



Technology Focus: Data Acquisition

Real-Time, High-Frequency QRS Electrocardiograph

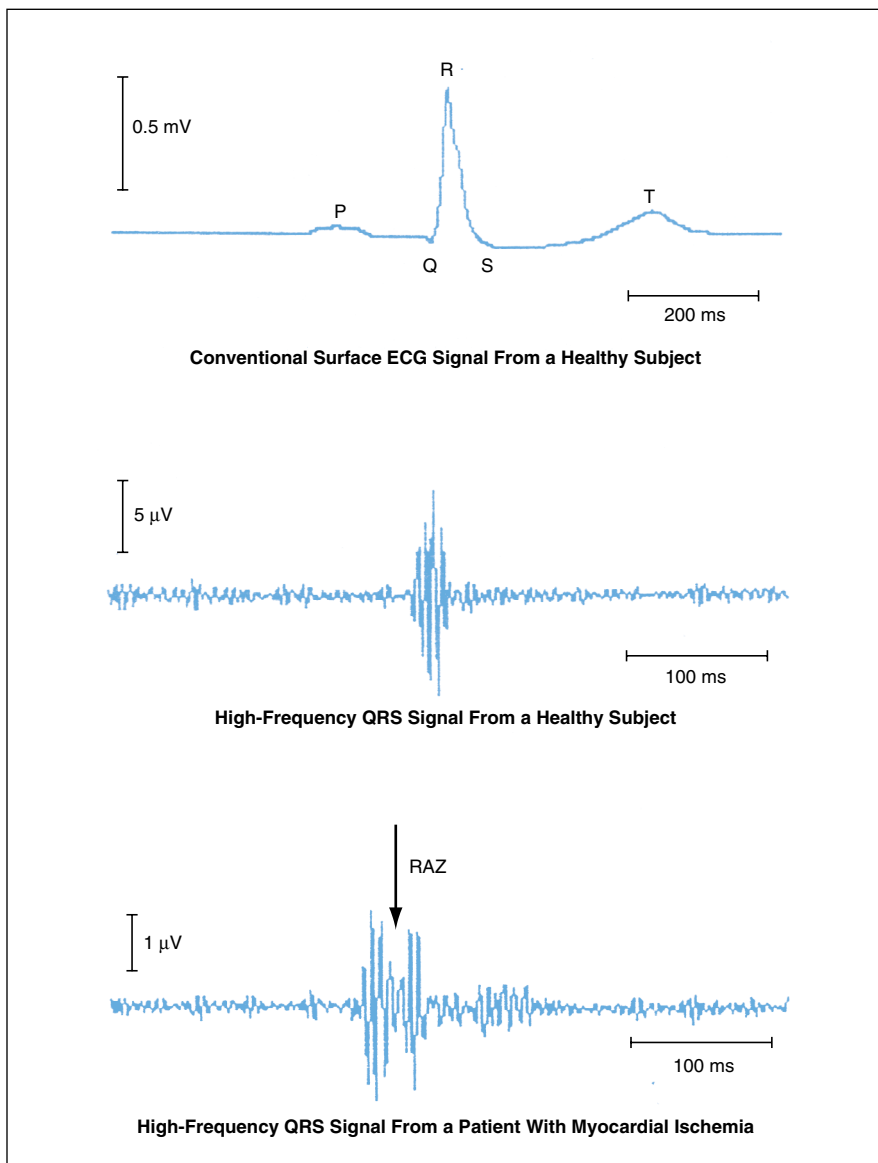
Signals indicative of ischemia or infarction can be identified in real time.

Lyndon B. Johnson Space Center, Houston, Texas

An electronic system that performs real-time analysis of the low-amplitude, high-frequency, ordinarily invisible components of the QRS portion of an electrocardiographic signal in real time has been developed. Whereas the signals readily visible on a conventional electrocardiogram (ECG) have amplitudes of the order of a millivolt and are characterized by frequencies <100 Hz, the ordinarily invisible components have amplitudes in the microvolt range and are characterized by frequencies from about 150 to about 250 Hz. Deviations of these high-frequency components from a normal pattern can be indicative of myocardial ischemia or myocardial infarction (see figure).

Prior to the development of this system, analyses of the high-frequency components of QRS signals entailed laborious, time-consuming post-measurement calculations and thus had research value only: they did not provide data quickly enough to provide guidance for clinical decisions for treating cardiac patients at immediate risk. The ability to provide clinically relevant information in real time makes the present system a prototype of a superior QRS electrocardiograph that could find its way into nearly every emergency room, ambulance, intensive-care unit, surgical operating room, cardiac hospital ward, cardiac-exercise/ECG testing facility, and cardiac-catheterization laboratory.

The system includes standard electrocardiograph electrodes, which are connected to high-input-impedance field-effect-transistor (FET) leads. The outputs of the FET leads are fed to a preamplifier, the output of which is fed to a data-acquisition circuit card in the Personal Computer Memory Card International Association (PCMCIA) slot in a personal computer. The card digitizes the electrocardiographic signal at a sampling rate of 1,000 Hz. The data thus acquired by the card are analyzed by special-purpose software running in a Windows operating system. Optionally, the data can be stored in a file for subsequent playback and analysis.



The **High-Frequency Signal Components** are invisible in a conventional surface electrocardiogram. These components can be extracted by filtering. A reduced-amplitude zone (RAZ) like the one shown in the lowermost plot may be indicative of dead or ischemic cardiac conduction tissue.

Whether processing real-time or previously recorded data, the special-purpose software performs several functions. The software detects R waves and QRS complexes and analyzes them from several perspectives. A conventional, unfiltered, beat-to-beat limb-lead ECG signal with an amplitude of the order of a millivolt is shown run-

ning across a window at the top of the computer screen. The software also computes and displays a signal that is similar except that it has been averaged over a number (selectable by the user) of consecutive beats in order to increase the signal-to-noise ratio.

The software includes a provision for special-purpose non-recursive digi-

tal filters with varying low- and high-frequency cutoffs. These filters, applied to the averaged signal, effect a band-pass operation in the frequency range from 150 to 250 Hz. The output of the band-pass filter is the desired high-frequency QRS signal. Further processing is then performed to obtain the power spectrum of the filtered sig-

nal, the beat-to-beat root mean square (rms) voltage amplitude of the filtered signal, certain variations of the rms voltage, and such standard measures as the heart rate and R-R interval at any given time.

This work was done by Todd T. Schlegel of Johnson Space Center, Jude L. DePalma of Texas A & M University, and Saeed

Moradi of Eix, Inc. Further information is contained in a TSP (see page 1).

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-0837. Refer to MSC-23154.

Software for Improved Extraction of Data From Tape Storage

Stennis Space Center, Mississippi

A computer program has been written to replace the original software of Racal Storeplex Delta tape recorders, which are used at Stennis Space Center. The original software could be activated by a command-line interface only; the present software offers the option of a command-line or graphical user interface. The present software also offers the option of batch-file operation (activation by a file that contains command lines for operations

performed consecutively). The present software is also more reliable than was the original software: The original software was plagued by several deficiencies that made it difficult to execute, modify, and test. In addition, when using the original software to extract data that had been recorded within specified intervals of time, the resolution with which one could control starting and stopping times was no finer than about a second (or, in some

cases, several seconds). In contrast, the present software is capable of controlling playback times to within 1/100 second of times specified by the user, assuming that the tape-recorder clock is accurate to within 1/100 second.

This program was written by Chiu-Fu Cheng of Lockheed Martin Corp. for Stennis Space Center. For further information, contact the Stennis Commercial Technology Office at (228) 688-1929. SSC-00156

Radio System for Locating Emergency Workers

Locations and identities of workers are tracked in real time.

John F. Kennedy Space Center, Florida

A system based on low-power radio transponders and associated analog and digital electronic circuitry has been developed for locating firefighters and other emergency workers deployed in a building or other structure. The system has obvious potential for saving lives and reducing the risk of injuries.

The system includes (1) a central station equipped with a computer and a transceiver; (2) active radio-frequency (RF) identification tags, each placed in a different room or region of the structure; and (3) transponder units worn by the emergency workers. The RF identification tags can be installed in a new building as built-in components of standard fire-detection devices or ground-fault electrical outlets or can be attached to such devices in a previously constructed building, without need for rewiring the building. Each RF identification tag contains information that uniquely identifies it. When each tag is installed, information on its location and identity are reported to, and stored at, the central station. In an emergency, if a building has not been prewired with

RF identification tags, leading emergency workers could drop sequentially numbered portable tags in the rooms of the building, reporting the tag numbers and locations by radio to the central station as they proceed.

Each RF identification tag periodically transmits a short-burst, low-power signal containing its unique identifier code. The intervals between these transmissions are made pseudorandom to minimize interference among transmissions from different RF identification tags. Each emergency worker wears a transponder unit, which receives the codes transmitted by one or more RF identification tag(s) and measures their relative signal strengths. Each transponder also transmits a unique identifier code, which makes it possible to distinguish its wearer from other emergency workers.

The central station periodically transmits a polling command, in response to which each transponder transmits its identification code plus all of the RF-identification-tag information it has received during the preceding 5 seconds.

For each such polling cycle, the central station issues only one polling command, and each transponder responds during a unique assigned time slot after that command, as determined by its code: this arrangement minimizes the "handshaking" needed to establish communication with transponders and reduces the cycle time for the location updates. On the basis of the relative strengths of RF-identification-tag signals reported by each transponder and the locations of the tags that transmitted those signals, the central-station computer calculates the location of the transponder and, hence, of the emergency worker who carries it. Thus, the locations of all emergency workers are repeatedly updated and displayed in real time at the central station.

The power for prewired RF identification tags is derived from the main AC power of the building by means of a rectifier/voltage-divider circuit, which also maintains a charge in a miniature, large-capacitance capacitor. The power demand of the RF identification tags is so low that in the likely event of loss of AC