Multichannel Measurement and Analysis of the Cardiac Electric Field

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INTRODUCTION: Multichannel measurements of cardiac signals contribute to more detailed knowledge about the cardiac electric field [4]. Analysis and topographic presentation of this information can be a valuable tool for nonivasive diagnostics of the heart state [3]. Technology of personal computers brings new possibilities to cardiac electric field studies. Detailed information about myocardium activation obtained form the torso surface by mapping techniques can be compared with simulated data where models of heart activation are used in forward and inverse computations. A personal computer based flexible measuring and processing system CardioPC was developed to enable the use of mapping techniques in electrophysiological and clinical studies. Its hardware and software enables recording and processing of heart electrograms or surface ecg signals. Body surface potential mapping, integral mapping or departure integral mapping is possible from a 24-lead system [1] and two 32-lead systems [3, 5].

Using additional software, forward simulation of body surface potential maps (BSPMs) or potentials on an arbitrary surface within the torso is possible using the boundary element method. The myocardium depolarization spreading through the cardiac muscle can be approximated by a multidipole, uniform dipole layer or by multipole model. Estimation of the model parameters from BSPMs by an inverse solution could contribute to the ability of nonivasive localization of cardiac electrical events and identification of the electrical disturbances of the myocardium activation. Multipole equivalent generator is a superposition of multipole sources. The basic problem is to make some transition from multipolar series as an theoretical characteristic to another more physiological representation [3] of the heart excitation process.

METHOD: The CardioPC system is built around standard PC 386/486 computer. The additional hardware consists of an input terminal with ecg amplifiers placed near the patient or physiological experiment and a data acquisition module pluggable into the computer system unit (Fig.1).

The input terminal for clinical use contains one module for limb lead signals I, II, III, aVR, aVL, aVF and one to eight 8-channel modules for unipolar leads. In this way measurement of standard 12-lead ecg, Frank vcg or up to

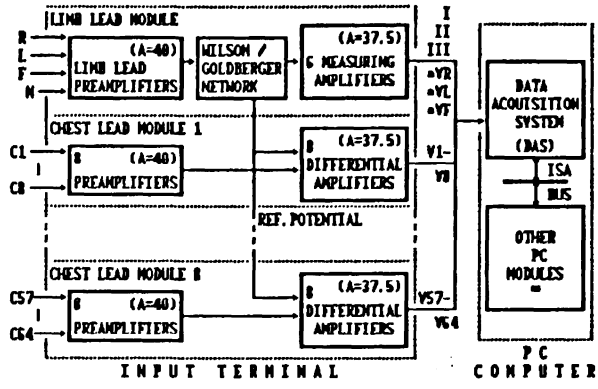

Fig. 1. Block diagram of the CardioPC mapping system.

64 mapping leads is possible. As the reference for all chest leads the potential of Wilson's central terminal generated by the limb lead module is used. Signals are amplified by a factor of 1500 to 12000 in the frequency range 0.05 - 250 Hz. Both types of modules enable to check the electrode contact quality based on the input current measurement. A modified input terminal enabling epicardial potential measurements was developed for electrophysiological studies [6]. It was used for long term monitoring of biopotentials in open heart studies of arrhythmogenetic mechanisms in dogs. The data acquisition system consists of a 64-channel multiplexer, programable gain amplifier and a 12 bit A/D converter. Its features enable to set gains separately for each channel, to measure selected leads only and to use the system as a real time multichannel oscilograph.

The mapping software enables simultaneous multichannel ecg measurement, processing and body surface potential mapping from 3 different limited lead systems: 24-lead system according to Barr [1], 32-lead system according to Lux [5] and 32-lead system NEKTAL [3]. Also measurement of 12 lead ecg and Frank vcg is implemented. Sampling frequency is 1, 2 or 4 milliseconds, record length is .5 to 20 seconds. The leads are checked for good contact with the skin, the amplification in each channel is automatically set to an optimum. During signal preprocessing the baseline is linearly corrected, signal can be filtered and desired time instants are interactively marked. After preprocessing all signals are stored on disk