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NASA TECH BRIEF

Marshall Space Flight Center

Computerized Logic Design of Digital Circuits

The problem:

Logic design is tedious and laborious work.

The solution:

A computerized logic design procedure is presented for a specially-developed computer program that performs all work required for the logic design of digital counters or sequential circuits and the simplification of Boolean expressions. The program provides a simple, accurate, and comprehensive logic design capability to users both experienced and totally inexperienced in logic design.

How it's done:

The program has been developed for two modes of operation: counter design and Boolean simplification. In the counter design mode, the program provides simplified flip-flop input equations for any desired sequence and for using any type of flip-flop. The simplified logic equations can be obtained in either sum-of-product or product-of-sum form for any one or all of the flip-flop types. The program also provides printouts of the intermediate design steps used in obtaining the flip-flop input equations. In the Boolean simplification mode, the program simplifies Boolean logic functions that can be entered in either sum-of-product or product-of-sum form.

The counter design mode can also be used for the design of sequential circuits other than counters. The program can be used for any sequential design application where a group of flip-flops is required to change states in a prescribed order:

a. Each flip-flop is assigned a binary bit representation which provides an equivalent count sequence for the prescribed state changes.
b. The equivalent count sequence is read into the computer in the same way as is done for regular counter designs.
c. The program provides the logic equations that will cause the flip-flops to change states in the prescribed order.

Considerable effort was expended in the development of these programs, to reduce the input data requirements to the simplest level possible and to present the output results in a self-explanatory and instructive format. The required input to the program is the data a designer usually begins with for hand calculations. For counter designs, the input is the type of flip-flop and the count sequence in decimal numbers. The output is the simplified logic equations in proper form for direct implementation with the specified flip-flops and the desired digital gates. For Boolean simplification, the function is read in and printed out in its normal handwritten form.

The program also instructs the user in counter design by printing out the intermediate design steps used in obtaining the simplified logic equations. These intermediate steps are the same as those that would be performed if the counter were designed by hand, and they include the flip-flop transition input requirements and the counter truth table. Hence, each program printout also serves as an instructive design example and demonstrates the design procedure used. The printouts of these intermediate steps can be suppressed by a simple option if desired.

The program greatly reduces the amount of time and effort required for logic design. Most counter design methods are fairly straightforward but do involve much work for long count sequences or unordered sequences, especially when logic equations are desired for more

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than one type of flip-flop. A useful feature of the program is that for a given count sequence counter design equations can be obtained for several or all of the available types of flip-flops. The designer can compare these equations for simplicity or some other desired characteristic and then can select the optimum type of flip-flop for the given sequence.

Notes:

1. This program was written in FORTRAN IV for the UNIVAC 1108 computer.
2. Inquiries concerning this program should be directed to:

   COSMIC
   112 Barrow Hall
   University of Georgia
   Athens, Georgia 30601
   Reference: MFS-22401

Source: S. Gussow and
R. Oglesby of
Sperry Rand Corp.
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