The TELEFUNKEN RAT 700 Analog Computer

The RAT 700

The picture on the left shows the TELEFUNKEN RAT 700 analog computer as it was introduced by the German electronics and computer manufacturer TELEFUNKEN in 1961 as a desktop analog computer (which shows that even the desks are not any longer what they used to be - the machine weighs in excess of 100kg and I really have no desk where could place it onto :-) so it has to sit on the floor which is a pain for the programmer who has to do all the patching lying on the floor).

The machine consists of four drawers which contain all necessary electronic and mechanic components to make up a complete electronic analog computer with 19 operational amplifiers, two general purpose diode function generators, four multipliers, etc.

From top to bottom these drawers are:

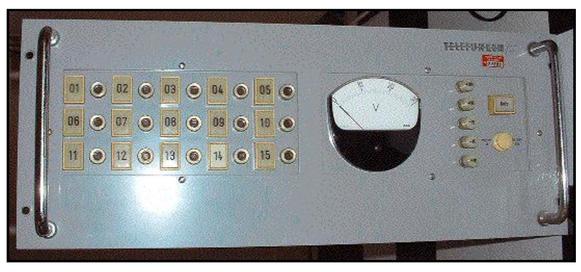
- Power supply and 15 operational amplifiers
- The two variable diode function generators
- Twenty 10 turn precision potentiometers for coefficients
- The patch board and control panel

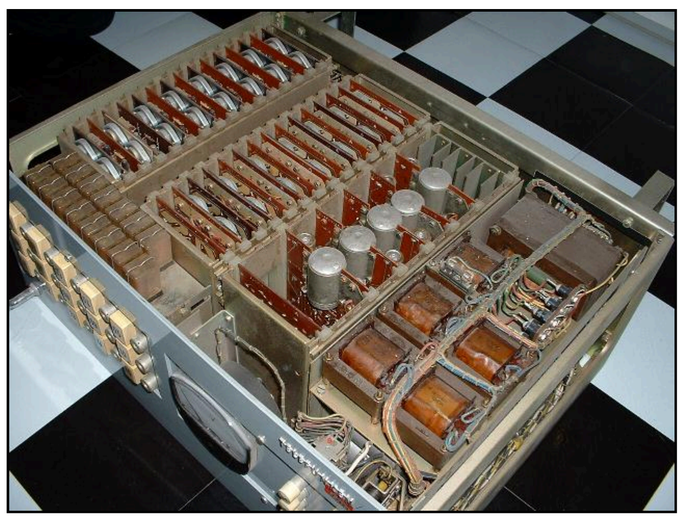
The following sections describe some of these units in somewhat greater detail.

The heart of the system is located in the upper drawer - it contains the power supply (capable of delivering +/-15 volts, +/-10 volts, a 400Hz line for the chopper relais, etc.) and 15 chopper stabilized operational amplifiers.

The picture on the right shows the front panel of this drawer: The right half contains the power supply with its large voltmeter and a row of pushbuttons used to control each output voltage for a quick performance check of the computer.

The left half contains the 15 operational amplifiers - each of these devices has its own overload indicator (labeled with the number of the amplifier) and a small potentiometer for the offset control of the amplifier.





The picture on the left shows the interior of this upper drawer - the power supply takes exactly the left half of the drawer. On the far left are the mains transformers, the rectifiers and some electrolytic filter capacitors.

Next to the transformers are six pertinax printed circuit boards which contain the stabilizing electronics - made up from discrete amplifiers and some power germanium transistors which are located on the heat sink at the back of the drawer. The large silver devices on the printed circuit boards are special relais which are used for overload and overvoltage protection.

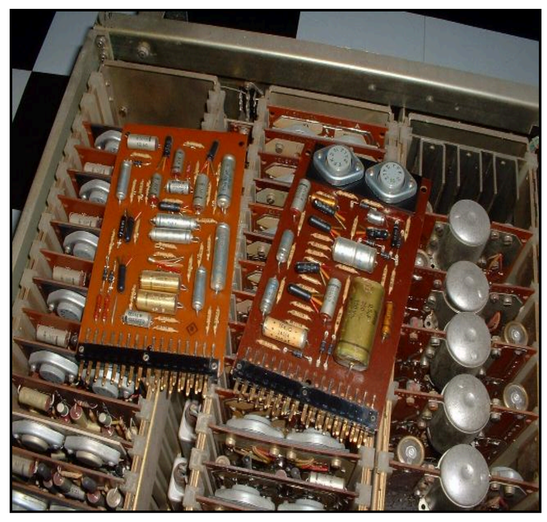
The left half contains the fifteen computation amplifiers - each amplifier consists of two printed circuit cards - one holding the main amplifier and the other one holding a second amplifier which amplifies the chopped offset voltage to generate a correction signal for the main amplifier thus ensuring minimal drift of the complete amplifier and increasing the open loop gain for low and very low frequencies.

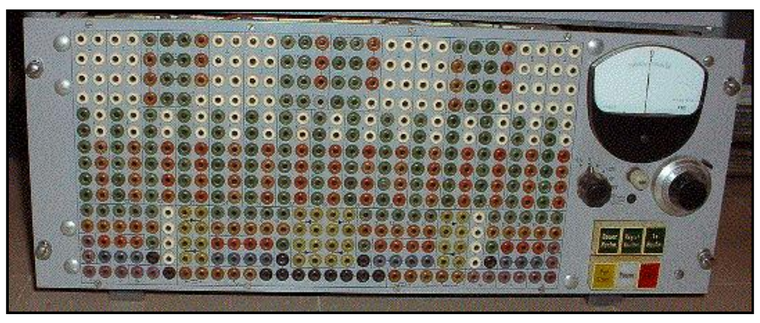
These amplifiers are real masterpieces of the art of electronics. The picture on the right shows one of these amplifiers pulled out of the card cage.

The card on the right holds the high current main amplifier - the two devices on top of the card are two high current germanium transistors in a TO-3 like anclosing. The card on the left holds the necessary electronics for the offset compensation amplifier.

The idea is to amplify the offset voltage of the main amplifier and to use this signal as a correction voltage to balance the drift of the main amplifier. Since this offset voltage is a near DC signal is it chopped with an electromechanical relais, a special device driven with 400Hz (and producing a unique hum during operation of the computer), amplified with a nearly drift free AC-coupled amplifier and then rectified by a synchronized diode bridge before being fed back into the main amplifier.

These chopper relais can be seen hidden between the two rows of card cages for the 15 amplifiers in the picture on the right.



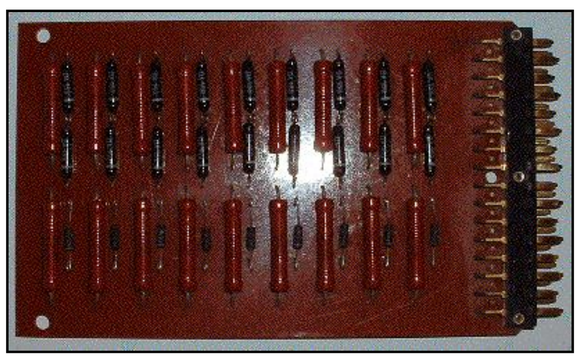


The picture on the left shows the patch board (or problem board as it is sometimes called) on the left and the control panel on the far right. Each computing element of the analog computer is connected to the patch panel and all of its inputs and outputs are available via 4mm banana jacks. Since precision amplifiers like the devices used in the RAT700 were very expensive they had to be configured to be used as summer or integrator in most cases. This is what the white jacks are for - with the aid of bottle plugs each of this general purpose computing amplifiers could be configured as integrator, summer or free amplifier.

Green jacks are normally input terminals while orange jacks denote output terminals. Red and blue denote +10 and -10 volts respectively, while black jacks are ground connections. The yellow jacks in the middle of the patch board are connected to so called "free" diodes which could be used to create dead zones, limiters and the like.

The control panel of the RAT700 is shown on the right. It serves several purposes - first of all it contains a precision bridge voltmeter - this device is used to setup the coefficient potentiometers which can be seen on the third drawer from top in the overall picture on top of this page. Since these potentiometers are used as voltage dividers it is necessary to take their actual load into account which is done by this compensation measurement unit. The program is wired and then the potentiometers are setup by comparing their output voltage with the voltage set on the precision potentiometer on the control panel. The instrument is very sensitive and is used only to the show the balance of the simple bridge circuit.

The push buttons on the bottom are the main control buttons for the computer. It is capable of working in "Dauerrechnern" (continuous operation), "Repetierendes Rechnen" (repetitive operation and "Einmalrechnern" (single run). These modi are controlled by the three buttons in the top row. The three buttons on the bottom row are used to enter "Potentiometer Einstellung" (coefficient potentiometer setup), "Pause" (setup time for setting initial conditions for the integrators and "Halt" (the computer is halted, all integrators store their current values).



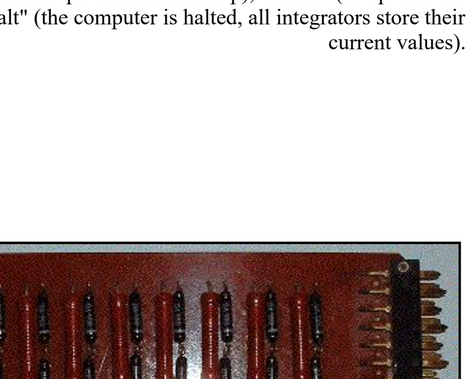
The circuit card on the left contains a network of precision resistors and germanium diodes which is used in the function generators of the analog computer.

The main idea is to approximate a function by a piecewise linear function which is accomplished by using 21 diode with different initial voltages applied to them to generate a set of 21 equidistant sampling points (-10 volts to +10 volts, including 0V).

With the aid of 21 potentiometers each of the intervals (of width 1 volt) can be assigned a selected steepness. So the desired function is approximated as a sum of secants by means of a diode/resistor network. The RAT700 contains two variable diode function generators to be setup by hand (which is a very tedious process and takes about 20 minutes per function if one is quite used to the procedure) and four parabola functions for the four multipliers.

The picture on the right shows a glimpse behind the patch panel of the analog computer. This is the place where the passive computing elements are located - the precision resistors for the input networks of the amplifiers, the phase compensation networks, etc. Note that the brown and grey cables carrying signals to and from the amplifier drawer are all coaxial cables.

All in all, the RAT700 is a wonderful example of the type of small "desktop" analog computer which was very much envogue in the late 1950s and 1960s. It was quite small, did not require air conditioning like its digital cousins (actually it consumes about 100W only) and was very reliable. Its amplifiers were so stable that offset correction procedures were seldom necessary and it even supported (not in the version shown here) a removable patch panel for quick program changes, etc.



The picture on the left has been taken from a the issue 6/1965 from the (long gone) German publication "Hobby" - this was a magazine for the hobbyist covering more or less every area which seemed to be of interest. In this particular issue a computer aided car development system was featured. Part of this system was a TELEFUNKEN RAT700 analog computer as the one shown on this page. The system was used to simulate the suspension system. Please note the complex program wiring and the incredible display of the car frame on the oscilloscope! I did my own version of this simulation to get a feeling for the complexity.

You may find the complete handbook for this table top analog computer here (German, 18 MB).

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