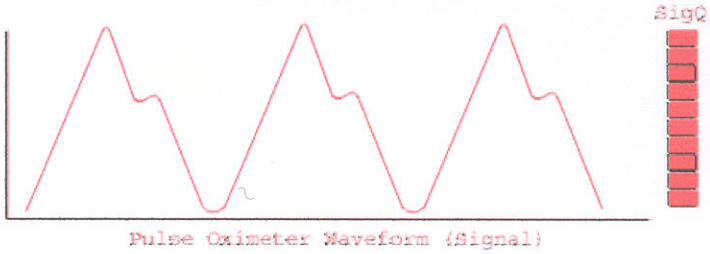
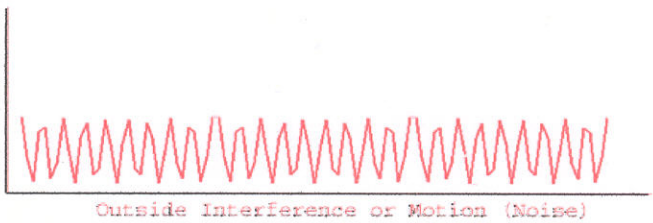
Pulse Oximetry: "Signal Quality"

"Signal Quality" is a term used to describe the ratio of "Noise" within a pulse oximeter waveform relative to the physical pulse rate information. Signal Quality is literally the Signal-to-Noise Ratio.

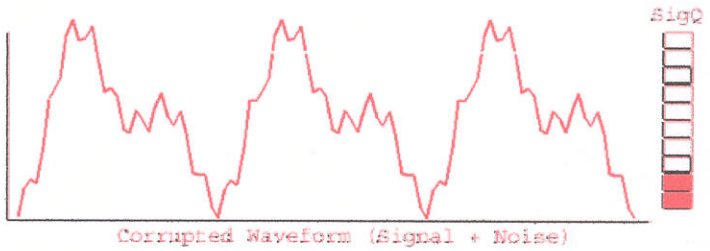
At left, the top waveform is a clean (noise-free) pulse oximeter waveform a healthcare provider would expect to see on their pulse oximeter after a successful sensor placement. The signal quality "meter" next to it is completely filled in.



The second waveform is pure noise. This can be introduced into the pulse oximeter signal from motion exterior to the patient (e.g. ambulance, helicopter, or jogging). This noise can also be the result of motion internal to the patient, such as tremor.



The third waveform is the result of the addition of the first (top) and second waveforms. The healthcare provider can easily determine the pulse oximeter monitoring site is "noisy" by observing the pulse oximeter waveform, however a Signal Quality meter or number is a useful indication.



A signal quality meter or number is derived by calculating the "energy" of the pulse rate portion of the pulse oximeter waveform relative to the entire "energy" content of the pulse oximeter waveform. It is known by pulse oximeter manufacturers and healthcare providers that a pulse oximeter waveform, properly termed "photoplethysmogram", contains respiratory rate and sympathetic and parasympathetic autonomic activity information. In a photoplethysmogram free of noise, the signal quality would be calculated as:

$$SigQ = \frac{(\text{Energy of Pulse Rate Signal})}{(\text{Energy of Pulse Rate Signal} + \text{Respiratory Rate} + \text{Autonomic Activity})}$$

where energy is loosely analogous to amplitude. In the presence of noise, the SigQ number decreases because some of the total energy of the photoplethysmogram is contained within the noise:

$$SigQ = \frac{(\text{Energy of Pulse Rate Signal})}{(\text{Energy of Noise Signal} + \text{Pulse Rate} + \text{Respiratory Rate} + \text{Autonomic Activity})}$$

Motion Artifact Rejection

A pulse oximeter that can correctly calculate SpO2 and Pulse Rate in the presence of noise is said to be capable of Motion Artifact Rejection. Modern pulse oximeters achieve motion artifact rejection through the use of complex algorithms and digital signal processing. Motion Artifact Rejection combined with pulse oximeter displayed signal quality indications and waveform can improve healthcare providers' decisions.