Real Time Systems Design

Lecture (6): Analog computer components (CONT.)

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Components of Analog Computer

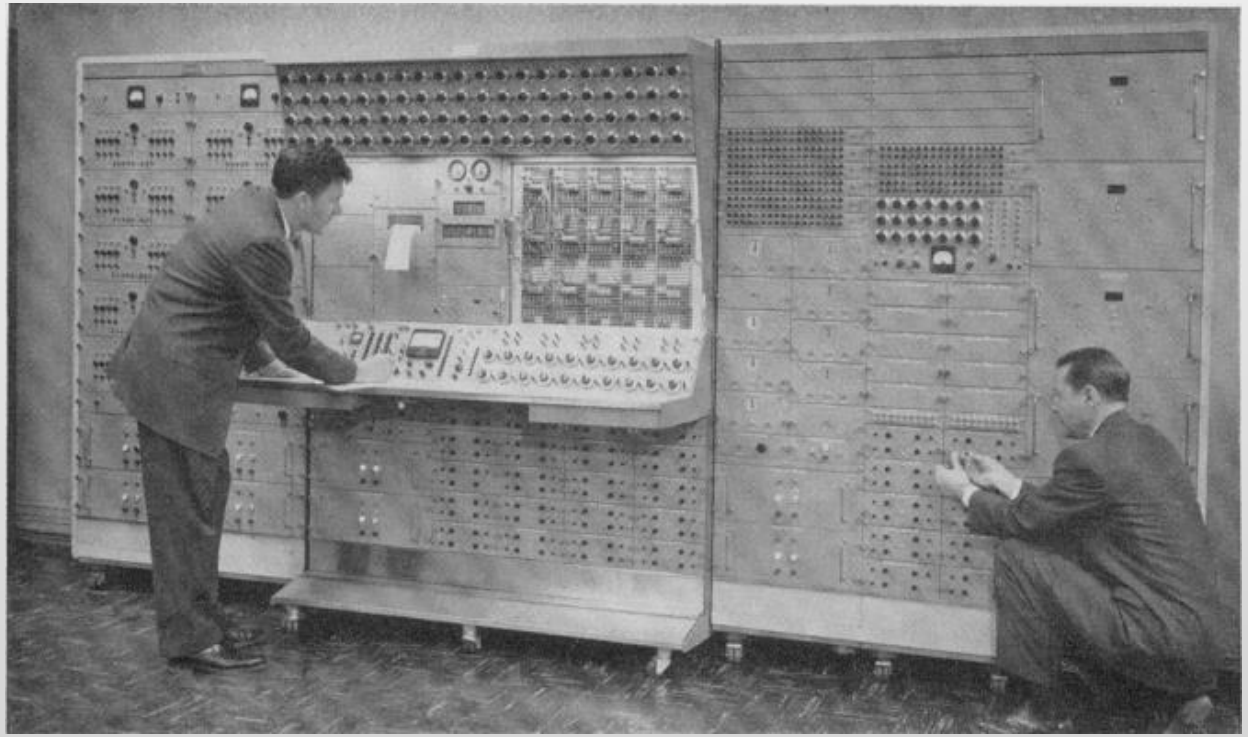
Analog computers often have a complicated framework, but they have, at their core, a set of key components which perform the calculations, where the operator manipulates through the computer's framework.

1. Key hydraulic components might include pipes, valves and containers.
2. Key mechanical components might include rotating shafts for carrying data within the computer, miter gear differentials, disc/ball/roller integrators, cams (2-D and 3-D), mechanical resolvers and multipliers, and torque servos.

Components of Analog Computer

3. Key electrical/electronic components might include:

- Precision resistors and capacitors
- operational amplifiers
- Multipliers
- potentiometers
- fixed-function generators



Types of analog computers

1. Slide Rules

Is one of the simplest and most recognizable mechanical analog computers, it is a device for approximating basic mathematical calculations Users slide a hashed rod to line up with various markings on another rod, and read the device based on the lineup of various hash marks As shown in figure (2).

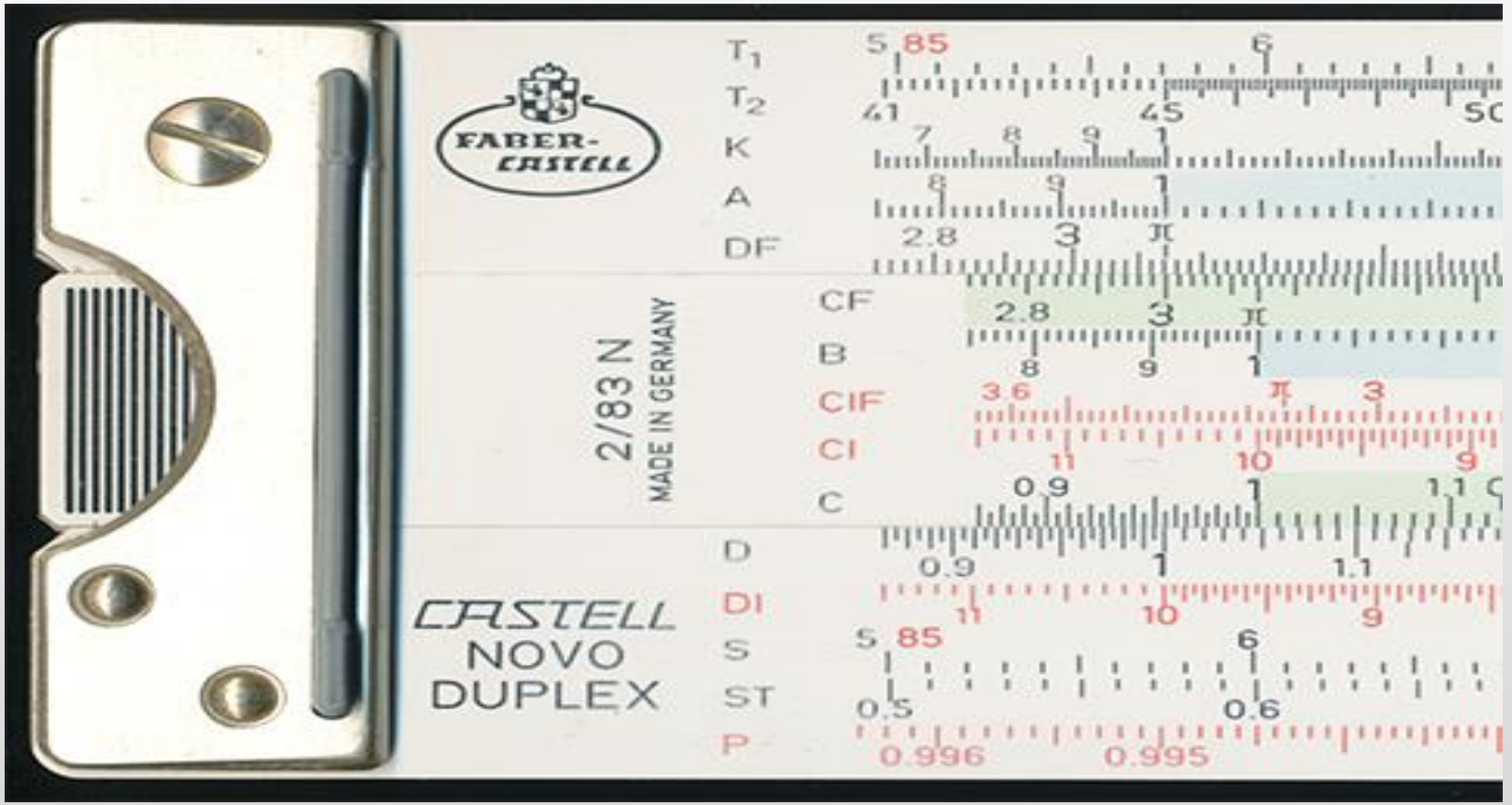


Figure (2): Slide Rule

Types of analog computers

2. Differential Analyzers

Which was able to solve differential equations. With designs as old as the early 1800s, the differential analyzer was refined in the 1930s, and used in the mid twentieth century. The machines were large in comparison to modern computers, filling a desk sized space.

Types of analog computers

3. Electronic Analog Computers

Modern analog computers use electrical signals flowing through various resistors and capacitors to simulate physical

Phenomena, rather than the mechanical interaction of components. The voltage of the signal provides the pertinent readouts or displays. Electronic analog computers saw wide use in computing and military technology throughout the middle portion of the twentieth century, in such capacities as missile and aircraft testing.

Mathematical operations used in an electric analog computer

- Addition
- Integration with respect to time
- Inversion
- Multiplication
- Exponentiation
- Logarithm
- Division

Differences between analog and digital computers

1. **Output**: Digital computers produce numbers as output. Analog computers output voltage signals, and has sets of analog meters and oscilloscopes to display the voltages.
2. **Electronic Circuits**: Analog computers circuits use op amps, signal generators and networks of resistors and capacitors. These circuits process continuous voltage signals. Digital computers use a variety of on-off switching circuits, such as microprocessors, clock pulse generators and logic gates.

Differences between analog and digital computers

3. Discrete versus Continuous Signals

Digital signals have two discrete states, on or off. The off state is usually zero volts, and the high state is typically five volts. Analog signals are continuous. They may have any value between two extremes, such as -15 and +15 volts. An analog signal's voltage may be constant or vary with time.

4. Emulation With improved technology, fast digital computers can emulate the behavior of analog computers. For example, a program in a digital computer can calculate a 2,000 Hz sine wave in real time, and with accuracy and reliability that analog circuits cannot match. Analog computers have a limited ability to mimic digital systems.

Differences between analog and digital computers

5. Noise: Analog computers must deal with a certain minimum level of electrical noise in the circuits, and this affects accuracy. Digital computer circuits also have electrical noise, though it has little to no effect on accuracy or reliability.

6. **Programming**: You can program both analog and digital computers, though the methods are different. Digital computers use carefully written lists of intricate instructions, including comparing two numbers, moving data from one location to another or multiplying two numbers together. To program an analog computer, you connect different sub-systems together electrically with patch cables. For example, connect a signal generator to a control knob which varies the signal strength.

Differences between analog and digital computers

7. Size: Analog computers vary in size from small desktop systems a large book to tall racks laden with equipment. Digital computers range from tiny microchips a few millimeters square to room-sized server installations.

8. Signal Coordination: A digital computer coordinates its signals with a master clock. The clock produces a high-frequency stream of on-off electrical pulses; each pulse being a "tick" of the clock. Every activity in the computer, from comparing numbers to moving data in memory, takes a defined number of clock pulses. The clock's speed determines the computer's overall speed. In an analog computer, signals simply flow from one circuit to the next, having no pre-existing central coordination. Because of this lack of coordination, analog computers can reveal chaotic and unpredictable behavior more readily than digital systems.

Differences between analog and digital computers

9 . Data Storage

The numeric, discrete nature of digital computers makes data storage simple. A memory circuit copies and retains the discrete states of another circuit. For analog computers, storing data is more difficult, as they use continuous signals. A circuit that stores an analog signal is prone to drift over time. The best approach for analog computers is a hybrid one. Convert the analog signal to a number and store the number in a digital circuit.

Summary

- ✓ Components of Analog Computer
- ✓ Types of analog computers
- ✓ Slide Rules
- ✓ Differential Analyzers
- ✓ Electronic Analog Computers
- ✓ Mathematical operations used in an electric analog computer
- ✓ Differences between analog and digital computers