

DataGeneral

**REAL TIME
OPERATING
SYSTEM
Reference Manual**

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SYSTEM
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CHAPTER 1

INTRODUCTION TO RTOS

The Real Time Operating System (RTOS) for the DGC family computers consists primarily of a small, general purpose multi-task monitor designed to control a wide variety of real time input/output devices. RTOS is entirely core-resident, highly modular and largely reentrant, and allows for the straightforward addition of special device handlers. Moreover, RTOS, revision 4.00 is a compatible subset of RDOS revision 4.00, Data General's Real Time Disk Operating System.

User programs are relieved from the details of I/O timing, data buffering, priority handling, and task scheduling. In addition, users are provided with a parallel processing capability plus inter-task communication and synchronization facilities. Communication with the RTOS monitor takes place through a small set of RTOS system and task calls.

A task is the basic logical unit controlled by RTOS. Tasks are created by means of one of the RTOS task calls, and having been created, a task may be terminated at any time. A large number of common processing situations lend themselves admirably to this sort of operational control philosophy. Examples of these processing situations include the reading or writing of a block of data while simultaneously performing arithmetic computations, listening for input from several devices at the same time, shared device use by multiple tasks, sophisticated communications problems, etc.

RTOS TASK CONCEPTS

A task is a logically complete, asynchronous locus of control through a program. A task demands use of system resources (including CPU control). Many tasks may be assigned to operate asynchronously in a single reentrant sequence of instructions, and each task may be assigned a unique priority and identification number.

Due to the serial nature of a computer, tasks which appear to be executing their operations in parallel are in actuality executing these operations in short, serial segments. It is necessary then for RTOS to maintain certain status information (primarily active registers) concerning all tasks which are not currently in control of the Central Processing Unit (CPU).

This information is retained in an information structure called the Task Control Block (TCB). The maximum number of TCBs is defined at the time of system generation.

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Task Identification Numbers

When a task is created, it may be created both with a unique identification number (I. D.) from 1 to 377_8 and at a specified priority level (from 0 to 377_8). The identification number allows tasks to be readied, suspended, or killed on a selective basis. If unique I. D. 's are not desired, tasks may all be created with I. D. 's of 0. Tasks may exist at priority levels of 0 (the highest) through 377_8 (the lowest priority). Moreover, several or all tasks may exist at the same priority level. The task scheduler always allocates CPU control to the highest priority ready task; ready tasks within the same priority level receive CPU control on a round-robin basis.

Task Synchronization and Communication

RTOS permits tasks to communicate with one another by sending and receiving one-word non-zero messages. A one-word message is sent to a task in an agreed-upon location in user address space. User address space is understood to include all locations from address 16 through NMAX inclusively.

The task sending a message may either return to the Task Scheduler immediately (.XMT) or it may wait (.XMTW) and place itself in the suspended state until the receiving task has issued a receive request (.REC) and has received the message. Receipt of the message includes the resetting of the contents of the message address to all zeroes. Upon receipt of the message, the recipient reverts to the ready state.

System and Task Call Formats

Calls to the RTOS monitor can be separated into two categories: system calls and task calls. System calls generally perform system I/O. Task calls perform user task management functions.

System command words and the mnemonic .SYSTEM that must precede each command word are recognized as legal mnemonics by both the RDOS and stand-alone extended assemblers. Appearance of the mnemonic .SYSTEM in a program results in the assembling of a JSR @ 17 instruction. The specific system command word is assembled as the word following the mnemonic .SYSTEM.

Once system action is complete and the task receives CPU control in priority fashion, normal return is made to the second instruction after the system command word. If an exceptional condition is detected, return is made to the first instruction following the system command word.

Task States

Tasks may exist in any of four states. Tasks are either ready to perform their functions, they are actually in control of the CPU and are executing their assigned instruction paths, they are suspended and temporarily unable to receive CPU control, or they are dormant, having no priority and no chance of gaining CPU control until activated by a .TASK or .QTSK command. The Task Scheduler always gives CPU control to the highest priority task that is ready.

Suspended tasks are tasks which were once ready. A task may become suspended for one or more of the following reasons:

1. It has been suspended by .SUSP, .ASUSP, or .TIDS.
2. It has suspended itself for a specified period by .DELAY.
3. It is waiting for a message from another task, .REC.
4. It has issued a message-and-wait call, .XMTW.
5. It is awaiting the completion of a .SYSTEM call.

Just as a number of different events may suspend a ready task, several events can cause a suspended task to be readied:

1. The completion of a .SYSTEM call (such as a request for I/O or the expiration of a time delay).
2. The posting of a message for a suspended task awaiting its receipt, or the awaited receipt of a transmitted message.
3. The readying of a task by .ARDY or .TIDR task calls.

If a task is suspended by both a task suspend call and by some other event, the call must be readied both by an .ARDY (or .TIDR) call and by whatever other event is required to ready the task.

Suspended and ready tasks are each connected in queues. Tasks may be deleted from either the ready or the suspended queues, either separately (.ABORT or .TIDK) or as a priority class (.AKILL). Tasks which have been deleted add their empty TCBs to an inactive chain of free TCBs. When a task is initiated (.TASK), a TCB is taken from the free chain, the state of the calling task is saved in its own TCB, and both tasks are entered into the ready queue as ready tasks. The .TASK command must be used to initiate a multitask environment.

If all tasks are killed, the effect is to place the entire system in the idle state and to close all channels, with control passing to the task scheduler. The system remains capable of servicing interrupts.

System and Task Call Formats (Continued)

Status of the accumulators upon return from the system (.SYSTEM or task call) is as follows. If the system returns no information as a result of the call, the carry and all accumulators except AC3 will be preserved. AC2 is used when an exceptional return is made to return a numeric error code. Error codes are listed in Appendix A.

AC3 is destroyed by a .SYSTEM or task call (as it is by the use of "JSR"). On return from NOVA[®]* RTOS systems however, AC3 is loaded with the contents of memory location 000016. This location is defined as a permanent symbol by the assemblers and has the name USP (User Stack Pointer). A convenient method of saving AC3 in such systems is to store it in USP before issuing the .SYSTEM or task call. The system will load AC3 with the contents of USP upon return from the call in NOVA RTOS systems.

Single task ECLIPSE[™]* RTOS programs loaded with TMIN also load USP into AC3. Programs loaded with BTMIN, however, load FP (the frame pointer) into AC3; all multitask programs run on ECLIPSE systems do this also. BTMIN must be loaded explicitly before the RTOS system libraries are scanned in order for BTMIN--instead of TMIN--to be included within a single task ECLIPSE program. In any case, the contents of USP will be restored to its former state in all systems.

Users with programs which assume that USP is contained in AC3 after system and task calls can run these same programs when the system loads FP, not USP, into AC3. This can be accomplished by creating a parameter file with the entry ".DUSR USP = 41". This file must be scanned at assembly time after, not before, the regular user parameter file, PARU.

Users of task calls are cautioned to reference all task call commands whose operations are required within a program by their call names in an .EXTN statement in that program. Only those calls which are so referenced will have the appropriate task call processing modules loaded by the relocatable loader.

The general form of a task call in a program is:

AC_n - required input to the call

command

error return (error code in AC2)

normal return (all AC's except AC3 are restored unless output is returned via accumulators)

AC_n - output from the call

*NOVA is a registered trademark, and ECLIPSE is a trademark of Data General Corporation, Southboro, Massachusetts.

System and Task Call Formats (Continued)

The general form of a system call description is:

AC_n - required input to the call
.SYSTEM
command
error return (error code in AC2)
normal return (all AC's except AC3 are restored unless output
is returned via accumulator)

AC_n - output from the call

There are 2 basic command word formats:

command n and command

where n is a number from 0 to 76₈ representing an I/O channel number. The maximum number of channels, like the maximum number of tasks, is defined at the time of system generation. Any system command requiring a channel number n need not specify this number in the command word. Instead, by specifying n to be octal 77, the system will use the number passed in AC2 as the channel number.

When no I/O is needed in command execution, the command word appears alone in the instruction. If the command requires arguments, these are passed in the accumulators.

AC2 is used when an exceptional return is made to return a numeric error code. Error codes are listed by number in the RTOS parameter listing, and the applicable codes are listed for each command.

MAGNETIC AND CASSETTE TAPE FILES

RTOS provides two means for accessing data on magnetic tape and cassettes: Tape file I/O and direct or free format I/O.

Tape file I/O is implemented in both line and sequential I/O modes. Tape file I/O is buffered by the system, whereas direct I/O is unbuffered by the system. RTOS will support up to 16 magnetic and 16 cassette tape drives. Magnetic tape units can be in any combination of 7- and 9-track units, with reading and writing at any density supported by the controller for direct I/O; other forms of I/O require high density.

If the controller detects a parity error during reading, the system will attempt to reread the data ten times before issuing error code ERFIL, "file data error." If an error is detected after writing, the system will attempt, up to 10 times, to backspace, erase, and re-write. If the re-write is unsuccessful after the tenth time, then an error will be signaled.

Seven-and Nine Track Data Words

Data recorded on 7-track units is necessarily encoded. Every data word, written on 7-track units in tape file I/O, is encoded as two data words, four successive frames. Data words written to 7-track units in free format I/O is encoded as two successive frames. Data words output to 9-track units, under both file I/O and free format I/O, is written as two successive eight-bit bytes. Data encoding is accomplished on 7 and 9-track units in the following manner.

		Original Data Word															
		7-track encoding								9-track encoding							
		parity data								parity data							
File I/O	frame 1	x	x	x	0	1	2	3	x	0	1	2	3	4	5	6	7
	frame 2	x	x	x	4	5	6	7	x	8	9	10	11	12	13	14	15
	frame 3	x	x	x	8	9	10	11									
	frame 4	x	x	x	12	13	14	15									
Free Form I/O	frame 1	x	2	3	4	5	6	7	x	0	1	2	3	4	5	6	7
	frame 2	x	10	11	12	13	14	15	x	8	9	10	11	12	13	14	15

System and Task Call Formats (Continued)

The significant differences between a .SYSTEM call and a task call are as follows:

1. Task calls are not preceded by the .SYSTEM mnemonic.
2. Not all task calls have error returns. Those which do not have an error return do not reserve an error return location. All system calls reserve error return locations even if there is no error return possible.

DEVICE SUPPORT UNDER RTOS

I/O devices are given special reserved names which often begin with the character \$. The following list gives the names of devices supported under RTOS and their reserved names:

\$CDR	-	Card reader.
\$CDR1	-	Second card reader.
CT \underline{n}	-	Data General cassette unit \underline{n} (\underline{n} can be from 0 to 7).
DK0	-	Data General fixed head NOVADISC®*.
D \underline{Pn}	-	Moving head disk, unit \underline{n} (\underline{n} can be from 0 to 3).
\$LPT	-	80- or 132-column line printer.
\$LPT1	-	Second line printer, 80 or 132 columns.
MCAR	-	Multiprocessor Communications Adapter Receiver.
MCAT	-	Multiprocessor Communications Adapter Transmitter.
MT \underline{n}	-	7- or 9-track magnetic tape transport (\underline{n} can be from 0 to 7).
\$PLT	-	Incremental plotter.
\$PLT1	-	Second incremental plotter.
\$PTP	-	Paper tape punch.
\$PTP1	-	Second paper tape punch.
\$PTR	-	High-speed paper tape reader.
\$PTR1	-	Second paper tape reader.
QTY	-	4060 asynchronous data communications multiplexer.
\$TTI	-	Teletype®**or video display terminal keyboard. ***
\$TTI1	-	Second Teletype or display terminal keyboard. ***
\$TTI2	-	Third Teletype or display terminal keyboard.***
\$TTO	-	Teletype printer or display terminal screen.
\$TTO1	-	Second printer or display terminal screen.
\$TTO2	-	Third printer or display terminal screen.

*NOVADISC is a registered trademark of Data General Corporation, Southboro, Massachusetts.

**Teletype is a registered trademark of Teletype Corporation, Skokie, Illinois.

***If the Teletype reader is turned on for line reads, data read will be echoed on the Teletype printer.

Referencing Files on Cassette and Magnetic Tape (Continued)

MT <u>n</u> : <u>m</u>	Magnetic tape unit <u>n</u> attached to the second controller, where <u>n</u> is from 0-7 and has no leading zero, with file number <u>m</u> from 0-99.
CT <u>n</u> : <u>m</u>	Cassette unit <u>n</u> attached to the first controller, where <u>n</u> is from 0-7 and has no leading zero, with file number <u>m</u> from 0-99.
CT1 <u>n</u> : <u>m</u>	Cassette unit <u>n</u> attached to the second controller, where <u>n</u> is from 0-7 and has no leading zero, with file number <u>m</u> from 0-99.

Either a one-digit or a two-digit number may be used to reference the first ten file numbers. Thus to reference file number 8 on cassette or magnetic tape unit 2 attached to the first controller, the following global specifiers would be used:

MT2:08 or MT2:8 CT2:08 or CT2:8

Both the tape global specifier and the file number must be given. Violation of this rule will cause the system to return error code ERFNM, "illegal file name."

Some examples of references to files on tape are:

```
WRITE:      LDA 0,MTAPE      ;GET UNIT NAME
            SUB 1,1        ;PARTIAL INITIALIZATION
            .SYSTEM
            .INIT         ;INITIALIZE UNIT MT0
            JMP ERROR     ;RECOVER FROM SYSTEM ERROR CONDITION
            SUB 1,1        ;PRESERVE DEVICE CHARACTERISTICS
            LDA 0,FILNM    ;GET TAPE UNIT NAME
            .SYSTEM
            .OPEN 1       ;OPEN MT0 FILE 1 ON CHANNEL 1
            JMP ERROR     ;ERROR UPON SYSTEM CALL
            LDA 0,BUF      ;GET BUFFER POINTER
            .SYSTEM
            .WRL 1        ;WRITE LINE TO FILE 1 OF MT0
            JMP ERROR     ;RECOVER FROM SYSTEM ERROR CONDITION
            .
            .
            .
            (see next page)
```

Cassette and Magnetic Tape File Organization

Cassette and magnetic tape files have the same format. Data is written and read in fixed length blocks of 257 16-bit words. Data files are variable in length, each one containing as many fixed length blocks as is required. The first 255₁₀ words of each block are data proper, and the last two words each contain the file number. The following illustration shows the structure of a data block:

Data words	255 words
File number	1 word
File number	1 word

After the first file, an end-of-file (EOF) mark is written. EOF marks separate each succeeding file, and two EOF marks are written after the last file. Files are written in consecutive order, starting with file number 0 and extending through file number 99.

Initializing and Releasing a Tape Drive

Before any tape files on a tape drive can be accessed the drive must be initialized via the .INIT system call. Initializing a tape drive causes the tape on that drive to be rewound. Full initialization causes the tape to be rewound and two EOFs to be written (effectively erasing all files from the tape). In both cases, the tape file pointer maintained by RTOS is reset to 0. A full initialization of all new (blank) tapes should be performed before using them.

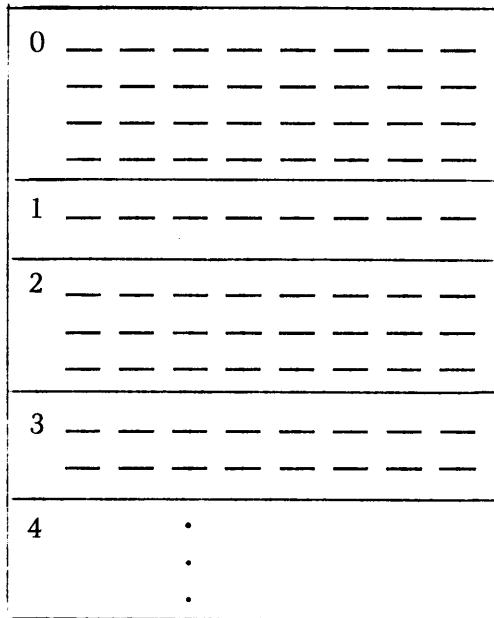
Referencing Files on Cassette and Magnetic Tape

Files are placed on tape in numeric order, beginning with file number 0. Up to 100 files may be placed on any given tape. The last permissible file is file number 99.

A given file is referenced in a command by a tape global specifier followed by a colon and file number. Global specifiers for the cassette and magnetic tape are:

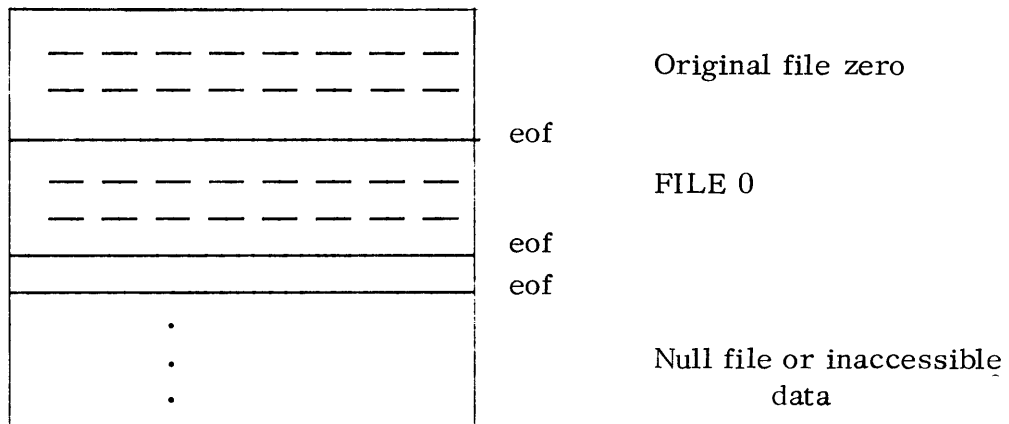
MTn:m Magnetic tape unit n attached to the first controller, where n is from 0-7 and has no leading zero, with file number m from 0-99.

Writing Files on Tape (Continued)



Null file.

A command to write FILE0 to file 1 will cause the contents of that file to overwrite the tape beginning at the file 1 position. When a tape is written in this manner, all subsequent files on tape are lost. In the example, the tape will contain:



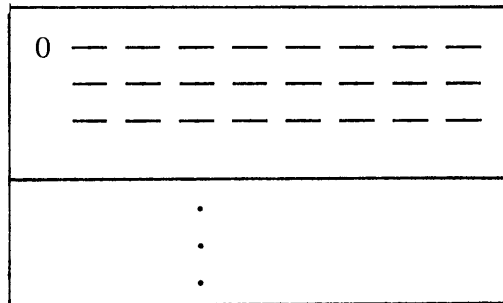
Users are cautioned to do either an .INIT or .RLSE of the tape transport before removing either a cassette or magnetic tape reel. Issuance of these commands resets the system tape file pointer to 0 so that accessing of rewound tape files can be accomplished correctly, and reassigns the default global specifier name as required.

Referencing Files on Cassette and Magnetic Tape (Continued)

```
FILENM:      .*2+1
              .TXT *MT0:1*
MTAPE:       .*2+1
              .TXT *MT0*
BUF:         .*2+1
              .BLK 132.
              .END
```

Writing Files on Tape

Files must be placed on cassette and magnetic tape in numeric order. For example, suppose the user transfers a file, FILE0, to tape unit 3 which has just been initialized. FILE0 will be the first file on the tape. The tape on drive 0 will now contain the following:



First file, containing the contents of FILE0.

Once a file is written, the file number of the next file is assigned. File 1 is a null file.

An attempt to place a new file on this tape at file position 2 where only FILE0 has been written on the tape, will result in error ERDLE being signaled, "file does not exist".

It is possible to overwrite a magnetic tape file. For example, assume a tape on drive 0 contains four files:

Writing Files on Tape (Continued)

An attempt to read file 2 will cause error ERDLE, "file does not exist," to be signaled since the system interprets the double EOF mark to be a logical end-of-tape marker.

FREE FORMAT I/O

Data is read and written on magnetic and cassette tape in free format. Data records may be of varying length, containing from 2 to 4096 16-bit words each, and with 1 or more records per file. Each tape reel can contain as many files as the reel size will permit, although only the first 100₁₀ files can be positioned directly when a file is opened.

Before any free format I/O can occur on a device, that device must first be initialized and then opened for this type of I/O. The system call .MTPD is issued to open either mag tape or cassettes for free format I/O. When a tape unit is opened, it is positioned to a specified file, and the unit is associated with an RTOS channel. Thus, even though the unit has positioned a tape reel to a specific file, all files on the tape can then be accessed via space forward/space backward commands, and all records within each file can be similarly accessed.

ASYNCHRONOUS DATA COMMUNICATIONS MULTIPLEXER (QTY)

The type 4060 asynchronous data communications multiplexor is another device supported by RTOS. RTOS assigns the system mnemonic QTY to this device. The QTY can accommodate from 1 to 64 full or half duplex lines, in either half or full duplex operation.

Each multiplexed line of the QTY corresponds to a file name of the form

QTY:xx

where xx is a multiplexor line number in the range 0-64 decimal. Input/output operations are performed on each line by RTOS line or sequential read and write commands.

Each single QTY line may be opened on a single RTOS channel only. No more than one read or one write request can be outstanding on any one line.

Writing Files on Tape (Continued)

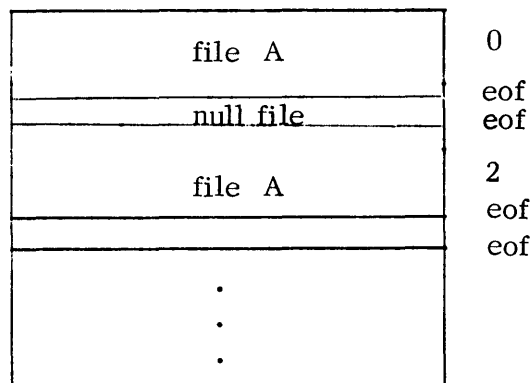
Users must also note the implications of the logical end-of-tape mark, double EOFs, employed by RTOS. If, by mistake, an attempt is made to access serially two files beyond the logical end-of-tape mark, the tape transport will be placed in a runaway condition. This error is illustrated by the following command sequence.

Full .INIT of MT0	User places a null file 0 on tape, terminated by the logical end-of-tape mark, EOF EOF.
.OPEN and .RDL of MT0:0	The system reads null data found between the double EOF characters, and stops at the second EOF.
.OPEN and .RDL of MT0:2	The system transport is placed in a runaway condition as the system searches in vain for an EOF mark.

A corollary error occurs when an attempt is made to write a null file between data files on tape. The following command sequence illustrates this problem:

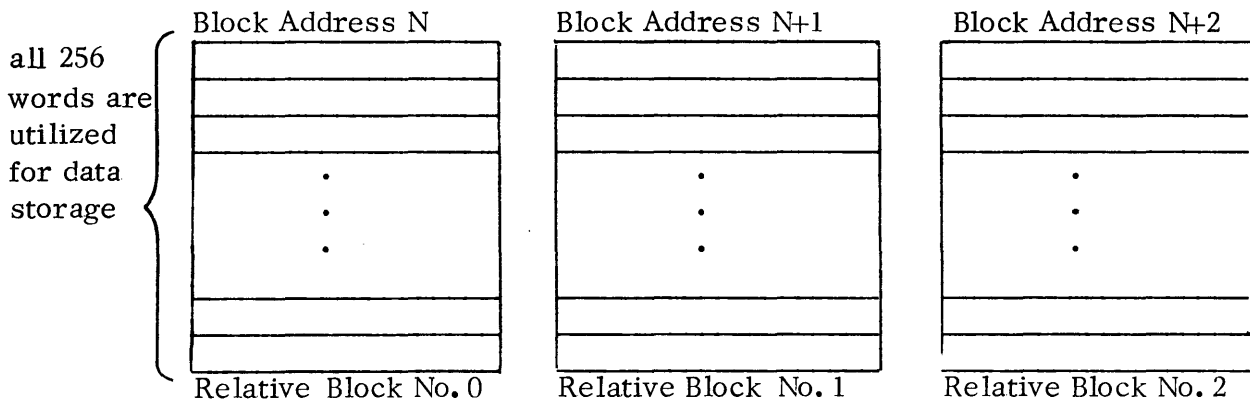
.OPEN MT0:0, .WRL file A	Data file A is written to file 0.
.OPEN MT0:1, .WRL file B	Null file B is written to file 1.
.OPEN MT0:2, .WRL file A	Data file A is written to file 2.
.RLSE and .INIT MT0	Transport is released and initialized to reset the tape file pointer to 0.

The file arrangement produced on MT0 looks like the following:



Disk File Organization (Continued)

File ABCD



Contiguously organized files have the advantage of allowing quick access to their data blocks, with all disk storage being used for data.

RTOS/RDOS COMPATIBILITY

The design intent of RTOS is to make this operating system a compatible subset of RDOS, the DGC Real Time Disk Operating System. Accordingly, all file structures, task concepts, system and task calls, and other features discussed for RTOS may be tested and run on an RDOS system. RDOS features omitted from RTOS were omitted because they could not be applied in RTOS, given the constraints of a quick responding core-resident-only operating system.

Tape and Disk File Structures

Cassette and magnetic tape file structures under RTOS are identical to those provided by free format I/O under RDOS.

Disk files in RTOS must be organized contiguously; sequentially and randomly organized disk files are available only under RDOS. Names are assigned to RTOS disk files at RTOSGEN time. Allowable ASCII characters in RTOS file names are all upper case alphabetic and numerals 0 through 9. Unlike RDOS, however, disk file names must be 4 to 6 characters in length, may not include the \$ character, and can have no file name extensions; file names defined at RTOSGEN time cannot be changed. Disk files must be opened before they may be accessed.

Task and System Calls

Unless otherwise specified, all RTOS system and task calls operate as they do under RDOS. Any attempt to reference a task call under RTOS which is not found in its library will cause an unresolved external to be reported by the loader.

ASYNCHRONOUS DATA COMMUNICATIONS MULTIPLEXER (QTY) Continued

RTOS provides a facility for monitoring line activity on all unopened QTY lines. If line number 64, QTY:64, is opened and either a read line or read sequential operation is attempted, the task issuing this call will be suspended until such time as an unopened line receives an interrupt request. When this occurs, the normal return of the read sequential or read line call will be taken, and AC2 will contain the following data word:

1	0	Line #	Char.
0	1	2	7 8 15

Thus this data word describes the line providing the character, and contains the character itself in its right byte.

If two unopened lines receive an interrupt, only the first one to receive the interrupt will be reported. There will be no report of other unopened interrupting lines occurring before the next read line or read sequential on QTY:64 is issued.

DISK FILES

RTOS extends support to both fixed and moving head disk units. RTOS supports a fixed head NOVADISC controller with up to eight logical units of 128K, 256K, 512K or 756K storage words; total fixed head storage per controller is from 131 thousand to 2 million words. Up to four moving head disk devices (disk pack or cartridge type) can also be included in any system, with from 2 to 20 surfaces per unit; maximum total moving head disk storage is 49.2 million words.

Disk files are defined at the time of system generation. At this time, file sizes are specified and names are assigned to each file. File names consist of from 4 to 6 ASCII characters followed by a trailing null. Allowable ASCII characters in the file name are all upper case alphabetic characters and numerals 0 through 9. A file must be opened (i. e., associated with an RTOS channel) before it can be accessed.

Disk File Organization

Disk files in RTOS may be organized contiguously only. Contiguously organized files consist of a fixed number of one or more disk blocks located at an unbroken series of disk block addresses. These files can be neither expanded nor reduced in size. Since the data blocks are at sequential logical block addresses, all that is needed to access a block within a contiguous file is the address of the first block and the relative block number within the file.

RTOS Program Development Under RDOS (Continued)

Complete details describing the use of the RDOS RLDR command, operation of TBOOT, CBOOT, HIPBOOT, and procedures for relocatable loading of an RTOS program module on a stand-alone system are outlined in Appendix B of this manual.

Avoiding Global Symbol Conflicts under RTOS

In order to minimize the incidence of global symbol conflicts between user programs and RTOS subprograms, RTOS generally follows the convention of using a dot as the first character in each symbol. Thus user-defined global symbols should always avoid the use of a dot as the first character in a symbol.

This rule has several exceptions which users should be aware of, i.e., several global symbols in RTOS are not preceded by dots. These undotted global symbols are as follows: PWRIS, RTCIS, DCT names (summarized at the end of system generations), entries in the buffer package (BFPKG), entries in Fortran libraries FORT.LB and RTOS FMT.LB, and user high priority interrupt handlers.

Generating Console Interrupts

RTOS does not permit the generation of console interrupts (CTRL A, CTRL C, or CTRL F) which are available under RDOS. Nonetheless, RTOS does provide a facility which resembles an RDOS keyboard interrupt. This facility is the keyboard character wait command, .WCHAR . This command, discussed fully in Chapter 2, activates logic within RTOS such that when a user-specified character is received from any console keyboard, control will branch to a user-specified routine for appropriate processing.

Inter-revision Source Level Incompatibilities

Users of RTOS 3.00 who wish to be upgraded to RTOS 4.00, the current revision, should be aware of certain source level incompatibilities between the two revisions. A summary of these considerations is given in Appendix E.

Task and System Calls (Continued)

In most cases, an attempt to execute an RDOS system call which is not implemented in RTOS results in an error return being taken with error code 2, ERICM (illegal system command), reported in AC2. However, some calls are treated as no-ops by RTOS to achieve downward compatibility (from RDOS to RTOS). The following list names all of these calls which cause control to go directly to the normal return with no further action:

.SYSI	SOS-compatible call.
.SPKL	Kill spooling.
.SPDA	Disable spooling.
.SPEA	Enable spooling.

Note that these calls will not operate correctly under RTOS in the presence of error conditions. Thus, for example, an attempt to delete a non-existent file would take the error return for .DELET under RDOS, but would take this call's normal return under RTOS.

Channel/Task Specification

The number of channels and tasks in a program run under RTOS is defined at RTOSGEN time. RTOS programs being tested under RDOS may specify channels and tasks by means of the RLDR local switches /C and /K, or by the .COMM TASK (or CHANTASK) statements.

RTOS Program Development Under RDOS

Bearing in mind the above restrictions, RTOS program development under an RDOS system is convenient. RTOS programs are edited, assembled, loaded and debugged under RDOS, and when they are considered to be error free they are reloaded with an RTOS module (produced by RTOS SYSGEN) and the RTOS library, using the RDOS RLDR command with the /C global switch. This load procedure creates a version of the program (called a save file) which can be run under RTOS.

Having created this save file, one of several bootstrap procedures are followed to execute the program, depending upon whether the RTOS program is to be run on the system which is currently executing under RDOS or whether it is to be run under another system, with or without disk, which is not running under RDOS.

CHAPTER 2

SYSTEM CALLS

The following page contains an alphabetized list of all RTOS system command word mnemonics.

All system calls except user interrupt calls will be discussed in this chapter, with calls being grouped in the following sections:

- File and Input/Output Commands
- Teletypewriter/Video Display Commands
- Memory Size Commands
- System Return Commands
- Clock and Calendar Commands

FILE AND INPUT/OUTPUT COMMANDS

All I/O is handled by system I/O commands. These commands require a channel number from 0 to 77 to be given in the argument field of the command word as discussed in Chapter 1. The number of channels available is determined by the user when the RTOS module is generated by the user (see Appendix B).

The user may also define a number of fixed length files when the RTOS module is generated, and may assign alphanumeric names to these files. Such files are organized contiguously, and are composed of a fixed number of disk blocks which are located at an unbroken series of physical block addresses. These files can neither be expanded nor reduced in size. Since the data blocks are in sequence, all that is needed to access a block within a contiguous file is the name of the file (indicating to RTOS the address of the first block) and the relative block number within the file. Since no time is required for reading a file index, disk files under RTOS can be accessed rapidly.

FILE AND INPUT/OUTPUT COMMANDS (Continued)

A channel is initially linked to a particular file or device by means of the .OPEN (or .APPEND) command. A channel is linked to a magnetic tape transport or cassette unit by means of the .MTPD command only. The association between file or device and channel number is broken by using the .CLOSE command. All currently open files and devices can be closed, and their associated channels freed, by means of the system .RESET command.

RTOS provides four different I/O modes for reading and writing. These modes are:

- direct block
- line
- sequential
- free format tape I/O

In direct block mode, the user effects a transfer of a continuous group of disk blocks. Core locations used in the transfer are also in sequence. The direct block mode commands are .RDB and .WRB, read a block series and write a block series. This mode is used only with disk I/O, and no other I/O mode is used for disk I/O under RTOS.

Line mode data transfers assume that the data read or written consists of ASCII character strings terminated by either carriage returns, form feeds, or nulls. Position within a file is implicit from the last call. That is, file data is processed line by line in sequence from the beginning of the file to its end. In this mode the system handles all device dependent editing at the device driver level. For example, line feeds are ignored on paper tape and teletype input devices and are supplied after carriage returns to all paper tape and teletype output devices. Moreover, reading and writing do not require byte counts since reading continues until a terminator is read and writing proceeds until a terminator is written. The line mode commands are .RDL and .WRL, read and write a line.

The third mode is sequential mode. In this mode data is transmitted exactly as read from the device or from core memory. No assumption is made by the system as to the nature of this information. Thus this mode would always be used for processing binary data. This mode requires the caller to specify a byte count for each read or write request. The sequential mode commands are .RDS and .WRS, read and write sequential.

Free format I/O permits the reading or writing of data on a word by word basis to cassette or magnetic tape. This mode provides users with the means of accessing data in variable size records within tape files. Free format I/O permits the reading or writing of data records containing from 2 to 4096 words each. Free format I/O commands also permit a tape reel to be spaced forward or backward from 1 to 4095 records or to the start of a new data file, and these commands permit the transport status word to be read.

System Call List

.APPEND	Append to a device.
.CLOSE	Close a file or device.
.DELAY	Suspend a task for a specific interval of time.
.DUCLK	Define a user clock.
.ERTN	Idle the system abnormally.
.GCHAR	Get a character.
.GCHN	Get a free channel number.
.GDAY	Get today's date.
.GHRZ	Get the real time clock frequency.
.GMCA	Get the current CPU's MCA number.
.GTOD	Get the time of day.
.IDEF	Identify a user interrupt device.
.INIT	Initialize a magnetic tape or cassette.
.IRMV	Remove a user interrupt device.
.MEM	Determine available memory.
.MEMI	Change NMAX.
.MTDIO	Perform free format I/O on magnetic tape or cassette.
.MTOPD	Open a magnetic tape or cassette for free format I/O.
.OPEN	Open a file or device other than the magnetic tape or cassette.
.PCHAR	Output a character to the teletypewriter.
.RDB	Read a disk block.
.RDL	Read a line.
.RDS	Read sequential bytes.
.RESET	Close all devices and files.
.RLSE	Release a magnetic tape or cassette unit.
.RTN	Idle the system normally.
.RUCLK	Remove a user clock.
.SDAY	Set today's date.
.STOD	Set the time of day.
.WCHAR	Wait for a character on a teletype.
.WRB	Write a disk block.
.WRL	Write a line.
.WRS	Write sequential bytes.

Open a File or Device (.OPEN) (Continued)

Having opened a file via .OPEN, the user is not guaranteed of being the exclusive user of the file; others may also have opened the file via .OPEN and may have modified its contents. This command cannot be used to open a cassette or magnetic tape file.

The format of the .OPEN command is:

- AC0 - Byte pointer to file or device name terminated by a null. The pointer must be even, i. e., the string must begin on a full word boundary.
- AC1 - Characteristic inhibit mask.

```
.SYSTEM
.OPEN n ; OPEN CHANNEL n
error return
normal return
```

In general, the user will wish to preserve all device characteristics as defined by the system. This can be accomplished by preceding the .OPEN call with a SUB 1,1 instruction, passing an all-zero mask in AC1.

As an example, if the user wishes to read an ASCII tape without parity from the high speed reader, he may inhibit parity checking by the following command sequence:

```
      LDA    0, READR
      LDA    1, MASK
      .SYSTEM
      .OPEN  3

READR:    .+1*2
          .TXT  *PTR *
MASK:     .DCPCK ;PARITY CHARACTERISTIC
```

Possible errors resulting from the .OPEN command are:

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
0	ERFNO	Illegal channel number.
1	ERFNM	Illegal file name.
12	ERDLE	File does not exist.
21	ERUFT	Attempt to use channel already in use.
31	ERSEL	Unit improperly selected.
60	ERFIU	Attempt to open a busy MCA unit.

FILE AND INPUT/OUTPUT COMMANDS (Continued)

Before free format I/O operations can be performed, the cassette or magnetic tape unit must be initialized (.INIT) and opened (.MTOPTD). To prevent further I/O access from occurring, the device is released (.RLSE) and its channel is closed (.CLOSE).

Open a File or Device (.OPEN)

Before other I/O commands can be used, files and devices must be linked to channels. Two parameters must be passed to .OPEN : a byte pointer to the device or file name string, and a characteristic inhibit mask.

For every bit set in the characteristic inhibit mask word a corresponding device characteristic is inhibited. (This mask is ignored when .OPEN is opening a file.) Furthermore, these characteristics will be inhibited for as long as the device remains open. The following lists the bit assignments, characteristic mnemonics, and the characteristics in the inhibit mask:

<u>Bit</u>	<u>Mnemonic</u>	<u>Meaning</u>
1	DCC80	80-column device.
2	DCLTU	Device changing lower case ASCII to upper case.
3	DCFFO	Device requiring a form feed on open.
4	DCFWD	Full word device (reads or writes more than a byte).
6	DCLAC	Device requiring line feeds after carriage returns.
7	DCPCK	Input device requiring a parity check; output device requiring parity computation.
8	DCRAT	Output device requiring a rubout after every tab.
9	DCNAF	Output device requiring nulls after every form feed.
10	DCKEY	A keyboard input device.
11	DCTO	A teletype output device.
12	DCCNF	Output device without form feed hardware.
14	DCCGN	Output device without tabbing hardware.
15	DCCPO	Output device requiring leader/trailer.

If an MCA line is being opened, AC1 cannot contain a characteristic inhibit mask. Instead, for receiver lines, AC1 must be cleared to all zeroes. If a transmitter line is to be opened and the default number of retries (specified at RTOSGEN time) is to be used, AC1 must be cleared to all zeroes. However, if a different timeout value is to be specified, bit 15 of AC1 must be set to one (and all other bits in AC1 must be cleared). The actual specification of a retry count will then be deferred to the time the write sequential I/O command (.WRS) is issued.

Open a Device for Appending (.APPEND) (Continued)

```
.SYSTEM .  
.APPEND n  
error return  
normal return
```

Possible errors resulting from the .APPEND command are:

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
0	ERFNO	Illegal channel number.
21	ERUFT	Attempt to use channel already in use.

Close a File or Device (.CLOSE)

This command closes a device (performing any housekeeping required like trailer output) and frees the device channel. If a file is closed, the file's channel is released. The format of the .CLOSE command is:

```
.SYSTEM  
.CLOSE n ;CLOSE CHANNEL n  
error return  
normal return
```

Possible errors resulting from a .CLOSE command are:

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
0	ERFNO	Illegal channel number.
15	ERFOP	Attempt to reference a channel not in use.

Close all Files and Devices (.RESET)

This command causes all currently open files and devices to be closed. The format of the .RESET command is:

```
.SYSTEM  
.RESET  
error return  
normal return
```

The error return is never taken.

Get the Number of a Free Channel (.GCHN)

This call enables the user to obtain the number of a channel that is currently unused, if any, so that a file may be opened on this channel via one of the file open calls. .GCHN does not open a file on a free channel; it merely indicates a channel that is free at the moment. Thus if .GCHN is issued in a multitask environment where it is followed by a call to one of the file open commands, the channel may not be free by the time the file open call is issued. To solve this problem, the user should process error return ERUFT ("Channel already in use") given by the file open command by reissuing the call to .GCHN; this will ensure that a truly free channel is discovered.

The format of this call is:

```
.SYSTEM
.GCHN
error return
normal return
```

Upon a normal return, the channel number is returned in AC2:

AC2 - Free channel number

One possible error return may occur.

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
21	ERUFT	No channels are free.

Open a Device for Appending (.APPEND)

An alternate system call for opening a device is implemented that is identical to .OPEN in every respect except that it may not be used with disk files.

This routine requires the same two input parameters as does .OPEN, viz., a byte pointer to the device name string, and a characteristic inhibit mask. The mask bit definitions are as described earlier for .OPEN.

The format of the .APPEND command is:

- AC0 - Byte pointer to device name. The pointer must be even, i.e., the string must begin on a full word boundary. The string must be terminated by a null.
- AC1 - Characteristic inhibit mask.

Open a Cassette or Magnetic Tape Unit for Free Format I/O (.MTOFD) (Continued)

Input parameters to this call are the same as for the .OPEN command. .MTOFD positions a free format tape to a desired file, since the file name passed to .MTOFD will be of the form MTn:m or CTn:m. The input parameter to .MTOFD is as follows:

AC0 - Byte pointer to cassette or magnetic tape file name terminated by a null. The pointer must be even, i.e., the string must begin on a full word boundary.

The format of the MTOFD command is:

```
.SYSTEM
.MTOFD n           ;n IS THE CHANNEL NUMBER
error return
normal return
```

Possible errors resulting from a .MTOFD command are:

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
0	ERFNO	Illegal channel number.
1	ERFNM	Illegal file name.
12	ERDLE	File does not exist.
21	ERUFT	Attempt to use channel already in use.
31	ERSEL	Unit improperly selected.

Release a Magnetic Tape Unit or Cassette (.RLSE)

To prevent further file access to either a magnetic tape or cassette unit, the system command .RLSE must be issued. This command prevents further file access until the device is initialized (see the .INIT command), and causes the tape to be rewound to BOT.

One input parameter is required for this call:

AC0 - Byte pointer to device name. The byte pointer must be even, i.e., the string must begin on a full word boundary.

The format of this call is:

```
.SYSTEM
.RLSE
error return
normal return
```

Initialize a Magnetic Tape Unit or Cassette (.INIT)

Before free format tape I/O can occur, the magnetic tape unit or cassette must be initialized. Initialization for a magnetic tape unit or cassette consists of making the device known to the system, rewinding the tape to BOT, and resetting the tape file pointer to zero.

A full initialization causes the tape to be rewound to BOT and two end-of-file marks to be written. This effectively erases any information which may have been on the tape. A partial initialization causes the tape to be rewound to BOT and resets the system tape file pointer to zero; no end of file mark is written.

Input parameters to this call are as follows:

- AC0 - Byte pointer to cassette or magnetic tape name (e.g., MT0, CT2, etc.).
The byte pointer must be even, i.e., the string must begin on a full word boundary.
- AC1 - -1 for full initialization; other values indicate a partial initialization.

The format of the .INIT command is:

```
.SYSTEM
.INIT
error return
normal return
```

Possible errors resulting from an .INIT command are:

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
2	ERICM	Illegal command for device.
31	ERSEL	Unit improperly selected ("unit ready" not set).
36	ERDNM	Device not in system.
45	ERIBS	Device already initialized.

Open a Cassette or Magnetic Tape Unit for Free Format I/O (.MTOFD)

Before free format reading or writing can be performed on either an initialized magnetic tape or cassette unit, the device must be opened and be linked to an RTOS channel. The RTOS command to open files or devices (.OPEN) cannot be used to open a magnetic or cassette tape unit for free format I/O; only .MTOFD can be used to open these devices.

Read a Line (.RDL)

This command causes an ASCII line to be read. Required input to this command is a byte pointer in AC0 to the starting byte address within the user area into which the line will be read. This area should be 133 bytes long.

Reading will be terminated normally after a carriage return, form feed, or null is detected. Reading will be terminated abnormally after reading 132 (decimal) characters without detecting a carriage return, form feed, or null; upon detecting a parity error; or upon an end of file. In all cases the read byte count, including the carriage return, form feed, or null, will be returned in AC1.

If the read is terminated because of a parity error, the character having the incorrect parity will be stored (with its parity bit cleared) as the last character read. The byte pointer to the character in error can always be computed as:

$$(AC0) + (AC1) - 1 \quad *$$

The format of the .RDL command is:

AC0 - Starting byte address.

```
.SYSTEM  
.RDL n ;READ FROM CHANNEL n  
error return  
normal return
```

AC1 - Byte count.

Possible errors resulting from a .RDL command are:

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
0	ERFNO	Illegal channel number.
3	ERICD	Illegal command for device.
6	EREOF	End of file.
15	ERFOP	Attempt to read an unopened file.
22	ERLLI	Line limit (132 characters) exceeded.
24	ERPAR	Parity error.
47	ERSIM	Simultaneous reads on same QTY line.
106	ERCLO	QTY input terminated by channel close.

* (ACn) means "contents of ACn"

Release a Magnetic Tape Unit or Cassette (.RLSE) (Continued)

Possible errors resulting from an .RLSE command are:

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
2	ERICM	Illegal command for device.
31	ERSEL	Unit improperly selected ("unit ready" not set).
36	ERDNM	Device not in system.

Read a Series of Disk Blocks (.RDB)

This command causes a series of disk blocks to be read into a user-specified area in core memory. This routine requires four input parameters including the number of the channel upon which the disk file was previously opened. These parameters are: the starting disk block number within the disk file, the number of disk blocks to be read, and the starting (i. e., lowest) core address to receive the data. In the case where the channel number n in the command argument is set to 77, the right byte of AC2 contains the channel number. The left byte of AC2 contains the number of blocks to be transferred. Each block that is read contains 256 16-bit words of disk storage.

The format of the .RDB command is:

- AC0 - Starting core address to receive the data.
- AC1 - Starting relative disk block number.
- AC2, left byte - Number of blocks to be read.
- AC2, right byte - Optional channel number.

```
.SYSTEM  
.RDB n ;n IS THE CHANNEL NUMBER.  
error return  
normal return
```

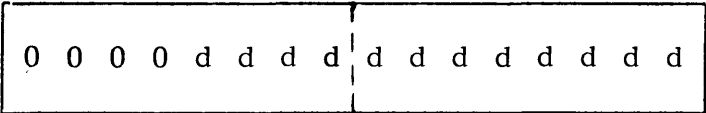
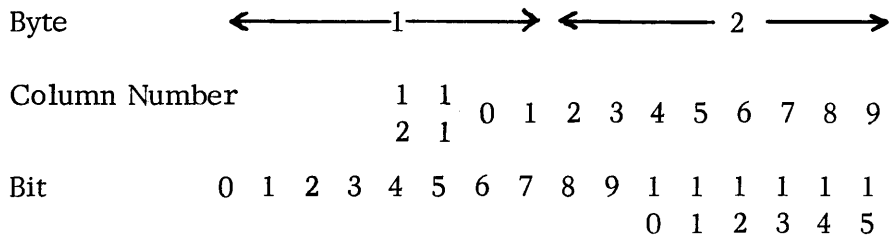
Possible error codes resulting from an .RDB command are:

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
0	ERFNO	Illegal channel number.
3	ERICD	Illegal command for device.
6	EREOF	End of file.
15	ERFOP	File is not opened.

Upon detection of error EREOF the error code is returned in the right byte of AC2; the left byte of AC2 contains the partial read count.

Use of the Card Reader in .RDL and .RDS Commands (Continued)

In an .RDS command, the card is read in image binary. Each two bytes will be used to store a single column. The packing is done as follows:



The "d's" will be 1 for every column punched.

The byte count and byte pointer input to an .RDS command must both be even.

Read Sequential (.RDS)

This command causes a sequential mode data transfer, causing data to be read exactly as is. Required input parameters to this command are as follows: a byte pointer to the starting byte address within the user area into which data will be read, and the number of bytes ($2^{15}-1$ maximum) to be read.

The format of the .RDS command is:

AC0 - Starting byte address.
AC1 - Number of bytes to be read.

```
.SYSTEM  
.RDS n ;READ SEQUENTIAL FROM CHANNEL n  
error return  
normal return
```

Possible errors resulting from an .RDS command are:

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
0	ERFNO	Illegal channel number.
3	ERICD	Illegal command for device.
15	ERFOP	Attempt to read an unopened device or file.
47	ERSIM	Simultaneous reads on same QTY line.
106	ERCLO	QTY/MCA input terminated by channel close.

Use of the Card Reader in .RDL and .RDS Commands

When using \$CDR or \$CDR1, the end of file condition on a .RDL will occur only if a special end of file code is detected in column 1 of a card. This code is "all rows punched." It can be punched on a 029 keypunch by multipunching "+", "-", and "0" through "9."

Note also that a Hollerith to ASCII translation only occurs if a .RDL has been requested. The translation assumes 029 keypunch codes. A table of Hollerith-ASCII translation is given in this section.

A .RDL is terminated upon the first trailing blank (which is translated as a carriage return). If all 80 columns are data, a carriage return is appended as the eighty-first character. If an illegal character is detected, a back slash is substituted for the illegal character.

CHAR.	CARD CODE	ASCII CODE	CHAR.	CARD CODE	ASCII CODE
@	8-4	100	`	8-1	140
A	12-1	101	a	12-0-1	141
B	12-2	102	b	12-0-2	142
C	12-3	103	c	12-0-3	143
D	12-4	104	d	12-0-4	144
E	12-5	105	e	12-0-5	145
F	12-6	106	f	12-0-6	146
G	12-7	107	g	12-0-7	147
H	12-8	110	h	12-0-8	150
I	12-9	111	i	12-0-9	151
J	11-1	112	j	12-11-1	152
K	11-2	113	k	12-11-2	153
L	11-3	114	l	12-11-3	154
M	11-4	115	m	12-11-4	155
N	11-5	116	n	12-11-5	156
O	11-6	117	o	12-11-6	157
P	11-7	120	p	12-11-7	160
Q	11-8	121	q	12-11-8	161
R	11-9	122	r	12-11-9	162
S	0-2	123	s	11-0-2	163
T	0-3	124	t	11-0-3	164
U	0-4	125	u	11-0-4	165
V	0-5	126	v	11-0-5	166
W	0-6	127	w	11-0-6	167
X	0-7	130	x	11-0-7	170
Y	0-8	131	y	11-0-8	171
Z	0-9	132	z	11-0-9	172
[12-8-2	133	{	12-0	173
\	0-8-2	134		12-11	174
]	11-8-2	135	}	11-0	175
␣ or ␣	11-8-7	136	~	11-0-1	176
- or -	0-8-5	137	DEL	12-9-7	177

Hollerith - ASCII Translation Table (Continued)

CHAR.	CARD CODE	ASCII CODE
NUL	12-0-9-8-1	000
SOH	12-9-1	001
STX	12-9-2	002
ETX	12-9-3	003
EOT	9-7	004
ENQ	0-9-8-5	005
ACK	0-9-8-6	006
BEL	0-9-8-7	007
BS	11-9-6	010
HT	12-9-5	011
LF	0-9-5	012
VT	12-9-8-3	013
FF	12-9-8-4	014
CR	12-9-8-5	015
SO	12-9-8-6	016
SI	12-9-8-7	017
DLE	12-11-9-8-1	020
DC1	11-9-1	021
DC2	11-9-2	022
DC3	11-9-3	023
DC4	4-8-9	024
NAK	9-8-5	025
SYN	9-2	026
ETB	0-9-6	027
CAN	11-9-8	030
EM	11-9-8-1	031
SUB	9-8-7	032
ESC	0-9-7	033
FS	11-9-8-4	034
GS	11-9-8-5	035
RS	11-9-8-6	036
US	11-9-8-7	037

CHAR.	CARD CODE	ASCII CODE
SPACE	NO PUNCHES	040
!	12-8-7	041
"	8-7	042
#	8-3	043
\$	11-8-3	044
%	0-8-4	045
&	12	046
' or '	8-5	047
(12-8-5	050
)	11-8-5	051
*	11-8-4	052
+	12-8-6	053
,	0-8-3	054
-	11	055
.	12-8-3	056
/	0-1	057
0	0	060
1	1	061
2	2	062
3	3	063
4	4	064
5	5	065
6	6	066
7	7	067
8	8	070
9	9	071
:	8-2	072
;	11-8-6	073
<	12-8-4	074
=	8-6	075
>	0-8-6	076
?	0-8-7	077

Hollerith - ASCII Translation Table

Write a Line (.WRL) (Continued)

the 133rd character is not a carriage return, form feed, or null. In all cases, AC1 will contain, upon termination of the write, the number of bytes written from the user area. The termination of a write line on a null allows formatting of output without forcing a carriage return.

The format of the .WRL command is:

AC0 - Starting byte address.

```
.SYSTM
.WRL n           ;WRITE FROM CHANNEL n
error return
normal return
```

AC1 - Byte count.

Possible errors resulting from the .WRL command are:

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
0	ERFNO	Illegal channel number.
3	ERICD	Illegal command for device.
15	ERFOP	Attempt to write an unopened file.
22	ERLLI	Line limit (132 characters) exceeded.
47	ERSIM	Simultaneous writes on same QTY line.
106	ERCLO	QTY output terminated by channel close.

Write Sequential (.WRS)

This command writes binary data from a user core area. In addition to the channel number, two parameters are input: a byte pointer to the starting address of the user area, and the number of bytes ($2^{15}-1$ maximum) to be written. The byte pointer must be even if this call is issued for an MCA transmission. To transmit an end-of-file in an MCA transmission, a byte count of zero is used in AC1 and the contents of AC0 are disregarded. Also, if the MCA transmit line was opened with a timeout to be specified, the left byte of AC2 input to .WRS specifies the length of the timeout period. Each unit period is approximately 200 milliseconds, and acceptable multiples input in AC2 are 1 to 255 decimal. A zero value yields the default timeout period specified at RTOSGEN time.

Write a Series of Disk Blocks (.WRB)

This command causes a series of data blocks, each 256 16-bit words in size, to be written onto disk from a user-specified area in core memory. This routine requires four input parameters including the number of the channel upon which the disk or disk file was previously opened. These parameters are: the starting relative disk block number within the file, the number of disk blocks to be written, and the starting (i.e., lowest) core address to transmit the data. In the case where the channel number n in the command argument field is set to 77, the right byte of AC2 contains the channel number. The left byte of AC2 contains the number of blocks to be written.

The format of the .WRB command is:

- AC0 - Starting core address to transmit the data.
- AC1 - Starting relative disk block number.
- AC2, left byte - Number of blocks to be read.
- AC2, right byte - Optional channel number.

```
.SYSTEM
.WRB   n           ;n IS THE CHANNEL NUMBER
error return
normal return
```

Possible error codes resulting from an .WRB command are:

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
0	ERFNO	Illegal channel number.
3	ERICD	Illegal command for device.
15	ERFOP	File is not opened.
27	ERSPC	Disk space is exhausted.

Upon detection of error ERSPC, the error code is returned in the right byte of AC2; the left byte of AC2 contains the partial write count.

Write a Line (.WRL)

This command writes a line to a user ASCII file. Required input to this command is a byte pointer in AC0 defining the user core area from which writing will occur.

Characters are written with even parity and writing will be terminated normally upon encountering a null, carriage return, or form feed. Writing will be terminated abnormally after the transmission of 132 (decimal) characters if

Free Format Tape I/O (.MTDIO) (Continued)

bit 0: set to 1 for even parity, 0 for odd parity.

bits 1-3: set to one of the seven command codes which follow.

0 - read (words)*

1 - rewind the tape

3 - space forward (over records or over a file of any size)

4 - space backward (over records or over a file of any size)

5 - write (words)

6 - write end of file

7 - read device status word

bits 4-15: word or record count. If 0 on a space forward (or space backward) command, the tape is positioned to the beginning of the next (or previous) file on the tape. If 0 on a read or write command 4096 words are read (or written) unless an end of record is detected.

AC2 - channel number if n equals 77₈. (Note that when a file is opened for free format I/O, it is opened globally. That is, all files on the specified device can be accessed.)

The format of the .MTDIO command is:

.SYSTEM:

.MTDIO n ;n IS THE CHANNEL NUMBER

error return

normal return

Upon a rewind or read status command, if no system error is detected, AC2 returns containing a status word with one or more of the following bits set:

bit 0 - error (bit 1, 3, 5, 6, 7, 8, 10 or 14 is set to 1)

bit 1 - data late

bit 2 - tape is rewinding

bit 3 - illegal command

bit 4 - high density if set to 1; otherwise, low density (always 1 for cassettes)

bit 5 - parity error

bit 6 - end of tape

bit 7 - end of file

* When attempting to read a 7-track tape with odd parity (i.e., a tape not written on an RTOS system), the end-of-file is not detected by the controller; the first word in the next record is read as 007417. Thus the first record of each file (after the first file) has appended to it the end-of-file of the previous file.

Write Sequential (.WRS) (Continued)

The format of the .WRS command is:

- AC0 - Starting address of the data within the user area.
- AC1 - Byte count.
- AC2, left byte - Optional timeout constant.
- AC2, right byte - Optional channel number.

```
.SYSTEM  
.WRS n ;WRITE TO CHANNEL n  
error return  
normal return
```

Possible errors are:

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
0	ERFNO	Illegal channel number.
3	ERICD	Illegal command for device.
15	ERFOP	Attempt to reference an unopened file or device.
47	ERSIM	Simultaneous writes on same QTY line.
101	ERDTO	Timeout has occurred.
103	ERMCA	No complementary MCA request.
104	ERSRR	Incomplete MCA transmission due to short receiver request.
106	ERCLO	MCA/QTY output terminated by channel close.
113	ERNMC	No MCA receiver request.

Free Format Tape I/O (.MTDIO)

This command permits the operation of magnetic tape and cassette units on a machine level: To read and write words in variable length records of from 2 to 4096 words within a data record, to space forward or backward from 1 to 4095 data records or to the start of a new data file, and to perform other similar machine level operations. Before free format I/O can be performed on a tape unit, that unit must first have been opened for free format I/O by means of the .MTPD system command.

The input parameters to .MTDIO are as follows:

- AC0 - Core data address, if data is to be transferred.
- AC1 - Command word, subdivided into the following fields:

Free Format Tape I/O (.MTDIO) (Continued)

COMMAND	RETURN	AC1	AC2
Any MTDIO command with a system error detected	Error	Same as input	System error code
Rewind (TSW bit 0 = 0)	Normal	Original input is lost	Transport status word (TSW)
Rewind (TSW bit 0 = 1)	Error		
Read Status (TSW bit 0 = 0)	Normal	Original input is lost	TSW (status bit 0 is 0)
Read Status (TSW bit 0 = 1)	Error	Original input is lost	TSW (status bit 0 is 1)
Read, Write, Space Forward, Space Backward; bit 0 in TSW is set to 0	Normal	Word or Record count	TSW
Read, Write, Space Forward, Space Backward; bit 0 in TSW is set to 1	Error (only after 10 retries in read/write)		
Write end-of-file (TSW bit 0 = 1)	Error	Original input is lost	TSW

The system will perform 10 read retries before taking the error return. For write errors, the following sequence will be performed 10 times before taking the error return: backspace and write 9 times, then backspace, erase a 2-1/2" length of tape, and write. Thus the system will perform 100 write retries before signaling an error.

Free Format Tape I/O (.MTDIO) (Continued)

- bit 8 - tape is at load point
- bit 9 - 9-track if set to 1; otherwise, 7-track (always set to 1 for cassettes)
- bit 10 - bad tape or write failure
- bit 11 - send clock (always set to zero for cassettes)*
- bit 12 - first character (always set to zero for cassettes)*
- bit 13 - write-protected or write-locked
- bit 14 - odd character (always set to zero for cassettes)
- bit 15 - unit ready.

For more information about each of these status bits, see "Nova Cassette" or "Magnetic Tape" in How To Use the Nova Computers.

Upon a read, write, space forward, or space backward command, if no system error is detected, AC1 contains the number of words written (or read) or the number of records spaced. A word or record count is returned in AC1 upon a premature end of file.

Upon detection of a system error, the error return is taken and AC2 is set to contain one of the following:

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
0	ERFNO	Illegal channel number.
3	ERICD	Illegal command for device (i. e., improper open).
15	ERFOP	Attempt to reference an unopened file.
30	ERFIL	File read error.

If no system error is detected but a hardware error occurs (i. e., bit 0 of the status word is set), the error return is taken and AC2 is set to the transport status word. If no system error and no hardware error occurs, the normal return is taken and the transport status word is returned in AC2.

The following table summarizes the return taken and contents of AC1 and AC2 with different MTDIO command selections.

* Bits used for maintenance only.

Wait for a Keyboard Character (.WCHAR)

This command suspends the caller until either a specified character is typed onto any console keyboard or the call is reissued by another task to terminate this keyboard wait. Only one task may be suspended for a keyboard character wait at any one moment.

The required input to this call is either the keyboard character which will ready the task or -1, terminating the keyboard character wait and readying the suspended task. These parameters are input via AC0. Since the calling task may be readied by either the transmission of a specified keyboard character or by the keyboard wait call being terminated, an appropriate code is returned in AC1 when the normal return is taken. This code will be either the device code of the console keyboard which issued the requested wait character, or -1; -1 indicates that the previous wait was terminated.

The format of this call is:

AC0 - Wait character in right byte, or -1 to terminate another task's wait request.

.SYSTEM
.WCHAR
error return
normal return

AC1 - Device code of the keyboard transmitting the wait character, or -1. Minus 1 indicates that the previous wait request was terminated.

The error return is taken if a second task tries to suspend itself for a keyboard character while another task is still suspended for a wait character. In this case, AC2 is set to the following:

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
47	ERSIM	A previous wait-character request is outstanding.

MEMORY SIZE COMMANDS

RTOS provides a pair of system commands used to determine the highest location of the loaded user program (NMAX), the highest memory address available in user address space (HMA), and a means to increase or decrease the address space allocated to the user program by varying NMAX. NMAX is a pointer

TELETYPEWRITER AND VIDEO DISPLAY COMMANDS

Transfer of single ASCII characters between \$TTI/\$TTO and AC0 is handled by the system commands .GCHAR and .PCHAR. No channel is required for the transfers, and \$TTI/\$TTO is always available without requiring a prior .OPEN command.

An additional system call exists which allows a task to be readied upon detection of a user-defined character input via a teletype or display keyboard.

Get a Character (.GCHAR)

This command returns a character input via \$TTI to AC0. The character is right adjusted in AC0 with bits 0-8 cleared. No channel is required; the \$TTI is always used as input for this command. The format of the .GCHAR command is:

```
.SYSTEM
.GCHAR
error return
normal return
```

AC0, bits 9-15 - ASCII input character

No error return is possible from this command.

Put a Character (.PCHAR)

This command transmits a character in AC0, right adjusted, to \$TTO. No channel is required, and the \$TTO is always used with this command. The format of the .PCHAR command is:

AC0, bits 9-15 - ASCII output character

```
.SYSTEM
.PCHAR
error return
normal return
```

No error return is possible from this command.

Allocate Memory by Changing NMAX (.MEMI) (Continued)

NMAX will not be changed if the new value would be equal to or higher than the lowest address of the binary loader. No check is made as to whether or not the user decreases NMAX below its original value (as determined at relocatable load time) nor, if a symbol table resided in upper memory, whether NMAX is increased beyond the bottom of the symbol table.

The format of the .MEMI command is:

AC0 - NMAX increment or decrement:

.SYSTEM
.MEMI
error return
normal return

AC1 - New NMAX.

There is one error which may result from a .MEMI command:

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
26	ERMEM	Attempt to overwrite the binary loader.

SYSTEM RETURN COMMANDS

These calls return control to their error returns unconditionally.

System Return (.RTN)

This command stops all tasks (except the caller), closes all channels, and returns control unconditionally to the error return; no normal return is reserved. The format of the .RTN command is:

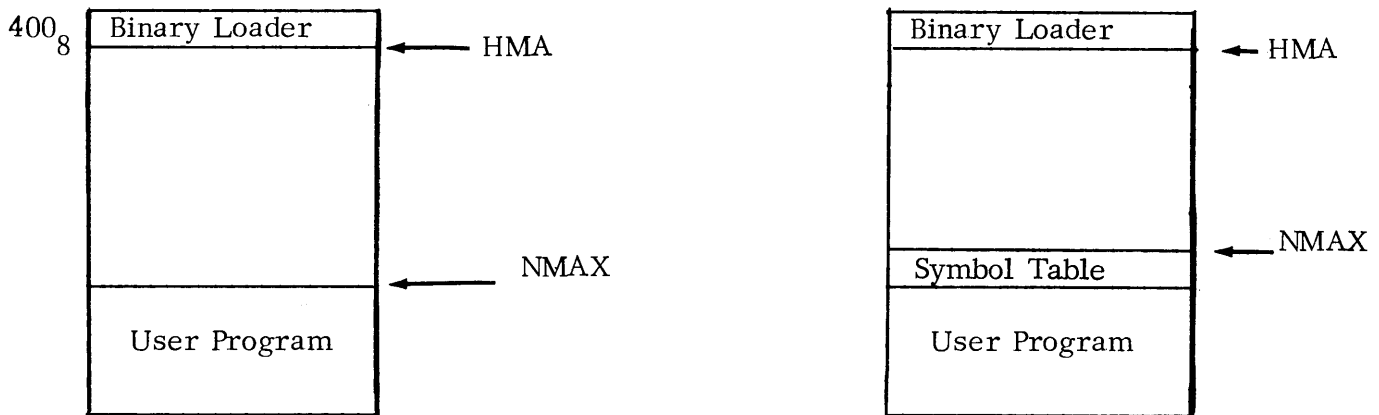
.SYSTEM
.RTN
error return

The following error code is returned:

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
23	ERRTN	Attempt to restore a nonexistent image (as in RDOS).

MEMORY SIZE COMMANDS (Continued)

contained in the User Status Table at displacement USTNM; this table is discussed in Chapter 5, SYSTEM ORGANIZATION. (Note that the /S switch must not be used in the RLDR command.)



Memory Maps with and without Symbol Table

Determine Available Memory (.MEM)

This command returns the current value of NMAX and the value of HMA. HMA represents the location immediately below the bottom of the binary loader (or the top of the symbol table). A SUB 1, 0 instruction after the .MEM call determines the additional amount of memory available to the user program by putting its value in AC0.

The format of the .MEM command is:

```
.SYSTEM
.MEM
error return
normal return
```

AC1 - NMAX.
AC0 - HMA.

There are no error returns from this command.

Allocate Memory by Changing NMAX (.MEMI)

This command returns the current value of NMAX and the value of HMA. HMA represents the location immediately below the bottom of the binary loader (or the top of the symbol table). A SUB1, 0 instruction after the .MEM call determines the additional amount of memory available to the user program by putting its value in AC0.

Delay the Execution of a Task (.DELAY) (Continued)

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
2	ERICM	Illegal system command (i. e., no RTC in system).

Get Today's Date (.GDAY)

This command requests the system to return the number of the current day, month, and year. The day is returned in AC0, the month in AC1, and the year in AC2. The format of the .GDAY command is:

.SYSTEM
.GDAY
error return
normal return

AC0 - Day of the month.
AC1 - Month of the year.
AC2 - Year.

The error return is never taken.

Set Today's Date (.SDAY)

This command permits the system calendar to be set to a specific date. The system will increment the date when the time of day passes 23 hours, 59 minutes, and 59 seconds. The caller passes the number of the day within the month in AC0, the number of the month in AC1 (January is month number 1), and the current year in AC2. The format of the .SDAY command is:

AC0 - Day of the month.
AC1 - Month of the year.
AC2 - Year.

.SYSTEM
.SDAY
error return
normal return

One possible error return is:

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
41	ERTIM	Illegal day, month or year.

Get the Time of Day (.GTOD)

This command requests the system to pass the current time in hours, minutes and seconds to the caller. The format of the .GTOD command is:

```
.SYSTEM
.GTOD
error return
normal return
```

AC0 - Second.
AC1 - Minute.
AC2 - Hour (using a 24-hour clock).

No error return is possible.

Set the Time of Day (.STOD)

This command permits the caller to set the system clock to a specific hour, minute, and second. The format of the .STOD command is:

AC0 - Second.
AC1 - Minute.
AC2 - Hour (using a 24-hour clock).

```
.SYSTEM
.STOD
error return
normal return
```

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

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
41	ERTIM	Illegal time of day.

Examine the System Real Time Clock (.GHRZ)

This system call permits the caller to examine the frequency of the real time clock (the frequency was set when the RTOS system was generated). One of five frequency codes is returned in AC0, as described below. The format of the .GHRZ command is:

Examine the System Real Time Clock (.GHRZ) (Continued)

.SYSTEM
.GHRZ
error return
normal return

- AC0: 0 - there is no real time clock in the system.
1 - the frequency is 10HZ.
2 - the frequency is 100HZ.
3 - the frequency is 1000HZ.
4 - line frequency is 60HZ.
5 - line frequency is 50HZ.

The error return is never taken.

Define a User Clock (.DUCLK)

This command permits the definition of a user clock. When the user-defined interval expires, the task scheduler and multitask environment--if any--are placed in suspension, and control goes to a user-specified routine outside the task environment. No task calls (other than .UCEX and .IXMT) may be issued from this interrupt routine, since multitask activity is in suspension. Only one user clock may be defined at any one moment.

The format of the .DUCLK command is:

- AC0 - Number of RTC pulses during each user clock interval.
AC1 - Address of user interrupt routine.

.SYSTEM
.DUCLK
error return
normal return

Only one error condition is possible:

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
45	ERIBS	A user clock already exists.

Exit from a User Clock Routine (.UCEX)

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, AC3 must be loaded with the return address that it contained upon entry to the routine, and task call .UCEX must be issued.

The format of this call is:

AC3 - Return address upon entry to routine.

.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.

Remove a User Clock (.RUCLK)

This system command removes a previously defined user clock from the system.

The format of this call is:

.SYSTEM
.RUCLK
error return
normal return

The error return is never taken.

CHAPTER 3

TASK CALLS

The following is a list of all RTOS task call mnemonics:

.ABORT	Terminate a task immediately.
.AKILL	Kill all tasks of a specified priority.
.ARDY	Ready all tasks of a specified priority.
.ASUSP	Suspend all tasks of a specified priority.
.DQTSK	Dequeue a queued task.
.IDST	Get a task's status by I. D. number.
.IXMT	Transmit an interrupt message.
.KILAD	Define a kill-processing address.
.KILL	Kill the calling task.
.PRI	Change the calling task's priority.
.QTSK	Queue a task for periodic execution.
.REC	Receive a task message.
.SUSP	Suspend the calling task.
.SMASK	Modify the current interrupt mask.
.TASK	Create a task.
.TIDK	Kill a task specified by I. D. number.
.TIDP	Change the priority of a task specified by I. D. number.
.TIDR	Ready a task specified by I. D. number.
.TIDS	Suspend a task specified by I. D. number.
.UCEX	Exit from a user clock routine.
.UIEX	Exit from a user interrupt routine.
.UPEX	Exit from a user power fail routine.
.XMT	Transmit a task message.
.XMTW	Transmit a task message and wait for its receipt.

Multitasking Concepts Summary

A full description of RTOS multitasking concepts is given in Chapter 1 of this manual and in the Introduction to RTOS, 093-000093. The following summary information is given to review these concepts.

Before a task can be run, it must be made known or initiated to the system. Tasks can be initiated by either the .TASK or .QTSK task calls. .TASK simply initiates a task, while .QTSK initiates the task for execution on a periodic basis.

Tasks which have been initiated into the system exist in one of three states: execution, ready, or suspended. The executing task is that task which is currently

Multitasking Concepts Summary (Continued)

in control of the CPU. A ready task is a task which is awaiting being raised to the execution state. A suspended task is one which, for one reason or another, is awaiting being raised to the ready state and can never gain control until it is so raised. Calls `.SUSP` and `.ASUSP` can be used to place one or more tasks in the suspended state. `.ARDY` is used to raise a group of tasks which are all at the same priority to the ready state.

Tasks are not only distinguished by their system states; they are also differentiated by priority and optionally by identification numbers. Although task priority is defined at the time that each task is initiated, task priority can be changed by the `.PRI` call. Task identification numbers are also established when a task is initiated. Several task calls are used to perform task functions on specific tasks identified by I.D. number. These calls are `.IDST`, `.TIDK`, `.TIDP`, `.TIDR`, and `.TIDS`.

A mechanism is provided for transmitting and receiving one-word messages between single tasks only. This mechanism can also be used to lock a task process, preventing multiple tasks from entering the process concurrently. One-word messages are deposited in locations whose contents are set to zero when they contain no message. If several tasks attempt to receive a message from the same address, only the highest priority task will receive the message.

The `.REC` and `.XMT` commands can be used to lock and unlock a process or data base which is shared by several tasks, preventing more than one task at a time from accessing the data base or the process path. In essence, the procedure is to define a synchronization word, the message location, which all tasks will attempt to receive. The task in control of the locked resource then issues an `.XMT` to the synchronization word when the resource is to be made available to the other waiting tasks. The highest priority task waiting to receive (`.REC`) the synchronization word is then readied and gains unique control of the resource. This task, in turn captures the use of the resource until it unlocks the resource by issuing an `.XMT` to the synchronization word, etc.

This technique requires that the locking facility be initialized before any tasks use it. Initialization can be performed either by setting the synchronization word initially to a non-zero value, or by having an initialization task issue an `.XMT` to the synchronization word.

The operating system provides a variety of means to terminate task operations. Tasks can be killed within a user program in an orderly fashion, or task operations can be halted abruptly (`.ABORT`). Tasks can be killed in an orderly fashion either singly by an I.D number (`.TIDK`), as a priority group (`.AKILL`),

Multitasking Concepts Summary (Continued)

or the calling task can kill itself (.KILL). To ensure that a task can be terminated in an orderly fashion, RTOS provides a facility to define for each task a special reprieve routine which will gain control upon an attempted orderly kill.

Upon most orderly task terminations, .AKILL or .TIDK, each task to be terminated is readied unless it was suspended due to a .SYSTEM call. Thus if it was suspended by a .REC, .XMTW, .SUSP, or .TIDS task call, the suspension would be lifted. If the task were in suspension due to an outstanding .SYSTEM call, that call would be completed before the task was readied. In either case, after the task to be killed has been elevated to the ready state, one of two actions then occurs depending upon the intention of the user. First, if no reprieve address is provided, then the task is simply terminated.

Alternatively, if the user wishes, a special kill-processing or reprieve address could have been specified for the task. If such an address has been specified, then when the task to be killed receives control, control goes to this special processing address. This facility gives the user flexibility in providing an orderly release of resources should the task be killed. The kill-processing routine can act as a reprieve, since the task executing this routine will not actually be terminated until it itself issues a .KILL call. Thus the kill-processing routine can also be used as a validation procedure to determine whether or not the target task should be terminated.

The case of self-termination, .KILL, is special. If a task attempting to terminate itself has a kill-processing address specified, then upon issuing the .KILL call this task will be readied and will gain control in its turn at its kill-processing address. If it has defined no such address, then the task will be terminated immediately.

Whether orderly kills or aborts are used to terminate a task, when the task is terminated its TCB is relinquished to the free TCB pool for possible use in the initiation of other tasks.

Tasks which were initiated by a .QTSK call have their periodic execution halted by means of a .DQTSK call. If a queued task is currently running, however, it will continue to run until it terminates itself or is terminated.

All RTOS task calls except .SMSK, .UCEX, .UIEX and .UPEX are described in this chapter in alphabetical order. .UCEX is found in Chapter 2, and the remaining task calls are described in Chapter 4.

Abort a Task (.ABORT)

The .ABORT task call causes a specified task to be readied immediately and to execute the equivalent of a .KILL task call as soon as it gains control of the CPU. The exact time of completion of the .KILL is dependent on the priority of the aborted task relative to other ready tasks. For example, a task attempting to perform a write sequential of 500 bytes might be aborted after writing any number of bytes. The task which is to be aborted is specified by I.D. number. Thus the caller may abort either itself or some other ready or suspended task.

Outstanding operations performed by the task, like waiting for a message transmission/reception (.XMTW/.REC), are terminated. Likewise, all system calls are aborted with the exception of calls performing QTY or MCA I/O. QTY and MCA I/O can be aborted by closing their channel(s) with a .CLOSE or .RESET system command.

The format of this call is as follows:

AC1 - I.D. of the task to be aborted.

.ABORT
error return
normal return

The contents of AC0 is lost upon return.

The error return is taken under one of two conditions:

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
61	ERTID	An I.D. of zero was specified, or no such task I.D. was found.
110	ERABT	The specified task was performing QTY or MCA I/O.

Kill All Tasks of a Specified Priority (.AKILL)

This command either kills all tasks of a given priority or transfers control to their kill-processing addresses. All TCBs that are deleted from the active queue are placed in the free TCB chain. Tasks in suspension due to .XMTW, .TIDS, .REC, or .SUSP calls will be raised to the highest priority ready state immediately. If an attempt is made to kill a task suspended by an outstanding .SYSTM call, that task will be raised to the highest priority at the completion of the .SYSTM call. The calling task itself may be deleted by this command.

Kill All Tasks of a Specified Priority (.AKILL) (Continued)

The format of this call is:

AC0 - Task priority.

.AKILL
normal return

There is no error from this call. If no tasks exist with the priority specified in AC0, no action is taken. If all tasks become deleted, the effect is to close all the channels and to idle the system, since control returns to the task scheduler.

Ready All Tasks of a Specified Priority (.ARDY)

This call readies all tasks which were previously suspended by .ASUSP (.SUSP or .TIDS) whose priority is specified in AC0. That is, bit 1 in word TPRST of each TCB (see Chapter 5) that was set by a previous call to .ASUSP, .SUSP, or .TIDS is now reset. Tasks suspended for other reasons too (e. g., outstanding system calls) will only be readied when the task is fully ready, i. e., bits 0 and 2 are also reset. The format of this call is:

AC0 - Task priority.

.ARDY
normal return

There is no error return from this call. If there are no tasks with the priority specified in AC0, no action is taken and control goes to the normal return.

Suspend All Tasks of a Given Priority (.ASUSP)

This command suspends all tasks with the priority given in AC0. The calling task itself may be suspended by this call. All tasks suspended by .ASUSP (including those additionally suspended for other reasons such as an outstanding system call or waiting for a task message transmission) will remain suspended until readied by an .ARDY or .TIDR command.

The format of this call is:

AC0 - Task priority.

.ASUSP
normal return

Suspend All Tasks of a Given Priority (.ASUSP) (Continued)

There is no error return from this call. If no tasks exist with the given priority, no action is taken and control goes to the normal return.

Dequeue A Core-resident or Overlay Task (.DQTSK)

This call causes a task which has been queued for execution by task call .QTSK to be dequeued. In effect, the .DQTSK call bypasses the value which is currently stored in displacement QNUM of the task's User Task Queue Table. If at some later moment the task is requeued by a call to .QTSK, the queuing process will resume its normal course since .DQTSK does not actually modify the contents of QNUM.

The format of this call is as follows:

AC1 - I. D. of the task to be dequeued.

.DQTSK
error return
normal return

Upon a normal return, AC2 returns the base address of the task's queue table (QPC). If the error return is taken, the following code is given:

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
61	ERTID	Task I. D. error.

Get a Task's Status (.IDST)

This command obtains a code describing a task's status. The task whose status is to be obtained is specified by inputting its identification number in AC1. The format of this call is:

AC1 - Task I. D. number

.IDST
normal return

Get a Task's Status (.IDST) (Continued)

- 0 - Ready.
- 1 - Suspended by a .SYSTEM call.
- 2 - Suspended by .SUSP, .ASUSP, or .TIDS.
- 3 - Suspended by .XMTW or .REC.
- 4 - Not used.
- 5 - Suspended by .ASUSP, .SUSP, or .TIDS and by .SYSTEM.
- 6 - Suspended by .XMTW or .REC and by .SUSP, .ASUSP, or .TIDS.
- 7 - Not used.
- 10- No task exists with the specified I. D. number.

There is no error return from this call.

Transmit a Message from a User Interrupt Service Routine (.IXMT)

Whenever a device requiring special user service generates an interrupt request, (see Chapter 4), the entire task environment becomes frozen until servicing of the special user interrupt is completed. All tasks will resume their former states when the environment is restarted unless the user transmits a message to one of them by means of the .IXMT call from the interrupt service routine. In the latter case, rescheduling occurs when the task environment is restarted.

If the task for which the non-zero message is intended has issued a .REC for the message, the task state is changed from suspended to ready even though task activity is in suspension. If more than one task is awaiting a message at this location, only one will receive the message and be readied. Contents of all accumulators are destroyed upon return from .IXMT, so the user is cautioned to restore AC2 and AC3 before attempting an exit from the service routine.

As with .XMT (described later in this chapter), .IXMT causes a non-zero message to be deposited in a location. The contents of this location must be zero at the time .IXMT is invoked, or else the location will be deemed to be already in use.

The format of this call is:

- AC0 - Message location.
- AC1 - Message.

.IXMT
error return
normal return

Transmit a Message from a User Interrupt Service Routine (.IXMT) (Continued)

The error return is taken if the message address is already in use (i. e., if its contents are non-zero).

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
43	ERXMT	Message location is in use.

Define a Kill-Processing Address (.KILAD)

The .KILAD task call permits a user to define a special address which will gain control the first time that the termination of a task, the "target task," is attempted. The second time that a termination of this task is attempted, the task will be terminated without control transferring to the kill-processing address.

The kill address can be defined to provide a means of releasing system resources before termination occurs. Such resources as overlay areas, channels, user devices and user clock definitions must be released explicitly by the user. Having released these resources and performed any other desired functions, the task must then itself issue a .KILL call in order for its termination to occur. Since this would be the second attempt to terminate the task, termination would occur immediately.

If, on the other hand, the target task decides not to terminate itself, then before branching out of the kill-processing routine it should issue a .KILAD call to the same or to a different kill-processing routine. This will ensure that if an attempt is made later to kill this task, it will not be killed immediately but will branch again to its kill-processing routine.

Users should note that a task in a kill-processing routine is in execution at the highest priority. Thus such routines will retain control until they relinquish this control by a task state transition or by a priority level change.

The format of the .KILAD task call is as follows:

AC0 - Address of the kill-processing routine.

.KILAD
normal return

There are no error returns from this call.

Delete a Calling Task (.KILL)

This command deletes the calling task's TCB from the active queue, and places it in the free element TCB chain. The calling task is the only task that may be deleted via this command. There is no return from this call. If a kill-processing address has been defined for this task, then control goes to this address. Otherwise, control returns to the task scheduler which allocates system resources to the highest priority task that is ready.

The format of this call is:

.KILL

There is no return from this call. Control goes to the task scheduler.

Change the Priority of a Task (.PRI)

This command changes the priority of the calling task. The calling task will be assigned the lowest position in the new priority class. That is, equal priority tasks receive control on a round-robin basis, and this task will be the last task in this priority class to be allocated CPU control by the scheduler.

The format of this command is:

AC0 - New task priority.

.PRI
normal return

There is no error return from this command. If a priority greater than 255_8 is requested, only the value in bits 8 through 15 will be accepted.

Queue a Core-resident Task (.QTSK)

This command periodically initiates a task and queues it for execution. If there is no TCB currently available for the creation of the new task, this call will be carried out as soon as a TCB becomes available. If two tasks are queued for execution at the same time of day, the higher priority task will receive control first. After each time that a new task is created and activated by this call, it is the user's responsibility to insure that this task is killed, suspended, etc.

AC 2 contains the starting address of a table, QTLN words long (see PARR, Appendix C), which describes the priority of the task, the time that is to be created, etc. The following discusses the entries in this table.

Queue a Core-resident Task (.QTSK) (Continued)

User Task Queue Table

<u>Displacement</u>	<u>Mnemonic</u>	<u>Meaning</u>
0	QPC	Starting address of the task.
1	QNUM	Number of times to queue the task (-1 if the task is to be queued an unlimited number of times).
2	QTOV	Reserved for compatibility with RDOS.
3	QSH	Starting hour (-1 if the task is to be queued immediately).
4	QSMS	Starting second in hour (reserved but unused if QSH=-1)
5	QPRI	Task I. D. /task priority.
6	QRR	Rerun time increments in seconds.
7	QTLNK	Same as TLNK of queued task's TCB (set by system).
10	QOCH	Reserved for compatibility with RDOS.
11	QCOND	Reserved for compatibility with RDOS.
12	QLDST	Reserved for compatibility with RDOS.

Entry QPC is reserved for the starting address within the task where execution will commence. QNUM is an integer value describing the number of times the task will be queued. The task will be queued QNUM times (or without limit if QNUM=-1) unless the task call .DQTSK is issued. This call halts the queuing of the specified task, essentially bypassing the value specified by QNUM.

Entries QSH, QSMS, and QRR all affect the time that the task will be created. QSH contains the hour in the day, and QSMS contains the second within that hour that the task will become created. If QSH contains -1, the task will be created immediately. QRR contains the increment in seconds between each time the task will be created.

QPRI contains the task I. D. (if any) in its left byte and task priority in its right byte. If a task with the same I. D. exists at the time this task is activated, this task's I. D. number will be cleared to zero. QTLNK is maintained by the system.

With AC2 containing a pointer to QPC of the User Task Queue Table, the calling sequence of this task call is:

Queue a Core-resident or Overlay Task (.QTSK) (Continued)

.QTSK
error return
normal return

If the error return is taken, AC2 will contain the following error code:

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
50	ERQTS	Illegal information in Task Queue Table.

If the error return is not taken, control returns to the task issuing the call at the normal return based on the task's priority; the calling task does not become suspended.

Receive a Message (.REC)

This command returns a message in AC1 that another task or interrupt service routine has posted by means of a transmit command, and restores the contents of the message location to all zeroes. Only one task at a time can receive a message from a given location.

If the transmitter has not yet posted a message for the receiving task, the receiver becomes suspended until the message is issued. If the message has already been issued and if the task has not also been suspended by some other event, control returns to the task scheduler.

The format of this command is:

AC0 - Message address.

.REC
normal return.

AC1 - Message.

There is no error return from this command.

Suspend a Task (.SUSP)

This command places the calling task in the suspended state by setting bit 1 of the task's status and priority word. The format of this call is:

.SUSP
normal return

Suspend a Task (.SUSP) (Continued)

There is no error return. The suspended task remains suspended until it is readied by an .ARDY or .TIDR command.

Create a Task (.TASK)

This command creates a new task in the user environment, and assigns to it a TCB from the TCB pool allocated during system generation. This command creates a task at a specified priority and assigns a unique identification number (I. D.) to the task, if desired. When the user program is started, only one task (the default task) exists. Thus this command is used to start up a multitask environment.

The new task can be assigned any priority from 0 through 255 decimal, and any task I. D. in the same range. If the priority input to this command is 0, the priority of the caller will be assigned to the new task. More than one task with an I. D. of zero can exist. This call will pass to the new task the contents of the caller's AC2; thus this accumulator can be used for relaying an initial one-word message to the newly created task.

The format of this command is:

- AC0, left byte - New task's I. D.
- AC0, right byte - New task's priority.
- AC1 - New task's starting address.
- AC2 - Caller's AC2 passed to the new task.

.TASK
error return
normal return

If the error return is taken, AC2 will contain one of the following error codes:

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
42	ERNOT	No TCB's available.
61	ERTID	Same I. D. number (except 0) already assigned.

Kill a Task Specified by I. D. Number (.TIDK)

This call kills only that task whose identification number is specified in AC1. The format of this command is:

Kill a Task Specified by I. D. Number (.TIDK) (Continued)

AC1 - I. D. of task to be killed.

.TIDK
error return
normal return

If the error return is taken, AC2 will contain the following error code:

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
61	ERTID	No task exists with this I. D.

Change the Priority of a Task Specified by I. D. Number (.TIDP)

This command changes the priority of that task whose identification is specified by the contents of AC1. The new priority to be assigned to the task is given in AC0, bits 8 to 15. Thus the format of this task call is as follows:

AC0, right byte - New priority.
AC1 - I. D. of task whose priority is to be changed.

.TIDP
error return
normal return

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

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
61	ERTID	No task exists with this I. D.

Ready a Task Specified by I. D. Number (.TIDR)

This command readies only that task whose identification number is input in AC1. That is, this command resets bit 1 in TPRST of this task's TCB which was set by a previous call to .ASUSP, .SUSP, or .TIDS. The format of this call is:

AC1 - I. D. of task to be readied.

.TIDR
error return
normal return

Ready a Task Specified by I. D. Number (. TIDR) (Continued)

If the error return is taken, AC2 will contain the following error code:

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
61	ERTID	No task exists with this I. D.

Suspend a Task Specified by I. D. Number (. TIDS)

This command suspends only that task whose identification number is input in AC1. That is, this call sets bit 1 in word TPRST of the specified task's TCB. The format of this command is:

. TIDS
error return
normal return

If the error return is taken, AC2 will contain the following error code:

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
61	ERTID	No task exists with this I. D.

Transmit a Message (.XMT), and Wait (.XMTW)

These two calls permit the sending of a one-word non-zero message by one task to an empty (all-zero) message location for another task. The difference between these commands is .XMT simply causes the message to be deposited, while .XMTW deposits the message and suspends the caller until the message is received. .XMTW will not cause the caller to be suspended if a .REC has already been issued for this message.

The format of this call is:

AC0 - Message address.
AC1 - Message.

.XMT (or .XMTW)
error return
normal return

Transmit a Message (.XMT), and Wait (.XMTW) (Continued)

The error return is taken if the message address is already in use (i.e., if the contents are non-zero). AC2 will then contain the following error code:

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
43	ERXMT	The message address is already in use.
115	ERXMZ	Zero message word.

Locking a Process via the .XMT/.REC Mechanism

The .REC and .XMT commands can be used to lock and unlock a process or data base which is shared by several tasks, preventing more than one task at a time from accessing the data base or the process path. In essence, the procedure is to define a synchronization word, the message location, which all tasks will attempt to receive. The task in control of the locked resource then issues an .XMT to the synchronization word when the resource is to be made available to the other waiting tasks. The highest priority task waiting to receive (.REC) the synchronization word is then readied and gains unique control of the resource. This task, in turn, captures the use of the resource until it unlocks the resource by issuing an .XMT to the synchronization word, etc.

This technique requires that the locking facility be initialized before any tasks use it. Initialization can be performed either by setting the synchronization word initially to a non-zero value, or by having an initialization task issue an .XMT to the synchronization word.

CHAPTER 4

USER INTERRUPTS AND POWER FAIL / AUTO RESTART PROCEDURES

SERVICING USER INTERRUPTS

User devices may be identified either at the time an RTOS system is generated (RTOSGEN time) or at run time. This chapter describes the procedure for identifying a user device at run time, and describes the special considerations applying to special, high priority user interrupt devices.

Upon detection of an interrupt request, the system will be dispatched through the device interrupt vector table, .ITBL. In this table are pointers to Device Control Tables (DCTs) for devices established at RTOSGEN time, whether system or user devices. Procedures for writing a device driver for insertion in the system at RTOSGEN time are given in DGC application note 017-000006, User Device Driver Implementation in the Real Time Operating System.

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:

<u>Displacement</u>	<u>Mnemonic</u>	<u>Purpose</u>
0	DCTSV	Pointer to the state save area (an 8-word area).
1	DCTMS	Interrupt service mask.
2	DCTIS	Interrupt service routine address.

DCTSV is a pointer to an eight-word state variable save area used by the system to store the PC, accumulators, carry, etc. 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.

SERVICING USER INTERRUPTS (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. (Caution: RDOS 4.00 does not place the DCT address in AC2.) Exit is accomplished by issuing task call .UCEX; this call may be issued in both single and multitask environments.

All multitask environment activity ceases at the moment 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 multi-task 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 3.

Identifying User Interrupt Devices (.IDEF)

In order to introduce to the system those devices (not identified at RTOSGEN time) whose interrupts the system is to recognize, the system call .IDEF must be issued. This call places an entry in the device interrupt vector table, .ITBL. Required inputs to this call are the device code of the user device and the starting address of this device's DCT. The format of this call is:

- AC0 - Device code of the user device.
- AC1 - Starting address of the user device's DCT.

.SYSTEM
.IDEF
error return
normal return

Possible error messages are:

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
36	ERDNM	Illegal device code (>77g). Device code 77g is reserved for the power monitor/auto restart option.
45	ERIBS	Interrupt device code in use.

Exit from a User Interrupt Routine (.UIEX)

Upon a user device interrupt, AC3 will contain the return address upon entry to the user routine and AC2 will contain the DCT address. To return from the user

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

interrupt routine, AC3 and AC2 must be restored to the values they contained upon entry to the routine, and task call.UIEX must be issued. (Caution: RDOS 04 will execute this call correctly without the DCT address in AC2.)

The format of this call is:

- AC2 - DCT address.
- AC3 - Return address upon entry to routine.

.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. Rescheduling occurs only if a task state change occurred.

Modifying the Current Interrupt Mask (.SMSK)

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.
 - AC2 - DCT address.
- .SMSK
normal return

There is no error return possible from this call. This call may be issued in a single task environment. (Caution: RDOS 04 will execute this call correctly without the DCT address in AC2.)

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 control table which is to be removed. The format of this call is:

- AC0 - Device code.
- .SYSTEM
.IRMV
error return
normal return

One possible error message may be given:

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

POWER FAIL/AUTO RESTART PROCEDURES

RTOS provides software support for the power fail/automatic restart option. Upon detection of a loss of power, 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:

- 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 printers, 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 FAIL/AUTO RESTART PROCEDURES (Continued)

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`. To use `.IDEF` for this purpose, `AC0` must be input with 778 and `AC1` must input the starting address of the user power up routine. Exit from this power up routine is accomplished by task call `.UPEX`, described below.

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 service routine, `AC3` must be loaded with this return address and task call `.UPEX` must be issued.

The format of this call is:

AC3 - Return address upon entry to the routine.

`.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.

HIGH PRIORITY USER INTERRUPT SERVICE

As described in Chapter 6 and in Appendix B, special high priority interrupt devices may be incorporated into an RTOS system at `RTOSGEN` time. The real time clock and power fail/auto restart device are two such high priority interrupt devices; users may also specify custom high priority interrupt service routines.

All high priority devices have entries in a high priority interrupt dispatch table, `.HINT`. Entries in this table are scanned whenever an interrupt occurs, and only if no high priority device has caused an interrupt will control branch through the normal interrupt table, `.ITBL`. All other system devices, and user devices announced at run time (via system call `.IDEF`), have entries in `.ITBL`.

Interrupts are disabled whenever high priority interrupt service is being performed. Users writing high priority interrupt service routines must also conform to several programming conventions. In general, these conventions are as follows:

HIGH PRIORITY USER INTERRUPT SERVICE (Continued)

- 1) Issue no task or system calls.
- 2) Save and restore accumulators and Carry if used by this routine.
- 3) Save the contents of location 0, and place a HALT instruction in location 0 (optional).

The state of Carry and the contents of accumulators AC0 through AC2 must be saved within this routine if they are altered in this routine, and these state variables must be restored before leaving the routine. AC3 is saved by the system in location .SAC 3 (a location within module INTD), and AC3 too must be restored before exit is accomplished even if the routine didn't use AC3. The contents of location 0 will contain the return address needed for exit; this address should be stored in a user-provided location, e.g., RET, and a HALT instruction should be stored in location 0. This practice is adhered to by RTOS to capture program control in the event of system failure.

The final two instructions which must be executed when leaving a high priority interrupt service routine are to enable interrupts and then to perform an indirect JMP to the location containing the original return PC, e.g., RET. Control will then pass to the next instruction which would have been executed had no high priority interrupt occurred. The following instruction sequence accomplishes these operations.

```
.EXTN .SAC3
.
.           ; RESTORE AC0, AC1, AC2, CARRY
.
LDA 3 @ SAC3
INTEN
JMP @ RET
SAC3: .SAC3
RET:  .BLK 1
.END
```

CHAPTER 5

MULTIPLE PROCESSOR SYSTEMS

MULTIPLE PROCESSOR PROGRAMMING

All features of RTOS discussed in previous chapters are available to systems with two or more processors. Additional hardware support extended to multiple processor systems by RTOS is in the form of a Multiprocessor Communications Adapter (MCA), option 4038.

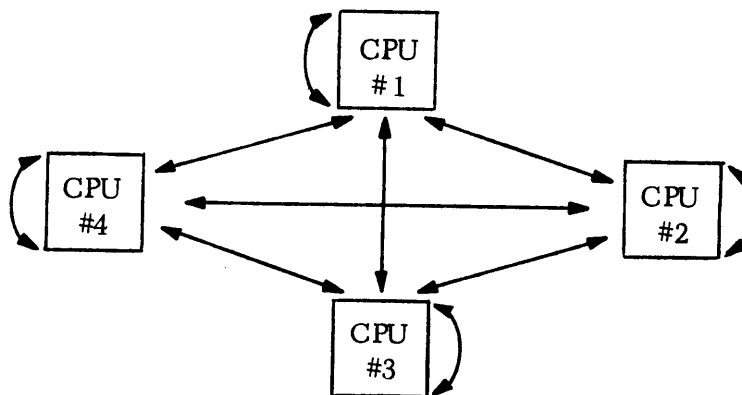
Data Transmissions

The type 4038 Multiprocessor Communications Adapter receiver/transmitter (MCAR/MCAT) makes it possible for full duplex interprogram communications to take place, in blocks of up to 8192 bytes, via the data channel. MCA support can be given to a single processor in a multiple processor system so that an RTOS program running in one processor can communicate with an RTOS program running in another processor or with either a foreground or background program running under RDOS in another processor. Each CPU may communicate with any of up to 14 other CPUs.

Each MCA line corresponds to a file name of the following form:

MCAT:mm or MCAR:nn

where mm represents a receiver unit number from 1 - 15 inclusive and where nn represents a transmitter unit number in the range 0 - 15. Thus a four-CPU, RTOS-only system would be logically configured with 10 separate lines if every possible communications link were to be used.



Data Transmissions (Continued)

If CPU #1 wanted to read from CPU #3, each unit would have to issue the following sets of instructions:

<u>Unit #1</u>	<u>Unit #3</u>
.OPEN <u>n</u> ;OPEN MCAR:3	.OPEN <u>n</u> ;OPEN MCAT:1
.RDS <u>n</u>	.WRS <u>n</u>

Note that units #1 and #3 are operating under distinct operating systems. Thus, in the illustration on the previous page there is no correspondence between channel n for unit #1 and channel n for unit #3.

If, in a receive request, unit number zero is specified to be the transmitter (e.g., MCAR:0), the receive request becomes generalized to indicate that any unit may transmit to this receiver. Thus if unit #1 had three outstanding receive requests, MCAR:4, MCAR:3, and MCAR:0, it could receive concurrent transmissions from three sources: a transmission unit from unit #4, a transmission from unit #3, and a message from any other unit that chose to transmit to it.

A timeout can occur only in the MCA transmitter; the receiver can wait indefinitely. The timeout period ranges from approximately 10 milliseconds to approximately 655 seconds. The default timeout, specified at RTOSGEN time, may be superseded by specifying a different timeout both when the transmitter is opened and when the write sequential is issued.

Get the Current CPU's MCA Number (.GMCA)

It is possible to get the MCA unit number in the CPU which is currently executing a user program. To obtain the unit number, system call .GMCA is issued. The format of this command is as follows:

```
.SYSTEM
.GMCA
error return
normal return
```

If the normal return is taken, the MCA unit number is returned in AC1. If the error return is taken, the following error code will be input in AC2:

<u>AC2</u>	<u>Mnemonic</u>	<u>Meaning</u>
36	ERDNM	Device not in system (i. e., no MCA was specified at SYSGEN time in this operating system).

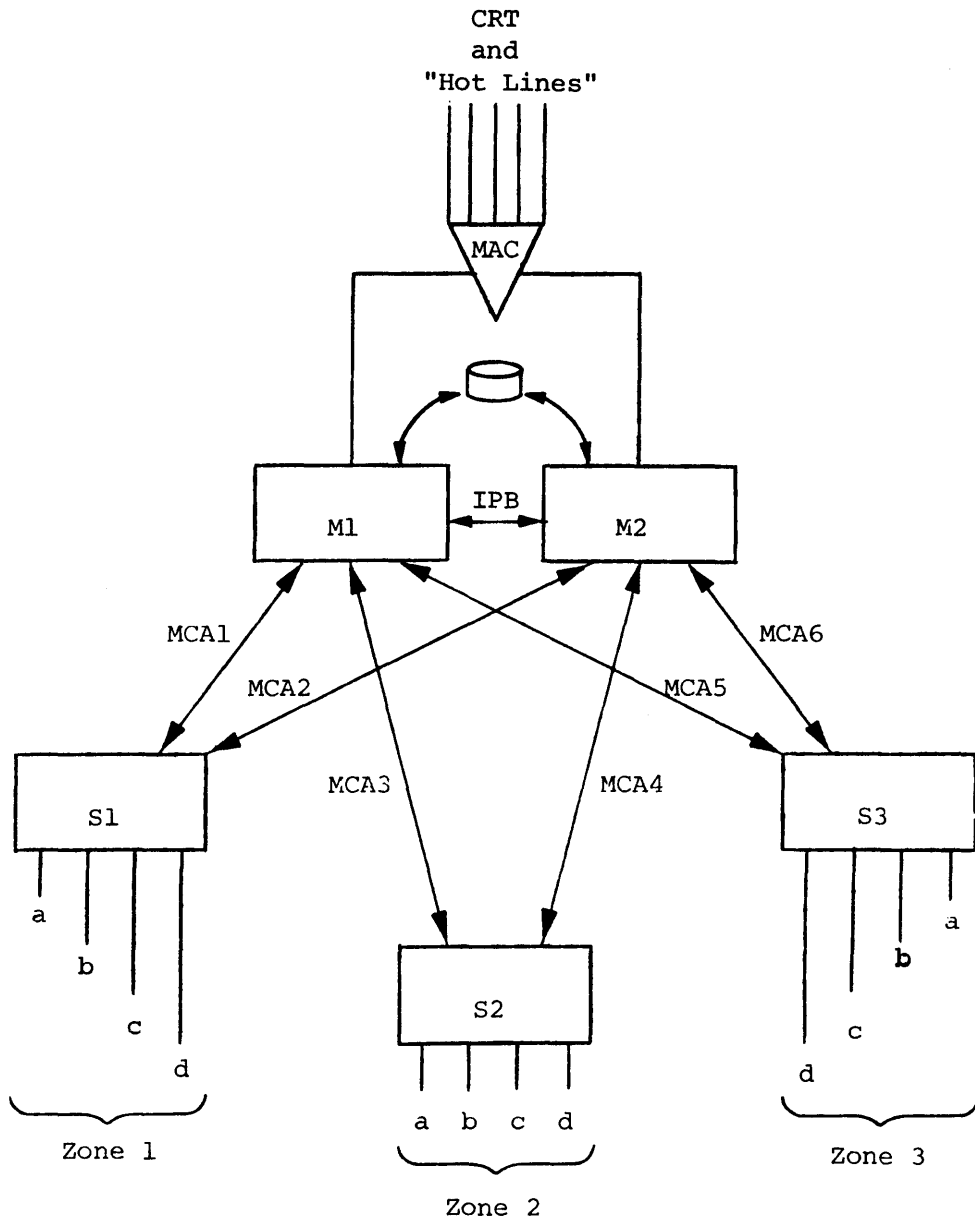
MULTIPROCESSOR SYSTEM ILLUSTRATION

Consider the following application for a multiprocessor system. A large laboratory complex needs an automated system to control the environmental conditions within the complex, to keep track of the number of personnel at locations throughout the complex, and to monitor the complex for alarm conditions (alerting key personnel when a condition cannot be corrected by the system itself). Moreover, the system must be fail-safe, and can allow down-time for no longer than a few seconds.

Such a system might well be configured along the lines suggested by the illustration at the end of this section. Two master CPUs, a Dual NOVA system running under RDOS, are connected in redundant fashion so that if one fails, the other detects this failure and gains immediate control. The masters access a common data base which contains, among other information, alarm messages and destinations to which they should be sent in the event of an alert. Also contained in this file space is a log of the current master's activity, so that if it should experience failure, the alternate master CPU would have a record of recent events. An IPB connects the masters so that they may access common disk files and so that one may act as a watchdog on the other's behavior.

There are three slave CPUs, each of which monitors and controls various parameters within one zone of the building complex. Each slave is capable of monitoring and adjusting both the humidity and the temperature of each zone. Additionally, each slave keeps track of the positions of personnel within each zone. Finally, each slave monitors its zone for the occurrence of alarm conditions, and it can perform limited response to emergencies, e.g., it can activate a sprinkler system if fire is detected. The functions performed by each slave are relatively simple and could be performed by NOVA 2 computers running under RTOS.

Each slave has a high speed data channel line, MCA1 through MCA6, to each of the two master computers, so that continuous status reports can be generated by them for transmission to CRT monitors via the Multiline Asynchronous Controller, MAC. The MAC also has direct "hot lines" to key personnel (security guards, fire station personnel, etc.) who should be alerted in the event of an emergency.



a - temperature sensing and control
 b - census taking
 c - humidity sensing and control
 d - intrusion/fire/smoke alarm and control

M1 - Master CPU
 M2 - Back-up Master CPU
 S1,S2,S3 - Slave CPUs

(MCA1 through MCA6 depict software lines, not physical cabling.)

MULTIPROCESSOR SYSTEM ILLUSTRATION

CHAPTER 6

SYSTEM ORGANIZATION

This chapter describes the collection of tables and fixed locations which are used by programs running under the real time operating system. As described in Appendix C, each user program supported by RTOS is loaded with an RTOS module generated by the RTOSGEN program, followed by user-supplied RTOS drivers and the RTOS system library. Loading itself is accomplished by means of the stand-alone or SOS extended relocatable loader or the RDOS loader. At the completion of loading, pointers and tables are found as illustrated in the RTOS Core Map shown on the following page.

RTOS Page Zero

Locations 0 through 15 are reserved for use by the system and cannot be taken by user programs. Location 0 receives the current PC upon each interrupt, and location 1 contains a pointer to the system interrupt dispatch logic. This is usually either .HINT, the high priority interrupt dispatcher, or .INTP, the regular interrupt processor. These modules are produced by RTOSGEN.

When a task in RTOS is in the executing state, the CPU is said to be in User Mode. Otherwise (as when RTOS is engaged in some system function like task scheduling) the CPU is said to be in System Mode. Location 5, .SYS. , is a flag which is set to zero when the system is in User Mode, and is set to non-zero in System Mode. Interrupts in a real-time environment occur randomly. Since it is inappropriate for certain interrupt-triggered system functions to be reentrant (e.g., task scheduling) .SYS. serves as an interlock to prevent undesired entries into these routines.

Location 2, BEGIN, contains a pointer to the RTOS initialization program. This program is used to initialize stacks and clear switches in RTOS. The first section of this routine zeroes system switches and initializes all device handlers. The starting task is initially set to a priority of zero, the hardware interrupt mask is made zero, the system is set in User Mode (.SYS. = 0), the real time clock is started, and TCB chain pointers are initialized. The wait character logic, activated by .WCHAR, is also reset.

The last operations performed by the initialization program are to enable the interrupt facility by the INTEN instruction, and to jump to the start of the user program (which must have been specified in an .END statement).

RTOS Core Map

Page Zero

Contents

1	Interrupt service routine address.
2 BEGIN	Starting address for system initializer.
3 CTCB	Address of currently executing task's TCB.
4 SCHED	Entry point to task scheduler.
5 .SYS.	System mode indicator.
6 RLOC	Page zero temporary.
7 IOEND	Entry point to I/O end processor.
10 .CMSK	Current system interrupt mask.
11 DISMISS	Interrupt dismissal address.
12 USTP	Reserved for RDOS/RTOS compatibility; set to 400.
13 TLINK	Entry point to routine linking ready TCB to TCB chain.
14 RSCHD	Entry point to reschedule the system.
15 .TSAVE	Address of TCB state save routine.
16 USP	User Stack Pointer (USP).
17	Entry point to system call processor.
20	First page zero location available to user program.

Page One

400 UST	Start of User Status Table.
426	End of User Status Table.
440	Beginning of NREL area into which RTOS and user modules may be loaded. The following global symbols may be present in the RTOS modules:
.TCBP	Start of TCB pool (total length = no. of TCBS * 12_{10}).
.UFPT	Start of User File Pointers Table, UFPT (total length = no. of channels * 2).
.DTBL	Start of fixed head disk table, DTBL (total length = 1 + 5 * number of disk files defined at RTOSGEN time).
.PTBL	Start of moving head disk table, PTBL (total length = 1 + 6 * number of disk files defined at RTOSGEN time).
.QTBL	Start of 4060 asynchronous multiplexor (QTY) table, QTBL (total length = 10_{10} * number of QTY lines).
.MCTB	Start of Multiprocessor Communication Adapter line table, (total length = 7 + number of adapters in the network * 14_{10}).
.HINT	Start of high priority dispatcher (length = 11_{10} + 3 * number of high priority interrupt devices).
.ITBL	Start of interrupt table, ITBL (64_{10} words long).
.ETBL	End (last location) of ITBL (user power fail handler, if present).
.CHTB	Start of device name table, CHTB (length = 1 + 4 * number of devices in system).
	User program with user device drivers, if any.
	RTOS device drivers.
	RTOS system library modules.

RTOS Page Zero (Continued)

Location 3, CTCB, contains the TCB address of the currently executing task. Location 4, SCHED, points to the main entry in the task scheduler. This entry causes the highest priority ready task (if any) to be executed. Location 14, RSCHD, points to an alternate entry in the scheduler. This entry links the currently executing task's TCB to the ready chain, then transfers control to the entry pointed to by SCHED .

Location 6, RLOC, is a temporary location used by RTOS; location 7, IOEND, is the entry point to the I/O end processor module. This routine is used to handle the end of I/O operations for a device handler at either the interrupt or system level. If while in this routine it is determined that another request is pending, the routine will cause the next I/O operation on the device to be started. .CMSK, location 10, contains the current system interrupt mask.

DISMISS, location 11, contains the interrupt dismissal routine address. USTP, location 12, is reserved for use by RTOS FORTRAN, and points to the start of the User Status Table (location 400). The value "0400" is also equivalent to a "JMP ." instruction, so RTOS transfers control to this location whenever a system panic is detected. System panics result from unknown system errors and are generally unrecoverable; restarting at location 376 will restart the system provided the RTOS program has not been damaged.

Location 13, TLINK, points to a routine which links a ready TCB to the ready chain. This routine is entered by the system whenever a task is raised to the ready state. RSCHD, location 14, contains the entry point to the task scheduler which links the current TCB to the ready chain, then executes the highest priority ready task. Location 15, .TSAVE, contains the address of the TCB state save routine.

Location 16 contains the User Stack Pointer, USP. This location is used by certain high-level languages, among them FORTRAN IV, and is loaded into AC3 by RTOS on return from system or task calls.* AC3 is destroyed whenever any such call is issued, since it is equivalent to a JSR instruction. On return from a call however, AC3 is loaded with the contents of USP.* Thus on NOVA systems and ECLIPSE systems with TMIN, a convenient method of saving AC3 before issuing a call is to first save AC3 in USP. AC3 will then be restored by the system upon returning from the call. Furthermore, since USP is saved in the TCB as part of the state of a task in execution, it may be used as the equivalent of an extra register by tasks without stacks.

*Unless RTOS is running on an ECLIPSE computer with BTMIN. See Chapter 1, System and Task Call Formats.

User Status Table (UST)

The User Status Table (UST) is found at the start of NREL memory. This table is 27₈ words long, and contains information pertaining to the status of the user program. Unused words within the UST are set to -1. The structure of the UST is as follows:

<u>Displacement</u>	<u>Mnemonic</u>	<u>Contents</u>
0	USTPC	Maintained for RDOS compatibility only.
1	USTZM	ZMAX, the lowest unused ZREL memory location.
2	USTSS	The start of the symbol table.
3	USTES	The end of the symbol table (i. e. , its lowest core address).
4	USTNM	NMAX, the lowest unused NREL memory location.
5	USTSA	The user program starting address.
6	USTDA	The address of the debugger.
7	USTHU	The highest address occupied by the user program and RTOS upon completion of loading.
10	USTCS	FORTTRAN common area size.
11	USTIT	— Maintained for RDOS compatibility only.
12	USTBR	— Maintained for RDOS compatibility only.
13	USTCH	Number of tasks (left half), number of channels right half).
14	USTCT	TCB address of the first user task to execute after RTOS initialization.
15	USTAC	Start of ready TCB queue.
16	USTFC	Start of the free (dormant) TCB chain.
17	USTIN	Start of user NREL program (set by the loader).
20	USTOD	— Reserved only for compatibility with RDOS.
21	USTSV	— Reserved for compatibility with RDOS.
22	USTSQ	Start of suspended TCB queue.
23	USTXQ	Start of the .XMTW/.REC queue.
24	USTPQ	Start of internal system queue of tasks being serviced (i. e. , TCBs returning to base level after I/O).
25	USTOS	Scheduler idle counter (used in checking \$PTR timeouts).
26	USTNA	Number of active tasks (TCBs in use).

The last word in the UST is also assigned the mnemonic USTEN.

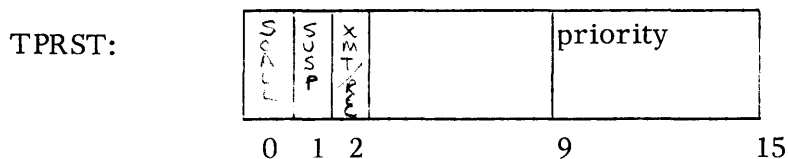
USTEN

Task Control Block (TCB) Pool

Given the asynchronous nature of tasks, the RTOS Task Scheduler must maintain certain status information about each task. This information is retained within a table called a Task Control Block (TCB), and there is one TCB for each task. All TCBs are found in a series or pool following the User Status Table. TCBs constructed for programs run on a NOVA computer are shorter by four words than TCBs for programs run on an ECLIPSE computer. The following illustration describes the structure of all TCBs:

<u>Displacement</u>	<u>Mnemonic</u>	<u>Contents</u>
0	TPC	Carry in bit 0, PC in bits 1-15.
1	TAC0	AC0
2	TAC1	AC1
3	TAC2	AC2
4	TAC3	AC3
5	TPRST	Task status and priority.
6	TSYS	System call word.
7	TLNK	TCB link word (-1 if last TCB in the queue).
10	TUSP	Task USP.
11	TELN	FORTRAN IV variables save area address.
12	TID	Task identifier.
13	TTMP	Used to service .ABORT calls.
14	TKLAD	Task kill address.
15	TSP	Stack pointer (ECLIPSE computer only).
16	TFP	Frame pointer (ECLIPSE computer only).
17	TSL	Stack limit (ECLIPSE computer only).
20	TSO	Overflow address (ECLIPSE computer only).

Word 5, the task status and priority, contains information describing the state of the task, its priority, and whether it has any outstanding message transmit or receive request:



Bit 0 is set to a 1 if the task is suspended due to an outstanding system call. Bit 1 is set to 1 if the task is suspended due to task calls .SUSP, .ASUSP, or .TIDS. Bit 2 is set to a 1 only if the task is suspended due to outstanding task calls .XMTW or .REC. The task priority is contained in bits 9-15.

Task Control Block (TCB) Pool (Continued)

Word 6, TSYS, is used by RTOS in executing system calls. Word 7 contains the starting address of the next TCB in the queue (the last TCB in a queue has a link of -1). Word 12, TID, contains the task's 8-bit identifier in bits 9-15.

TKLAD contains the address which is to receive control upon a task's being killed, if such an address has been defined via a .KILAD call. The remaining four words contain stack state save information which is relevant only for ECLIPSE machines. Nonetheless, these words are reserved for TCBs in all single task programs so that programs such as utilities can be run on both the NOVA and ECLIPSE computers.

User File Pointers Table (.UFPT)

Following the TCB pool is a table called the User File Pointers Table (.UFPT). The purpose of this table is to indicate what device or file is open on which RTOS channels. The .UFPT consists of a series of two-word frames, one for each channel defined for the RTOS system at RTOSGEN time. The first frame represents the device (or file) opened on channel zero, etc.

The two-word frame will contain one of two sets of information, depending upon whether it is a single- or multi-file device which is opened on the designated channel. Frames for all devices contain the device DCT address in displacement 0. Displacement 1 for single-file device frames is unspecified. Displacement 1 of multi-file device frames, however, contains a pointer to a frame within a device file table or within a device driver itself. Device file tables are discussed in the following section. Frames within device file tables describe disk files, QTY lines, or MCA units. Frames for cassettes and magnetic tape units point to unit control tables for these units.

Device File Tables

One or more device file tables may follow the .UFPT. The following devices have special device tables and have no entries in the standard device name table (.CHTB, to be discussed later):

<u>Device</u>	<u>Table Name</u>
fixed head disk	.DTBL
moving head disk	.PTBL
asynchronous mux	.QTBL
Multiprocessor Communications Adapter	.MCTB

Device File Tables (Continued)

<u>Device</u>	<u>Table Name</u>
magnetic tape	.MTU _n
cassette	.CTU _n

The device file table established for fixed head disks is composed of a series of five-word frames, one for each file defined at RTOSGEN time. Each frame contains the name of the file and its contiguous disk block address boundaries. This approach allows four-, five-, or six-character file names to be given to each disk, fully compatible with contiguous disk files as defined in the real time disk operating system, RDOS. Each frame in .DTBL has the following structure:

	<u>Displacement</u>	<u>Contents</u>
.DTBL frame	0-2	File name, left justified, trailing null bytes.
	3	Starting disk block address.
	4	Ending disk block address.

The device file table for moving head disks (cartridge or pack) is similar to .DTBL, but has one additional entry to describe the drive unit number:

	<u>Displacement</u>	<u>Contents</u>
.PTBL frame	0	Drive unit number.
	1-3	File name, left justified, trailing null bytes.
	4	Starting disk block address.
	5	Ending disk block address.

The 4060 asynchronous multiplexor driver (QTY) device table is named .QTBL . This table consists of a series of ten-word frames with one frame reserved for each QTY line; the first frame corresponds to line number 0, the second frame corresponds to line number 1, etc. Each frame in .QTBL has the following structure:

Device File Tables (Continued)

	<u>Displacement</u>	<u>Contents</u>
.QTBL frame	0	Bit zero set if not opened; line number if open.
	1	Receive byte pointer.
	2	Transmit byte pointer.
	3	Read request TCB address.
	4	Write request TCB address.
	5	Read sequential limit; 0 if read line.
	6	Write sequential limit; -1 if finished writing; 0 if write line.
	7	Character hold for echo during read line.
	10	Line feed insertion flag (non-zero for insertions).
	11	Device characteristics:
		DCKEY
	DCPCK	parity check/generation
	DCLAC	line feeds after carriage returns.

The device file table for MCA lines is named .MCTB . This table consists of a series of seven-word frames, each frame reserved for an MCA unit number; each MCA line connects two MCA units (a transmitter and a receiver). The total number of frames equals two times the number of lines defined at RTOSGEN time plus one (for unit number zero reception requests). The first frame corresponds to unit number zero, etc. Each frame in .MCTB has the following structure:

	<u>Displacement</u>	<u>Contents</u>
.MCTB frame	0	List link.
	1	Word count.
	2	Current address.
	3	Device code of the adapter at the other end of the line; code is positioned as in the MCA status words.
	4	Error retry count.
	5	TCB address of task issuing the read or write request; -1 if no task is issuing such a request. This word is set to zero if the line is closed.
	6	Device retry specification input in AC1 to .OPEN .

Device File Tables (Continued)

Line table entries are linked via displacement 0 of each frame. Entries in the chain correspond to MCA units which have MCA transmit or receive requests outstanding.

There are two kinds of unit control tables (UCTs) for magnetic tape and cassette units. A truncated UCT is employed for units which will use only direct or unbuffered I/O, and a standard UCT is used for units which are to utilize both unbuffered and buffered I/O.

Each standard UCT is found in a module entitled MTUn or CTUn. Each of these modules contains a standard UCT followed by an octal 401 word buffer. If unbuffered I/O is specified at RTOSGEN time, a module entitled SMTU or (SCTU for cassettes) is loaded which contains 8 truncated UCTs, one for each possible tape unit.

Each UCT has the structure described below; truncated UCTs contain only the first three words of this structure:

<u>Displacement</u>	<u>Contents</u>
0	Current file number.
1	Status of unit: +1: release of tape unit is in progress. 0: unit is not initialized. -1: unit is initialized. -2: initialization of unit is in progress.
2	Unit number of this UCT (truncated UCT ends here).
3	First byte address of buffer.
4	Size of buffer in bytes.
5	Input buffer byte pointer.
6	Output buffer byte pointer.
7	Number of bytes to be read.
10	Number of bytes written.
11	Pointer into user data area.
12	Counter governing user data area.

High Priority Interrupt Table (.HINT)

If any high priority interrupt devices were defined during system generation, one of two high priority interrupt dispatch tables will be loaded. If only the power fail/ auto restart option was selected in the RTOS system, a truncated high priority interrupt dispatcher will be placed after the last device file table; otherwise, the full high priority interrupt dispatcher, .HINT, will be placed there. These dispatch routines are illustrated on the following page. In essence, the operation of .HINT is as follows. Each high priority interrupt device is examined to see if it generated the interrupt. The power fail monitor is tested first, then the real time clock, and then each of the other devices specified at RTOSGEN time in the order that they were specified during system generation. If the source of the interrupt is found, control is dispatched to its interrupt service routine; otherwise, control is given to the ordinary interrupt dispatcher.

The format of the high priority interrupt dispatcher is as follows:

```

      SKPDZ CPU           ; CHECK FOR POWER FAIL INTERRUPT
      JMP @ A             ; YES. GO TO POWER FAIL INTERRUPT SERVICE.
      STA 3@ B           ; OTHERWISE, SAVE 3
      INTA 3             ; AND GET INTERRUPT DEVICE CODE.
      SKPDZ RTC          ; WAS IT THE REAL TIME CLOCK?
      JMP @ C             ; YES. GO TO RTC INTERRUPT SERVICE
      SKPDZ device1     ; WAS IT DEVICE 1?
      JMP @ D             ; YES. GO TO DEVICE 1 INTERRUPT SERVICE
      :
      SKPDZ devicen
      JMP @ N             ; GO TO DEVICE N INTERRUPT SERVICE, BUT IF
      JMP @ .+1          ; NO HIGH PRIORITY DEVICE INTERRUPT
      .INTD              ; GO TO ORDINARY INTERRUPT DISPATCH ROUTINE
B:    .SAC3
A:    PWRIS             ; POWER FAIL INTERRUPT SERVICE ADDRESS
C:    RTCIS            ; RTC INTERRUPT SERVICE ADDRESS
D:    DV1IS            ; DEVICE 1 INTERRUPT SERVICE
      :
N:    DVNIS            ; DEVICE N INTERRUPT SERVICE.
```

High Priority Interrupt Table (.HINT) (Continued)

The power fail - only interrupt dispatcher looks like the following:

```
SKPDZ CPU      ; POWER FAIL INTERRUPT?
JMP @ .+3      ; YES. GO TO POWER FAIL SERVICE
JMP @ .+1      ; NO, GO TO ORDINARY INTERRUPT DISPATCHER
.INTP
PWRIS          ; POWER FAIL INTERRUPT SERVICE ROUTINE
```

Interrupt Table (.ITBL)

One table which is always loaded is the interrupt table, .ITBL. .ITBL is a 64_{10} -word table which has 64 one-word frames, one for every possible device code. The first entry in the table corresponds to device code zero, the second entry corresponds to device code 1, etc. Table entries corresponding to devices in the system will contain the address of that device's Device Control Table (DCT). Moreover, if the device is a system device, bit zero of this entry will be set to one; if the device is a user device, bit zero will be reset to zero.

The last entry in this table, the entry for device code 77_8 , is named .ETBL. This entry is reserved for a user power fail/auto restart handler address.

System devices will be initialized by the RTOS initialization program .RTOS. No such initialization is performed for user devices. User device drivers must perform their own initialization.

Standard Device Name Table (.CHTB)

The last RTOS table which may be loaded is the name table, .CHTB. This is a table containing entries for single-file devices like the teletypewriter, paper tape reader/punch, card reader, line printer, and plotter. This table is built at system generation time, and consists of a series of four-word frames.

Device entries are listed in this table in the order that the devices are found in .ITBL (i. e., order is by ascending device code). The first three words of each frame contain the system name for the device, left justified and with trailing nulls. The fourth word in each frame contains the base address of the device's DCT. .CHTB is terminated with a -1.

Standard Device Name Table (.CHTB) (Continued)

Thus a typical .CHTB would have the following structure:

\$	T
T	I
null	null
TTIDC	
\$	T
T	O
null	null
TTODC	
~~~~~	
\$	L
P	T
I	null
LPT1DC	
-1	

*****

APPENDIX A

RTOS COMMAND SUMMARY

Call	AC0	AC1	AC2
.ABORT		I. D. of task to be aborted.	
.AKILL ⁽¹⁾	Priority of tasks to be killed.		
.SYSTEM .APPEND <u>n</u>	Byte pointer to device name.	Device characteristics mask (see .OPEN).	Channel number (if <u>n</u> = 77).
.ARDY ⁽¹⁾	Priority of tasks to be readied.		
.ASUSP ⁽¹⁾	Priority of tasks to be suspended.		
.SYSTEM .CLOSE <u>n</u>			Channel number (if <u>n</u> = 77).
.SYSTEM .DELAY			
.DQTSK		I. D. of task to be dequeued.	
.SYSTEM .DUCLK	Number of RTC ticks.	Address of user interrupt routine.	
.SYSTEM ⁽²⁾ .ERTN			Data word to be placed in AC2.
.SYSTEM .GCHAR	bits 9-15: character. bits 0-8: clear.		
.SYSTEM .GCHN			(returned) Free channel number

(1) No error return.

(2) No normal return.

Call	AC0	AC1	AC2
.SYSTM .GDAY	(returned) Day.	(returned) Month.	(returned) Year.
.SYSTM .GHRZ	0: no RTC. 1: 10 HZ. 2: 100 HZ. 3: 1000 HZ. 4: 60 HZ (line frequency) 5: 50 HZ (line frequency)		
.SYSTM .GMCA		(returned) Unit number.	
.SYSTM .GTOD	(returned) Second.	(returned) Minute.	(returned) Hour (using a 24-hr clock).
.SYSTM .IDEF	Device code.	DCT.	
.IDST	(returned) 0: ready. 1: suspended by .SYSTM call. 2: suspended by .SUSP, .TIDS, .ASUSP. 3: waiting for .XMTW/.REC . 4: not used. 5: suspended by .SUSP, ASUSP, or .TIDS and .SYSTM call. 6: suspended by .XMTW/.REC and .SUSP, ASUSP, or .TIDS 7: not used. 10: killed.	bits 8-15: task I.D. number.	
.SYSTM .INIT	Byte pointer to device name.	-1: full init. 0: partial init.	
.SYSTM .IRMV	Device code.		
.IXMT	Message address.	Message (non-zero).	



Call	AC0	AC1	AC2
.KILAD	Kill-processing address.		
.KILL ^{(1) (2)}			
.SYSTEM .MEM	HMA	NMAX	
.SYSTEM .MEMI	NMAX increment or decrement (2's complement).	(returned) New NMAX (after change).	
.SYSTEM .MTDIO <u>n</u>	Core data address, if a data transfer.	bit 0: 1, even parity; 0, odd parity.  bits 1-3: 0 read (words) 1 rewind tape. 3 space forward. 4 space backward. 5 write (words). 6 write EOF. 7 read device status word.  bits 4-15: word or record count. If 0 on space command, position tape to new file.	Channel number (if $n=77$ ). (Status word or system error code if error return; status word if read status normal return.) 1B0: error. 1B1: data late. 1B2: tape rewinding. 1B3: illegal command. 1B4: high density or cassette if 1; low density if 0. 1B5: parity error. 1B6: end of tape. 1B7: end of file. 1B8: tape at load point. 1B9: 9-track or cassette if 1; 7-track if 0. 1B10: bad tape; write failure. 1B11: send clock (0 if cassette) 1B12: first character (0 if cassette). 1B13: write-protected or write-locked 1B14: odd character (0 if cassette). 1B15: unit ready.
.SYSTEM .M TOPD <u>n</u>	Byte pointer to tape file specifier.	Characteristic inhibit mask (see .OPEN).	Channel number (if $n = 77$ ).
.SYSTEM .OPEN <u>n</u>	Byte pointer to file name	1B1: 80-column device 1B2: lower-to-upper case ASCII. 1B3: form feed on open. 1B4: full word device.  (continued on next page)	Channel number (if $n = 77$ ).

- (1) no error return  
(2) no normal return

Call	AC0	AC1	AC2
.SYSTEM .OPEN <u>n</u> (Continued)		1B6: LF after CR. 1B7: parity check/ generation. 1B8: rubout after tab. 1B9: null after FF. 1B10: keyboard input. 1B11: TTY output device. 1B12: no FF hardware. 1B14: no TAB hardware. 1B15: leader/trailer. ("01" if user-specified MCAT timeout).	
.SYSTEM .PCHAR	bits 9-15: character		
.PRI ⁽¹⁾	bits 8-15: new task priority.		
.QTSK			Task Queue Table address.
.SYSTEM .RDB <u>n</u>	Starting core address to receive data.	Starting disk relative block number.	bits 0-7: number of blocks to be read. ⁽²⁾ bits 8-15: channel number (if <u>n</u> = 77). ⁽²⁾
.SYSTEM .RDL <u>n</u>	Byte pointer to user core area.	Read byte count (including terminator) at end of read.	Channel number (if <u>n</u> = 77).
.SYSTEM .RDS <u>n</u>	Byte pointer to core buffer. (even for MCA)	Number of bytes to be read (if EOF detected, partial byte count returned).	Channel number (if <u>n</u> = 77).
.REC ⁽¹⁾	Message address.	Message.	
.SYSTEM .RESET			
.SYSTEM .RLSE	Byte pointer to device name.		
.SYSTEM ⁽³⁾ .RTN			

(1) no error return

(2) if error EREOF, error code in bits 8-15, partial read count in bits 0-7.

(3) no normal return

Call	AC0	AC1	AC2
.SYSTEM .RUCLK			
.SYSTEM .SDAY	Day.	Month.	Year.
.SMSK	New interrupt mask to be ORed with old mask.		DCT address
.SYSTEM .STOD	Second.	Minute.	Hour.
.SUSP ⁽¹⁾			
.TASK	bits 0-7: task I.D. bits 8-15: task priority.	New task entry point address	Message to new task.
.TIDK		bits 8-15: task I.D. number.	
.TIDP		bits 8-15: task I.D. number.	
.TIDR		bits 8-15: task I.D. number.	
.TIDS		bits 8-15: task I.D. number.	
⁽¹⁾⁽²⁾⁽³⁾ .UCEX		Any non-zero value if rescheduling is to occur.	
⁽¹⁾⁽²⁾⁽³⁾ .UIEX		Any non-zero value if rescheduling is to occur.	DCT address
⁽¹⁾⁽²⁾⁽³⁾ .UPEX		Any non-zero value if rescheduling is to occur.	

- (1) no error return.
- (2) no normal return.
- (3) return address is in AC3.

Call	AC0	AC1	AC2
.SYSTEM .WCHAR	-1, terminate wait request. bits 9-15: wait character.	Device code of keyboard transmitting the wait char- acter or -1 if wait request terminated.	
.SYSTEM .WRB <u>n</u>	Starting core address.	Starting relative block number.	bits 0-7: number of disk blocks. bits 8-18: channel number (if <u>n</u> = 77).
.SYSTEM .WRL <u>n</u>	Byte pointer to core buffer.	Write byte count, including terminator, returned at end of write.	Channel number (if <u>n</u> = 77).
.SYSTEM .WRS <u>n</u>	Byte pointer to core buffer.	Number of bytes to be written.	right byte: channel number (if n = 77). left byte: # of MCA retries (each retry takes 200 milliseconds).
.XMT	Message address.	Message (non-zero).	
.XMTW	Message address.	Message (non-zero).	

## ERROR MESSAGE SUMMARY

<u>Code</u>	<u>Mnemonic</u>	<u>Meaning</u>	<u>Applicable Commands</u>		
0	ERFNO	Illegal channel number.	.APPEND .MTOPTD .RDL .WRB	.CLOSE .MTDIO .RDR .WRL	.OPEN .RDB .RDS .WRS
1	ERFNM	Illegal file name.	.OPEN	.MTOPTD	.INIT
2	ERICM	Illegal system command.	.RLSE .RENAM .CRAND	.INIT .DELET .CCONT	.DELAY .CREAT
3	ERICD	Illegal command for device.	.RDS .WRL .MTDIO	.WRS .RDB .GMCA	.RDL .WRB
6	EREOF	End of file.	.RDB	.RDL	
12	ERDLE	Attempt to refer to a non-existent file or device.	.OPEN	.MTOPTD	
15	ERFOP	Attempt to reference an unopened file or device.	.RDS .WRS .RDB	.WRL .CLOSE .WRB	.RDL .MTDIO
21	ERUFT	Attempt to use a channel which is already in use.	.APPEND .MTOPTD	.GCHN	.OPEN
22	ERLLI	Line limit exceeded.	.RDL	.WRL	
23	ERRTN	Attempt to return (.RTN/.ERTN) from current program.	.RTN	.ERTN	
24	ERPAR	Parity on read line.	.RDL		
26	ERMEM	Not enough memory available.	.MEMI	.RDL	.RDS
27	ERSPC	Out of disk space.	.WRB		
30	ERFIL	File read error.	.RDS		.MTDIO
31	ERSEL	Unit improperly selected.	.INIT	.OPEN	.MTOPTD .RLSE

<u>Code</u>	<u>Mnemonic</u>	<u>Meaning</u>	<u>Applicable Commands</u>		
36	ERDNM	Device not in system, or illegal device code.	.INIT .IDEF	.RLSE .GMCA	.IRMV .STMAP
41	ERTIM	Attempt to set illegal time or date.	.STOD	.SDAY	
42	ERNOT	Out of TCBs.	.TASK		
43	ERXMT	Message address already in use.	.IXMT	.XMT	.XMTW
45	ERIBS	Device code already in system.	.DUCLK	.IDEF	.INIT
47	ERSIM	Simultaneous read or write attempt on same QTY line.	.RDL .WRS	.RDS .WCHAR	.WRL
50	ERQTS	Bad information in Task Queue Table.	.QTSK		
60	ERFIU	Attempt to open a busy MCA unit.	.OPEN		
61	ERTID	Task I. D. error.	.TASK .TIDS .DQTSK	.TIDK .TIDP	.TIDR .ABORT
101	ERDTO	Device timeout.	.WRS		
103	ERMCA	No complementary MCA request.	.RDS	.WRS	
104	ERSRR	Short MCA receive request.	.RDS	.WRL	.WRS
106	ERCLO	Channel closed by another task.	.RDL .WRS	.RDS	.WRL
110	ERABT	Task not abortable.	.ABORT		
113	ERNMC	No MCA receive request.	.WRS		
115	ERXMZ	Attempt to transmit a zero message word.	.XMT	.XMTW	.IXMT

*****

## APPENDIX B

### GENERATING AND LOADING AN RTOS SYSTEM

#### DEFINITION OF TERMS

This appendix details the steps to be followed when creating an RTOS system tailored to a specific device/core configuration and to the channel/task environment of the real time program which will be supported by the system and user program, both in a disk and in a non-disk environment.

System generation is the procedure followed to produce a relocatable binary which will trigger the loading of appropriate device drivers from the RTOS library, allocate tables and control blocks used by the system, and allocate a fixed number of channels and task control blocks. The system generation program, RTOSGEN, produces a relocatable binary with the default name RTOS.RB, by issuing a series of questions about the hardware configuration and the task/channel requirements of the user program.

System loading is the procedure followed to load the system generation relocatable binary, user drivers if any, user relocatable binaries, and the RTOS library. System loading is accomplished by using a relocatable loader.

#### PREPARATION FOR SYSTEM GENERATION

If the system is configured with either a type 4048 or type 4057 moving head disk pack drive, it is necessary to format the disk pack using the appropriate formatter program before system generation is attempted. In general, all disk packs that are to be used in the system must be formatted prior to their use. Note that it is not necessary to format the disk cartridges used in a type 4047 disk drive. The disk pack formatter programs are stand-alone programs. The appropriate formatter programs and their associated manuals are listed below:

<u>Disk Pack Drive</u>	<u>Formatter Program</u>	<u>Manual</u>
Type 4048	095-000072	096-000039
Type 4057	095-000071	096-000038

#### SYSTEM GENERATION

The following page contains lists of tapes required to generate and load a system in stand-alone and RDOS environments. To generate an RTOS program under the Stand-alone Operating System (SOS), the RTOSGEN program itself must be configured with appropriate device support before it can be used. Consult the Stand-alone Operating System User's Manual, 093-000062, for the procedures to be followed to configure and load SOS programs.

(To be supplied in an addendum to this manual)

List of Tapes for System Generation and System Loading



### Loading RTOSGEN in a SOS or Stand-alone Environment

RTOSGEN is provided as a stand-alone program on paper tape for users wishing to perform RTOS system generations without the support of RDOS. Standard binary load procedures, described in section 2.8 of How to Use the Nova Computers, must be followed to load either the stand-alone RTOSGEN program or RTOSGEN run under SOS.

### Loading RTOSGEN in an RDOS Environment

RTOSGEN is provided as a save file on paper tape for users wishing to perform a system generation on an RDOS system. To load this save file, mount tape number 088-000082 in the reader, and type the following command to the CLI:

```
LOAD/V { $PTR }  
        { $TTR }
```

The system will respond:

```
LOAD { $TTR }  
     { $PTR }, STRIKE ANY KEY.
```

Load the reader with the dump tape and strike any console key. The tape will be read, and the teletype will respond:

```
RTOSGEN.SV
```

### Producing the RTOS Module

You are now ready to begin executing RTOSGEN. This program configures the system by interrogating you as to the hardware characteristics and channel/task requirements of your program. If RTOSGEN is loaded using binary load procedures, it will self-start. In an RDOS system, type the command

```
RTOSGEN )
```

to invoke the program.

The system generation program now outputs the message:

```
RTOS SYSTEM GENERATION
```

and proceeds to issue a series of questions requiring operator keyboard responses. An improper reply to an RTOSGEN question causes the question to be repeated. The questions are given and responded to in the following order unless stated otherwise.

Producing the RTOS Module (Continued)

1. CORE STORAGE (IN K WORDS)

Respond with any number from 4 (4K) to 32 (32K) in increments of 2 (2K), and follow this and all other responses with a carriage return.

2. RTC FREQ (0=NONE, 1=10HZ, 2=100HZ, 3=1000HZ, 4=LINE)

Respond with 0,1,2,3, or 4 as appropriate. If you give a non-zero response, the system will maintain the system clock and calendar. You are cautioned to select the lowest acceptable frequency, since higher clock frequencies increase system overhead. If the line frequency is requested, RTOS asks question 3; otherwise, it steps to question 4.

3. LINE FREQ (0=50HZ, 1=60HZ)

Select 0 or 1 as appropriate. RTOSGEN now goes to question 4.

4. TASKS (1-255) ?

Respond with a decimal integer from 1 through 255 corresponding to the number of tasks required by your program which will be loaded with the RTOS module. If you select one task, the minimum task scheduler, TMIN, will be loaded from the RTOS library; otherwise the multitask scheduler, TCBMON, will be loaded.

5. CHANNELS (1-63) ?

Respond with a decimal integer from 1 through 63, corresponding to the number of simultaneously open channels required by your program.

After you have answered questions 1 through 5, RTOSGEN responds:

RESPOND WITH NUMBER OF UNITS

RTOSGEN now continues with a series of questions concerning peripheral support given to your program.

6. DSK (0-1) ? (fixed head disks)

If you respond "0", the program steps to the next question; a response of "1" prompts the following series of questions:

DISK STORAGE (IN K WORDS)

Respond with any decimal integer from 128 (K equals 1024₁₀) through 2048 (2 million words) in increments of 128 (128K). The program then queries you about the file subdivisions and file names you may wish to assign to the disk space for the fixed head disk. These queries are made in a series of questions with three parts each:

Producing the RTOS Module (Continued)

1ST BLOCK ?  
END BLOCK ?  
NAME ?

You respond with the first logical block address in each disk file; the first available block will be 0 unless you plan to use the disk bootstrap program, HIPBOOT, to load and execute RTOS programs. If disk space for HIPBOOT is to be reserved, the first available block address is block number 6.

You must assign a file name to all disk space which you want to be program accessible. The file names you define will be the names by which the disk files are opened via the system .OPEN command. File names consist of from 4 to 6 upper-case alphabetic and numeric characters. Each file name must uniquely identify its associated file; the same block cannot be assigned more than one file name, since one disk block cannot be included within the file space of more than one file. Files defined during system generation cannot be expanded or reduced in size. For a discussion of contiguous disk files, see Chapter 1, "Disk File Organization."

After defining all file space, respond with a carriage return to the "1ST BLOCK" question. RTOSGEN will now proceed to question number 7.

7. DKP (0-4) ? (moving head disks)

Respond with the number of moving head disk units in your system (the 4047B is considered to be two units). If there are no moving head units, respond 0; the system will then proceed to question 8.

After you answer the unit number question affirmatively, the program requests the number of sectors per surface in each unit, and the number of disk surfaces per unit ( see How to Use the Nova Computers for a discussion of disk terms):

#SECTORS ?  
# SURFACES/UNIT ?

Specify 6 sectors for the 4048 unit, or 12 sectors for either the 4047 or the 4057 units. Specify 2 surfaces for the 4047 unit, 10 for the 4048 unit, or 20 for the 4057 unit.

The program then queries you about the file subdivisions and file names you wish to assign to the disk space for each moving head disk unit. These queries are made in a series of questions with three parts each:

Producing the RTOS Module (Continued)

1ST BLOCK?  
END BLOCK?  
NAME?

You respond with the first logical block address in each disk file. The first available block in each unit will be 0 unless you intend to run one or more RTOS programs using disk file space found on an RDOS pack. In this case, file space which will be accessed by RTOS must be allocated by an RDOS CCONT (.CCONT) command. The LIST/E CLI command will then indicate the starting and ending block numbers comprising the contiguous files; it is these numbers which you would then use in responding to this RTOSGEN question series.

You must assign a file name to all disk space which you want to be program accessible. The file names you define will be the names by which the disk files are opened via the system .OPEN command. File names consist of from 4 to 6 upper-case alphabetic and numeric characters. Each file name must uniquely identify its associated file; the same block cannot be assigned more than one file name, since a single disk block cannot be included within the file space of more than one file. Files defined during system generation cannot be expanded or reduced in size. For a discussion of contiguous disk files, see Chapter 1, "Disk File Organization."

After defining all file space within each moving head unit, respond with a carriage return to the "1ST BLOCK" question. RTOSGEN will now proceed to question number 8.

8. MTA (0-8) ? (magnetic tape transports)

Respond with the appropriate integer indicating the number of 7- or 9-track magnetic tape transports in your system. If your response is non-zero, go to question 9; otherwise go to 10.

9. BUFFERED I/O (1=YES 0=NO) ?

Respond with the appropriate integer indicating whether line and sequential (buffered) I/O is to be available for magnetic tape units. A response of "1" makes buffered I/O available for cassettes too if any are selected in question 10; a response of "0" makes buffered I/O unavailable to both magnetic tape and cassette units.

Producing the RTOS Module (Continued)

10. CAS (0-8) ? (cassette units)

Respond with the appropriate integer indicating the number of cassettes in your system. If your response is non-zero, then step to question 11 unless you have already responded to question 9. Any response given to question 9 will be applied to cassettes also.

11. BUFFERED I/O (1=YES 0=NO) ?

Respond with the appropriate integers indicating whether line and sequential (buffered) I/O is to be available for cassette units.

12. PTR (0-2) ? (high-speed paper tape readers)

Respond with the appropriate integer indicating the number of high-speed paper tape readers in your system.

13. PTP (0-2) ? (high-speed paper tape punches)

Respond with the appropriate integer indicating the number of high-speed paper tape punches in your system.

14. LPT (0-2) ? (line printers)

Respond with the appropriate integer indicating the number of line printers in your system. If your response is 1 or 2, the program asks you for the column size(s) of your printer(s) with the query:

COLUMN SIZE (80, 132)

The query is repeated if you have specified 2 line printers in your system.

15. CDR (0-2) ? (punched or mark sense card readers)

Respond with the appropriate integer indicating the number of card readers in your system.

16. PLT (0-2) ? (incremental plotters)

Respond with the appropriate integer indicating the number of digital plotters in your system.

Producing the RTOS Module (Continued)

17. QTY (0-64) ? (asynchronous data communications multiplexor lines)

Respond with the appropriate integer indicating the number of full duplex lines in your system.

18. TTYS (0-3) ? (teletypewriters or video displays)

Respond with the appropriate integer indicating the number of teletypewriters or video display units in your system.

19. MCA (0-15) ?

Respond with the appropriate integer indicating the number of MCA lines in your system (each line is capable of both transmitting and receiving). If your response is non-zero, the program asks you for the default number of transmission retries:

#TIMEOUT RETRIES (0-65535) ?

Each hardware timeout consumes approximately 10 milliseconds. After you respond to this question, the program outputs a query signaling the approach of the last block of RTOSGEN questions:

RESPOND WITH 0 FOR NO, 1 FOR YES

20. AUTO RESTART?

Respond "1" if the power fail/auto restart is included in your system; otherwise, respond to "0".

21. HIGH PRIORITY INTERRUPTS?

Respond "1" if you have any user-written drivers whose interrupts you want to be serviced before all system devices (but after the power fail monitor and real time clock). Respond "0" if you do not have any high priority interrupt devices. If you respond "1", the program will ask you for the name and device code of each high priority interrupt device (the name consists of 3 alphanumeric characters):

DEVICE CODE?  
NAME?

Producing the RTOS Module (Continued)

21. HIGH PRIORITY INTERRUPTS ? (Continued)

The system appends "IS" to the device name and inserts the name into the high priority interrupt table. After listing all high priority interrupt devices, respond with a carriage return to the DEVICE CODE query, and the program will then step to question 20.

22. USER SUPPLIED DRIVERS?

Respond "1" if you have any user-written drivers you want included in the RTOS module output by RTOSGEN. (This is an alternative to introducing drivers at run time by the system call .IDEF .) If you have no such drivers, respond "0". If you respond in the affirmative, the program requests the device code and name of each device (the name consists of 3 alphanumeric characters):

DEVICE CODE?  
NAME?

The system appends "DC" to the device name to create the DCT name for the device. After listing all user device drivers, respond with a carriage return to the DEVICE CODE query, and the program will then step to the next question.

23. COMPUTER: NOVA (0) OR ECLIPSE (1) ?

Respond "0" if the system will use a NOVA computer, or "1" if you will be using an ECLIPSE computer. Follow this response with a carriage return, and the program will then proceed to output the system generation summary.

RTOS now outputs a list of all device codes, DCT names, and device names for all system devices and user devices specified during the system generation process. The power fail/auto restart option and high priority user interrupt devices are not included in this list, since there is no DCT associated with these devices.

24. After the list has been finished, the program asks whether the system generation procedure has been followed satisfactorily:

SYSGEN OKAY?

Producing the RTOS Module (Continued)

At this point you must decide whether or not there are any errors in your selections of devices; if there are no errors, type "1"; otherwise type "0". If you type "0" the entire system generation dialogue will be repeated.

If you respond "1", RTOSGEN will then ask the name of the file or device which is to be used for outputting the RTOS module:

OUTPUT FILENAME?

Respond with the name of the appropriate file or device. Respond with a carriage return if the default name RTOS.RB is desired.

RTOSGEN will output a 50-null leader (if the punch is used) followed by the RTOSGEN module proper. After the RTOS module has been output under RDOS, the system will output an R prompt and return to the CLI. RTOSGEN will restart itself in a stand-alone program.

The following information, correct when this manual went to print, is given as a guide for estimating the size in words of any tailored RTOS system for either NOVA or ECLIPSE computers. Sizes are given in octal and exclude page zero requirements:

<u>Basic System:</u> (1)	<u>NOVA system</u>	<u>ECLIPSE system</u>
<u>Options:</u>	2632	2642
multitasking programming (2)	1674	1674
each additional TCB	15	21
each additional channel		
power fail/auto restart (PWRDR)	165	165
high priority interrupts ( <u>n</u> = number of high priority devices excluding RTC and PWR)	11+3 <u>n</u>	11+3 <u>n</u>
real time clock (RTCDR)	466	466

(1) TMIN, SYSTE, INTD, RTIN, GENIO, IOSER, and one TCB

(2) TCBMON (less the size of TMIN), TXMT, TACAL, TSKID, TUMOD, TABOR, and TQTAS



Producing the RTOS Module (Continued)

<u>Peripherals:</u>	<u>NOVA system</u>	<u>ECLIPSE system</u>
fixed head disk (DSKDR)	213	213
moving head disk (DKPDR)	500	500
each disk file: fixed head/moving head	5/6	5/6
magnetic tape driver (MTADR)	54	54
each magnetic tape unit (MTU _n )	414	414
cassette tape driver (CASDR)	56	56
each cassette tape unit (CTU _n )	414	414
tape service routine (MTSER); shared by MTADR and CASDR	726	726
buffered tape I/O package, i. e., support for mag tape/cassette .RDL/.RDS/.WRL/.WRS	377	377
teletypewriter driver (TTYDR)	347	347
each additional console (TTY1D, TTY2D)	101	101
paper tape reader (PTRDR)	215	215
second paper tape reader (PTR1D)	45	45
paper tape punch (PTPDR)	54	54
second paper tape punch (PTP1D)	30	30
card reader (CDRDR)	646	646
second card reader (CDR1D)	170	170
line printer (LPTDR)	70	70
second line printer (LPT1D)	44	44
plotter (PLTDR)	53	53
second plotter (PLT1D)	30	30
device name table (.CHTB)	4*no. of devices	4*no. of devices
type 4060 multiplexer (QTYDR)	764	764
each QTY line	12	12
multiprocessor communications adapter (MCADR)	740	740
MCA device file table (.MCTB)	20*(no. of lines +1)	20*(no. of lines +1)

This page illustrates a sample output listing of the RTOSGEN dialogue.

```
RTOS SYSTEM GENERATION

CORE STORAGE (IN K WORDS) 12

RTC FREQ (0=NONE, 1=10HZ, 2=100HZ, 3=1000HZ, 4=LINE) 4
LINE FREQ (0=50HZ, 1=60HZ) 1

TASKS(1-255) ? 10
CHANNELS(1-63) ? 8

RESPOND WITH NUMBER OF UNITS

DISK (0-1) ? 1
  DISK STORAGE (IN K WORDS) 128
  DISK FILE STRUCTURE
  1ST BLOCK? 5
    END BLOCK? 200
    NAME? FILEA
  1ST BLOCK? 201
    END BLOCK? 506
    NAME? FILEB
  1ST BLOCK? 507
    END BLOCK? 509
    NAME? FILEC
  1ST BLOCK? 510
    END BLOCK? 511
    NAME? FILED
DKP(0-4) ? 0
MTA(0-8) ? 0
BUFFERED I/O (1=YES, 0=NO) 1
CAS(0-8) ? 0
PTR(0-2) ? 1
PTP(0-2) ? 1
LPT(0-2) ? 1
  COLUMN SIZE (80,132) 80
CDR(0-2) ? 0
PLT(0-2) ? 0
QTY(0-64)? 0
TTYS(0-3)? 1
MCA(0-15)? 2
  #TIMEOUT RETRIES (0-65535) ? 200

RESPOND WITH 0 FOR NO, 1 FOR YES

AUTO RESTART ? 1

HIGH PRIORITY INTERRUPTS? 0

USER SUPPLIED DRIVERS? 0

COMPUTER: NOVA (0) OR ECLIPSE (1) ? 0

SUMMARY OF RTOS SYSGEN

CODE   DCT     NAME
06     MCTDC
07     MCRDC
10     TTIDC   $TTI
11     TTODC   $TTO
12     PTRDC   $PTR
13     PTPDC   $PTP
14     RTCDC
17     LPTDC   $LPT
20     DSKDC

SYSGEN OKAY? 1
OUTPUT FILENAME ? SYS1
R
```

## LOADING AND RUNNING A PROGRAM IN A STAND-ALONE ENVIRONMENT

Having produced the RTOS module, you are now ready to load the operating system with program relocatable binaries and execute it as an RTOS program or run it under RDOS. If you wish to load and execute it in a stand-alone environment you must first perform a stand-alone or SOS relocatable load.

### Performing a Stand-alone or SOS Relocatable Load

For a complete description of operating procedures using the SOS and stand-alone extended relocatable loaders, refer to the Extended Relocatable Loaders Manual, 093-000080. The following summarizes stand-alone procedures required for loading system and user programs.

The stand-alone relocatable loader is in absolute binary format, and thus it is loaded by means of the binary loader. Once loaded, the relocatable loader self-starts and types on the console:

SAFE=

You respond with a carriage return to reserve the upper 200 words of memory, preserving both the bootstrap and binary loaders. The relocatable loader now outputs the prompt:

*

You now proceed to load a series of paper tapes, following tape loading procedures which will be described. The order in which the first three categories of tapes is loaded is not critical; the RTOS libraries must be the last items loaded:

1. The RTOS module
2. User drivers (if any)
3. User relocatable binaries (the user program proper)
4. The RTOS libraries

To load each of the above paper tapes, mount each tape in turn in either the teletype reader or the paper tape reader, and type either 1 or 2 indicating to the loader whether the teletype reader (1) or the high-speed reader (2) is to be used. After loading each tape, the loader outputs the star prompt (*).

### Performing a Stand-alone or SOS Relocatable Load (Continued)

After the last paper tape has been loaded, you may request a loader map by typing the number 6. Then, to terminate the load process and prepare the program for execution, type the number 8. This causes the previously loaded program to be moved so that it resides at the absolute addresses indicated by the loader map. After shuffling the program downward to its indicated positions in core memory, the loader halts.

If the SOS Magnetic Tape/Cassette relocatable loader (SOS loader) is to be used, the core image loader/writer should first be loaded into main memory; the same series of files must then be loaded in sequence. After the prompt

RLDR

is received, a command line must be input via the console. Suppose that cassette files are used and three cassette transports are available. Moreover, the user RTOS program binaries exist on file zero of one cassette, and the RTOSGEN module, user drivers, and RTOS libraries exist on files 0, 1, and 2 of another cassette. One possible command line would be as follows:

```
$TTO/L CT0:1/S CT1:0 CT1:1 CT2:0 CT1:2 )
```

This command line would cause a numeric symbol table listing to be output on \$TTO and the RTOS save file to go to file 1 of transport 0 (CBOOT, the cassette bootstrap, exists on file 0). The RTOS module, user drivers user program binaries, and RTOS libraries are then loaded in order. Upon the successful completion of the relocatable load, the message "OK" is output on the console and the system halts with the loaded program in core memory ready to be executed.

### Executing a Stand-alone Program

The first operation performed by any program run under RTOS is a system initialization. Since the address of the RTOS initialization routine always resides in location 2, control must be dispatched to the address in location 2 in order to start an RTOS program. RTOS has a JMP @2 instruction at location 376. Thus to start your program, place "376" in the data switches, press RESET, then START.

RTOS will initialize the system and transfer control to your program if you defined a starting address in your program in the .END statement. If you defined no such starting address, you must now place your program starting address in the data switches and press START. Your program now runs until a HALT or JMP . instruction is encountered, or all tasks are killed (in which case control is returned to the task scheduler).

## LOADING AND RUNNING A PROGRAM IN AN RDOS ENVIRONMENT

After writing your program, you may test it as an RDOS save file, you may run it on an RDOS system as a stand-alone program (disabling RDOS temporarily), or you may output it as an absolute program on some external medium for execution on another system.

Running the program under RDOS for test purposes may save you debugging time. This procedure is equivalent to testing and running an RDOS save file, since the RTOS command set is a compatible subset of the RDOS command repertoire. If you wish to test your program under RDOS, consult the Extended Relocatable Loaders Manual, 93-000080, and the Real Time Disk Operating System User's Manual, 93-000075. Note that you may specify task/channel information either via RLDR local switches /C and /K, or in the .COMM TASK statement.

Alternatively, you want to load your RTOS program using the RDOS loader but with the RTOSGEN module and RTOS libraries, and execute your program on this RDOS system or on another RDOS system. The following sections describe these procedures.

### Loading an RTOS Program under RDOS

For a complete description of operating procedures using the RDOS relocatable loader, refer to the Extended Relocatable Loaders Manual, 93-000080, and to the Real Time Disk Operating System User's Manual, 93-000075. The following summary information gives procedures for loading a user program with the RTOS module under RDOS.

The following files are required for the relocatable loading process:

1. RTOS.RB (produced during RTOS system generation).
2. User drivers, if any.
3. User relocatable binaries (i.e., the user program proper).
4. The RTOS libraries.

These four files must be loaded onto disk by mounting each on the teletype reader or high-speed reader and by issuing the following command:

```
XFER { $PTR } filename )
      { $TTR }
```

Having loaded all the necessary tapes, you now issue the CLI relocatable load command:

### Loading an RTOS Program under RDOS (Continued)

```
RLDR/C { /D } user binaries { user drivers } RTOSGEN module RTOS libraries ↑  
    [ { ($TTO/L) }  
      { ($LPT/L) } ] ,
```

This command will cause the complete save file to be constructed, starting at location zero. The load map will be output on the listing device, if one is specified.

If in the above illustration you have loaded the debugger (global /D), you must do one of two things to transfer control to the debugger. Your choice depends upon the means selected to start the RTOS program. These means are described fully in the following section. If location 2 will receive control upon the execution of the save file, then the debugger address (found in the load map, DEBUG) must be placed on location 2 via the Octal Editor. Alternatively, you may get the debugger address from location 406 of the program's User Status Table and start at that address. In either case, after starting the debugger, the command ".RTOS\$R" will transfer control to the RTOS initializer, starting the RTOS program.

### Executing an RTOS Program with HIPBOOT

Having performed a relocatable load of your program with the RTOS module and RTOS libraries, you may now choose from many different methods to execute the program; your choice of method will be made largely on the basis of the type of system which will be used to run the program.

If you intend to execute the program on an RDOS system, you may use the disk bootstrap program, HIPBOOT, to transfer control to your program. Otherwise, you must produce an absolute binary paper tape, or a magnetic tape/cassette version of the program and load it on another system by means of an appropriate loader. If HIPBOOT is used, the computer halts at the termination of loading. This provides an opportunity to activate the debugger via the front panel switches, if desired.

If your program is to be executed on the present RDOS system or on another RDOS system you may invoke the disk bootstrap program, HIPBOOT, to execute your program. If the RTOS program is on a removable pack or cartridge you may simply transfer the pack or cartridge to the new system; otherwise you must dump the RTOS save file and reload it on the new system:

Executing an RTOS Program with HIPBOOT (Continued)

DUMP	<u>outputdevicename</u>	<u>program-name.SV</u> )
LOAD	<u>inputdevicename</u>	<u>program-name.SV</u> )

Having obtained a copy of the RTOS program on the RDOS system where it is to be run, you now invoke HIPBOOT, following ordinary disk bootstrap procedures. These procedures are described fully in the RDOS Reference Manual, Appendices A and E; a summary of these procedures follows.

Disk bootstrap procedures vary with the type of computer used and the presence or absence of the program load feature. The following three procedures are given.

1. NOVA[®]* 2/NOVA 1200/NOVA 800 series and ECLIPSE[™]** without the Program Load Option:
  - a. Enter in location 376: 601nn  
where nn=20 when bootstrapping from the fixed head disk and  
nn=30 when bootstrapping from the moving head disk.
  - b. Enter in location 377: 377.
  - c. Press RESET, then start at location 376; go to step 3c.
2. NOVA 2/NOVA 1200/NOVA 800 series and ECLIPSE series with the Program Load Option:
  - a. Set bit 0 of the data switches up.
  - b. Enter the proper disk device code (20 or 33 as described in 1a.) into the data switches, bits 10-15.
  - c. Press RESET, then PROGRAM LOAD; go to step 3c.
3. SUPERNOVA[®]*:
  - a. Enter the proper disk device code (20 or 33 as described in 1a).
  - b. Press RESET, then CHANNEL START.
  - c. HIPBOOT now requests the name of your program.

FILENAME?

*NOVA and SUPERNOVA are registered trademarks of Data General Corporation, Southboro, Massachusetts.

**ECLIPSE is a trademark of Data General Corporation, Southboro, Massachusetts.

### Executing an RTOS Program with HIPBOOT (Continued)

You must now respond with the name of your program in one of two ways:

1. name/A )
2. name )

If you select the first method, your program will be loaded into memory and the computer will halt. You then place a starting address (your program's or the debugger's) into the address switches, press RESET, and then START. If you select the second response, the program will self-start.

Having been loaded, if the RTOS program self-starts it will initialize the system and transfer control to your program if you defined a starting address via your program's .END statement. If the program does not self-start, you may start at either the contents of location 2 or, to activate the debugger, at the contents of location 406.

Since this procedure overwrites portions of RDOS, RTOS gains control; RDOS can only be restored via disk bootstrap procedures similar to those given on the previous page.

### Executing an RTOS Program with TBOOT, CBOOT or MCABOOT

If you wish to execute your program on a system which has a magnetic tape transport or cassette unit, you must first transfer the magnetic tape bootstrap (TBOOT) or cassette bootstrap (CBOOT) to file 0 of the tape on unit 0.

INIT      { MT0 }  
            { CT0 } ↘

XFER      { TBOOT.SV }    { MT0:0 }  
            { CBOOT.SV }    { CT0:0 } ↘

After transferring the appropriate tape bootstrap to file 0, transfer the RTOS program to file 1 of the same tape:

XFER      program name.SV    { MT0:1 }  
                                          { CT0:1 } ↘



Executing an RTOS Program with TBOOT, CBOOT or MCABOOT (Continued)

If several RTOS programs are to be stored on the tape reel, they can be transferred to sequential file numbers following file 1.

Having produced the tape reel, release the reel via the RDOS command

RELEASE  $\left. \begin{array}{l} \{MT0\} \\ \{CT0\} \end{array} \right\} )$

Dismount the reel, and mount it on the unit zero transport or cassette unit of the system where the RTOS program(s) is to be executed.

After mounting the reel, perform one of the following operation sequences:

1. On machines having the Program Load feature (NOVA 2/800/1200 and ECLIPSE families), set the console switches to 100022 for a magnetic tape transport, or 100034 for a cassette unit, and press PROGRAM LOAD.
2. On SUPERNOVA computers with the Channel Start option, set the console switches to octal 22 (for a magnetic tape unit) or octal 34 (for a cassette unit), and press RESET, then CHANNEL START.
3. On machines without Channel Start or Program Load options, deposit NIOS MTA (60122) or NIOS CTA (60134) in location 376, deposit 377 in location 377, press RESET, and START at location 376.

The appropriate tape bootstrap program will be loaded into memory, and the following initialization message will be output on the console:

FULL (0) OR PARTIAL (1) ?

Type "1" in response to this query, and the tape bootstrap will then request the number of the file containing the program which is to be executed:

FROM  $\left. \begin{array}{l} \{MT0:\} \\ \{CT0:\} \end{array} \right\}$

## Executing an RTOS Program with TBOOT, CBOOT or MCABOOT (Continued)

Respond with the number of the file containing the program, and follow this with a carriage return. The tape file will be read, and control will be given to your program.

To transmit an RTOS program from one CPU to another via the multiprocessor communications adapter, two actions must be performed: one at the transmitting RDOS CPU, and another at a receiving CPU. At the transmitting CPU, the following CLI command must be issued.

```
MCABOOT      MCAT:n      RTOS program name/S
```

where n is a number from 1 to 15 decimal denoting the receiving MCA unit number. At the receiving CPU, an operator must have requested the sender's transmission by first placing "100007" in the receiver's data switches, then by depressing RESET, followed by PROGRAM LOAD. The transmitting unit will wait for the receiver to request the transmission, up to the default timeout period. After the RTOS program has been received, the receiving operator must place the value "376" in the data switches, and then press RESET followed by START.

## EXECUTING AN RTOS PROGRAM VIA PAPER TAPE WHICH WAS PRODUCED UNDER RDOS

If you have loaded your RTOS program via the RDOS relocatable loader, but now wish to run this program in a stand-alone environment, you may output this program onto paper tape. If you do not wish to preserve a disk file containing this RTOS program, simply issue the command:

```
MKABS/Z  program name.SV { 376/S} { $TTP }  
                                                { $PTP } )
```

Alternatively, if you wish to preserve a disk copy of this program before outputting it onto paper tape, issue the commands:

```
MKABS/Z  program name.SV  program name.AB { 376/S} )  
  
XFER  program name.AB  $PTP )
```

The paper tape version of your program can now be loaded onto a non-RDOS system following conventional binary load procedures. After loading the paper tape, if you supplied the initializer entry with the /S switch, control will be

## EXECUTING AN RTOS PROGRAM VIA PAPER TAPE WHICH WAS PRODUCED UNDER RDOS (Continued)

transferred to the RTOS initializer; if you did not specify an initializer entry address, you must place the value "376" into the data switches, press RESET, then START.

In either case, after RTOS performs its initialization it will transfer control to the starting address of your program if you specified a starting address as an argument in the main program's .END statement. If you specified no such starting address, the machine will stop after initialization and you must place your program's starting address in the data switches, press RESET, then START. Your program will now run until a HALT or JMP instruction is encountered.

## EXECUTING AN RTOS PROGRAM WITH THE SOS CORE IMAGE LOADER/WRITER

If the SOS core image loader/writer is to be used to execute an RTOS program, one of two relocatable loaders must have been used and one of two corresponding means must have been used to place the RTOS program onto cassette or magnetic tape:

1. SOS relocatable loader (the core image loader/writer must have been resident in main memory before the relocatable load).
2. RDOS relocatable loader.

If the first method is selected, the core resident RTOS program must be written onto either a reel of magnetic tape or a cassette cartridge onto which the loader/writer has been written as file zero. Core image loader/writer operation is discussed in detail in the SOS User's Manual, 093-000062. In summary, to transfer the SOS relocatably loaded program to tape, start the computer at the next to last address in main memory. This will activate the loader/writer, which outputs a prompt, "#". After outputting the prompt, the loader/writer waits for you to input a device number and file number, separated by a colon, to which the core resident program is to be written. After the file has been specified, the core image writer will request specification of the upper core address (NMAX) to be written onto tape. It does this by typing

NMAX:

on the console. You must then respond with the highest core address (in octal) which is to be written out.

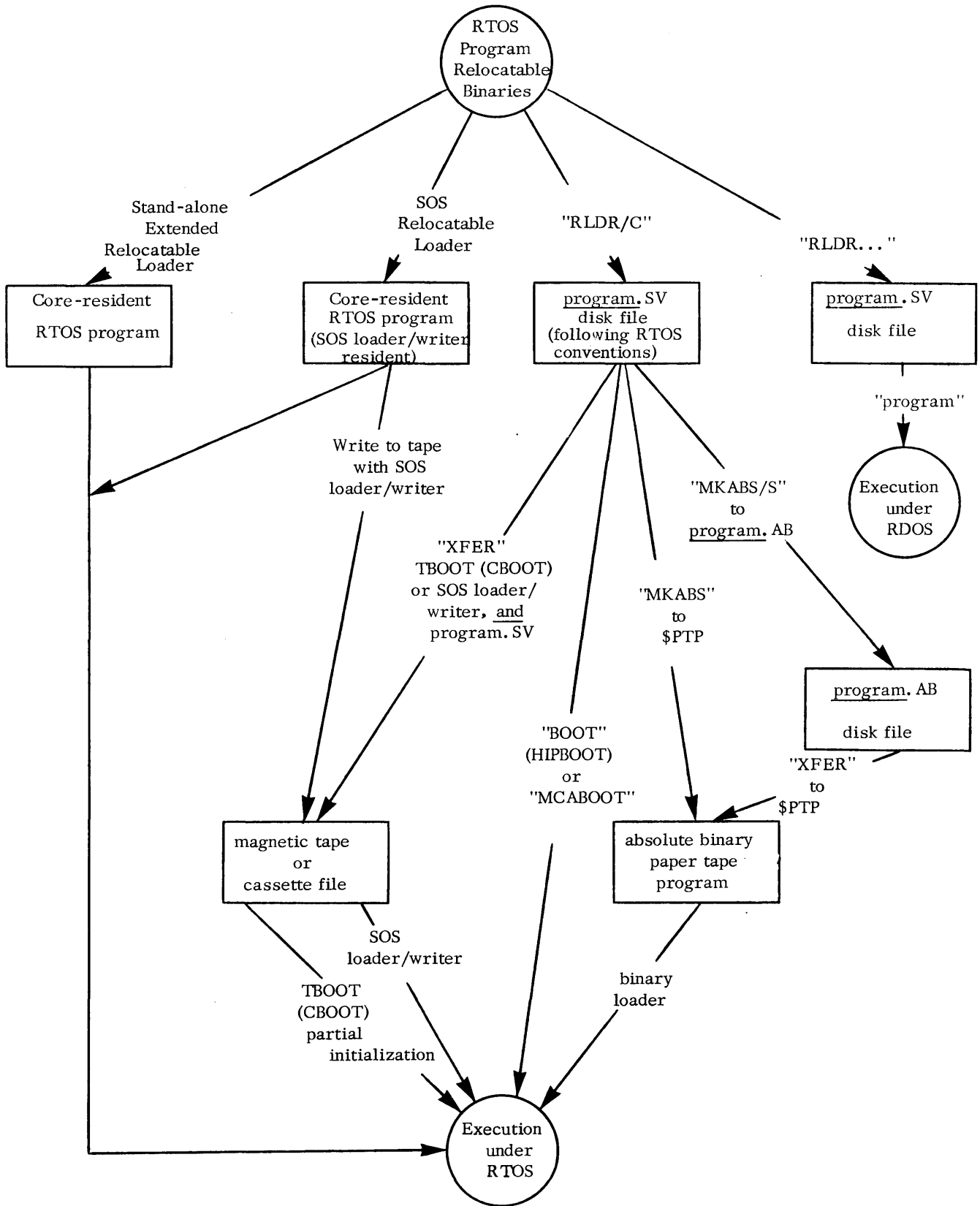
## EXECUTING AN RTOS PROGRAM WITH THE SOS CORE IMAGE LOADER/WRITER

(Continued)

Having written the RTOS program onto tape, it then may be read in from tape and be executed by means of the core image loader. Set the console data switch 0 up, and activate the core image loader by starting the computer at the highest available memory address. The loader issues the '#' prompt on the console, and then awaits your response of a device number (0-7), colon, and a file number (0-99) followed by a carriage return. The indicated tape file is then loaded into memory starting at address zero. The loader will halt after loading is complete.

If instead of the SOS loader the RDOS relocatable loader is used to create the RTOS program, this save file can be XFERed by the CLI to a file on cassette or magnetic tape. This file can then be executed by means of the core image loader as described above.

The illustration on the following page summarizes the various methods which may be used to execute an RTOS program. The illustration starts with the relocatable binary modules comprising the program; these binaries are produced either by an RDOS assembler or by the SOS assembler.



RTOS Execution Procedures

*****



## APPENDIX C

### RTOS PARAMETERS

Supplied with RTOS is a set of parameters, PARR, which must be assembled with programs using RTOS and using system-defined mnemonics. A listing of these parameters begins on page C-2.

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57

```

;*****;
;
;      RRRRR      TTTTTT      0000      SSSS
;      R   R      T           0   0      S   S
;      R   R      T           0   0      S
;      RRRRR      T           0   0      SSSS
;      R   R      T           0   0      S   S
;      R   R      T           0   0      S   S
;      R   R      T           0000      SSSS
;
;      THE OPERATING SYSTEM YOU CAN UNDERSTAND
;*****;

```

```

; RTOS - - REAL TIME OPERATING SYSTEM
;      - - FOR THE DATA GENERAL FAMILY OF COMPUTERS

```

```

; **** RTOS PARAMETER TAPE ****
; FORTRAN 4 CONDITIONAL ASSEMBLY SWITCH

```

```

000000 F4Sw=0          ; SUPERSEDED BY FORTRAN IV PARAMETERS IF PRESENT

```

```

; DEFINE THE USER STACK DISPLACEMENTS

```

```

000000 .DUSR SSAC2 = 0          ; (DON'T MODIFY THIS DISPLACEMENT)
177777 .DUSR SSAC1 = SSAC2-1    ; SAVE FOR CALLERS' ACCUMULATORS
177776 .DUSR SSAC0 = SSAC1-1    ;
177775 .DUSR SSCRY = SSAC0-1    ; CARRY
177774 .DUSR SSEAD = SSCRY-1    ; ENTRY ADDRESS OF CALLED PROGRAM
177773 .DUSR SSRTN = SSEAD-1    ; RETURN ADDRESS TO CALLING PROGRAM
177772 .DUSR SSOSP = SSRTN-1    ; PREVIOUS STACK POINTER
177771 .DUSR SSLGT = SSOSP-1    ; VARIABLE LENGTH OF CALLING PROGRAMS' FRAME

```

```

; DEVICE CHARACTERISTICS

```

```

; .DUSR ... 1815 ; IF SUPPRESSED ON OPEN;
; USER SPECIFIED TIMEOUT (MCA).
000001 .DUSR DCCPO= 1815 ; REQUIRES LEADER/TRAILER
000002 .DUSR DCCGN= 1814 ; REQUIRES TAB SIMULATION
000004 .DUSR DCIDI= 1813 ; BUF'D INPUT DEV. (RDOS: OP. INTERV.)
000010 .DUSR DCCNF= 1812 ; OUTPUT DEV. WITHOUT FORM FEED HARDWARE
000020 .DUSR DCTO= 1811 ; TELETYPE OUTPUT DEVICE
000040 .DUSR DCKEY= 1810 ; KEYBOARD DEVICE
000100 .DUSR DCNAF= 1809 ; REQUIRES NULLS AFTER FORM FEEDS
000200 .DUSR DCRAT= 1808 ; REQUIRES RUBOUTS AFTER TABS
000400 .DUSR DCPCK= 1807 ; REQUIRES PARITY CHECK
001000 .DUSR DCLAC= 1806 ; REQUIRES LINE FEEDS AFTER C.R.'S
002000 .DUSR DCPFR= 1805 ; INTERNAL TO RTOS: AUTORESTART MODE BIT
004000 .DUSR DCFWD= 1804 ; INTERRUPT PER FULL WORD I/O DEVICE
010000 .DUSR DCFFO= 1803 ; REQUIRES FORM FEED ON OPEN
020000 .DUSR DCLTU= 1802 ; CHANGE LOWER CASE ASCII TO UPPER
040000 .DUSR DCC80= 1801 ; WRITE 80 COLUMNS
; .DUSR ... 180 ; DEVICE WITH BEAD QUEUE
; (INTERNAL TO RTOS, NON-PARAMETRIC)

```



LICENSED MATERIAL - PROPERTY OF DATA GENERAL CORPORATION

!0002 .MAIN

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55

; USER STATUS TABLE (UST) TEMPLATE

```

000400 .DUSR  UST=      400      ; START OF USER STATUS AREA
000000 .DUSR  USTPC=    0        ; RESERVED FOR RDOS COMPATIBILITY
000001 .DUSR  USTZM=    1        ; ZMAX
000002 .DUSR  USTSS=    2        ; START OF SYMBOL TABLE
000003 .DUSR  USTES=    3        ; END OF SYMBOL TABLE
000004 .DUSR  USTNM=    4        ; NMAX
000005 .DUSR  USTSA=    5        ; STARTING ADDRESS
000006 .DUSR  USTDA=    6        ; DEBUGGER ADDRESS
000007 .DUSR  USTHU=    7        ; HIGHEST ADDRESS USED
000010 .DUSR  USTCS=   10        ; FORTRAN COMMON AREA SIZE
000011 .DUSR  USTIT=   11        ; INTERRUPT ADDRESS (NOT USED)
000012 .DUSR  USTBR=   12        ; BREAK ADDRESS (NOT USED)
000013 .DUSR  USTCH=   13        ; # TASKS (LEFT), # CHANS (RIGHT)
000014 .DUSR  USTCT=   14        ; INITIAL TCB ADDRESS
000015 .DUSR  USTAC=   15        ; START OF R E A D Y TCB QUEUE
000016 .DUSR  USTFC=   16        ; START OF FREE TCB CHAIN
000017 .DUSR  USTIN=   17        ; INITIAL START OF NREL CODE
000020 .DUSR  USTOD=   20        ; RESERVED FOR RDOS COMPATIBILITY
000021 .DUSR  USTSV=   21        ; FORTRAN STATE SAVE ROUTINE (OR 0)
;
000022 .DUSR  USTSQ=   22        ; START OF SUSPEND QUEUE
000023 .DUSR  USTXQ=   23        ; START OF .XMT/.REC QUEUE
000024 .DUSR  USTPQ=   24        ; START OF PSEUDO TASK QUEUE
000025 .DUSR  USTOS=   25        ; 1-SECOND CLOCK, SCHEDULER IDLE COUNTER
000026 .DUSR  USTNA=   26        ; NUMBER OF ACTIVE (LIVE) TASKS
000026 .DUSR  USTEN=   26        ; LAST ENTRY

```

; LAYOUT OF AN RTOS TASK CONTROL BLOCK (TCB)

```

000000 .DUSR  TPC=0      ; USER PC + CARRY
000001 .DUSR  TAC0=1     ; AC0
000002 .DUSR  TAC1=2     ; AC1
000003 .DUSR  TAC2=3     ; AC2
000004 .DUSR  TAC3=4     ; AC3
000005 .DUSR  TPRST=5    ; STATUS BITS + PRIORITY
000006 .DUSR  TSY=6      ; SYSTEM CALL WORD
000007 .DUSR  TLNK=7     ; LINK WORD
000010 .DUSR  TUSP= 10   ; USP
000011 .DUSR  TELN=11    ; TCB EXTENSION ADDR(USED BY FORTRAN SCHEDULERS)
000012 .DUSR  TID=12     ; TASK ID ENTRY
000013 .DUSR  TTMP=13    ; RDOS REV 3'S CONTRIBUTION
000014 .DUSR  TKLAD=14   ; KILAD ROUTINE ADDRESS
000015 .DUSR  TSP=15     ; STACK POINTER
000016 .DUSR  TFP=16     ; FRAME POINTER
000017 .DUSR  TSL=17     ; STACK LIMIT
000020 .DUSR  TSO=20     ; OVERFLOW ADDR
; DEFINE NON-BIRD TCB LENGTH
000015 .DUSR  TLN=TKLAD-TPC+1
; DEFINE BIRD TCB LENGTH
000021 .DUSR  TLNB=TSO-TPC+1

```

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```

10003 .MAIN
01      ; INTERRUPTED MACHINE STATUS STORAGE BLOCK LAYOUT
02
03      000000 .DUSR  IPCC=  0      ; PROGRAM COUNTER AND CARRY
04      000001 .DUSR  IAC0=  1      ; ACCUMULATOR STORAGE
05      000002 .DUSR  IAC1=  2
06      000003 .DUSR  IAC2=  3
07      000004 .DUSR  IAC3=  4
08      000005 .DUSR  ICMSK= 5      ; CURRENT HARDWARE MASK
09      000006 .DUSR  IRLOC= 6      ; RLOC
10      000007 .DUSR  ISVLN= IRLOC+1 ; SAVE AREA LENGTH
11
12      ; FIXED LOCATION PAGE ZERO STORAGE (LOCATIONS 0-17)
13
14      ;      ...      0      ; INTERRUPT PC STORAGE
15      ;      ...      1      ; INTERRUPT SERVICE ROUTINE ADDRESS
16      000002 .DUSR  BEGIN= 2      ; OVERALL STARTING ADDRESS (FIXED AT 2)
17      000003 .DUSR  CTCB=  3      ; CURRENT TCB ADDRESS--INITIALLY HAS
18      ; ; STARTING ADDR FOR TBOOT USE (FIXED
19      ; ; AT 3).
20      000004 .DUSR  SCHED= 4      ; ENTRY POINT TO SCHEDULER
21      000005 .DUSR  .SYS.= 5      ; SYSTEM MODE INDICATOR
22      ; ; (INITIALLY 0 FOR HIPBOOT)
23      000006 .DUSR  RLOC=  6      ; PAGE ZERO TEMP (=6 FOR COMPATIBILITY)
24      000007 .DUSR  IOEND= 7      ; ENTRY POINT TO I/O END PROCESSOR
25      000010 .DUSR  .CMSK= 10     ; CURRENT SYSTEM INTERRUPT MASK
26      000011 .DUSR  DISMISS=11   ; INTERRUPT DISMISSAL ROUTINE ADDRESS
27      000012 .DUSR  USTP=  12     ; DEFINED FOR COMPATIBILITY, SET TO 400
28      000012 .DUSR  PANIC= USTP   ; SYSTEM PANIC (CONTAINS JMP .)
29      000013 .DUSR  TLINK= 13     ; ENTRY POINT TO ENQUEUE READY TCB
30      000014 .DUSR  RSCHD= 14     ; ENTRY POINT TO READY (CTCB), SCHEDULE
31      000015 .DUSR  .TSAVE= 15    ; ADDRESS OF TCB STATE SAVE ROUTINE
32      ;.DUSR  USP=  16            ; USER STACK POINTER
33      ;      ...      17      ; ENTRY POINT TO SERVICE SYSTEM REQUEST
34
35      ; BIRD SPECIFIC LOCATIONS
36      000040 .DUSR  SP=  40        ; STACK POINTER
37      000041 .DUSR  CSP=  41        ; FRAME POINTER (LOGICAL STACK POINTER)
38      000042 .DUSR  CSL=  42        ; STACK LIMIT
39      000043 .DUSR  CSO=  43        ; STACK OVERFLOW ROUTINE POINTER
40      000044 .DUSR  XOPA=  44        ; XOP ORIGIN ADDRESS
41      000045 .DUSR  FPFA=  45        ; FLOATING POINT FAULT ADDRESS
42
43      ; SYSTEM CONSTANTS
44
45      000204 .DUSR  SCLLG= 132.     ; MAX LINE LENGTH FOR LINE MODE

```

LICENSED MATERIAL - PROPERTY OF DATA GENERAL CORPORATION

!0004 .MAIN

```

01           ; DEVICE CONTROL TABLE (DCT) TEMPLATE
02
03     000000 .DUSR DCTSV=  0           ; INT STATE SAVE ADDR
04     000001 .DUSR DCTMS=  1           ; MASK OF LOWER PRIORITY DEVICES
05     000002 .DUSR DCTIS=  2           ; INTERRUPT SERVICE ADDR
06     000003 .DUSR DCTCH=  3           ; DEVICE CHARACTERISTICS
07     000004 .DUSR DCTCD=  4           ; DEVICE CODE
08     000005 .DUSR DCTEX=  5           ; WHERE TO EXECUTE I/O INSTRUCTION
09     000006 .DUSR DCTDT=  6           ; COMMAND DISPATCH TABLE ADDRESS
10
11           ; DEFINE THE COMMAND OFFSETS
12     000000 .DUSR  OF=  0           ; OPEN A FILE
13     000001 .DUSR  CF=  1           ; CLOSE A FILE
14     000002 .DUSR  RS=  2           ; READ SEQUENTIAL
15     000003 .DUSR  RL=  3           ; READ LINE
16     000004 .DUSR  WS=  4           ; WRITE SEQUENTIAL
17     000005 .DUSR  WL=  5           ; WRITE LINE
18     000006 .DUSR  RB=  6           ; READ BLOCK
19     000007 .DUSR  WB=  7           ; WRITE BLOCK
20     000010 .DUSR  OA= 10           ; OPEN FILE FOR APPENDING
21
22     000007 .DUSR DCTST=  7           ; DEVICE START ROUTINE
23     000010 .DUSR DCTIN= 10           ; DEVICE INITIALIZATION ROUTINE
24     000011 .DUSR DCTLK= 11           ; FORWARD TCB LINKAGE
25     000012 .DUSR DCTTO= 12           ; TIMEOUT CONSTANT OR ZERO
26     000013 .DUSR DCTD2= 13           ; DISPLACEMENT TO 2ND PART OF DCT
27
28           ; THE REMAINING DEFINITIONS ARE FOR BEAD DEVICES ONLY.
29
30     000013 .DUSR DCTQL= 13           ; LINK IN DEVICE REQUEST BEAD CHAIN
31     000014 .DUSR DCTDP= 14           ; DEVICE BYTE DATA POINTER
32     000015 .DUSR DCTDC= 15           ; DEVICE DATA COUNT
33     000016 .DUSR DCTQS= 16           ; BEAD STATUS WORD
34
35     000017 .DUSR DCTBD= 17           ; BEAD ADDRESS (.-4)
36     000020 .DUSR DCTQP= 20           ; REQUEST BEAD QUEUE STARTING ADDR
37     000021 .DUSR DCTOC= 21           ; OPENED DEVICE CHARACTERISTICS
38     000022 .DUSR DCTT1= 22           ; TEMP 1 FOR DEVICE CONTROL
39     000023 .DUSR DCTT2= 23           ; TEMP 2 FOR DEVICE CONTROL
40     000024 .DUSR DCTCT= 24           ; CURRENT TIMEOUT COUNT (INPUT DEVICE)
41     000024 .DUSR DCTCC= 24           ; COLUMN COUNTER (OUTPUT DEVICE)
42     000025 .DUSR DCTPR= 25           ; ECHO DEVICE PAIR POINTER (TTI ONLY)
43     000025 .DUSR DCTLCL= 25          ; LINE COUNTER (OUTPUT DEVICE)
44           ; -FOR SPECIAL OUTPUT MODE:
45     000026 .DUSR DCTSC= 26           ; SAVED DEVICE REQUEST BYTE COUNTER
46     000027 .DUSR DCTGN= 27           ; CHARACTER FOR GENERATION

```

LICENSED MATERIAL - PROPERTY OF DATA GENERAL CORPORATION

!0005 .MAIN

01 ; BEAD COMPONENTS

02  
 03 000000 .DUSR RQLK= 0 ; REQUEST LINK  
 04 000001 .DUSR RQPTR= 1 ; REQUEST BYTE POINTER  
 05 000002 .DUSR RQCNT= 2 ; REQUEST BYTE COUNT  
 06 000003 .DUSR RQST= 3 ; REQUEST STATUS (MODE)

07  
 08 ; STATUS/MODE BITS ARE DEFINED AS FOLLOWS:  
 09 ;

10 ; 1B0 BEAD IN DCT (MAIN BEAD), ASSOCIATED WITH TCB @DCTLK  
 11 ; 1B1 PRESERVE TASK'S AC1, DON'T CALCULATE BYTES TRANSMITTED  
 12 ; 1B15 MEANING DEPENDS ON BIT 0 -  
 13 ; MAIN BEAD: LINE MODE  
 14 ; OTHER BEAD: REQUEST DONE (CLEARED IN ENQUE ROUTINE)

15  
 16  
 17  
 18  
 19

20 ; OFFSETS FOR USER TASK QUEUE TABLE

21  
 22 000000 .DUSR QPC= 0 ; STARTING PC  
 23 000001 .DUSR QNUM= 1 ; NUMBER OF TIMES TO EXECUTE  
 24 000002 .DUSR QTOV= 2 ; OVERLAY NUMBER (RDOS)  
 25 000003 .DUSR QSH= 3 ; STARTING HOUR  
 26 000004 .DUSR QSMS= 4 ; STARTING SEC IN HOUR  
 27 000005 .DUSR QPRI= TPRST ; MUST BE SAME  
 28 000006 .DUSR QRR= 6 ; RERUN TIME IN SECONDS  
 29 000007 .DUSR QTLNK= TLNK ; MUST BE SAME  
 30 000010 .DUSR QOCH= 10 ; CHAN OVERLAYS OPEN ON (RDOS)  
 31 000011 .DUSR QCOND= 11 ; TYPE OF LOAD  
 32 000012 .DUSR QLDST= 12 ; LOAD STATUS (RDOS ONLY)  
 33 ; 1B0=LOADING, 1B15=DEQUE REQ REC  
 34 000013 .DUSR QTLN= QLDST-GPC+1

LICENSED MATERIAL - PROPERTY OF DATA GENERAL CORPORATION

!0006 .MAIN

```

01           ; DEFINE THE DEVICE MASK BITS
02           ;         RDOS REV 3 VERSION
03
04      000003 .DUSR   MKTTO=  1B14+1B15           ; TTO
05      000003 .DUSR   MKTTI=  MKTTO              ; TTI
06      000003 .DUSR   MKQTY=  MKTTI              ; QTY
07      000007 .DUSR   MKPTP=  1B13+MKTTI         ; PTP
08      000017 .DUSR   MKMCA=  1B12+MKPTP         ; MCA
09      000017 .DUSR   MKPLT=  MKMCA              ; PLT
10      000010 .DUSR   MKLPT=  10                  ; LPT (SPECIAL CASE)
11      000217 .DUSR   MKDPO=  1B08+MKMCA         ; DPO
12      000217 .DUSR   MKDPI=  MKDPO              ; DPI
13      000617 .DUSR   MKDKP=  1B07+MKDPO         ; MHD
14      000717 .DUSR   MKDSK=  1B09+MKDKP         ; FHD
15      001717 .DUSR   MKIPB=  1B06+MKDSK         ; IPB
16      001737 .DUSR   MKPTR=  1B11+MKIPB         ; PTR
17      001777 .DUSR   MKCDR=  1B10+MKPTR         ; CDR
18      001777 .DUSR   MKMTA=  MKCDR              ; MTA
19      001777 .DUSR   MKCAS=  MKMTA              ; CAS

```

LICENSED MATERIAL - PROPERTY OF DATA GENERAL CORPORATION

10007 .MAIN

```

01           ; DEFINE THE EXCEPTIONAL STATUS CODES
02
03     000000 .DUSR ERFNO=    0           ; ILLEGAL CHANNEL NUMBER
04     000001 .DUSR ERFNM=    1           ; ILLEGAL FILE NAME
05     000002 .DUSR ERICM=    2           ; ILLEGAL SYSTEM COMMAND
06     000003 .DUSR ERICD=    3           ; ILLEGAL COMMAND FOR DEVICE
07     000006 .DUSR EREOF=    6           ; END OF FILE
08     000012 .DUSR ERDLE=   12           ; A NON-EXISTENT FILE
09     000015 .DUSR ERFOP=   15           ; FILE NOT OPENED
10     000020 .DUSR ERNUL=   20           ; NULL ERROR
11     000021 .DUSR ERUFT=   21           ; ATTEMPT TO USE A UFT ALREADY IN USE
12     000022 .DUSR ERLLI=   22           ; LINE LIMIT EXCEEDED
13     000023 .DUSR ERRTN=   23           ; .RTN/.ERTN WITH NOWHERE TO GO
14     000024 .DUSR ERPAR=   24           ; PARITY ERROR ON READ LINE
15     000026 .DUSR ERMEM=   26           ; NOT ENUF MEMORY AVAILABLE
16     000027 .DUSR ERSPC=   27           ; OUT OF FILE SPACE
17     000030 .DUSR ERFIL=   30           ; FILE READ ERROR
18     000031 .DUSR ERSEL=   31           ; UNIT NOT PROPERLY SELECTED
19     000036 .DUSR ERDNM=   36           ; ILLEGAL DEVICE NAME
20     000041 .DUSR ERTIM=   41           ; USER SET TIME ERROR
21     000042 .DUSR ERNOT=   42           ; OUT OF TCB'S
22     000043 .DUSR ERXMT=   43           ; SIGNAL ADDRESS ALREADY BUSY
23     000045 .DUSR ERIBS=   45           ; DEVICE ALREADY IN SYSTEM
24     000047 .DUSR ERSIM=   47           ; QTY ERROR
25     000050 .DUSR ERQTS=   50           ; ERROR IN USER TASK QUEUE TABLE
26     000060 .DUSR ERFIU=   60           ; FILE IN USE
27     000061 .DUSR ERTID=   61           ; TASK ID ERROR
28     000101 .DUSR ERDTC=  101           ; DEVICE TIMEOUT
29     000103 .DUSR ERMCA=  103           ; MCA ERROR
30     000104 .DUSR ERSRR=  104           ; SHORTER RECEIVE REQUEST
31     000106 .DUSR ERCLC=  106           ; I/O TERMINATED BY CLOSE
32     000110 .DUSR ERABT=  110           ; TASK NOT ABORTABLE
33     000113 .DUSR ERNMC=  113           ; NO MCA RECEIVE REQUEST
34     000115 .DUSR ERXMZ=  115           ; .XMT OR .IXMT TRANSMITTING ZERO MESSAGE
35
36

```

LICENSED MATERIAL - PROPERTY OF DATA GENERAL CORPORATION

```

10008 .MAIN
01      ; PARAMETERS FOR RTOS MAGTAPE MODULES
02
03      000401 MTBZ= 257.    ; BUFFER SIZE, WORDS
04      000377 SCWPB= 255.  ; USABLE WORDS PER BUFFER
05
06      ; DCT DISPLACEMENTS
07
08      000013 UNUM= DCTQL   ; UNIT NUMBER
09      000014 ADUCT= DCTDP  ; UNIT CONTROL TABLE ADDRESS
10      000015 DADR= DCTDC   ; DATA AREA BASE ADDRESS
11      000016 DCNT= DCTQS   ; WORD OR RECOR D COUNT
12      000017 IOFRP= DCTBD  ; I/O FUNCTION ROUTINE INDIRECT POINTER
13      ; = 1B0 + A(BRANCH TABLE ENTRY)
14      000020 CMDWD= DCTQP  ; COMMAND WORD, READY FOR DOA
15      000021 TEMP= DCTOC   ; TEMPORARY
16      000024 OPRET= DCTCC  ; I/O OPERATION SUBR. RETURN ADDRESS
17      000025 .UCTX= DCTPR  ; A(UCTX) -> UCT INDEX
18      000026 .ST= DCTSC   ; A(STATU) -> GET STATUS SUBROUTINE
19      000027 .ISSU= DCTGN  ; A(ISSUE) -> ISSUE COMMANDS SUBROUTINE
20      000030 PFR= .ISSU+1 ; BIT 0: POSITIONING-FOR-RETRY MODE FLAG
21      ; B1-B15: ERASE-FOR-WRITE-RETRY COUNTER
22      000031 RTCTR= PFR+1 ; RETRY COUNTER
23      000032 MODE= RTCTR+1 ; 1=LINE, 0=SEQUENTIAL
24      000033 MTOCL= MODE+1 ; LENGTH OF MAG TAPE DCT
25
26      ; UCT DISPLACEMENTS
27
28      000000 UCTPO= 0      ; POSITION COUNTER (CURRENT FILE #)
29      000001 UCTST= 1      ; STATUS BIT LOGIC WORD
30      000002 UCTUN= 2      ; UNIT NUMBER OF THIS UCT
31      ; SHORT UCT ENDS HERE
32      000003 UCTBF= 3      ; BUFFER FIRST BYTE ADDRESS
33      000004 UCTBS= 4      ; BUFFER SIZE, BYTES
34      000005 UCTBI= 5      ; BUFFER INPUT BYTE POINTER
35      000006 UCTBO= 6      ; BUFFER OUTPUT BYTE POINTER
36      000007 UCTBR= 7      ; BUFFER READ COUNT (BYTES TO BE READ)
37      000010 UCTBW= 10     ; BUFFER WRITE COUNT (BYTES WRITTEN)
38      000011 UCTUP= 11     ; POINTER INTO USER DATA AREA
39      000012 UCTUC= 12     ; COUNTER GOVERNING USER DATA AREA
40
41      ; STATUS VALUES
42
43      ; 0: OUT OF SYSTEM
44      ; -2: INITIALIZATION I/O IN PROGRESS
45      ; -1: IN SYSTEM
46      ; +1: RELEASE I/O IN PROGRESS
47
48      ; DEVICE STATUS MASKS
49
50      020000 RWNDE = 1B2    ; DEVICE REWINDING
51      .EOT

```

LICENSED MATERIAL - PROPERTY OF DATA GENERAL CORPORATION

0010 .MAIN

ADUCT	000014	8/09	
BEGIN	000002	3/16	
CF	000001	4/13	
CMWD	000020	8/14	
CSL	000042	3/38	
CSO	000043	3/39	
CSP	000041	3/37	
CTCB	000003	3/17	
DADR	000015	8/10	
DCC80	040000	1/55	
DCCGN	000002	1/42	
DCCNF	000010	1/44	
DCCPO	000001	1/41	
DCFFO	010000	1/53	
DCFWD	004000	1/52	
DCIDI	000004	1/43	
DCKEY	000040	1/46	
DCLAC	001000	1/50	
DCLTU	020000	1/54	
DCNAF	000100	1/47	
DCNT	000016	8/11	
DCPCK	000400	1/49	
DCPFR	002000	1/51	
DCRAT	000200	1/48	
DCT8D	000017	4/35	8/12
DCTCC	000024	4/41	8/16
DCTCD	000004	4/07	
DCTCH	000003	4/06	
DCTCT	000024	4/40	
DCTD2	000013	4/26	
DCTDC	000015	4/32	8/10
DCTDP	000014	4/31	8/09
DCTDT	000006	4/09	
DCTEX	000005	4/08	
DCTGN	000027	4/46	8/19
DCTIN	000010	4/23	
DCTIS	000002	4/05	
DCTLG	000025	4/43	
DCTLK	000011	4/24	
DCTMS	000001	4/04	
DCTO	000020	1/45	
DCTOC	000021	4/37	8/15
DCTPR	000025	4/42	8/17
DCTQL	000013	4/30	8/08
DCTQP	000020	4/36	8/14
DCTQS	000016	4/33	8/11
DCTSC	000026	4/45	8/18
DCTST	000007	4/22	
DCTSV	000000	4/03	
DCTT1	000022	4/38	
DCTT2	000023	4/39	
DCTTO	000012	4/25	
DISMI	000011	3/26	
ERABT	000110	7/32	
ERCLO	000106	7/31	
ERDLE	000012	7/08	
ERDNM	000036	7/19	
ERDTO	000101	7/28	
EREOF	000006	7/07	



LICENSED MATERIAL - PROPERTY OF DATA GENERAL CORPORATION  
 0011 .MAIN

ERFIL	000030	7/17		
ERFIU	000060	7/26		
ERFNM	000001	7/04		
ERFNO	000000	7/03		
ERFOP	000015	7/09		
ERIBS	000045	7/23		
ERICD	000003	7/06		
ERICM	000002	7/05		
ERLLI	000022	7/12		
ERMCA	000103	7/29		
ERMEM	000026	7/15		
ERNMC	000113	7/33		
ERNOT	000042	7/21		
ERPAR	000024	7/14		
ERQTS	000050	7/25		
ERRTN	000023	7/13		
ERSEL	000031	7/18		
ERSIM	000047	7/24		
ERSPC	000027	7/16		
ERSRR	000104	7/30		
ERTID	000061	7/27		
ERTIM	000041	7/20		
ERUFT	000021	7/11		
ERXMT	000043	7/22		
ERXMZ	000115	7/34		
F4SW	000000	1/24		
FPFA	000045	3/41		
IAC0	000001	3/04		
IAC1	000002	3/05		
IAC2	000003	3/06		
IAC3	000004	3/07		
ICMSK	000005	3/08		
IOEND	000007	3/24		
IOFRP	000017	8/12		
IPCC	000000	3/03		
IRLOC	000006	3/09	3/10	
ISVLN	000007	3/10		
MKCAS	001777	6/19		
MKCDR	001777	6/17	6/18	
MKDKP	000617	6/13	6/14	
MKDPI	000217	6/12		
MKDPO	000217	6/11	6/12	6/13
MKDSK	000717	6/14	6/15	
MKIPB	001717	6/15	6/16	
MKLPT	000010	6/10		
MKMCA	000017	6/08	6/09	6/11
MKMTA	001777	6/18	6/19	
MKPLT	000017	6/09		
MKPTP	000007	6/07	6/08	
MKPTR	001737	6/16	6/17	
MKQTY	000003	6/06		
MKTTI	000003	6/05	6/06	6/07
MKTTO	000003	6/04	6/05	
MODE	000032	8/23	8/24	
MTBZ	000401	8/03		
MTDCL	000033	8/24		
OA	000010	4/20		
OF	000000	4/12		

LICENSED MATERIAL - PROPERTY OF DATA GENERAL CORPORATION

0012 .MAIN

OPRET	000024	8/16		
PANIC	000012	3/28		
PFR	000030	8/20	8/22	
QCOND	000011	5/31		
QLDST	000012	5/32	5/34	
QNUM	000001	5/23		
QOCH	000010	5/30		
QPC	000000	5/22	5/34	
QPRI	000005	5/27		
QRR	000006	5/28		
QSH	000003	5/25		
QSMS	000004	5/26		
QTLN	000013	5/34		
QTLNK	000007	5/29		
QTOV	000002	5/24		
RE	000006	4/18		
RL	000003	4/15		
RLOC	000006	3/23		
RQCNT	000002	5/05		
RQLK	000000	5/03		
RQPTR	000001	5/04		
RQST	000003	5/06		
RS	000002	4/14		
RSCHD	000014	3/30		
RTCTR	000031	8/22	8/23	
RWNDE	020000	8/50		
SCHEd	000004	3/20		
SCLLG	000204	3/45		
SCWPB	000377	8/04		
SP	000040	3/36		
SSAC0	177776	1/30	1/31	
SSAC1	177777	1/29	1/30	
SSAC2	000000	1/28	1/29	
SSCRY	177775	1/31	1/32	
SSEAD	177774	1/32	1/33	
SSLGT	177771	1/35		
SSOSP	177772	1/34	1/35	
SSRTN	177773	1/33	1/34	
TAC0	000001	2/36		
TAC1	000002	2/37		
TAC2	000003	2/38		
TAC3	000004	2/39		
TELN	000011	2/44		
TEMP	000021	8/15		
TFP	000016	2/49		
TID	000012	2/45		
TKLAD	000014	2/47	2/53	
TLINK	000013	3/29		
TLN	000015	2/53		
TLNB	000021	2/55		
TLNK	000007	2/42	5/29	
TPC	000000	2/35	2/53	2/55
TPRST	000005	2/40	5/27	
TSL	000017	2/50		
TSO	000020	2/51	2/55	
TSP	000015	2/48		
TSYS	000006	2/41		
TTMP	000013	2/46		

LICENSED MATERIAL - PROPERTY OF DATA GENERAL CORPORATION  
 0013 .MAIN

TUSP	000010	2/43	
UCTBF	000003	8/32	
UCTBI	000005	8/34	
UCTBO	000006	8/35	
UCTBR	000007	8/36	
UCTBS	000004	8/33	
UCTBW	000010	8/37	
UCTPO	000000	8/28	
UCTST	000001	8/29	
UCTUC	000012	8/39	
UCTUN	000002	8/30	
UCTUP	000011	8/38	
UNUM	000013	8/08	
UST	000400	2/05	
USTAC	000015	2/19	
USTBR	000012	2/16	
USTCH	000013	2/17	
USTCS	000010	2/14	
USTCT	000014	2/18	
USTDA	000006	2/12	
USTEN	000026	2/30	
USTES	000003	2/09	
USTFC	000016	2/20	
USTHU	000007	2/13	
USTIN	000017	2/21	
USTIT	000011	2/15	
USTNA	000026	2/29	
USTNM	000004	2/10	
USTOD	000020	2/22	
USTOS	000025	2/28	
USTP	000012	3/27	3/28
USTPC	000000	2/06	
USTPQ	000024	2/27	
USTSA	000005	2/11	
USTSQ	000022	2/25	
USTSS	000002	2/08	
USTSV	000021	2/23	
USTXQ	000023	2/26	
USTZM	000001	2/07	
WB	000007	4/19	
WL	000005	4/17	
WS	000004	4/16	
XOPA	000044	3/40	
.CMSK	000010	3/25	
.ISSU	000027	8/19	8/20
.ST	000026	8/18	
.SYS.	000005	3/21	
.TSAV	000015	3/31	
.UCTX	000025	8/17	

*****



## APPENDIX D

### RTOS ASSEMBLY LANGUAGE AND FORTRAN IV PROGRAMMING

This appendix illustrates a sample real time assembly language program and describes the procedures which must be followed in order to load and execute a FORTRAN IV program under the Real Time Operating System.

#### Assembly Language Illustration

The sample assembly language program, illustrated on the following pages, causes four user tasks to compete for the use of the system console, \$TTO. Each task types a unique message on channel zero. The sequence of events in the user program is as follows.

First, all of the task calls which will be issued within the program are referenced externally by an .EXTN statement on line 6. Thus the following two task calls will be issued: .PRI and .TASK. If any task call were issued which was not externally referenced, the assembler would report an undefined symbol and the program would not be executable. System calls, on the other hand, must not be externally referenced; the SOS and RDOS assemblers recognize each system call mnemonic and assemble the appropriate value for each mnemonic. The .TXTM 1 statement, line 7, packs all text strings from left to right; this is always required under RTOS and RDOS.

Upon entry to TOT, the start of the program and only entry point declared by the .ENT statement (line 5), the teletype is opened on channel zero. Next, the program creates three tasks and passes to each task a different displacement into the series of message byte pointers which will be used when the tasks output to the teletype. Note that each of the three tasks is created at priority 108. When rescheduling occurs after each task call, the default task will continue to receive control since it is created at priority zero when the program is first started. After creating the three tasks, the default task adjusts its priority to that of the other three tasks so that it can compete for the teletype on an equal priority basis (line 30).

Each of the four tasks now executes the code beginning on line 33, and outputs its message via system call .WRS. As each task issues the system call, it becomes suspended and control goes to the task scheduler, which raises the highest priority ready task to the executing state. Each task remains suspended until its system call is completed. If the error return from any system or task call is taken, the program issues a "JMP." call, and the task is idled.

The program .END statement has the argument "TOT". This will enable the RTOS initializer to transfer control directly to the program.

01  
02 ;TYPEOUT TEST WITH MULTITASKING  
03

```

05          .TTL TOT
06          .ENT TOT
07          .EXTN .PRI .TASK
08          .TXM 1
09          .NREL
10 000001'020436 TOT: LDA 0 .TTO
11 000001'126400 SUB 1 1
12 000002'000017 .SYST
13 000003'014000 .OPEN 0
14 000004'004401 JSR ERR
15
16 000005'020425 LDA 0 PRIOR
17 000006'024425 LDA 1 NEWTASK
18 000007'152400 SUB 2 2
19 000010'177777 .TASK
20 000011'004424 JSR ERR
21
22 000012'151400 INC 2 2
23 000013'000010 .TASK
24 000014'004421 JSR ERR
25
26 000015'151400 INC 2 2
27 000016'000013 .TASK
28 000017'004416 JSR ERR
29
30 000020'177777 .PRI
31 000021'151400 INC 2 2
32
33 000022'034420 L: LDA 3 .MESS
34 000023'157000 ADD 2 3
35 000024'021400 LDA 0 3
36 000025'024407 LDA 1 COUNT
37 000026'000017 .SYST
38 000027'016400 .WRS 0
39 000030'004405 JSR ERR
40 000031'000771 JMP L
41
42 000032'000010 PRIOR: 10
43 000033'000022 NEWTASK: L
44 000034'000010 COUNT: 8.
45
46 000035'000400 ERR: JMP .
47
48 000036'000076 .TTO: .+1*2
49 000037'022124 .TXT /$TTO/
50          052117
51          000000
52
53 000042'000043 .MESS: .+1
54 000043'000116" MESS0*2
55 000044'000130" MESS1*2
56 000045'000142" MESS2*2
57 000046'000154" MESS3*2
58 000047'052101 MESS0: .TXT /TASK 1<15><12>/
59          051513
60          020001
    
```

Sample Assembly Language Program

```

0002 TOT
01      006412
02      000000
03 00054 052101 MESS1: .TXT /TASK 2<15><12>/
04      051513
05      020062
06      006412
07      000000
08 00061 052101 MESS2: .TXT /TASK 3<15><12>/
09      051513
10      020063
11      006412
12      000000
13 00066 052101 MESS3: .TXT /TASK 4<15><12>/
14      051513
15      020064
16      006412
17      000000
18
19                      .END TOT

```

Sample Assembly Language Program (Continued)

0003 TOT

COUNT	000034'	1/36	1/44			
ERR	000035'	1/14	1/20	1/24	1/28	1/39
L	000022'	1/33	1/40	1/43		1/46
MESS0	000047'	1/54	1/58			
MESS1	000054'	1/55	2/03			
MESS2	000061'	1/56	2/08			
MESS3	000066'	1/57	2/13			
NEWTA	000033'	1/17	1/43			
PRIOR	000032'	1/16	1/42			
TOT	000000' EN	1/04	1/05	1/10	2/19	
.MESS	000042'	1/33	1/53			
.PRI	000020' XN	1/06	1/30			
.TASK	000016' XN	1/06	1/19	1/23	1/27	
.ITO	000036'	1/10	1/48			

Sample Assembly Language Program (Continued)



The relocatable binary produced by assembling this program can be loaded by either the stand-alone extended relocatable loader, the SOS loader, or the RDOS loader. In this illustration we show the dialogue that ensues when the program is loaded by the stand-alone loader.

After the loader is loaded, it self-starts and outputs the message "SAFE= ." A carriage return response causes the top 200 locations to be saved, preserving the binary loader. After this, the star prompt is output. The program relocatable binary (TOT), RTOSGEN module, and two RTOS libraries are then loaded. The RTOS module loaded with this program specifies 5 user tasks. Four user tasks are needed, and a system task is also required since use of the peripheral device is simultaneously requested by more than one user task. At the termination of loading, (*8), the initializer starting address, 376, is placed in the data switches. RESET, is then pressed, followed by START. The program is initialized and begins at entry TOT, outputting the task messages until STOP is pressed.

```
SAFE =
*2 TOT
*2 RTOS
*2
*2
*8TASK 1
TASK 2
TASK 3
TASK 4
TASK 1
TASK 2
TASK 3
TASK 4
TASK 1
TASK 2
TASK 3
TASK 4
TASK 1
TASK 2
TASK 3
TASK 4
TASK 1
TASK 2
TASK 3
TASK 4
TASK 1
TASK 2
TASK 3
```

#### Load Dialogue and Program Output

## Real Time FORTRAN IV Programming

Since RTOS is a compatible subset of RDOS, RTOS will support a subset of DGC Real Time FORTRAN IV. To write a Real Time (RT) FORTRAN IV program for use with RTOS, you may use either the RDOS FORTRAN IV compiler or the 12K SOS FORTRAN IV compiler. Operating procedures for using these compilers are documented in the FORTRAN IV User's Manual, 093-000053, Appendix D. The only restriction on use of DGC RT FORTRAN IV under RTOS is that only those real time calls may be used which have corresponding system and task calls implemented in RTOS.

Having produced one or more FORTRAN IV relocatable binaries, you use relocatable load procedures which are similar to those documented in this manual, Appendix B, for assembly language program binaries. The only addition to these procedures is the loading of the FORTRAN run time libraries, RTOSFMT.LB, FORT1.LB, FORT2.LB, FORT3.LB and the appropriate integer multiply/divide library. Thus the relocatable load sequence using either the stand-alone extended relocatable loader, the SOS relocatable loader, or the RDOS relocatable loader is as follows:

1. FORTRAN relocatable binaries (the program proper)
2. RTOS module produced by RTOSGEN.
3. RTOSFMT.LB (the RTOS real time FORTRAN IV run time library).
4. FORT1.LB
5. FORT2.LB
6. FORT3.LB
7. An integer multiply/divide library
8. RTOS1.LB
9. RTOS2.LB
10. Other RTOS libraries as required (RTOS MTA.LB, RTOS CAS.LB, RTOS DSK.LB, or RTOS DKP.LB)

After relocatable loading is complete, the FORTRAN program is started just as any other RTOS program is started. Details for executing an RTOS program are given in Appendix B.

*****

## APPENDIX E

### RTOS Inter-revision Incompatibilities

1. Task call .REC now readies the highest priority task which has attempted to receive a common task message.
2. The User Status Table has increased in size by two words, and TCBs are from 1 to 5 words longer.
3. Single task programs running in an ECLIPSE system load USP into AC3 upon return from system and task calls only if the task scheduler used is TMIN. Multitask ECLIPSE programs and single task programs using task scheduler BTMIN load CSP (the frame pointer) into AC3 upon return from system and task calls.
4. Issuance of RDOS .SYSTM calls .CREAT, .CRAND, .CCONT, .DELET, or .RENAME will cause the error return to be taken with error ERICM signaled ("illegal system command"). Formerly these calls were executed as no-ops taking the normal return.

*****



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*"f" means "and the following page";

**"ff" means "and the following pages".

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# DataGeneral

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