NASA TECH BRIEF

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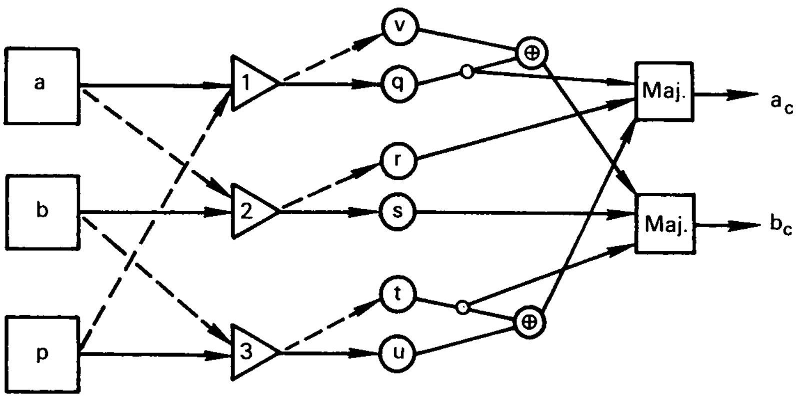
Logic Redundancy Improves Digital System Reliability



The problem: In binary-signal systems, the generation of false zeros and false ones due to noise or faulty equipment are not uncommon. These false signals result in errors in communication or computation and repetition of message is not always feasible.

The solution: A redundant-channel system that automatically corrects any single error in a set of three binary signal channels.

How it's done: The system is composed of four parts as shown in the illustration:

(1) Simultaneous binary signal sources a, b, and p.
(2) Signal channels 1, 2, and 3.
(3) Temporary storage elements q, r, s, t, u, and v.
(4) Logic circuits consisting of parity functions ($\oplus$) and majority functions.

Signal sources a and b are independent but source p produces a signal that is the parity function of a and b, that is, it is 1 if a and b are unlike, and 0 if a and b are like values. In a computer, if a and b are logical functions of a set of variables, x, p may be derived directly as a combinational function of a and b, or indirectly from the same set of variables, x. In this system, identical values of a, b, and p are produced twice. The first set of values a, b, and p are transmitted through channels 1, 2, and 3, respectively, and stored in elements q, s, and u, these transmissions being represented by the heavy solid lines in the figure. The second set of values of a, b, and p are transmitted (along the dotted lines) through channels 2, 3, and 1, respectively, that is, transposed with respect to the first transmission, and stored in elements r, t, and v. The signals a_c and b_c are generated by the combinational logic elements as the following functions:

$$a_c = \text{majority function } (q, r, [\, t \oplus u \,])$$

$$b_c = \text{majority function } (s, t, [q \oplus v])$$

where the majority function of three binary variables is defined as being 1 if, and only if, two or three of the variables are 1, and the symbol $\oplus$ represents the parity function of the associated variables as defined above. The functions a_c and b_c are the true values of the independent signals a and b, respectively, if there is no more than one faulty channel. The explanation of

(continued overleaf)

this for a_c is that: if channels 1, 2, and 3 are perfect then q, r, and v have the value a and $[t \oplus u]$ also has the value a, since $t = b$, $u = p\ [a \oplus b]$, and $(b \oplus (a \oplus b)) = a$. Finally, the majority function of (a, a, a) is a. If one of the channels fails, only one of the values q, r, or $[t \oplus u]$ may differ from the others, so that the majority function of the three still has the value a. The explanation for b_c follows a similar argument.

Notes:

1. This system could be used to correct signal channel errors in applications where data is transmitted naturally in parallel channels, such as within a digital computer, and where the channel is substantially less reliable than the associated correction equipment.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California, 91103
   Reference: B65-10025

Patent status: NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

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