3. CARDIAC MONITOR

there are several clinical situations in which continuous observation of the ECG and heart rate is important to the care of the patient. Continuous observation of the ECG during the administration of anesthesia helps doctors monitor the patient condition while he or she is undergoing medical procedures and during recovery from anesthsia. Constant monitoring of the ECG and heart rate of the myocardial infarction patient during the danger period of several days following the initial incident has made possible the early detection of life threatening cardiac arrhythmias.

Continuous monitoring of the fetal heart rate during labor may help in the early detection of complications. These and other clinical application of continuous monitoring of the ECG and heart rate are made possible by cardiac monitors. Figure**1** shows the basic cardiac monitor in block diagram form. Its front end circuitry is simillar to that of the ECG. A pair of electrodes, usually located on the anterior part of the chest, pick up the ECG and are connected by lead wires to the input circuit of the monitor. The input circuit contains circuitry, to protect the monitor from high voltage transient that can occur during defibrillation procedure.

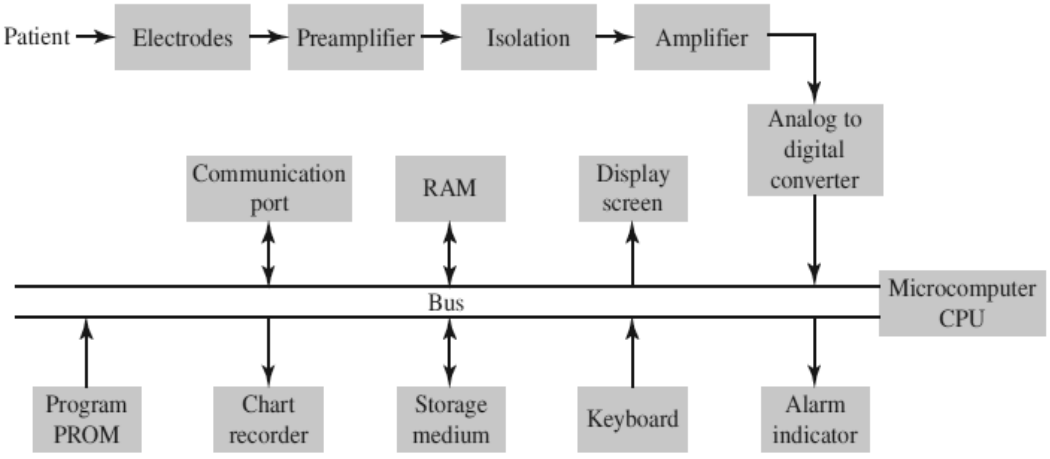

Figure 1. *the cardiac monitor displays a continuous electrocardiogram and heart rate and also identifies alarm conditions.*

The next stage of the monitor is a standard biopotential amplifier designed to amplify the ECG.

Cardiac monitors often have a slightly narrower frequency-response than would be acceptable for a diagnostic electrocardiograph. The reason for this is that much of the motion-artifact signal seen during movement of the patient is at very low frequencies. By filtering out some of these low frequencies, we can obtain a vast movement in SNR and recording stability without seriously affecting the information that pertains to cardiac rhythm in the ECG.

Frequency response should be from 0.67 to 40 Hz. Cardiac monitors should not trigger on pacemaker spikes, which continue even when the heart has stopped. To avoid double counting, cardiac monitors should not trigger on tall T wave.

Patient isolation circuitry is usually found in the circuit following an ECG preamplifier. This is followed by an additional amplifier to raise the signal to levels appropriate for further processing. In most modern cardiac monitors, the amplified ECG signal is digitized by an ADC, and the remaining processing is carried out by a computer. The digital signal is processed by a microcomputer in the monitor. This system block can perform many functions depending on the program that controls it.

The digital signal can be filtered and displayed on a computer screen, the heart rate determined by cardiotachometer software, alarm conditions identified and alarms sounded, data stored in temporary or permanent memory. An ECG rhythm strip printed for review and charting, and communication of the data to other systems within or outside of the hospital.

Often a physician wants to have a permanent record of the ECG being monitored, for this reason many cardiac monitor have a small chart recorder or graphic printer built into them that can be switched on by the operator or the computer to record a particularly interesting ECG as it appears on the screen.

The heart is determined from the ECG using computer algorithms that perform the function of a cardiotachometer. The output is displayed on a rate display so that the operator can immediately tell the patient's heart rate.

Alarm circuitry to warn of high and low heart rate is also associated with this algorithm. The alarm system can also produce a hard copy of the events that led up to the alarm for analysis by clinician. This can be a valuable aid to clinician in selecting appropriate therapy for the alarm - producing event. Most hospitals also utilize cardiac monitors in an organized system called an ***intensive care unit***. In such units, there are individual monitors at each patient's bedside that display the ECG in real time as well as the heart rate and any alarm conditions that have recently occurs. These individuals monitor are connected to a central unit located at the nursing station that shows the ECG for all patients being monitored, along with a heart rate display and alarm indicator for each patient.

A printer at the central station can be activated either locally or by remote control from the individual monitors at the patient's bedside. Computer algorithms that can recognize cardiac arrhythmias and record the frequency of their occurrence are also included in cardiac monitors. The machine can also prepare hard-copy chart showing trends in the patients monitored parameters and can keep records of various therapeutic measures taken by the clinical stuff. The computer can also be a big help in the intensive care unit by carrying out many observational and charting functions, thereby freeing the clinical staff to care for the patient.

The availability of microcomputer and high –capacity memory has made it possible to monitor ambulatory patients with detection of cardiac arrhythmias. These monitors consist of an ECG amplifier that provides a signal to an ADC, where it is digitized and stored in memory for later download and analysis. Such devices can collect data from ambulatory patients, and these data are analyzed later by a computer.

Microcomputers in cardiac monitors perform two basic functions, data management and data analysis. In the former case, the microcomputer controls the various components of the system and directs the transport of the data from one block to another along the bus. Carrying out the second function involves the actual analysis of the electrocardiogram. It includes filtering and artifact, identification of the various components of the electrocardiogram, determination of the heart rate, and identification of

arrhythmias. More than one computer can be used in a monitor system to carry out these functions. The microcomputer is under the software control. This makes it possible to update the monitor by replacing the software rather than modifying any hardware of the instrument. The microcomputer can temporarily store the data, and an alternative medium such as a separate hard drive is used to archive selected incidents or the entire monitored data. There is also a staff interface to the system that consists of a keyboard and a display monitor.

Computerized cardiac monitors can be integrated into other hospital information systems. Frequently these monitors also have a network connection that enables them to interact with other information system or to transmit data to physician offices located away from the intensive care unit.

Ambulatory cardiac monitors are often used in the diagnosis and treatment of heart disease. The most frequently applied ambulatory monitor- the Holter monitor- include a miniature digital recorder with electronic memory that the patient wears. These devices consist of a battery powered ECG amplifier and recorder that are connected to electrodes placed on the patient's chest. The instrument is sufficiently small to allow the patient to wear it like a necklace, and the recorder memory can hold from 24 to 48 hour of continuous ECG recording. Some recorders can collect data from three leads simultaneously so that vectorcardiograms can be stored.

Holter monitors are used by a physician to detect cardiac arrhythmias that occur infrequently in patients and are usually not detected during office or hospital examinations. Microelectronics has made it possible to make these monitor recorders so small that they can be surgically implanted under the skin of the patients or incorporated into other implanted devices such as pacemakers.