Device History and Theory.

Précis

Because of their ease of use, Pulse Oximeters are extremely popular and have become one of the first measurements attempted in any critical medical situation, from the scene of event, to postoperative care, even home care. They have been proven to be reliable and accurate in the indication of SpO_2 within the range 80 – 100%.

Details.

It is not the intention here to describe, in detail, the theory and practice of pulse Oximetry in any depth, this has been exhaustively covered by others. This is an attempt to explain in simple, easily understood terms, the basics. The user is advised to seek detailed explanations from published works, and the individual manufacturers, and not to use this section as an absolute reference.

The principles behind SpO2 are very simple, the colour of blood changes depending upon the oxygen saturation of the haemoglobin. As the haemoglobin loses oxygen, the skin changes colour from pink to taking on a blue tint.

The technique of SpO2 monitoring depends on the principal that haemoglobin and oxyhaemoglobin absorb different amounts of light. The amount absorbed varies as a function of the wavelength (colour). The amount of blue determined by the saturation of oxyhaemoglobin relatively has limited effect over the range 600nm to 1000nm, compared to the haemoglobin. It needs to remembered that the extinction curves are logarithmic.

If two specific wavelengths are used e.g. Red @ 660nm and IR @ 900nm, the wavelength is partially absorbed by both, the oxyhaemoglobin, and its reduced counterpart, the haemoglobin. By contrast, the absorption of the 600nm wavelength is largely due to the reduced haemoglobin.

Pulse Oximeters have to differentiate between light absorption due to arterial blood, and that due to other fluids and soft tissues. Arterial blood pulsates, whilst most of the other components remain stationary. The change in volume of the arterial pulse during the cardiac cycle alters the optical path, and therefore outputs and AC signals. It is then possible for the software to calculate, from this signal, the SpO2 values.

Most current Pulse Oximeters measure the ratio of the absorption of light by two principal forms, haemoglobin and saturated arterial haemoglobin (often referred to as oxyhaemoglobin, and represented as *HbO2* / SAT, and unsaturated (or reduced) haemoglobin *Hb*).
The oxygen saturation SpO2 is defined as the ratio of the concentration of oxyhaemoglobin to reduced haemoglobin. Oxygen saturation is commonly expressed as a percentage, and is calculated according to the manufacturers specific formulae.

The L.E.D.'s used in pulse Oximetry need to emit sufficient power to travel through heavily pigmented tissue, and yet still function without a system overload, when a thin lightly pigmented area is used. The output of L.E.D.'s is approximately linear in relation to the drive currents used, so pulse Oximeters are designed to be able to automatically control their outputs to match the physical conditions encountered.

A wide band photo-diode detector is used, as it has a large dynamic range for detecting wavelengths in the visible, and IR, electromagnetic spectrum. However, they are unable to differentiate between the wavelengths, so alternating Red and IR is used, so that the Oximeter always knows which wavelength it is looking at.

Pulse Oximetry is general, not absolute, but has questionable accuracy due to problems with interference from ambient light, and patient movement. Thus calibration is difficult.

The elimination of the effects of absorption, which is caused by the presence of venous, and capillary blood, soft tissue and ambient light changes, are part of the manufacturers software. The Pulse Oximeter software calculates the AC component of both wavelengths, and divides this by the corresponding DC (amplitude) component.

The "R" ratio is then derived from the formula:

$$(AC_{660} / DC_{660}) / (AC_{900} / DC_{900})$$

When the ratio equals 1.00, the oxygen saturation is approximately 85%.