

Bluetooth Enabled Neo-Natal Monitor

Four students of Dual Degree, Communication and Signal Processing, EE Dept, Abhishek Jain, Hariharan Narayanan, Shruti Mahajan and Premal Shah, developed **Mobicare**, a Bluetooth enabled Neo-Natal monitoring system, with a web-based interface under the guidance of Prof. U B Desai and Prof R Lal as a part of their Electronic Design

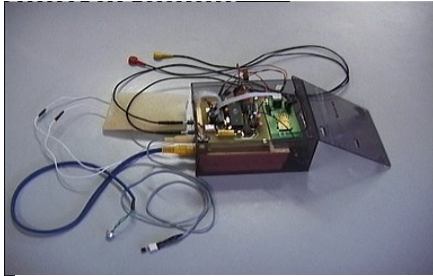


Figure 1 Mobicare: A Bluetooth enabled web based neo-natal monitor

Project in their 3rd year working in-house, at IIT Bombay. Mobicare measures an infant's breath rate and heartbeat rate for apnea detection. As a comfort add-on, it also measures body temperature, and detects crying and wetting conditions. The monitor is a micro-controller based Bluetooth enabled system that automatically connects to a host PC or a laptop programmed as a monitoring station in its vicinity. The system is expected to be of use in hospitals and home, to relieve burden on the nurses or parents.

About Apnea:

Apnea is a serious respiratory condition in which the patient undergoes spells termed as apneic spells where she suddenly stops breathing. The spell, if it lasts for more than 10 seconds, can be dangerous and in some case even fatal. Apneic events are followed by fall in heart beat rates (from 120 per min to 90 per min.)

Premature infants, particularly those born more than 7 weeks early (before 32 weeks of pregnancy), have been found to suffer from apnea. Such infants have to be kept in an incubator in hospitals for a couple of months and then at homes where they should be continuously monitored to detect apnea spells. As many as 5 % of the new-borns suffer from apnea. The tasks of monitoring such infants, in India, are mostly relegated to human-intensive means, in the form of nurses or parents maintaining a constant vigil. Apnea and other breathing disorders are also common in adults

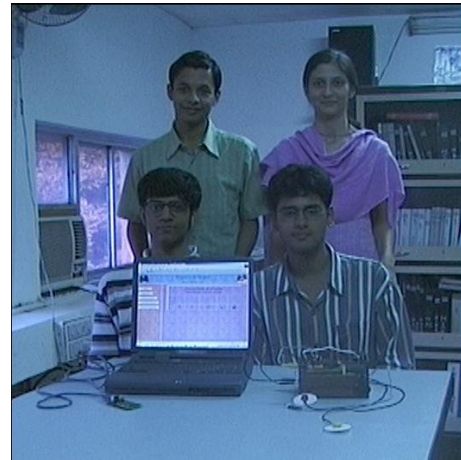


Figure 2 Clockwise from top left Abhishek Jain, Shruti Mahajan, Premal Shah and Hariharan N. with Mobicare.

System Design & Challenges Involved:

High reliability and user safety was demanded of the system by the very nature of its application. Other design objectives were minimum patient intrusion for maximum comfort, power efficiency and compactness for portability.

Detection of apnea spells requires real time monitoring and reporting of the infant's breathing and heartbeat rate. Apneic spells are generally of two kinds. When the infant does not make an effort to breathe, the condition termed as central apnea. An apneic spell due to central apnea may be detected by a relatively reliable and non-intrusive method called transthoracic impedance measurement, which detects breathing efforts or rather, the lack of them by continuously measuring the resistance of the infant's chest. A breathing effort by the infant would cause a change in this resistance. The change however is less than 0.2% and hence requires a high degree of precision in measurement. In Mobicare, we achieve this by applying an extremely low amplitude AC current (typically $100 \mu A$) at high frequency ($>50 kHz$) regarded safe by Medical Standards, across the patient's chest. The sensitive circuits in Mobicare are capable of detecting the extremely small and low frequency ($0.5 Hz$) variations in the signal that a breathing effort would cause. To do so, Mobicare uses a high precision current source, extremely low noise amplifiers at the sensors, that is followed by complex analog processing to reliably extract the breathing signals

It may be possible that although the infant makes efforts to breathe, she is actually unable to breathe because no airflow occurs. Apneic spells in such cases called Obstructive apnea can only be detected by changes in heartbeat rate. The heartbeat rate is measured by processing an ECG signal that has amplitude as low as 2-5 mV and a bandwidth of 100 Hz and can be corrupted by various motion artifacts. For patient comfort, the same pair of electrodes as those for breathing rate is used for ECG measurement, inviting interference from the high frequency exciting source. MobiCare measures heartbeats by using superior instrumentation and amplification followed by extensive filtering stages to eliminate noise and extract the requisite relevant heartbeat related information hidden in the input signal.

Mobicare also monitors temperature of the infant. For power efficiency the system employs minimum hardware components. The system also detects crying conditions by applying highly selective filters to an audio signal obtained from a microphone placed close to the infant's mouth. Wetting by the infant is detected by change in impedance of a sensor developed for the purpose.

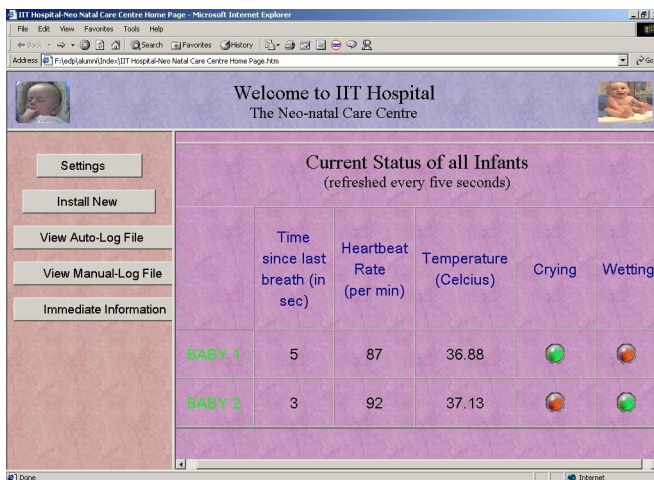


Figure 3 Web-based Graphical User Interface of Mobicare

A micro-controller continuously processes the input signals from the various sensors to detect apnea conditions and other abnormal conditions. The micro-controller is also furnished with a Bluetooth Driver to control a Bluetooth card and to detect, establish and maintain connection with a monitoring station in its vicinity. The entire task of analog signal interfacing, monitoring and wireless

communications is done using a fairly low-end microcontroller.

The system contains a monitoring station with an application program that would process information sent by the micro-controller based monitors. The application program is capable of connecting to, keeping tabs on and maintaining logs for up to 7 such monitors thus providing a tremendous potential to reduce manpower in hospitals.

The monitoring station is also configured as a web-server and provides a convenient GUI to inspect status in real-time and obtain information on infants being monitored. The relevant data is displayed on the web page, and is logged for future reference.

A glimpse at some salient features of the Mobicare –

- ✓ Continuous real-time monitoring and evaluation to keep tabs on patient status anytime, anywhere – thus also enabling personalized patient care for early detection of emergencies.
- ✓ Wireless enabled bedside monitoring with automatic data logging – a more efficient, reliable alternative to medical charts.
- ✓ Automatic emergency detection and alerting by sounding an alarm.
- ✓ Web-based interface for observation from remote terminals.
- ✓ Suited for use in both hospital and home environments.
- ✓ Wireless connection to a host terminal capable of handling up to 7 monitors.
- ✓ Battery (6V-12V) operated for portability.
- ✓ Complete isolation of patient from the mains for safety.
- ✓ Compact Design.
- ✓ Uses commonly available OPAMPS and ICs only.