The Use of Arbs in Pacemaker and Electrocardiograph Applications

Application Data

Overview

The design and test of medical devices such as electrocardiographs and pacemakers has become more sophisticated as electronic test instruments have developed greater capabilities. The use of arbitrary waveform generators (arbs) in design and test greatly simplifies production of the complex waveforms required for biophysical applications.

Arbs in ECG Applications

Biophysical waveforms generally are low-frequency signals with periods of high information content. These complex waveforms cannot be characterized with the simple waveshapes available from standard signal generators, which increases the difficulty of testing the electronic equipment that is used in biomedical applications such as patient monitoring. For example, and electrocardiograph (ECG) is a complex voltage-time relationship representation of the cardiac cycle.

Figure 1 shows the schematic of a typical front end in an ECG-monitoring device. The voltage output of such a device is digitized and analyzed, often by complex-waveform analyzers.

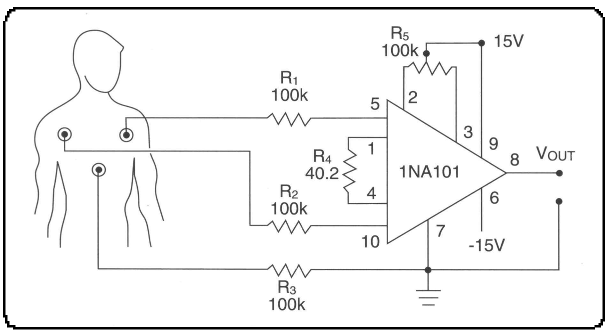

Figure 1 A schematic of a typical front end in an ECG-monitoring device

Figure 2 shows an idealized voltage-time variation in a normal cardiac cycle. Medical personnel can extract information from the waveforms in the cycle to detect the possibility of heart arrhythmia, hypertension, congenital heart defects, and other cardiac syndromes.

Medical waveform analyzers designed to monitor specific components of the cardiac cycle must be tested by having them analyze both normal and abnormal ECG signals. In the past, the method most used for testing such equipment was to simulate a heartbeat with an audio tape played through an amplifier. In this method, however, there is no way to modify information other than amplitude in the waveform. In addition, not only does the signal-to-noise ratio degrade over time, but also analog recording techniques suffer from limited sequence control.

The simplest method of producing both types of waveforms as needed is to digitize the output of an ECG, and then load the digital information into an arbitrary waveform generator, such as Fluke's model 395, for controlled output to a waveform analyzer.

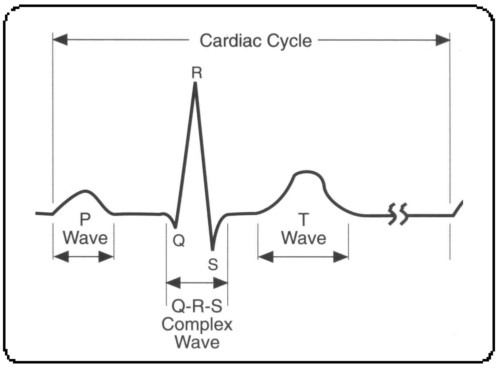

Figure 2 An idealized voltage-time variation in a normal cardiac cycle

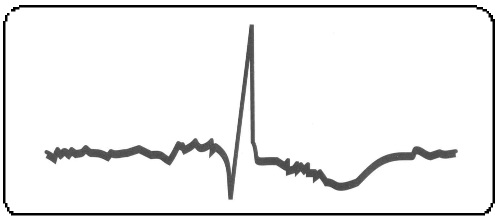

Figure 3 an example of a 2,300-point waveform

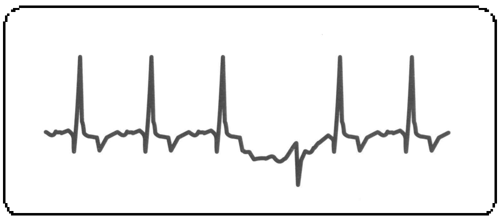

Figure 4 The resultant arbitrary waveform

The test engineer or technician can easily modify information stored in the memory of the arb to change the amplitude and duration of key waveform elements in the cardiac cycle. And digital recording techniques used in arbs provide excellent sequence control.

Figure 3 shows an example of a 2,300-point waveform that was repeated three times in the arbitrary waveform generator's memory and followed by an abnormal cardiac cycle. The result is shown in Figure 4.

Arbs in Pacemaker Applications

Pacemaker design and test is another application where arbs are particularly useful in providing sophisticated signals. A pacemaker works by sensing the presence of neuro-physiological signals that cause the heart muscle to contract and pump blood. The pacemaker determines when the signal becomes too weak or erratic to control the heart correctly and then provides control. An arb can be used to test a pacemaker by simulating these neurophysiological signals over a broad range of test criteria. Figure 5 shows a typical test setup for testing the sensitivity of the pacemaker.

In this test, the normal 70 beats-per-minute output from the pacemaker is used to trigger the arb to generate a signal simulating the heart nerve signal. This signal is attenuated to very small levels normally generated by the heart nerve. The amplitude and duration of this signal can be varied to test the pacemaker's sensitivity.

An arb may also be used to program the operating parameters of the pacemaker even while in use. Programming is accomplished through complex sequences of high frequency signal bursts transmitted to the pacemaker. The programming codes can be used to control pacemaker parameters such a sensitivity level, output pulse width, and beats per minute, customizing it to the patient.

Additional Biophysical Applications

Because arbs provide digital data patterns that are representations of analog waveforms, they can be easily modified on a point-by-point basis to produce whatever test signal is required by the test engineer. This capability makes arbs the perfect test instrument for many biophysical applications where complex representations are needed to simulate physiological conditions.

Some additional capabilities that make arbs even more versatile are digital storage oscilloscope (DSO) transfer and multiple channels. With DSO transfer, the user can simply download existing waveforms into the arb and edit as required.

Multiple channels increase the versatility of an arb by allowing different signals to be sent simultaneously (perfect for auditory test) or signals of even greater complexity to be developed by summing channels.

A partial list of biophysical applications of arbs includes blood impedance measurement; heart rate monitor test; blood pressure device test; muscle stimulation and energetics research; cell, bone, and tissue property research; auditory and optical research and test; biological research and test in areas such as bat and dolphin sonar, oceanographic studies, and animal physiological studies.

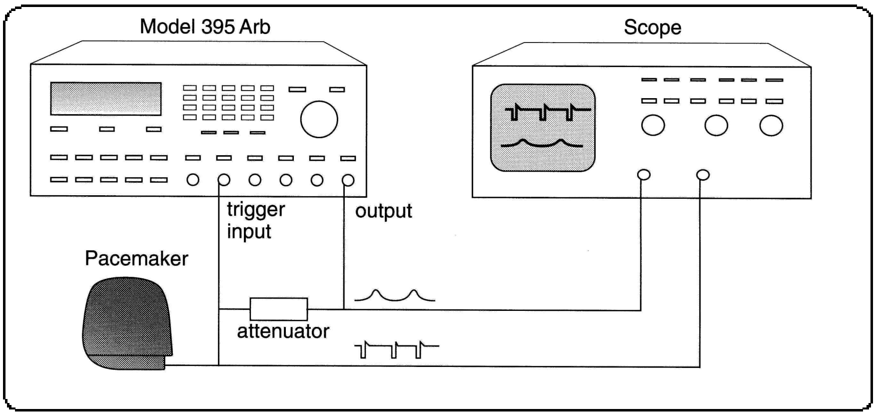

Figure 5 A typical test setup for testing the sensitivity of the pacemaker

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