The data retention time of flash memories is 10 years at 150°C and 20 years at 125°C. Although flash memories are not rewritten very often in most devices, at the moment the industry-guaranteed number of programming/erase cycles is 100,000.

Nonvolatile memories are built using floating gate cells to store each bit. The gate is called floating because it is not connected directly to the rest of the circuit. Charge can only be injected or taken out by forcing electrons through a layer of insulating oxide. One method to do this consists of applying a high current to the gate. This is called *hot electron injection*. Another alternative, which is used in flash memories, is *Fowler–Nordheim tunneling*, in which the charge is removed from the gate using low currents and activating a quantum mechanical electron tunneling effect.

The flash memory market is expected to explode once information appliances such as **MP3** digital music players become more popular. Instead of carrying a device with moving parts (such as traditional Walkmans), the user carries a smaller, yet qualitatively better, MP3 player. The expected demand of flash memory cards for 2000 was 5.2 million cards just for this kind of application. Software for cellular telephones, such as small browsers for the Internet, will also be stored in flash memory which, can easily be upgraded. The market for flash memory was expected to reach 34.1 billion megabytes in the year 2000.

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—*Margarita Esponda*

Flip-Flop

A flip-flop is an electronic element used to store one bit of information. Also called the Eccles–Jordan switch (or circuit) after its inventors, the flip-flop first appeared in 1919. It was used primarily as a counting device until the 1940s and 1950s, when it became an important part of binary computers.

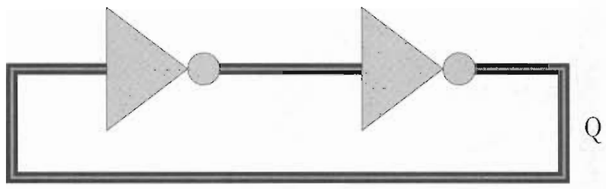

Figure 1. *The basic operation of a flip-flop circuit.*

A flip-flop, which can be built using **vacuum tubes** or transistors, has only two stable states and it can be toggled from one state to the other. The basic operation of a flip-flop can be explained using the first figure.

The two triangles with a small circle at the end represent inverters. If the input to an inverter is 1, the output is 0, and vice versa. Therefore, if the initial input to the first inverter is 1, the output of this inverter is 0; the input to the second inverter is 0 and the output is 1 (on the line labeled "Q"). When the circuit is initialized using a 1, it stores this 1 in Q. Something similar happens when the circuit is initialized with a zero from the left: The zero will be stored in Q. The circuit recomputes the stored bit repetitively.

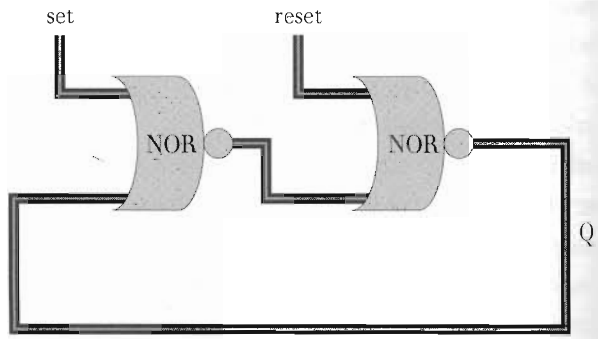

Figure 2. *Setting and resetting a flip-flop circuit.*

In order to set and reset the flip-flop (i.e., store a 1 or a 0), we need two extra data lines. The second figure shows the final diagram of a flip-flop.

The elements used are known as "NORs," for "not OR." The output of an NOR is 1 when both inputs are 0; otherwise, it is 0. The lines "set" and "reset" are always held to 0, except when we want to change the state of the flip-flop. If set = 1, the output of the first NOR is 0 and the output of the second NOR is 1 (since reset = 0). Therefore, the flip-flop stores a 1 in the line labeled "Q." If set = 0 and reset = 1, the Q line is switched to 0 and the flip-flop stores this bit.

There are many variations of this kind of circuit. The flip-flop in the example above is called an *SR flip-flop* since it contains set and reset lines. Flip-flops that change state at the edge of a clock signal are called *edge-triggered flip-flops*. Common flip-flops are the *D-type flip-flop* (also called a *latch*) and the *JK flip-flop*.

Flip-flops are used to build static memories, which are faster than dynamic memories. The latter store a single bit using a capacitor. Since the capacitor loses its charge slowly, dynamic memories have to be refreshed periodically (dynamically recharged). Flip-flops do not lose their contents, but they compute continuously and need more power. Also, since the transistors needed are larger than the small capacitors used in dynamic memories, fewer bits can be stored in the same silicon area. Static memories are therefore more expensive but faster than dynamic memories. Usually, static **RAM** (random access memory) chips lag a generation behind dynamic RAMs in terms of capacity and price. A RAM generation has a life span of about three years. The storage capacity of each new generation is four times larger than the capacity of the former one. Static RAMs are used to build faster memories, which are used as caches.

Flip-flops also have other applications. Since they can be toggled between two states, they can be used for binary counters; this was their most common use before the advent of computers. The early literature referred to the flip-flop as the Eccles–Jordan circuit for bistable multivibrators, or the Eccles–Jordan binary counter. Two vacuum tubes were used to amplify and invert the signals. Using these components connected in a ring, a ring counter, a counter that starts back at zero after going through all numbers it can count, could be implemented.

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— *Raúl Rojas*

Floating Point

Floating point in computer systems is a type of representation of numbers similar to scientific notation, by which a number is represented as a mantissa multiplied by a base raised to an exponent, where the mantissa is usually a signed fraction, and the exponent a signed integer.

Two examples of numbers represented in the conventional scientific notation are 0.52×10^{-3} and -0.78×10^{6}. Floating point stands in contrast to *fixed-point* representation, by which a numerical value is represented as a single mixed number, including potentially an integer part and a fractional part separated by a decimal point. The two numbers above have the following equivalent fixed-point representations: 0.00052 and -780000, respectively.

A floating-point number is represented by the pair (significand, exponent) and has the value significand × $\text{base}^{\text{exponent}}$, where the *significand* is the equivalent of the mantissa in scientific notation. Since the base is common to all floating-point numbers, it is not included in the representation, allowing more bits (out of the total of 32 or 64 bits that are commonly allocated to each number) to be assigned to the significand and exponent fields. Because computers perform operations using binary numbers, the base of the exponent is always either 2 or some power of 2 (e.g., 4 or 16) rather than 10 as in the scientific notation. Having three components—significand, base, and exponent—implies that there are many different ways to define a floating-point representation.

In the early days of computers, almost each computer manufacturer had its own floating-point format that specified the value of the base, the number of bits allocated to the significand and exponent fields, and the way negative values of these two fields were represented. This situation made the transportation of computer programs, or even just data, extremely difficult. This led to the establishment of a standards committee which in the early 1980s, decided on the **Institute for Electrical and Electronics Engineers** (IEEE) 754 standard for binary floating-point numbers. Almost all modern **microprocessors** currently follow this standard.