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Card Capacitor– A Semipermanent, *Read Only* Memory

The random access, high-speed memories most frequently used today are of the magnetic core type, which have the ability to be read from and written into at speeds of the order of a few microseconds. In some applications another form of memory can be used that may be read at these high speeds, with capability of being changed in a few minutes. Memories of this type, in which the fast-read cycle is of prime importance, may be called READ ONLY memories.

READ ONLY memories can be logically divided into two types: permanent and semipermanent. A permanent READ ONLY memory is fixed by construction so that any necessary changes in data require reconstructing at least a part of the storage device. In a semipermanent READ ONLY memory, data can be changed by replacing only the changeable data element. A permanent type of capacitor block memory, using metallized sheets of paper instead of punch cards, has been described by Gutermakher.[1] This Letter describes a semipermanent READ ONLY memory designated as the *Card Capacitor,* a model of which is shown in Fig. 1.

A memory array consists of groups of two printed-circuit boards with parallel conductors arranged on each, so that when the boards are placed with the conductor sides facing each other, the crossings between orthogonal pairs of conductors correspond to the 960 possible hole positions in the IBM card. The information to be stored is punched in the form of holes in a metallized IBM card with a hole representing a stored ONE and no hole representing a stored ZERO. Thus we will have either twelve 80-bit words or eighty 12-bit words arranged on the card, depending upon whether the row or column is defined as a word. The card is inserted between the two printed-circuit boards previously mentioned and the foil portion of the card is grounded. During readout the voltage pulse will be applied to a selected conductor corresponding to the word to be read out. Where there is a hole in the card, this voltage will be coupled through the hole by capacitive means to one of the orthogonal sense lines and may be detected by the magnitude of the voltage appearing on the sense line. Where a ZERO is stored, and consequently there is no hole, any coupling from the driven line to the corresponding sense line is prevented; thus only small noise voltages will appear on a sense line corresponding to a stored ZERO.

To create large memory arrays, the sense lines would be connected in parallel so that, for example, 500 cards require only 80 sense amplifiers for 80-bit words. The cards used for the storage of information will be capable of being punched, reproduced, sorted, et cetera, on existing IBM equipment. There is, of course, no necessity of limiting use to the standard IBM card and punch except for the previously mentioned advantage.

Theory of operation

The voltage output is given by the equation

$$V_o = V_d \frac{C_c}{NC_x},$$

where V_d is the drive voltage applied to read out a selected word, C_c is the capacitance between conductors through a hole, C_x is the capacitance of a sense line to ground with the shield at ground potential, and N is the number of cards. Note that the output voltage is independent of frequency. Experimental results show this to be true for signals from about 10 kc to 50 Mc/sec. Typical values for C_c/C_x are 1/200 for a standard IBM punched card, where a column is driven and rows are sensed as for 80-bit words. Thus for 100v input and a memory composed of 500 standard IBM cards, with 960 bits per card, the output voltage for a stored ONE would be 1 mv. This size memory block seems to represent a reasonable limit on the maximum modular size without utilizing any special compensation techniques to reduce the output capacity. While this may permit a module size of ten times greater capacity, it is likely that drive considerations may become limiting.

For low-impedance drivers the 1/0 signal ratio is given by $\frac{1}{0} = \frac{C_x}{2C_{lx}}$, where C_{lx} is the capacitive coupling between adjacent sense lines. Note that this ratio is independent of the number of sense lines connected in parallel. Although the expression derived for high-impedance drivers is more complex and permits sneak paths, the

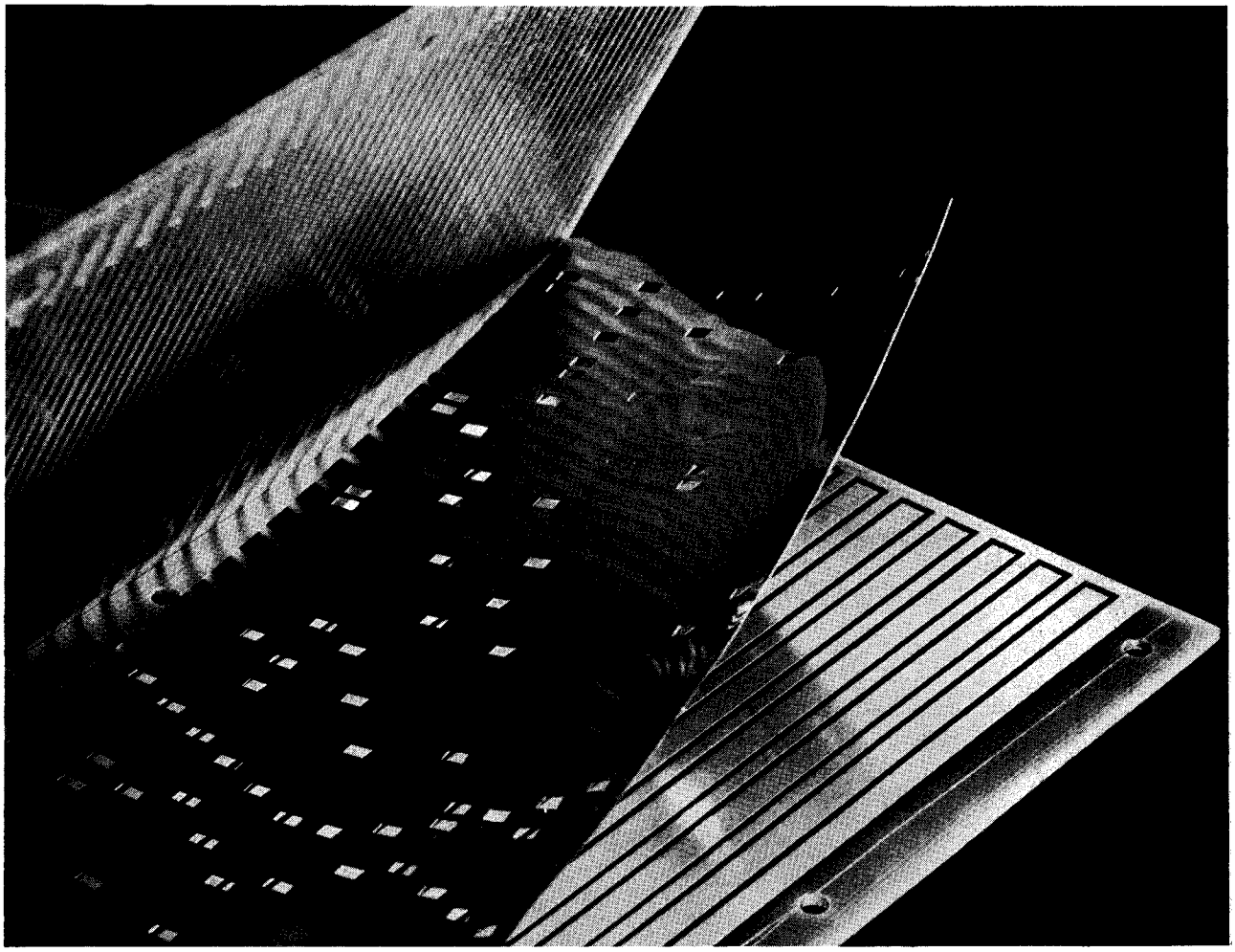

Figure 1 **Opened view of the Card Capacitor.**
Information is stored in the holes of a metallized IBM card, to control the capacitive coupling between printed drive lines on one card and sense lines on the other.

same relationships to N are valid. Experimental work has shown the above to be valid and that 1/0 ratios of better than 10 can be achieved for the most pessimistic conditions. Since the transfer characteristics of the array are linear, the system would be sensitive to noise in the drive circuits. This can, of course, be easily handled through proper engineering of the driving circuitry.

Characteristics

Memory systems covering a range of access time and capacity are feasible using the shield card as an interchangeable storage element. These would probably range from 10^7 bits at 10 μsec to 10^4 bits at less than 10^{-1} μsec. Its potential ruggedness and reliability are apparent. Since there is practically no loss in memory, the system power requirements are extremely low (500 w for 10^7 bits at 10 μsec).

All of the proven advantages of standard unit record preparation and handling may be effectively combined with the operating capabilities described above. The usual machine functions such as sorting, collating, reproducing, et cetera, may be performed by existing equipment and, where desired, supplemented by automatic changing of cards in the memory.

An important area of application exists in program storage and the closely related area of supervisory and input-output routines. Also, it appears useful for the storage of tables and in other essentially look-up operations, such as the substitution of memory for logic and stored arithmetic. Additional applications may exist in signal switching and summation (as in crossbar switches) because of the inherent wideband and linear characteristics of the card capacitor device.

Reference

1. L. I. Gutermakher, "Prospects of Using Magnetic and Capacitance Blocks and Elements in Automatic Systems," *Proceedings of Conference on Scientific Problems of Automatic Production,* Academy of Sciences, USSR, Oct. 15-20, 1956.

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