safety rules for reducing the risk.
    - Assist state/local health officials in preparing Civil Emergency Messages in severe heat waves. Meteorological information from Special Weather Statements will be included as well as more

detailed medical information, advice, and names and telephone numbers of health officials.

How Heat Affects the Body

Human bodies dissipate heat by varying the rate and depth of blood circulation, by losing water through the skin and sweat glands, and - as the last extremity is reached - by panting, when blood is heated above 98.6 degrees. The heart begins to pump more blood, blood vessels dilate to accommodate the increased flow, and the bundles of tiny capillaries threading through the upper layers of skin are put into operation. The body's blood is circulated closer to the skin's surface, and excess heat drains off into the cooler atmosphere. At the same time, water diffuses through the skin as perspiration. The skin handles about 90 percent of the body's heat dissipating function. Sweating, by itself, does nothing to cool the body, unless the water is removed by evaporation - and high relative humidity retards evaporation. The evaporation process itself works this way: the heat energy required to evaporate the sweat is extracted from the body, thereby cooling it. Under conditions of high temperature (above 90 degrees) and high relative humidity, the body is doing everything it can to maintain 98.6 degrees inside. The heart is pumping a torrent of blood through dilated circulatory vessels; the sweat glands are pouring liquid - including essential dissolved chemicals, like sodium and chloride - onto the surface of the skin.

Too Much Heat

Heat disorders generally have to do with a reduction or collapse of the body's ability to shed heat by circulatory changes and sweating, or a chemical (salt) imbalance caused by too much sweating. When heat gain exceeds the level the body can remove, or when the body cannot

compensate for fluids and salt lost through perspiration, the temperature of the body's inner core begins to rise and heat-related illness may develop. Ranging in severity, heat disorders share one common feature: the individual has overexposed or overexercised for his age and physical condition in the existing thermal environment. Sunburn, with its ultraviolet radiation burns, can significantly retard the skin's ability to shed excess heat. Studies indicate that, other things being equal, the severity of heat disorders tend to increase with age - heat cramps in a 17-year-old may be heat exhaustion in someone 40, and heat stroke in a person over 60. Acclimatization has to do with adjusting sweat-salt concentrations, among other things. The idea is to lose enough water to regulate body temperature. with the least possible chemical disturbance.

Cities Pose Special Hazards

The stagnant atmospheric conditions of the heat wave trap pollutants in urban areas and add the stresses of severe pollution to the already dangerous stresses of hot weather, creating a health problem of undiscovered dimensions. A map of heat-related deaths in St. Louis during 1966, for example, shows a heavier concentration in the crowded alleys and towers of the inner city, where air quality would also be poor during a heat wave. The high inner-city death rates also can be read as poor access to air-conditioned rooms. While air-conditioning may be a luxury in normal times, it can be a lifesaver during heat wave conditions. The cost of cool air moves steadily higher, adding what appears to be a cruel economic side to heat wave fatalities. Indications from the 1980 Texas heat wave suggest that some elderly people on fixed incomes, many of them in buildings that could not be ventilated without air conditioning, found the cost too high, turned off their units, and ultimately succumbed to the stresses of heat.

Preventing Heat-Related Illness

Elderly persons, small children, chronic invalids, those on certain medications or drugs (especially tranquilizers and anticholinergics), and persons with weight and alcohol problems are particularly susceptible to heat reactions, especially during heat waves in areas where a moderate climate usually prevails.

Know These Heat Disorder Symptoms

- **SUNBURN:** Redness and pain. In severe cases swelling of skin, blisters, fever, headaches. Ointments for mild cases if blisters appear and do not break. If breaking occurs, apply dry sterile dressing. Serious, extensive cases should be seen by physician.
- **HEAT CRAMPS:** Painful spasms usually in muscles of legs and abdomen possible. Heavy sweating. Firm pressure on cramping muscles, or gentle massage to relieve spasm. Give sips of water. If nausea occurs, discontinue use.
- **HEAT EXHAUSTION:** Heavy sweating, weakness, skin cold, pale, and clammy. Pulse thready. Normal temperature possible. Fainting and vomiting. Get victim out of sun. Lay down and loosen clothing. Apply cool, wet cloths. Fan or move victim to air conditioned room. Sips of water. If nausea occurs. discontinue use. If vomiting continues, seek immediate medical attention.
- **HEAT STROKE or SUN STROKE:** High body temperature (106 degrees F or higher). Hot dry skin. Rapid and strong pulse.
- Possible unconsciousness. HEAT STROKE IS A SEVERE MEDICAL EMERGENCY SUMMON EMERGENCY MEDICAL ASSISTANCE OR

GET THE VICTIM TO A HOSPITAL IMMEDIATELY. DELAY CAN BE FATAL. Move the victim to a cooler environment. Reduce body temperature with cold bath or sponging. Use extreme caution. Remove clothing, use fans and air conditioners. If temperature rises again, repeat process. Do not give fluids.

You can use this calculator for temperature conversion, windchill, relative humidity, and the Heat Index.

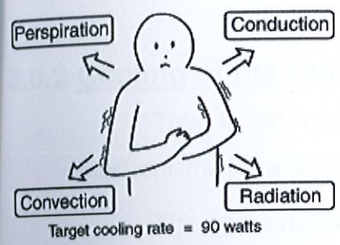
Humans are homeotherms , meaning uniform or warm blood animals ; that is, we can maintain a constant body temperature , even though the environmental temperature varies. Maintenance of the constant body temperature is very important to homeostasis . Most enzymes are very temperature sensitive and function only within narrow temperature ranges . Environmental temperature are too low for normal enzymes function. The heat produce by metabolism and muscle contraction helps maintain the body temperature at steady , elevated level that is high enough for normal enzymes function . Excessively high temperature can alter enzymes structure , resulting in the loss of the enzymes function .

Free energy is the total amount energy that can be liberated by the complete catabolism is of food. About 40% of the total energy released by the catabolism is used to accomplish biological work such as anabolism , Muscular contraction and other cellular activities . The remaining energy is lost as heat .Normal body temperature is regulated like other homeostatic conditions in the body . The average normal temperature is usually considered to be 30ºc when it is measured manually orally , and 37.6 ºc when it is measured rectally . Rectal temperature comes closer to be the true core body temperature , but an oral temperature is more easily obtained in older children and therefore is the preferred measure. The

normal oral temperature may very from person to person , with a range of approximately 36.1ºc to 37.2ºc .Body temperature is maintained by balancing heat input with heat loss. Heat exchanged between the body and the environmental occurs in a number of ways . Radiation is the gain or loss of heat as infrared energy between two objects that are not in physical contact with each other. For example , heat can be gained by radiation from the sun , a hot coal , or the hot sand of a beach . On the other hand , heat can be lost as radiation to cool vegetation, Water in the ocean , and now on the ground .

Conduction is the exchange of heat between objects that that in the direct contact with each other , such as the bottom of the feet and the ground . Convection is transfers of heat between the body and loss of heat from a liquid to a gaseous form. As water evaporates from body surfaces , heat is lost .

3.0.1 Temperature Regulation of the Human Body



Target cooling rate = 90 watts

The human body has the remarkable capacity for regulating its core temperature somewhere between 98°F and 100°F when the ambient temperature is between approximately 68°F and 130°F according to Guyton. This presumes a nude body and dry air.

The external heat transfer mechanisms are radiation, conduction and convection and evaporation of perspiration. The process is far more than the passive operation of these heat transfer mechanisms, however. The body takes a very active role in temperature regulation.

The temperature of the body is regulated by neural feedback mechanisms which operate primarily through the hypothalmus. The hypothalmus contains not only the control mechanisms, but also the key temperature sensors. Under control of these mechanisms, sweating begins almost precisely at a skin temperature of 37°C and increases rapidly as the skin temperature rises above this value. The heat production of the body under these conditions remains almost constant as the skin temperature rises. If the skin temperature drops below 37°C a variety of responses are initiated to conserve the heat in the body and to increase heat production. These include

- Vasoconstriction to decrease the flow of heat to the skin.
- Cessation of sweating.

- Shivering to increase heat production in the muscles.
- Secretion of norepinephrine, epinephrine, and thyroxine to increase heat production
- In lower animals, the erection of the hairs and fur to increase insulation

3.0.2 Cooling of the Human Body

This is an active graphic. Click on one of the heat transfer mechanisms for a discussion of its role in cooling the human body.

This is a simplified model of the process by which the human body gives off heat. Even when inactive, an adult male must lose heat at a rate of about 90 watts as a result of his basal metabolism. One implication of the model is that radiation is the most important heat transfer mechanism at ordinary room temperatures.

This model indicates that an unclothed person at rest in a room temperature of 23 Celsius or 73 Fahrenheit would be uncomfortably cool. Select one of the cooling mechanisms for further details about how the model numbers were obtained. The skin temperature of 34 C is a typical skin temperature taken from physiology texts, compared to the normal core body temperature of 37 C.

3.0.3 Body Temperature Regulation

Since you are a warm-blooded animal, your body attempts to keep its internal temperature constant. Human life is only compatible with a narrow range of temperatures:

Temperature (C)	Symptoms
28	muscle failure
30	loss of body temp. control
33	loss of consciousness
37	normal
42	central nervous system breakdown
44	death*

(* by irreversible protein "denaturation", or unfolding; once their shape changes, they cease to function properly.) As we will see in the next section, you are constantly generating heat, and so your body must take active steps to lose that heat. The following table illustrates the power cost of various common activities:

Activity	Energy Cost (Cal/m^2 hr)
sleeping	35
sitting	50
working at a desk	60
standing	85
washing & dressing	100
walking (3 mph)	140
bicycling	250
swimming	350
running	600

Approximately 80 % of these costs is waste heat. The other side of this coin is cold weather: your body must then work to stay warm. The mechanisms which either are used by your body or affect its function are "conduction", "convection", "radiation" and "evaporation".

Conduction is the flow of heat energy from regions of warmer temperature to regions of cooler temperature. In Chapter 4, we associated this with the electric potential (voltage), whose gradient (the electric field) was responsible for the motion of charges (current). Similarly, in Section A of the present chapter we spoke briefly about the diffusion current, which represented the motion of particles due to a concentration gradient. The

three are mutually analogous, as we see in the following equation for the "heat current" (rate of heat flow):

$$Q / t = k A T / x,$$

where k is the "conductivity". Note that since the temperature occurs as a linear difference, you can use Celsius as well as Kelvin scales. The analogy to Ohm's Law is made complete by equating Q / t to I, T to V, and x / k A to R (resistively corresponds to 1 / k). Note that in this analogy, R would have units of C / Watt; this is the common "R-value" of insulation. When multiple layers of insulating material are used (i.e., in clothing), the "total resistance" to heat flow is just the sum of the individual resistances. Some useful conductivity are given in the following table: Assume that you walk at 2.2 mph on flat ground. At this speed, an average person burns 3.33 kcal / min, 80% of which must be lost in heat . Consider first the conduction of heat from the center of your body to the skin. Assuming that the average area (inside the body) through which heat is conducted is 1 square meter and that the average distance the heat must travel is 10 cm, the temperature difference necessary to maintain normal body temperature is 89K! Clearly your body cannot rely on conduction for this service! Now consider the conduction of heat away from the skin. Due to the nature of the surface of your body, it has a "private climate" about 3 mm deep through which the temperature changes from skin temperature to the surrounding air temperature. At room temperature, a person with 2 square meters of body surface area must (when nude) have a skin temperature of almost 32 C when the air is still. This is actually a pretty reasonable estimate.

Convection is the movement of heat by currents in the medium, ie., the wind. The convection current in Watts is (empirically)

$$Q / t = 14.5 A \text{ Sqrt } (v) T$$

when A is measured in square meters and v is the (wind) speed in m / s. Still air actually has a convection velocity of .23 m / s (called "natural convection") because warm air rises. For the body in air, convection is in series with private climate conduction. Within the body, blood convection is used to move the heat from the inside of your body to your skin. Here the area is the surface area of the capillary bed, which for the average adult male is about 160 square meters. Using the skin temperature and heat current above, we see that the blood flow must be around 2 mm / s, which is the correct order of magnitude. Since the specific heat of blood is larger than that of air, we expect the thermal current to be larger for blood, and hence the velocity to be smaller than this estimate.

Radiation is the emission of electromagnetic energy (which your body does in the infrared wavelengths). The radiation current (in Watts) is

$$Q / t = \quad A (T_b^4 - T_a^4)$$

Where is the "emissivity" (a dimensionless radiation "effectiveness", which is .97 for human skin independent of color, under equilibrium conditions), is the "Stefan-Boltzmann" constant ($5.67 * 10^{-8}$ $W / m^2 K^4$) and the temperature MUST be in K (due to the fourth power dependence; "b" denotes body, while "a" denotes "ambient", or air, temperature). In the above scenario, your body's radiation power output is only about .002 W. When considering radiation absorbed by the skin from the sun,the Emissivity (which is equal to the absorbency) depends on

frequency and therefore on skin color (we know this is not an equilibrium situation, because many people can get severe sun burns!). Using data on the reflectance of human skin as a function of wavelength (where reflectance is 1 -), we can construct a weighted average emissivity for various skin colors (weighted by the solar power output as a function of wavelength). Using this data, Caucasian skin has a weighted average of .566, while Negroid skin has a weighted average of .838.

Evaporation is of course simply the change of phase of sweat. The rate of sweat is then related to the thermal current by the latent heat of vaporization:

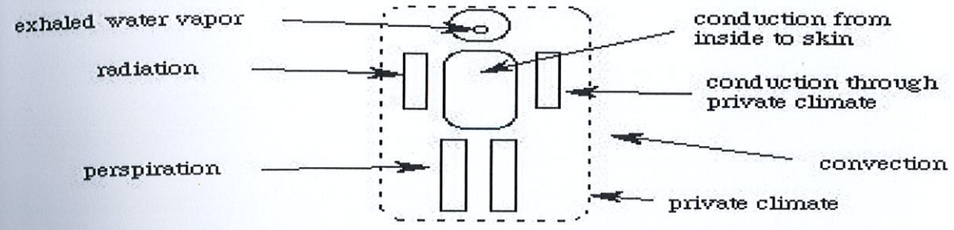
$$Q / t = (m / t) L.$$

At body temperature, the latent heat of vaporization of water is 580 cal / g. For short periods, you can sweat up to four liters per hour; for longer periods (up to 6 hours), 1 liter per hour is common. In addition to sweat, however, your body also loses water vapor during respiration. Your body to saturation must humidify the volume of air, which you inhale with each breath, in order to be used efficiently. This vapor is then exhaled, resulting in an evaporative loss which at high altitudes can rival sweat as a cooling factor. This makes evaporation a major contributor to heat regulation, up to a point: body functions are severely limited when you have lost 10% of your weight due to dehydration.

Your body has a number of mechanisms to help it cope with cold weather. Constriction of surface capillaries is helpful when the ambient temperature is above 19 C (for a nude person). Shivering raises the average person's metabolic rate about 250 kcal / m^2 hr (relative of course

to body surface area). In fact, for any well-insulated animal, an evaporative loss in breathing limits the ability to withstand cold temperatures.

We can summarize the various modes of heat transfer with the following diagram:



We can use the "Body Heat" Mathematics notebook to analyze the dominant effects when your body moves from heat gain to heat loss. The notebook defines the various heat loss mechanisms and allows us to choose which ones we want to include in the model. The model corresponds to exercise on a level treadmill. We will assume that the resultant heat loss (wastage) is a parabolic function of speed, with a value of 11.2 Cal / min at a speed of 9 kph. We will further assume that your skin temperature varies parabolically from 28.2 C at an ambient temperature of 9.5 C to 37.2 C at an ambient temperature of 35 C. Finally, we will assume that you do not sweat when the ambient temperature is below 30 C, and that above 30 C the rate of sweat is proportional to the amount by which your skin temperature exceeds 30 C. These assumptions are based on studies on medical students in the mid-twentieth century. We will supplement them with an estimate of the amount of water vapor exhausted during respiration, which is proportional to the rate of exercise.

Since the net heat loss or gain is a function of three variables (ambient temperature, rate of walking and wind speed), we have to analyze a three dimensional field. The slice function illustrates the parameter ranges for the three variables, which correspond to your body switching from heat gain to heat loss. The other graphs show which effects dominate, and allow us to find optimum exercise conditions.

CARDIAC ANATOMY AND PHYSIOLOGY

3.2 Introduction to Cardiac Anatomy

An understanding of normal and abnormal cardiac morphology is basic to the management of congenital heart defects. Problems exists in the nomenclature of cardiac morphology, suffice it to say that the most appropriate terminology is that which is functional, accurate, and to the best extent possible, accepted by the majority of workers in the field. In a typical example, a ventricle may be referred to as left-sided, systemic, pulmonary, arterial, etc., but the question remains, which ventricle is it - the morphologically left or the morphologically right? The diagnostic problem is that a positional left ventricle may be a morphologically right ventricle. Morphologic anatomic identification is therefore cornerstone of accurate diagnosis.

The segmental approach to the diagnosis of congenital heart defects is based upon an understanding of the morphologic features of the different segments of the heart. The cardiac segments *are the building blocks out of which all hearts are built, and include the great veins, atria, ventricles, and great arteries.* The ability to distinguish the different segments of the heart is the cornerstone of cardiac morphology, and distinctions are based on knowledge of the structure of the normal heart. However, what would seem to be the most diagnostic features of any particular cardiac segment in the normal heart may not always be the most reliable indicator of its true identity in the malformed heart. For example, the most distinguishing feature of the left atrium might well be considered its connections to the pulmonary veins. However, this feature is of little value in identifying the left atrium in the presence of total anomalous

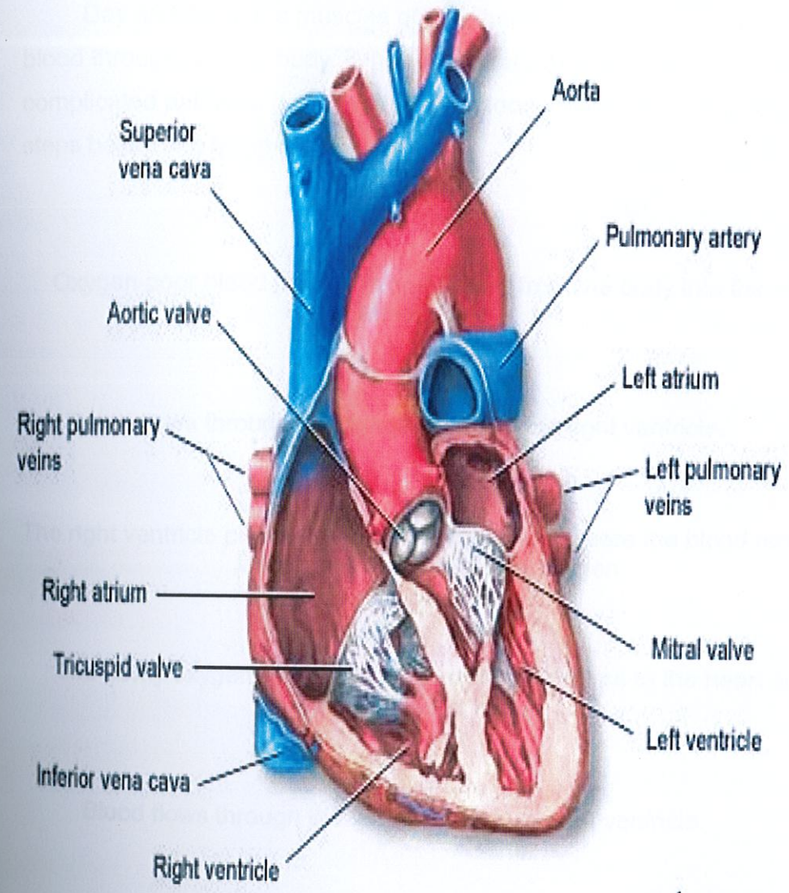
Pulmonary venous connection. Hence, the morphological method, by which cardiac segments are identified according to their most constant features, is the most accurate way to identify structures in a malformed heart. The morphological features identifying the great veins are the organs that they drain; for the atria, it is their appendages; for the ventricles, it is the pattern of their apical trabeculations; and for the great arteries, it is the pattern of their branching.The method by which the cardiac segments are joined one to another are referred to as the connections. *These connections are termed the venoatrial, atrioventricular, and ventriculoarterial connections.* The venoatrial connection defines the connection of the great veins to the atria. It is principally concerned with the situs of the heart when considering the systemic venoatrial connection, and with anomalous pulmonary veins when considering the pulmonary venoatrial connection. Unlike the remaining two connections, the venoatrial connection does not include any functional valves. The atrioventricular connection consists of the atrioventricular septum and the ventricular valves (mitral and tricuspid). The atrioventricular connection defines the morphology and function of the ventricular valves and the atrioventricular septum, along with the mode of connection of the atria to the ventricular mass. The ventriculoarterial connection consists of the subarterial infundibuli and the arterial valves (aortic and pulmonary). The ventriculoarterial connection defines the morphology and function of the arterial valves and the subarterial infundibuli, along with the mode of connection of the ventricular mass to the great arteries. It is important to note that these connections can be related one to another. In the normal heart, for example, there is aortic-mitral valvar continuity, while the

pulmonary valve is separated from the ventricular valves. This relationship of the atrioventricular to the ventriculoarterial connection is due to the normal presence of a muscular infundibulum beneath the pulmonary valve which separates the pulmonary valve from the ventricular valves, and the absence of a subaortic infundibulum, which results in aortic-mitral fibrous continuity. Hence, the various connections may have important relationships to each other.

For the sake of surgical diagnosis, seven segments and connections need to be completely identified, these being the four cardiac segments (the great veins, atria, ventricles, and great arteries) and their connections (venoatrial, atrioventricular, and ventriculoarterial). The approach in the present communication is to consider first the cardiac segments then the connections by which they are joined together. Special consideration is then given to the septation of the human heart, cardiac malpositions, and the conduction system of the heart.

Medical Encyclopedia

Heart, section through the middle



A.D.A.M.

The interior of the heart is composed of valves, chambers, and associated vessels.

3.2.1 Map of the Human Heart

Day and night, the muscles of your heart contract and relax to pump blood throughout your body. When blood returns to the heart, it follows a complicated pathway. If you were in the bloodstream, you would follow the steps below one by one.

Oxygen-poor blood (shown in blue) flows from the body into the right atrium.

↓

Blood flows through the right atrium into the right ventricle.

↓

The right ventricle pumps the blood to the lungs, where the blood releases waste gases and picks up oxygen.

↓

The newly oxygen-rich blood (shown in red) returns to the heart and enters the left atrium.

↓

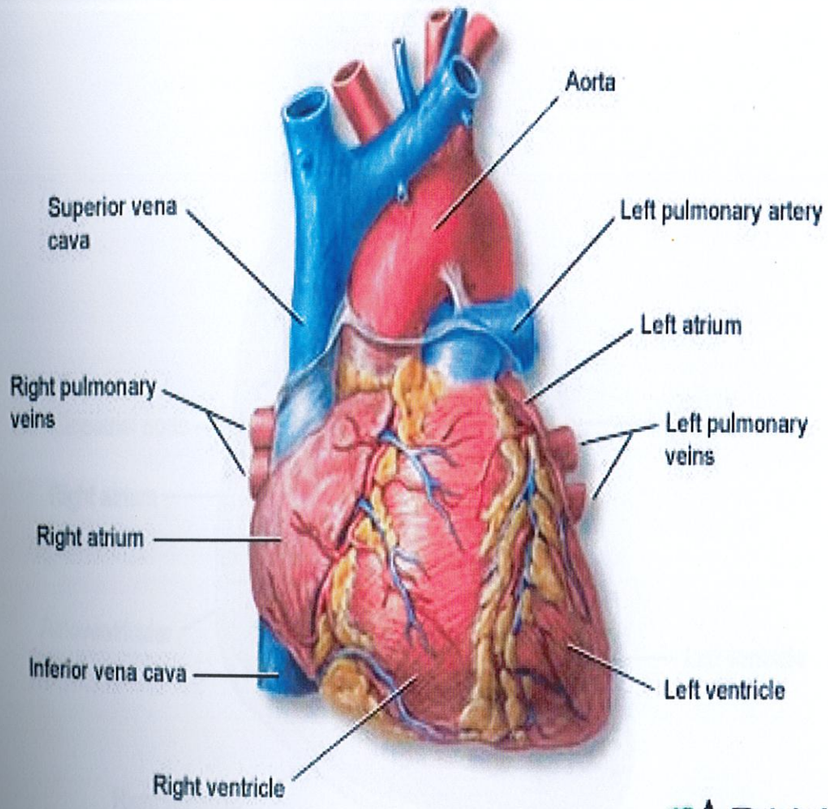
Blood flows through the left atrium into the left ventricle.

↓

The left ventricle pumps the oxygen-rich blood to all parts of the body.

Medical Encyclopedia

Heart, front view

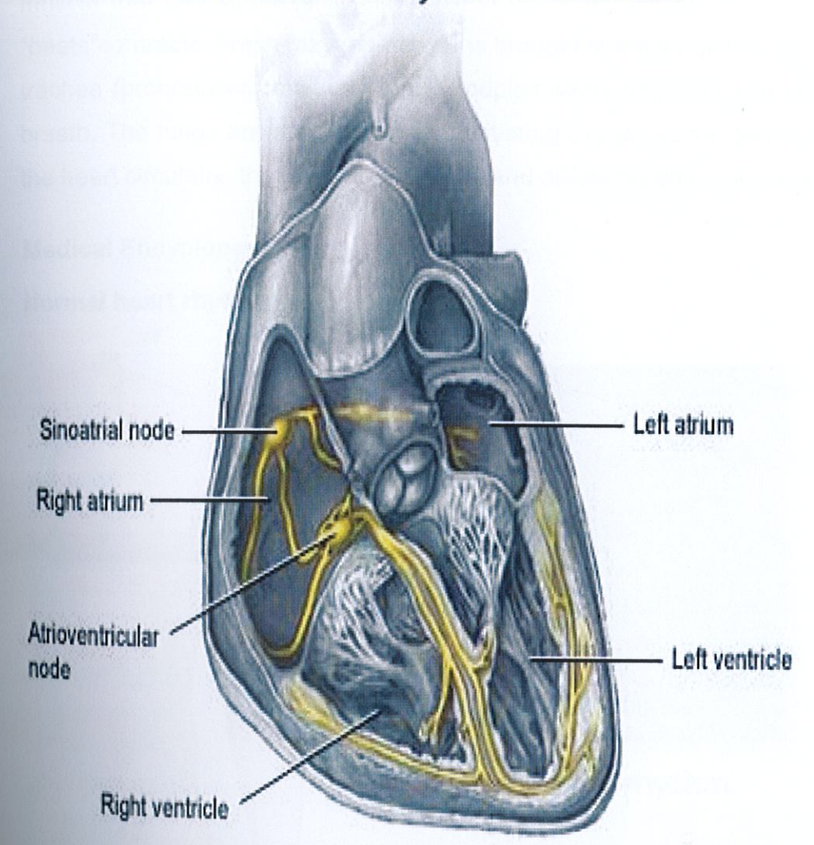


A.D.A.M.

The external structures of the heart include the ventricles, atria, arteries and veins. Arteries carry blood away from the heart while veins carry blood into the heart. The vessels colored blue indicate the transport of blood with relatively low content of oxygen and high content of carbon dioxide. The vessels colored red indicate the transport of blood with relatively high content of oxygen and low content of carbon dioxide.

Medical Encyclopedia

Conduction system of the heart

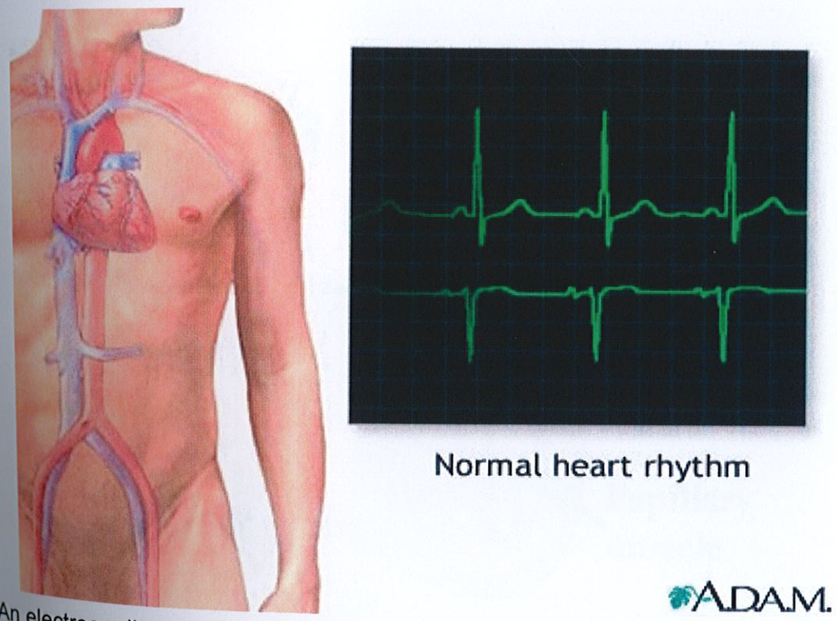


The intrinsic conduction system sets the basic rhythm of the beating heart by generating impulses which stimulate the heart to contract.

The heart is the pump station of the body and is responsible for circulating blood throughout the body. It is about the size of your clenched fist and sits in the chest cavity between two lungs. Its walls are made up of muscle that can squeeze or pump blood out every time that the organ "beats"contracts. Fresh, oxygen-rich air is brought to the lungs through the trachea (pronounced tray-kee-ya) or windpipe every time that you take a breath. The lungs are responsible for delivering oxygen to the blood, and the heart circulates the blood to the lungs and different parts of the body.

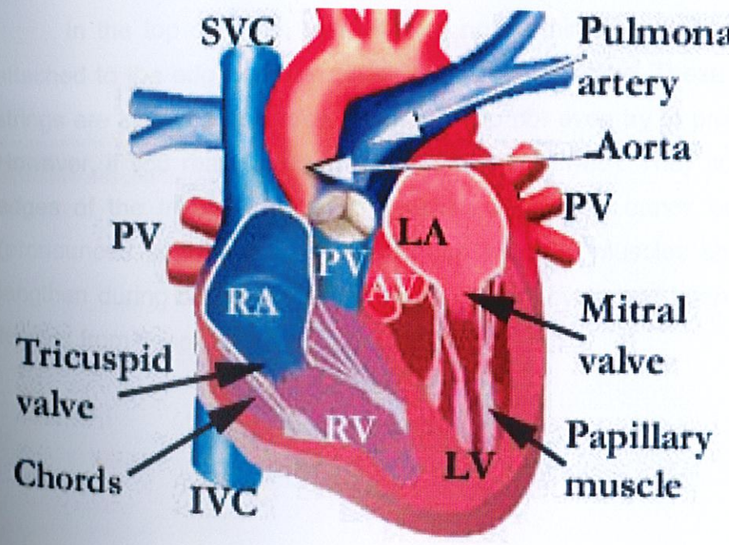
Medical Encyclopedia

Normal heart rhythm



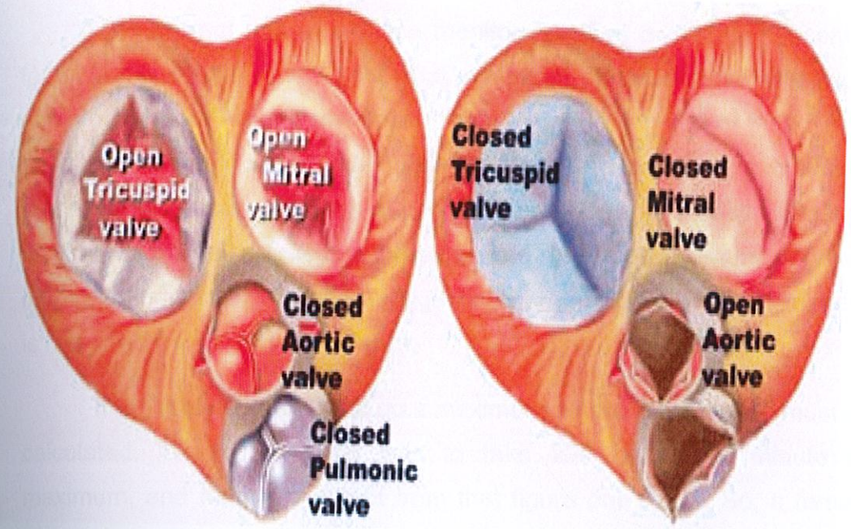
An electrocardiogram test measures the electrical activity of the heart. A normal resting heart rate is 60 - 100 beats per minute.

The heart is divided into FOUR chambers or "rooms". You can compare it to a Duplex apartment that is made up of a right and a left unit, separated from each other by a partition wall known as a SEPTUM (pronounced sep-tum).The right side of the heart is responsible for sending blood to the lungs, where the red blood cells pick up fresh oxygen. This OXYGENATED blood is then returned to the left side of the heart. From here the oxygenated blood is transported to the whole body supplying the fuel that the body cells need to function. The blood cells of the body extract or removes oxygen from the blood. The oxygen-poor blood is returned to the right atrium, where the journey began. This round trip is known as the CIRCULATION of blood.



The figure shown above is a section of the heart, as viewed from the front. It demonstrates the four chambers. You will also notice that there is an opening between the right atrium (RA) and the right ventricle (RV). This is actually a valve known as the TRICUSPID (pronounced try-cus-pid) valve. It has three flexible thin parts, known as leaflets, that open and shut. The figure below shows the mitral and tricuspid valves, as seen from above, in the open and shut position, when shut, the edge of the three leaflets touch each other to close the opening and prevent blood from leaving the RV and going back into the RA. Thus, the tricuspid valve serves as a trapdoor valve that allows blood to move only in one direction - from RA to RV. Similarly, the MITRAL valve (pronounced my-trull) allows blood to flow only from the left atrium to the left ventricle. Unlike the tricuspid valve, the mitral valve has only two leaflets.

In the top diagram, you will also notice thin thread like structures attached to the edges of the mitral and tricuspid valves. These chords or strings are known as chordae tendineae (do not even try to pronounce it. However, if you really must, it is chord-ee tend-in-ee). They connect the edges of the tricuspid and mitral valves to muscle bands or papillary (pronounced pap-pill-lurry) muscles. The papillary muscles shorten and lengthen during different phases of the cardiac cycle and keep the valve leaflets from flopping back into the atrium.



The chords are designed to control the movement of the valve leaflets similar to ropes attached to the sail of a boat. Like ropes, they allow the sail to bulge outwards in the direction of a wind but prevents them from helplessly flapping in the breeze. In other words, they provide the capability of a door jamb that allows a door to open and shut in a given direction and NOT beyond a certain point.

When the three leaflets of the tricuspid bulge upwards during contraction or emptying of the ventricles, their edges touch each other and close off backward flow to the right atrium. This important feature allows blood to flow through the heart in only ONE direction, and prevents it from leaking backwards when the valve is shut. The two leaflets of the mitral valve functions in a similar manner and allows flow of blood from the left atrium to the left ventricle, but closes and cuts off backward leakage into the left atrium when the left ventricle contracts and starts to empty.

3.3 What is Pulse Rate and Heart Rate

The correct use of a pulse monitor revolves around an essential factor – the athlete must know what maximum possible pulse rate he or she can achieve. Now, it was once thought that running 400 or 800 meters at full effort would register a maximum. Well, it's not far off; however, these two distances when run at full effort, produce a lot of lactic acid very quickly which seems to retard the pulse rate reaching maximum. A recent research finding from Sweden suggests that running full out for 3 minutes is more likely to register maximum.

If the athlete declines to do a maximum pulse rate outing, it must be calculated. The old method was to take 220 beats per minute as maximum, and then to subtract from that figure one's age. So, a female aged twenty five years would have this formula: 220 minus 25 = 195 bpm maximum. This is close but not close enough! Recent research suggests a more accurate estimation – 209 beats per minute maximum minus point seven for every year of age – 209 minus 25 x 0.7 (17.5) = 191.5 bpm: this is less than the old calculation.

The figure for males is 214 bpm minus point eight for every year of age. Given a male aged twenty five, the formula would be: 214 minus 25 x 0.8 (20) = 194 bpm. Note that the old formula is more accurate for men than women.

Pulse rates are intricately linked with work done at a percentage of VO_2 max. They are closely linked with training at what is called the lactate threshold. This is a point in our training when the blood starts to get more and more saturated with lactic acid. The idea of lactate threshold running, sometimes called lactate response running, is to run for about 4 miles

(6.5 km) just short of this sudden lactate increase point. By so doing, we eventually "push" or delay the point of lactate increase. In practical terms this means we can run faster (at a slower pulse rate) than before without incurring a lactate penalty. Twelve weeks of once-a-week lactate threshold running will boost fitness levels which may not be detected in a $V0_2$ max test. It also has the advantage of not being so fast as track repetitions thereby reducing injury risks.

We must now ask how the aforementioned world record breakers achieved their success without the use of a pulse monitor? The answer is that they trained at speeds which were a percentage of their $V0_2$ max and in doing so, elevated their pulse rates to the required point. For example, if a 3k runner wished to improve his time from 8:30 to 8:15, by running 3 x 1,500m in 4:07.5 with 3 mins rest, it would be 100 per cent of his $V0_2$ max and would involve the pulse rate achieving maximum.

If we take the example of the 25 year old female above with an estimated maximum of 191bpm, we can plan out what pulse rates should be used to record specific percentages of $V0_2$ max. In doing this, we must remember one vital criteria – **the greatest fitness gains come from work between 90 and 100 per cent of the $V0_2$ max.** Most of the world's physiologists favour the figure of 95 per cent of the $V0_2$ max (about 5K speed); however Russian coaches working with female athletes favour 100 per cent of the $V0_2$ max (about 3K speed). We also come to another important point – **the lower the $V0_2$ max percentage of work – the greater the duration of the repetition.** Thus, an athlete training at 90 per cent of his or her $V0_2$ max (about 10K speed), should do 4 x 10 minutes at

10K speed with very short recovery (about 90 seconds). The minimum duration of any repetitions between 80 – 100 per cent of the $V0_2$ max is 3 minutes.

% of $V0_2$ max	Equivalent % of max pulse rate	Actual pulse (bpm)
35 (jogging)	55	105
50 (long slow running)	60	115
60 (steady running)	73	139
70 (slow marathon pace)	80	153
80 (fast marathon pace)	88 (near lactate threshold running)	168
90 (10K speed)	93	178
95 (5K speed)	98	187
100 (3K speed)	100	191

A rule-of-thumb rough guide is to remember that whatever the percentage of the $V0_2$ max is required, the percentage of the pulse rate is that figure **plus**, so that given a workout at 80 per cent, the required pulse rate **starts** at 80 per cent maximum plus about 10 beats more.

When we come to calculating what speed and pulse rate our lactate threshold runs should be, there is much to put us off! Ideally, we require a sports physiologist or coach with a portable lactate measuring computer to decide from a sample of an athlete's blood at what speed of running lactate starts to increase markedly. Failing that, there is a thing called the **Conconi Test**, where an athlete runs with a heart-rate monitor increasing speed every 200 metres by 2 seconds, and from a slow start involves about 2,400 – 3,200m of running during which time about sixteen pulse measurements are taken. The 200 metre times have to be converted into km/h. The formula being: v=720/t (t=split time). A graph is then drawn of the heart-rate on the left vertical and the km/h values at base. The breakaway point from the linear is known as the "deflection point". The test is subject to human error on many counts. But, analysis is made easier when an interface and an IBM compatible computer are available. There are computer programmes on the market – such as HRCT Leuenberg Medicine Technique AG, that make an automatic analysis of the test possible.

A greatly under-rated method of calculating lactate threshold speed is a table drawn up by the notes physiologist Jack Daniels (USA), who uses the 3K or 2 mile time of an athlete to assess what the lactate response should be. The author has compared the findings of this table with known blood sample readings of some of Britain's leading athletes and they were identical.

A rule-of-thumb method is to take this 3K time per **mile** and to add 22 seconds to it, this is about 90 per cent accurate. For example, given a 3K time of 8:30 (68 secs per 400m), this is about 4:34 per mile + 22 seconds = 4:56 per mile (close to the tabulated value of 4:53) for 4 miles on a lactate response run. A person with a time of 11:15 for 3K (90 secs per 400m), about 6 minutes per mile pace, however, needs to add about one minute to that figure i.e. 7 minutes a mile, for 4 miles. Once past 9:15 for 3K the lactate response run per mile rapidly slows. Here is a table of accurate recommendations:

Best 3K time	Recommmended lactate response time for 4 mile	Mile difference (secs)
7:30	4:16	15
8:30	4:53	19
9:30	5:32	26
10:30	6:23	45
11:15	6:54	52
12:15	7:38	64

Many heart-rate monitor devotees may have never run in a 3K race and, therefore, Daniels' table will be of little use. But there is more to this table than at first meets the eye. If we look at the mile differential column of the table, it will be noted that a 7:30 3K runner who will be running at about 4:01 a mile in that event, is only going to be running 15 seconds

slower per mile on a lactate response run (4:16 per mile)! That's 5K pace and 95 per cent of the $V0_2$ max AND 93 per cent MHR.If we take one more example, a 11:15 3K performer (6:02 per mile), the lactate response run is 6:54, some 52 seconds per mile slower than 10K speed, about 85 per cent of the $V0_2$ max, about 90 per cent MHR. This last calculation has led some physiologists to a rule of thumb recommendation for lactate response runs: "Run about 10 seconds per mile slower than per mile for your best 10K time." This may be apt for the 37:30 plus 10K performer, but not for those who are much speedier.

What it boils down to is this: if an athlete can run for more than 30 minutes at 80 per cent of maximal heart rate – that run is not a lactate threshold run: it's a useful outing, but will do nothing to improve the lactate threshold. Moving the run up to 85 per cent MHR should be tried and if the athlete can just make 4 miles distance at that rate and no further, the target pattern has been set.

One winter, Yvonne Murray, GB International (8:29.02/3K), had her lactate response runs set (by blood analysis) at 5:20 per mile. Six months later it was set at 4:53 per mile. This shows what can be achieved with regular lactate threshold running done correctly.

Where a pulse monitor scores over the stop-watch is when running into a stiff wind. While the timer per mile advocate will struggle to keep to the schedule the pulse monitor athlete will keep to the required pulse-rate even though the speed of running may decline – **but the effort remains constant.** This is a valuable preventative of over-training.

CHAPTER 4
(Methodology)

METHODOLOGY

4.0 Project Methodology

This project report provides clinical information is used primarily illustrate the application of the basic knowledge. Even though clinical information emphasizes hoe relevant knowledge of physiology theory and technical medical electronic theory. The ability to apply information to solve a problem is a skill that will always be an asset for the student, even after knowledge learned today is no longer current. This bio-medical project encourages student using the physiology theory and the technical theory to think critically with the clinical knowledge they have gained.

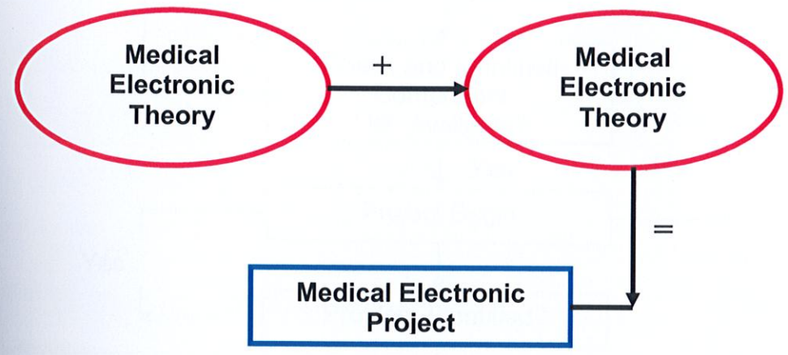


Figure 4.0; Concept of Bio-medical Project

4.1 Flow Chart How To Make Bio-medical Project

Simple facts are presented first, and explanations are develop in a logical sequence. Through the project discussion, we introduce the define key to make this project clear and relevant.

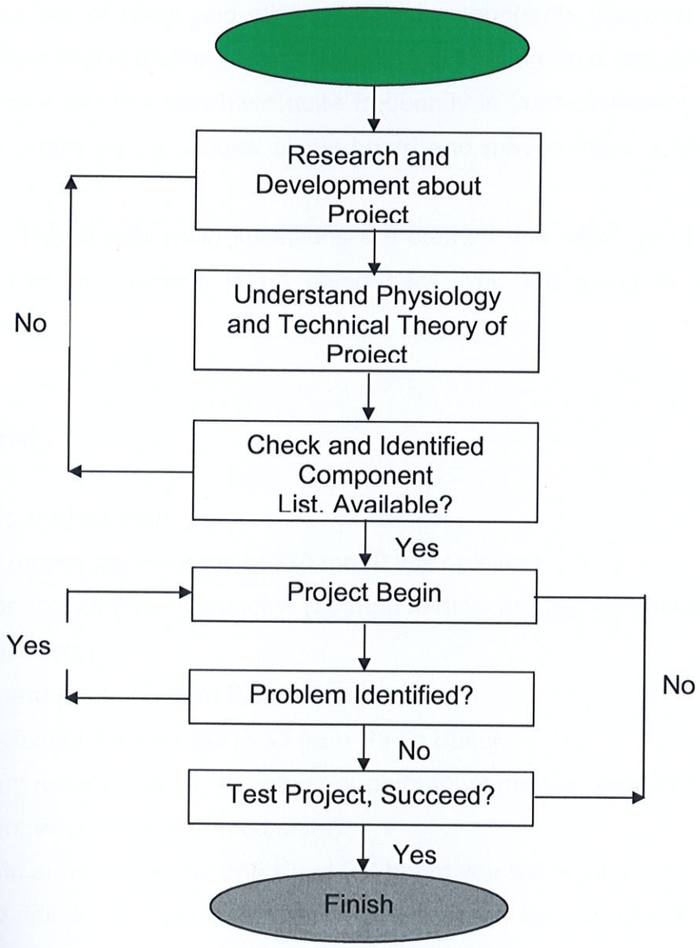


Figure 4.1; Project Flow Chart

4.2 Circuit Creation

The circuit board is one of the 19h centuries-greatest electrical products to come out; it introduced the model of smaller, faster, and cheaper. This is of cores referring to the time it takes to produce a product out of wires and other electrical components. Suppose you are faced with a problem like you want to quickly rig up a circuit tester for a problem that you have quite frequently in your profession, you could simply rig up a quick circuit board and maybe make a fortune off.

This is how most inventions are created and when you find a your stile of inventing is no going back, you are going to be a millionaire.

4.2.1 Material

Plastic or glass dish
Latex gloves,(approximately $20 for 50 latex gloves)
Scrubs "old clothes or smocks" ($0 from relative or neighbor, never use you own)
PC board ($2 to $5 from Radio Shack)
PCB etchant solution ($2 to $3 from Radio Shack)
Etchant resistant strips "transfers" or permanent marker "pen" ($2 to $3 from Radio Shack or food store)
Electric or hand-drill "for one sided PC board you will want a high speed drill, for two sided CP board you will want a low speed drill"

4.2.2 Overview

Although there are many ways to create a circuit board, the only way that is fool proof while keeping the total cost below 10$ is to use the method in this discussion. What we will be doing is taking a two-sided circuit board and remove any unwanted copper. We will do this by taking echant-resistant strips and "sticking" them on the circuit board to make electron paths, then we will drop the circuit board into a dish of echant that will dissolve all the copper that doesn't have resistant strips on top of it. This will leave wire tracers behind that will conduct electrons between circuits.

These metal tracers are just a good or even better the wires. If you are looking for a way to make your circuits more compact and a better way of organizing your circuits, you may want to try designing circuit boards as an option.

4.2.3 Design Circuit

One trick that I have learned in aiding the process of designing the circuit is to lay a piece of paper on a desk with a pencil and a big eraser. Draw the components on the scratch paper taking no consideration on the size, shape, or layers. Now just start drawing circuits starting with the most crucial components while isolating specific functions as much as possible. For instance, if you were creating a power supply you would have the power input and transformation as one function, rectification as another function and finally filtering as the final stage. Doing this will also help if in the case

something goes wrong, it will be much easier to troubleshoot, if there is no power output then you can rule out an entire sector of the motherboard in seconds. When you are satisfied that all the connections are complete, check them again, design flaws are common and can not be undone without ugly and maybe expensive work! The circuitry can be fixed with wires later on but can be a headache if you have already started to mass-produce the circuit. Now that you are satisfied completely you will want to refine the circuit on another piece of paper; drafting skills are a plus when performing this step but it is only important that you can understand what you are doing. Since you are doing this your own way it is also your choice as to what rout you are going to do, use exact measurements for all components or to lay the pieces down and mark where the component leads contact the paper. Sometimes measuring everything out can produce mind-boggling errors if you don't have the proper equipment so you might want to try a combination of the both.

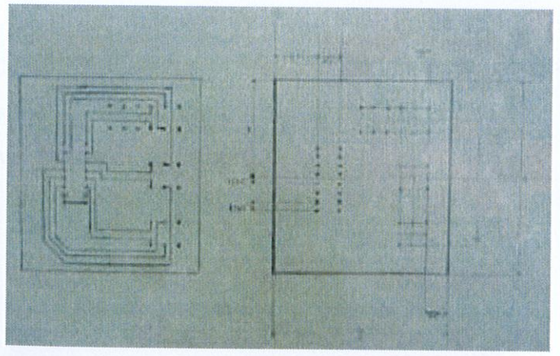


Figure 4.2.3; Circuit Design

4.2.4 Draw the Circuit

There are two basic ways of making a circuit board with conventional tools, the first way is to draw the circuits out with a permanent marker and the second is to use dry resist transfers. These can be found at your local hardware store. I have chosen to use Radio Shack brand because they contain all the shapes needed in order to complete this project.This method is one of the most dangerous ways of making a circuit board if you are not careful. For example, the ink does not bond with the copper perfectly and if the pen gets too dry then it will start taking more ink off then it puts on.

Using the etchant resistant transfers does require some skill with the eyes and hands, what I do is flip the transfers over so the sticky side is up and place it over the circuit board and mark the length that I need. I then take a utility knife or razor blade and cut the strips to the specified length and turn it over once again. The two strips are still connected to the plastic paper because they are both sticky and require force to transfer over the strips. I then flip the plastic paper with the strips sill on it and place it over the circuit board. Here you will align the custom cut strip with the location where it was designed to be and taking a ball-point pen, use about .5 pounds of pressure to transfer over to the circuit board.

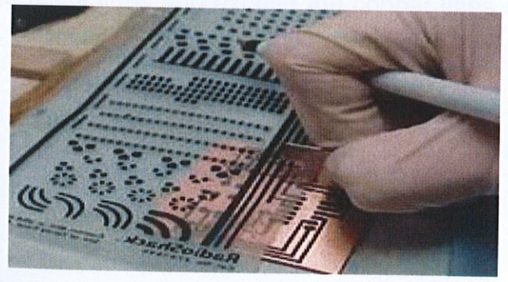


Figure 4.2.4; Draw the Circuit

3.2.5 Etching Process

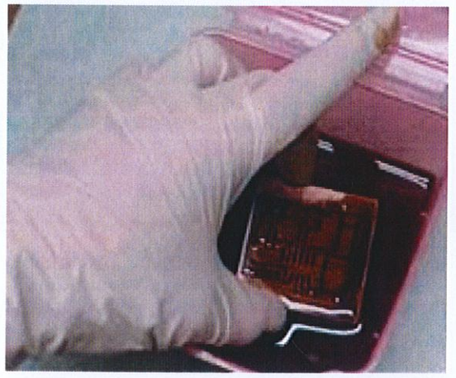


Figure 4.2.5 (a); Etching Process

When you are satisfied with the outline of the circuits poor the etchant solution in a plastic or glass dish approximately 3/4 inches high so there is sufficient liquid on the bowl to dissolve the copper skin. Now place the circuit board in the dish and oscillate for approximately 20 minutes or until all the unwanted copper is dissolved.

By now you should only see brown board and black likes left over from the etching process, to clean up the board place it under water and scrub for 2 minutes to stop the chemical reaction. To remove the black lines and expose the copper lines simple take steel wool or a fine grit sand paper and scrub away.

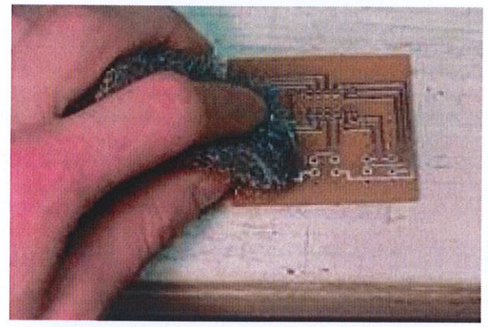


Figure 4.2.5 (b); clean up the Board

4.3 Soldering Skill

Soldering is the process of a making a sound electrical and mechanical joint between certain metals by joining them with a soft solder. This is a low temperature melting point alloy of lead and tin. The joint is heated to the correct temperature by soldering iron. For most electronic work miniature mains powered soldering irons are used. These consist of a handle onto which is mounted the heating element. On the end of the heating element is what is known as the "bit", so called because it is the bit that heats the joint up. Solder melts at around 190 degrees Centigrade, and the bit reaches a temperature of over 250 degrees Centigrade. This temperature is plenty hot enough to inflict a nasty burn, consequently care should be taken.

It is also easy to burn through the PVC insulation on the soldering iron lead if you were to lay the hot bit on it. It is prudent, therefore, to use a specially designed soldering iron stand. These usually incorporate a sponge for keeping the bit clean.

Soldering irons come with various ratings from 15W to over 100W. The advantage of a high wattage iron is that heat can flow quickly into a joint, so it can be rapidly made. This is important when soldering connectors as often there is a quite a large volume of metal to be heated. A smaller iron would take a longer time to heat the joint up to the correct temperature, during which time there is a danger of the insulation becoming damaged. A small iron is used to make joints with small electronic components that are easily damaged by excess heat.

Always use good quality multicore solder. A standard 60% tin, 40% lead alloy solder with cores of non-corrosive flux will be found easiest to use. The flux contained in the longitudinal cores of multicore solder is a chemical designed to clean the surfaces to be joined of deposited oxides, and to exclude air during the soldering process, which would otherwise prevent these metals coming together. Consequently, don't expect to be able to complete a joint by using the application of the tip of the iron loaded with molten solder alone, as this usually will not work. Having said that, there is a process called tinning where conductors are first coated in fresh, new solder prior to joining by a hot iron. Solder comes in gauges like wire. The two commonest are 18 swage, used for general work, and the thinner 22 swage, used for fine work on printed circuit boards.

Good soldering is a skill that is learnt by practice. The most important point in soldering is that both parts of the joint to be made must be at the same temperature. The solder will flow evenly and make a good electrical and mechanical joint only if both parts of the joint are at an equal high temperature. Even though it appears that there is a metal to metal contact in a joint to be made, very often there exists a film of oxide on the surface that insulates the two parts. For this reason it is no good applying the soldering iron tip to one half of the joint only and expecting this to heat the other half of the joint as well.

When the iron is hot, apply some solder to the flattened working end at the end of the bit, and wipe it on a piece of damp cloth or sponge so that the solder forms a thin film on the bit. This is tinning the bit.

Melt a little more solder on to the tip of the soldering iron, and put the tip so it contacts both parts of the joint. It is the molten solder on the tip of the iron that allows the heat to flow quickly from the iron into both parts of the joint. If the iron has the right amount of solder on it and is positioned correctly, then the two parts to be joined will reach the solder's melting temperature in a couple of seconds. Now apply the end of the solder to the point where both parts of the joint and the soldering iron are all touching one another. The solder will melt immediately and flow around all the parts that are at, or over, the melting part temperature. After a few seconds remove the iron from the joint. Make sure that no parts of the joint move after the soldering iron is removed until the solder is completely hard. This can take quite a few seconds with large joints. If the joint is disturbed during this cooling period it may become seriously weakened.

The hard cold solder on a properly made joint should have a smooth shiny appearance and if the wire is pulled it should not pull out of the joint. In a properly made joint the solder will bond the components very strongly indeed, since the process of soldering is similarly to brazing, and to a lesser degree welding, in that the solder actually forms a molecular bond with the surfaces of the joint.

It is important to use the right amount of solder, both on the iron and on the joint. Too little solder on the iron will result in poor heat transfer to the joint, too much and you will suffer from the solde forming strings as the iron is removed, causing splashes and bridges to other contacts. Too little solder applied to the joint will give the joint a half finished appearance: a good bond where the soldering iron has been, and no solder at all on the other part of the joint.

Remember it is much more difficult to correct a poorly made joint than it is to make the joint properly in the first place. Anyone can learn to solder, it just takes practice.

Preheat the area to be soldered by placing the iron tip on the legs and PCB trace for approximately 2 seconds. Make sure to heat both the part leg and PCB trace.

Keeping the iron in place, bring the solder to this area and melt it for 1-2 seconds.

First, pull the solder away.

Then, pull the iron away.

Cut the excess leads with a diagonal cutter. The solder should cover both the leg and PCB trace.

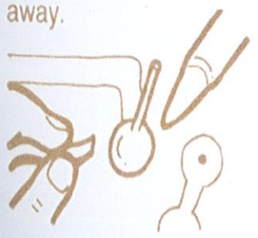


Figure 4.3;Soldering Skill on PCB Board

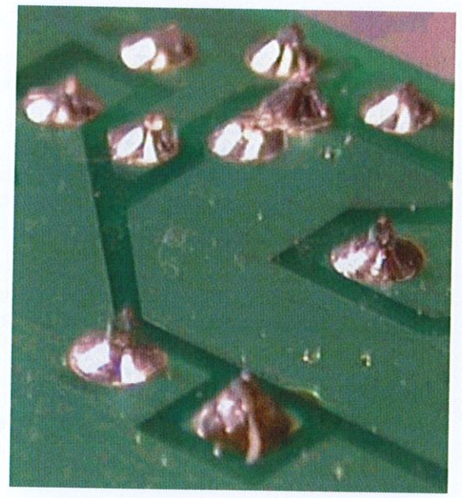


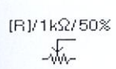
Figure 4.3; Good Soldering on the PCB Board

4.4 Component Definition

Ground: The ground has a voltage of 0. It is often used interchangeable with the negative side of a battery.

Fuse: A fuse is a resistive component that protects against surges and overloads. A fuse will blow (open) if the current goes above the current rating of the fuse.

Resistor: Resistors come in a variety of sizes depending on the power they can dissipate. A resistor is like a valve, lowering the power going through.

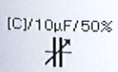


Potentiometer (variable Resistor): A potentiometer is a adjustable resistor. All potentiometers have different value ranges.

Battery: Produces current.

Capacitor: Stores electrical energy in the form of an electrostatic field. Capacitors are widely used to filter or remove AC signals or noise.

Polarized capacitor: Like above but the curved side is connected to ground or negative.



Variable capacitor: Like above capacitors but the capacitance can be adjusted.

Transformer: Coils of wire that are intertwined. Transformers are often used to step up or down AC voltages.

Inductor: Stores energy in the form of an electromagnetic field created by changes in current through it.

Diode: Allows current to flow in only one direction.

Zener Diode: A Zener diode id designed to operate in the reverse breakdown or zener region. Used primarily for voltage regulation.

Shockley Diode: Similar to a normal diode but the shockley diode remains off until the forward **current** reaches the forward break over voltage, also called the switching voltage.

SCR, Silicon-Controlled Rectifier: Is a Shockley diode that also has a third terminal that controls the gate. Current can pass in the forward direction when it reaches break over voltage or when a current pulse is applied to the gate.

Diac: A diac is a voltage dependant bi-directional switch. It functions like two Shockley diodes back to back. The diac restricts current flow in both directions until the voltage across the diac exceeds the switching voltage.

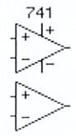
Triac: A triac is a bi-directional switch capable of conducting current in both directions. The triac operates like a diac but also has a gate like the SCR.

Full-Wave Bridge Rectifier: Made up of four diodes and does a full wave rectification of the input AC voltage. The top and bottom can be used for the AC input terminals. The left and right terminals can be used for the DC terminals. The average DC voltage is given by: VDC= 0.636*(VP - 1.4) Where VP is the peal value of the input AC voltage.

LED or Light Emitting Diode: Emits visible light when forward **current through** it exceeds *I*on.

NPN Transistor: A NPN Transistor is a valve or switch for current. It is turned on and off by the amount of positive current present at the base. The terminal with the arrowhead is the emitter

PNP Transistor: Like above but is regulated by negative current on the base in stead of positive.



Opamp (Operational Amplifier): A opamp is a amplifier that has a very high voltage gain, Very high input impedance and a very low output impedance. The + is a non inverting input and the - is a inverting input. The 741 shown is a 5 terminal Opamp. It is a improvement to the one below. Its two extra terminals are used for a positive and negative power supply.

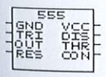
Multiplier: A multiplier multiplies two input voltages. The output is given by: Vout=kVxVy Where: k = multiplier constant

Divider:

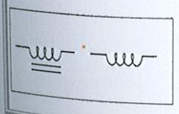
Relay: A a switching device. When current is put on the coil, one or many connections are made or broken.

Light bulb: Emits light.

Switch: If you do not know what a switch is, then I can't help you. Go away.



555 Timer: The 555 is a simple timing IC. It is commonly used as an astable or monostable vibrator. It can be used for a clock, timer, flasher etc.



Inductor: Circuit elements that resist change. If, after a period of current flow, an attempt is made to interrupt the current flow, the inductor will continue to force current.

CHAPTER 5
(Technical with Physiology Theory)

TECHNICAL WITH PHYSIOLOGY THEORY

5.0 Action Potential in Cardiac Muscle

Like action potential in skeletal muscle and neurons, those in cardiac muscle exhibit depolarization followed by repolarization of the resting membrane potential. In cardiac muscle however, the plateau phase, which is a period of slow repolarization, greatly prolongs the action potential in contrast to action potentials in skeletal muscle, which take less than 2 milliseconds (ms) to complete, action potentials in cardiac muscle take approximately 200 to 500 ms to complete.

Action potentials are conducted from cell in cardiac muscle. Not only does the action potential take longer, but also the rate of conduction throughout the heart is slower than the rate of conduction of action potentials in skeletal muscle and neurons.

In cardiac muscle each action potential consists of a rapid depolarization phase followed by a rapid, but partial early repolarization phase. Then a longer period of slow repolarization, called the plateau phase,occurs. At the end of the plateau of the plateau phase, a more rapid final repolarization phase takes place. During the final repolarization phase the membrane potential returns to its resting level.

Changes in membrane channels are responsible for the changes in the permeability of the cell membrane that produce action potentials. The depolarization phase of the action potentials results from three permeability changes. Voltage gated sodium ion channels open, increasing the permeability of the cell membrane to sodium ions. Sodium ions then defuse into the cell membrane, causing the depolarization. Voltage gated potassium ion channels quickly close, decreasing the permeability of the cell membrane to potassium ions. The decreased diffusion of potassium ions out of the cell also causes depolarization. Voltage gated sodium ion channels slowly open, increasing the permeability of the cell membrane to calcium ions.

Calcium ions then diffuse into the cell and causes depolarization. It is not until the plateau phase that the most of the voltage gated calcium ion channels are opened.

Early repolarizations occur when the voltage gated sodium ion channels close and small number of voltage gated potassium ion channels open. Diffusion of sodium ions into the cell stops and there is some movements of potassium ions out of the cell. The changes in ion movements result in an early, but small repolarization.

The plateau phase occurs as voltage gated calcium ion channels continue to open, and the diffusion calcium ions into the cell counteracts the potential change produced by the diffusion of potassium ions out of the cell. The plateau phase ends and final repolarizations begins as the voltage gated calcium ion channels close, and many voltage gated potassium ion channels open. Diffusion of calcium ions into the cell decreases and diffusion of potassium ions out of the cell increases. These changes cause the membrane potential to return to its resting level.

The SA node, which functions as the pacemaker of the heart is located in the superior wall of the right atrium and ignites the contraction of the heart. The SA node is the pacemaker because its produces actions potentials at a faster rate than others areas of the heart. The SA node have a large number of voltage gated calcium ion channels than other areas of the heart. As soon as the resting membrane potentials are reestablished after an action potential, some of the voltage gated calcium ion channel open spontaneously. As they open, calcium ions begin to diffuse into the cell and cause depolarization. The depolarization stimulates additional voltage gated sodium ion channels to open. Thus, additional calcium ions and sodium ions diffuse into the cell and cause further depolarization. Quickly threshold is reached and another action potential is produced.

Action potentials in cardiac muscle exhibit a refractory period, like that of action potentials in skeletal muscle and neurons. The refractory period lasts about the same length of the same length time as the prolonged action potentials in cardiac muscle, however that amount of the time allows cardiac muscle to contract and almost complete relaxation before another action potential can be produced.

5.1 Conduction System of The Heart

Specialized cardiac muscle cells in the walls of the heart that form the conduction system of the heart coordinate contraction of the atria and ventricles. Action potentials originate in the SA node and spread over the right and left atria, causing them the contract.

A second area of the heart, called the atrioventricular (AV node) is located in the lower potential of the right atrium. When the actions potential reached the AV node, they spread slowly through it and then into the bundle of specialized cardiac muscle called the atrioventricular bundle. The slow rate actions potential conduction in the AV node allows the atria to complete their contraction before action potentials are delivered to the ventricles.

After actions potential pass through the AV node, they are transmitted through the atrioventricular bundle, which projects through the fibrous connective tissue plate that separates the atria and the ventricles. The atrioventricular bundle then divides into two branches of conducting tissue called the left and right bundle branches. At the tips of the left and right bundle branches, the conducting tissue forms many small bundles of purkinje fibers. These purkinje fibers pass to the apex of the heart and then extend to the cardiac muscle of the ventricle walls. The atrioventricular bundle, the bundle branches, and the purkinje fibers are composed of specialized cardiac muscle fiber that conduct actions potentials more rapidly than do other cardiac muscle

fibers. Consequently, action potentials are rapidly delivered to all the cardiac muscle of the ventricle. The coordinated contraction of the ventricles depends on the rapid conduction of action potentials by the conduction system.

Action potentials originate in the sinoatrial (SA) node and travel across the wall of the atrium (arrows) from the SA node to the atrioventricular (AV node)

↓

Action potentials pass through the atrioventricular AV node and along the AV bundle, which extends from the AV node, through the fibrous skeleton, into the interventricular septum

↓

The AV bundle divides into the right and left bundle branches and actions potentials descend to the apex of the each ventricle along the bundle branches

↓

Action potentials are carried by the purkinje fibers from the bundle branches to the ventricular walls

Figure 5.1.: Flow Chat of Heart Rate Conductivity

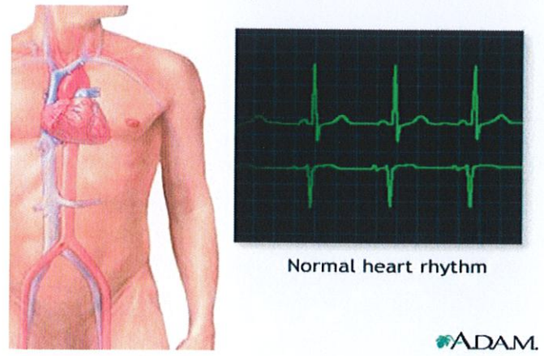


Figure 5.1(b); Conduction System of the Heart

5.2 Block Diagram of Pulse Rate

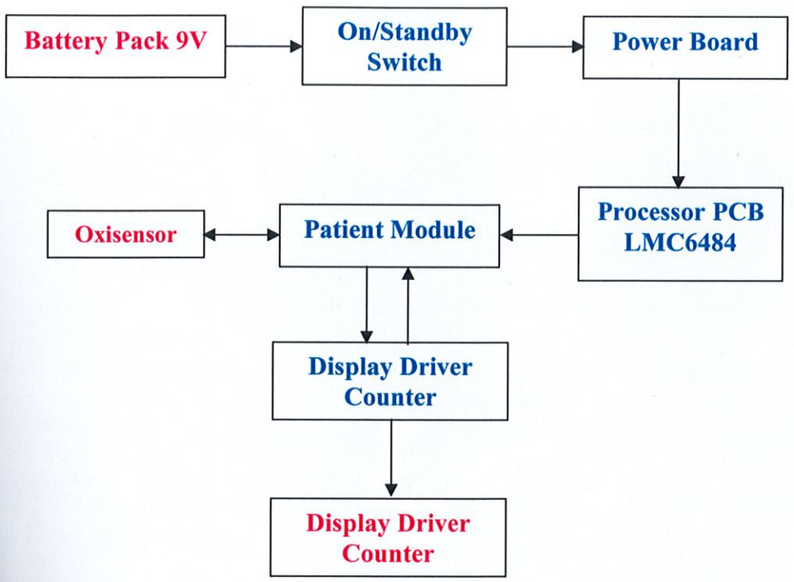
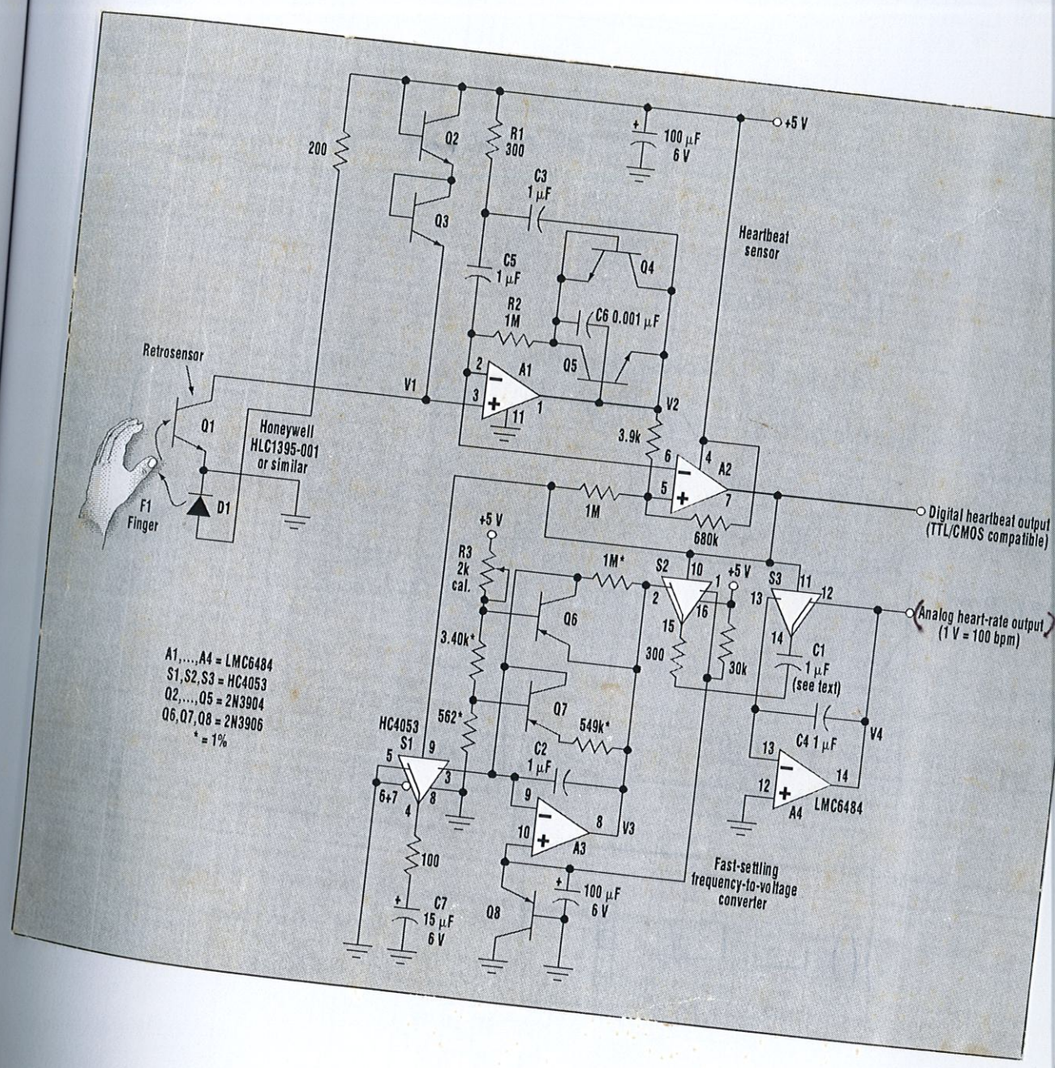
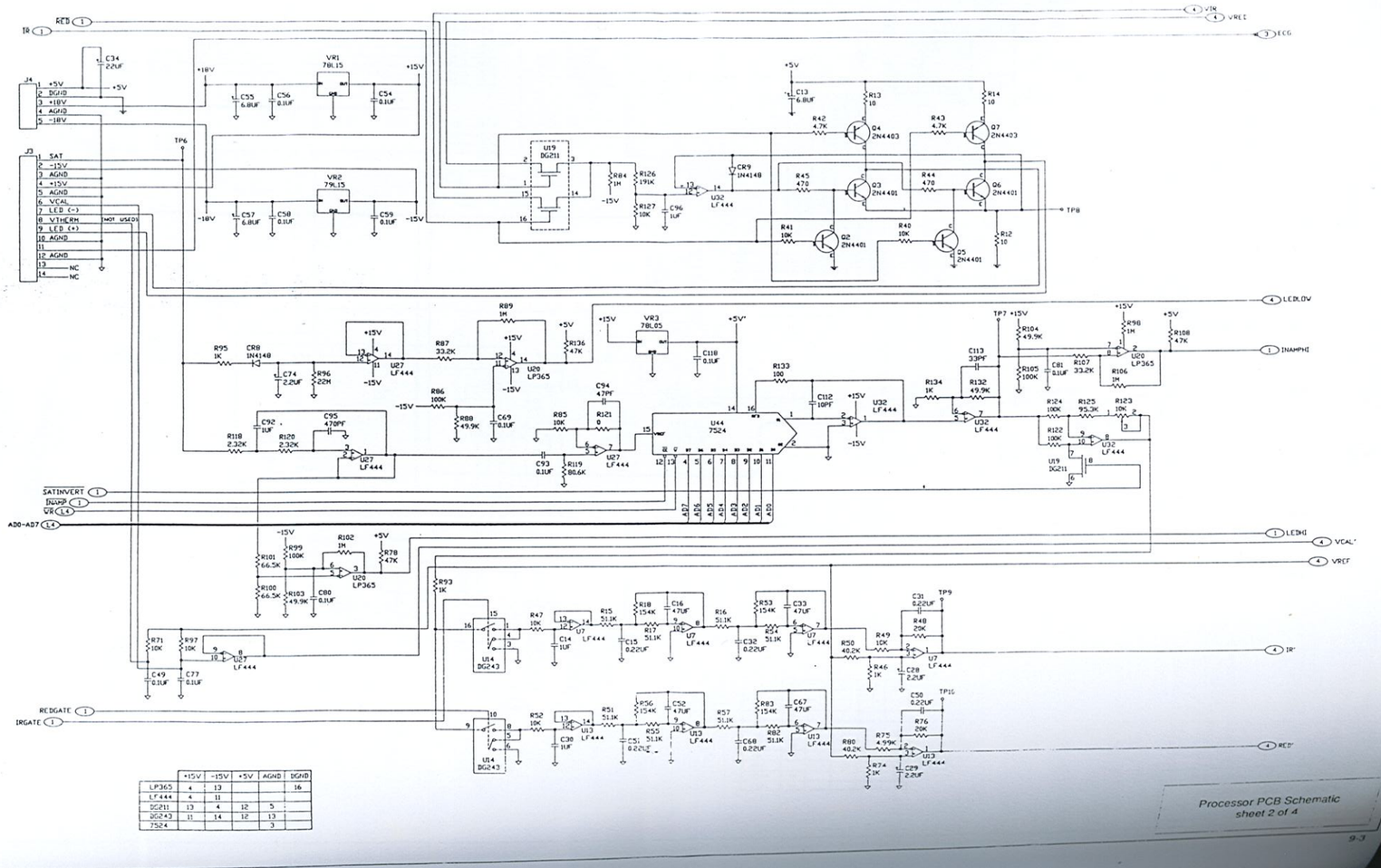


Figure 5.2: Block Diagram for Pulse Rate/Heart Rate

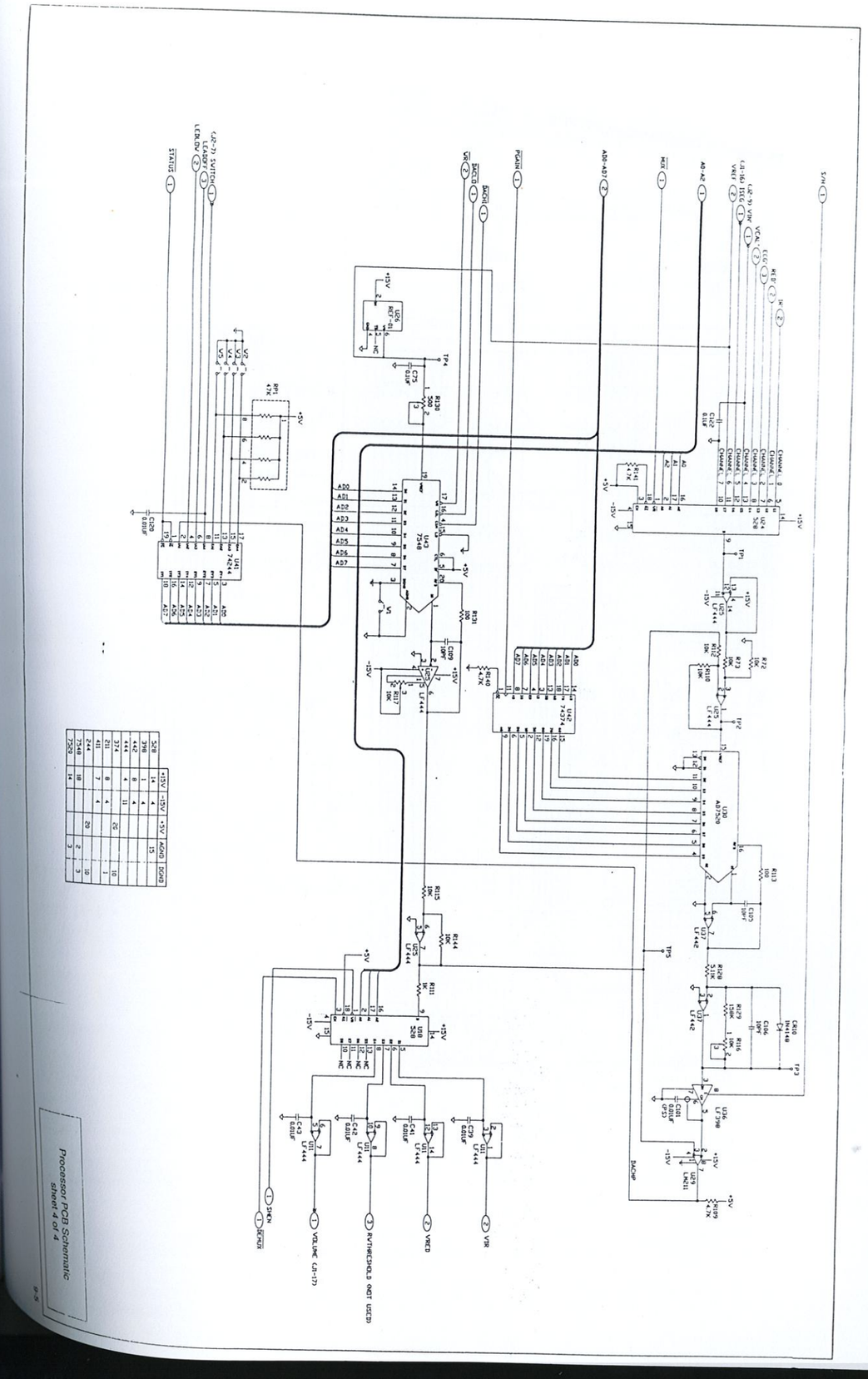
5.3 Technical Schematic Diagram of Heart Rate/Pulse Rate

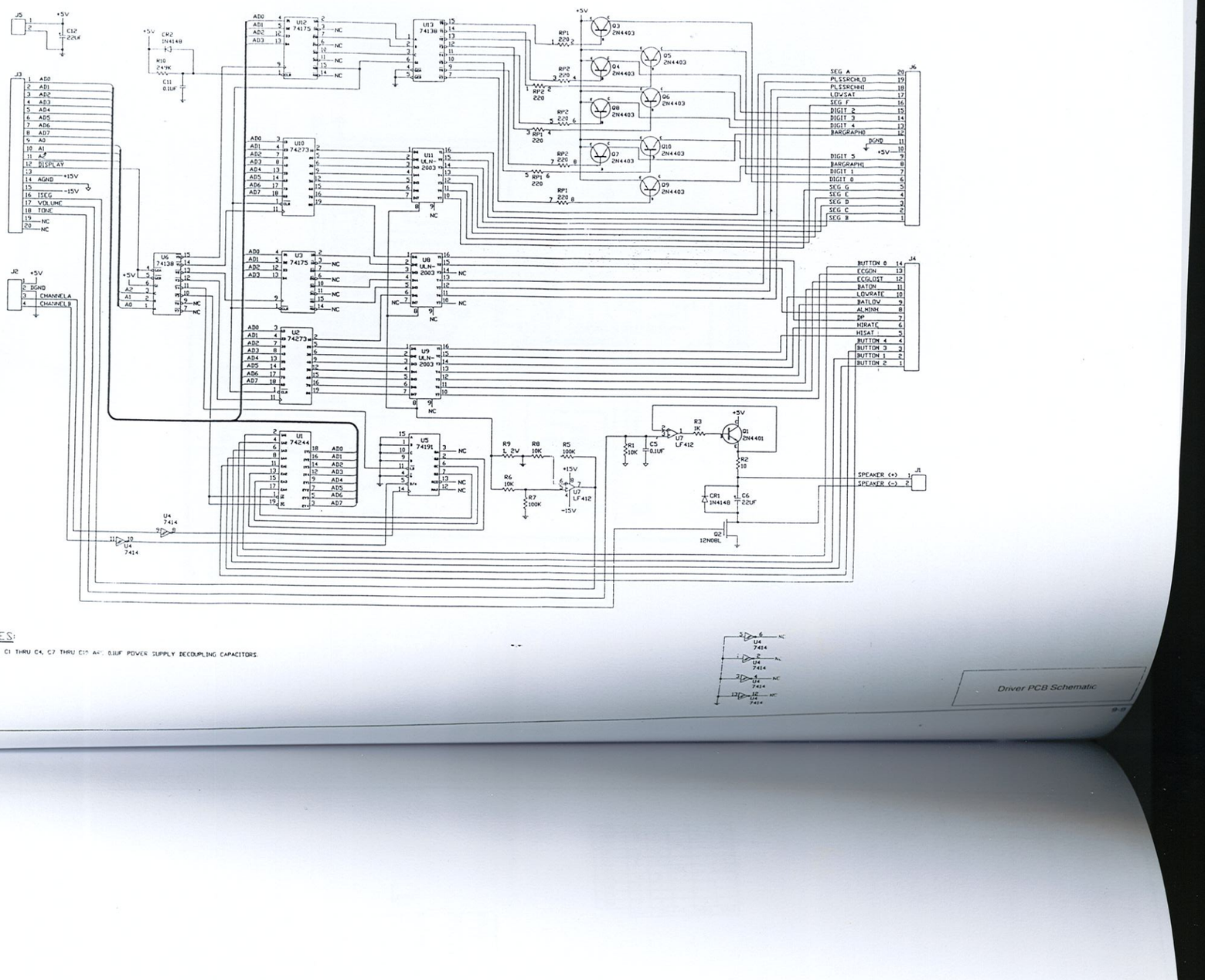




	+15V	-15V	+5V	AGND	DGND
LP365	4	13			16
LF444	4	11			
DG211	13	4	12	5	
DG243	11	14	12	13	
7524				3	

Processor PCB Schematic
sheet 2 of 4

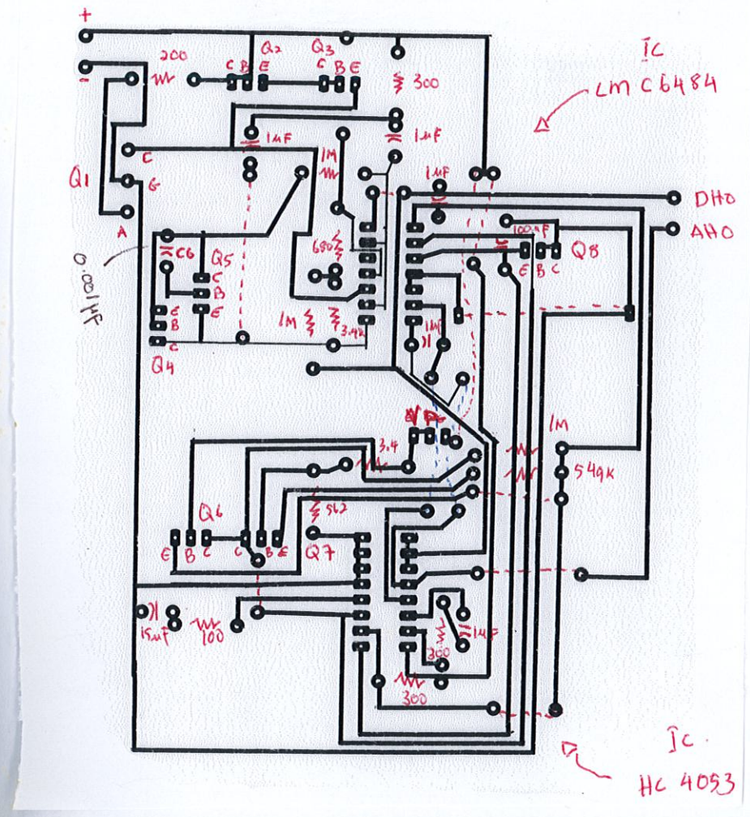

Processor PCB Schematic
sheet 4 of 4



NOTES:

1. C1 THRU C4, C7 THRU C10 ARE 0.1UF POWER SUPPLY DECOUPLING CAPACITORS.

Driver PCB Schematic


+
-
200
Q2
Q3
300
IC
LM C6484
1MF
Q1
DHO
AHO
0.001MF
C6
Q5
Q8
680
Q4
3.4K
3.4
549K
Q6
Q7
15uF
100
14E
300
IC
HC 4053

BODY TEMPERATURES REGULATION

5.4 Human Body Temperatures Regulations

Humans are homoeterms or warm blooded animals, that is we can maintain a constant body temperatures, even through the environmental temperatures varies. Maintenance of a constant body temperature is very important to homeostasis. Most enzymes are very temperature sensitive and functions only within narrow temperatures ranges. Environmental temperatures are too low for normal enzyme function. The heat produced by metabolism and muscle contraction helps maintain the body temperatures at steady, elevated level that is high enough for normal enzyme function. Excessively high temperatures can alter enzyme structure, resulting in the loss of the enzyme's function.

Free energy is the total amount of energy that can be liberated by the complete catabolism of food. About 40% of the total energy released by catabolism is used to accomplish biological work such anabolism, muscular contractions, and other cellular activities. The remaining energy is lost as heat.

Normal body temperatures is regulated like other homeostatic conditions in the body. The average normal temperatures is usually considered to be 37 degree Celsius (98.6 degree Ferenheit) when it is measured orally, and 37.6 degree Celsius when it is measured rectally. Rectal temperatures comes closer to the true core body temperatures, but an oral temperature is more easily obtained in older children and adults and therefore is the preferred measure. The normal oral temperatures may vary from person to person, with a range of approximately 36.1 degree Celsius to 37.2 degree Celsius.

Body temperatures are maintained by balancing hear input with heat loss. Heat exchange between the body and the environment occurs in a numbers of ways. Radiation is the gain or loss of heat as infrared energy between two objects that are not in physical contact with each other. For example, heat can be gained by radiation of the sun, a hot coal or the hot sand on the beach. On the other hand, heat can be lost as radiation to cool vegetation, water in the ocean, and snow on the ground. Conduction is exchange of heat between objects that are in direct contact with each other, such the bottom of the feet and the ground. Convection is a transfer of heat between the body and the air. A cool breeze results in movement of air over the body and loss of heat from the body. Evaporation is the conversion of water from a liquid to a gaseous form. As water evaporates from body surfaces, heat is lost.

Physiologically, temperature difference can be controlled through dilation and constriction of blood vessels in the skin. When blood vessels dilate, they bring warm blood to surface of the body, rising the skin temperatures, whereas blood vessel constriction decreases blood flow and lower skin temperatures.

When an environmental temperature is greater than body temperatures, dilation of blood vessels to the skin brings blood to the skin, causing an increase the gain of the heat from the environment. At the same time, evaporation carries away excess heat to prevent heat gain and overheating.

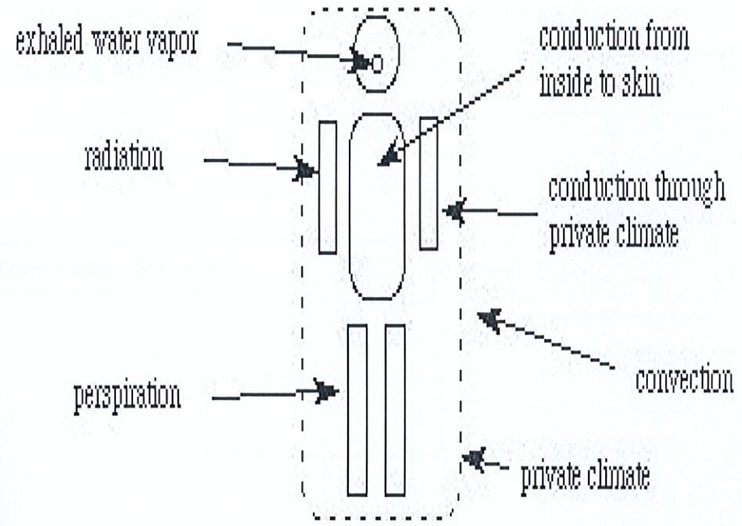


Figure 5.4; Body Temperatures Regulation

5.5 Block Diagram of Human Body Thermoscan

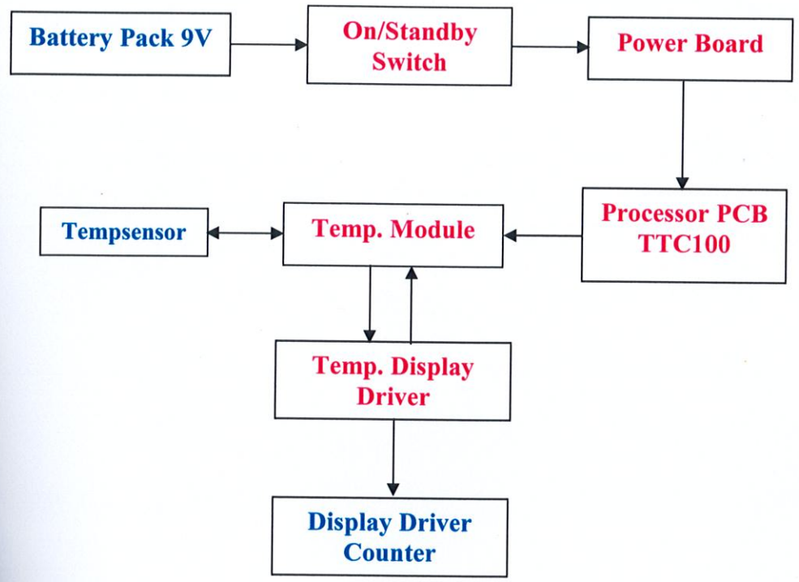
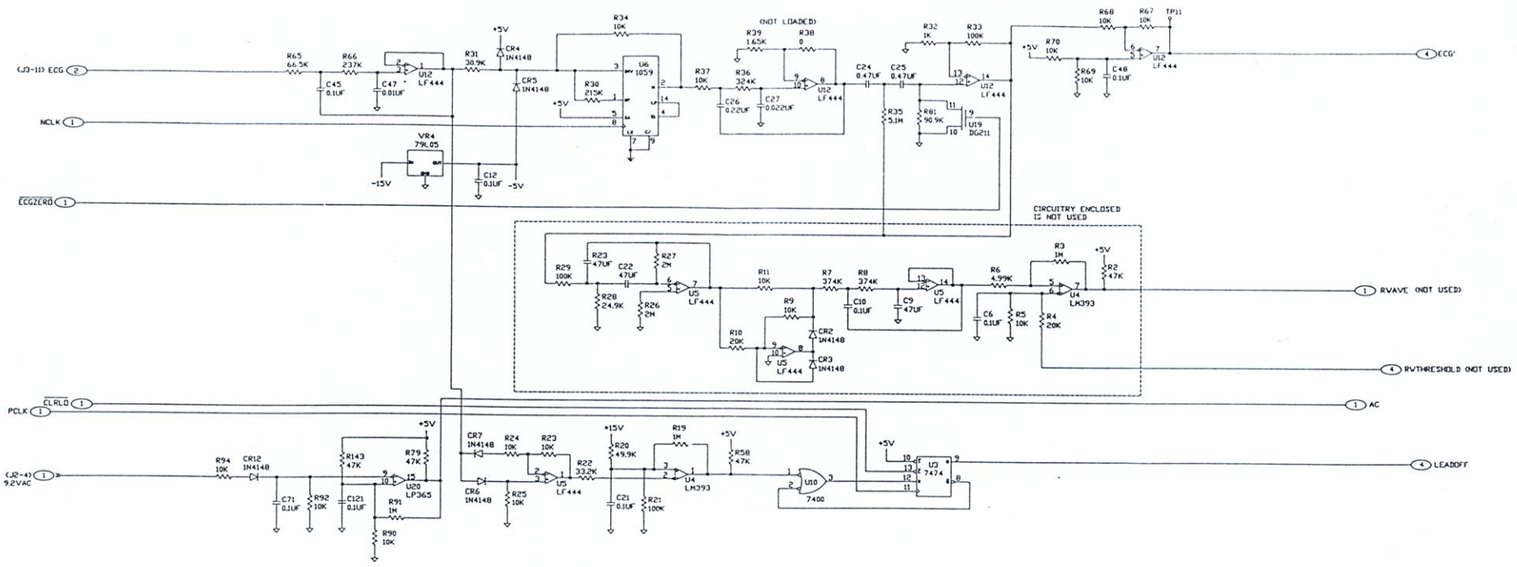


Figure 5.5: Block Diagram for Human Body Thermoscan

5.6 Technical Schematic Diagram of Human Body Thermoscan



	+15V	-15V	+5V	-5V	AGND	DGND
444	4	11				
211	13	4	12		5	
393	8					4
365	4	13			16	
74			14			7
00			14			7
1059			6	10	11	

Processor PCB Schematic
sheet 3 of 4

TYPE OF ELECTRONIC SENSOR

5.7 Oximetry of Human Body Sensor

While all oximeters operate on similar principles, much of the reliability of oximetry reading can be attributed to a proper sensor application and fit. There are a range of sensors designed to provide accurate readings on a variety of patients under a wide range of monitoring conditions and situation.

5.7.1 Single Patient Use Sensors

Adhesive sensors are designed to enable the sensor's light source and photodetector to be securely and properly positioned on the patient. The adhesive stabilizes these important optical components and provides a comfortable fit.

Adhesive sensors are patient-dedicated and can travel with patients. Single patient use sensors do not present the risk of cross contamination caused by products that are reused from a patient to patient. The adhesive sensors are ideal choice when environmental electronic noise levels are high and the patient's pulse is weak, because special shielding in both the sensor and the cable helps protect the pulse signal. Different the adhesive sensor model are available to fit different patient sizes.

5.7.2 Electronic Sensors Basic Concept

All sensors contain a light source and photodetector, which are the essential optical components necessary to determine arterial oxygen saturation by pulse oximetry. Sensors are designed so that the light source and the photodetector are positioned at positioned at a certain distance from one another to provide for proper fit various sizes of tissue.

Sensors should be chosen according to patients body weight to ensure the optical components are properly aligned when applied when to the recommended area. All sensors must be positioned so that the light source and photodetector are directly appeased to one another across an arteriolar bed

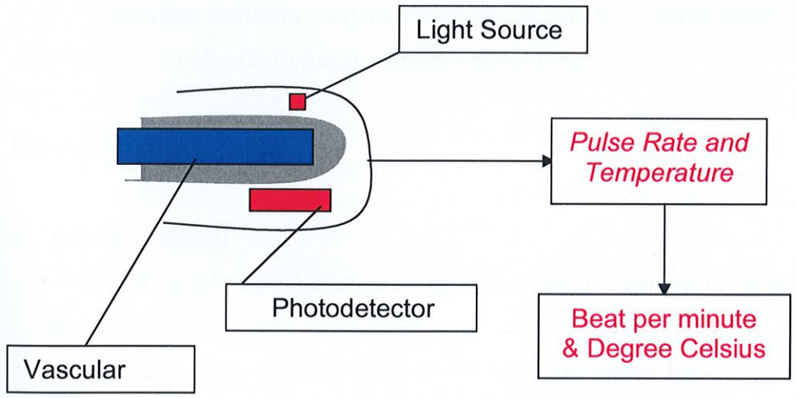


Figure 5.7(a); Electronic Sensors Meterial

5.7.3 Duration of Use

While adhesive sensors can be used for short or long-term monitoring, reusable sensors are generally indicated for spot check measurement or for short term monitoring or less than four hour.

Adhesive sensor sites should be checked for skin integrity and distal circulation at least once every eight hours and changed as appropriate. Reusable sensor sites must be checked and changed at least every four-hour or as specified in directions for use.

5.7.4 Infection Control

Adhesive sensors are medically clean in their unopened packages. They are made from quality new materials and assembled under clean room conditions.

Disposable sensors offer an infection control advantage for patients with suspected or confirmed infections and for those at greater risk for infections such neonates or immunosuppressed patients.

Reusable sensors require cleaning between patients with 70% alcohol or 1:10 bleach to meet infection control guidelines.

5.7.5 Sensor Characteristic

- **Adults (>40kg)**

  -Prefered applications site is index finger, with cable running along top of hand.

  -Alternative sites thumb, other small finger or great toe with cable running along sole of foot.

  -When using the ear clip sensors, alternative sites are the ear lobe and ear pinna with the cable running down the site of the patient face and body.

  -Change sites at least every 4 hours.

- **Pediatric (15-40kg)**

  -Prefered application sites is in index finger, which cable running along top of hands.

  -Alternatives sides are thumb, other small finger or great toe with cable running along sole of foot.

  -For patients who more 30kg, alternative sites are the ear lobe and ear pinna when using the ear clip sensors.

-Change sites at least every 4 hours.

- **Infants (3-15kg)**

  -Prefered applications sites is great toe, with cable running along sole of foot.

  -Change every 4 hours.

- **Neonates (1-3kg)**

  -Prefered application site is ball of foot.

  -Alternative site is palm of hand below the fingers, with cable running along palm.

  -Adhesive wraps are disposable.

  -Change every 4 hours.

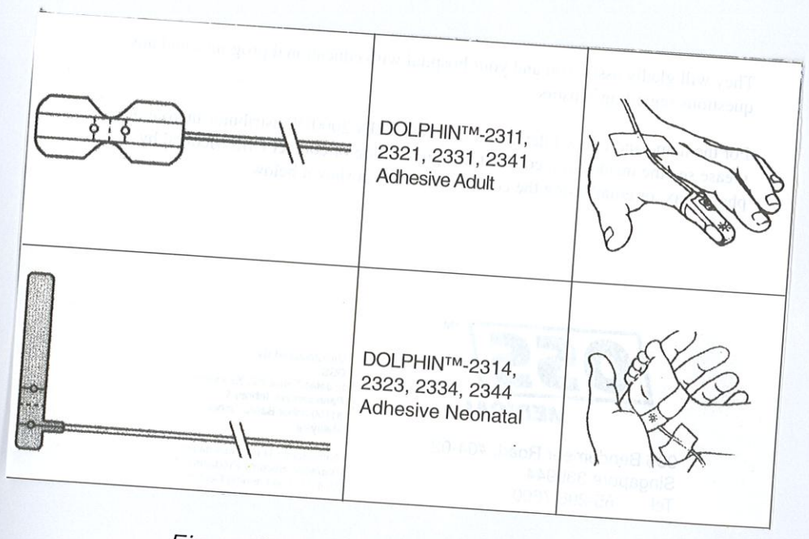


Figure 5.7(b): Sensor Appearance

CHAPTER 6
(Patient Data Entry System for Healthcare Support System)

6.0 Patient Data Entry - Healthcare Support System

Access to Patient Data Entry System (PDS System) information Is personalized and secure. Access to each user is by password, and each user operates in his own space dashboard and catalog.

Patient Data Entry allows you and your management to define and drill down on all possible dimensions of your patient for which data exists.

Patient Data Entry can show Target Vs achievements of business performance and allow to analyze why certain business areas did well and while others did not.

Graph or Data can be downloaded and imported directly into Microsoft excel. With Patient Data Entry we are more informed, connected and thereby confident that our actions will bring required results.

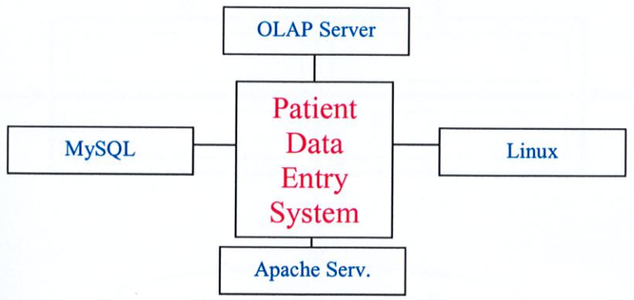


Figure 6.0 : Patient Data Entry (PDS System) Interface Framework

Patient Data Entry has in built in OLAP server, application server, and run in linux with apache web server and mySQL database. This means no other component is required for implementation and hence the low solution cost. Patient Data Entry can run on Oracle where required.

6.1 Patient Data Entry System Framework (PDS System)

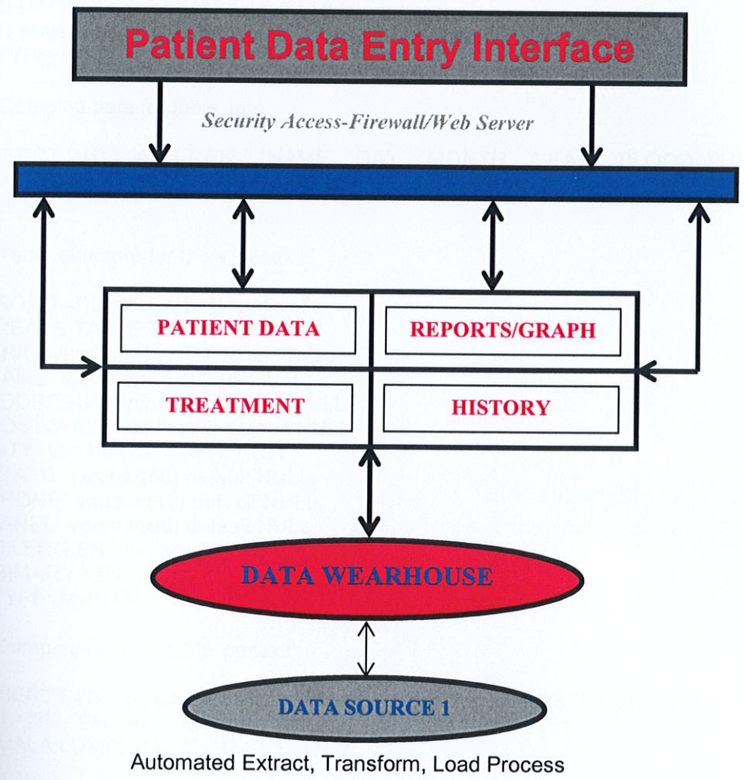


Figure 6.1: Flow Chart of PDS Design Framework

6.2 Programmer Language for Patient Data Entry System

```
# Server version 3.23.52-max-debug
USE PDE;
#
# Table structure for table 'lab'
#
DROP TABLE IF EXISTS `lab`;
CREATE TABLE `lab` (
`NRIC` varchar(12) NOT NULL default '0',
`NAME` varchar(60) default NULL,
`DAY` char(3) default NULL,
`MONTH` varchar(20) default NULL,
`YEAR` varchar(5) default NULL,
`BLOOD_PH` varchar(15) default NULL,
`GLUCOSE` varchar(15) default NULL,
`REMARK` text
) TYPE=MyISAM;
#
# Dumping data for table 'lab'
#
INSERT INTO `lab` (`NRIC`, `NAME`, `DAY`, `MONTH`, `YEAR`, `BLOOD_PH`,
`GLUCOSE`, `REMARK`) VALUES("1", "1", "1", "JANUARY", "2000", "1", "1", "ttrtrt
rtetr t ");
#
# Table structure for table 'pesakit'
#
DROP TABLE IF EXISTS `pesakit`;
CREATE TABLE `pesakit` (
`NRIC` varchar(12) NOT NULL default '0',
`NAME` varchar(60) default NULL,
`ADDRESS` varchar(60) default NULL,
`POSTCODE` varchar(5) default NULL,
`CITY` varchar(25) default NULL,
`STATE` varchar(40) default NULL,
`PHONE` varchar(15) default NULL,
`PANEL` varchar(60) default NULL,
`ALLERGIES` varchar(60) default NULL,
PRIMARY KEY  (`NRIC`)
) TYPE=MyISAM;
#
# Dumping data for table 'pesakit'
#
INSERT INTO `pesakit` (`NRIC`, `NAME`, `ADDRESS`, `POSTCODE`, `CITY`,
`STATE`, `PHONE`, `PANEL`, `ALLERGIES`) VALUES("1", "1", "1", "1", "1",
"KUALA LUMPUR", "1", "1", "1");
#
# Table structure for table 'rawatan'
#
DROP TABLE IF EXISTS `rawatan`;
```

```
CREATE TABLE `rawatan` (
 `NRIC` varchar(12) NOT NULL default '0',
 `NAME` varchar(60) default NULL,
 `DAY` char(3) default NULL,
`MONTH` varchar(20) default NULL,
`YEAR` varchar(5) default NULL,
`PULSE` varchar(15) default NULL,
 `BODY` varchar(15) default NULL,
 `BLOOD` varchar(15) default NULL,
`REMARK` text
) TYPE=MyISAM;
#
# Dumping data for table 'rawatan'
#
INSERT INTO `rawatan` (`NRIC`, `NAME`, `DAY`, `MONTH`, `YEAR`, `PULSE`,
`BODY`, `BLOOD`, `REMARK`) VALUES("1", "1", "1", "AUGUST", "2003", "111",
"111", "111", "null");
INSERT INTO `rawatan` (`NRIC`, `NAME`, `DAY`, `MONTH`, `YEAR`, `PULSE`,
`BODY`, `BLOOD`, `REMARK`) VALUES("1", "1", "1", "JANUARY", "2000", "21",
"21", "21", "12");
INSERT INTO `rawatan` (`NRIC`, `NAME`, `DAY`, `MONTH`, `YEAR`, `PULSE`,
`BODY`, `BLOOD`, `REMARK`) VALUES("1", "1", "4", "MAY", "2006", "233", "333",
“33”, “33333333333333333333333333333333333333
```

Figure 6.2: Programmer Language for PDE Icon

6.3 Patient Data Entry System Application

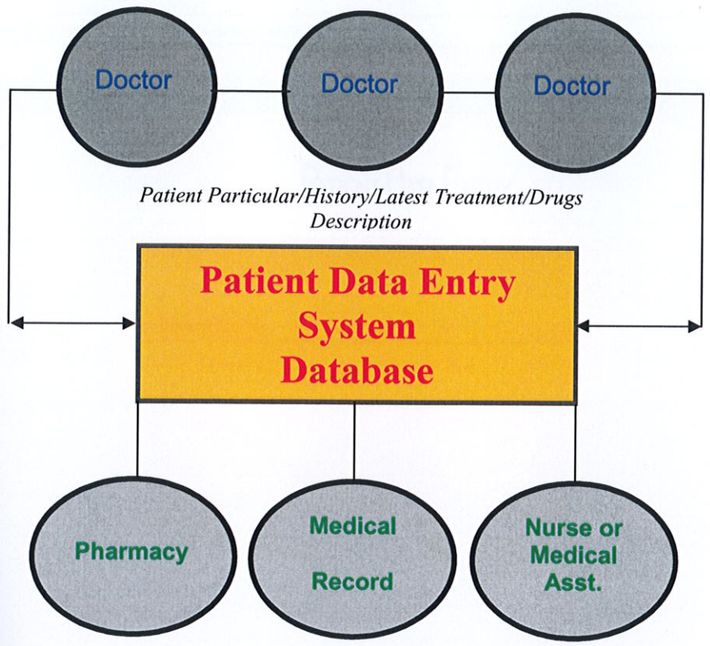
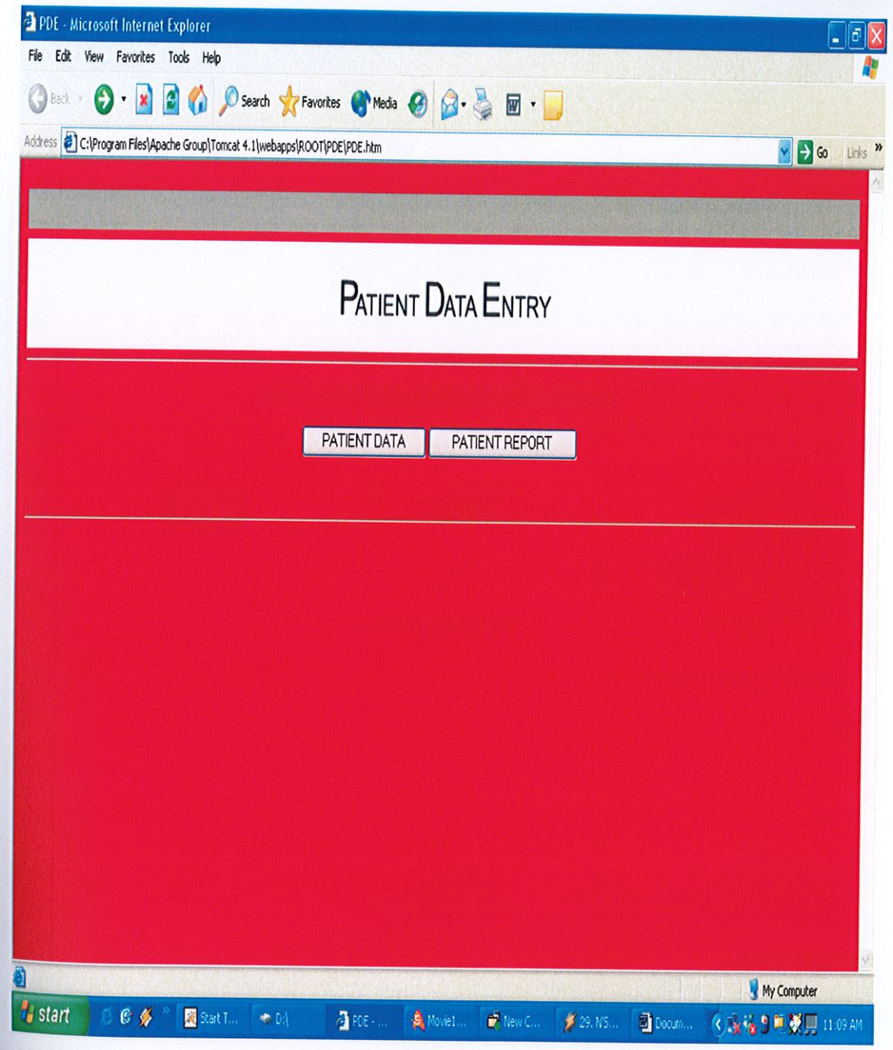
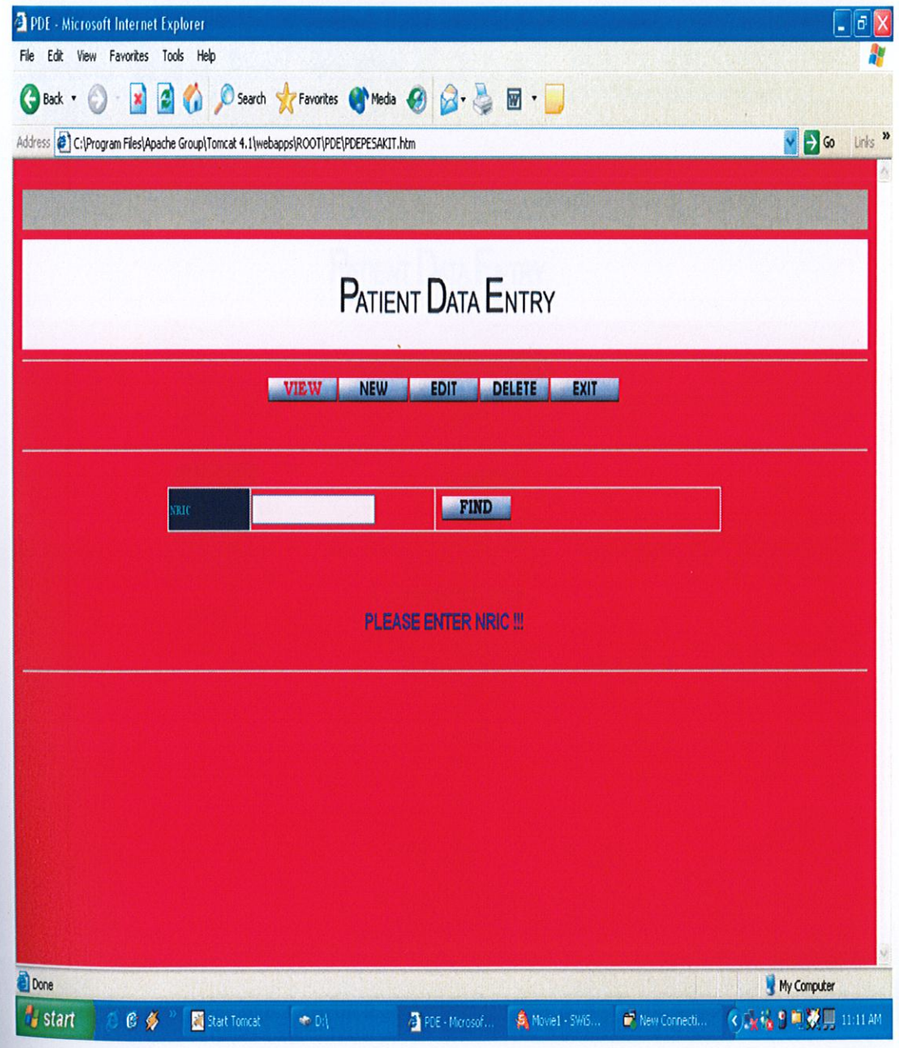


Figure 6.3: Application Flow Chart at Hospital

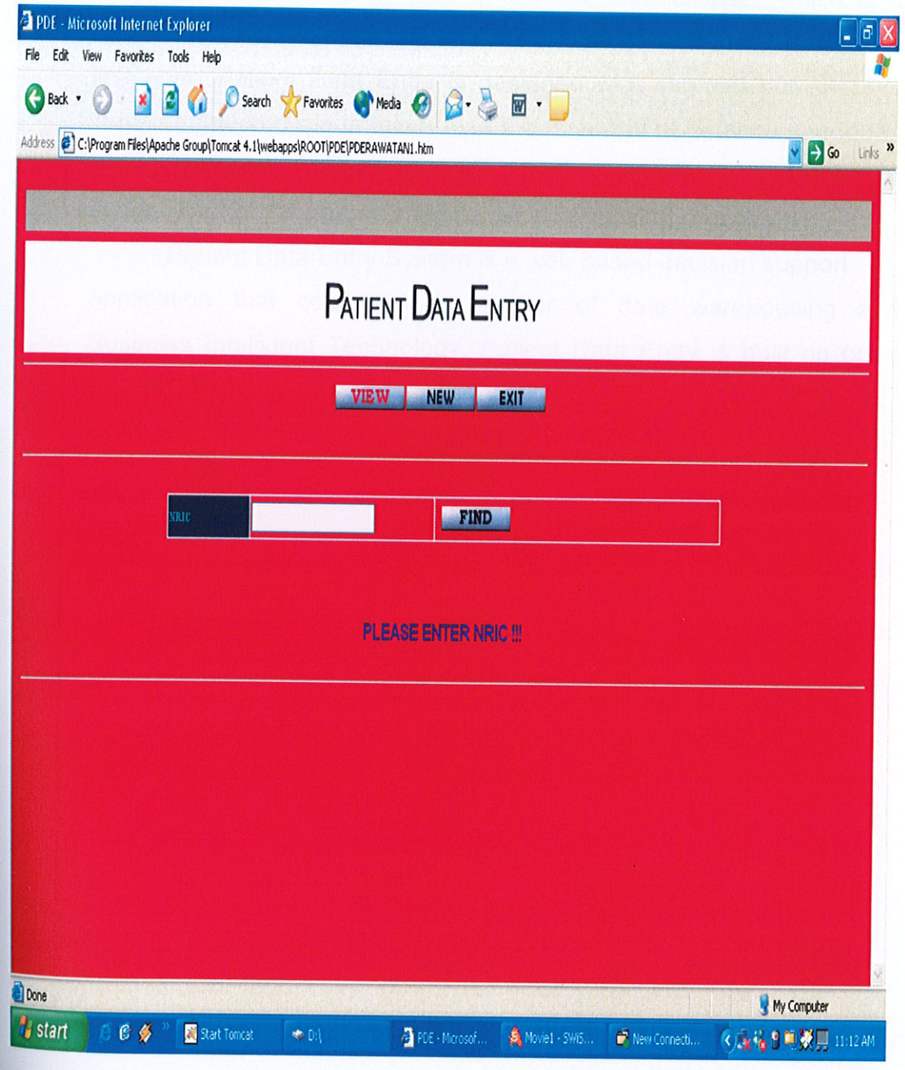
6.4 Interface Framework Design/Application



Picture 6.4(a): Examples of Interface Framework



Picture 6.4(b): Examples of Interface Framework



Picture 6.4(c): Examples of Interface Framework

Patient Data Entry front end is the web browser which is a similar tool, and the interface is intuitive. Users are productive from the first hour. Patient Data Entry is designed with shortest but effective implementation cycle in mind. Also the technical assistance needed to use is minimal. Thus is no time Patient Data Entry becomes an integral part of your organization's decision making process.

Patient Data Entry System is a web based decision support application that combines the power of data warehousing and Business Intelligent Technology. Patient Data Entry is built on open systems to ensure integration with your organization's IT applications.

CHAPTER 7
(Project Operation Manual)

7.0 Operation Manual for Project

Procedures to follow (multi-user):

1. The finger sensor cable is inserted into the Multi-user meter.
2. The subject moistens the forefinger, where contacted are placed. Attached the finger sensor over the moistened areas of the finger.
3. The subject should sit quietly with eyes closed and head lowered.
4. Set On/Off switch to the ON position. Advance the Multi-user and lets subject remain at the rest for 15-20 second.
5. If the light and indicators move up and down repeatedly, press reset button.
6. Determine whether the subject's responds and takes about 1 or 15 second after the touch. This is the normal response time for heart to respond to heart rate or pulse rate.
7. OPTIONAL: Remove the finger sensor and turn OFF the instrument. Allow the subject to the rest.

Procedures to follows (Thermometer Scan):

1. The heat sensor cable is inserted into the Multi-user meter.
2. The subject moistens the tongue, where contacted are placed. Attached the finger sensor over the moistened areas of the tongue.
3. The subject should sit quietly with eyes closed and head lowered.
4. Set On/Off switch to the ON position. Advance the Multi-user and lets subject remain at the rest for 1-10 second.
5. If the light and indicators move up and down repeatedly, press reset button.
6. Determine whether the subject's responds and takes about 1 or 15 second after the touch. This is the normal response time for temperature to respond to body thermo-scan.
7. OPTIONAL: Remove the heat sensor and turn OFF the instrument. Allow the subject to the rest.

Procedures to follows (Thermometer Scan):

1. Access to Patient Data Entry System(PDS) information is Personalized and secure. Access to each other is by password, each user operates in his own space with on dash board.
2. Patient Data Entry allows you to define and drill down on possible dimensions of your patient data.
3. Icon on Patient Data Entry Interface:

Patient Data : For new patient registration must be key in by the user. For example, Name, Identification Number, Address, Date of birth, Allergies, phone number, panel(Doctor) and Other.

Patient Report : Contains medical report that must be key in into the PDS interface. For example; Heart Rate, Pulse Rate, Body Temperature and remarks from the doctor to future actions.

CHAPTER 8
(Maintenance Manual)

8.0 Maintenance Manual for Project

All the medical equipment needs to service to ensure that all the application to the patient will not bring any problem when the user try to get the best point. Below is the Plan Preventive Maintenance for this bio-medical project.

PPM Checklist (Basic Inspection)

Multi-user Oximeter

Visual Inspection:

No	Description	Checked	Results
1	Check Chasis	Yes / No	
2	Check AC Plug	Yes / No	
3	Check Line Cord	Yes / No	
4	Check All Button	Yes / No	
5	Check Fitting/Connector	Yes / No	
6	Check Fuses	Yes / No	
7	Clean PCB Board	Yes / No	
8	Check Indicator Display	Yes / No	
9	Check the Probe Port	Yes / No	

Functional Test :

No	Description	Checked	Results
1	Check Ground Resistance	Yes / No	
2	Run Unit in normal Condition	Yes / No	

Remarks:.....

.....

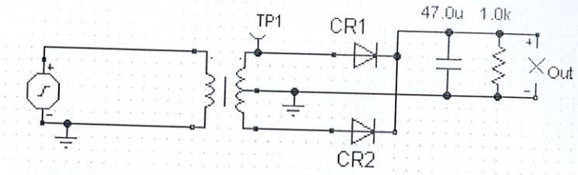
.....

CHAPTER 9
(Troubleshooting)

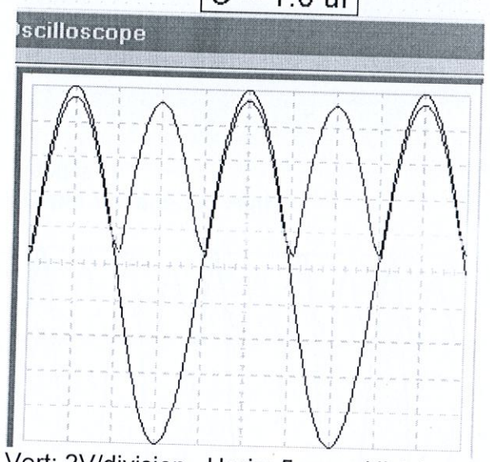
9.0 Electronic Troubleshooting

Rectifier Troubleshooting

The scope shows the waveform at TP1(Red) and the output of the rectifier (Green). The animation shows the effect of varying C from 1.0 uf to 1000 uf on the ripple voltage of the rectified output.



C = 1.0 uf



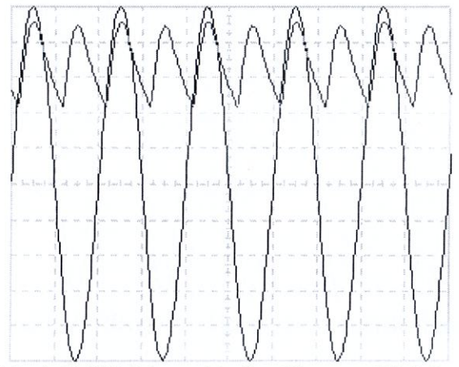
Vert: 2V/division Horiz: 5 msec/division

Use above as Base Line when troubleshooting problems below.

Possible Faults

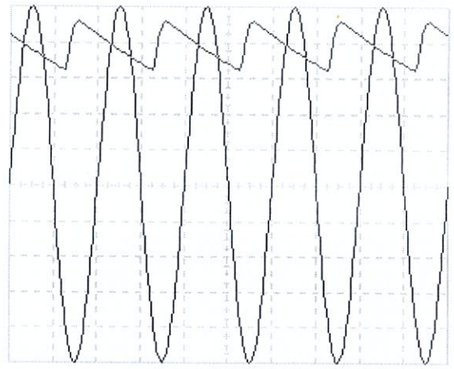
1. Capacitor Open
2. Capacitor Leaky
3. Capacitor Shorted
4. Resistor Open
5. Diode CR1 Shorted
6. Diode CR1 Open
7. Diode CR2 Shorted
8. Diode CR2 Open

Failure
Ripple Voltage too High



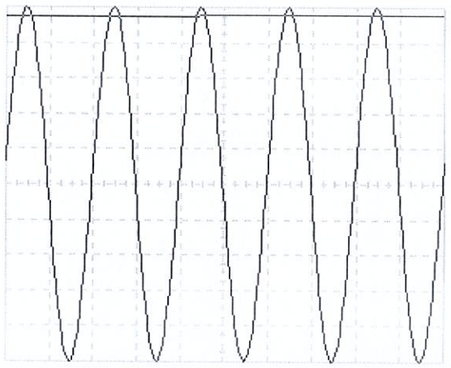
Vert: 2V/division Horiz: 10 msec/division

Failure
Ripple Voltage to High



Vert: 2V/division Horiz: 10 msec/division

Failure Ripple very low



Vert: 2V/division Horiz: 10 msec/division

The ripple voltage was very low which is generally a good thing; however, circuits don't improve spontaneously. Capacitors don't increase over an order in magnitude due to failure. Here, no ripple indicates no load. Even high amperage regulated outputs generally have ripple between 10mV and 100 mV.

CHAPTER 10
(Conclusion)

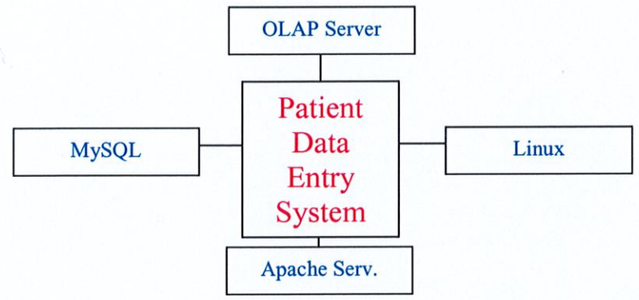
10.0 Project Conclusion

This project provides clinical examples to promote interest and demonstrate relevance, but clinical information is used primarily illustrate the application of the basic knowledge. Even though clinical information emphasizes hoe relevant knowledge of physiology theory and technical medical electronic theory. The ability to apply information to solve a problem is a skill that will always be an asset for the student, even after knowledge learned today is no longer current. This bio-medical project encourages student using the physiology theory and the technical theory to think critically with the clinical knowledge they have gained.

Oximeters are now a standard part of preoperative monitoring which give the operator a non-invasive indication of the patient's cardio-respiratory status. Having been successfully used in intensive care, the recovery room and during anaesthesia, they have been introduced in other areas of medicine such as general wards apparently without staff undergoing adequate training in their use [(1)]. The technique of project does have pitfalls and limitations and it is possible that patient safety may be compromised with untrained staff. This article is therefore intended for the 'occasional' user of this design.

Patient Data Entry (PDS System) helps by collecting patient data from your exisiting systems and data bases, and tranforming them into the various management dashboard and alerts for you and your key managers.

It also categorizes and summarizes information, and prepare graphical views and multi-dimensial reports. Its easy to use drill-down feature lets you zoom in on any aspect of your business instantly.

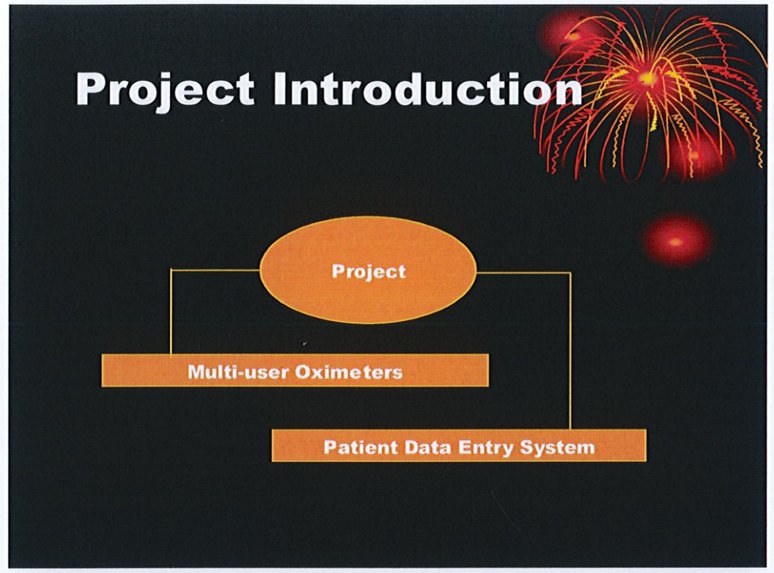


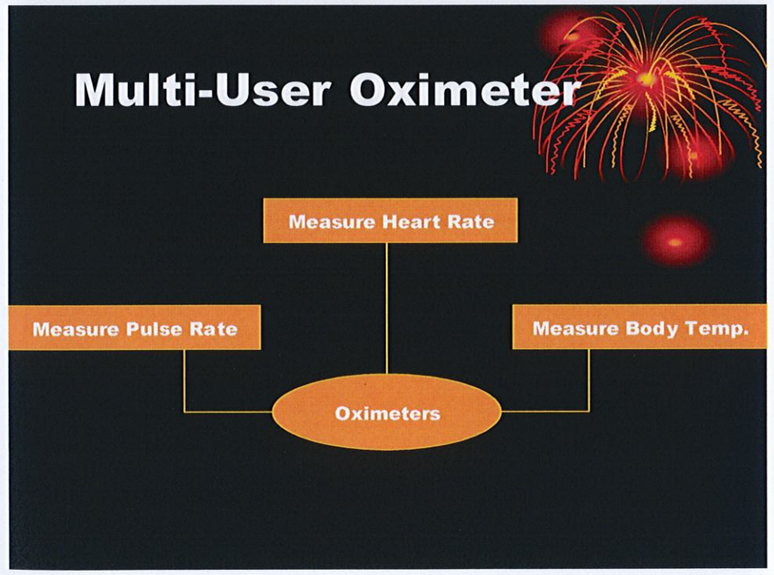
Patient Data Entry (PDS System) Interface Framework

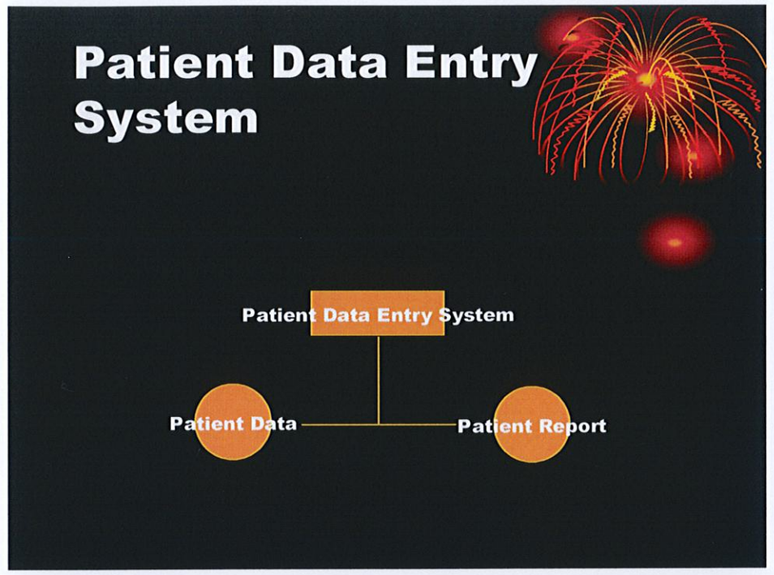
Presentation Show Slide

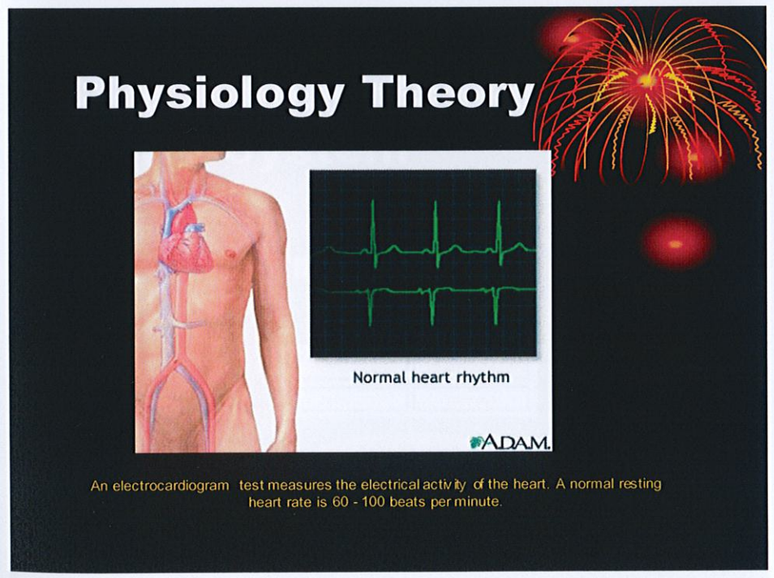

Healthcare Support System

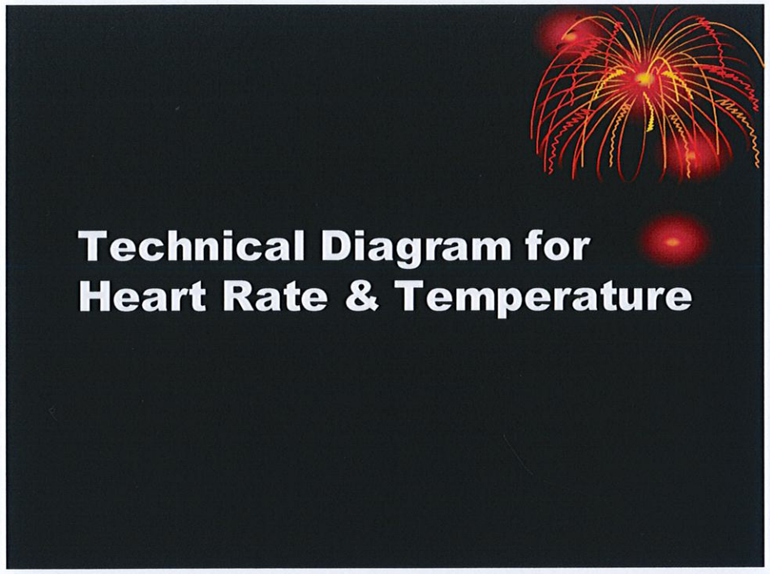

Project Team Members
• Mohd Nazrullah B. Mustafa
• Shazril Asrul B. Suhaimi
• Kathiresh A/L Rajagobal

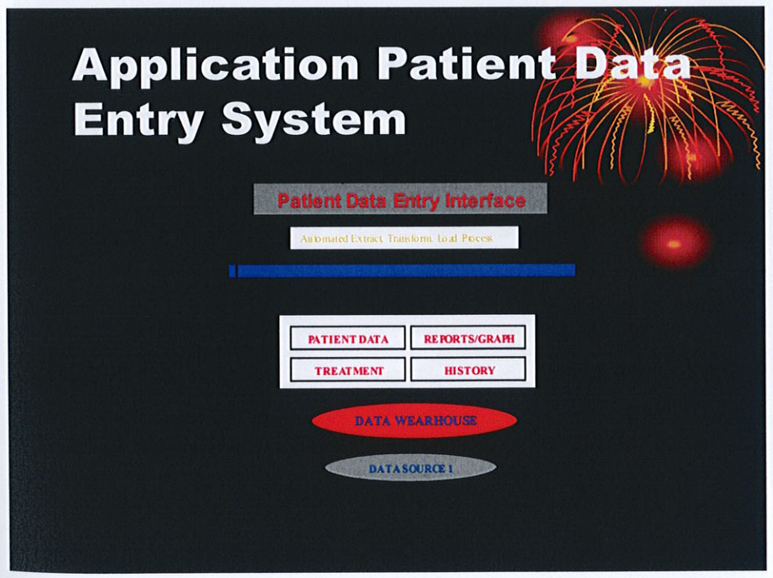

Project Introduction
Project
Multi-user Oximeters
Patient Data Entry System

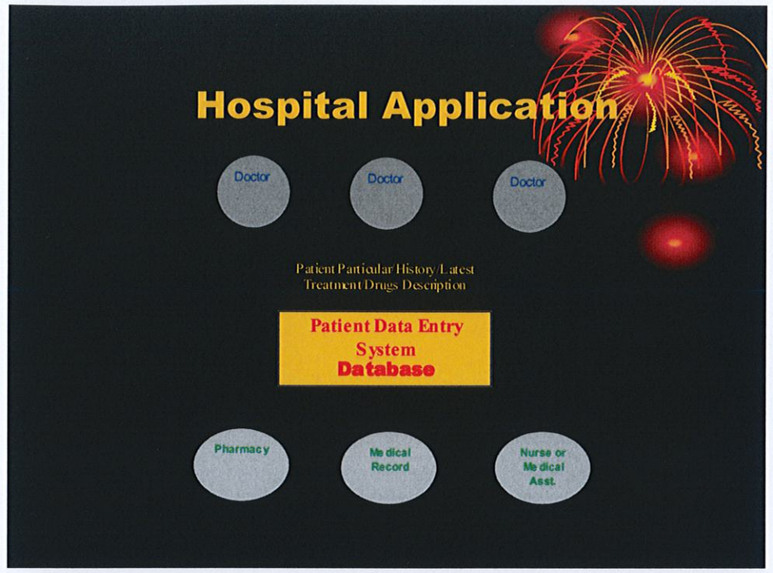

Multi-User Oximeter
Measure Heart Rate
Measure Pulse Rate
Measure Body Temp.
Oximeters

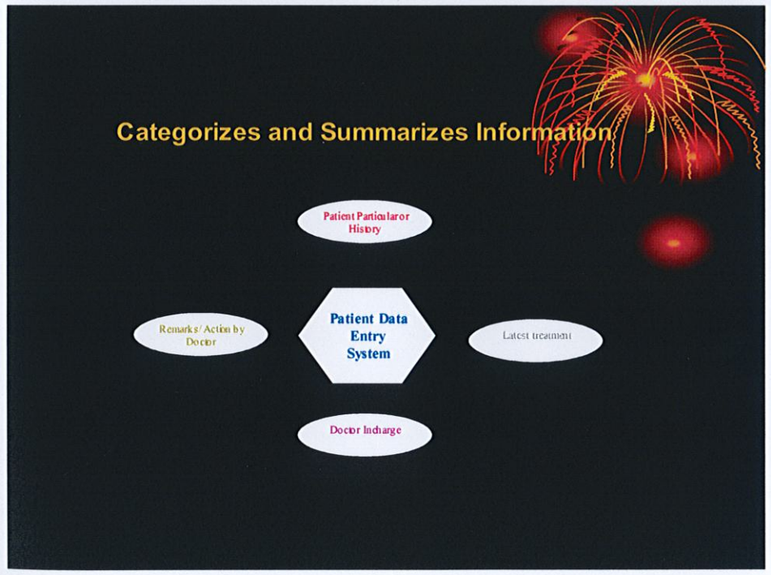

Patient Data Entry System
Patient Data Entry System
Patient Data
Patient Report


Physiology Theory
Normal heart rhythm
A.D.A.M.
An electrocardiogram test measures the electrical activity of the heart. A normal resting heart rate is 60 - 100 beats per minute.


Technical Diagram for
Heart Rate & Temperature


Application Patient Data
Entry System
Patient Data Entry Interface
Automated Extract Transform Load Process
PATIENT DATA
REPORTS/GRAPH
TREATMENT
HISTORY
DATA WEARHOUSE
DATA SOURCE 1


Hospital Application
Doctor
Doctor
Doctor
Patient Particular History Latest Treatment Drugs Description
Patient Data Entry System
Database
Pharmacy
Medical Record
Nurse or Medical Asst.


Categorizes and Summarizes Information
Patient Particular or History
Remarks/Action by Doctor
Patient Data Entry System
Latest treatment
Doctor Incharge

REFERENCES

Reference;

1. Mr. Mohd Hanizan
   Senior Bio-Medical Engineer,
   Ampang Puteri Specialist Hospital.

2. Mr. Elman El-Bakri Mustafa,
   Senior Bio-Medical Engineer,
   Healthcare Technical Services Sdn Bhd,
   Healthcare Kumpulan Perubatan Johor, Kuala Lumpur.

3. Miss. Norafidah,
   Bio-Medical Technician,
   Pusat Pakar Tawakal, Kuala Lumpur.

4. Dr. Razak B. Haji Muhamad (MBBS USM)

5. Advance Spare Part Medical Sdn Bhd,
   Batu Berendam, Melaka.

Further Reading;

1. Stoneham MD, Saville GM, Wilson IH. Knowledge about pulse oximetry among medical and nursing staff. Lancet 1994:334:1339-1342.

2. Moyle JTB. Pulse oximetry. Principles and Practice Series. Editors: Hahn CEW and Adams AP. BMJ Publishing, London, 1994.

3. Davidson JAH, Hosie HE. Limitations of pulse oximetry: respiratory insufficiency - a failure of detection. BMJ 1993;307:372-373.

4. Hutton P, Clutton-Brock T. The benefits and pitfalls of pulse oximetry. BMJ 1993;307:457-458.

ADVANCE PACT SDN BHD
MEDICAL SPARE PART LIST

M	MANUFACTURER	EQUIPMENT NAME	MODEL NO.	DESCRIPTION	PART NO.
QUETTE		Marquette Tram-A	400SL	Data Acquisition Board	800514-001
ROSCOPE	Leica	Operating Microscope	M690	Zoom Unit Assembly	10406239 (New P/N : 10445173R)
ROSCOPE	Olympus Optical	Flourescent Microscope	BX 40-F4	Flourescent 100W	8B192U
ROTOME	Leica	Microtome	RM 2145	Motor	14050229448
ROTOME	Leica	Microtome		Lifting Table Complete	0418 18723
otome	Leica	Microtome		Motor for Lifting	12328365
ROTOME	Reichart Jung	Microtome	CM 1800	Lifting Table Cp1	14039818000
R N2O/O2	Ohmeda	Mixer N20/02	Mark II	3L Re-Breathing Bag	372763
ITOR	Air Shield	Infant Monitor	System VI	Mother Board Assy. (220/240vac Series 3)	8955070
ITOR	Air Shield	Infant Monitor	System VI	Front And Board Assembly	8955170
ITOR	Air Shield, USA	Infant Monitor	System VI	Refurbished'	
ITOR	Artema Monitoring	Physiologic Monitor	Diascope N.T	Power Supply Unit	SW/57677-4
ITOR	Artema Monitoring	Physiologic Monitor	Diascope N.T	Battery Unit	SW/49355-8
ITOR	BCI International	Multi Gas Monitor	BCI 9020	Oximetry Finger Probe	3044
ITOR	BCI Oximeter	Multi Gas Monitor	BCI 9020	Finger Cable	3044
ITOR	Catalyst Research	Oxygen Monitor	Miniox 111	O2 Sensor	
ITOR	Caymans Mindray Electronics	Patient Monitor	PM9000	Standard Configuration (complete set) including	
ITOR	Corometric, USA	ECG Fetal Monitor	118	Toco Transducer, Nautilus	2264LAX
ITOR	Corometric, USA	ECG Fetal Monitor	118	Toco Transducer - compatible replacement for Corometric 116/118 Trimline	2260EAX-CR
ITOR	Corometric, USA	ECG Fetal Monitor	118	Toco Transducer - compatible replacement for Corometric 145/118 Trimline	2260AAX-CR
ITOR	Corometric, USA	ECG Fetal Monitor	118	Toco Transducer, Trimline - exchange	2260EAX
ITOR	Corometric, USA	ECG Fetal Monitor	118	Toco (Rectangular) - exchange, Model 145	2260AAX
ITOR	Critikon	Monitor	81,009,300	Key Pad 8100	701252
ITOR	Critikon	Monitor	81,009,300	Key Pad 9300	701398
ITOR	Critikon	Monitor	81,009,300	Battery	320378
ITOR	Critikon	Patient monitor	81,009,300	Key Pad 8100	701252
ITOR	Critikon	Patient monitor	81,009,300	Key Pad 9300	701398
ITOR	Critikon	Patient monitor	81,009,300	Battery	320378
ITOR	Critikon	NIBP Monitor	1846	Pump Motor Assy	712264
ITOR	Critikon	NIBP Monitor	1846	CPU Board - Outright	315-258
ITOR	Critikon	NIBP Monitor	1846	CPU Board - exchange	315-258
ITOR	Critikon	NIBP Monitor	1846	Switch Pressure Adjusted for 310MHz	662-1258
ITOR	Critikon	NIBP Monitor	1846	Battery Y2 AA, 3 AV	
ITOR	Datascope	Physiologic Monitor	Parsport	IBP Cable (Invensive Boold Pressure)	2000-2002
ITOR	Datascope	Portable Monitor	Parsport	Panel Board	670-00-0443
ITOR	Datascope	Portable Monitor	Parsport	LCD Display/CCT	160-00-0007
ITOR	Datascope	Portable Monitor	Parsport	Battery	146-00-0043
ITOR	Datascope	Portable Monitor	Parsport	Finger Sensor	0600-00-0026-01
ITOR	Datex	Capnomac Ultima		Oxygen Sensor (O2 Measuirng Unit, Complete)	888511

M	MANUFACTURER	EQUIPMENT NAME	MODEL NO.	DESCRIPTION	PART NO.
NITOR	Datex	Capnomac Ultima		MAX-1 (Replacement for Datex Ohmeda)-Oxygen sensor Ohmeda* 4700 Oxicap, 5200 RGM, Modulus & Excel Series, 5120 O2 Series	
NITOR	Datex	Capnomac Ultima		MAX-10 (Replacement for Datex Ohmeda Extral-life Oxygen Sensor Anesthesia systems that use the 7900	
NITOR	Datex Ohmeda	Patient monitor	AS/3	300 Series 5 Lead Trunk Cable; 3m/10ft. IEC	545301
NITOR	Datex Ohmeda	Patient monitor	AS/3	300 Series 5 Lead Set with Clips;125cm/49inc. leg.& 75cm/30inc. Chest	545316
NITOR	Datex Ohmeda	Patient Monitor	AS/3	300 Series 3 Lead Trunk Cable 3m/10feet	545305
NITOR	Datex Ohmeda	Patient Monitor	AS/3	300 Series 3 Lead Trunk Cable 75m/30feet	545315
NITOR	Datex-Ohmeda	Anaesthesia Monitor	AS/3	MBP Frame, M-MBP-00-03	880427
NITOR	Dinamap Critikon, USA	Vital Sign Monitor	XL 9301	Power Supply PCB	315-291 (Old P/N : 315-503)
NITOR	Dinamap Critikon, USA	Vital Sign Monitor	8100	CPU Board	315-320
NITOR	Dinamap Critikon, USA	Vital Sign Monitor	8100	Front Panel	
NITOR	Draeger	PEEG Monitor	8601280	Set of Batteries	8201729
NITOR	Draeger	PEEG Monitor II	8601280	Insert Only	8.4V 1.84AH
NITOR	Draeger, Germany	PEEG Monitor II	8601280	Rep. Exch PCB I/O	8601304
NITOR	Eastwood	Apnea Monitor	RE 2000	Reusable Sensoe Pads	EW/RES
NITOR	GE Marquette	Monitor	Solar 8000	12 Lead ECG Cable	E9002ZH
NITOR	GE Marquette	Transport Monitor	Smart Pac	Smart Pac Rechargeable	900151-001
NITOR	Hewlett Packard	Fetal Monitor	50 A Series	Complete Transducer	M1355-69013
NITOR	Hewlett Packard	Fetal Monitor	50 A Series	Complete Transducer - ex-	M1355-69013
NITOR	Hewlett Packard	Fetal Monitor	50 A Series	Ultrasound Transducer	M1356-69013
ONITOR	Hewlett Packard	Fetal Monitor	50 A Series	Ultrasound Transducer - ex-change	M1356-69013
ONITOR	Hewlett Packard	Fetal Monitor	50 A Series	US Transducer	M1356-60011
ONITOR	Kontron	Physiologic Monitor	7136B	Extension Cable	0743-000
ONITOR	Kontron	Physiologic Monitor	7136B	Patient Cable 3 Lead, Minimon	0740-000
ONITOR	Kontron France	Monitor Minimon	7173B	Pump & Plate assembly	71331149
ONITOR	Kontron France	Monitor Minimon	7173B	Pump Assembly	71330149
ONITOR	Kontron Inst., UK	Patient monitor	Minimom 7136B	Main Board for Minimom	71310811
ONITOR	Marquette	Patient Monitor	4000	IBP Cable - Adult	E9001TE
ONITOR	Marquette	Patient Monitor	4000	IBP - Cable - Neonate	E9001TF
ONITOR	Marquette	Patient Monitor	4000	ECG Cable - Multilink 12'	E9002ZB
ONITOR	Marquette	Patient Monitor	4000	5 Lead Wire Set (Grabber)	E900ZW
ONITOR	Marquette	Patient Monitor	4000	Tru Link Lead Cable - 29"	E9003CE
ONITOR	Marquette	Patient Monitor	4000	Tru Link Lead Cable - 51"	E9003CF
ONITOR	Marquette	Patient Monitor	4000	Tru Link Lead Cable - 29" Snap	E900CR
ONITOR	Marquette	Patient Monitor	4000	Tru Link Lead Cable - 51" Snap	E9003CS
ONITOR	Marquette	Patient monitor	930308	SPO Finger Sensor	015-0130-00
ONITOR	Marquette	Patient Monitor	Eagle 4000	Upgrade Kit Color Display Serv.	412186-025
ONITOR	*Marquette*	*Patient monitor*	*Solar 800*	*5 Lead Cable*	*412681-002*

M	MANUFACTURER	EQUIPMENT NAME	MODEL NO.	DESCRIPTION	PART NO.
ITOR	Marquette	Patient monitor	Solar 8000	5 Lead MultiLink ECG Patient Cable	412931-001
ITOR	Marquette	Patient monitor	Solar 8000	5 Set Grabber Lead Wire	412681-001
ITOR	Marquette	Physiologic Monitor	Eagle 4000	3 Lead Cable	411203-004
ITOR	Marquette	Physiologic Monitor	Eagle 4000	Nellcor Cable	407252-002
ITOR	Marquette	Physiologic Monitor	Solar 8000	5 Lead Cable - 12 feet	E9002ZB
ITOR	Marquette	Physiologic Monitor	Solar 8000	5 Lead Cable - 20 feet	E9002ZD
ITOR	Marquette	Physiologic Monitor	Eagle 4000	ECG Patient Cable	E9002ZB
ITOR	Marquette	Monitor		ECG 12 Lead Cable (Multilink Cable)	416035-001
ITOR	Marquette	Monitor	450SL	Eagle Interf Cable (Extension Cable SPO2)	407252-002
ITOR	Marquette	Patient monitor	Eagle 1000	ECG Cable (3 Lead Wire)	412682-002
ITOR	Marquette, USA	Physiologic Monitor	Eagle 4000	Display	412 186 025
ITOR	Marquette, USA	Physiologic Monitor	Eagle 4000	Ethernet Address Cable	800400-001
ITOR	Marquette, USA	Physiologic Monitor	Eagle 4000	Flex Circuit	800401-001
ITOR	Nihon Kohden	Patient monitor	LIFESCOPE L	Battery NKB- 102v 12v 1700 MHz	NKB - 101
ITOR	Novametrix	CO2 Monitor	Capnostat III	CO2 Sensor	7167
ITOR	Ohmeda	Mixer N2O/O2	Duno MK2	Filter	6600-0043-800
ITOR	Ohmeda	Mixer N2O/O2	Duno MK2	Upper Wall Retainer	6600-0148-500
ITOR	Oxford	Fetal Monitor	Sonicaid Team	Toco Transducer - pink connector	OX-8400-6921
ITOR	Oxford	Fetal Monitor	Sonicaid Team	CTG Cardio Transducer - blue, 2MHz Ultrasound, 12228	OX-8400-6920
ITOR	S & W	Patient Monitor	Diascope NT 3050	3 Lead Patient Cable	49317-7
ITOR	S&W	Central Monitoring System	8600	Real-Time Clock Board	180-1-0946
ITOR	S/No. 309-004975	Spacelabs Portable Monitor	90309	Iris PCBA/ Bezel Assembly	050-0085-00
ITOR	Spacelabs	Monitor		Compatible SpO2 Finger Probe	3262
ITOR	Spacelabs	Patient monitor	9135	Rechargeable Battery	146-0014-00
ITOR	Spacelabs	Patient monitor	9135	Lithium Battery	384322-001
ITOR	Spacelabs	Patient monitor	90305	Monitor, Shadow Mask 14"	650-0454-00
ITOR	Spacelabs	Patient monitor	90305	Monitor, Shadow Mask 14" - exchange	650-0454-00
ITOR	Spacelabs	Patient monitor	90513	02 Sensor	015-0132-03
ITOR	Spacelabs	Patient monitor	90385 (ucw)	Touch Screen Monitor - ex-	010-0681-00
ITOR	Spacelabs	Patient monitor	90385 (ucw)	Filter, Fan	019-0239-01
ITOR	Spacelabs	Patient Monitor	AUST	Paper Drive Roller - Printer	019-0112-00
ITOR	Spacelabs	Patient monitor	PC 290305	Tru Link Lead Wire Set Safety	12032600
ITOR	Spacelabs	Patient monitor		ECG Respiratory Cable	012-0201-00
ITOR	Spacelabs	Physiologic Monitor	90305	Cardiac Output Cable	306655002
NITOR	Spacelabs	Physiologic Monitor	90515	Mainstream Capnograph Sensor Factory repair	011-0710-00
NITOR	Spacelabs	Physiologic Monitor	90515	Mainstream Capnograph Sensor new	011-0710-00
NITOR	Spacelabs	Physiologic Monitor	90721	ECG Lead	C020283
ONITOR	Spacelabs	SPACELABS UCW MONITOR	90385	MONITOR DISPLAY ASSY.(EX.BASIS)	010-0681-00
ONITOR	Spacelabs	SPACELABS UCW MONITOR	90385	PCB ASSY. CPU NO.E2 8TRACE (EX.BASIS)	673-0173-00
ONITOR	Spacelabs	Bedside Monitor		Touch Screen including Bazel-new	019-0249-00

M	MANUFACTURER	EQUIPMENT NAME	MODEL NO.	DESCRIPTION	PART NO.
NITOR	Spacelabs	Bedside Monitor		touch Screen Including Bazel-exchange	019-0249-00
NITOR	Spacelabs	Bedside Monitor		CPU PCB 16 Trace Configuration-new	672-0175-00
NITOR	Spacelabs	Bedside Monitor		CPU PCB 16 Trace Configuration-exchange	672-0175-00
NITOR	Spacelabs	Bedside Monitor		Touch Screen (IRTS) Bezel Assy.-new	650-0111-11
NITOR	Spacelabs	Bedside Monitor		Touch Screen (IRTS) Bezel Assy.-exchange	650-0111-11
NITOR	Spacelabs	Bedside Monitor		Touch Screen (IRTS) Bezel Assy.-New	650-0108-02
NITOR	Spacelabs	Bedside Monitor		Touch Screen (IRTS) Bezel Assy.-exchange	650-0108-02
NITOR	Spacelabs	Patient monitor	90513	O2 Sensor (Capnogaraph)	015-0132-03
NITOR	Spacelabs	Patient monitor	90518	O2 Sensor (Multigas)	010-1120-00
NITOR	Spacelabs	Patient monitor		DC Power Supply Unit	90486
NITOR	Spacelabs	Patient monitor	90385	CPU Module - Outright	010-0681-00 Rev M
NITOR	Spacelabs	Patient monitor	90385	CPU Module - Exchange	010-0681-00 Rev M
NITOR	Spacelabs	Patient monitor	90385	Monitor - Exchange	
NITOR	Spacelabs	Patient Monitor	90515	CO2 Sensor for 90515	011-0710-00
NITOR	Spacelabs	Patient monitor	90385	Wyse Assy., including Monitor (Exchange)	010-0681-00
NITOR	Spacelabs	Patient monitor	90385	PCB Assy., CPU NO e2, 8 Trace (Exchange)	673-0173-00
NITOR	Spacelabs	Patient Monitor	90515	PCB Assy., CO2 90515 (New)	670-8188-00
NITOR	Spacelabs	Patient Monitor	90515	PCB Assy., CO2 90515 (Exchange)	670-8188-00
NITOR	Spacelabs	Patient Monitor	90515	PCB Assy., CO2/SLDC Capnograph (New)	671-0775-00
NITOR	Spacelabs	Patient Monitor	90515	PCB Assy., CO2/SLDC Capnograph (Exchange)	671-0775-00
NITOR	Spacelabs	Patient Monitor	90515	CO2 Sensor for 90515 (Refurbished), Exchange	011-0710-00
NITOR	Teledyne	Monitor	TED200	O2 Cell	00M10ST7
NITOR	Teledyne	Oxygen Monitor	R22	TED R22 Oxygen Sensor	
NITOR	Welch Allyn	Life Sign Monitor	CE 0050	Charger 230V - 50Hz or transformer with power cord	5200-101(transformer) & 5200-110 (Cord)
NITOR	Welch Allyn	NIBP Monitor	52000	Main PCB Assembly (Exchange)-silent button is blue	130S45
NITOR	Welch Allyn	NIBP Monitor	52000	Main PCB Assembly (Exchange)-silent button is grey	130S3
NITOR		Oxygen Monitor	Mini OX 111	O2 Sensor	406931
TAL SIGN NITOR	Dinamap Critikon	Vital Sign Monitor	8100	Bezel Assembly English	332-159
TAL SIGN NITOR	Dinamap Critikon	Vital Sign Monitor	8100	Pneumatic Module PWA	315-296
TAL SIGN NITOR	Dinamap Critikon	Vital Sign Monitor	8100	Case Assembly English	300-609
TAL SIGN NITOR	Dinamap Critikon	Vital Sign Monitor	8100	Front Panel English	701-252

M	MANUFACTURER	EQUIPMENT NAME	MODEL NO.	DESCRIPTION	PART NO.
AL SIGN NITOR	Dinamap Critikon	Vital Sign Monitor	8100	Pneumatic Assembly, PWA	315-316
				SPO2 Cable	175-0646-00

N	MANUFACTURER	EQUIPMENT NAME	MODEL NO.	DESCRIPTIONS	PART NO.
EBULIZER	PARI	Nebulizer	PARI Master	Diaphragm	03.36.24
EBULIZER	PARI	Nebulizer	PARI Master	Nozzle	19.211
EBULIZER	PARI	Nebulizer	PARI Master	Top Section - min qty 35	12.1700
EBULIZER	PARI	Nebulizer	PARI Master	Bottom Section - min qty 20	12.1000
EBULIZER	PARI	Nebulizer	PARI Master	Drug Reservoir - min. qty. 12	12.1601P2
EBULIZER	PARI	Nebulizer	PARI Master	Atomizer - complete set	22F81
EBULIZER	PARI	Nebulizer	PARI Master	LC Plus	22G86
EBULIZER	PARI	Nebulizer	PARI Master	Interrupter Button	
EBULIZER	PARI	Nebulizer	PARIWalkboy	Rechargable Battery for Walkboy	03-45-1200

O	MANUFACTURER	EQUIPMENT NAME	MODEL NO.	DESCRIPTIONS	PART NO.
ODONTOMETER	Goof Denmark	Odontometer		Pulp Sensivity Test-Probe	
OPERATING SCOPE	Leica	Operating Scope	Leica	Halogen Lamp 12V/50W - Microscope	M1643
OPTHALMOSCOPE	Heine Optotechnik	Opthalmoscope	Omega 200	ACCU Box II c/w rechargeable Battery	X-04.99.634
OPTHALMOSCOPE	Vista Diagnostic Inc.	Opthalmoscope	Keeler	Vista 20 Head	1112P1298
OPTHALMOSCOPE	Welch Allyn	Opthalmoscope	Welch Allyn	Opthalmoscope Head - 2.5 Volt System	11470
OPTHALMOSCOPE	Welch Allyn	Opthalmoscope	Welch Allyn	Opthalmoscope Head - 3.5 Volt System; Basic	11710
OPTHALMOSCOPE	Welch Allyn	Opthalmoscope	Welch Allyn	Opthalmoscope Head - 3.5 Volt System; Coax	11720
OPTHALMOSCOPE	Welch Allyn	Opthalmoscope	Welch Allyn	Opthalmoscope Head - 3.5 Volt System; Auto Step Coax	11730
OPTHALMOSCOPE	Welch Allyn	Opthalmoscope	Welch Allyn	Bulb	4900
OPTHALMOSCOPE	Welch Allyn	Opthalmoscope	Welch Allyn	Bulb	6000
OPTHALMOSCOPE	Welch Allyn	Opthalmoscope	Welch Allyn	Lamp	04900
OPTHALMOSCOPE	Welch Allyn	Opthalmoscope	Welch Allyn	Lamp - compatible	04900-CR
OPTHALMOSCOPE	Welch Allyn	Opthalmoscope	Welch Allyn	Lamp 3.5V	03000
OPTHALMOSCOPE	Welch Allyn	Opthalmoscope	Welch Allyn	Lamp 3.5V - compatible	03000 - CR
OPTHALMOSCOPE	Welch Allyn	Opthalmoscope		Bulb Opthal 2.5V	04400
OT TABLE	Unicell, Japan	OT Table	TLA 12260	Sealed Lead Acid Battery 12V, 26AH	
OT TABLE	Unicell, Japan	OT Table	TLA 624	Sealed Lead Acid Battery 6V, 2.4AH/ 20 hrs (Dimension 66mm x 33mm x 97mm)	
OTOSCOPE	Linvatec Corp.	Orthoscope	C9800	Apex Basic Handpiece - exchange price	C9820
OTOSCOPE	Linvatec Corp.	Orthoscope	C9800	Apex Basic Handpiece - outright price	C9820
OVEN	Clear Medical LLC, USA	Drying Oven		Fan, recirculating 110V	010100-00
OVEN	Memmert	Oven	UL 40	Power Switch 240V (S/N: 830686)	
OVEN	Oven		Mentmert	Mercury Switch/3 Terminal (10Amp)	220v/2200w

P	MANUFACTURER	EQUIPMENT NAME	MODEL NO.	DESCRIPTIONS	PART NO.
PERIMETER	Humphery (Carl Zeiss)	Perimeters	750	PCBA Projection Lamp - assy with buld	30323
PHOTOTHERAPY	Phillip	Phototherapy		Phototherapy Lamp	TL20W/52
PHOTOTHERAPY	Phillip	Phototherapy		Halogen Bulb 21V, 150W	EKE13629
PULSE OXIMETER	BCI	Pulse Oximeter	3100	Infant wrap Probe	3025
PULSE OXIMETER	BCI	Pulse Oximeter	3100	SPO2 Probe	3044
PULSE OXIMETER	BCI	Pulse Oximeter	3100	Extension Cable	3109
PULSE OXIMETER	BCI International	Pulse Oximeter	3100	Main Mother Board	70750A3
PULSE OXIMETER	BCI International	Pulse Oximeter	9004001 Capnocneck	Moisture Trap (10pcs/pkt)	1178
PULSE OXIMETER	BCI International	Pulse Oximeter	9004001 Capnocneck	Internal C02 Absorber	20632B
PULSE OXIMETER	BCI International	Pulse Oximeter	9004001 Capnocneck	External Disc Filter	31191B1
PULSE OXIMETER	BCI International	Pulse Oximeter	9004001 Capnocneck	Internal Disc Filter	31191B2
PULSE OXIMETER	BCI International	Pulse Oximeter	B 100	SP02 Y Sensor Complete with 1m of Patient Cable	
PULSE OXIMETER	BCI International	Pulse Oximeter	BCI 3100	Extension Cable	3109
PULSE OXIMETER	BCI International	Pulse Oximeter		SPO2 Adult Finger Probe	3109-02-8806
PULSE OXIMETER	BCI Int'l - compatible	Pulse Oximeter		Finger Probe - 3 feet	Dolphin 2050
PULSE OXIMETER	BCI Int'l - compatible	Pulse Oximeter		6 feet extension cable	Dolphin 2415
PULSE OXIMETER	BCI Int'l - compatible	Pulse Oximeter		10 Feet Extension Cable	Dolphin 2425
PULSE OXIMETER	BCI Int'l - compatible	Pulse Oximeter		Finger Probe 3 feet	Dolphin 2050
PULSE OXIMETER	BCI Int'l - compatible	Pulse Oximeter		Y Probe 36" c/w ear clip	Dolphin 2250
PULSE OXIMETER	Compatible to ' BCI'	Pulse Oximeter		SPO2 Adult Finger Probe	
PULSE OXIMETER	Compatible to ' CSI'	Pulse Oximeter		SPO2 Adult Finger Probe	
PULSE OXIMETER	Compatible to ' Datex'	Pulse Oximeter		SPO2 Adult Finger Probe	
PULSE OXIMETER	Compatible to ' Novametrix'	Pulse Oximeter		SPO2 Adult Finger Probe	
PULSE OXIMETER	Compatible to ' Ohmeda'	Pulse Oximeter		SPO2 Adult Finger Probe	
PULSE OXIMETER	Compatible to Novametrix	Pulse Oximeter	Compatible to Novametrix	SPO2 Adult Finger Probe	
PULSE OXIMETER	CSI - compatible	Pulse Oximeter		Finger Probe - 10 feet	Dolphin 2040
PULSE OXIMETER	CSI - compatible	Pulse Oximeter		Finger Probe - 4 feet	Dolphin 2041
PULSE OXIMETER	CSI - compatible	Pulse Oximeter		6 feet Extension Cable	Dolphin 2414
PULSE OXIMETER	CSI - compatible	Pulse Oximeter		10 Feet Extension Cable	Dolphin 2424
PULSE OXIMETER	CSI - compatible	Pulse Oximeter		Y Probe 36" c/w ear clip	Dolphin 2240
PULSE OXIMETER	Datex - compatible	Pulse Oximeter		Finger Probe - 13 feet	Dolphin 2030
PULSE OXIMETER	Datex - compatible	Pulse Oximeter		6 feet extension cable	Dolphin 2413
PULSE OXIMETER	Datex - compatible	Pulse Oximeter		10 feet Extension Cable	Dolphin 2423
PULSE OXIMETER	Datex - compatible	Pulse Oximeter		Y Probe 36" c/w ear clip	Dolphin 2230
PULSE OXIMETER	Datex - compatible	Pulse Oximeter		10ft extension cable	Dolphin 2423
PULSE OXIMETER	Draeger	Pulse Oximeter		O2 Sensor	6850645
PULSE OXIMETER	Hewlett Packard	Pulse Oximeter	M1190A	SPO2 Adult Finger Sensor, 12 pin, Rubber Pouch	M1190A
PULSE OXIMETER	Hewlett Packard	Pulse Oximeter	M1190A	SPO2 Adult Finger Sensor - compatible	M1190A-CR
PULSE OXIMETER	Hewlett Packard	Pulse Oximeter		Neonatal Hand or Foot SPO2 Sensor	M1193A
PULSE OXIMETER	Hewlett Packard - compatible	Pulse Oximeter		6 feet adaptor cable	Dolphin 2417
PULSE OXIMETER	Hewlett Packard - compatible	Pulse Oximeter		10 feet adaptor cable	Dolphin 2427

P	MANUFACTURER	EQUIPMENT NAME	MODEL NO.	DESCRIPTIONS	PART NO.
ULSE OXIMETER	Invivo	Pulse Oximeter	4500	Finger Probe	9378
ULSE OXIMETER	Invivo	Pulse Oximeter	4500	*if the order is more than 5 units*	
ULSE OXIMETER	Invivo	Pulse Oximeter	4500	Battery	HB07
ULSE OXIMETER	Invivo	Pulse Oximeter	4500	Finger Probe (9373)	9373
ULSE OXIMETER	Invivo	Pulse Oximeter	4500	Finger Clip	9383
ULSE OXIMETER	Invivo	Pulse Oximeter	4500	Oxi-clip Finger Sensor	9373
ULSE OXIMETER	Invivo	Pulse Oximeter	4500	Oxiwrap Flex Sensor Paed	9388A
ULSE OXIMETER	Invivo	Pulse Oximeter	4500	Oxiwrap Flex Sensor Adult	9388B
ULSE OXIMETER	Invivo	Pulse Oximeter	4500	Oxiwrap Interface Cable	9393
ULSE OXIMETER	Invivo Research	Pulse Oximeter	4500 Plus	PCA, Analog Oximeter Board	AB 17C
ULSE OXIMETER	Invivo Research	Pulse Oximeter	4500 Plus 2	Finger Probe Oxiwrap Flex for Pediatric	9388A
ULSE OXIMETER	Invivo Research	Pulse Oximeter (serial: OX	4500 Plus 2 -Exp	RF Transformer for Power PCB	AB 18
ULSE OXIMETER	Invivo Research	Pulse Oximeter		Power Supply Board	AD 18 Rev. AN
ULSE OXIMETER	Marquette	Pulse Oximeter	Solar 4000	Extension Cable for Nellcor	E9004DE (Old # 407252-002)
ULSE OXIMETER	Nellcor	Pulse Oximeter	100A	Reusable SP02 Adult Finger Probe	
ULSE OXIMETER	Nellcor	Pulse Oximeter	100A	compatible to Nellcor 100A	
ULSE OXIMETER	Nellcor	Pulse Oximeter	100A	*price applies to minimum order of 10 units	
ULSE OXIMETER	Nellcor	Pulse Oximeter	D - 25	Oxisensor 11 Adult Sensor	
ULSE OXIMETER	Nellcor	Pulse Oximeter	EC-8	Extension Cable	EC-8
ULSE OXIMETER	Nellcor	Pulse Oximeter	N 3000	Lead Acid Battery - Yuase NP2-12	640115
ULSE OXIMETER	Nellcor	Pulse Oximeter	N 3000	Lead Acid Battery - (12V,2A) - compatible	640115-CR
ULSE OXIMETER	Nellcor	Pulse Oximeter	N185	Power Entry Module	624002
ULSE OXIMETER	Nellcor	Pulse Oximeter	N185	Dura Sensor Adult Finger	DS100A
ULSE OXIMETER	Nellcor	Pulse Oximeter	N185	Battery	640110
ULSE OXIMETER	Nellcor	Pulse Oximeter	N185	Display Module	027602
ULSE OXIMETER	Nellcor	Pulse Oximeter	N185	Encoder Assembly	022152
ULSE OXIMETER	Nellcor	Pulse Oximeter	N185	Processor PCB (new P/N: UT027976)	027547
ULSE OXIMETER	Nellcor	Pulse Oximeter	N185	LCD PCB (New P/N: UT027735	028049
ULSE OXIMETER	Nellcor	Pulse Oximeter	N185	LCD Control Switch Board	027534
ULSE OXIMETER	Nellcor	Pulse Oximeter	N185	On/Off Switch Assembly	027357
ULSE OXIMETER	Nellcor	Pulse Oximeter	N185	Dual Y SP02 Sensor	E-203-01
ULSE OXIMETER	Nellcor	Pulse Oximeter	N185	SP02 Cable Extension 0.9 to 2.4m	EL-8
ULSE OXIMETER	Nellcor	Pulse Oximeter	N185	Inverter Assembly Board	UT026647
ULSE OXIMETER	Nellcor	Pulse Oximeter	N185	Inverter Assembly	SPO26647
ULSE OXIMETER	Nellcor	Pulse Oximeter	N185	Module Controller PCB	UT030097
ULSE OXIMETER	Nellcor	Pulse Oximeter	N185	Module Controller PCB - exchage	UT030097
ULSE OXIMETER	Nellcor	Pulse Oximeter	N200	Finger Clip SPO Sensor	DS100A
ULSE OXIMETER	Nellcor	Pulse Oximeter	N200	Battery	640105
ULSE OXIMETER	Nellcor	Pulse Oximeter	N3000	Power Supply	33876
ULSE OXIMETER	Nellcor	Pulse Oximeter	N3000	SP02 PCB (new P/N: UT030063)	30063

P	MANUFACTURER	EQUIPMENT NAME	MODEL NO.	DESCRIPTIONS	PART NO.
PULSE OXIMETER	Nellcor	Pulse Oximeter	N3000	Encoder	291169
PULSE OXIMETER	Nellcor	Pulse Oximeter	N3000	Display PCB (new P/N: UT045985)	030641
PULSE OXIMETER	Nellcor	Pulse Oximeter	N3000	LCD Controller	UT027705
PULSE OXIMETER	Nellcor	Pulse Oximeter		Finger Sensor	DS100A
PULSE OXIMETER	Nellcor	Pulse Oximeter		Oxiband/ Neonate Sensor	OXI-A/N
PULSE OXIMETER	Nellcor	Pulse Oximeter		Oxiband O2 Sensor-Pediatric/ Infant	OXI/PI
PULSE OXIMETER	Nellcor	Pulse Oximeter	N300	UIF PCB - outright	UT034971
PULSE OXIMETER	Nellcor	Pulse Oximeter	N300	UIF PCB - exchange	UT034971-EX
PULSE OXIMETER	Nellcor	Pulse Oximeter	N300	UIF PCB - repair, saturation VS (90-days warranty)	UT034971-REP
PULSE OXIMETER	Nellcor	Pulse Oximeter	N-185	Minsoom PCB	MP203
PULSE OXIMETER	Nellcor	Pulse Oximeter	NPB-195	UIF PCB	SP035263
PULSE OXIMETER	Nellcor	Pulse Oximeter	N-185	Cable Extension	EC-8
PULSE OXIMETER	Nellcor	Pulse Oximeter	N-190	Finger Clip SPO2 Sensor	DS100A
PULSE OXIMETER	Nellcor	Pulse Oximeter	N-195	Dura-Y Multi Site Sensor	D-YS
PULSE OXIMETER	Nellcor	Pulse Oximeter	N-195	CO2 Sensor	RMS6000
PULSE OXIMETER	Nellcor	Pulse Oximeter	N-3000	Extension Cable	SCP-10
PULSE OXIMETER	Nellcor - compatible	Pulse Oximeter		Finger Probe 3 feet	Dolphin 2010
PULSE OXIMETER	Nellcor - compatible	Pulse Oximeter		6 feet Extension Cable	Dolphin 2411
PULSE OXIMETER	Nellcor - compatible	Pulse Oximeter		10 Feet Extension Cable	Dolphin 2421
PULSE OXIMETER	Nellcor-Compatible	Pulse Oximeter		Y Probe 36" c/w ear clip	Dolphin 2210
PULSE OXIMETER	Nihon Kohden	Pulse Oximeter	Oxypal	Pediatric Finger Sensor, Compact	212-5013
PULSE OXIMETER	Nonin	Pulse Oximeter	8600	Battery Unit	1088-000
PULSE OXIMETER	Novametric 515 B	Pulse Oximeter	Novametric 515 B	Oxysnap Y Sensor	8793-00
PULSE OXIMETER	Novametrix	Pulse Oximeter		Battery	04132
PULSE OXIMETER	Novametrix	Pulse Oximeter	515B	Reusable Y Sensor	8793
PULSE OXIMETER	Novametrix	Pulse Oximeter	515B	Finger Sensor	8744
PULSE OXIMETER	Novametrix	Pulse Oximeter	515B	Capnometer Cable	7167-00
PULSE OXIMETER	Novametrix	Pulse Oximeter	515B	Extension Cable	8853
PULSE OXIMETER	Novametrix - compatible	Pulse Oximeter		Finger Probe - 10 feet	Dolphin 2060
PULSE OXIMETER	Novametrix - compatible	Pulse Oximeter		6 feet Extension Cable	Dolphin 2416
PULSE OXIMETER	Novametrix - compatible	Pulse Oximeter		10 Feet Extension Cable	Dolphin 2426
PULSE OXIMETER	Novametrix - compatible	Pulse Oximeter		Y Probe 36" c/w ear clip	Dolphin 2260
PULSE OXIMETER	Ohmeda	Pulse Oximeter	3800	Paed Clip Finger Sensor	7015
PULSE OXIMETER	Ohmeda	Pulse Oximeter	4700	Finger Probe Sensor - 13 feet	6051-0000035
PULSE OXIMETER	Ohmeda	Pulse Oximeter	3700E	Front Assembly	0380-0700050
PULSE OXIMETER	Ohmeda	Pulse Oximeter	Biox 3740	Power Supply Board (new P/N: 0380-0800-118)	A125-007
PULSE OXIMETER	Ohmeda	Pulse Oximeter	Biox 3740	Ohmeda Flex II Sensor (original)	0380-1000-080
PULSE OXIMETER	Ohmeda	Pulse Oximeter	Biox 3740	Ohmeda Flex II Sensor (compatible)	
PULSE OXIMETER	Ohmeda	Pulse Oximeter	Boix 3700c	Power Line Filter, 10V Select	0380-0200192
PULSE OXIMETER	Ohmeda	Pulse Oximeter	Boix 3700c	True Fit Oxytip Sensor, Neon 10/box - replacement of '0380-1000-051	6051-0000-116
PULSE OXIMETER	Ohmeda	Pulse Oximeter	Boix 3700c	Flex 2 Probe	

P	MANUFACTURER	EQUIPMENT NAME	MODEL NO.	DESCRIPTIONS	PART NO.
PULSE OXIMETER	Ohmeda	Pulse Oximeter	M3700	Battery	0279-0102-300
PULSE OXIMETER	Ohmeda	Pulse Oximeter	M3700		0380-0200-129
PULSE OXIMETER	Ohmeda	Pulse Oximeter	M3700	Lead Probe	6051-0000-035
PULSE OXIMETER	Ohmeda	Pulse Oximeter	M3700	Adult Probe & Oxy Lead Interconnect Cable	6051-0000-111
PULSE OXIMETER	Ohmeda	Pulse Oximeter	M3700	Battery Pack	6051-0000036
PULSE OXIMETER	Ohmeda	Pulse Oximeter	M3700	Rechargeable Battery	0279-0102-300
PULSE OXIMETER	Ohmeda	Pulse Oximeter	M3700	Rechargeable Battery 8V - compatible replacement	0279-0102-300
PULSE OXIMETER	Ohmeda	Pulse Oximeter	M3740	Battery 12V, 2.2 Ahr	0380-0200129
PULSE OXIMETER	Ohmeda	Pulse Oximeter	M3740	3 feet Oxylead Interconnect Cable	6038-6000022
PULSE OXIMETER	Ohmeda	Pulse Oximeter	M3740	Rechargeable Battery	0380-0200-129
PULSE OXIMETER	Ohmeda	Pulse Oximeter	M3740	Rechargeable Battery 12V - compatible replacement	0380-0200-129
PULSE OXIMETER	Ohmeda	Pulse Oximeter		Ear Oxytip sensor with Oxylead Interconnect Cable	6051-0000115
PULSE OXIMETER	Ohmeda	Pulse Oximeter		True Fit Oxytip Sensor, Neon 10/box	6051-0000116
PULSE OXIMETER	Ohmeda	Pulse Oximeter		Reusable Flex II Sensor - 8 feet	0380-1000080
PULSE OXIMETER	Ohmeda	Pulse Oximeter		Reusable Flex II - 12' (3.7m) cable	0380-1000081
PULSE OXIMETER	Ohmeda	Pulse Oximeter		Disposable Tru-Fit Oxytip Sensor Assembly - 3 feet (1m), 10pcs/box	6051-0000-16
PULSE OXIMETER	Ohmeda	Pulse Oximeter		10 feet Oxylead Interconnect Cable (is required in order to use the above part)	6051-0000109
PULSE OXIMETER	Ohmeda	Pulse Oximeter	Boix 3700c	Tru Fit Oxytip Sensor	0380-1000-051
PULSE OXIMETER	Ohmeda-Compatible	Pulse Oximeter		Finger Probe 10 feet	Dolphin 2020
PULSE OXIMETER	Ohmeda-Compatible	Pulse Oximeter		6 feet extension cable	Dolphin 2412
PULSE OXIMETER	Ohmeda-Compatible	Pulse Oximeter		10 feet Extension Cable	Dolphin 2422
PULSE OXIMETER	Ohmeda-Compatible	Pulse Oximeter		Y Probe 36" c/w ear clip	Dolphin 2220
PULSE OXIMETER	Oxford	Pulse Oximeter	Team Series	1.5MHz Cordio Transducer	8400-6919
PULSE OXIMETER	Oxford	Pulse Oximeter	Team Series	Toco Transducer Head Assembly	8401-6902
PULSE OXIMETER	Oxford	Pulse Oximeter	Team Series	Speaker 4R Team	8900-8002-2
PULSE OXIMETER	Palco	Pulse Oximeter	400/ A300	Adult Finger Sensor	02-100
PULSE OXIMETER	Palco	Pulse Oximeter	340	Finger Sensor (30 inch cable)	PXO020-100
PULSE OXIMETER	Palco	Pulse Oximeter	340	Finger Sensor (96 inch cable)	PXO020-105
PULSE OXIMETER	Spacelab - compatible	Pulse Oximeter		6 feet adaptor cable	Dolphin 2418
PULSE OXIMETER	Spacelab - compatible	Pulse Oximeter		10 feet adaptor cable	Dolphin 2428
PULSE OXIMETER	Spacelab - compatible	Pulse Oximeter		Adhesive wrap for Y probe	Dolphin 24xx
PULSE OXIMETER	Spacelab - compatible	Pulse Oximeter		Tru-Link SPO2 Cable for Pulse Oximeter sensor	175-0646-00

P	MANUFACTURER	EQUIPMENT NAME	MODEL NO.	DESCRIPTIONS	PART NO.
PULSE OXIMETER		Pulse Oximeter	Ohmeda - Compatible	12" Finger Sensor	212-1017
PULSE OXIMETER		Pulse Oximeter		Nellcor DYS Sensor Compatible	
PULSE OXIMETER		Pulse Oximeter		Ohmeda Compatible 12" Finger Sensor	
PULSE OXIMETER		Pulse Oximeter		Oxygen Cell T7 00M105	
PULSE OXIMETER		Pulse Oximeter		Ohmeda Original Flex 11 Sensor	
PULSE OXIMETER		Pulse Oximeter		Clip Tip, One Piece, Adult Finger Sensor, 13 feet (New)	OXY-F4
PUMP, INFUSION	B.Braun	Infusion Pump		Drop Sensor Complete	3450578 A
PUMP, INFUSION	Terumo	Infusion Pump Syringe	STC 523	Rechangeable Battery (6N - 1200SCK)	7.2V 1200MHz
PUMP, INFUSION	Top	Infusion Pump	3100	Air Bubble Sensor	T631-1787 (5)
PUMP, INFUSION	Top	Infusion Pump	3300	Drop Sensor Complete	T633-0522 (5)
PUMP, PERFUSOR	B.Braun	PCA Pump	Perfusor FM	PCA - Safety Box	871607/2
PUMP, SYRINGE	Baxter	Syringe Pump -	PCA II	Demand Button PCA	6464585
PUMP, SYRINGE	Baxter	Syringe Pump -	PCA II	Rechargeable Battery	6464825
PUMP, SYRINGE	Sim Graseby	Syringe Pump	G3100	Front Panel Label	
PUMP, SYRINGE	Sim Graseby	Syringe Pump	G3100	Syringe Size Sensor Flag	
PUMP, SYRINGE	Terumo	Syringe Pump	STC 503	HIC Circuit Board	05LN052
PUMP, SYRINGE	Terumo	Syringe Pump	STC 503	Finger Guide Kit	06LN102
PUMP, SYRINGE	Terumo	Syringe Pump	STC 503	OCC/ Air Detector	05LN0091
PUMP, SYRINGE	Terumo	Syringe Pump	STC 503	I/O & CPU Circuit Board	05LN041
PUMP, SYRINGE	Terumo	Syringe Pump	STC 503	Front Panel Keyboard	06LN521
PUMP, SYRINGE	Terumo	Syringe Pump	STC 503	Holder Plate Un	05LP181
PUMP, SYRINGE	Terumo	Syringe Pump	STC 508	Battery Unit	06LN520
PUMP, SYRINGE	Terumo	Syringe Pump	STC 523	Rechargeable Battery	
PUMP, SYRINGE	Terumo	Syringe Pump	STC 523	Control Board Unit	05LT08
PUMP, SYRINGE	Terumo	Syringe Pump	STC 523	DC Motor Unit	05LT07
PUMP, SYRINGE	Terumo	Syringe Pump	STC 523	Panel Keyboard	06LT528
PUMP, SYRINGE	Terumo	Syringe Pump	STC 523	Lower Case Unit	06LT505
PUMP, SYRINGE	Terumo	Syringe Pump	STC 523	Slider Unit	05LT18
PUMP, SYRINGE	Terumo	Syringe Pump	STC 523	Clutch	05LT29
PUMP, SYRINGE	Terumo	Syringe Pump	STC 523	Shield Sheet	05LT27
PUMP, SYRINGE	Terumo	Syringe Pump	STC 523	Clamp Unit	06LT504
PUMP, SYRINGE	Terumo	Syringe Pump	STC 523	200V Switching Regulator	06LT5021
PUMP, SYRINGE	Terumo	Syringe Pump	STC521	Clamp Unit	05LS10
PUMP, SYRINGE	Terumo	Syringe Pump	STC521	Battery Unit	05LS18
PUMP, SYRINGE	Terumo	Syringe Pump	STC521	Slider Unit	05LS11
PUMP, SYRINGE	Terumo	Syringe Pump	TE 311	Transformer	48-2056 83AS
PUMP, SYRINGE	Top	Syringe Pump	5100	Rechargeable Battery - 9.6V, 0.7AH	T651-3177 (5)
PUMP, SYRINGE	Top Corporation, Japan	Syringe Pump	TOP5100/5200	Power Supply Unit	KWS10-12
PUMP, SYRINGE	Top Corporation, Japan	Syringe Pump	TOP5100/5200	PCB for Top 5100B	T651-3231(4)
PUMP, SYRINGE	Top Corporation, Japan	Syringe Pump	TOP5100/5200	Inlet assembly for EMC	T652-3159(4)
PUMP, SYRINGE	Top Corporation, Japan	Syringe Pump	TOP5100/5200	Inlet assembly for Non-EMC	T651-3158 (4)

R	MANUFACTURER	EQUIPMENT NAME	MODEL NO.	DESCRIPTIONS	PART NO.
GRANT RIPPLE MATRESS	Grant Stamford, USA	Grant Ripple Matress		Grant Ripple Matress	A.H.2.7.96
GRANT RIPPLE MATRESS	Grant Stamford, USA	Ripple Mattress		Grant motor	CT0605
RADIANT WARMER	Airshield	Radiant Warmer	IICS90	Bracket	7816220
RADIANT WARMER	Draeger	Radiant Warmer	PP 800	Halogen Lamp 12V/ 20W	2M 18653
RADIANT WARMER	Draeger	Radiant Warmer	PP 800	Heating Element 220V/ 150W	2M 18669
RESUSCITATOR	Laerdal	Resuscitator		Infant Bag 240ml	85 01 00
RESUSCITATOR	Laerdal Medical Ass.	Oxygen Reservoir Bag	Standard	Bag 240ml	
RESUSCITATOR	Laerdal Medical Ass.	Oxygen Reservoir Bag	Standard	Patient Valve with Pressure Regulator	
RESUSCITATOR	Laerdal Medical Ass.	Oxygen Reservoir Bag	Standard	Mask Size 00, 0/1,2	
RESUSCITATOR	Laerdal Medical Ass.	Oxygen Reservoir Bag	Standard	Reservoir Bag 600ml	
RESUSCITATOR	Laerdal Medical Ass.	Oxygen Reservoir Bag	Standard	Reservoir Valve	
RIPPLE HEAT		Ripple Heat	MKA19/10/89 A	Service Manual	16155-20
RIPPLE HEAT		Ripple Heat	MKA19/10/89 A	Complete New Pump Assembly-Motor and Pump Head	16125-00
RIPPLE HEAT		Ripple Heat	MKA19/10/89 A	Pump Heat Assy.	16197-00
RIPPLE HEAT		Ripple Heat	MKA19/10/89 A	Flow Sensor	16136-00
RIPPLE HEAT		Ripple Heat	MKA19/10/89 A	Unit Valve Set of 4 Poly	16166099
RIPPLE MATTRESS	Grant Stamford, USA	Ripple Mattress	CT 06905	Control Unit along with Tubing (comprise of Ripple Mattress Machine PCA Grant App. Model G, Transformer and Diaphragm)	
RIPPLE MATTRESS	Hawksley	Ripple Mattress 16100		Mattress with water (adult)	16107-00
RIPPLE MATTRESS	Hawksley	Ripple Mattress 16100		Mattress with water (child)	16106-00
RIPPLE MATTRESS	Huntleigh	Ripple Mattress	AC001/2	Bubble Pad Matteress	OPB/2
RIPPLE MATTRESS	Huntleigh	Ripple Mattress	Betabed	Complete Compressor (Note: p/n:CL 007 3696 coil alone is not available for purchase)	BP477
RIPPLE MATTRESS	Huntleigh	Ripple Mattress	Betabed	Diaphragm	B214 & B215