Vacuum Tube Logic

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Some Early Digital Computers

- ENIAC, 1946 18000+ tubes
- UNIVAC I, 1951 first commercial machine
- ERA 1101, 1955 most powerful scientific
- IBM 650, 1954 first > 1000 units delivered
- IBM 70x, 195x
- anything before 1959 is vacuum tubes
How was it done?

- Lee deForest 1906 invented Triode
- Vacuum tube as digital switch / inverter
- Several tubes/diodes for OR / AND
- Theory: any digital machine can be built from
  - inverter
  - either OR or AND gate
Figure 20. Development of the Triode Tube
a direction which is away from the control which originate at each of the grid wires point
to the plate, electrons boiled off the cathode will be attracted to the plate, as with the simple diode, so that they will now have to pass between the grid wires. If a negative, repelling voltage is added to the grid, electrons will flow through the tube and resistor in its plate circuit, causing a current to flow from one end of the resistor to the other. This is the type used in the 604, at the supply voltage.

**Figure 21. Basic Inverter Circuit**
of the tube as drawn in the manufacturers' tube basing diagrams (Figure 22 and in the Appendix). A subscript 2 is used to indicate the circuits for the right half of the tube (such as $4-7E_2$).

Because almost all vacuum tubes have heaters and their presence is so widely understood, it is common practice to omit the symbol for the heater wire itself when drawing a circuit diagram. This convention will

through the 470k and 390k resistors and up through the 20k plate load of the driving stage, the voltage on the plate of the driving stage rests at about +140 volts with the tube cut off rather than the +150 volt level considered earlier. Point C, the connecting point of three grid circuit resistors, will be found to be at about +30 volts if Ohm's law is applied to the voltage divider network. It would seem that the grid of the inver-
Figure 24. The Compensating Capacitor
Both Tubes Cut Off Except During Active Signal Times. Signals Applied Must be Positive Shifts.
fact that one inverter triode conducting through a normal 20k plate load will reduce the potential on the plate down to about +50 volts. When a second inverter triode is connected to share the same plate load and is conditioned to conduct, a current sharing action takes place. When the second triode is told to conduct while the first triode is also conducting, only a plus 50 volt potential is available on the second plate to attract electrons. Electrons leaving the second triode cathode are repelled by the first triode anode, and vice versa. This will be found true of any circuits in which a load resistor is shared by two or more units. It should be noted that the Inverter Switch is more frequently used than the Inverter Mixer.

Power (PW) Units (G and H)

The inverter units previously discussed are designed to work with tubes capable of passing safely a current of about 100 ma. The Inverter Switch is used in all the same circuits as the Inverter Mixer and is capable of handling a single current of about 20 ma. The Inverter Switch is therefore used in switch duty only.
Any A, B, C HIGH will pull Z HIGH

\[ Z = \text{HIGH} \text{ IF } A \text{ OR } B \text{ OR } C \text{ ANY HIGH} \]

Any A, B, C LOW would pull X LOW

\[ X = \text{HIGH} \text{ IF } A \text{ OR } B \text{ OR } C \text{ ALL HIGH} \]

Fig. 2-1. Diode AND and OR Circuits.
swtiching circuit.

Fig. 2-2. Two-Level diode

\[ G \text{ATE} \]

\[ \text{INVERTER} \]

\[ \text{AND - OR} \]

\[ \downarrow \]

\[ z = x \oplus \overline{y} \]

\[ y = c \text{ AND} \overline{d} \]

\[ x = a \text{ AND } b \]
AND-OR-INVERT GATE

\[ X = ABC + DEF \]

\[ R = ABC \]

\[ S = ABC + DEF \]
Interconnect the sockets of the pluggable units on the opposite side, showing the

Figure 2.8

Packaging of electronic circuits in the IBM 604. A pluggable circuit unit is shown.
densely enhanced circuit speeds by allowing reduced circuits to be con-
by isolating circuit assembly from plumbing and wiring. The component
component through the vacuum tube era. Simplified manufacturing
in a production machine. The unit, the basic building block for IBM
inter more than an inch wide; Figure 5.2 shows a typical array of them
almost 10 inches long, 5 inches high, from base to tube deck, and a
occurred in two separate motions. The eight-tube plug-gable unit was

![Figure 5.2: Electronic panel of the Defense Calculus with eight-tube plug-gable units.](image-url)