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The Distribution of Useful Frequencies in Polygraph Sensor Channels

Разделение полезных частот между различными датчиками каналов полиграфа

Key words: polygraph sensor channels, infrared plethysmo, pneumo, electrodermal, cardio

Purpose: to help other polygraph researchers better understand the distribution of energy across different frequencies in the standard six polygraph channels in common use. The channels shown will be pneumo, electrodermal (Axciton), cardio cuff pressure, movement sensor, and infrared plethesmo (Axciton). In all cases we use a zero phase high pass filter with a fourth order roll off. Unless otherwise noted, all frequency traces are kept with a constant gain to show their relative energy or strength content.

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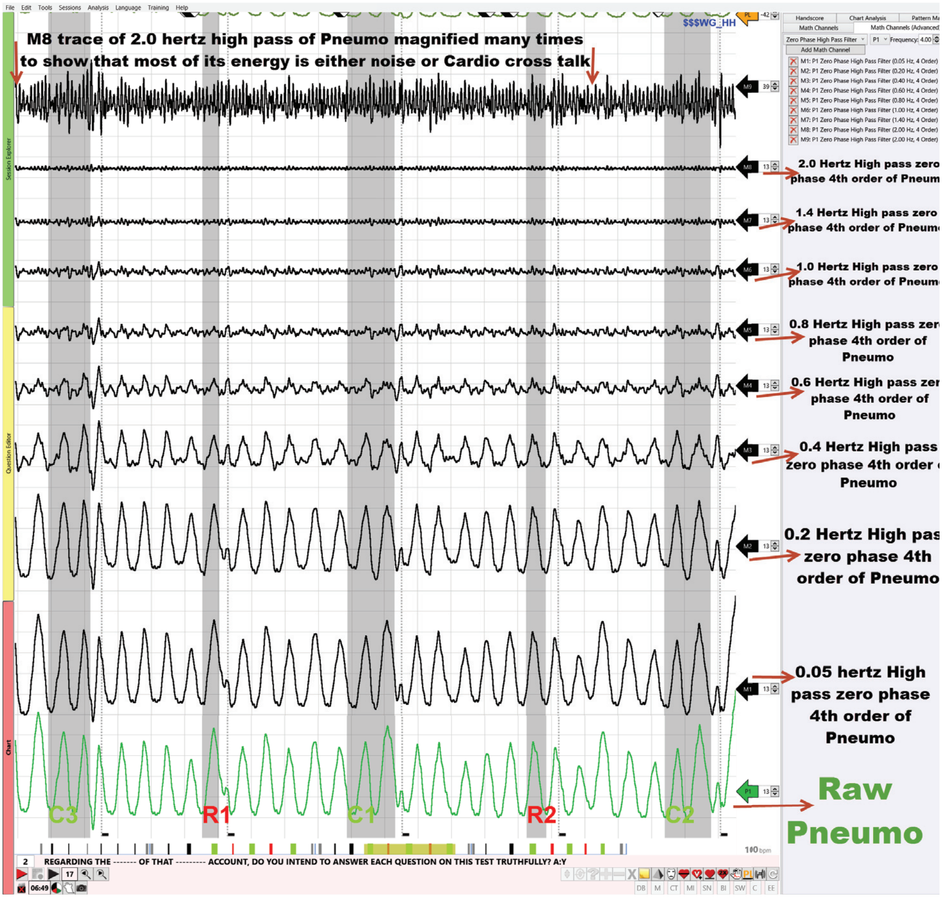
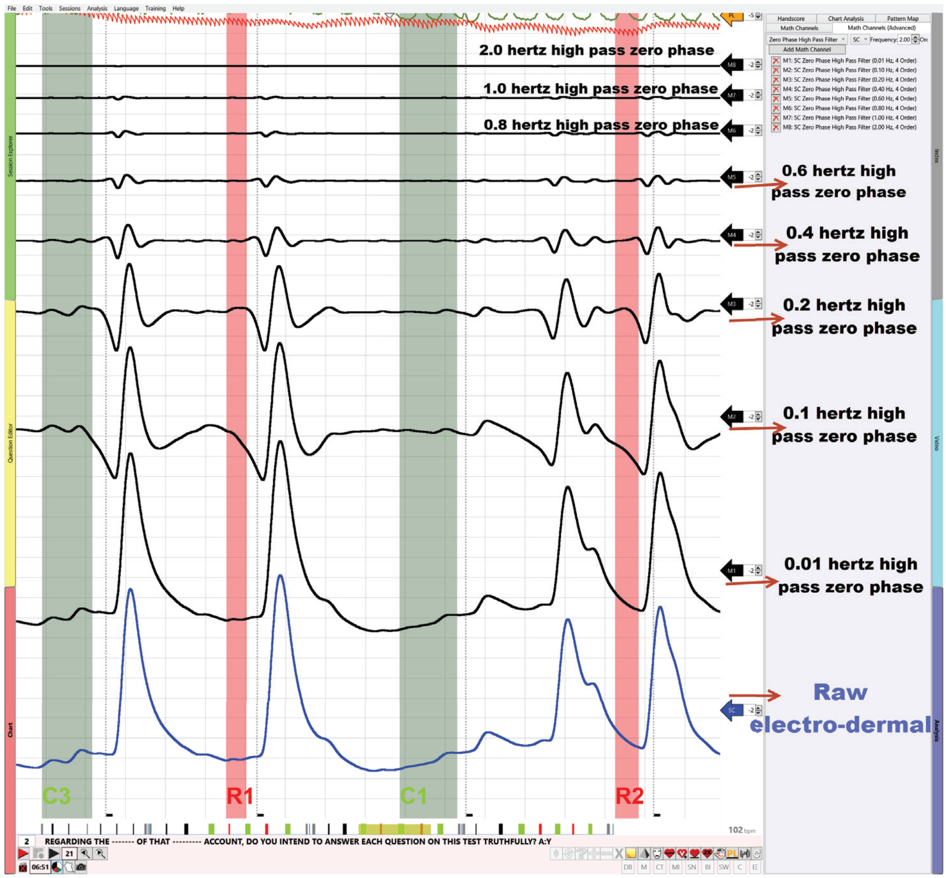
Pneumo



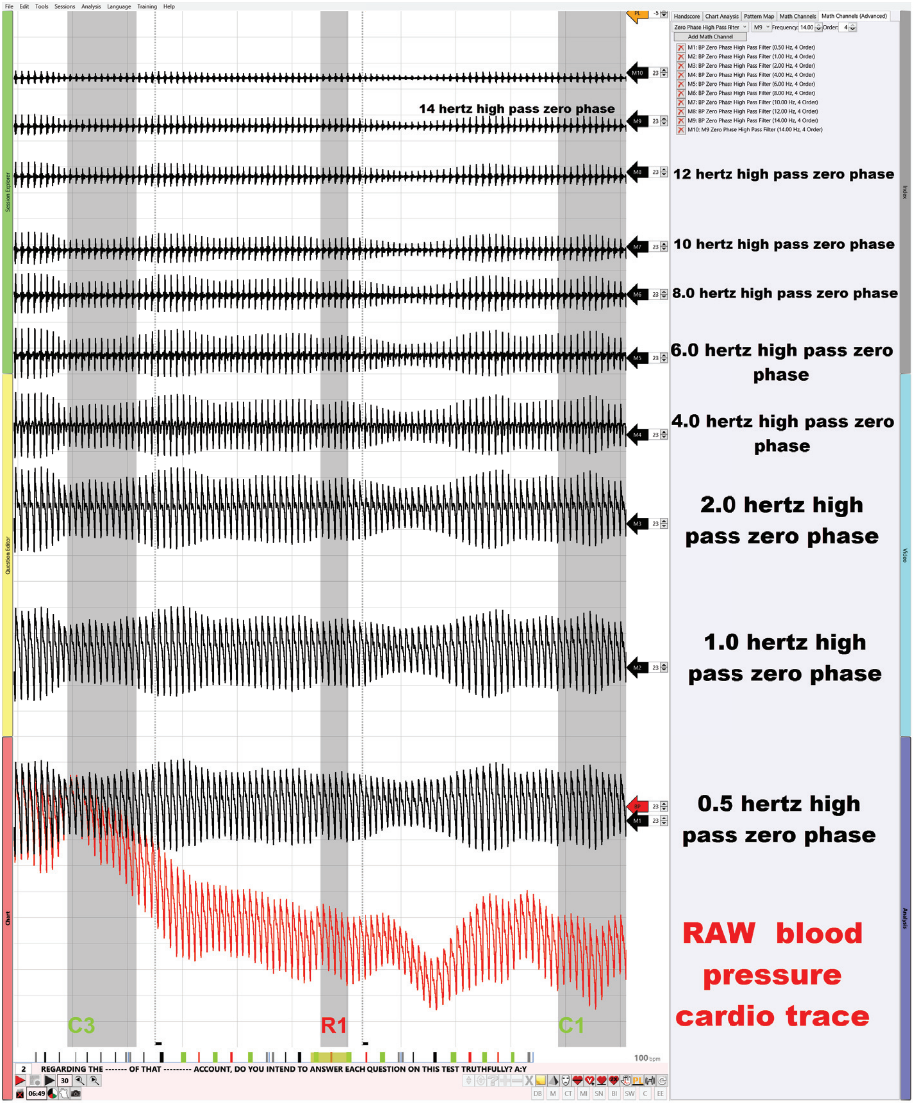
The upper usable frequencies of the pneumo channel are around 1÷2Hz. At higher frequencies, the cross talk of the cardio systolic pulse becomes the dominant form of noise. Coughing, sneezing, and upper body movement can also appear in this higher frequency range. Producing a math channel that isolates pneumo frequencies above 4 Hz is a useful way to identify upper body movement artifacts that may sometimes be difficult to see otherwise, but are helpful in noticing subtle countermeasures.

Electrodermal (Axciton)



The sweat glands response to fight or flight is relatively slow with most of its energy in frequencies below 0.5 Hz. Note: this paper does not address our research in the relation between resistive and self-potential signals.

Cardio

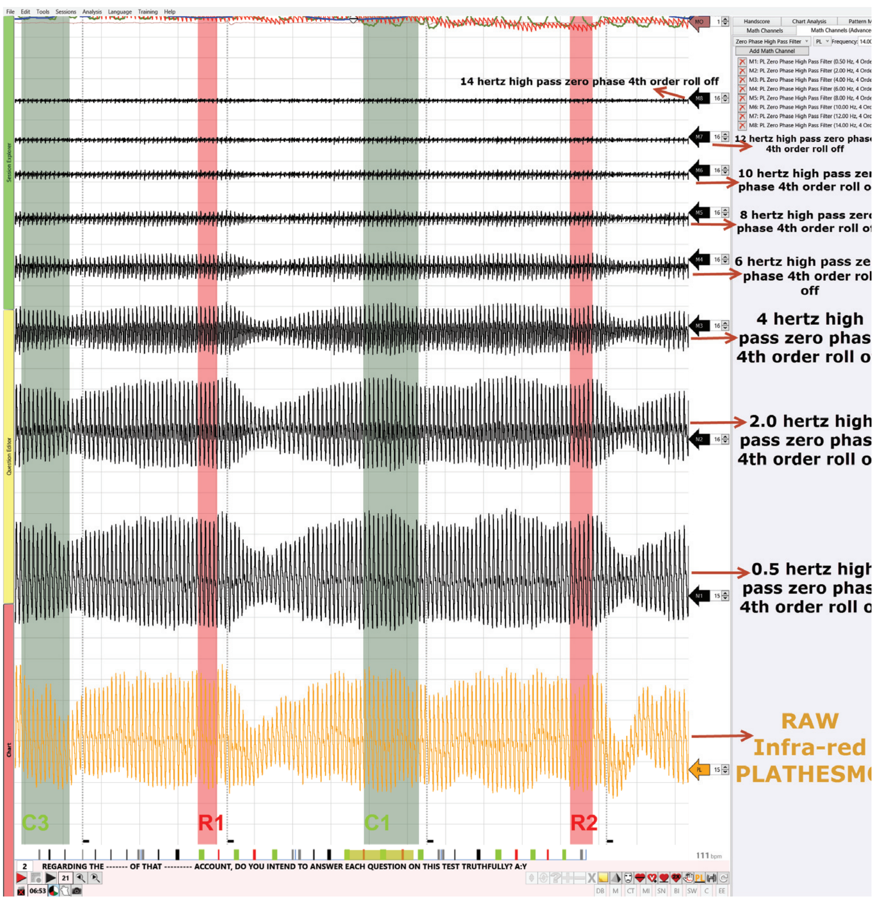


The polygraph upper arm cuff cardio covers a wide range of frequencies. The low frequency baseline below 0.5Hz is the most important for polygraph examiners in their scoring of the systolic base. But the systolic pulse component can have useful energy up to 20 Hz or higher.

Plethesmo infrared

The above plethesmo example is of a strong PLE signal that has usable energy with a good signal to noise ratio up to 8÷12 Hz. Notable concerns with the PLE is that vascularization may greatly vary in subjects, depending on the "fleshiness" of their fingers, reaction to stress, cold and other factors, and theses may result in a weak signal that, when sufficiently magnified to reach polygraph needs, looks erratic and raggedeven at frequencies above 2 or 3 Hz. When confronted by a "ragged" PLE, it may be a good idea not to score it. In general, it is a healthy practice to apply a zero phase low pass filter of 10 Hz on the PLE, as well as a 0.5 Hz zero phase highpass filter for an improved signal to noise ratio for best scoring (i.e. a band pass of 0.5 to 10.0 Hz).

Movement



For the movement channel, frequencies of above 3÷4 Hz are usually dominated by cardio pulse crosstalk as the heartbeat of the subject pressed against a motion pad is recorded. Moreover, the lower frequency breathing at ca. 0.15÷0.3 Hz may show up in the motion pad channel.

Additional notes on frequency filters

Frequency filter design is a discipline that requires high skills as it involves many tradeoff considerations. Some of them include the following:

- Frequency filters come in 3 forms: mechanical, electronic, and digital. It is the aggregate of these three filters that produces the final displayeddata.
- Analog electronic filters, such as resistor capacitor combination pi filters, are often preferred at the point of sensor acquisition to protect the signal from frequencies higher than half the data sample rate. Once the analog data has been digitised, digital filters are used.
- In designing frequency filters for polygraph use, it is best to use real time zero phase filters to avoid time shifting to the left, as this could affect polygraph scoring.
- When designing digital filters it is essentially best to be aware that too high a filter roll off can cause "ringing" artefacts, and too low or slow a roll off for polygraph makes for a fuzzy filter boundary. In general a roll off of a 4th to a 6th order roll off can be used. A 4th order roll off is a good choice for the polygraph.
- Designers of filters for the polygraph should bear in mind that their digital filters behave the same way during the real time exam as they do during replay, the difference being that during the initial exam a digital algorithm can only look into the present and past but not into the future, which it can do in the replay. The best solution to solve this concern for both real time and replay trace data is to use real time zero phase filters.

It is always better to reduce sources of noise in polygraph sensors and circuitry up front, in the circuit and sensor design, rather than only to rely on a filter to clean up a dirty signal. It is so as cleaning up a clean signal is always preferred to cleaning up a dirty signal.