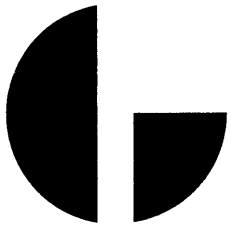

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APPLICATION NOTE

# User Device Driver Implementation in the Real Time Disk Operating System

User device drivers may be supported by the Real Time Disk Operating System (RDOS) in two ways: on a system level and on a user program level. Incorporating a user driver into the operating system provides the same level of support for the user device which the system accords to system devices. Implementing a user driver in a user program is simpler, yet requires more support by the user program.



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This revision of application note 017-000002-02, is a major revision. A vertical bar on the outside margin of each page indicates substantially new, changed or deleted information.

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# CHAPTER 1

# RDOS DRIVER IMPLEMENTATION

## INTRODUCTION

In all real time computer control systems, the CPU reacts to input data from a real world environment and provides output data to correct or control the environment. The incoming data is normally the result of a process device interrupt or an input-output operation completion interrupt. In general these interrupts differ from one another only in the way in which they are serviced.

When a significant event occurs, a signal is transmitted to the computer as an interrupt requiring a special subroutine to take appropriate action. Interrupts are usually assigned in order of urgency or priority, so that if two interrupts occur at the same moment, the more important interrupt is serviced first by the computer.

How well a computer is able to respond to interrupts generally determines the maximum capability of the real time system. A significant element in the responsive ability of any real time system is the inclusion of a powerful and flexible multi-priority interrupt control program.

This document outlines the methods of adding customer-assignable multi-priority servicing routines. These device drivers can be included as part of the resident RDOS operating system or they can be implemented as part of the user application program and attached to the interrupt dispatch program.

## CHARACTERISTICS OF INTERRUPTS

Interrupts can be generated by conditions internal to the computer hardware itself (power monitor option), or by events which originate in the plant or the environment that is being controlled (an external hardware interrupt like an analog-to-digital converter completion).

Non-process interrupts may be caused by an error condition being detected, an interval timer run-down, an input-output (I/O) complete interrupt, etc. The I/O interrupt is characterized by the completion of an I/O device operation such as a paper tape or disk storage transfer function, which may involve the reading or writing of one character or word in the case of program control or multiple words in the case of data channel operation. The concept of this type of interrupt is based on the importance of keeping I/O devices active, thus improving job throughput .

Process interrupts reflect process conditions which have been detected and which require an immediate change in program execution, such as may be caused by the closing of an electrical switch or contact, a rise in temperature above a prescribed limit, etc.

## INTERRUPT PRIORITY SCHEME

There are several ways in which priorities are determined for or assigned to devices on the I/O bus. An elementary priority is established by the hardware for devices that are requesting interrupts simultaneously: among those devices waiting with an active interrupt, the one which is physically closest to the processor on the bus is at the highest priority.

The most significant method is to specify which devices can interrupt a service routine currently in progress. This is done by using a 16 bit priority mask. Each device is wired to a particular bit of this mask word.

By means of the mask word, the interrupt servicing program can inhibit specified levels of interrupts and thus establish any priority structure. The biggest advantage of this means of priority level control is a near optimum priority response. To guarantee minimum response time to an interrupt, the mask bit assigned to this device should not be set for long periods of time. Through the judicious use of masking, data channels can be kept functioning for the transmission of data into and out of core storage while process interrupts are prevented from occurring. The function of masking is used to delay recognition of an interrupt (the important fact is that the interrupt is not lost).

The mask bit assignments for standard devices supplied by DGC are as follows:

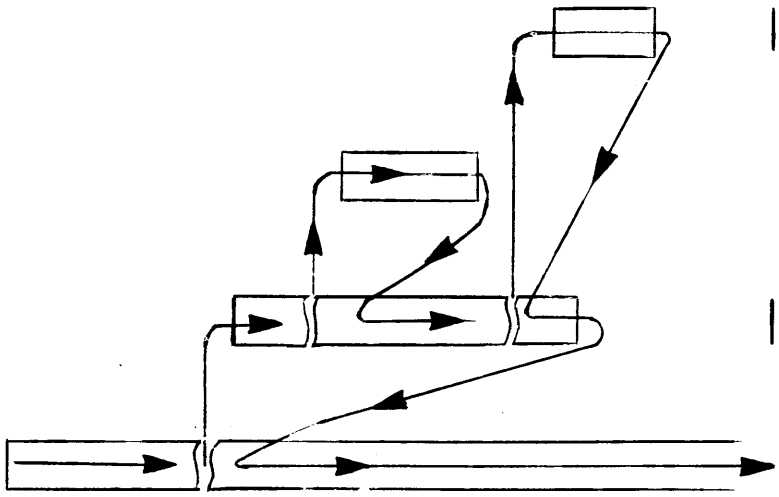
| Bit Positions | Assigned Devices |
|---|---|
| 15 | TTO |
| 14 | TTI, QTY (4060 quad multiplexor), SLA (4073/4074 Synchronous Line Adapter) |
| 13 | PTP, RTC, IBM 360/370 interface |
| 12 | PLT, LPT, MCAT (4038 multiprocessor communications adapter transmitter), MCAR (4038 multiprocessor communications adapter receiver) |
| 11 | PTR |
| 10 | CDR, CAS, MTA |
| 9 | DSK |
| 8 | ADCV, SCR (4015 synchronous communications controller receiver), SCT (4015 synchronous communications controller transmitter) |
| 7 | DKP, DIO (4066 digital interface) |
| 6 | XI (4067 external interrupt generator), PIT (Programmable Interval Timer 4068), IPB (Interprocessor Buffer) |
| 5 | unassigned |
| 4 | " |
| 3 | " |
| 2 | " |
| 1 | " |
| 0 | DCM (4026 asynchronous data communications multiplexor) |

## INTERRUPT PRIORITY SCHEME (Continued)

Although slower devices are assigned to higher numbered bits in the mask, there is no established priority, since the program can use any mask configuration. All devices which have their mask bits set cannot cause an interrupt and are therefore regarded by the program as being of lower priority.

An example of multi-level priority interrupt servicing is shown below for an environment including a Teletype, line printer, and fixed head disk.

| Program | Mask |
|---|---|
| Fixed Head Disk Interrupt | 717 |
| Line Printer Interrupt | 17 |
| Teletype Interrupt | 3 |
| Main Line User | 0 |



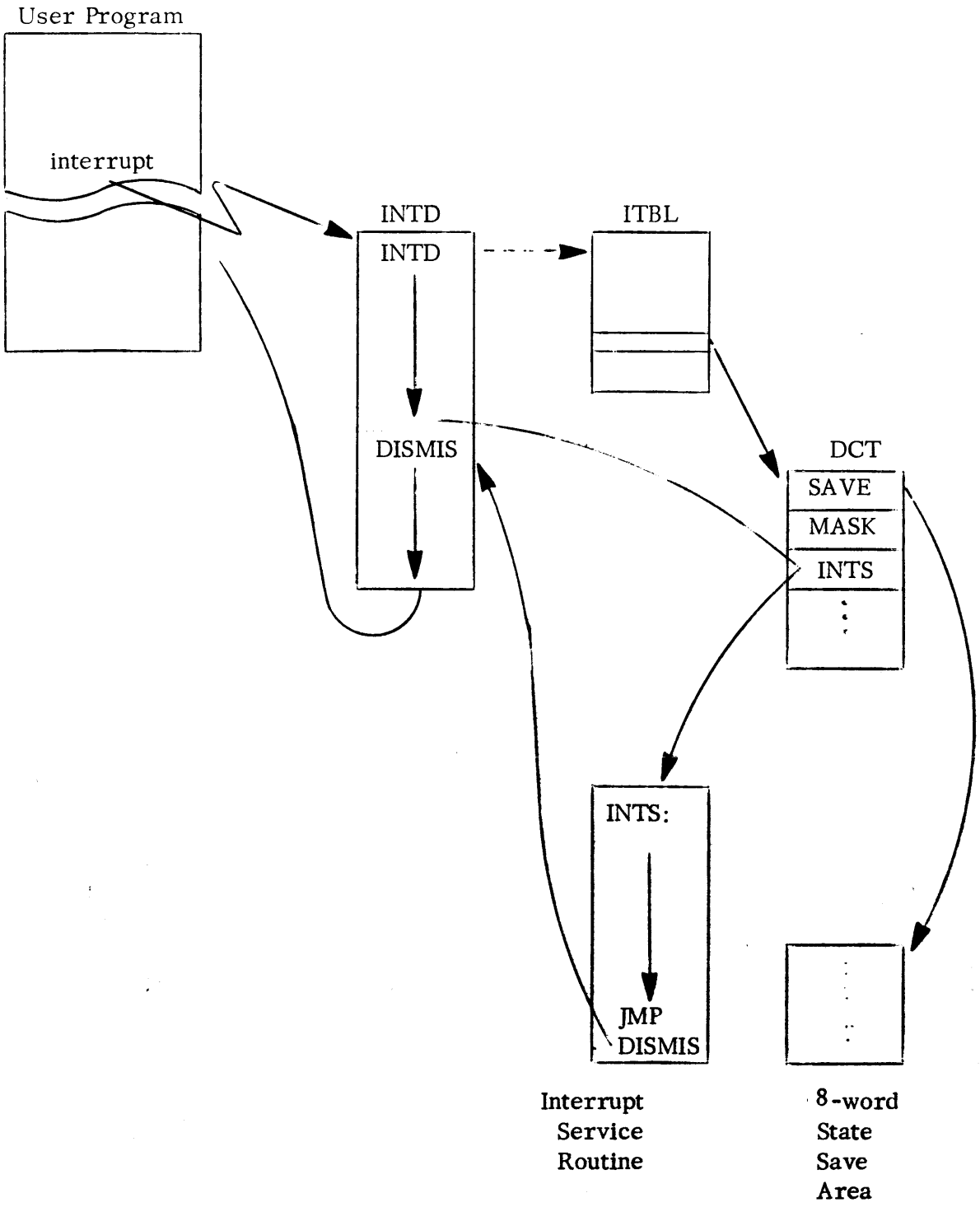
## INTERRUPT DISPATCH PROGRAM

At the precise moment an unmasked interrupt has been detected at the hardware level, the Interrupt Dispatch program (INTD) receives control to service the interrupt. The INTD program is assembled as an integral portion of the RDOS system and resides in core at all times.

The INTD program is designed to do the following:

- Identify the interrupting device
- Save the machine status and all addressable registers
- Set up the new priority mask
- Direct control to the proper servicing routine.
- Restore the previous priority mask
- Restore the machine status and registers
- Return to the interrupted program

The INTD program directs control to the correct servicing routine by using the correct entry in the system Interrupt Branch Table (ITBL). ITBL is a $66_{10}$ word table, with displacements 1-64 corresponding to device codes 1-64. Each displacement corresponding to a device in the system contains the address of that device's DCT. All other displacements contain -1.




Flow of Control During Interrupts

## DEVICE CONTROL TABLE (DCT) STRUCTURE

Each device defined in the RDOS system must have the address of its DCT included in the interrupt branch table (ITBL) as explained in later sections. For interrupt servicing routines defined in the user's area, only the first three entries are needed. Words 7-26 of the DCT differ for byte and block oriented devices.

Word 0, DCTSV: Address of an eight word interrupt state save area not used by RDOS but reserved for compatibility with RTOS.

Word 1, DCTMS: Mask Word. Clear a bit for every priority considered higher than the priority of this device. The devices corresponding to the priority bits that are left cleared will be permitted to interrupt the current device. Mask words which disable interrupts for all devices of equal or lesser priority than the named device follow:

| | |
|---|---|
| TTO | 3 |
| TTI, QTY, SLA | 3 |
| PTP, RTC, IBM | 7 |
| PLT, LPT, MCAT, MCAR | 17 |
| PTR | 1737 |
| CDR, MTA, CAS | 1777 |
| DSK | 717 |
| ADCV, SCR, SCT | 200 |
| DKP, DIO | 617 |
| XI, PIT | 1000 |

Word 2, DCTIS: Address of the device interrupt service routine.

Word 3, DCTCH: Device characteristic word. A list of device characteristics is given in the table on the page following.

DEVICE CONTROL TABLE (DCT) STRUCTURE (Continued)

| MNEMONIC | BIT | MEANING |
|---|---|---|
| DCCPO | 15 | Device requiring leader/trailer |
| DCCGN | 14 | Device requiring tab simulation |
| DCIDI | 13 | Device requiring operator intervention |
| DCCNF | 12 | Device requiring form feed simulation |
| DCTO | 11 | Teletype output device |
| DCKEY | 10 | Keyboard input device (uncontrollable) |
| DCNAF | 9 | Device requiring nulls after form feeds |
| DCRAT | 8 | Device requiring rubouts after tabs |
| DCPCK | 7 | Device requiring even parity check on input, even parity computation on output |
| DCLAC | 6 | Device requiring line feeds after carriage returns |
| DCSPO | 5 | Spoolable device (LPT, PTP, PLT, TTO) |
| DCFWD | 4 | Full word device (any size greater than a byte). |
| DCFFO | 3 | Form feed sent on .OPEN |
| DCLTU | 2 | Convert lower to upper case ASCII |
| DCC80 | 1 | Read 80 columns on input if set, 72 if reset. Send 80 characters on output, 72 if reset. |
| DCSPC | 0 | Spooling enabled if set to 1, disabled if reset |

Word 4, DCTCD: Device code.

Word 5, DCTEX: Address of variable I/O instruction routine.

Word 6, DCTDT: Address of the device command dispatch table; bit 0 set implies disk device. One entry for every RDOS I/O function. The table order must correspond exactly to the order of the function given below. Each entry is an address to the routine implementing the named RDOS function. If the device does not permit a command, a -1 should be entered in place of the address.

| MNEMONIC | DISPLACEMENT | MEANING |
|---|---|---|
| OF | 0 | Open a file for reading/writing by one or more users |
| CF | 1 | Close a file |
| RS | 2 | Read Sequential |
| RL | 3 | Read Line |
| RR | 4 | Read Random |
| WS | 5 | Write Sequential |
| WL | 6 | Write Line |
| WR | 7 | Write Random |

DEVICE CONTROL TABLE (DCT) STRUCTURE (Continued)

| MNEMONIC | DISPLACEMENT | MEANING |
|---|---|---|
| OA | 10 | Open a file for appending |
| RO | 11 | Open for reading only |
| EO | 12 | Exclusive read/write open |
| TO | 13 | Transparent (exclusive) open (does not alter file access info) |

Words 7-26, byte-oriented devices

Word 7, DCTST: Address of the device start routine. The device start routine specification is as follows:

| | |
|---|---|
| Input device: | Activate the device and return |
| Output device: | Character is passed in AC0 |

Word 10, DCTBC: Size of device buffer in bytes.

Word 11, DCTBP: Byte pointer to device buffer.

Word 12, DCTPC: Base level (program) byte count.

Word 13, DCTPP: Base level (program) byte pointer.

Word 14, DCTQL: Link to device request bead chain.

Word 15, DCTDP: Device data byte pointer.

Word 16, DCTDC: Device data count.

Word 17, DCTQS: Bead status word (described in GENERALIZED I/O ROUTINES).

Word 20, DCTBD: Bead address (i.e., the starting address of the first bead, word 14)

Word 21, DCTQP: Device queue starting address (initially -1).

Word 22, DCTT1: First temporary for device control.

Word 23, DCTT2: Second temporary for device control.

Word 24, DCTTO: Time out constant for input devices.

(Word 24, DCTCC: Output device column counter.)

Word 25, DCTLC: Output device line counter.

(Word 25, DCTPR: Echo device DCT pair pointer, TTI only.)

Word 26, DCTON: "ON" DCB address for spooler.*

(Word 26, DCTLK: Link to TTR, TTI DCTs only.)*

Word 27, DCTOF: "OFF" DCB address for spooler.*

Word 30, DCTSL: Link to next spoolable device DCT (-1 terminates the chain).

*set by RDOS.

Word 31, DCTOP: Device queue starting address for operator messages.

Word 32, DCTT3: Temporary for operator message status word whose bits are defined as follows:

| Bit | Meaning |
|---|---|
| 0 | Set to 1 if "!" has been received. |
| 15 | Set if "F" or "B" has been received. |

Words 7-26, block transfer devices

Word 7, DCTRD: Read a Block.

Word 10 (no label): Used by the system to reconstruct the original device name upon the release of an EQUIValenced name.

Word 11, DCSTR: Device start routine.

Word 12, DCDST: Set DST word (used for logical-to-physical disk block address computation).

Word 13, DCCRQ: Current request pointer.

Word 14, DCTSZ: Routine to perform disk sizing (not used by MTA/CAS).

Word 15, DCTRL: Read last block.

Word 16, DCTRN: Read next block.

Word 17, DCTIN: Device initialization routine.

Word 20, DCTRS: Device release routine.

Word 21, DCNBK: Number of blocks on device.

Word 22, DCTNS: Number of sectors per track.

Word 23, DCTNH: Number of heads per unit.

Word 24, DCTMN: Hash frame size (one of the following):

| Moving Head Disk Type | Frame Size (decimal) |
|---|---|
| 4047 | 97 |
| 4048 | 193 |
| 4057 | 773 |

| Aggregate Fixed Head Storage | Frame Size (decimal) |
|---|---|
| 128K | 7 |
| 256K | 13 |
| 384K | 23 |
| 512K | 31 |
| 640K | 41 |
| 768K | 47 |
| 896K | 53 |
| 1024K | 61 |
| 1152K | 71 |
| 1280K | 79 |
| 1480K | 89 |
| 1536K | 97 |
| 1664K | 103 |
| 1792K | 113 |
| 1920K | 113 |
| 2048K | 127 |

(For a description of hashing under RDOS, see the Stand Alone Disk Editor manual, 093-000092, appendix B.)

Word 25, DCHMP: First slot in data channel map (mapped systems only).

Word 26, DCHNM: Number of slots needed in data channel map (mapped systems only).

*****

# CHAPTER 2

# OPERATING SYSTEM DEVICE IMPLEMENTATION

## GENERAL

The list of I/O devices that are included as part of RDOS can be found in the RDOS User's Manual (093-000075). The user can, however, add device drivers to RDOS enabling the use of additional devices not furnished by DGC. All changes to RDOS to incorporate another device into the operating system should be made at the source program level. This section describes briefly the required changes to add a device. However, to completely understand the process of adding a device driver, the user may need to review listings of those RDOS programs mentioned later that require modification. The source programs required are available from DGC.

During full initiatization of the system, names of all single-file peripheral devices in the system are added to the system file directory, SYS.DR . The device name will be entered only if the user has forced the driver to be loaded. The general procedure for adding a device driver is as follows:

- declare a DCT entry for the device
- enable entry of the device name in SYS.DR
- update the system library
- create a system queue entry
- perform a system generation

Sections following describe each of these steps.

## REENTRANT CODING AND SUBROUTINE LINKAGE

One of the basic problems that arises in multi-level priority interrupt programming is that different levels require use of the same subroutine. This means that a higher priority interrupt could interrupt a lower priority one before it has completely used a common subroutine and argument pointers, temporary core storage locations, etc., with the result that the return point for the lower level interrupt would be lost. Reentrancy, then, is defined as that property of a subroutine whereby use of the routine does not modify any of its locations; temporary values are stored outside the routine. Thus one user may be prevented temporarily from completing use of a reentrant routine because a higher priority user needs to use it. When the higher priority user has finished with the routine, the lower priority user completes his use of the routine at the point where he was interrupted.

A method of reentrant coding using a system stack has been devised for RDOS to allow one subroutine to be entered at any time and from any interrupt level without loss of results. The operating system has several stacks used for the saving of state variables whenever a call to a system subroutine is executed. Each of these stacks is of a fixed length and stack frames are defined in the same manner for each stack. The stack frame is the basic increment of storage on a system stack.

Each system stack frame is 16 octal locations in length, and each of these locations has the following definitions:

| Displacement | Mnemonic | Contents |
|---|---|---|
| -1 | SP | Beginning of stack pointer (i.e., pointer to RTLOC) |
| 0 | RTLOC | Return location |
| 1 | AC0 | AC0 |
| 2 | AC1 | AC1 |
| 3 | AC2 | AC2 |
| 4 | TMP | General purpose subroutine storage |
| : | | " |
| 13 | MXTMP | Eighth and last storage location |
| 14 | VRTN | Overlay virtual address |

The system maintains a pointer for the current system stack in location 10, CSP. Linkage to save subroutine state variables on a system stack and restore these variables is provided by three routines contained in the RDOS utility package called GSUB. The save/restore routines are entitled SAV, SRTN, AND RTN. Calls to these routines are defined in the system parameters as being SAVE, SRTRN, and RTRN.

## GENERAL SUBROUTINE PACKAGE (GSUB, MGSUB)

GSUB (MGSUB) is a core resident module which contains a series of other utilities for the system's use; GSUB is used by RDOS, and MGSUB is used by mapped RDOS (MRDOS). Each of these utilities is self-contained, i.e., none of them calls out to other routines and none of them save variables outside a system stack frame (except the byte-handling and compare-word routines, as noted later). The following list gives the entry names and uses of each of the utilities in the GSUB or MGSUB module; starred modules ( *) are available only to mapped RDOS (MRDOS), and are found only in MGSUB. All other routines are available to both RDOS and MRDOS.

| NAME | USE |
|---|---|
| RTN | Restore state variables, return the frame to the system stack. |
| SAV | Save state variables on a system stack. |
| SRTN | Restore current state variables and do not return a frame to the system stack; return to the immediate caller (not to the address stored in RTLOC). |
| MVBYT | Move byte string. |
| LDCHR | Load an eight bit byte. |
| STCHR | Store an eight bit byte. |
| XOR | Perform an exclusive or. |

| NAME | USE |
|---|---|
| CLEAR | Set a block of core to all zeroes |
| MVWD | Move a word string |
| CMPWD | Compare two word strings |
| DIVD | Perform double precision integer divide |
| DIVI | Perform single precision integer divide |
| SETFL | Mask bits in a word to a one state |
| FIDCB | Initialize a DCB |
| DLCK** | Lock a directory process |
| DFLSH** | Flush a system buffer to disk, and erase if needed |
| DULK** | Unlock a directory process |
| MTMVB* | Move bytes with a mapped to address |
| MFMVB* | Move bytes with a mapped from address |
| MLDBT* | Mapped load byte (both byte pointers mapped) |
| MSTBT* | Mapped store byte (both byte pointers mapped) |
| MTMVW* | Move words with a mapped to address |
| MVMVW* | Move words with a mapped from address |
| MBMVW* | Move words with both addresses mapped |
| MCLR* | Clear a block of words with a mapped starting address |
| MBLK* | Convert user address to mapped address |

Except for RTN, SAV, and SRTN, each of these routines is called by means of an indirect call to a pointer within the calling routine containing the routine name, e.g., a call to XOR would be performed in the following manner:

```
        .EXTN   XOR
        JSR     @.XOR
        .
        .
        .
.XOR:   XOR
```

SAV, RTN, and SRTN are used frequently in the operating system routines, so their entry points have been stored in the RDOS page zero area at locations 3, 4, and 11 octal respectively. Calls to these routines are defined in the system parameters (PARS or MPARS) as follows:

```
SAVE  =  JSR @3
RTRN  =  JSR @4
SRTRN =  JSR @11
```

** dual CPU shared-disk systems only
* mapped systems only

Use of these mnemonics is sufficient to invoke the routine (except that SAVE must be preceded by one additional instruction as shown below).

The following summarizes the inputs required by each GSUB routine and describes the outputs obtained upon return from each call. Each description (except SAV, RTN, and SRTN) presumes the existence of a pointer containing the routine name as illustrated above.

Save State Variables

Calling Sequence: STA @ 3,CSP (CSP, the current stack pointer, is defined in PARS.SR)
SAVE

Output: AC0, AC1, and AC2 are saved on a stack frame and are returned unchanged to the caller. AC3 contains the address of a new stack frame.

Restore State Variables, Return a Frame

Calling Sequence: RTRN

Output: Accumulators AC0 through AC2 are restored; program control returns to the caller. A frame is returned to the system stack.

Calling Sequence: SRTRN

Output: Accumulators AC0 through AC2 are restored; program control returns to the immediate caller (i.e., not to the next higher level). The system stack pointer remains unchanged, since no frame is released.

Move a Byte String

Input: AC0, From byte pointer
AC1, To byte pointer
AC2, Byte count

Calling Sequence: JSR @ .MVBYT

Output: The specified byte string is copied to the destination string area. MVBYT cannot be called during interrupt servicing, since MVBYT is not reentrant.

Load/Store a Byte

Input: AC1, Byte pointer
AC0, Byte (right adjusted)

Calling Sequence: JSR @ .LDCHR (or .STCHR)

Output: The specified byte is loaded or stored. STCHR cannot be called during interrupt servicing, since it is not reentrant.

Exclusive Or

Input: AC1, First operand
AC0, Second operand

Calling Sequence: JSR @ .XOR

Output: The exclusive OR of the input operands is returned in AC1. Both AC0 and AC2 are restored to their input values.

Clear a Block of Core

Input: AC0, Number of sequential words to be cleared to zeroes
AC2, Starting (lowest) address of the block

Calling Sequence: JSR @ .CLEAR

Output: The specified block of core is cleared. AC0 through AC2 are restored upon exit.

Move a Word String

Input: AC0, Starting address of the string to be copied
AC1, Starting address to receive the string copy
AC2, Number of words to be copied

Calling Sequence: JSR @ .MVWD

Output: The specified word string is copied to the specified receiving core area. AC0 through AC2 are restored to their input values.

Compare Two Word Strings

Input: AC0, Starting address of the first string
AC1, Starting address of the second string
AC2, Number of Words to be compared

Calling Sequence: JSR @ .CMPWD
success return
failure return

Output: The word strings are compared. If equal, control returns to the success return; otherwise, control goes to the failure return. AC0 through AC2 are restored upon exit. CMPWD cannot be called during interrupt servicing, since CMPWD is not reentrant.

Single/Double Precision Integer Divide

Input: AC0, more significant dividend word for double precision divide only
AC1, less significant dividend word
AC2, integer divisor

Calling Sequence: JSR@ .DIVI (single precision) or
JSR@ .DIVD (double precision)

Output: Quotient is returned in AC1, remainder in AC0. AC2 is restored upon exit.

Set/Reset Bits in a Word

Input: AC0, operand word whose bits are to be set to 1 (or reset to 0).
AC1, bit mask

Calling Sequence: JSR@ .SETFL (.RSTFL)

Output: Operand has all its bit positions set which correspond to bit positions set in the mask word.

## Initialize a Device Control Block

Every 256-word disk block has a unique identifier which might be used to locate the block within core memory if it has already been read from disk. This identifier consists of three elements, the first three entries in the device control block portion of a UFT:

| | |
|---|---|
| DCBDC or UFTDC | DCT address (the core address of the DCT associated with the device containing the disk block) |
| DCBUN or UFTUN | Unit number (the number of the disk unit, i.e., DP3, DK1, etc.) |
| DCBA or UFTCA | Current Block Address (the logical address--as opposed to physical address--of the disk block) |

If the block has been read into core memory, and thus is resident within a system buffer, the above identifier triplet is sufficient to locate the block; if the block is not core resident, it can be read into a system buffer.

Whenever either a file is to be opened on a channel or a directory is to be initialized, a DCB for the file or directory must be initialized via a call to the GSUB/MGSUB routine FIDCB. (A DCB is a portion of a UFT which describes information listed below; the other portion of a DCB describes user information about the file such as file name, last access time, etc.)

DCB information for a file opened on a channel or for a directory is as follows:

| Directory Mnemonic | File Mnemonic | |
|---|---|---|
| DCBDC | UFTDC | Core address of the DCT address for the device containing the file or directory. |
| DCBUN | UFTUN | Specific unit number of the device (since there is only one DCT for each device controller). |
| DCBCA | UFTCA | Current block address (logical block address of that portion of the file which was most recently accessed). |
| DCBCB | UFTCB | Current block number ( i.e., relative block number of the block within the file). |
| DCBST | UFTST | Status of the file. The status is indicated by the following bits: |

| | |
|---|---|
| 1B15 | Error detected |
| 1B14 | I/O in progress |
| 1B13 | The first write of the file has been made |
| 1B12 | Directory is in use |
| 1B9 | Opened for MTA read/write block (.MTOPD) |
| 1B1 | File can be initialized (i.e., is a directory other than the master directory). |
| 1B0 | The file is being read |

Initialize a Device Control Block (Continued)

| | | |
|---|---|---|
| DCBUC | UFTEA | If a directory, this word indicates whether the Foreground or Background initialized the directory, and how many files within the directory are open. If this is a file's DCB, UFTEA is the logical address of the portion of the system directory which contains this file's entry. |
| DCBNA | UFTNA | The next logical block address of the file. |
| DCBLA | UFTLA | The last logical block address of the file. |
| DCBDR | UFTDR | The file's SYS.DR DCB address. This is needed so that the MAP.DR associated with this file can be accessed in the event the file changes size, and so that other elements in its UFD can be accessed (e.g., the file use count). |
| DCBFA | UFTFA | The first logical block address of the file or directory. This is the first logical block of the file if it is contiguously or sequentially organized, or the starting address of the index if it is randomly organized (all directories are randomly organized). |

The DCB had a four-word extension if it is for a file opened on a channel:

| | |
|---|---|
| UFTBN | The relative block number of that portion of the file currently being processed. |
| UFTBP | The byte pointer to the character position where processing in the file is to resume. |
| UFTCH | Data words per block ($376_8$ for sequential files, 377 for random and contiguous files). |
| UFTCN | Active system request count. This count indicates how many requests have been made to the system to access the file. |

The calling sequence for the routine used to initialize a DCB is as follows:

Input:
- AC0, First logical block address of the file or directory (the starting address of the index if randomly organized)
- AC1, The starting core address of the DCB describing the SYS.DR which contains the file or directory entry
- AC2, The starting core address of the DCB which is to be initialized.

Calling Sequence: JSR @ .FIDCB

Initialize a Device Control Block (Continued)

Output: DCBDC,DCBUN, and DCBDR of the system directory containing the file or directory entry are copied into the new DCB. The first logical block address (input via AC0) is copied into DCBNA and DCBFA of the new DCB. The current block number contained in DCBCB is set to -1 (indicating that no processing within the file or directory has taken place), and the last address, current address and user count (DCBLA, DCBCA, and DCBUC) are cleared to zero. Lastly, the status of the file or directory is cleared, setting bits 12, 11, 1 and 0 only if they were set in the system directory containing this file or directory entry.

Lock a Directory

In systems with two CPUs and shared disk space, a directory lock-out mechanism is required so that only one CPU at a time can access and modify the contents of a directory. Failure to lock out a directory would render it impossible to retain current directory information for either CPU's use. Thus, in a dual CPU shared-disk environment when one CPU desires to access a directory, it must first lock the directory. After accessing the directory, the CPU must re-write the directory to disk and erase its copy of the directory from core memory, and finally it must unlock the directory so that the directory can again be accessed by either CPU.

The format of this call is as follows:

Input: AC2 - DCB of directory to be locked.

Calling Sequence: JSR @ .DLCK

Output: The directory status word, DCBST, is set to indicate the directory is locked (bit 12 is set to 1).

Flush a System Buffer to Disk (and erase if a dual-CPU system)

This routine flushes a system buffer by writing its contents out to disk. In the case of a buffer containing a directory, the updated copy of the directory is written out to disk. In a dual CPU environment, the core resident buffer is erased so the contents of the buffer must be re-read to be re-used by the system.

The format of this call is as follows:

Input: AC2 - Starting address of the system buffer to be flushed.

Flush a System Buffer to Disk ( and erase if a dual-CPU system) (Continued)

Calling Sequence: JSR @ .DFLSH

Output: The modified contents of the system buffer are returned to the host device, and the buffer's identity is erased.

Unlock a Directory

Having locked and modified a directory and then flushed the system buffer containing the directory, the directory must be unlocked so that the other CPU can access the directory. The format of this call is:

Input: AC 2 - DCB of directory to be unlocked.

Calling Sequence: JSR @ .DULK

Output: The directory status word is set to the unlocked state.

Move a Byte String (mapped system only)

There are two move byte string routines for mapped systems; one routine accepts a mapped "to" address, while the other accepts a mapped "from" address. The result accomplished by both routines is identical: the specified byte string is copied to the destination area. Neither of these routines is reentrant.

The formats of the two routines are as follows:

1) Input: AC0, Mapped "from" byte pointer
AC1, "To" byte pointer
AC2, Byte count

Calling Sequence: JSR @ .MFMVB

2) Input: AC0, "From" byte pointer
AC1, Mapped "to" byte pointer
AC2, Byte count.

Calling Sequence: JSR @ .MTMVB

## Load and Store Bytes (mapped system only )

There are two load/store byte routines for mapped systems; each routine accepts mapped byte pointer inputs only. The result accomplished by both routines is identical: the byte is loaded or stored where the mapped byte pointer specifies that it should be accomplished. Neither of these routines is reentrant.

The formats of the two routines are as follows:

1) Input: AC1, Mapped byte pointer
AC2, Byte to be stored (right adjusted)

Calling Sequence: JSR @ .MSTBT

2) Input: AC1, Mapped byte pointer

Calling Sequence: JSR @ .MLDBT

Output: AC2, Byte (right adjusted)

## Move a Word String (mapped system only)

There are three move word string routines for mapped systems. One routine accepts a mapped "to" address, another routine accepts a mapped "from" address, while the third accepts both a mapped "to" address and a mapped "from" address. The result accomplished by all three routines is identical: the specified word string is copied to the specified receiving core area. AC0 through AC2 are restored to their input values.

The formats of the three routines are as follows:

1) Input: AC0, Mapped starting address of the string to be copied
AC1, Starting address to receive the string copy
AC2, Number of words to be copied

Calling Sequence: JSR @ .MVMVW

2) Input: AC0, Starting address of the string to be copied
AC1, Mapped starting address to receive the string copy
AC2, Number of words to be copied

Move a Word String (mapped system only) (Continued)

Calling Sequence: JSR @ .MTMVW

3) Input: AC0, Mapped starting address of the string to be copied
AC1, Mapped starting address to receive the string copy
AC2, Number of words to be copied

Calling Sequence: JSR @ .MBMVW

Clear a Block of Core (mapped system only)

Mapped systems may clear a block of core memory to zeroes by means of a routine which accepts a mapped starting address. The format of this call is as follows:

Input: AC0, Number of sequential (mapped) words to be cleared
AC2, Starting (lowest) mapped address of the block

Calling Sequence: JSR @ .MCLR

Output: The specified core area is set to zeroes. AC0 through AC2 are restored upon exit.

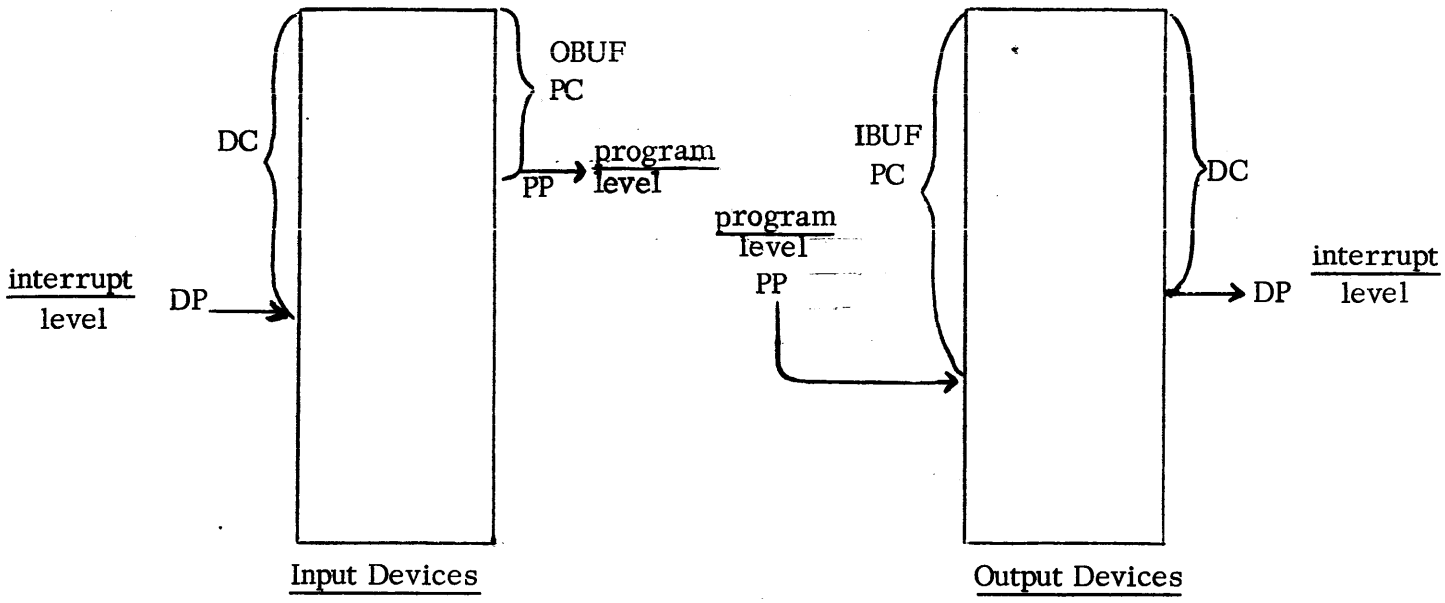
There also exist three sets of system I/O commands, modules entitled RING1, RING2, and RING3. Each of these modules is a system overlay, described in the following section.

## GENERALIZED I/O ROUTINES

The I/O modules (RING1, RING2, and RING3) provide a number of useful, general purpose reentrant routines for handling byte I/O from any device, on input or output, using the program interrupt facility. Entry names of the appropriate I/O routines are placed in each device driver dispatch table as required (see Device Control Table Structure, word 6). Each I/O module is a system overlay.

The basic buffer philosophy is to maintain one or more fixed length buffers, with pointers and counters maintained to indicate the amount of data in the buffers and the current word input or output. A virtually unlimited number of buffers can be appended to the first buffer, with a four-word bead assigned to maintain status information and pointers for each additional buffer.

An input device inputs to the buffer at interrupt time and outputs from the buffer at program base level. An output device inputs to the buffer at program base level and outputs from the buffer at interrupt time.




Pointers PP and DP indicate the current slot in the buffer used for character storage or retrieval by the program and device respectively. Counters PC and DC indicate the current number of characters stored or retrieved from the buffers by the program and device respectively. The inputting of data to the buffer by the program or device halts temporarily when the last buffer has been filled. When the program or device retrieves the last buffer character, characters may once again be input to the beginning of the buffer. In the case of multiple buffers, each buffer becomes free to receive input as soon as the last character in that buffer has been retrieved by the program or device.

When DC becomes equal to zero (after the last character in a buffer has been accepted by an output device), or when DC becomes non-zero (when a character is placed in a buffer by an input device), the task with pointer PP is readied.

A virtually unlimited number of buffers can be appended to the first buffer, providing the facility for unformatted stream I/O and substantially reducing system overhead. Moreover, these additional buffers may exist in user program space as well as in system address space. Additional I/O buffers are appended to the first buffer by linking or stringing additional beads to the first bead. Each bead has a link to the next bead in the string; the terminating bead has a -1 link.

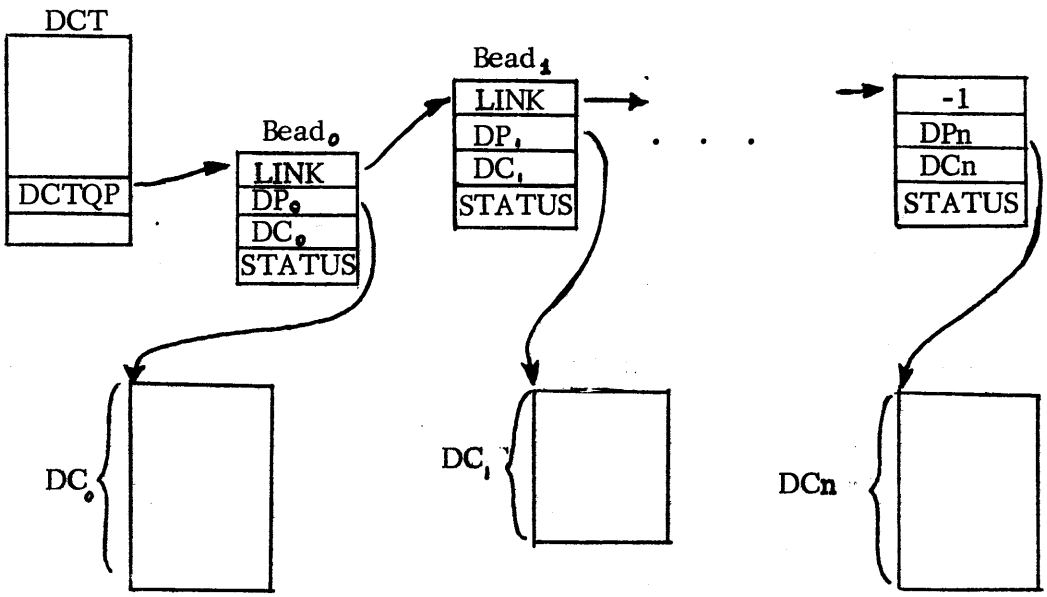
One device bead consists of words 14 through 17 of the device's DCT. The structure of each bead is as follows:

| | |
|---|---|
| Word 0 | Link word |
| Word 1 | Data Pointer (DP) |
| Word 2 | Data Count (DC) |
| Word 3 | Bead status/mode word |

Succeeding beads, used by system tasks like echoing, are linked to by previous bead links. The first bead in the string is pointed to by DCTQP of the device's DCT.

The status/mode bit definitions for word 3 of each bead are as follows:

| Bit | Meaning |
|---|---|
| 1B0 | Ready the task after each character |
| 1B1 | Ready the task upon request completion |
| 1B2 | I/O request made by the foreground |
| 1B3 | I/O request made by the background |
| 1B4 | Foreground operator message is outstanding |
| 1B5 | Background operator message is outstanding |
| 1B6 | Device opened |
| 1B14 | Echo the character (TTI only) |
| 1B15 | Request is completed (cleared by ENQUE routine) |



GENERALIZED I/O ROUTINES (Continued)

A brief description of the major routines and their calling sequences follows. More detailed information can be obtained by reviewing the listing of RING1, RING2, and RING3. I/O Buffer management funtions are also provided by the RING I/O modules; these functions are discussed in the following section entitled I/O BUFFER MANAGEMENT. It is important to note that although buffer input/output is in byte increments, devices transmitting larger data widths can use the same basic scheme. The card reader, for example, inputs its full word by calling for two consecutive byte inputs. Before discussing specific I/O routines, the following observations must be made about all I/O routines whose entries are used in device dispatch tables.

First, system I/O routines are usually not called in the conventional sense. Rather, the names of those routines which are required by a device driver are inserted into the appropriate displacements of that driver's dispatch table. If the routines provided by the I/O modules are inadequate, the user writing a device driver must write his own I/O routines (preferably making them core resident), and insert their names into his driver's dispatch table. User-written routines may either do some preprocessing of inputs to the .SYSTM call and then transfer control to one of the I/O routines, or the user-written routine may perform all the processing of inputs to the .SYSTM call. (Preprocessing of inputs to the system OPEN or CLOSE calls are not allowed.)

The following descriptions of routines in the I/O module also provide the parameters passed to these subroutines as input to the system. Users wishing to write their own resident I/O routines may usually pass whatever parameters they wish in AC0 and AC1. However, ordinarily the parameters passed in AC0 and AC1 are the same as were given in the user-issued .SYSTM call. The value passed in AC2 is always provided by the system.

Open (OPNO, OPNI)

OPNO is used to open output devices, while OPNI is used to open input devices. OPNI issues an operator intervention message (if required), while OPNO issues the message, provides a form feed, and outputs leader if required. Both routines clear a device and initialize its DCT. This implies that the DCT has provided all necessary I/O buffer information as well as the seven words of variable storage (words 12-16 and 22-23 of the DCT.)

Input:

AC2 - UFT address

Calling Sequences: 1) Insert OPNO (OPNI) mnemonic into device dispatch table at displacement 0, OF. (Input is provided by the system.)

Open (OPNO, OPNI) (Continued)

Calling Sequences: (Continued)

2)
```
.EXTN OPNO (OPNI), OVLAY
JSR @ .OVLY
OPNO (OPNI)
error return (never taken)
normal return
   :
.OVLY: OVLAY
```

Users may do no preprocessing of inputs to OPNO (OPNI). If a user wishes to provide a special open routine for a device, the system OPNO (OPNI) routine cannot also be called for that device.

Close (CLSO, CLSI)

CLSO should be used only to close output devices. It waits until all output has settled, clears the column counter, clears the device, initializes the DCT, and provides trailer if required. Alternatively, CLSI should be used only to close input devices. It merely clears the device and initializes the DCT.

Input: AC2 - UFT address

Calling Sequences:

1) Insert either mnemonic CLSO or CLSI into the device dispatch table at displacement 1 (CF). (Input is provided by system.)

2)
```
.EXTN CLSO (CLSI), OVLAY
JSR @ .OVLY
CLSO (CLSI)
error return (never taken)
normal return
   :
.OVLY OVLAY
```

Users may do no preprocessing of inputs to CLSO (CLSI). If a user wishes to provide a special close routine for a device, the system close CLSO (or CLSI) routine may not also be called for that device.

Read Sequential (RDS)

The device will be read, one byte at a time, until the byte count requested is satisfied. The data is not modified in any manner; this command is used for binary transfers.

Input:
AC2 - UFT address
AC1 - byte count for RDS
AC0 - destination byte pointer

Read Sequential (RDS) (Continued)

Calling Sequences: 1) Insert RDS mnemonic into device dispatch table at displacement 2 (RS). (Input is provided by system.)

2)
```
.EXTN  RDS, OVLAY
JSR  @  .OVLY
RDS
error return
normal return
      :
.OVLY:  OVLAY
```

The error return is taken if an end of file or device timeout occurs, at which time error code EREOF is returned in AC2 and the partial byte count is returned in AC1. If the normal return is taken, the full byte count read is returned in AC1.

Read Line (RDL)

This routine is used to transmit ASCII data and terminate after transmission of a carriage return, form feed, or null. All bytes transmitted are masked to seven bits. Line feeds and rubouts are unconditionally ignored.

Input:
AC2 - UFT address
AC0 - destination byte pointer

Calling Sequence: 1) Insert RDL mnemonic into device dispatch table at displacement 3 (RL). (Input is provided by system.)

2)
```
.EXTN  RDL, OVLAY
JSR@   .OVLY
RDL
error return
normal return
      :
.OVLY:  OVLAY
```

The read byte count is returned in AC1, whether the error or normal returns are taken. The error return is taken and a system error code returned in AC2 for the following conditions:

| AC2 | Mnemonic | Meaning |
|---|---|---|
| 6 | EREOF | End of file or device timeout. |
| 22 | ERLLI | Line length exceeded 132 characters without a valid terminator. |
| 24 | ERPAR | Parity error in the last character transmitted. |

Write Sequential (WRS)

Data is output in byte form to a device until the byte count has expired. The data is not altered in any manner. This mode is therefore the standard mode for binary output transfers.

Input:
AC2 - UFT address
AC1 - byte count for WRS
AC0 - source byte pointer

Calling Sequences: 1) Insert mnemonic WRS into the device dispatch table at displacement 5 (WS). (Input is provided by the system.)

2)
```
        .EXTN   WRS, OVLAY
        JSR@    .OVLY
        WRS
        error return
        normal return
        .
        .
        .
.OVLY:  OVLAY
```

The byte count written is returned in AC1. The error return is never taken.

Write a Line (WRL)

This routine transmits ASCII data to the appropriate device and terminates after transmitting either a carriage return or a form feed. Termination also occurs upon detection of a null, but the null is not written. Checks are made of the device characteristics to determine whether to perform:

1. Parity on output
2. Nulls after form feeds
3. Line feeds after carriage returns
4. Tab simulation (every 8 columns)
5. Rubouts after tabs

Input:
AC2 - UFT address
AC0 - source byte pointer

Calling Sequences: 1) Insert WRL mnemonic into device dispatch table at displacement 6, WL . (Input is provided by the system.)

2)
```
        .EXTN   WRL, OVLAY
        JSR@    .OVLY
        WRL
        error return
        normal return
        .
        .
        .
.OVLY:  OVLAY
```

Write Line (WRL) (Continued)

The write byte count is return in AC1 upon exit. The error return is taken after 132 bytes have been written without detection of a valid terminator, and AC2 contains the following error code:

| AC2 | Mnemonic | Meaning |
|---|---|---|
| 22 | ERLLI | Line limit exceeded. |

The RING I/O modules do not provide for random record reading or writing.

Get Master or Default Directory Name (GMDIR/GDIRS)

These routines pass the name of the master directory device (GMDIR) or the name of the current directory (GDIRS). The master directory device is the primary or secondary partition which becomes the current directory after a full system initialization or a bootstrap; this directory also contains the system overlays. Since several versions of the operating system may be available for bootstrapping, different devices may become the master device. If the name of the current directory is requested, only the current directory name, not the colon delimiter and not the names of superior directories, is returned. The format of these calls is:

Input: AC0 - Byte pointer to $13_8$ byte user area

Calling Sequences:

```
.EXTN  OVLAY, GMDIR, GDIRS
JSR  @  .OVLAY
GMDIR                    ; GET THE MASTER DIRECTORY NAME
error return             ; ATTEMPT TO OVERWRITE THE SYSTEM
normal return
    :
JSR  @  .OVLAY
GDIRS                    ; GET THE CURRENT DIRECTORY NAME
error return             ; ATTEMPT TO OVERWRITE THE SYSTEM
normal return
    :
.OVLAY: OVLAY
```

Two error codes may be returned:

| AC2 | Mnemonic | Meaning |
|---|---|---|
| 33 | ERRD | Attempt to overwirte system (unmapped only). |
| 74 | ERMPR | Address outside address space (mapped only). |

I/O BUFFER MODULE (IOBUF)

IOBUF is a core-resident module used by nearly all system drivers. One use of IOBUF is to execute certain types of I/O instructions; this permits the writing of reentrant drivers used by multiple devices (e.g., a multiple TTY system requiring only one TTY driver). Another use of IOBUF is to provide common input/output

character device interrupt processing. IOBUF also provides routines to place a bead at the end of a bead string and to remove any bead from the string. Finally, IOBUF provides routines which perform common input and output character device interrupt servicing.

The following list summarizes the entries in IOBUF:

| Entry | Use |
|---|---|
| CISER | Common input interrupt service. |
| COSER | Common output interrupt service. |
| DEQUE | Remove any bead from the string. |
| ENQUE | Add a bead at the end of the string. |
| FINP | Partial input interrupt service. |
| IBUF | Input a character to the I/O buffer. |
| OBUF | Output a character from the I/O buffer. |
| PENQU | Priority enqueue a bead. |
| STOUT | Initiate an output device, then provide interrupt service. |
| XDIAC | DIAC instruction processor. |
| XDOAS | DOAS instruction processor. |
| XNIOC | NIOC instruction processor. |
| XNIOS | NIOS instruction processor. |
| XSKPB | SKPBZ instruction processor. |
| XDIAP | DIAP instruction processor. |
| XIBUF | Priority enqueue a bead and input to buffer. |

Calls to any of the instruction processor entries (XDIAC, XDOAS, etc.) cause that instruction to be built (for the specific device in question), stored in the driver's "execute I/O instruction" area (pointed to by DCTEX of the device's DCT), and executed. Control is then returned to the caller. Calls to the instruction processors are issued solely by the system; specific call types depend upon the entries selected in the device dispatch table or in displacement DCTST of the Device Control Table.

## Common Input Device Interrupt Service (CISER)

CISER provides interrupt service for character input devices. CISER is called either by placing the mnemonic CISER in word 2 of the input device's DCT or by means of the following calling sequence:

Input: AC2 - DCT address

```
Calling Sequence:   .EXTN  CISER
                    JSR @  .CISE
                    return to DISMIS

                .CISE:  CISER
```

Common Input Device Interrupt Service (CISER) (Continued)

Output: If the instruction execution returns a character, this character is returned in the device buffer. The input contents of AC1 are lost; the input contents of AC2 are preserved.

Common Output Device Interrupt Service (COSER, STOUT)

COSER provides interrupt service for character output devices. STOUT initiates an output device, starts the device, then branches to COSER. Each routine can be called either by placing its mnemonic in word 2 (DCTIS) of the DCT or by means of the following calling sequence:

Input: AC2 - DCT address

Calling Sequence:
```
.EXTN COSER (STOUT)
JSR @ .COSE
return to DISMISS

.COSE: COSER (STOUT)
```

Output: If a character is available for output in the device buffer, it is output. AC2 is preserved upon exit.

Add a Bead to the String(ENQUE)

ENQUE attaches a bead and I/O buffer to the end of the string of beads and buffers. This new bead becomes the last bead in the string, and is given a LINK of -1. ENQUE is called by means of the following calling sequence:

Input: AC1 - Bead address
AC2 - DCT address

Calling Sequence:
```
.EXTN ENQUE
JSR @ .ENQU
return

.ENQ: ENQUE
```

Output: The bead and its associated buffer are attached to the end of the bead string. If the device is not busy, it is started. AC2 is unchanged upon exit.

Terminate Bead from Head of List (DEQRQ)

Like FINP, DEQRQ shares common code with CISER. DEQRQ's operations, however, are limited to the following: Sets "Request Done" in the bead status word, readies a system task if necessary, and determines if any other beads are enqueued

Terminate Bead from Head of List (DEQRQ) (Continued)

for the device. If other beads are enqueued, updates the bead pointer in DCTQP and restarts the device; otherwise clears the device.

Input: AC2 - DCT address

Calling Sequence:
```
.EXTN  DEQRQ
JSR @  .DEQRQ
normal return
```

```
.DEQRQ:DEQRQ
```

Remove a Bead from the String (DEQUE)

DEQUE removes a bead from the bead string by setting the bead status word to "inactive" and adjusting the adjoining bead links, and by clearing the device associated with this string if the device is no longer active. The DEQUE calling sequence is:

Input: AC1 - Address of the bead to be removed
AC2 - DCT address

Calling Sequence:
```
.EXTN  DEQUE
JSR @  .DEQU
return
```

```
.DEQU:  DEQUE
```

Output: The bead is inactivated and removed from the string. AC2 is unchanged upon exit.

Partial Input Interrupt Service (FINP)

FINP performs all functions accomplished by CISER without initially issuing a call to XDIAC followed by a restart of the device; FINP is thus an entry in CISER code which omits those two functions. FINP presumes that these functions have been performed elsewhere (as in the TTY and CDR drivers).

Input: AC2 - DCT address

Calling Sequence:
```
.EXTN  FINP
JSR @ FINP
normal return
```

```
.FINP:  FINP
```

## Input a Character to the I/O Buffer (IBUF)

IBUF places an eight-bit character in the currently available buffer slot. All bookkeeping in the DCT is maintained.

Input:
AC0 - character (left byte ignored)
AC2 - DCT address

Calling Sequence:
```
.EXTN IBUF
JSR @ .IBUF
return - buffer full
return - buffer not full

.IBUF: IBUF
```

## Priority Enqueue a Bead (PENQU)

PENQU places a bead and its buffer at the head of a bead string. If the device is not busy, it is started.

Input:
AC1 - Bead address
AC2 - DCT address

Calling Sequence:
```
.EXTN PENQU
JSR @.PENQU
normal return

.PENQU: PENQU
```

Output: The bead and its associated buffer are attached to the beginning of the bead string. If the device is not busy, it is started. AC2 is unchanged upon exit.

## Priority Enqueue a Bead and Input to an I/O Buffer (XIBUF)

XIBUF places a bead and its buffer at the head of a bead queue, and places an eight-bit character in the currently available buffer slot. All bookkeeping in the device's DCT is maintained.

Input:
AC0 - Character
AC2 - Base address of a dummy DCT. The only portion of this DCT which is used by the routine is the bead portion of the DCT: displacements DCTQL through DCTQS. It is this bead which is placed at the head of the device queue.

Priority Enqueue a Bead and Input to an I/O Buffer (XIBUF) (Continued)

```
Calling Sequence:   .EXTN XIBUF
                    JSR @.XIBUF
                    error return      ;BUFFER FULL
                    normal return
                       :
          .XIBUF:   XIBUF
```

Output a Character from the I/O Buffer (OBUF)

OBUF retrieves an eight-bit character from position PP of the input buffer if one is available. All bookkeeping in the DCT is maintained.

Input: AC2 - DCT address

```
Calling Sequence:   .EXTN OBUF
                    JSR @ .OBUF
                    return - buffer empty
                    return - buffer not empty
          .OBUF:    OBUF
```

Output: If the buffer was empty, a character is returned in AC0, bits 8-15.

I/O BUFFER MANAGEMENT

As mentioned earlier, there is an I/O buffer for each device in the system, whose size may be increased or decreased by the addition or removal or buffer beads. At program base level (as opposed to interrupt level), users wishing to fetch a character from a buffer issue either an RDL or RDS call which, in turn, calls another routine, RCHR. RCHR, RDL, and RDS are disk resident I/O routines in RING I/O. The purpose of RCHR is to perform a generalized character fetch using the Device Control Table address to read a character from the physical device. Having received a character from the buffer, RCHR passes this character to the calling read routine.

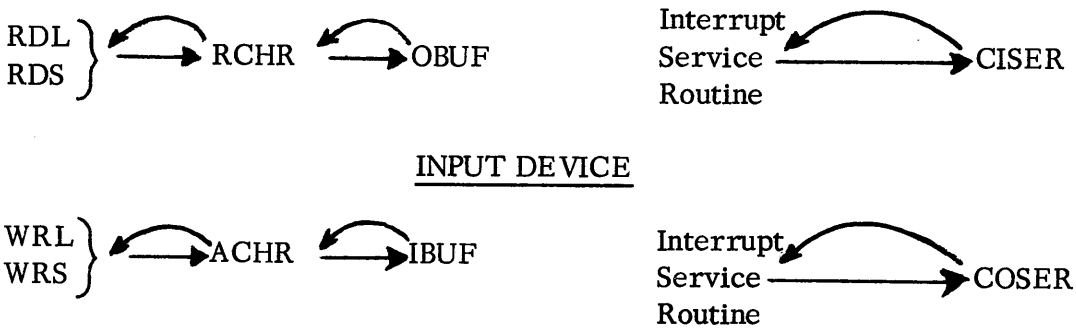
Each time RCHR is called, interrupts are disabled and OBUF is called. A character is fetched from the buffer, if one is available. (OBUF is a core resident routine in the IOBUF module, described earlier.) If a character is not available in the buffer, the caller is suspended for a period of time less than or equal to the device timeout constant, DCTTO. If a timeout occurs, RTRN is executed; otherwise a loop back to the beginning of the RCHR sequence is made.

At interrupt level, input devices input characters to a buffer by means of a call to CISER, also described above.

A similar sequence of subroutine calls occurs for output devices. At program base level, a call to WRL or WRS results in a call to ACHR which adds a character to the I/O buffer. ACHR is a disk resident I/O routine which calls IBUF to add a character to the buffer.

RCHR makes an attempt to place the character in the I/O buffer by means of a call to IBUF. IBUF, described earlier, performs functions complementary to those of OBUF. If the buffer was not full, then the character is added to the buffer and thence is output to the device (spooled, if possible). If the buffer was full, a spool for the data is started (if spooling is possible). Otherwise the system task is suspended for a period less than or equal to the device timeout constant.

At the output interrupt level, COSER is used to output a character to the device.




## Retrieve a Character from the I/O Buffer (RCHR)

Retrieve a character from the buffer by means of a call to OBUF.

Input: AC2 - DCT address

Calling Sequence:
```
        .EXTN  RCHR  OVLAY
        JSR  @ .OVLY
        RCHR
        timeout return
        normal return
.OVLY:  OVLAY
```

Output: AC0 - (if successful) character in bits 8-15.

## Add a Character to the I/O Buffer (ACHR)

Insert a character in the I/O buffer by means of a call to IBUF.

Input: AC2 - DCT address
AC0 - character to be inserted

Calling Sequence:
```
        .EXTN  ACHR, OVLAY
        JSR @  .OVLY
        ACHR
        normal return
.OVLY:  OVLAY
```

## Declaring the DCT Address

The last relocatable binary in system library RDOSC.LB is TABLE. TABLE contains the interrupt vector, named ITBL, discussed earlier. This vector is a linear array of DCT addresses which the system interrupt handler indexes by device code. The form of each ITBL entry is:

```
.dvdDCT:  dvdDCT    ;  OCTAL  DEVICE  CODE
```

where dvd represents the DGC device mnemonic for each device, and dvdDCT is the DCT address of each device. Each DCT address must be declared as a normal external. When adding an entry, the user can select any three-letter device mnemonic not used by a DGC device.

## Creating a Peripheral Device Entry in a Directory

All peripheral device entries are created (and deleted) as required on every initialization of a disk device. All information necessary to accomplish this is in the system overlay CRSFS (revision 02 of RDOS) or SFTAB (revision 03). The information has the same format in either overlay and is as follows:

| | |
|---|---|
| Word 1: | Byte pointer (overlay relative) to entry name, packed left to right. |
| Word 2: | File attributes of the required entry. |
| Word 3: | Logical device code. This is the same as the physical device code except in cases where two or more logical devices share the same device code, such as $TTI/$TTR. |

The latter part of the overlay contains the directory entry text strings. The text string for the paper tape reader, for example, is as follows:

```
        PTRP                    ;NAME POINTER
        ATPER+ATWP+ATCHA        ;ATTRIBUTES
        PTR                     ;LOGICAL DEVICE CODE


        .TXTM 1
PTRP:   .TXT    /$PTR/
```

## Updating the System Libraries

The RDOS 03 system libraries (RDOSA, RDOSB, RDOSC and the mapped versions) are arranged as shown in the following table. Differences between the RDOS 03 and 02 revision libraries are indicated after the table. For a listing of the modules in other libraries, perform an analyze via the library file editor (LFE). To add a driver, insert it into any of the libraries (A,B, or C) provided it is inserted after SYSTE and before TABLE (MSYST and MTABL in the mapped versions).

### RDOS (MRDOS) 03 SYSTEM LIBRARY LIST

| Relocatable Binary Title | Primary Function or Contents |
|---|---|
| INIT1, INIT2, INIT3 | Full and partial system initializations. |
| (MPWRF) | Mapped power fail handler. |
| (MAPZ) | Mapped system page zero. |
| SYSTE (MSYST) | .SYSTM call processor. |
| OVLAY (OVLAY) | System overlay handler. |
| FILIO (MFILI) | Disk file I/O. |
| BLKIO (BLKIO) | Block I/O management. |
| OPPRO (MOPPR) | Operator-Foreground/Background communications. |
| TTY1D (TTY1D) | Second Teletype driver. |
| TTYDR (MTTYD) | Teletype/video display driver. |
| DPMOD (DPMOD) | Dual processor module. |
| GSUB (MGSUB) | General purpose subroutines and linkage. |
| PLT1D (PLT1D) | Second plotter driver. |
| PLTDR (PLTDR) | Incremental plotter driver. |
| CDR1D (CDR1D) | Second card reader driver. |
| CDRDR (CDRDR) | Card reader driver. |
| PTP1D (PTP1D) | Second high speed punch driver. |
| PTPDR (PTPDR) | High speed punch driver. |
| PTR1D (PTR1D) | Second high speed reader driver. |
| PTRDR (PTRDR) | High speed reader driver. |
| LP132 (LP132) | 132 column line printer characteristics word for $LPT. |
| LP180 (LP180) | 80 column line printer characteristics word for $LPT. |
| LP232 (LP232) | 132 column line printer characteristics word for $LPT1. |
| LP280 (LP280) | 80 column line printer characteristics word for $LPT1. |
| LPT1D (LPT1D) | Second line printer driver. |

RDOS (MRDOS) 03 SYSTEM LIBRARY LIST (Continued)

| Relocatable Binary Title | | Primary Function or Contents |
|---|---|---|
| LPTDR | (LPTDR) | Line printer driver. |
| IOBUF | (IOBUF) | I/O buffer handlers. |
| M17DB | (M17DB) through M00DB (M00DB) | Magnetic tape device control blocks. |
| C17DB | (C17DB) through C00DB (C00DB) | Cassette device control blocks. |
| MTADR | (MMTAD) | Magnetic tape/cassette driver. |
| MTA1D | (MTA1D) | Second magnetic device control table. |
| MTADC | (MTADC) | Magnetic tape device control table. |
| CTA1D | (CTA1D) | Second cassette device control table. |
| CTADC | (CTADC) | Cassette device control table. |
| STK09 | (STK09) through STK00 (STK00) | System stacks nine through zero. |
| DKDCB | (DKDCB) | Fixed head disk DCB, first controller. |
| DK1DB | (DK1DB) | Fixed head disk DCB, second controller. |
| DSKDR | (MDSKD) | Fixed head disk driver. |
| DSKDC | (DSKDC) | First fixed head disk device control table. |
| DSK1D | (DSK1D) | Second fixed head disk device control table. |
| DP7DB | (DP7DB) through DP0DB (DP0DB) | Moving head disk DCBs for units 7 through 0. |
| DKPDR | (MDKPD) | Moving head disk driver. |
| DKPDC | (DKPDC) | First moving head disk device control table. |
| DKP1D | (DKP1D) | Second moving head disk device control table. |
| MCT1D | (MMCT1) | Second MCA device control table. |
| MCTDC | (MMCTD) | First MCA device control table. |
| MCADR | (MMCAD) | MCA driver. |
| QTYDR | (MQTYD) | Asynchronous multiplexor driver. |
| P31DB | (P31DB) through P00DB (P00DB) | Partition/subdirectory DCBs 31 through 0. |
| PWRFL | | Unmapped power fail handler. |
| INTD | (MINTD) | Interrupt determinator. |
| PANIC | (MPANI) | System PANIC handler. |
| TABLE | (MTABL) | Tables section. |

The major differences between the RDOS 03 and 02 libraries are as follows. First, RDOS 02 does not support the multiprocessor communications adapter; thus modules MCT1D (MMCT1) and MCTDC (MMCTD) are not found in the 02 libraries. Secondly, the system stack modules were entitled PSTK5 through PSTK1 in RDOS 02. Finally, full and partial initialization was performed by module INIT in RDOS 02. For more information about the contents of the RDOS 02 libraries, perform an analyze.

## Creating a System Queue Entry

A system queue must be created for the device within the device driver. The structure of this entry is as follows:

```
        .ENT    dvdQ
dvdQ:   .BLK 2          ;USED TO POINT TO DCT AND UFT
        100000          ;SYSTEM STACK IS REQUIRED
        dvdDCT          ;DCT ASSOCIATED WITH QUEUE
        .BLK  SGLN-.+dvdQ ;SYSTEM STORAGE AREA
```

The address of this queue entry must be defined in the system queue table (SQ) in the TABLE module.

An example of a system queue entry for the paper tape reader is as follows:

```
PTRQ:   .BLK 2
        100000
        PTRDCT
        .BLK  SQLN-.+PTRQ
```

## System Generation

Invoke the SYSGEN save file and answer all queries. Determine the additional space necessary to load the new, user driver plus any additional words added to the system. Before creating the new operating system save file, the value contained in the file named NREL should be adjusted down by the additional amount of space required by the new device driver.

To insure that the driver will get loaded from the library at system generation time, a small program should be written and loaded at this time ahead of the RDOSA.LB (MRDOSA.LB) library. The program could take the following form:

```
.EXTN   dvdDC
.END
```

and the relocatable binary called DUMMY.RB .

File SRLDR.CM (SRLDR1.CM, MSRLDR.CM, or MSRLDR1.CM) must be modified so that DUMMY appears as an entry after @NREL@.

Invoke SRLDR.CM (SRLDR1,CM, etc.) to build the new RDOS system

## PRACTICAL HINTS FOR SYSTEM DEVICE DRIVER IMPLEMENTATION

This section is devoted to a line-by-line examination of an actual RDOS driver, the high speed paper tape reader.

## Elements Required in User-Written I/O Routines

User device drivers may perform I/O in three ways:

1. By using system routines, placing the routine names in the user device dispatch table.
2. By appending some pre-processing instructions to an existing system routine.
3. By substituting system I/O routines with user written routines, and either placing these routines in-line or by placing the routine names in the dispatch table.

The first case, placing a system I/O routine name in the device dispatch table, is the easiest to implement.

In the second case, where the user wishes to do some pre-processing of input parameters,* then transfer control to a system routine, the following steps must be followed. The steps in this example illustrate the case where RDL is the system call which will have instructions appended to it by the user:

1. Perform a SAVE before calling RDL.
2. Ensure that RDL is passed its requisite parameters. These are the UFT addresses in AC2 and the destination byte pointer in AC0. Use the RDL calling sequence defined earlier.
3. Perform an RTRN upon return from the call to RDL.

In the last case, a user wishes to write an I/O routine which will be used instead of a system routine (perhaps placing this routine in his driver module). The following example sketches the essential elements of such a routine (leaving blank the I/O code sequence proper):

```
            .ENT    RDL1
RDL1:       STA@    3,CSP
            SAVE                    ;SAVE CALLER'S AC'S
            LDA     0,OAC0,3        ;FETCH INPUT AC0
             :
            MOV#    2,2,SNR         ;TEST FOR END OF FILE ERROR
            JMP     TIMEOUT
             :
            ISZ     ORTN,3          ;GO TO NORMAL RETURN
            RTRN
TIMEOUT:    LDA     2, ERROR        ;GET ERROR CODE
            STA     2,OAC2          ;RETURN ERROR CODE IN AC2
            RTRN
ERROR:      EREOF
```

* except upon opening or closing a device.

## Examination of a System Device Driver

This section is devoted to a line-by-line examination of an actual RDOS driver, the high-speed paper tape reader driver (PTRDR).

Following are the first 11 lines of the RDOS paper tape reader driver:

```
!0002 PTRDR
01
                        .TITLE  PTRDRV  ! PAPER TAPE READER DRIVER
03
04                      .NREL
05
06                      .ENT PTRDC,PTRQ,PTRDT,PRSAV,PTREX
07
08                      .EXTN RDS,OPNI,CLSI,RDL !COMMAND ENABLE
09                      .EXTN XNIOS     !EXECUTE I/O INSTRS
10                      .EXTN CISER     !INTERRUPT SERVICE
11
```

The entries PTRDC and PTRQ on line 6 define the PTR Device Control Table address and the system queue entry respectively. PTRDT, PRSAV and PTREX define the dispatch table address, start of the save state routine, and the execute - I/O instruction routine respectively. PTRDT, PRSAV and PTREX are entered so that they can be referenced by PTR1D, the second paper tape reader driver.

```
12                ; PAPER TAPE READER DEVICE CONTROL TABLE
 3
14 00000'000110'PTRDCT: PRSAV                    ; SAVE MACHINE STATE
15 00001'000577         MSPTR+MSTTI+MSTTO+MSPTP+MSLPT+MSCDR+MSDSK+MSDKP ; MASK
16 00002'177777         CISER           ;INT SERVICE
17 00003'000404         DCIDI+DCPCK                  ; CHARACTERISTICS
18 00004'000012         PTR             ;DEVICE CODE
19 00005'000065'        PTREX           ;EXECUTE IO INSTRUCTION
20 00006'000120'        PTRDT                ; DISPATCH TABLE ADDRESS
21 00007'177777         XNIOS                ; READER START ROUTINE ADDRESS
22 00010'000100         PTRSZ*2              ; BUFFER SIZE
23 00011'000052"        PTRBF*2              ; BUFFER FIRST BYTE ADDRESS
24 00012'000001         .BLK 1          ;PROGRAM BYTE COUNT
25 00013'000001         .BLK 1          ;PROGRAM BYTE POINTER
26 00014'000001         .BLK 1          ;DEVICE BEAD LINK
27 00015'000001         .BLK 1          ;DEVICE DATA BYTE POINTER
28 00016'000001         .BLK 1          ;DEVICE DATA COUNT
29 00017'040001         1B1+1B15        ;BEAD STATUS WORD- INIT TO REQUEST DONE
30 00020'000014'        .-4             ;BEAD ADDRESS
31 00021'177777         -1              ;REQUEST QUEUE POINTER
32 00022'000002         .BLK 2          ;DEVICE TEMPS
33 00024'000002         2               ;TIME OUT IN SECONDS
```

Locations 0 through 24 (lines 14-33) comprise the paper tape reader Device Control Table (DCT). PRSAV is the start of the state save area (this area is defined later on). Word 1 (line 15) defines the interrupt mask. The paper tape reader mask word, 577, prevents all devices with mask bit assignments 7 and 9 - 15 inclusive from interrupting the reader (thus preventing chatter). Word 2 specifies that reader interrupt service is performed by CISER, the common interrupt service routine found in the IOBUF module. Words 4 and 5 define the device characteristics and device code; DCIDI indicates that the reader requires operator intervention, while DCPCK indicates that the reader is a device requiring an even parity check on input.

PTREX, word 5, is a pointer to the reader I/O execute instruction area. This area will be seen later. PTRDT points to the reader dispatch table; this table will be seen on page 2 of the reader driver listing. XNIOS, line 21, is an entry in the IOBUF module and will be resolved by the loader. XNIOS starts the reader.

Words 10 and 11 (lines 22 and 23) define the size of the reader buffer in bytes (100) and a pointer to the first byte in this buffer. Words 12 and 13 (lines 24 and 25) are allocated for the program byte count (PC) and the program byte pointer (PP) respectively.

Words 14 through 17 (lines 26-29) allocate a bead frame for the reader buffer, and initialize the bead status word to "request done." Word 20 contains the address of the bead allocated by words 14-17, and word 21 contains the pointer to the currently active bead. This word is initialized to -1.

Words 22 and 23 (line 32) are allocated for the first and second temporaries for device control. The last word in the DCT, word 24, contains the reader timeout constant, 2 seconds.

Line 35 defines the size of the reader buffer in words, and line 37 allocates the buffer space.

Lines 39 through 41 define the I/O instruction execution area defined for the paper tape reader. Location PTREX receives the I/O instruction constructed by IOBUF, and after executing that instruction control is returned to the interrupt service routine by either the second or third instructions, lines 40 and 41 (depending upon whether that instruction causes a skip or not).

PTRQ (entered previously on line 6) defines the system queue entry for the paper tape reader.

```
34
35          000040 PTRSZ=  40                        ; BUFER SIZE
36
37  00025'000040 PTRBF:   .BLK     PTRSZ             ; RESERVE THE BUFFER SPACE
38
39  00065'000000 PTREX:   0
40  00066'001400          JMP 0,3
41  00067'001401          JMP 1,3
42
43
44  00070'000002 PTRQ:    .BLK 2
45  00072'100000          100000
46  00073'000000'         PTRDC
47  00074'000014          .BLK SQLN-.+PTRQ
48
```

Finally, on page 3 of the driver listing we find the machine save state area definition, PRSAV, and the paper tape reader dispatch table, PTRDT. This table provides entries to open and close the reader and to perform read line and read sequential operations:

```
!0003 PTRDR
01
02  00110'000010 PRSAV:   .BLK ISVLN                ;SAVE MACHINE STATE
03
04                  ; DEFINE THE PAPER TAPE READER DISPATCH TABLE
05
06  00120'177777 PTRDT:   OPNI                      ; PTR OPEN
07  00121'177777          CLSI                      ; PTR CLOSE
08  00122'177777          RDS                       ; PTR READ SEQUENTIAL
09  00123'177777          RDL                       ; PTR READ LINE
10  00124'177777          -1                        ; PTR READ RANDOM
11  00125'177777          -1                        ; PTR WRITE SEQ
12  00126'177777          -1                        ; PTR WRITE LINE
13  00127'177777          -1                        ; PTR WRITE RANDOM
14  00130'177777          -1                        ; PTR OPEN FOR APPENDING
15  00131'000120'         OPNI                      ; PTR READ ONLY OPEN
16  00132'000131'         OPNI                      ; PTR EXCLUSIVE OPEN
17  00133'177777          -1                        ; PTR TRANSPARENT OPEN
18                        .END
```

The read random record and all write commands are illegal for the paper tape reader. This is indicated by the placement of -1 in these positions of the dispatch table.

Following is the cross-referenced symbol listing for the paper tape reader driver:

```
0004 PTRDR

CISER 000002' XN      2/10    2/16
CLSI  000121' XN      2/08    3/07
OPNI  000132' XN      2/08    3/06    3/15    3/16
PRSAV 000110' EN      2/06    2/14    3/02
PTRBF 000025'         2/23    2/37
PTRDC 000000' EN      2/06    2/14    2/46
PTRDT 000120' EN      2/06    2/20    3/06
PTREX 000065' EN      2/06    2/19    2/39
PTRQ  000070' EN      2/06    2/44    2/47
PTRSZ 000040          2/22    2/35    2/37
RDL   000123' XN      2/08    3/09
RDS   000122' XN      2/08    3/08
XNIOS 000007' XN      2/09    2/21
```

# CHAPTER 3

# USER PROGRAM SERVICED INTERRUPTS

## SERVICING USER INTERRUPTS

Special user devices may be identified either at the time an RDOS system is loaded or at run time. This chapter describes the procedure for identifying a user device at run time and for creating a user clock driven by the system real time clock. The considerations given for identifying a user device are common to both single and multitask environments; the user clock facility may also be used in both task environments.

Upon detection of an interrupt request, the system will be dispatched through the device interrupt vector table, .ITBL (see Chapter 1). In this table are pointers to Device Control Tables (DCTs) for devices established at system initialization time, whether system or user devices. Chapter 1 describes the structure of system DCTs.

### User Device Driver Implementation at Run Time

In order to identify a user device to the system at run time, the user must provide a three-word DCT as an interface between the system interrupt dispatch routine and the user-interrupt servicing routine. The structure and mnemonic assignments of this three-word table are as follows:

| Displacement | Mnemonic | Purpose |
|---|---|---|
| 0 | DCTSV | Pointer to an 8-word state save area. |
| 1 | DCTMS | Interrupt service mask. |
| 2 | DCTIS | Interrupt service routine address. |

DCTSV is a pointer to an eight word state variable save area reserved by the system for compatibility with RTOS. DCTIS is a pointer to the routine which services this particular device interrupt. DCTMS is the interrupt mask* that the user wants to be ORed with the current interrupt mask while in the user interrupt service routine. This mask establishes which devices--if any--will be able to interrupt the currently interrupting device.

*See "How to Use the Nova Computers," Section 2.4.

User Device Driver Implementation at Run Time (Continued)

Upon transferring control to the user interrupt service routine, the system will ensure that AC3 contains the return address required for exit from the routine, and that AC2 contains the address of the DCT upon exit from the routine. In revision 02 of RDOS, for unmapped systems, exit is accomplished by a jump to the return address specified by AC3 upon entry. Rescheduling does not occur. For mapped systems under revision 02 of RDOS, return and rescheduling is accomplished by loading integer 3 into AC0, then by issuing instruction NIOC MAP. In revision 03 of RDOS, task call .UIEX is issued, and rescheduling may occur as an option.

All multitask environment activity ceases at the moment that a user device interrupt is detected. Nonetheless, it is possible for a user to communicate a message to a task from a service routine. If the task in question has been expecting such a message through issuance of a .REC and is now in the suspended state, issuance of the message via .IXMT will cause that task to be readied even though multitask activity is in abeyance. If no task has issued a .REC for such a message, .IXMT simply posts the message and takes no further action. For more information on communicating to tasks from a user interrupt service routine, see Chapter 5 of the RDOS User's Manual, 093-000075-04.

In addition to .IXMT, certain other task calls can be issued from a user interrupt routine or user power fail routine. A complete list of these task calls follows: .IXMT, .SMSK, .UIEX and .UPEX.

All user devices are removed from the system when either a program swap or chain occurs. Receipt of a user interrupt on a new program level (which has not identified the user device) will cause the system to clear the device's done and busy flags and then return to normal program execution.

Identify a User Interrupt Device (.IDEF)

In order to introduce to the system those devices (not identified at SYSGEN time) whose interrupts the system is to recognize, the system call .IDEF must be issued. This places an entry in the interrupt vector table. AC0 contains the device code of the new device. AC1 contains the address of the new device's DCT. In unmapped systems, this address must exceed $400_8$; in mapped systems, bit 0 of this address is set if the device is a data channel device. In mapped systems with a device using the data channel, AC2 contains the number of 1K core memory blocks which will be needed by the data channel map. This number will be one larger than the integer number of $1024_{10}$ word blocks used for data channel core buffers. The format of this command is:

```
.SYSTM
.IDEF
error return
normal return
```

Possible error messages are:

| AC2 | Mnemonic | Meaning |
|---|---|---|
| 36 | ERDNM | Illegal device code (> $77_8$). Device code $77_8$ is reserved for the power monitor/auto restart option. |
| 45 | ERIBS | Interrupt device code in use. |
| 65 | ERDCH | Insufficient room in data channel map. |
| 74 | ERMPR | Address outside address space (mapped systems only). |

## Exit from a User Interrupt Routine (.UIEX)

Upon a user device interrupt, AC3 will contain the return address upon entry to the user routine. In both revision 02 and 03 of RDOS, exit may be accomplished by either a jump to the return address specified by AC3 upon entry to the user routine, or by loading "3" into AC0 and then by issuing an NIOC MAP. In revision 03 of RDOS, however, task call .UIEX is issued.

In unmapped systems, before issuing task call .UIEX AC3 must be loaded with the return address that it contained upon entry to the user routine. In mapped systems, the contents of AC3 are ignored when .UIEX is issued. In both mapped and unmapped systems, rescheduling of both the task and program environment (if a foreground/background system) will occur upon exit only if AC1 contains some non-zero value.

The format of this call is:

AC1 - Zero only if rescheduling is to be suppressed.
AC3 - Return address upon entry to routine (unmapped systems only).

```
.UIEX
```

Control returns to the point outside the user routine which was interrupted by the user device. No errors are possible from this call. This call can be issued in a single task environment.

## Remove User Interrupt Servicing Program (.IRMV)

To prevent the system's recognition of user interrupts which have been previously identified by the .IDEF command, the .IRMV command is issued. Required input to this call is the user device code corresponding to the device which is to be removed.

The format of this call is:

AC0 - Device code.

```
.SYSTM
.IRMV
error return
normal return
```

Remove User Interrupt Servicing Program (.IRMV) (Continued)

One possible error message may be given.

| AC2 | Mnemonic | Meaning |
|---|---|---|
| 36 | ERDNM | Illegal device code ($>77_8$) or attempt to remove a system device (i.e., one established at SYSGEN time). |

Set the Data Channel Map (.STMAP)

User devices employing the data channel in mapped systems must issue a system call to set up the data channel map. (A separate map is maintained by the mapping hardware for data channel usage.) This call sets up the data channel map for the user device and returns in AC1 the logical address which should be sent to the device. Required inputs to this call are the user device code in AC0, and in AC1 the starting address of the device buffer in user address space.

The format of this call is:

```
.SYSTM
.STMAP
error return
normal return
```

This call is a no-op when issued in unmapped systems. In mapped systems, two possible error conditions may occur.

| AC2 | Mnemonic | Meaning |
|---|---|---|
| 36 | ERDNM | Device code not previously identified as a data channel device. |
| 74 | ERMPR | Address outside address space (mapped systems only). |

## Modifying the Current Interrupt Mask (.SMSK)

RDOS 03 and subsequent revisions contain a task call which permits the current interrupt mask to be modified. Whenever a user interrupt occurs, the interrupt mask is ORed with the mask contained in DCTMS of the user DCT to produce the current interrupt mask. Nonetheless, it is possible in the service routine to produce a current mask which ignores the contents of DCTMS, producing a new mask which is the logical OR of the old mask (upon entry to the service routine) and a new value. This is done by task call .SMSK, whose format is as follows:

```
AC0     -   New value to be ORed with old mask.

.SMSK
normal return
```

There is no error return possible from this call. This call may be issued in a single task environment.

## WRITING USER POWER FAIL SERVICE

RTOS provides software support for the power fail/automatic restart option. Upon detection of a power loss, the system transfers control to a power fail routine which saves the status of accumulators 0 through 3, the PC and Carry.

When power is restored, if the console key is in the LOCK position, the message

```
**POWER FAIL**
```

is output on the system console and the state variables are restored before control resumes operation at the point where it was interrupted. If the console key was in the ON position when input power failed, the user must set the console switches to all zeroes (down) and START must be pressed when power is restored. This causes the console message to be output and state variables to be restored as when the key is in the LOCK position.

The following system devices are given power-up restart service by RDOS:

paper tape readers/punches
Teletypes
quad multiplexors
card readers
line printers
disks

Character devices may lose one or more characters during power up. Each card reader may lose up to 80 columns of information on a single card. Line printers may lose up to a single line of information. Since power up service for disks includes a complete re-read or re-write of the current disk block, no disk information is lost, although moving head disk units will require 30 to 40 seconds before disk operations can continue. Devices requiring operator intervention (like line printer, card readers, etc.) must receive such action if power was lost for an extended period of time. No power up service is provided for magnetic tape or cassette units.

Power up service for special user devices (or for magnetic tape or cassette units) must be provided by the user via the system call .IDEF. The format of this call when used to identify user power up service is as follows:

| | | |
|---|---|---|
| AC0 | - | $77_8$ |
| AC1 | - | Starting address of user power up service routine. |

```
.SYSTM
.IDEF
error return
normal return
```

The error return is never taken.

Exit from a user power-up service routine for mapped systems under RDOS 02 forces rescheduling, and is accomplished by loading integer 4 into AC0, then by issuing the instruction NIOC MAP. Unmapped revision 02 systems must exit from user power-up service routines by jumping to the return address specified by AC3, and this also forces rescheduling to occur.

Exit from user power-up service routines under revision 03 of RDOS may be performed in the same manner as for revision 02. Alternatively, revision 03 provides a task call .UPEX, for performing this exit.

### Exit from a Power Fail Service Routine (.UPEX)

Upon entering a user power fail service routine, AC3 will contain the address required for exit from the routine. To return from the user power fail routine in an unmapped environment, AC3 must be loaded with this return address and task call .UPEX must be issued. In mapped systems, the value input in AC3 when this call is issued is ignored.

The format of this call is:

AC3 - Return address upon entry to the routine (unmapped systems only).

```
.UPEX
```

Control returns to the location which was interrupted by a power failure. No error return or normal return need be reserved. .UPEX can be issued in a single task environment. Note that this call can be issued only in revision 03 and higher revisions of RDOS.

## USER PROGRAMMED CLOCK

Two system commands, .DUCLK and .RUCLK, are available to permit the definition and removal of a user clock driven by the system's real time clock (RTC). This user clock generates interrupts at user-definable intervals. When one of these intervals expires, control goes to a user-specified routine outside the current single or multitask environment. No task calls (other than .IXMT) may be issued from this interrupt servicing routine.

### Define a User Clock (.DUCLK)

This command permits the definition of a user clock. When an interrupt is generated by this clock, the task scheduler and multitask environment--if any--are placed in suspension, and control goes to a user-specified routine. The format of this call is:

AC0 - Integer number of RTC cycles between each user interrupt.

AC1 - Address of user routine to receive control.

```
.SYSTM
.DUCLK
error return
normal return
```

Define a User Clock (.DUCLK) (Continued)

If the error return is taken, the following error code is issued:

| AC2 | Mnemonic | Meaning |
|---|---|---|
| 45 | ERIBS | A user clock already exists |

Upon a user clock interrupt, AC3 will contain the address of the return upon entry to the user routine. Exit from the user clock routine can be performed in all unmapped versions of RDOS by jumping to the return address specified by AC3 upon entry to the routine. If this means of exit is selected, rescheduling will not occur. In the mapped version of RDOS 02, AC0 must be loaded with "2" and instruction NIOC MAP must be executed. In rev. 03 and higher revisions of RDOS, task call .UCEX can be issued to provide a means of exiting from the clock routine; optional rescheduling of the task environment is permitted if this means of exit is selected.

Upon a user clock interrupt, AC3 will contain the address of the return upon entry to the routine specified in .DUCLK. To return from the user clock routine in an unmapped environment, AC3 must be loaded with the return address that it contained upon entry to the routine and task call .UCEX is issued. In mapped systems, the value input in AC3 when this call is issued is ignored. In both mapped and unmapped systems, rescheduling of both the task environment and the program environment (if a foreground/background system) will occur upon exit only if AC1 contains some non-zero value.

The format of this call is:

AC1 - Zero only if rescheduling is to be suppressed.
AC3 - Return address upon entry to routine (unmapped systems only).

```
.UCEX
```

Control returns to the point outside the user routine which was interrupted by the user clock. No errors are possible from this call. This call can be issued in a single task environment. Note that this call can be issued only in revision 03 and in higher revisions of RDOS.

Remove a User Clock (.RUCLK)

This system command removes a previously defined user clock from the system. The format of this call is:

Remove a User Clock (.RUCLK) (Continued)

```
.SYSTM
.RUCLK
error return
normal return
```

The error return must be reserved, but it is never taken.

## EXAMPLES OF USER SERVICED INTERRUPTS

This section illustrates two implementations of user-written interrupt servicing programs for devices not incorporated into the system at SYSGEN time.

### Analog to Digital Converter

The first of the two illustration programs is an analog to digital converter driver, found on page 3-12. This driver consists of four subroutines which can be called from a user program, the interrupt servicing subroutine, and a Device Control Table. The following is a line by line analysis of the A/D driver.

Lines 6 - 10 show that the title of the driver is AIDEV, that four entry points exist for user access of this driver, and that the driver program is normal relocatable (i.e., that it does not use any page zero locations). Line 15 gives the address of the Device Control Table which is defined in lines 17-19. This is an abbreviated DCT as discussed earlier.

The first location in the DCT (line 17) points to an 8-word state save area defined on line 30. The second entry in the table is the hardware mask that is set while the A/D interrupt is serviced. 1B8 indicates that all other devices can interrupt the A/D converter. The third and final entry in the DCT is the address of the interrupt servicing program, AINTS. AINTS is found on page 4 of the driver listing, and will be discussed later.

Lines 25 - 29 contain additional variables and constants which are required while servicing requests to this handler. These values are, in order, the device code of the A/D converter, a busy/done status flag, pointers to the address and data tables, and the number of points to be read for this call.

Page 2 of the driver listing illustrates two subroutines called by the user to attach (detach) the A/D converter interrupt servicing routine to (or from) the RDOS dispatch table, ITBL. The first routine, AIDEF, clears the ACTIV flag to indicate that there are no active requests in the handler for data. AIDEF then issues the system call .IDEF to define this handler and introduce it to RDOS. An error return

could result if the A/D converter device code ($21_8$) already was assigned to some other device. This would happen if a second call to AIDEF were issued without any intervening call to AICLR. AICLR removes the A/D routine from the RDOS dispatch table.

Page 3 of the driver listing contains two subroutines, the analog read random routine (AIRDR) and the read request routine (AICHK). The first of these routines, AIRDR, is called with AC2 containing the address of a control table. This table is described on page 1 of the listing (lines 34 - 50). This subroutine first checks whether the device is currently active on another request by testing the ACTIV flag defined earlier (page 1, line 26). If the handler is already active, an error return is made to the user. If the handler is not active, the ACTIV flag is set and the request is initiated. The address of the control table is saved in the active switch and the number of points to be read is moved into the handler from the table. Since this routine performs reads of analog inputs, two tables must be provided by the user. One table must contain the input point addresses to be read, and the other table (of equal or greater size) is used to store the analog input readings. The addresses of these two tables is given in the control table. Before returning control back to the caller, the address of the first point is fetched, sent to the converter, and the converter is started.

The fourth routine, AICHK, is used to check the status of a call made to the converter. There are two returns to the caller: busy and call completed.
Page 4 of the driver listing contains the interrupt service routine, AINTS. This routine is entered from the RDOS interrupt dispatch program with AC2 containing the address of the A/D converter DCT and AC3 containing the address of the RDOS interrupt dismissal program. AINTS reads the new converted value, saves it in the user-supplied data buffer, and then checks to see if there are additional points to be read. If there are, it initiates the next conversion. If this was the last point to be read, AINTS sets the status of the request to indicate that the call is completed and the handler is available for the next user request.

```
        LICENSED MATERIAL - PROPERTY OF DATA GENERAL CORPORATION
 0001  AIDEV MACRO REV 02                    01:10:26 12/08/73
01
02                ; ANALOG TO DIGITAL CONVERTER DEVICE DRIVER
03                ; ---------------------------------------
04                ; ---------------------------------------
05
                          .TITL AIDEV
07
08                        .ENT AIDEF,AICLR,AIRDR,AICHK
09
10                        .NREL
11
12                ; DEVICE CONTROL TABLE LAYOUT
13                ; --------------------------
14
15 00000'000001'ADDCT:   USDCT              ; ADDRESS OF ADCV DCT
16
17 00001'000011'USDCT:   AISAVE             ; INTERRUPT STATE SAVE AREA
18 00002'000200          188                ; MASK WORD
19 00003'000063'         AINTS              ; INTERRUPT ROUTINE ADDRESS
20
21                ; ADDITIONAL VARIABLES FOR ADCV HANDLER
22                ; -------------------------------------
23
24 00004'000021 DCODE:   ADCV               ; DEVICE CODE OF A/D CONVERTER
25 00005'000000 ACTIV:   0                  ; STATUS FLAG
26 00006'000000 DAPTR:   0                  ; DATA ADDRESS ARRAY POINTER
27 00007'000000 DVPTR:   0                  ; DATA VALUE ARRAY POINTER
28 00010'000000 DTCNT:   0                  ; DATA COUNT STORAGE
29
30 00011'000010 AISAVE:  .BLK 10            ; STATE SAVE AREA
31
32
33                ;  USER CONTROL TABLE LAYOUT
34                ; --------------------------
35
36                ;  WORD 0        STATUS FLAG
37                ;                  0 = CALL COMPLETED SUCCESSFULLY
38                ;                -VE = REQUEST BEING PROCESSED
39
40                ;  WORD 1        ADDRESS TABLE POINTER
41
42                ;  WORD 2        DATA STORAGE TABLE POINTER
43
44                ;  WORD 3        NUMBER OF POINTS TO BE READ
45
46        000000 .DUSR     STAT=0
47        000001 .DUSR    ATPTR=1
48        000002 .DUSR    VTPTR=2
49        000003 .DUSR      NPT=3
50
```

```
        LICENSED MATERIAL - PROPERTY OF DATA GENERAL CORPORATION
!0002 AIDEV
01
02                ; INITIALIZE THE A/D HANDLER
03                ; --------------------------
04
05                ; CALLING SEQUENCE:
06                ;       JSR AIDEF
07                ;       <ERROR RETURN>  ; DEVICE CODE IN USE ALREADY
08                ;       <NORMAL RETURN>
09
10 00021'054016 AIDEF:  STA 3 USP       ; SAVE RETURN ADDRESS
11 00022'102400         SUB 0 0         ; SET ROUTINE NOT BUSY
12 00023'040762         STA 0 ACTIV
13 00024'020760         LDA 0 DCODE     ; GET DEVICE CODE
14 00025'024753         LDA 1 ADDCT     ; GET DCT ADDRESS
15 00026'006017         .SYSTM          ; ATTACH TO RDOS INTERRUPT SYSTEM
16 00027'021007         .IDEF
17 00030'001400         JMP 0 3         ; ERROR RETURN
18 00031'001401         JMP 1 3         ; NORMAL RETURN
19
20
21                ; DETACH THE INTERRUPT SERVICING ROUTINE
22                ; --------------------------------------
23
24                ; CALLING SEQUENCE:
25                ;       JSR AICLR
26                ;       <NORMAL RETURN>
27
28
29 00032'054016 AICLR:  STA 3 USP       ; SAVE RETURN ADDRESS
30 00033'020751         LDA 0 DCODE
31 00034'006017         .SYSTM          ; DETACH FROM RDOS INTERRUPR SYSTEM
32 00035'021010         .IRMV
33 00036'001400         JMP 0 3
34 00037'001400         JMP 0 3         ; NORMAL RETURN
```

```
        LICENSED MATERIAL - PROPERTY OF DATA GENERAL CORPORATION
!0003 AIDEV
01
02
03                ; ANALOG READ RANDOM SUBROUTINE
04                ; -----------------------------
05
06                ; INPUT:
07                ;       AC2=CONTROL TABLE ADDRESS
08
09                ; CALLING SEUENCE:
10                ;       JSR AIRDR
11                ;       <ERROR RETURN>  ; HANDLER ALREADY ACTIVE
12                ;       <NORMAL RETURN>
13
14
15 00040!020745 AIRDR:  LDA 0 ACTIV      ; PICKUP STATUS FLAG
16 00041!101004         MOV 0 0 SZR      ; CHECK IT
17 00042!001400         JMP 0 3          ; ALREADY ACTIVE--ERROR RETURN
18 00043!050742         STA 2 ACTIV      ; SAVE CONTROL BLOCK ADDRESS
19 00044!021003         LDA 0 NPT 2      ; GET # POINTS TO BE READ
20 00045!040743         STA 0 DTCNT      ; SAVE AS DATA COUNT
21 00046!021001         LDA 0 ATPTR 2    ; GET STARTING ADDRESS OF POINT ADDRESSE
22 00047!040737         STA 0 DAPTR      ; SAVE POINT ADDRESS TABLE
23 00050!021002         LDA 0 VTPTR 2    ; GET VALUE STORAGE TABLE ADDRESS
24 00051!040736         STA 0 DVPTR      ; SAVE FOR STORING VALUES
25 00052!102000         ADC 0 0          ; SET REQUEST ACTIVE STATUS
26 00053!041000         STA 0 STAT 2
27 00054!022732         LDA 0 @DAPTR     ; GET FIRST POINT ADDRESS
28 00055!061121         DOAS 0 ADCV      ; START UP CONVERSION
29 00056!001401         JMP 1 3          ; TAKE NORMAL RETURN
30
31
32                ; ANALOG INPUT READ REQUEST CHECK SUBROUTINE
33                ; ------------------------------------------
34
35                ; INPUT:
36                ;       AC2=CONTROL TABLE ADDRESS
37
38                ; CALLING SEQUENCE:
39                ;       JSR AICHK
40                ;       <BUSY RETURN>
41                ;       <COMPLETED RETURN>
42
43
44 00057!021000 AICHK:  LDA 0 STAT 2     ; GET CALL STATUS
45 00060!101004         MOV 0 0 SZR
46 00061!001400         JMP 0 3          ; REQUEST BEING PROCESSED
47 00062!001401         JMP 1 3          ; CALL COMPLETED
```

```
        LICENSED MATERIAL - PROPERTY OF DATA GENERAL CORPORATION
!0004 AIDEV
01
02
03                ; ANALOG TO DIGITAL CONVERTER INTERRUPT ROUTINE
04                ; ---------------------------------------------
05
06                ; INPUT:
07                ;       AC2=DCT ADDRESS
08                ;       AC3=INTERRUPT DISMISSAL ROUTINE ADDRESS
09
10 00063'062621 AINTS:  DICC 0 ADCV       ; READ VALUE--CLEAR CONVERTER DONE FL
11 00064'042723          STA 0 @DVPTR     ; SAVE NEWLY READ DATA VALUE
12 00065'014723          DSZ DTCNT        ; DECREMENT DATA COUNTER
13 00066'000405          JMP AIMORE       ; MORE TO COME
14 00067'102400          SUB 0 0          ; REQUEST COMPLETE
15 00070'042715          STA 0 @ACTIV     ; SET USER DONE FLAG
16 00071'040714          STA 0 ACTIV      ; SET CONVERTER NON-BUSY
17 00072'001400          JMP 0 3          ; DISMISS THE INTERRUPT
18
19 00073'010713 AIMORE: ISZ DAPTR        ; INCREMENT ADDRESS POINTER
20 00074'010713          ISZ DVPTR        ;      "     DATA TABLE POINTER
21 00075'022711          LDA 0 @DAPTR     ; SETUP NEXT CONVERSION
22 00076'061121          DOAS 0 ADCV      ; START IT
23 00077'001400          JMP 0 3          ; DISMISS THE INTERRUPT
24
25                       .END
```

```
        LICENSED MATERIAL - PROPERTY OF DATA GENERAL CORPORATION
  0005 AIDEV

ACTIV 000005'        1/25    2/12    3/15    3/18    4/15    4/16
ADDCT 000000'        1/15    2/14
AICHK 000057' EN     1/08    3/44
AICLR 000032' EN     1/08    2/29
AIDEF 000021' EN     1/08    2/10
AIMOR 000073'        4/13    4/19
AINTS 000063'        1/19    4/10
AIRDR 000040' EN     1/08    3/15
AISAV 000011'        1/17    1/30
DAPTR 000006'        1/26    3/22    3/27    4/19    4/21
DCODE 000004'        1/24    2/13    2/30
DTCNT 000010'        1/28    3/20    4/12
DVPTR 000007'        1/27    3/24    4/11    4/20
USDCT 000001'        1/15    1/17
```

## External Interrupt Recognition

This driver program illustrates an interrupt servicing routine which readies a user task as a result of an external interrupt. This program illustrates a type 4066 digital interface device driver.

Page 1 of the listing is almost identical in form to the first page of the A/D driver listing discussed earlier. The only difference is in the variables and storage required by the digital interface. Here, the user must supply the address of a communications core location. When a call is made to attach the interrupt routine. address to the RDOS dispatch table (page 2 of the listing), AC0 must contain the communications core address. After attaching the interrupt to the RDOS dispatch vector table, the initialization routine arms the digital interface so that is can cause an interrupt.

When the external interrupt occurs, control is dispatched to the digital interface servicing routine, starting on line 38 of page 2. After the service routine gains control, it reads a sixteen bit digital register provided by the interface. If the register's contents are non-zero, the contents are transmitted to a user task using the task call .IXMT; after this, the interrupt is dismissed. If the register's contents is zero, the interrupt is simply dismissed. Upon dismissal of the interrupt, the system re-arms the digital interface interrupts.

A practical example of the use of such a scheme would be the servicing of an operator's console. Such a console would generate an external interrupt indicating that the operator desires some form of action by the computer; the sixteen bit register contents (selected by the console operator) would indicate exactly the type of action desired.

```
        LICENSED MATERIAL - PROPERTY OF DATA GENERAL CORPORATION
 0001 DIDEV MACRO REV 02                    01:11:02 12/08/73
01
02
03                ; DIGITAL INTERFACE (TYPE 4066) DEVICE DRIVER
04                ; ------------------------------------------
05                ; ------------------------------------------
06
                          .TITL DIDEV
08
09                        .ENT DIDEF,DICLR
10
11                        .EXTN .IXMT
12
13                        .NREL
14
15        000042 .DUSR    DIO=42              ; DEVICE CODE DEFINITION
16
17                ; DEVICE CONTROL TABLE LAYOUT
18                ; ---------------------------
19
20 00000'000001'DIDCT:  USDCT                 ; ADDRESS OF DIO DCT
21
22 00001'000004'USDCT:  DISAVE                ; INTERRUPT STATE SAVE AREA
23 00002'000400         1B7                   ; INTERRUPT MASK
24 00003'000036'        DINTS                 ; INTERRUPT ROUTINE ADDRESS
25
26                ; ADDITIONAL VARIABLES AND STORAGE USED BY HANDLER
27                ; ------------------------------------------------
28
29 00004'000010 DISAVE: .BLK 10               ; STATE SAVE AREA
30 00014'000042 DCODE:  DIO                   ; DEVICE CODE
31 00015'000000 DICOM:  0                     ; COMMUNICATIONS ADDRESS
```

```
        LICENSED MATERIAL - PROPERTY OF DATA GENERAL CORPORATION
!0002 DIDEV
01
02                ; INITIALIZE THE DIGITAL INTERFACE
03                ; --------------------------------
04
05                ; INPUT: AC0=MESSAGE ADDRESS
06
07                ; CALLING SEQUENCE:
08                ;       JSR DIDEF
09                ;       <ERROR RETURN>  ; DEVICE CODE (DIO) ALREADY IN USE
10                ;       <NORMAL RETURN>
11
12 00016'054016 DIDEF:  STA 3 USP
13 00017'040776         STA 0 DICOM     ; SAVE COMMUNICATIONS ADDRESS
14 00020'020774         LDA 0 DCODE
15 00021'024757         LDA 1 DIDCT
16 00022'006017         .SYSTM          ; ATTACH TO RDOS INTERRUPT SYSTEM
17 00023'021007         .IDEF
18 00024'001400         JMP 0 3         ; ERROR RETURN
19 00025'060142         NIOS DIO        ; ARM THE EXTERNAL INTERRUPT
20 00026'001401         JMP 1 3         ; NORMAL RETURN
21
22                ; DETACH THE INTERRUPT SERVICING ROUTINE & CLEAR DEVICE
23                ; ----------------------------------------------------
24
25                ; CALLING SEQUENCE:
26                ;       JSR DICLR
27                ;       <NORMAL RETURN>
28
29 00027'054016 DICLR:  STA 3 USP
30 00030'060242         NIOC DIO        ; CLEAR DIO DEVICE
31 00031'020763         LDA 0 DCODE
32 00032'006017         .SYSTM          ; DETACH HANDLER
33 00033'021010         .IRMV
34 00034'001400         JMP 0 3         ; NORMAL RETURN
35 00035'001400         JMP 0 3         ;    "      "
36
37
```

```
        LICENSED MATERIAL - PROPERTY OF DATA GENERAL CORPORATION

38                      ; DIGITAL INTERFACE EXTERNAL INTERRUPT HANDLER
39                      ; ------------------------------------------
40
41                      ; INPUT: AC2=DCT ADDRESS
42                      ;         AC3=INTERRUPT DISMISSAL ADDRESS
43
44 00036'064542 DINTS:  DIAS 1 DIO      ; READ 16 BIT REGISTER
45 00037'125005         MOV 1 1 SNR     ; VALUE ZERO ?
46 00040'001400         JMP 0 3         ; YES--DISMISS INTERRUPT
47
48 00041'054412         STA 3 DISMISS   ; NO--SAVE DISMISSAL ROUTINE ADDRESS
49 00042'050410         STA 2 SAVE2     ; SAVE AC2 ALSO
50 00043'102400         SUB 0 0         ; CLEAR SIGNAL ADDRESS
51 00044'042751         STA 0 @DICOM
52 00045'020750         LDA 0 DICOM     ; GET SIGNAL ADDRESS
53 00046'177777         .IXMT           ; WAKE UP USER TASK
54 00047'000401         JMP .+1
55 00050'030402         LDA 2 SAVE2     ; RESTORE AC2
56 00051'002402         JMP @DISMISS    ; DISMISS THE INTERRUPT
57
58 00052'000000 SAVE2:  0               ; TEMPORARY STORAGE FOR AC2
59 00053'000000 DISMISS: 0              ; INTERRUPT DISMISSAL ADDRESS

                        .END
```

```
        LICENSED MATERIAL - PROPERTY OF DATA GENERAL CORPORATION
0003 DIDEV

DCODE 000014'          1/30    2/14    2/31
DICLR 000027' EN       1/09    2/29
DICOM 000015'          1/31    2/13    2/51    2/52
DIDCT 000000'          1/20    2/15
DIDEF 000016' EN       1/09    2/12
DINTS 000036'          1/24    2/44
DISAV 000004'          1/22    1/29
DISMI 000053'          2/48    2/56    2/59
SAVE2 000052'          2/49    2/55    2/58
USDCT 000001'          1/20    1/22
.IXMT 000046' XN       1/11    2/53
```

## Multiprocessor Communications Adapter

RDOS 03 extends system support to option 4038, the multiprocessor communications adapter (MCA). Nonetheless, the MCA can be treated as a user defined device. The following program illustrates such an MCA driver and illustrates the .STMAP call which is required when running data channel devices in the user area on a mapped system.

Page 1 of the listing illustrates the MCA receiver and transmitter DCT's, RUSDCT and TUSDCT. These DCT's are standard user DCT's; note that bit zero is set to one. This is required when the devices are identified to the system in subroutine MIDEF, since they are data channel devices used in a mapped system.

The MCA handler must be initialized before use, and this is done by a user call to MIDEF illustrated on page 5 of the listing. This routine identifies both the transmitter and receiver to the system and defines the number of $1024_{10}$ word blocks which will be required for data channel transfers (two blocks each for transmissions and receptions). Additionally, this routine converts the logical buffer addresses, input to the initialization call, to physical addresses required for data channel transfers in mapped machines (lines 34-43). That is, whenever a user program sets aside a series of logical locations as a data channel buffer, .STMAP returns the actual address assignments made by the mapping unit. All addresses in mapped user programs are logical, since the user program is unaware of the actual locations assigned by the hardware; the actual address assignements, however, must be sent to data channel devices. Beyond sending these addresses to the data channel devices, the user program need not be concerned with the actual address assignments.

Since MIDEF identifies the MCA units to the system only once, MIDEF can be invoked by the user whenever different read/write buffers are to be used.

The read and write subroutines proper are found on listing pages 2 and 3. Each of these routines first checks to see if the device is busy; if so, the error return is taken. Otherwise, each routine outputs the word count and logical starting address to its device, and the transmit routine also outputs the receiver number to the transmitter. Then each routine waits, via a call to .REC, until its associated interrupt processor (page 4 of the listing) readies it via an interrupt message call, .IXMT, indicating that the process is complete. The read/write routine then resets its busy flag and takes the call's normal return.

```
        LICENSED MATERIAL - PROPERTY OF DATA GENERAL CORPORATION
 0001 MCADR MACRO REV 02                    13:12:24 12/18/73
01
02
03
04                ; MULTIPROCESSOR COMMUNICATIONS ADAPTER (TYPE 4038)
05                ; ---------------------------------------------
06                ; ---------------------------------------------
07
                          .TITLE MCADR     ; MCA DRIVER
09
10                        .ENT MCARD MCAWT MIDEF
11
12                        .EXTN .IXMT,.REC
13
14                        .NREL
15
16                ; DEVICE CONTROL TABLE LAYOUT
17                ; ---------------------------
18
19 00000'100002'MRDCT:   1B0+RUSDCT              ; ADDRESS OF MCA RECEIVER DCT
20 00001'100005'MTDCT:   1B0+TUSDCT              ; ADDRESS OF MCA TRANSMITTER D
21
22 00002'000012'RUSDCT: MSAVE             ; INTERRUPT STATE SAVE AREA
23 00003'000010          1B12             ; MASK WORD
24 00004'000101'         RINTS            ; INTERRUPT ROUTINE ADDRESS
25
26 00005'000012'TUSDCT: MSAVE             ; INTERRUPT STATE SAVE AREA
27 00006'000010          1B12             ; MASK WORD
28 00007'000106'         TINTS            ; INTERRUPT ROUTINE ADDRESS
29
30                ; ADDITIONAL VARIABLES FOR MCA DRIVER
31                ; -----------------------------------
32
33 00010'000007 RCODE:   MCAR             ; RECEIVER DEVICE CODE
34 00011'000006 TCODE:   MCAT             ; TRANSMITTER DEVICE CODE
35 00012'000010 MSAVE:   .BLK 10          ; STATE SAVE AREA
```

```
        LICENSED MATERIAL - PROPERTY OF DATA GENERAL CORPORATION
!0002 MCAUR
01
02                ; MCA READ SUBROUTINE
03                ; --------------------
04
05                ; INPUT:-
06                ;       AC0=WORD COUNT
07
08                ; CALLING SEQUENCE:-
09                ;       JSR MCARD
10                ;       <ERROR RETURN>  ; HANDLER ALREADY ACTIVE
11                ;       <NORMAL RETURN>
12
13                ; OUTPUT:-
14                ;       AC1=MCA STATUS WORD
15
16 000022'030420 MCARD:  LDA 2 RBUSY      ; PICKUP STATUS FLAG
17 000023'151004         MOV 2 2 SZR      ; CHECK IT
18 000024'000422         JMP RERTN        ; DEVICE BUSY
19 000025'010415         ISZ RBUSY        ; SET ROUTINE BUSY
20 000026'050416         STA 2 RSIGL+1    ; RESET DONE SISGNAL
21 000027'054412         STA 3 RRTN       ; SAVE RETURN ADDRESS
22 000030'062007         DOB 0 MCAR       ; SEND WORD COUNT TO RECEIVER
23 000031'024414         LDA 1 RADDR      ; PICK UP LOGICAL STARTING ADDRESS
24 000032'065107         DOAS 1 MCAR      ; SEND STARTING ADDRESS
25 000033'042410         LDA 0 RSIGL      ; WAIT FOR OPERATION COMPLETE FLAG
26 000034'177777         .REC
27 000035'102400         SUB 0 0
28 000036'044404         STA 0 RBUSY      ; RESET RECEIVER BUSY FLAG
29 000037'010402         ISZ RRTN
30 000040'002401         JMP @RRTN        ; TAKE NORMAL RETURN
31
32 000041'000000 RRTN:   0
33 000042'000001 RBUSY:  1
34
35 000043'000044'RSIGL: .+1
36 000044'000001         .BLK 1
37
38 000045'000000 RADDR:  0                ; RECEIVER BUFFER LOGICAL ADDRESS
39                                        ; AS DEFINED BY .STMAP SYSTEM CALL
40                                        ; DURING DEVICE INITIALIZATION .
41
42 000046'030402 RERTN:  LDA 2 RDVBSY     ; DEVICE ALREADY BUSY
43 000047'001400         JMP 0 3          ; PROCESSING A PREVIOUS CALL
44
45 000050'000047 RDVBSY: ERSIM            ; SIMULTANEOUS READS OR WRITES NOT ALLOW
```

```
        LICENSED MATERIAL - PROPERTY OF DATA GENERAL CORPORATION
10003 MCADR
01
02                ; MCA WRITE SUBROUTINE
03                ; --------------------
04
05                ; INPUT:-
06                ;       AC0=WORD COUNT
07                ;       AC1=RECEIVER NUMBER IN BITS 0-3 (1-17(8))
08
09                ; CALLING SEQUENCE:-
10                ;       JSR MCAWT
11                ;       <ERROR RETURN>
12                ;       <NORMAL RETURN>
13
14                ; OUTPUT:-
15                ;       AC1=MCA STATUS WORD FOR TRANSMITTER
16
17 00051'030423 MCAWT:  LDA 2 TBUSY      ; PICKUP STATUS FLAG
18 00052'151004          MOV 2 2 SZR      ; CHECK IT
19 00053'000773          JMP TERTN        ; ALREADY ACTIVE - ERROR RETURN
20 00054'010420          ISZ TBUSY        ; INDICATE DEVICE IS BUSY
21 00055'044423          STA 1 RECDV      ; SAVE RECEIVER NUMBER
22 00056'050420          STA 2 TSIGL+1    ; RESET TRANSMITTER DONE SIGNAL
23 00057'054414          STA 3 TRTN       ; SAVE RETURN ADDRESS
24 00060'062006          DOB 0 MCAT
25 00061'024416          LDA 1 TADDR      ; PICKUP LOGICAL STARTING ADDRESS
26 00062'065006          DOA 1 MCAT
27 00063'030415          LDA 2 RECDV
28 00064'073106          DOCS 2 MCAT
29 00065'020410          LDA 0 TSIGL      ; WAIT FOR OPERATION COMPLETE
30 00066'000034'         .REL
31 00067'102400          SUB 0 0
32 00070'040404          STA 0 TBUSY      ; RESET TRANSMITTER BUSY FLAG
33 00071'010402          ISZ TRTN
34 00072'002401          JMP @TRTN        ; TAKE NORMAL RETURN TO USER
35
36 00073'000000 TRTN:    0
37 00074'000001 TBUSY:   1
38
39 00075'000076'TSIGL: .+1
40 00076'000001          .BLK 1
41
42 00077'000000 TADDR:   0                ; TRANSMITTER BUFFER LOGICAL ADDRESS
43                                        ; AS DEFINED BY .STMAP SYSTEM CALL
44                                        ; DURING DEVICE INITIALIZATION .
45
46        000046'TERTN=  RERTN    ; TRANSMITTER BUSY ERROR RETURN
47
48
49 00100'000000 RECDV:   00               ; RECEIVER DEVICE NUMBER
```

```
        LICENSED MATERIAL - PROPERTY OF DATA GENERAL CORPORATION
!0004 MCAUR
01
02                ; MCA RECEIVER INTERRUPT PROCESSOR
03                ; ---------------------------------
04
05 00101'060607 RINTS:  DICC 1 MCAR      ; CLEAR RECEIVER/READ STATUS
06 00102'020741          LDA 0 RSIGL      ; GET SIGNAL ADDRESS
07 00103'177777          .IXMT
08 00104'000406          JMP DISMISS
09 00105'000405          JMP DISMISS
10
11                ; MCA TRANSMITTER INTERRUPT PROCESSOR
12                ; ------------------------------------
13
14 00106'060606 TINTS:  DICC 1 MCAT      ; CLEAR TRANSMITTER/READ STATUS
15 00107'020766          LDA 0 TSIGL      ; GET SIGNAL ADDRESS
16 00110'000103'         .IXMT
17 00111'000401          JMP .+1
18 00112'030402 DISMISS: LDA 2 DSCDE      ; GET DISMISS CODE
19 00113'060202          NIOC MAP         ; TRIGGER THE MMPU
20
21 00114'000003 DSCDE:   03               ; CODE FOR DISMISSING THE INTERRUPT
22                                        ; UNDER A NOVA 840 SYSTEM
```

```
        LICENSED MATERIAL - PROPERTY OF DATA GENERAL CORPORATION
10005 MCAUR
01
02
03                ; INITIALIZE THE MCA HANDLER
04                ; ----------------------------
05
06                ; INPUT:-
07                ;       AC0=STARTING CORE ADDRESS OF RECEIVER BUFFER
08                ;       AC1=STARTING CORE ADDRESS OF TRANSMITTER BUFFER
09
10                ; CALLING SEQUENCE:-
11                ;       JSR MIDEF
12                ;       <ERROR RETURN>
13                ;       <NORMAL RETURN>
14
15 00115'054437 MIDEF:  STA 3 MIRTN       ; SAVE RETURN ADDRESS
16 00116'040724         STA 0 RBUSY       ; SAVE USER BUFFER ADDRESSES
17 00117'044755         STA 1 TBUSY
18 00120'010435         ISZ MCATV         ; DEVICE ALREADY INTRODUCED TO SYSTEM?
19 00121'000414         JMP MACTV         ; YES, JUST GET LOGICAL ADDRESSES
20 00122'020666         LDA 0 RCODE       ; RECEIVER DEVICE CODE
21 00123'024655         LDA 1 MRDCT       ; RECEIVER DEVICE CONTROL TABLE
22 00124'030432         LDA 2 C2          ; NUMBER OF 1K BLOCKS
23 00125'000017         .SYSTM            ; DEFINE DEVICE TO SYSTEM
24 00126'021007         .IDEF
25 00127'002425         JMP @MIRTN        ; TAKE ERROR RETURN
26 00130'020661         LDA 0 TCODE       ; TRANSMITTER DEVICE CODE
27 00131'024650         LDA 1 MTDCT       ; TRANSMITTER DEVICE CONTROL TABLE
28 00132'000017         .SYSTM            ; DEFINE DEVICE TO SYSTEM
29 00133'021007         .IDEF
30 00134'002420         JMP @MIRTN        ; TAKE ERROR RETURN
31 00135'054420 MACTV:  STA 3 MCATV       ; SET ACTIVE FLAG
32 00136'020652         LDA 0 RCODE       ; GET DEVICE CODE
33 00137'024703         LDA 1 RBUSY       ; USER BUFFER ADDRESS
34 00140'000017         .SYSTM            ; GET LOGICAL ADDRESS OF BUFFER
35 00141'021035         .STMAP
36 00142'002412         JMP @MIRTN        ; TAKE ERROR RETURN
37 00143'044702         STA 1 RADDR       ; SAVE LOGICAL ADDRESS
38 00144'020645         LDA 0 TCODE       ; DEVICE CODE
39 00145'024727         LDA 1 TBUSY       ; GET BUFFER ADDRESS
40 00146'000017         .SYSTM            ; GET LOGICAL ADDRESS OF USER BUFFER
41 00147'021035         .STMAP
42 00150'002404         JMP @MIRTN        ; TAKE ERROR RETURN
43 00151'044726         STA 1 TADDR       ; SAVE LOGICAL ADDRESS OF TRANSMITTER B
44 00152'010402         ISZ MIRTN
45 00153'002401         JMP @MIRTN        ; NORMAL RETURN
46
47 00154'000000 MIRTN:  0                 ; RETURN ADDRESS
48
49
50 00155'177777 MCATV:  -1                ; MCA DEVICE ACTIVE FLAG
51 00156'000002 C2:     2                 ; NUMBER OF 1024 WORD BLOCKS FOR MCA
52
53                      .END
```

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| C2 | 000156' | | 5/22 | 5/51 | | | | | |
| DISMI | 000112' | | 4/08 | 4/09 | 4/18 | | | | |
| DSCDE | 000114' | | 4/18 | 4/21 | | | | | |
| MACTV | 000135' | | 5/19 | 5/31 | | | | | |
| MCARD | 000022' | EN | 1/10 | 2/16 | | | | | |
| MCATV | 000155' | | 5/18 | 5/31 | 5/50 | | | | |
| MCAWT | 000051' | EN | 1/10 | 3/17 | | | | | |
| MIDEF | 000115' | EN | 1/10 | 5/15 | | | | | |
| MIRTN | 000154' | | 5/15 | 5/25 | 5/30 | 5/36 | 5/42 | 5/44 | 5/45 |
| | | | 5/47 | | | | | | |
| MRDCT | 000000' | | 1/19 | 5/21 | | | | | |
| MSAVE | 000012' | | 1/22 | 1/26 | 1/35 | | | | |
| MTDCT | 000001' | | 1/20 | 5/27 | | | | | |
| RADDR | 000045' | | 2/23 | 2/38 | 5/37 | | | | |
| RBUSY | 000042' | | 2/16 | 2/19 | 2/28 | 2/33 | 5/16 | 5/33 | |
| RCODE | 000010' | | 1/33 | 5/20 | 5/32 | | | | |
| RDVBS | 000050' | | 2/42 | 2/45 | | | | | |
| RECDV | 000100' | | 3/21 | 3/27 | 3/49 | | | | |
| RERTN | 000046' | | 2/18 | 2/42 | 3/46 | | | | |
| RINTS | 000101' | | 1/24 | 4/05 | | | | | |
| RRTN | 000041' | | 2/21 | 2/29 | 2/30 | 2/32 | | | |
| RSIGL | 000043' | | 2/20 | 2/25 | 2/35 | 4/06 | | | |
| RUSDC | 000002' | | 1/19 | 1/22 | | | | | |
| TADDR | 000077' | | 3/25 | 3/42 | 5/43 | | | | |
| TBUSY | 000074' | | 3/17 | 3/20 | 3/32 | 3/37 | 5/17 | 5/39 | |
| TCODE | 000011' | | 1/34 | 5/26 | 5/38 | | | | |
| TERTN | 000040' | | 3/19 | 3/46 | | | | | |
| TINTS | 000100' | | 1/28 | 4/14 | | | | | |
| TRTN | 000073' | | 3/23 | 3/33 | 3/34 | 3/36 | | | |
| TSIGL | 000075' | | 3/22 | 3/29 | 3/39 | 4/15 | | | |
| TUSDC | 000005' | | 1/20 | 1/26 | | | | | |
| .IXMT | 000110' | XN | 1/12 | 4/07 | 4/16 | | | | |
| .REC | 000066' | XN | 1/12 | 2/26 | 3/30 | | | | |

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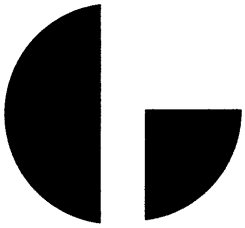

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