

# Bell Labs Digital Synthesizer

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The **Bell Labs Digital Synthesizer**, better known as the **Alles Machine** or **Alice**, was an experimental additive synthesizer designed by Hal Alles at Bell Labs during the 1970s. The Alles Machine used 64 computer-controlled oscillators whose output was mixed to produce a number of discrete "voices" for output. The Alles Machine has been called the first true digital additive synthesizer,<sup>[1]</sup> following on earlier Bell experiments that were partially or wholly implemented as software on large computers. Only one full-length composition was recorded for the machine, before it was disassembled and donated to Oberlin Conservatory's TIMARA department in 1981.<sup>[2]</sup> Several commercial synthesizers based on the Alles design were released during the 1980s, including the Atari AMY sound chip.

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## Description

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The Alles Machine consisted of three main parts; an LSI-11 microcomputer, the programmable sound generators, and a number of different input devices. The system was packaged into a large single unit, and weighed 300 pounds – the designers optimistically referred to it as being portable.<sup>[3]</sup>

The microcomputer was supplied with two 8-inch floppy disk drives (from Heathkit, which sold their own LSI-11 machine, the H11) and an AT&T color video terminal. It was connected to a customized analog-to-digital converter that sampled the inputs at 7 bit resolution 250 times a second. The input devices consisted of two 61-key piano keyboards, four 3-axis analog joysticks, a bank of 72 sliders, and various switches.<sup>[3]</sup> Any of the controllers could be used to control any parameter, under program control. The inputs were interpreted and then used to generate outputs that were sent to the sound generators as a series of parameters. The bandwidth needed to control the synthesizer was quite limited. The computer could process about 1,000 parameter changes per second before it would bog down in the CPU.<sup>[4]</sup>

The sound generator was fairly complex, containing 1,400 integrated circuits.<sup>[5]</sup> The first bank of 32 oscillators were used as master signals, and generally meant the system had up to 32-note polyphony (see below). A second set of 32 oscillators was slaved to one of the masters, generating the first N harmonics, where N was from 1 (first harmonic) to 127. Additionally there were a bank of 32 programmable filters, 32 amplitude multipliers, and 256 envelope generators. All of these signals could be mixed in an arbitrary fashion into a bank of 192 accumulators. These were then sent to one of four 16-bit output channels, and from there to a digital-to-analog converter for output.<sup>[5]</sup>

The actual waveforms were generated by looking up the amplitude for a given time from a 64 kWord ROM-based table. Alles used several tricks in the table in order to reduce the amount of math the system needed to run in the controller CPU. In one instance, a multiplication was avoided by looking up two numbers from the table and subtracting them, as it was noticed the result was the same

as a multiplication of two related numbers. Running everything was a set of 255 timers with 16 FIFO stacks for events. The controller posted events into the queues which were then sorted by timestamp and fed into the generator in order<sup>[5]</sup>

## Influence

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The Alles Machine was highly influential within the industry but the cost of implementation was so high that it was some time before machines based on its principles were available at a price point most musicians could afford.

Crumar of Italy and Music Technologies' of New York collaborated to form Digital Keyboards in an effort to re-package the Alles Machine. The result was a smaller two-part system, with a Z-80-based microcomputer and disk drives as one unit, and a single keyboard and limited set of input sliders as the second unit. Known as the **Crumar General Development System**, or **GDS**, it was released in 1980 for \$30,000. It was sold to studios that needed a flexible system that could guarantee the same performance time after time.<sup>[6][7][8]</sup> Analog synths of the same era were subject to environmental changes in the input controls that meant every performance, even after a short delay would be different. Wendy Carlos owned a GDS and used it on the Tron soundtrack.<sup>[9]</sup> She was also one of the instrument's most devoted users, and still uses it to this day

Further work on the same basic concept produced the lower-cost **Synergy**, released in 1981.<sup>[10]</sup> The Synergy removed the computer component, and re-packaged the entire system into a case with a 77-key keyboard. Another additive synth reached the market at about the same time, the Con Brio ADS200 at the slightly lower price of \$20,000. Neither the Con Brio or GDS sold well, while the Synergy managed to find some market share. However, when the famous Yamaha DX7 was released in 1983, it quickly took over the market. The DX7's FM synthesis offered the same basic control over output sound as an additive synth, but could duplicate the effects of many ganged oscillators in as few as two.<sup>[11]</sup> Its \$2,000 price point eliminated any competition from the additive synths. Production of the Synergy ended in 1985.

A final version of the original machine was produced after Digital Keyboards was shut down in early 1985. Digital Keyboards' chief designer, Mercer Stockell, decamped and formed Mulogix with Jim Wright and Jerry Ptascynski. The **Mulogix Slave 32** was a Synergy re-packaged into two rack-mount modules with a MIDI interface. The Slave 32 could read and write EPROM cartridges from the Synergy.<sup>[12]</sup>

In 1981, Ceasar Castro and Alan Heaberland introduced their Casheab S-100 board. It also bore striking resemblance to Alles & Bayer's design. One early adopter was Roger Powell who designed his "Databoy" system around it. Powell used a home-brew 8800 system to scan the keyboard and modulation controllers as well as provide access to a custom library of sounds he created.<sup>[13]</sup>

Starting in 1984, Atari started an effort to develop a single-chip implementation of the Alles Machine in their Sierra project. The resulting AMY 1 chip used 64 oscillators and added noise generators to provide special effects needed in games. However the AMY was never released, and a 3rd party effort to produce a low-cost synth based on the chip ended when Atari threatened a lawsuit.<sup>[14]</sup>

## Artists who performed on the instrument

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Two artists of note known to have performed on the Alles Machine are Roger Powell and Laurie Spiegel. Powell gave the first public Live performance. Unfortunately, this performance was never recorded. The other known performance is by composer Laurie Spiegel. A YouTube Video of Spiegel's performance can be found in the external links section.

Several tracks on the album *Games* by Larry Fast (Synergy) were taken from sessions recorded at Bell Labs on the digital synthesizer.

## References

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### Citations

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## External links

- [A Digital "Phase Shifter" for Musical Applications](#)
- [Laurie Spiegel Playing 1977 Bell Labs Hal Alles Synth](#)
- [The SYNERGY Digital Synthesizer](#) Archived February 27, 2012, at the [Wayback Machine](#)
- [Crumar GDS from italian crumar museum](#) Archived March 14, 2012, at the [Wayback Machine](#)

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