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MUSIC DEPARTMENT

TECHNICAL REPORT

THE CEMS SYSTEM:
system design by
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engineering and
construction by
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Background

The CEMS (Coordinated Electronic Music Studio) System, recently installed at the State University of New York at Albany, is the partial realization of a project sponsored by the Research Foundation of the State University of New York.

The goals of the project were to design a completely programmable voltage-controlled system and to construct a prototype model, so that further design improvements, based on working experience, could be made.

This report is an introductory description of the system.

Introduction

At first, the idea was to be able to program events in time, thus bypassing the need for tape manipulation in electronic music, but the system is no longer viewed as an analogy for another technique. Studio tape manipulation and other classical techniques are methods of working that have their own precise identity, and can be used in conjunction with, before, after, or instead of, the CEMS System.

The approach is to the machine language. How does the machine work, how does that system of working limit the output, how is it controlled, and what sounds can it make? We feel that voltage-controlled systems provide an interesting and useful machine language, and that the sound output is flexible enough to warrant finding the optimum solution to voltage-controlled systems design. Further, we feel that systems of the CEMS type will be, in the near future, standard for studios.

One Basic Concept

The essential difference between electronic and instrumental sounds is measured by the extent to which parameters are coordinated. In instrumental music, the parameters of sound are in a dependent relationship (harmonic content varies as loudness varies as pitch varies as...). In electronic music, parameters are independent of one another (although the equivalents are not exact - the audio parameters are described later) and can be controlled independently.

The basic design concept of the system deals with coordination of controls, so that all the parameters of any particular sound may be controlled by a single source, or each parameter may be controlled by a separate, independent source, or anywhere in between. This concept may be used as a guideline in voltage-controlled system planning: there should be a workable balance between control generators and controllable parameters.

Each parameter may consist of a sum of different types of motion. For example, the frequency of the source oscillator (one of the audio parameters) may shift in many different ways (each way is one aspect of that motion) simultaneously.

In the construction of a complex sound, simultaneous and independent changes may exist in such number, and at so many levels, that real-time performance control becomes impossible. In that case, the aspects of the sound must be set up one-at-a-time and "remembered" by the machine which will, at a signal, play it all back together. The advantage of programming is twofold: (1) there is no need for tape manipulation as a compositional aid, and (2) sounds can be made that would be impossible to make any other way.

The nature of the programming is important, because it must (1) allow the composer to hear the sound as he is shaping it, and (2) it should not require a symbolic information translation. Programming, and storage, in the CEMS System, means simply leaving a knob set where it is. This type of memory has two additional advantages: (1) any portion of the program may be changed without affecting any other portion, and (2) the program may be changed while it is running.

The idea is that simultaneously, but independently, changing motions are a defining characteristic of electronic music, and that a programming and control system of the type described here provides one excellent way of achieving it.

Description - Equipment

The CEMS System comprises three interrelated modular systems (timing, control, and audio) mounted in four wooden cabinets. Most of the component modules are standard R. A. Moog modules, of which the specific functions are well enough known to make detailed description of each module unnecessary here. There are several modules, however, indicated in this list with an asterisk, that were especially constructed to be incorporated into this system. But whether the modules are standard or special is irrelevant to the central focus, which is the overall system.

Audio System	Control System	Timing System
6 voltage-controlled oscillators	8 sequencer systems, including: 8 sequencers, 8 sequential switches, 13 portamento units*, 2 voltage-controlled envelope generators*, and function circuits*	1 four-digit clock*
1 random signal source	10 envelope generators* (modified)	10 decoder/delays*
2 four-in four-out matrix mixers	8 direct-coupled mixers*	(sequencers may be used)
2 voltage-controlled filters	1 four-in reverse-out direct-coupled mixer	
3 voltage-controlled amplifiers	(oscillators and random signal source may be used)	
1 four-in four-out matrix design voltage-controlled mixer*	accoessories, such as multiples, attenuators, dc amplifiers*	

It should be understood that equipment listed in one system may be used in another if it functions in a useful way. "System" means a group of modules that perform different aspects of a function.

Equipment - Functions

The timing system incorporates a four-digit clock which counts from 0000 to 9999 in a time span that is controlled by an internal oscillator, the frequency of which is continuously variable between 1 cycle per second and 10,000.

Each of ten decoders is set to respond to a certain number that appears on the clock, at which time a trigger voltage is initiated. The duration of that voltage is pre-set in each of the ten delays. The procedure is twostep: (1) the decoder reads the clock and generates a voltage (2) for the duration indicated on the delay. These voltages function to turn modules on and off.

The clock may be used in any of three ways, each of which establishes a different type of time continuum: (1) it may be cycled indefinitely, (2) it may be run through only once, and (3) by bypassing the internal oscillator and using an external voltage-controlled oscillator, the clock's speed may be controllably variable.

Signals from oscillators and envelope generators may be used, alone or mixed with others, as control voltages, but the central part of the control system is the sequencer bank.

Each of the eight sequencer systems has one sequencer and sequential switch, and a function circuit that allows for the sequencers to be used in any combination of simultaneity and succession, as well as coordinated in any number of complex relationships.

The output voltages of the sequencer can be run through the portamento unit, which converts the discrete steady-state voltages into a glide within a pre-set time constant. The input "leads" the output, as it does in the voltage-controlled envelope generator, but in the voltage-controlled envelope generator there is a second control input for time, which makes the duration of the slope continuously variable.

The significance of this control section is that virtually any pattern or form of control voltage can be produced in a non-repetitive flow.

The audio system can be used to produce more than one signal at a time. The normal signal path is from oscillator to filter to output mixer, and signals may be running concurrently to the extent that equipment is available. But each normal signal path will comprise the audio parameters, which are (1) the oscillator frequency, (2) the filter's high- and (3) low-pass cutoff frequencies, as well as the (4) bandwidth and (5) center frequency, and (6) the final output amplitude control.

Each of these parameters is controlled by some sum of control voltages, and variety in a sound depends upon how these sums change by adding, subtracting, turning off, on, or whatever. The variables increase greatly when the generators that are producing the control voltages can themselves be controlled, and each level of controls controlled by other controllers adds a new complexity to that particular motion.

The timing system turns controllers on and off, and the controllers determine changes in the audio parameters.

Closing Comment

The approach is to the machine language, which means that compositions are constructed in terms of what the machine, or system, does. Interconnections between modules are equivalents for interconnections between characteristics of the composition. New systems, then, lead to new music.

Joel Chadabe
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