

Case Study: Cardiac Output Monitor



Innovative Cardiac Output Monitor Designed to Provide Accurate, Non-invasive Measurement Capability

Accurately measuring cardiac output, that is, the volumetric rate at which blood is expelled from the left ventricle of the heart, enables anaesthetists, surgeons and cardiologists to quickly diagnose and manage cardiac problems.

Existing methods for measuring cardiac output in the operating theatre all have limitations; most of them are invasive, and the non-invasive methods are inaccurate, or require additional personnel or are too bulky for theatre use.

This Cardiac Output Monitor is designed to provide an accurate and non-invasive way to measure cardiac output in an operating theatre or intensive care unit.

The Challenge

Continually and accurately measuring a patient's cardiac output in a general operating theatre, using a simple to use non-invasive procedure, is something that has not been done before. To do this, the team needed to develop a completely new way to collect cardiac output data.

Jon Eggins, COO at Genesys Electronics Design, took the lead on this complex and innovative project.

“Determining cardiac output non-invasively is essentially a mathematical exercise, but one which requires stable and distortion-free inputs so the algorithms can accurately determine cardiac output.”

“The raw inputs can be collected through optical PPG sensors. These sensors are quite commonly used in the medical practice to measure a patient's heart rate. However, the required application and management of these sensors to deliver the data

required for measuring cardiac output, is not conventional.”

“The key challenge in this project was to design a solution that would collect accurate data through this non-conventional application of the PPG sensor technology.”

“Signal quality and stability, patient movement, sensor drift, and the fact that sensors were to be fitted by medical practitioners who may not be familiar with optimal sensor placement, all had to be taken into consideration.”

“ I chose Genesys because of their expertise in this type of hardware and software and easy communication style.”



The Solution

Anaesthetist Duncan Campbell invented the Cardiac Output Monitor.

Duncan designed the patented solution based on non-invasive infrared optical sensors that could be applied to a patient's finger, toe or ear, to produce a waveform proportional to an arterial pressure waveform obtained by inserting an intra-arterial line.

The optically derived waveform is calibrated using a non-invasive standard brachial blood pressure apparatus to produce a scaled and calibrated trace, virtually identical to that produced with an intra-arterial line. Standard equations are then used to establish the values for the various cardiac parameters.

Correct placement of three sensors and treatment of the electrical signals that come from the sensors is critical, as the frequency content of these signals is crucial to correct algorithmic functioning.

The team at Genesys worked closely with Duncan to apply the physiological theory to the application of PPG sensors in order to measure cardiac output.

"Working within the requirements of Duncan's patented solution, we focused on developing a sensor and interference electronics to maximise the signal quality and magnitude, and the time synchronisation of the samples from the different sensors," explained Jon.

Aside from the core function of the device, Genesys handled other key aspects of the project, including patient safety and user interface design.

"Patient safety was dealt with by making the unit completely battery powered, ensuring that the sensors had no electrical contact with the patient and emitted safe levels of optical energy. The user interface was designed to allow intuitive patient setup and monitoring, including logging, export and replay of data."



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The Result

The non-invasive Cardiac Output Monitor is now under clinical evaluation in a Sydney Teaching Hospital.

"Prior to my engagement with Genesys, I had a system which needed 5 to 10 minutes to calculate a single Cardiac Output at one point in time," explained Duncan. "The new monitor continuously displays and updates not only Cardiac Output, but a myriad of other Cardiovascular parameters which previously I had only dreamed possible."

"I chose Genesys because of their expertise in this type of hardware and software, and their easy communication style."

"I was impressed with the enormous efforts Jon Egginns made to develop the prototype according to my specifications. He personally developed the monitor, and as the project was not shunted about from person to person, he always knew exactly what point we were at throughout the whole process. This, combined with his dedication and expertise, has resulted in a very impressive monitor."



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