VI

INTRODUCTION

The bulk of the system data flow in the BUIC NCC is provided by inter-equipment operations between the terminal devices of the BUIC NCC and the central data processing modules (computers, memory modules and I/O modules) of the data processing set. These inter-equipment (commonly called input/output (I/O)) operations, are those in which operational data are transferred between the core memory modules of the data processing set and the following terminal devices:

a. Message processor modules

b. Display/bulk drum system

c. Bulk-only drum system

d. Data display consoles

e. Magnetic tape recorder-reproducer set

f. Punch card reader set

g. Typewriter-punch-reader set

h. Teleprinter

i. Simulator group

j. Status display console

The data flow (I/O) operations between the memory modules of the data processing set and above equipments are controlled by the I/O modules of the data processing set. Operations with as many as four of these equipments may be performed concurrently, one operation being controlled by each of the four I/O modules in the data processing set. By means of these inter-equipment (I/O) operations, input data and programs which are to be processed by the central data processing modules are stored in the memory modules and are thereby made available to the computers and to the programs which control computer operation. Similarly, processed data stored in the memory modules are transferred to the terminal equipments for storage, display, printout, or transmission to other facilities.

IV

DESCRIPTION OF INPUT-OUTPUT (I/O) MODULES

The four I/O modules of the data processing set are each a descriptor-controlled input-output control unit (IOCU) capable of controlling the transfer of data between a peripheral terminal equipment and the core memory modules of the data processing set. Input-output operations in the data processing set are defined and initiated by computer action, but then proceed independently under the control of the I/O modules. The computers can initiate as many input or output operations to be performed concurrently with different peripheral terminal devices as there are I/O modules in the data processing set. Data are transferred between an I/O module and a peripheral terminal device as successive character transfers of six data bits and one parity bit in parallel. The I/O module provides a buffer for a full memory word which it assembles or disassembles as the character transfers are performed. Only full memory words are transferred between the I/O modules and the core memory modules. Manipulation of data within the I/O modules thus consists primarily of transforming the memory words into the six-data characters applicable to the peripheral terminal devices and vice versa. The I/O modules also modify descriptor words sent to them and return the modified descriptors to a designated place, called the descriptor list, in the core memory modules. These descriptors, which are then examined by the computer under program control, indicate the active, error and completion status of the I/O operation.

The operation of the I/O modules in the data processing set is initiated and completely controlled by descriptor words which are sent from the memory modules to all I/O modules of an I/O bus. Descriptor words are specially-formatted memory words coded to define a particular operation or function that is to be performed by all I/O modules, or one specific I/O module, of the I/O bus. When an I/O operation or control function is to be performed, the computer program in control of one of the computers forms an appropriate descriptor word for defining the operation and stores the descriptor in the memory modules. The computer then executes a transmit-to-I/O (TIO) instruction in the program. The TIO instruction, by specifying the descriptor word address and identifying the I/O bus, causes the applicable memory module to apply the descriptor word thru the data lines to the I/O modules and to signal all I/O modules on the bus to receive and interpret the descriptor. An entire I/O data transfer operation as defined by the coding of the descriptor word now proceeds independently under the control of an I/O module. Thus, the computer is free to continue with other task processing functions of the computer program while the I/O module performs the transfer of input or output data between the core memory modules and peripheral terminal equipment.

There are three different types of descriptor words sent to the I/O modules from the memory modules (program-generated descriptors), and two different types of descriptor words are returned to the memory modules from the I/O modules (hardware-generated descriptors). The program-generated descriptor words are Setup, Release and Command Descriptors. The Setup and Release Descriptors are used to establish initial conditions in the I/O modules so that they can properly receive and execute the Command Descriptors sent to them. The contents of each Command Descriptor define an I/O data transfer operation to be performed with a specific terminal device. The hardware-generated descriptor words are In-progress and Result Descriptors, which are stored by the I/O modules in the memory modules for inspection by the computer program in operation. An In-process Descriptor is sent by an I/O module to a predesignated location in the memory modules after one of the program-generated descriptor words is received at the I/O module. The In-process Descriptor, which is essentially a copy of the descriptor sent to the I/O module, indicates whether the I/O control function or data transfer operation was initiated properly. A Result Descriptor is sent by an I/O module to a predesignated location in the memory modules whenever an I/O data transfer operation in progress is terminated for some reason. The Result Descriptor is an updated copy of the Command Descriptor for the operation and indicates the extent of completion of the I/O operation when terminated. The Result Descriptor also specifies the reason the operation was terminated. The I/O module generates an interrupt signal which is sent to the computers to indicate when an I/O operation has ended.

Each I/O module shares an access bus into the core memory with one other I/O module. Modules I/O 1 and I/O 2 share I/O bus A, and modules I/O 3 and I/O 4 share I/O bus B. Only one of the I/O modules assigned to an I/O bus can use the bus at a time. Each I/O module contains priority conflict circuitry that resolves conflicts for use of the I/O bus on the basis of the I/O module number and the priority of the operation being performed. An I/O operation is assigned a higher priority (priority A) by the setting of a priority bit in the command descriptor. The I/O modules connected on different I/O busses (A and B) operate independently of one another. The I/O modules common to an I/O bus also operate independently except that they share a common data transfer bus into the core memory modules. Since only one I/O module can use the I/O bus at any one time, an I/O module may have to wait for bus access when it desires to transfer a word to or from the memory modules. In addition, the I/O bus may be delayed in gaining access to the desired memory module. The time delays experienced, however, are usually insignificant because of the relatively slow operating speeds of more of the BUIC NCC terminal equipments. These time delays, however, can become significant when operations are performed with terminal devices whose data transfer rates approach the maximum capability of the I/O module (500,000 characters per second). In the BUIC NCC, the three magnetic drum systems of the data processing set possess data transfer rates of a sufficiently high value to prohibit the operation of any other terminal equipments on the same I/O bus when a drum transfer operation is being performed.

Data transfers between the I/O modules and the core memory modules are performed one word at a time. Data transfers with the terminal equipments are performed as successive character transfers of six data bits and one parity bit in parallel.

The maximum I/O channel capability of each I/O module is 64 single (one-way) channels (32 input and 32 output). Thus, any combination of simple (one-way) or complex (two-way) terminal devices totaling 32 input and 32 output channels can be connected to each I/O module. In the BUIC NCC, however, only 36 channels (26 input and 10 output) are wired for use and only 30 channels (21 input and 9 output) are actually used. Each I/O module provides single-thread operation; that is, only one channel for one terminal device can be operated at a time. Each I/O module has a unit identification number or address (0001 thru 0100) which is physically wired into the hardware. Each I/O module also contains a control panel and test circuitry which enable manual operations to be performed for (1) initiating input-output operations with the peripheral terminal equipments, (2) performing maintenance, and (3) debugging programs. Operations which are selectable at the I/O module control panel are: on line, subsystem test, channel test, module test, and memory test.

SWITCHING INTERLOCK

The computers and I/O modules of the data processing set are electronically interconnected with the memory modules by means of the SWITCHING INTERLOCK. The SWITCHING INTERLOCK consists of logic circuitry in each of these modules that provides control of intermodule communication. Intermodule communication consists of data transfers between the computers and the memory modules and between the I/O modules and the memory modules. This communication is accomplished by use of four data transfer BUSES (2 computer buses and 2 I/O buses). A computer or I/O module initiates communication by requesting access to a specific memory module through the SWITCHING INTERLOCK. The function of the SWITCHING INTERLOCK is to connect the data transfer BUS of the requesting computer or I/O module to the memory module to which access is requested.

Certain conflicts will arise if more than one computer or I/O bus simultaneously request access to the same memory module. It is the function of the SWITCHING INTERLOCK to resolve these conflicts. If two or more BUSES simultaneously address the same memory module, the SWITCHING INTERLOCK automatically resolves the conflict by ordering the requests based on a given priority scheme. The priority is pre-emptive in that a higher priority request pre-empts a lower priority request. The priority scheme is as follows (from highest priority to lowest priority):

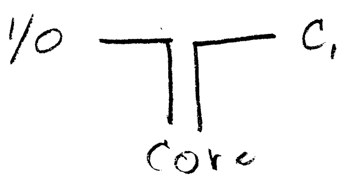
a. I/O bus A

b. I/O bus B

c. Computer 2 (C2) bus

d. Computer 1 (C1) bus

Switching interlock



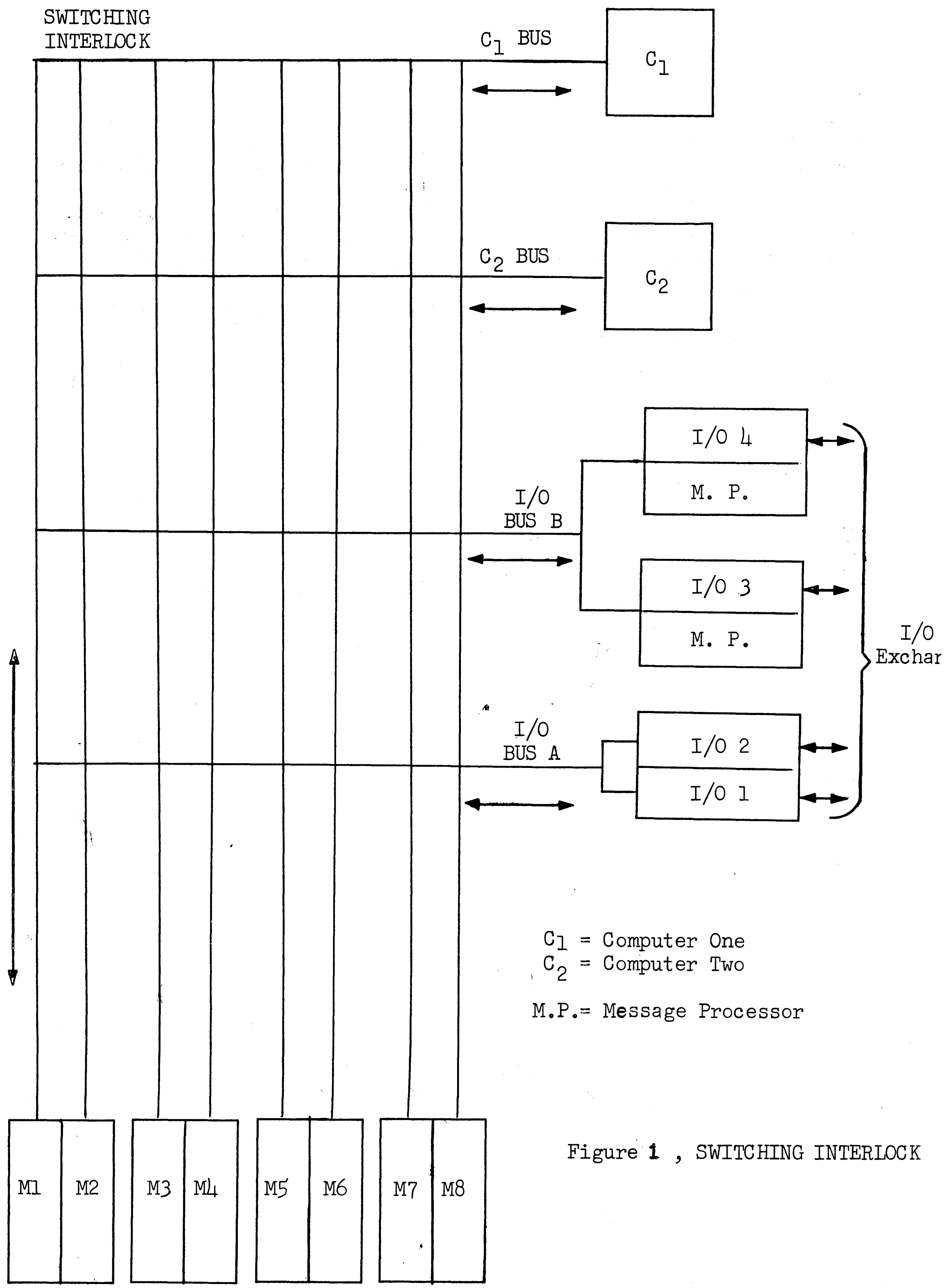
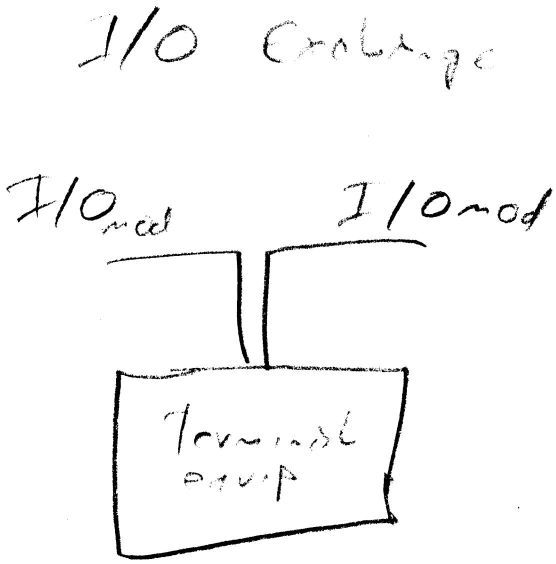


Figure 1 , SWITCHING INTERLOCK

INPUT/OUTPUT EXCHANGE

The I/O exchange permits two-way data flow between an I/O module and any of the terminal devices connected to it. During I/O operations, selected I/O devices are automatically connected with specific I/O modules by means of the I/O exchange. The I/O exchange consists physically of logic circuitry in the terminal equipment and in the I/O modules that controls the transfer of data between a terminal device and an I/O module. Normally, all I/O modules will be able to communicate with all the terminal devices.



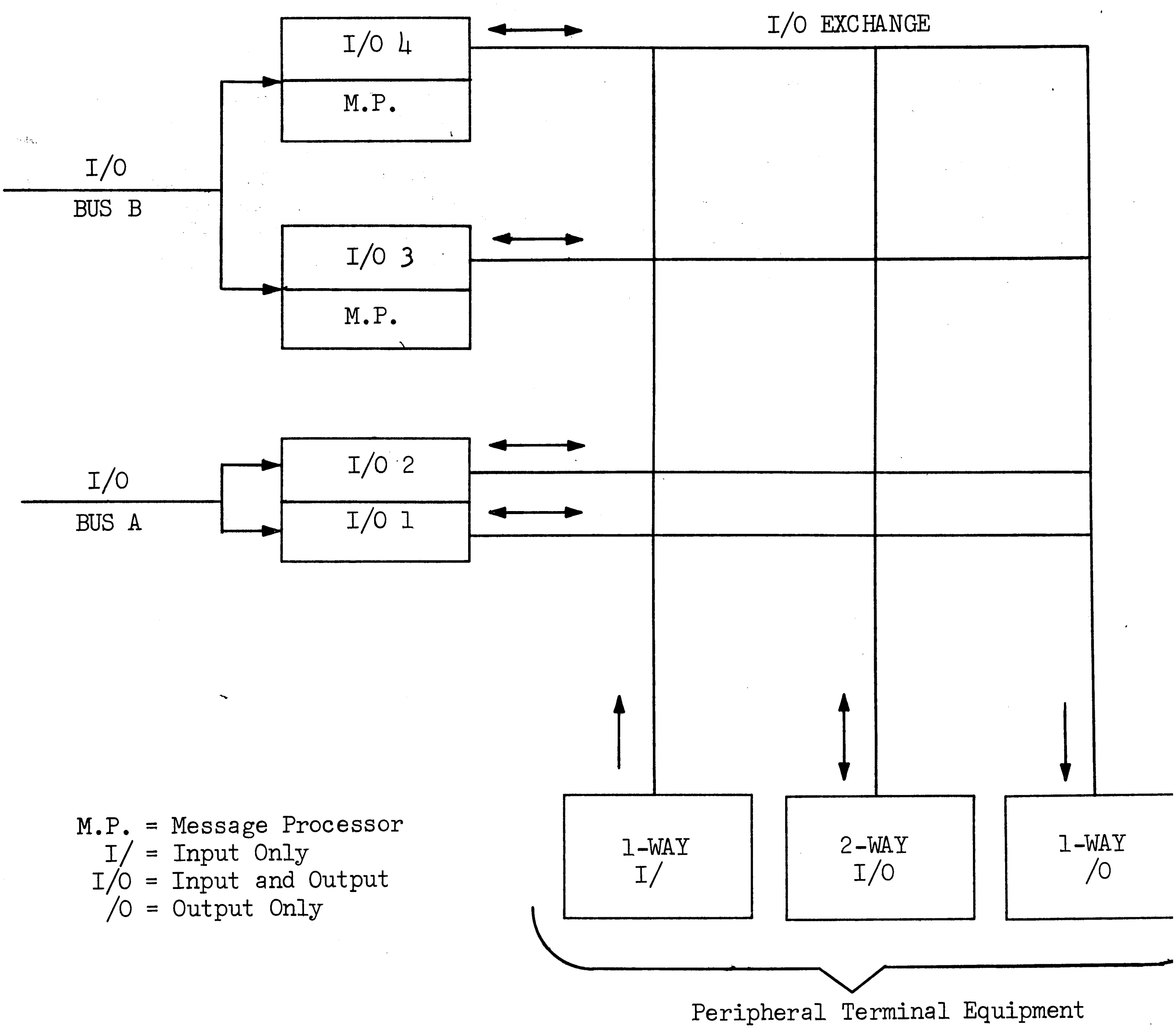


Figure 2, INPUT/OUTPUT EXCHANGE