SUBJECT: INPUT-OUTPUT REGISTERS

INTRODUCTION

In many applications it is desired that the G-15 be used as an on line device to do computations. In such an instance the computer may act as a control unit, a direct coupled processing unit, or be tied to other devices for input and output such as a graph plotter, etc.

As part of the standard equipment supplied with the G-15, certain logic allows an external connection to the computer which facilitates the tying in of external equipment in a variety of ways.

1.1 Limitation of the Standard Input and Output facilities.

In many instances, the standard input/output facilities of the G-15 allow the connection of external devices. However, certain limitations regarding the standard input/output facilities make it desirable to augment these facilities with other procedures. In particular, the speed of the standard input/output system (maximum rate of 3200 bits per second in and out) limit the ability of the computer to work in real time with many systems, or limit the external equipment to a speed at which the computer may accept and give out data.

A second limitation on the standard input/output facilities is that the format is limited to a fixed format, especially at the speed mentioned above.

11. General System Concepts

2.1 Typical Requirements of an External System.

The general requirements of a system to which the computer must be connected are, of course, divided into two categories:

1. Requirements for input.

2. Requirements for output.

2.1.1 Input requirements to the computer

A typical real time system will be required to furnish certain data to the computer which the computer will use in certain computations or other data processing operations. In particular, the information may be a multiplicity of different quantities which may exist in either a digital or analog form. For purposes of this discussion it will be assumed that the data exists in a digital representation, or if such is not the case (data exists in analog form) an analog/digital converter will be assumed.

The multiplicity of digital information will be assumed to exist in parallel, and even though a multiplicity of different quantities of arbitrary numbers of binary bits each exist, it may be generalized that all the quantities appear to the computer as a series of parallel binary signals, in essence making up one quantity of arbitrary number of bits. As will become apparent later, if the signals exist serially rather than in parallel, the problem of entering the data in the computer is simplified.

An electronic digital register, consisting of a series of flip flops (one for each of the signals appearing in parallel from the external system) is assumed available. This register is not a standard item but must be built especially for each application, although in many instances a standard register could be applied to a number of these applications. Each of the signals which appear on the parallel lines from the external system will be used to set the individual flip flops in the register on a one to one basis. After this is done the data needed to be entered into the computer exists in the register and the computer may obtain the data under its own control.

2.1.2 Output Requirements from the Register

Assume that the computer has delivered information into the register by means of its program. The external system is to use this information in some manner for control, etc. The register supplies signals in parallel which the external device may use directly, or in the case that the external device requires serial information, the register could be used as a shifting register and supply the data in such a manner, or as will be seen later the register may not be required in this case.

2.2 Programming Characteristics of the Computer

In Section 2.1 it was assumed that an external register to the computer is supplied for furnishing data to an external system and for obtaining data from an external system. The computer has direct control over this register in a manner such that the computer requirements are met for the transferring of data in and out.

The method of transferring data to and from this register by the computer involves the use of commands in the computer repertoire. Therefore, for an understanding of this section it is necessary that the reader be familiarized with the programming procedure used within the G-15.

2.2.1 Output to the Register

The output data must be stored within the G-15 memory, specifically in line 20. Assume that the data is stored in a particular word of this line, word 0, and that a full 29 bits is to be transferred to the external register. In this case the external register will be assumed to have a total of 29 flip flops.

The procedure for transferring this information from line 20 to the external register follows:

Step 1 . . . . The even half of the ID is filled completely full of I's (if the word in line 20 were an odd location the odd portion of ID would be filled with I's);

Step 2 . . . . A command would then be given to have the execution occur at a time equivalent to word 0 MOD 4. This command would have a destination code equal to 31 and a source code equal to 18.

Upon obeying this command, the computer would transfer this information in word 0 of line 20 to the external register with no further operations required. Of course, it must be realized that if the information is not in line 20 it must first be put there by suitable commands; furthermore, the information may be put in any word on line 20.

If the amount of information to be transferred to the external register does not contain 29 bits but contains more than 29 bits, it must be stored in two words of line 20 and a command executed which operates during both of the two words. Further, if a complete word is not filled up with the data that is to be transferred to the register (for example, less than 29 bits worth of information must be transferred to the external register), it must be known by the programmer where the bits are located with respect to the beginning or end of the word in which they are stored. The programmer must then put binary I's in the ID register corresponding to the bit locations of the word in which the data is stored. For example, if 20 bits of a word are to be transferred, 20 binary I's must be put into the ID register at the bit locations corresponding to the locations of the 20 bits in the word.

2.2.2 Input

Assume now that the external register has been filled with information from the external system, and that the computer is to obtain the information from the register, transferring it to some place in the memory. The steps for accomplishing this follow:

Step 1 . . . . a series of binary I's are put into line 20, the number of I's corresponding to the number of bits stored in the external register.

Step 2 . . . . a command is given in which the source code is 29 and the destination code is the line to which the data is to be transferred, any line desired by the programmer. The timing number must be such that the proper word of the destination is chosen by the programmer in which he wants the information to be located. The information will be transferred (one bit from the input register for each bit read in line 20) to the desired location upon the obeying of this command.

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3.1 Output

During the time that the command is being obeyed for transferring the information to the external register (i.e. during execution), information is supplied to the external register on two different wires. The first of these wires is to be considered as the write pulse, or timing pulse, which indicates to the external register that a bit of information is being transferred from the computer. This write pulse occurs at a maximum rate of one every 10 seconds. The number of write pulses supplied by the c omputer is equal to the number of I's which the programmer put in the ID register. If the programmer inserted a combination of I's in the ID so that 0's were interspersed among the I's the write pulse output of the computer would be at a lower rate than that mentioned above.

Impressed upon the second line emanating from the computer is a varying DC voltage which will contain either one of two voltages at a given instant, either -20 volts or 0 volts. If this line is at 0 volts at the time a write pulse occurs, the output register will accept a binary one from the computer; and if this line is at -20 volts at the time the write pulse occurs the output register will accept a binary 0.

The write pulse may be used by the external register to signal the register that information is to be shifted from one flip flop in the register to another flip flop. The characteristics of the write pulse are such that it also varies from -20 to 0 volts in a manner shown in figure 1.

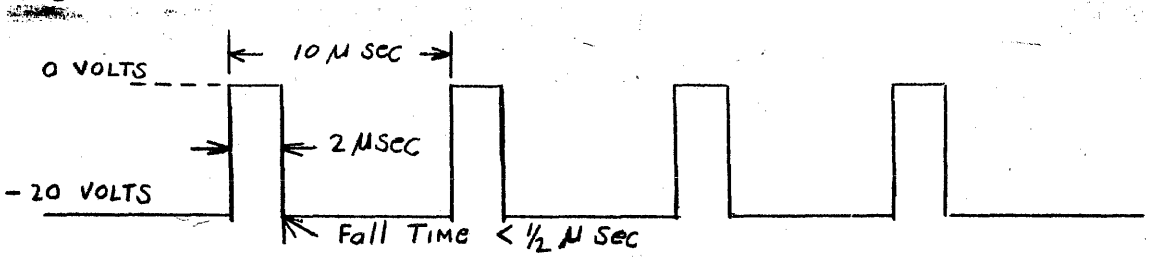

FIGURE 1

Block diagram of the above described procedure is shown in figure 2.

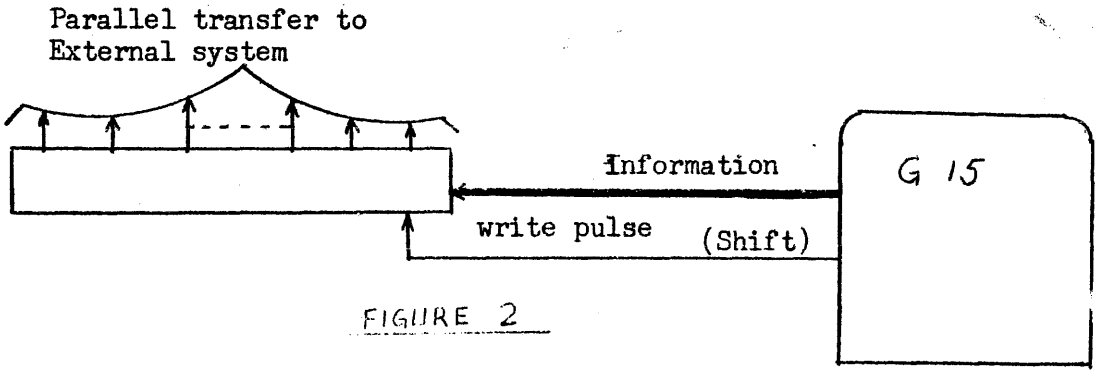

FIGURE 2

3.2 Input

When the external register contains information which the computer will secure by means of the command described in section 2.2.1, the computer will furnish a similar set of write pulses as was described for output. This will signal the external register to shift information from one flip flop to another and the information from the last flip flop of the register will be used by the computer as the information which it must secure. To do this, the computer must examine an input line which must contain a varying DC voltage giving the output of the last flip flop in the register. The computer will examine this two level voltage at each write pulse time in order to obtain one bit of the input data.

IV Synchronization of the Computer with the External Device.

In order to synchronize the computer with the external system it is necessary to supply synchronization signals back and forth. Facilities for doing this have been built into the computer which allow the computer to essentially slave itself to the time requirements to the external system. In other words, the computer is made to operate the input and output registers at the rate which is determined by the external device.

4.1 Input

The provisions for synchronization input are as follow:

Assume that the external device loads the input register in the manner heretofore described and that the external device is able to signal the computer that it has so loaded the input register. The computer is capable of inquireing of the signal given by the external device to see when this occurs providing, the proper voltages are used in supplying the signals. A signal wire is connected from the external device to the computer such that when the input register has been loaded by the external system a voltage of 0 volts is impressed upon this wire and when the register has not yet been filled a voltage of -20 volts is impressed.

The computer inquires of this signal by obeying the "Ready In" test command; namely, destination 31, source 28 and characteristic 1.

4.2 Output

In a similar manner to that described above the computer can load the output register and then inquire of a signal furnished by the external device when the external device has secured the information stored in the output register by the computer. The command for accomplishing this is destination 31, source 28 and characteristic 2 - the "Ready Out" test command.