APPLICATION OF SIGNAL ADVANCE TECHNOLOGY TO ELECTROPHYSIOLOGY

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ABSTRACT

Medical instrumentation used in diagnosis and treatment relies on the accurate detection and processing of various physiological events and signals. While signal detection technology has improved greatly in recent years, there remain inherent delays in signal detection/processing. These delays may have significant negative clinical consequences during various patho-physiological events. Reducing or eliminating such delays would increase the ability to provide successful early intervention in certain disorders thereby increasing the efficacy of treatment.

In recent years, a physical phenomenon referred to as Negative Group Delay (NGD), demonstrated in simple electronic circuits, has been shown to temporally advance the detection of analog waveforms. Specifically, the output is temporally advanced relative to the input, as the time delay through the circuit is negative. The circuit output precedes the complete detection of the input signal. This process is referred to as signal advance (SA) detection.

An SA circuit model incorporating NGD was designed, developed and tested. It imparts a constant temporal signal advance over a pre-specified spectral range in which the output is almost identical to the input signal (i.e., it has minimal distortion).

Certain human patho-electrophysiological events are good candidates for the application of temporally-advanced waveform detection. SA technology has potential in early arrhythmia and epileptic seizure detection and intervention. Demonstrating reliable and consistent temporally advanced detection of electrophysiological waveforms may enable intervention with a pathological event (much) earlier than previously possible. SA detection could also be used to improve the performance of neural computer interfaces, neurotherapy applications, radiation therapy and imaging.

In this study, the performance of a single-stage SA circuit model on a variety of constructed input signals, and human ECGs is investigated. The data obtained is used to quantify and characterize the temporal advances and circuit gain, as well as distortions in the output waveforms relative to their inputs.

This project combines elements of physics, engineering, signal processing, statistics and electrophysiology. Its success has important consequences for the development of novel interventional methodologies in cardiology and neurophysiology as well as significant potential in a broader range of both biomedical and non-biomedical areas of application.