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LSI-11

MICROCOMPUTER CONTROLLED  
DIGITAL SOUND SYNTHESIZER

## A Portable Digital Sound Synthesis System

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A complete real time digital sound synthesis system has been constructed. In one compact unit (42" w x 25" h x 18"d, weighing ~300 lb). The following equipment has been included:

A. Digital Equipment Corp. LSI-11 based general purpose computing system with:

1. Two floppy discs with DMA controllers
2. A 64k word mapable memory for Table and I/O buffering
3. An ASCII AT&T gaphics video-terminal with full ASCII keyboard

B. A performer interface that samples and independently filters the position of 256 input devices with ~7 bit resolution (~100-200 different positions) at a 250hz sampling rate. The input devices include:

1. Two 61 key organ type manuals (the position of each key is measured with 7 bit resolution, 250 times/sec)
2. 72 slide levers
3. Four 3-axis joysticks
4. A variety of other things

C. A 16 bit digital synthesizer operating at 30k samples/sec with:

1. 32 FM sinewave oscillators (.002 hz frequency resolution and 14 bit accuracy)
2. 32 FM oscillators that directly generate the first N ( $1 < N < 127$ )

harmonics of the specified frequency.

3. 32 completely programmable second order digital filters (two pole and two zeros) that may be signal controlled
4. 32 AM (4 quadrant) multipliers
5. 256 envelope generators (linear or logarithmic)
6. A 2 second (48k word) digital reverberation and/or signal driven lookup table with 64 programmable taps
7. An array of 192 accumulating registers for interconnecting all the devices in any arbitrary way.
8. Four channels of 16 bit D/A output
9. Two channels of 14 bit A/D input
10. An array of 255 independent timers (1 ms resolution) with 16 FIFO's for sorting and storing timing events.

All the devices are bus interfaced to the LSI-11 computer and all the control words appear in LSI-11 address space (6k words). Approximately 1400 IC's are used in the entire system.

All of the system components have been designed to complement each other's capabilities. Special purpose hardware was constructed to perform those tasks which are repetitive and time consuming (timekeeping and performer input filtering).

Since there are no handwired connections between the input devices and the synthesizer hardware, and since synthesizer interconnections are accomplished through program loaded control registers, the whole system may be used in a variety of ways. For example:

- A. All the control parameters may be specified in real time and at performance time.
- B. Several files may be prepared in real time, but before the

performance. Then at performance time the files may be played with some subset of the control parameters supplied during performance.

C . Files may be prepared and/or edited in nonreal time, incrementally improving the original performance.

The total real time synthesis capacity depends, of course, on the type of synthesis techniques and configuration used. The LSI-11 and floppy disc multiple file system can support ~1000 parameter changes/sec. These parameters may be used to specify frequencies, envelopes, configuration changes, graphic displays, etc. This data rate should be able to generate ~100 reasonably complex notes per second.

This system is perhaps the first representative of a new generation of musical instruments that combines in one relatively portable unit all the hardware and interfaces necessary to produce in real time and in a performance environment sounds approaching the complexity of a modest orchestra.

