

## XIX. SPEECH COMMUNICATION\*

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### A. SPEECH COMPUTER FACILITY

The Speech Communication Group has recently acquired a medium sized general-purpose digital computer for online usage, and has added to the system peripherals that are primarily oriented to the processing of types of data relevant to speech research. We shall describe briefly some of the features of that system.

#### 1. Basic System

The central processor of the system is an 18-bit word length machine, a PDP-9 sold by Digital Equipment Corporation (DEC). The present configuration of DEC supplied hardware includes 16,384 words of 1- $\mu$ sec memory, a 10-cps teleprinter (Model KSR-35), a paper tape punch and reader, three small digital magnetic tape transports (DECTape), one analog-to-digital converter (ADC), three digital-to-analog converters (DAC), and a point-by-point oscilloscope display controller (two 10-bit DAC's for two display axes).

The software supplied by the manufacturer includes a context text editor, a relocating linking loader, a macro assembler, a FORTRAN IV compiler and library, various file transfer and manipulation programs, and an online debugging program (DDT).

#### 2. Graphical Output

An ITT display monitor consisting of a 16-inch cathode-ray tube with a useful plotting area of approximately 10 inches square. The maximum point plotting rate is approximately 15  $\mu$ sec per point.

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### 3. Graphical Input

A Grafacon 1010A is interfaced to the system for graphical input. This device supplies stylus position data with a resolution of 100 lines per inch over an area of 10 inches square.

### 4. Analog Tape Recorder

A high quality audio dual channel tape recorder that can be controlled locally, remotely from the knob panel, or by computer program.

### 5. Audio Amplifier and Speaker

For audio monitoring.

### 6. Microphone

For audio input.

### 7. Knob Panel

An assortment of small devices useful for program and device control are mounted together in a convenient location on what is known as the knob panel. These include: 18 toggle switches – useful for program control; analog tape recorder control; real time clock – useful for controlling sampling rates; analog multiplexer – usually used ahead of the general-purpose ADC; and knobs – generate a variable output voltage and usually used in conjunction with the multiplexer and ADC to provide smoothly variable inputs to a program.

### 8. Push-Button Box

Thirty-six push buttons are available for general usage. They are normally used on a program interrupt basis to provide fast program response to operator requests, e.g., to start and stop other input/output activity, to control displays, and with graphical input programs.

### 9. Spectrum Analyzer

A filter bank and multiplexer can be used for inputting spectral data. The filter bank consists of 36 simple tuned bandpass filters with center frequencies of from 150 Hz to 7025 Hz and bandwidths gradually increasing with frequency of from 100 Hz at 150 Hz to 475 Hz at 7025 Hz. Each filter is followed by a rectifier and lowpass filter, and all of these outputs are connected to a multiplexer. A special purpose 6-bit logarithmic ADC (64 dB range, 1 dB steps) or the general-purpose linear ADC can be used to digitize the filter outputs. One complete scan of the 36 filters requires between 1 and 2 msec. Typical usage is to scan the filter bank every 10 msec, encode

each filter output into a 6-bit energy measure, and pack the resulting thirty-six 6-bit bytes into a 12-word block.

#### 10. Channeled Buffers for Sampled and Digitized Input and Output

A common process is the sampling and quantizing (analog-to-digital conversion) of an analog signal for input and the digital-to-analog conversion at a sampling rate for output. This can be done by using the aforementioned clock and converters, but in order to decrease the requirements on the central processor and thus allow other concurrent processes, we have interfaced to the machine digital buffers using the data channel facility of the PDP-9. These buffers are directly connected to a DAC and ADC so that sampling, conversion, and transmission to/from core memory are all controlled by the hardware without need for central processor action during block transmission.

#### 11. Terminal Analog Speech Synthesizer

A hardware terminal analog speech synthesizer (i. e. , a formant type of synthesizer) is available. This device, known as SPASS, uses transistorized operational amplifier type of circuitry in the analog signal paths to achieve the desired resonances, and includes the necessary logic to enable the various parameters such as formant frequencies, glottal period, amplitude, etc. , to be set by computer program.

#### 12. Analog Patch Panel

A patch panel provides a centralized interconnection point for analog signals throughout the system. Typical signal paths might be as follows:

Sampled speech input: microphone or recorder – lowpass filter – multiplexer – ADC.  
Spectral speech input: tape recorder – filter bank – multiplexer – ADC.  
Sampled and digitized audio output: channeled output buffer and DAC – lowpass filter – recorder and/or speaker.

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