A REAL-TIME PHASE VECTOR DISPLAY FOR EEG MONITORING

Herbert J. Finger, M.S.E.E.; James E. Anliker, Ph.D.; and
Tamara Rimmer, B.S.
NASA-Ames Research Center, Moffett Field, California 94035

A real-time, computer-based, phase vector display system has been developed which will output a vector whose phase is equal to the delay between a trigger and the peak of a function which is quasi-coherent with respect to the trigger. The system also contains a sliding averager which enables the operator to average successive trials before calculating the phase vector. Data collection, averaging and display generation are performed on a LINC-8 computer. Output displays appear on several X-Y CRT display units and on a kymograph camera/oscilloscope unit which is used to generate photographs of time-varying phase vectors or contourograms of time-varying averages of input functions.

The system enables the operator to input a signal, characterized by some reference trigger, and obtain a continuous display of the phase of a particular occurrence within the trial cycle. Each cycle begins at the trigger and ends either at the next trigger or at some shorter time predetermined by the operator. Zero phase (in the polar coordinate sense) corresponds to the occurrence of a peak in conjunction with the trigger. The 360° phase position corresponds to the end of the trial cycle at the occurrence of the next trigger.

This type of circular display is particularly attractive for those applications where the signal is continuously sampled and trials are delineated by stimulus triggers. In this case, the trial essentially wraps around a closed loop. Whereas linear displays appear unstable when the data have phases around zero to 360°, no such problem occurs with the phase vector since the display itself is circular or continuous. The phase vector is useful for monitoring the time correlation of two signals (say, a stimulus and some physiological response).

The examination of quasi-coherent physiological signals has been shown to lend itself to signal-to-noise improvement by the use of coherent time averaging techniques.[1,2] To this end a real-time sliding averager has been included in the system. Using a sample rate chosen by the operator, the system collects data and averages the newly collected trial with the previous N-1 trials. Sampling parameters are chosen by the operator prior to the data collection and are as follows:

- S - Sample interval in msec.
- T - Trial length in msec. (Trial length is normally equal to the time between two successive trigger periods.)
- N - Number of trials included in running average.
- D - Delay after trigger for beginning of trial.

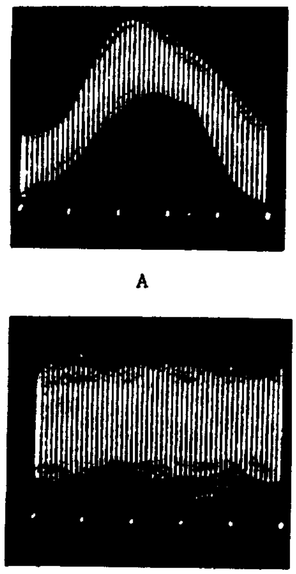

FIGURE 1

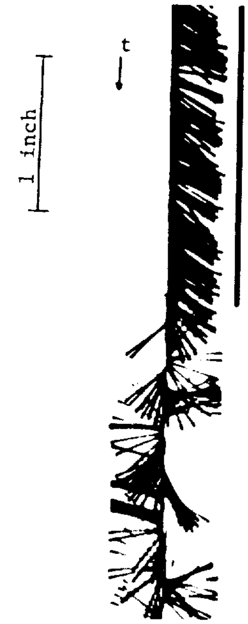

FIGURE 2

The system continuously collects data at the sample rate, calculates the time coherent average and outputs the average function as a separate display function (see Figure 1).

The system was designed to provide the operator with a continuously updated estimate of the phase relationship between a stimulus (trigger) and the alpha rhythm of the electroencephalogram.[3] However, the system has also been applied to other problems such as averaging and displaying power spectral functions, auto- and cross-correlations, and other related "finite" functions.

Figure 1 gives two examples of signals which are (a) coherent with respect to the stimulus trigger, and (b) incoherent with respect to the stimulus trigger. The camera shutter was left open approximately 1 minute on each display. Figure 2 shows the phase vector on a time scale of 10 seconds to the inch using the kymograph camera/oscilloscope system.

1. Bodo, J., "Response Averaging Methods - Their Effectiveness and Limitations," Conf. of Data Acq. & Proc. in Bio. & Med., 1963, pp 211-221

2. Rhyne, V.T., "A Comparison of Coherent Averaging Techniques for Repetitive Biological Signals," Med. Res. Eng. Aug.-Sep., 1969

3. Anliker, J., Finger, H., Rimmer, T., "Entrainability of Cortical Alpha Phase as an Estimator of Alertness," Aero. Med. Assoc. Meeting, 1973