

## Konrad Zuse and Floating-Point Numbers

In his news story “Lost and Found” (July 2012), Paul Hyman characterized Konrad Zuse’s Z9 as “the world’s first program-controlled binary relay calculator using floating-point arithmetic.”

This is not correct but rather the other way round; the Z9/M9 was the only one of Zuse’s computers to use binary-coded-decimal fixed-point arithmetic.

Zuse used binary floating point **from the time of his earliest computer designs**, because **his own** thorough analysis showed binary representation reduced the complexity of the arithmetic unit and that floating point is adequate for engineering calculations, which, as a civil engineer, is what he had **primarily** in mind.

Among the early computer pioneers, from Babbage to Aiken to Wilkes, Zuse was the only one to use floating-point arithmetic. His general-purpose computers Z1 (1938), Z3 (1941), Z4 (1945), Z5 (1953), and Z11 (1955) all used binary floating-point arithmetic. Beginning with the Z22 (1958), the computers developed by the Zuse Company used binary fixed-point arithmetic, implementing floating-point arithmetic through microprograms.

Zuse invented a format for binary floating-point numbers similar to the format of IEEE 754, using it in his very first machine, the Z1. Donald Knuth attributes the invention of normalized floating-point numbers to Zuse. The Z3 included representations for 0 (zero) and  $\infty$  (infinity); operations involving these “exceptional” numbers were performed as usual, e.g.  $0 - 0 = 0$  or  $\infty + 5 = \infty$ .

Operations with an undefined result (such as  $0/0$ ,  $\infty - \infty$ , and  $\infty/\infty$ ) were detected automatically and signaled **by a special light before the machine stopped**.

Zuse discussed the question of binary vs. decimal arithmetic with Howard Aiken, writing, “We also had some differences of opinion on technical matters. Aiken advocated the decimal system and had developed very beautiful codes for decimal numbers using several bits. I was more a proponent of pure binary representation—in any case, at least where large scientific computers were concerned. However, I had also used encoded decimal numbers in the mechanical solution for the punch card machine.”<sup>1</sup> The “punch card machine” was the Z9/M9.

**Jürgen F.H. Winkler**, Feldkirchen-Westerham, Germany

## Reference

1. Zuse, K. *The Computer—My Life*. Springer, New York, 1993.