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FEATURE DOCUMENT

OFFICE OVERLOAD CONTROLS FEATURE

2-WIRE NO. 1 ELECTRONIC SWITCHING SYSTEM

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INTRODUCTION

1. GENERAL INFORMATION

SCOPE

1.01 This section provides information for the Office Overload Controls in the No. 1 Electronic Switching System (ESS). Office Overload Controls consist of Automatic Overload Control and Line Load Control (LLC).

REASON FOR REISSUE

1.02 This section is reissued to provide information about the Improved Overload Strategy (IOS) available in No. 1 ESS offices with 1E6 and later generic programs. Since this reissue is a general revision which includes conversion to the standard 18-part format, no revision arrows have been used to denote significant changes.

FEATURE AVAILABILITY

1.03 Office Overload Controls are provided in all active No. 1 ESS base generic programs. The Improved Overload Strategy is provided in 1E6 and later generic programs as part of the base generic program.

2. DEFINITION/BACKGROUND

DEFINITION

2.01 Office Overload Controls provide the means to detect, control, and alleviate various system overload conditions. System overload occurs when excessive demands are made on any of the three basic system resources which are hardware, software, and real time. An overload condition exists when the call handling capacity of an office is exceeded for a sustained period of time or when one or more of the system resources are exhausted at any particular time.

BACKGROUND

A. General

2.02 Office Overload Controls are not a single feature per se; rather, Office Overload Controls are provided using several methods. For discussion purposes, the types of Office Overload Controls are termed Automatic Overload Controls and LLC. Automatic Overload Controls are inherent in the system operational design and automatically provide controls for hardware, software, and real-time overloads. LLC is an arrangement available to temporarily limit originating service to some or all of the lines not considered essential during an overload condition which may be due to a disaster or emergency situation.

> ***Note:*** LLC can affect customer service; therefore, the mode of operation for LLC is selected via the maintenance or traffic teletypewriter (TTY).

2.03 Since office overloads may be contributed to by interoffice traffic, the Automatic Overload Controls in an office interact dynamically with Network Management. Network Management can cause traffic to be routed away from an office experiencing congestion and/or overload conditions. The relationship between the Automatic Overload Controls provided in an office and Network Management is discussed in Part 7. For a detailed description of Network Management, refer to item A(1) in Part 18.

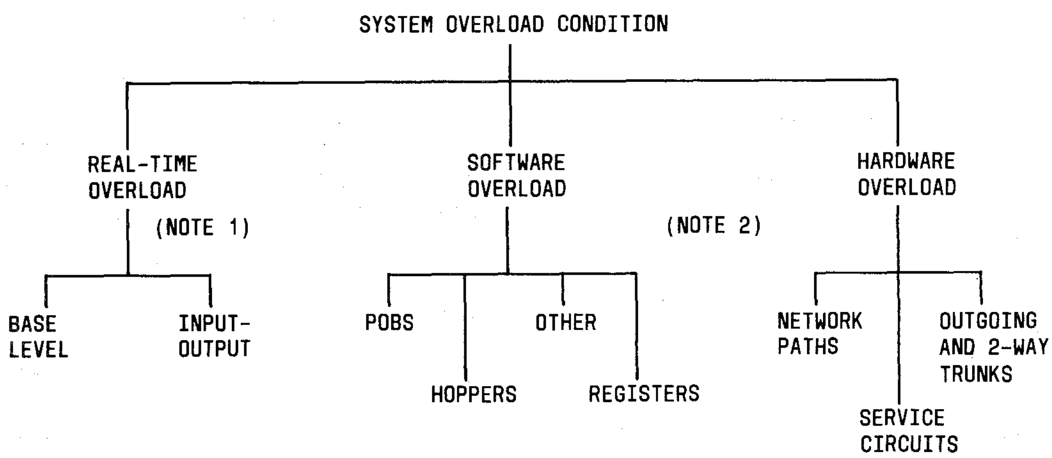
2.04 To preclude ambiguity, Automatic Overload Controls inherent in the system operation and LLC are discussed separately in this document. Also, since different strategies are used for hardware, software, and real-time overloads, Automatic Overload Controls are discussed in terms of these system resources (ie, hardware, software, and real time).

B. Overload Classifications

2.05 Since there are fundamental differences in the basic strategies used for the various types of overloads, hardware, software, and real time are convenient overload classifications. Many types of overloads can occur within the system; however, all overloads may be grouped into the three main classifications. (Refer to Fig. 1.) Generally, a hardware or software overload occurs when the demand exceeds the supply. Hardware overloads can occur as a result of all network paths being blocked. Also, hardware overloads occur when the total demand exceeds the amount of available service circuits, outgoing trunk circuits, or 2-way trunk circuits. Software overloads occur when the demand for memory resources exceeds the supply. Two examples of software overloads are (1) a hopper overflow condition and (2) no registers of a particular type are available. Real-time overloads occur when the system work load requires more time than is generally available to maintain efficient system operations. Real-time overloads are the result of the central control (CC) not cycling through all classes of base level work within a prescribed time interval or not handling input-output work on a real-time basis.

2.06 All classifications of overloads occur for one of two basic reasons: (1) heavy traffic or (2) system problems (Fig. 2). Heavy traffic may be either local or general, as a result of a local or general emergency situation, or simply due to peaked traffic. System problems encompass both hardware and software problems which degrade the office call processing capability.

2.07 Based on the preceding discussions, it is apparent that overload classifications and overload sources are interrelated. Furthermore, it is



NOTES:

1. THE STRATEGY FOR REAL-TIME OVERLOADS IS TO POSTPONE AND/OR ELIMINATE WORK.
2. THE STRATEGIES FOR SOFTWARE AND HARDWARE OVERLOADS ARE TO: TRY ANOTHER WAY, QUEUE, TRY AGAIN LATER, DO NOT SERVE THE CALL.

Fig. 1—Overload Classifications

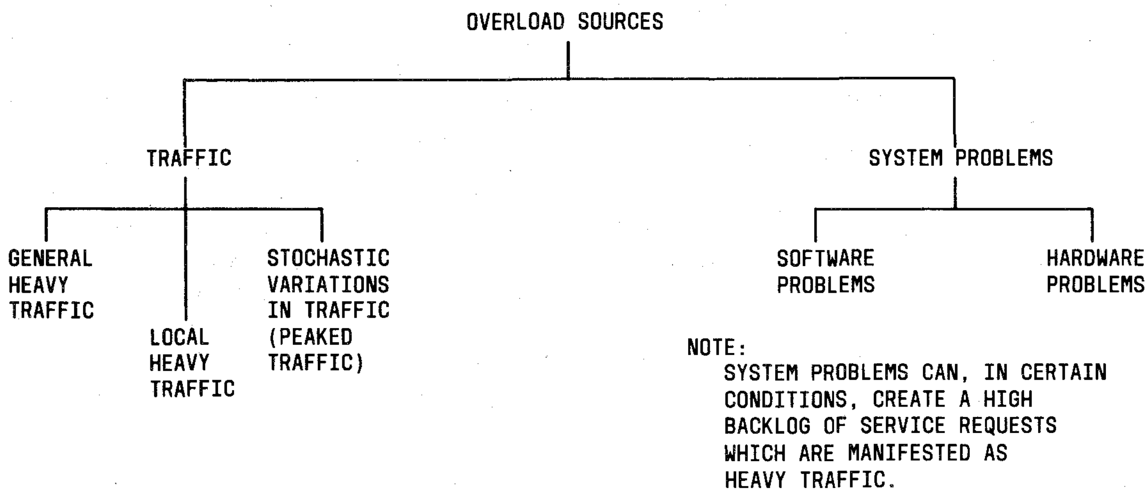


Fig. 2—Overload Sources

possible for one type of overload to cause another type of overload to occur. For example, during periods of heavy traffic, it is possible for network blockage to occur causing subsequent retries for a network path, or the unavailability of a call register may make it necessary to place the call on a queue. Both of these examples cause additional real time to be utilized during call processing; thus, hardware and software availability may contribute to a real-time overload.

Traffic Overloads

2.08 Telephone offices are engineered to provide high quality telecommunications services for the lines and trunks served. The hardware and software facilities are engineered using the assumption, based on statistical probability, that only a certain percentage of the trunks and lines served will require service at the same time. If larger percentages attempt to obtain service at the same time (as during a local or general emergency), the office facilities may become overloaded. Heavy traffic may cause a hardware, software, or real-time overload or any combination thereof, depending on the specific circumstances.

2.09 As traffic increases, network path blockage may occur causing subsequent retries for a network path. Also, service circuits, outgoing trunk circuits, or 2-way trunk circuits may not be immediately available due to heavy traffic. Registers may not be available due to utilization, or hoppers may become full causing a hopper overflow condition. The strategies used for hardware and software overloads are:

- Try another way
- Queue
- Try again later
- Do not serve the call.

2.10 Real-time availability for call processing decreases as traffic increases. Since real-time availability can also be affected by hardware and software overloads, real-time availability is a major factor in providing and administering Office Overload Controls.

System Problem Overloads

2.11 System problems may be caused by either a fault, error, or failure condition within the software or hardware. The system operational design provides the inherent means for detecting and alleviating system problems via hardware redundancy and automatic maintenance routines. The automatic maintenance routines provide a means to insure system operational integrity and call processing capability. As used herein, the term "maintenance routines" includes the various self-checks included in call processing programs as well as the maintenance programs utilized for the maintenance interrupt levels. A detailed discussion of maintenance programs and interrupt levels is beyond the scope of this document; however, when a maintenance interrupt occurs, real time available for call processing is reduced to some degree depending on the cause of the interrupt and interrupt level. Therefore, maintenance interrupt levels and the impact of maintenance interrupts are discussed in general terms in paragraphs 2.21 through 2.24.

C. System Programs

2.12 System operations are determined by the generic program. Programs contained within the generic program are divided into six functional groups. Figure 3 depicts the types of programs within the generic program. Programs within the generic program are functionally grouped as follows:

(a) ***Executive Control Programs:*** Schedule the order in which input, output, and call processing programs are initiated and administer certain traffic and overload controls.

(b) ***Input Programs:*** Look for work (eg, incoming calls) that is to be acted on by the system. The resulting information is reported to call processing programs.

(c) ***Output Programs:*** Process parts of a call under control of call processing programs.

(d) ***Call Processing Programs:*** Control the various aspects of call processing.

(e) ***Service Routine Programs:*** Aid in the translation of information. Service routine programs are shared by input, output, and call processing programs.

(f) ***Maintenance Programs:*** Provide direction for the detection and diagnosis of system failures. These programs locate, remove from service, and isolate faulty equipment.

2.13 The executive control programs and the maintenance control program (Fig. 3) are the main programs for controlling system operations. Pertinent functions of these programs are discussed in order to describe the basis for Office Overload Controls. For a more detailed description of the various programs, refer to items A(2) through A(6) in Part 18.

Executive Control Programs

2.14 The executive control main program directly or indirectly controls the execution of call processing programs and service programs. The executive control input-output (I/O) control program schedules the I/O work. Call processing programs receiving control directly from the executive control programs are mainly task dispenser programs which unload hoppers, queues, and other buffers. Certain task programs such as traffic measurements, dial tone speed tests, and the maintenance control program also receive control directly from the executive control main program.

> ***Note:*** The maintenance control program administers all maintenance programs; however, traffic and overload controls are administered by the executive control main program.

2.15 The traffic and overload control programs administered by the executive control main program provide for:

(a) Collecting and printing traffic measurements

(b) Accomplishing performance tests, such as dial tone speed tests

(c) Controlling office overloads by limiting incoming and originating traffic, unloading queues, etc.

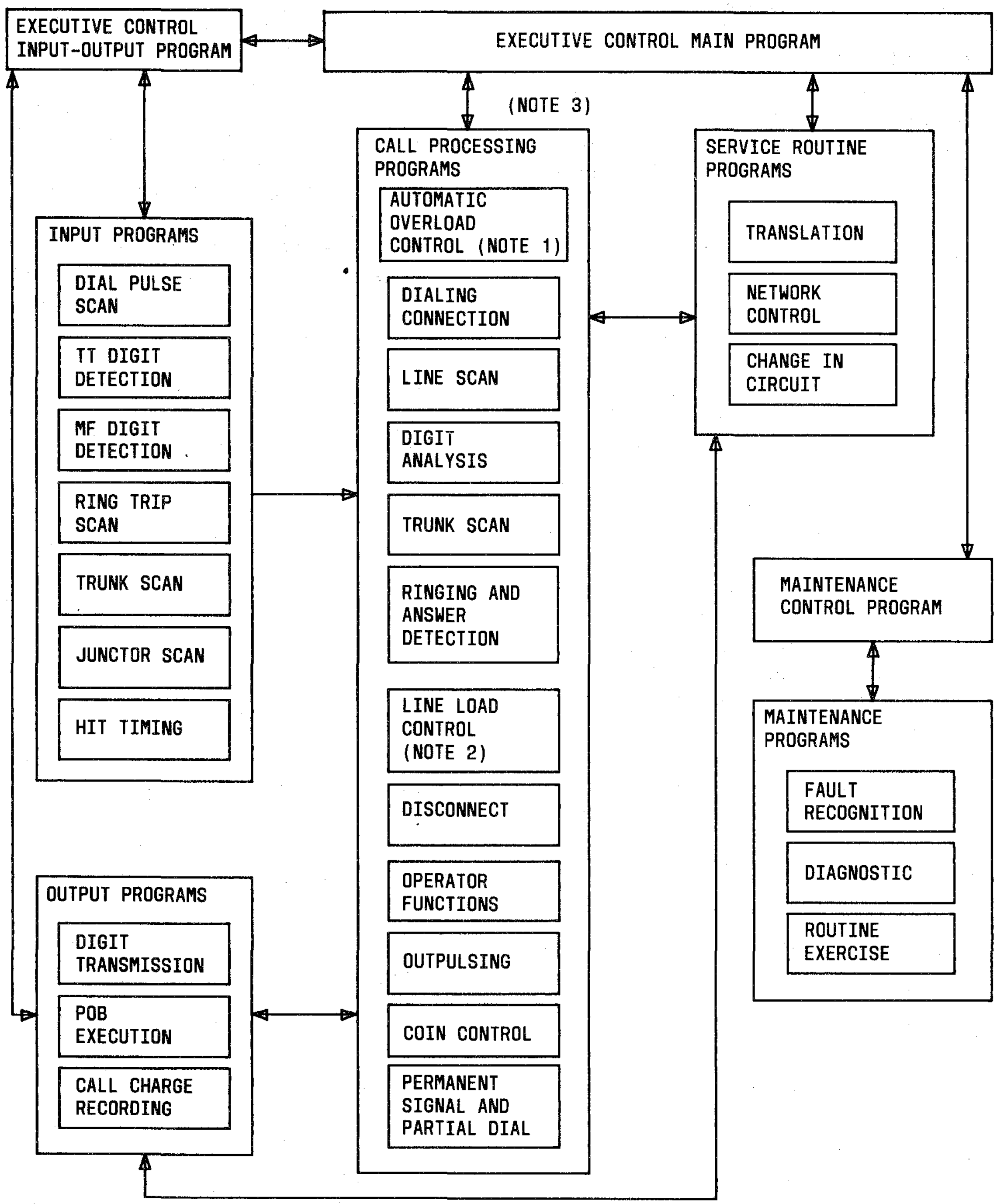
(d) Reporting on the general conditions and status, network blockage, and delays encountered within an office.

2.16 The executive control main program schedules task dispensers (referred to as main program task dispensers) which pass control to programs that perform necessary system tasks. Upon completion of work by the task dispenser programs, a return is made to the executive control main program.

2.17 In addition, the executive control main program maintains and uses the system clock to perform the scheduling and control functions. For a more detailed description on the executive control main program, refer to item A(2) in Part 18.

Maintenance Programs

2.18 Maintenance programs provide detection and diagnosis of hardware failures. If a unit in the



NOTES:

1. THE AUTOMATIC OVERLOAD CONTROL PROGRAM CONTAINS BOTH CALL PROCESSING AND OVERLOAD CONTROL ROUTINES.
2. LINE LOAD CONTROL IS DEPICTED UNDER CALL PROCESSING SINCE CALL PROCESSING IS AFFECTED WHEN LINE LOAD CONTROL IS ACTIVE.
3. THE INTERCONNECTION LINES INDICATE THE GENERAL FLOW OF INFORMATION AMONG PROGRAMS. THESE LINES DO NOT DEPICT SPECIFIC PROGRAM RELATIONSHIPS OTHER THAN THE RELATIONSHIP TO THE EXECUTIVE CONTROL MAIN PROGRAM AND TO THE TYPES OF PROGRAMS. THE EXECUTIVE CONTROL MAIN PROGRAM SCHEDULES THE WORK OF ALL CALL PROCESSING PROGRAMS.

Fig. 3—Program Functional Grouping

system becomes faulty, it is important that the faulty unit is identified and isolated as rapidly as possible. After the faulty unit has been removed from service, diagnosis of the problem is a deferrable task that can be completed when the system work load permits. Some maintenance programs are not deferrable; therefore, nondeferrable maintenance programs have the highest priority for execution in system operation. The maintenance programs are controlled by the maintenance control program. A priority interrupt scheme is used to administer the various maintenance programs.

2.19 Maintenance programs provide the means to maintain call processing capability and to isolate faulty equipment. The types of maintenance programs are as follows:

(a) ***Fault Recognition Programs:*** These programs are nondeferrable. The purpose of fault recognition programs is to restore the call processing capability of the system when a trouble is detected. These programs determine whether the trouble detected is an ***error*** or a ***fault.***

(1) An ***error*** is a malfunction that cannot be reproduced. For example, central control may detect a mismatch which is not present upon verification.

(2) A ***fault*** is a reproducible malfunction that can be diagnosed. In the case of a fault, the program will identify the faulty unit and remove it from service. The program then records a request for a diagnosis of the faulty unit and records all pertinent information. The system is then returned to normal call processing.

(b) ***Diagnostic Programs:*** Diagnostic programs localize a fault to a small number of plug-in circuit packs within a unit that has been taken out of service. Typically, diagnostic programs carry out a fixed sequence of tests. The programs record tests that pass or fail. Unlike the fault recognition programs, diagnostic programs are deferrable.

(c) ***Routine Exercise Programs:*** Routine exercise programs are deferrable programs. The purpose of these programs is to:

(1) Supplement the trouble detection facilities. For example, test calls are initiated occasionally to detect troubles that might escape circuit detection.

(2) Search for uncorrected errors. For example, some routine exercise programs check the validity of information contained in the call stores.

(3) Check the trouble detection circuits. For instance, mismatches are intentionally induced to check the system response.

D. Program Hierarchy

2.20 The ESS programs are designed to handle the call processing requirements of the office and, in addition, to provide for other operational, maintenance, and recovery functions. Operational software can be functionally divided into the following parts:

- Call processing
- Equipment dependent overhead
- Administrative work.

System Interrupt Structure

2.21 The system essentially operates in real time to promptly respond to service requests and to assure system integrity for dependable operations at all times. To accomplish this, the various system operations are assigned to particular interrupt levels according to the priority of work to be done. These levels are referred to as interrupt levels A through L (excluding I) and level S. Refer to Table A. Interrupt levels A through G are used for system maintenance. The remaining levels (H, J, K, L, and S) are used for input-output work and for call processing work. Interrupt levels H and J are used for input-output work. Interrupt level S is used in central control (CC) only offices with 1E4 and later generic programs for trunk scanning supervision. Interrupt level K is used only in signal processor (SP) offices for SP-CC communications. Interrupt level L, referred to as the base level, is used for the complex work necessary to handle and complete call processing.

Note: Certain maintenance routines and checks are performed in base level during call processing. These routines are administered by the maintenance control program which is given control by the executive control main program. Office overload detection and control is accomplished in base level (level L).

2.22 Overall system operations are, in a general sense, accomplished and controlled by the executive control programs and the maintenance control program as discussed in paragraphs 2.12 through 2.19. Since these control programs coexist for overall system operations, it is difficult to precisely define control boundaries and specific tasks accomplished. Table B illustrates the general relationship of the type of programs to the interrupt levels, task, and other programs used within the system. The basic program control structure, including the hierarchy of the interrupt sources, is illustrated in Fig. 4. For a description of the program philosophy and organization, refer to item A(2) in Part 18.

2.23 The interrupt structure is a hierarchy of interrupt levels, with A being the highest priority level and L, the lowest. An interrupt can seize control from the base level (level L) or from any interrupt level of lower priority. Interrupts are caused by various conditions in the CC; for example, a timeout of a 5-ms interval by the system clock causes a J-level interrupt. When such conditions occur, the interrupt system causes the CC to stop its present program task, stores the program address at which the

TABLE A

SYSTEM INTERRUPT LEVELS

LEVEL	USE	CONDITION
A	Maintenance	Manual Control
B	Maintenance	Emergency Action
C	Maintenance	CC Mismatch
D	Maintenance	CS Reread Failure
E	Maintenance	PS Reread Failure
F	Maintenance	SP Mismatch, CPD Alarms, ASW Scanner Failures
G	Maintenance	Error Evaluation and Generic Utilities
H	Input-Output Work	High Priority Input-Output Work
J	Input-Output Work	High and Low Priority Input-Output Work
K	SP-CC Communication	Priority Communications Request (SP Hopper Overflow)
L	Call Processing	Base Level Call Processing (Class A Through E Tasks)
S	Trunk Supervision (Non-SP Offices Only)	Entered Once Every 50 Milliseconds

TABLE B

PROGRAM CLASSIFICATION

PROGRAM CLASSIFICATION	LEVEL	PROGRAM TYPE OR TASK
Call Processing and Service Programs (Executive Control Main Program)	L	Interject Tasks
		Class A Tasks
		Class B Tasks
		Class C Tasks
		Class D Tasks
		Class E Tasks
Input-Output Programs	H	High Priority Input-Output Tasks
	J	High and Low Priority Input-Output Tasks
SP-CC Communications (SP Office Only)	K	Periodic or Maintenance Interrupt of SP
Trunk Supervision (Non-SP Office Only)	S	Trunk Scanning
Maintenance Programs	L-B	Maintenance Control Program
		Fault Recognition Programs
		Diagnostic Programs
		Exercise Programs
		Miscellaneous Programs

interrupt occurred, and then transfers to the appropriate interrupt-level program. When interrupt processing is complete, control is returned to the program that was interrupted or to a safe point in the maintenance program.

2.24 The maintenance interrupt levels are not considered a part of Office Overload Controls; however, they are used to maintain a viable system by correcting system hardware and software problems. Therefore, the maintenance interrupt levels help to preclude an office overload condition due to system problems.

Input-Output Interrupt Levels

2.25 Tasks associated with the system input-output functions are called "nondeferrable" tasks. These tasks must be performed punctually and usually repetitively; otherwise, critical data (eg, dial pulses) will be lost. "Deferrable" tasks (executed on the base or L level) are associated with data already in the system and are not, therefore, as critically synchronized to real time as the nondeferrable tasks.

2.26 To ensure punctual performance of the nondeferrable tasks without impairing the efficiency of the deferrable tasks, the interrupt levels J

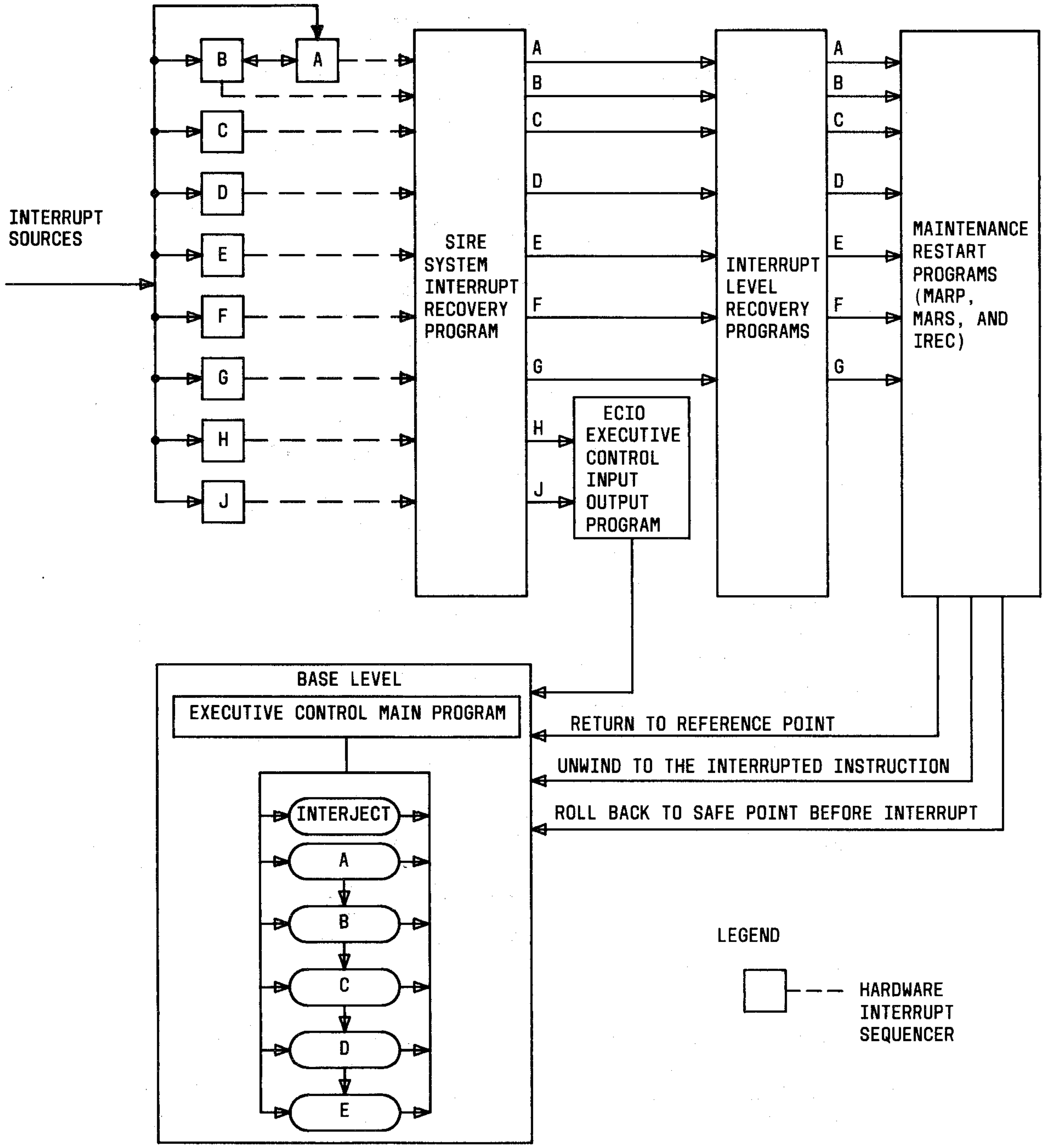


Fig. 4—Basic Program Control Structure

and H are provided in both SP and non-SP offices for input-output work. Interrupt level S is used only in non-SP offices with 1E4 and later generic programs for trunk scanning supervision of trunks requiring a 50-millisecond scan rate. Prior to 1E4, all supervisory trunk scanning is accomplished in J and H interrupt levels. By using level S for most trunk scanning work, the call handling capacity in base level is effectively increased since the average time required for input-output work in levels H and J has been decreased.

> ***Note:*** In an SP office, most input-output work is accomplished by the SP.

2.27 Every 5 milliseconds a clock pulse causes a J-level interrupt which will activate, one at a time, all input-output programs that require action according to a high priority timetable. When all high priority tasks are completed, all low priority programs requiring action are done. After completion of all input-output work, control is returned to the base level (level L) programs for the remainder of the 5-millisecond time period. Input-output work typically requires from 0.2 to 2 milliseconds. To insure the timeliness of critical I/O jobs, a method is provided to handle cases where the J-level interrupt requires more than 5 milliseconds.

2.28 J-level input-output programs are classed as high or low priority programs according to the frequency and accuracy required. All low priority programs are assigned to J level. The high priority programs are considered during both J and H levels. Low priority tasks can be delayed for a few milliseconds without adverse effect on the system operation; however, high priority tasks cannot be delayed. Therefore, if it takes more than 5 milliseconds to complete all high and low priority tasks during a J-level interrupt, an H-level interrupt will occur on the next 5-millisecond clock pulse. This may occur while a low priority task is still being performed; in which case the high priority work will interrupt the J-level low priority work. When the H-level high priority work has been completed, control is returned to the interrupted low priority J-level program. After all high and low priority work has been completed (normally within 2 milliseconds), control is returned to the base level (level L) programs. In non-SP offices, since level S is used to supervise trunks requiring a 50-millisecond minimum scan rate, at the completion of J-level work in every tenth J-level interrupt (every 50 milliseconds), S level is entered. After S-level work is completed, control is returned to base level. The typical H-, J-, and S-level interrupt sequence is depicted in Fig. 5. The priority interrupt scheme is illustrated in Fig. 6.

2.29 Input-output programs generate new work for the system by monitoring service requests and execute existing work by sending orders to peripheral equipment. Thus, as traffic increases, more input-output work is required. It becomes apparent that increasing traffic affects the system operation in two ways. First, more input-output work is required, which interrupts the base level (level L) call processing programs. This reduces the amount of call processing performed during that period of time. Second, increasing traffic creates additional call processing work to be accomplished in base level. Therefore, Automatic Overload Controls are used to smooth the system load due to traffic by providing automatic controls for both call processing and input-output work.

Base Level Structure

2.30 All L-level programs collectively form the base-level program. Despite functional subdivisions that are made, this is operationally a single program made up of a complex of loops without a beginning or an end. The core of this base-level program is the executive control main program (ECMP). In the absence of interrupts, the system operates on the base or L level.

2.31 Frequency classes A through E and interject represent the classes of base-level programs. Within each class, there is a fixed sequence of major program units called task dispensers. The majority of these are for call processing and administration. In general, they dispense program control to one or more task programs a consecutive number of times, depending on the number of tasks that the task dispenser program finds waiting. Occasionally, another task program is interjected into the flow between any two task executions. When a task program returns control to its task dispenser program, the latter checks to see if an interject request has been made. If so, the interject request will be executed before task dispensing is resumed.

2.32 The various tasks to be accomplished in base level are scheduled and executed via the executive control main program . All base level tasks can be deferred to some extent, but the amount of tolerable delay varies. Therefore, a preference scheme is

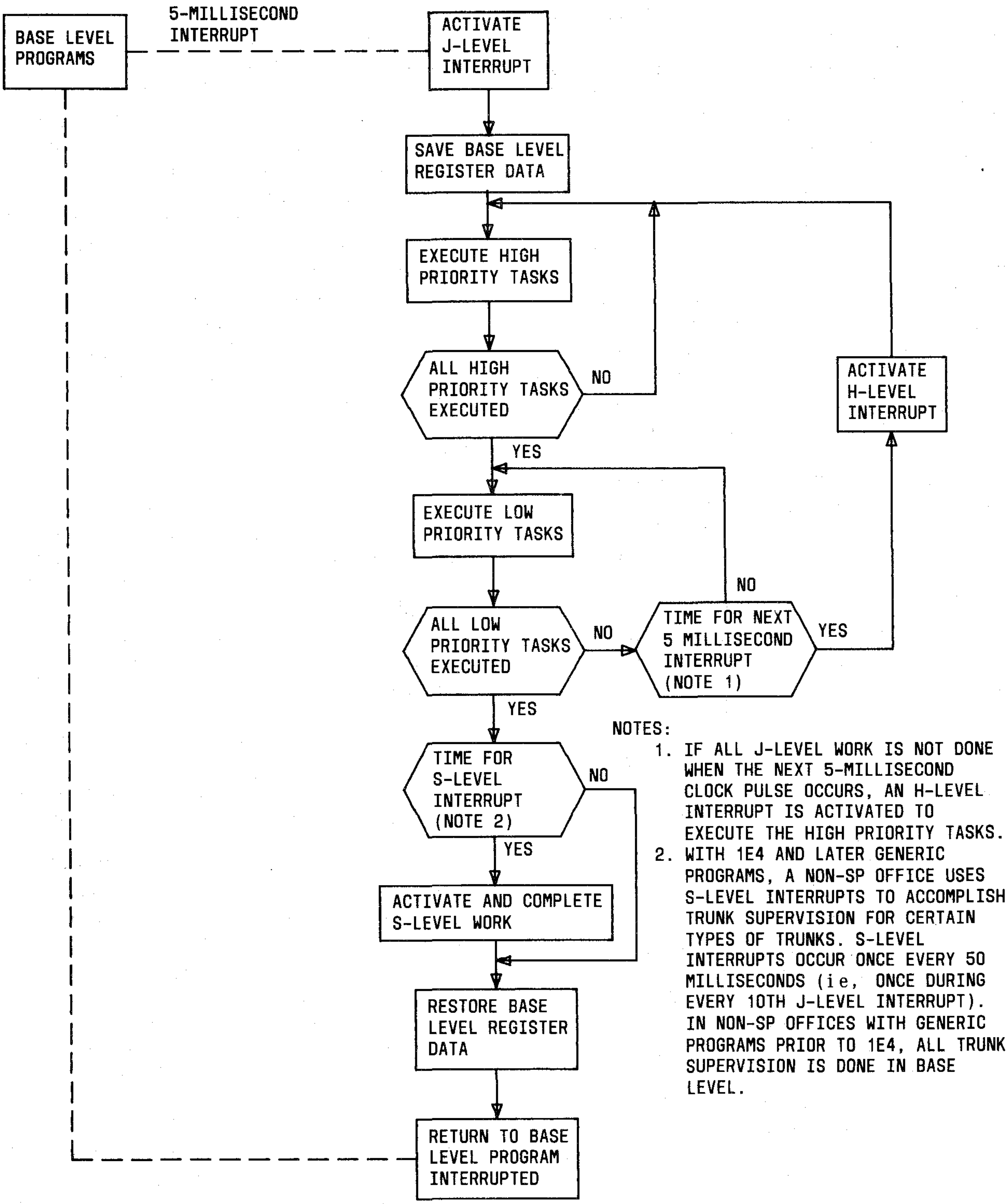


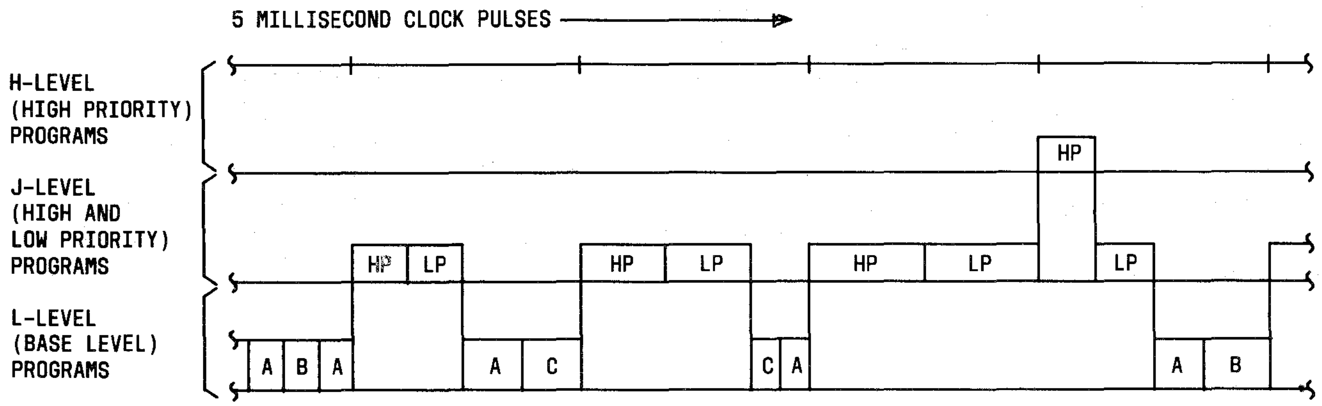
Fig. 5—Typical H-, J-, and S-Level Interrupt Sequence

used to schedule base level tasks. Base level tasks are grouped into classes according to the priority and frequency in which they are executed. Interject tasks have the highest priority in base level. Classes A through E have less priority, in that order. Class A through E tasks are scheduled and executed, via the executive control main program, according to a frequency table. Interject tasks are accomplished as required in any of the other classes (A through E). At the end of E-class work a forced interject is unconditionally executed, whether or not interject had been requested in any other job class in the E-to-E cycle.

2.33 Class A through E tasks are entered with varying frequency in the ratio of A:B:C:D:E = 15:8:4:2:1 and are continuously repeated in the following sequence:

ABACABADABACABABACABADABACABAE

Thus, except for interject tasks, class A tasks are the least deferrable and class E tasks are the most deferrable tasks in base level. (See Fig. 7.)



NOTE:
ONLY HIGH PRIORITY INPUT-OUTPUT WORK IS DONE IN LEVEL H. WITH 1E4 AND LATER GENERIC PROGRAMS, A NON-SP OFFICE USES S-LEVEL INTERRUPTS TO ACCOMPLISH TRUNK SUPERVISION FOR CERTAIN TYPES OF TRUNKS. S-LEVEL INTERRUPTS (NOT SHOWN) OCCUR ONCE EVERY 50 MILLISECONDS (i e, ONCE DURING EVERY 10TH J-LEVEL INTERRUPT). IN NON-SP OFFICES WITH GENERIC PROGRAMS PRIOR TO 1E4, ALL TRUNK SUPERVISION IS DONE IN BASE LEVEL. AFTER ALL REQUIRED H-, J-, AND S-LEVEL (IF APPLICABLE) WORK IS DONE, BASE LEVEL WORK IS RESUMED.

Fig. 6—H-, J-, and S-Level Priority Interrupt Scheme

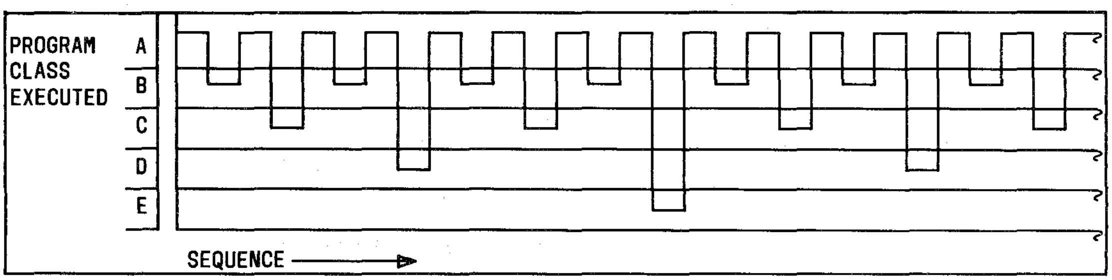


Fig. 7—Base Level Class Frequency Sequence

2.34 The main program cycle time (known as the E-to-E time) is the time required by the central processor to complete one cycle from one class E to the next class E. It is important to understand that the E-to-E cycle time is not fixed but varies according to the work to be done in all classes. Each class consists of many tasks. Once a class is entered according to the frequency table, all tasks in that class are done prior to entering the next class.

2.35 The executive control main program controls (via a frequency table) the execution of class A through E tasks. Each class consists of a series of task dispenser programs. Work in each class is done using task dispenser programs and task programs. The task dispenser programs execute the task programs. A task program does a particular kind of work. The task dispenser programs are linked directly to each other. (See Fig. 8.) The executive control main program begins a class by transferring to the first job (generally referred to as a task dispenser) in that class. The task dispenser typically distributes work to task programs which accomplish the work. When there is no work remaining, the task dispenser transfers control directly to the next job. The last job in the chain returns control to the executive control main program which causes the next class, via the frequency table, to be executed.

2.36 As discussed earlier, interject work has the highest priority in base level. A check is typically made for interject work each time a task program returns control to a task dispenser program. If interject work is found, the interject task is immediately executed. After the interject work is completed, control is returned to the task dispenser program. Also, a forced interject is unconditionally executed at the end of E-class work.

2.37 Based on the preceding paragraphs, it is apparent the E-to-E cycle time varies according to the work to be done in all classes. Therefore, the E-to-E cycle time is an indication of the system load and real-time availability for call processing. The E-to-E cycle time is used to detect system real-time overloads and to determine the degree of overload.

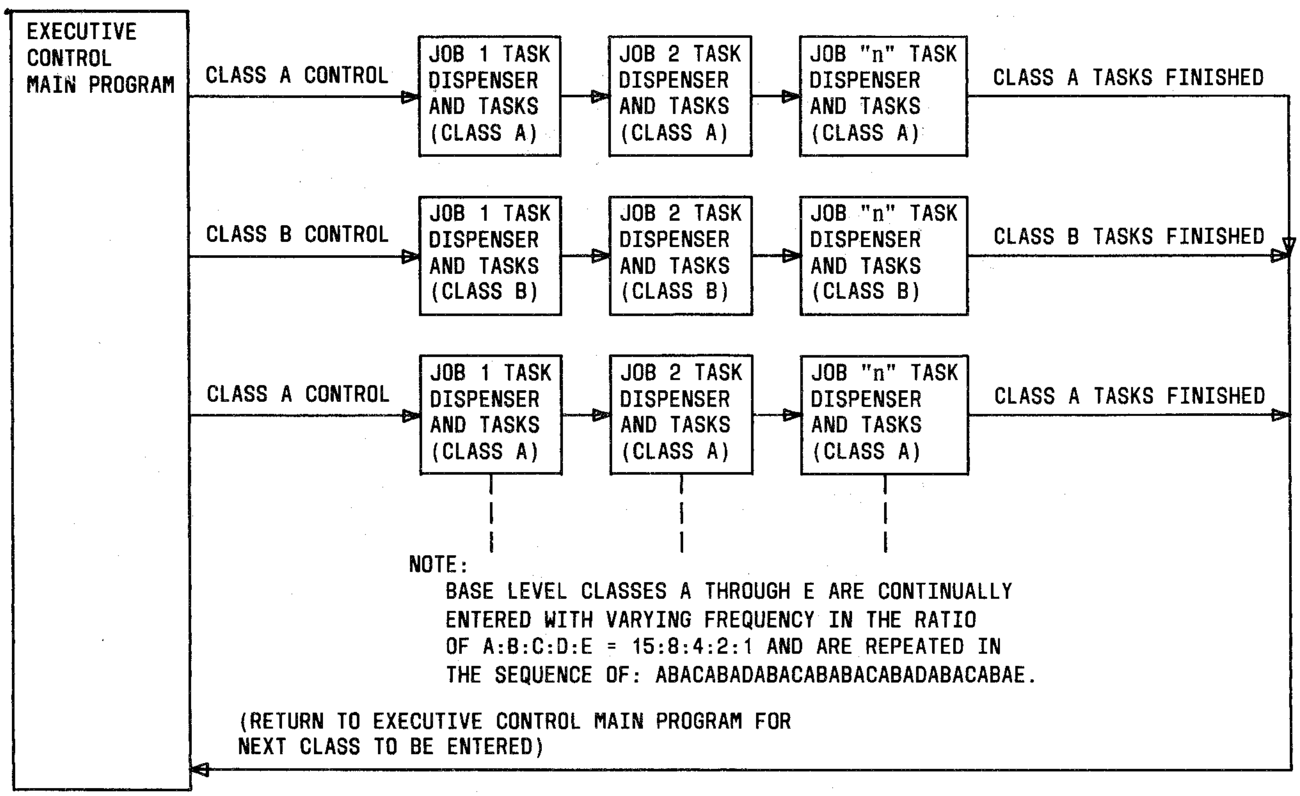


Fig. 8—Base Level Class Execution

E. Overload Strategies

Automatic Overload Control

2.38 The principles used for Automatic Overload Controls are separated into three periods:

(1) Transitional period from the nonoverload state to an overload state

(2) Period during an overload state

(3) Transitional period from an overload state to the nonoverload state.

2.39 Transition into the overload state is characterized by the fact that normal methods of operation are no longer sufficient to provide acceptable service, although a maximum traffic handling capability has not been reached. The main objective is to continue to honor all service requests. Call processing is to continue so that equality of service is maintained. Excessive delays of calls are to be avoided. The two main strategies during this transitional period are:

(1) Uniform degradation of service which is allowed to reach only a minimum tolerable level.

(2) The elimination and/or delay of various nonessential tasks. The elimination and/or delay of nonessential tasks serves two purposes. It has the effect of raising priority of call processing work with respect to nonessential tasks in base level. It also makes available more real time for call processing during the E-to-E cycle.

2.40 The overload state is characterized by one or more of the system resources being exhausted. The ultimate goal in this situation is to maintain system stability and processor efficiency to (1) provide maximum possible service and (2) eliminate the overload condition. During the overload state, it is no longer possible to honor all service requests. A maximum number of requests are accepted so that minimum service standards are maintained for those calls which are processed. All tasks that can be delayed are postponed and nonessential tasks are eliminated during this period. Incoming traffic is given priority over originating traffic.

2.41 As the overload condition subsides, the objectives are to again honor all service requests and to reestablish equality of service. Service is improved and nonessential tasks are restored. The Automatic Overload Controls are designed to gradually restore the system to the nonoverload state.

Real-Time Overload Control Strategy

2.42 A continuing overload condition can, regardless of the cause, manifest itself as a real-time overload. Refer to paragraphs 2.05 through 2.10. A real-time overload is usually due to heavy originating and/or incoming traffic which can cause real-time performance degradation of the processor. The real-time overload control objectives can be categorized according to the following levels of traffic:

- Idle system
- Low traffic
- High traffic
- Real-time overload
- Decreasing traffic.

2.43 During periods with virtually no traffic, all nonessential task are performed and line and trunk scanning are performed at their maximum rates. The traffic acceptance rate is kept at a sufficient value to allow for any reasonable surge or change in traffic level without introducing processing delays.

2.44 Low traffic is characterized by a plentiful supply of available real time. Thus all nonessential tasks are performed as closely to the maximum rates as available real time allows. The acceptance rate should be very high so that the probability of delaying any traffic into the system is virtually zero. Sufficient real time is available to handle the processing of any unexpected surge or change in level of traffic.

2.45 During periods of high traffic, real time is at a premium and nonessential tasks are suspended. Trunk and line scanning are performed as time allows with the provision that the trunk scanning rate be maintained at a minimum rate of approximately 300 ms except for those trunks requiring a 50 ms scan rate. The acceptance rate is decreased to provide a firm upper limit on traffic into the system and to react quickly in the event of an overload.

However, the acceptance rate is still maintained at a sufficiently high value to keep the probability of imposing delays on traffic into the system at a very low level.

2.46 During a real-time overload condition an immediate reaction is required to limit traffic. Since originating and incoming traffic can cause a real-time overload, controls are provided for the line service request hopper (LSRH) and trunk seizure and answer hopper (TSAH) unloading rates. Further control is provided to prohibit an excessive amount of traffic into the system during short intervals of time when it appears that adequate real time is available due to statistical occurrences of finding little work in the hoppers. Incoming traffic is given priority over originating traffic. All incoming traffic is accepted to a point where originating traffic has been limited to some minimum value. At this juncture, limiting also begins to include incoming traffic. This coordination operates virtually instantaneously and implies the overload control is generic and adaptive in the sense that it reacts appropriately regardless of the traffic mix.

2.47 With decreasing traffic, as the system moves from the overload state to the high traffic state or from high traffic to low traffic, etc, the stated objectives of the new traffic level are rapidly met. For example, as an overload subsides an immediate reaction is to allow all traffic into the system and thereby eliminate processing delays.

Improved Overload Strategy

2.48 As the number of local No. 1 ESS offices deployed in the field increased, and the traffic load offered increased, various overload scenarios became an increasing concern. The concern was not only for throughput degradation with increasing load, but also the recovery characteristics for both traffic induced overloads and short system outages. Traffic induced overloads and short system outages caused real-time overloads which, in turn, caused system performance to be degraded.

2.49 Prior to the Improved Overload Strategy (incorporated in 1E6 and later generic programs) a key factor in system degradation due to a real-time overload was the first in-first out (FIFO) discipline used for the LSRH and the suspension of line scanning when the LSRH filled. This resulted in nearly all customers receiving long dial tone delays. One result of excessive dial tone delay is that a customer may receive dial tone while dialing or after completion of dialing. Studies of customer behavior indicate that a significant portion of the customers do not wait for dial tone before dialing. This usually results in one of the following call dispositions:

- Partial dial abandonment
- Partial dial time-out
- False start
- Misdirected call
- Abandonment which is not seen.

Such calls have two deleterious effects on system real time. They consume a nontrivial percentage of real time needed to process a good call, and they generate retrials, which not only compound the problem but tend to perpetuate it. The combination of these two effects results in a catastrophic type of behavior in an overload situation. That is, system performance degrades catastrophically as the load increases. Even as the load subsides, the throughput remains poor until a substantial load reduction has been made. Thus, once an overload has started, a significant decrease in the first offered load is needed to return the system to the preoverload throughput. This hysteresis effect also adversely affects the recovery of the system due to brief outages.

2.50 The Improved Overload Strategy available in 1E6 and later generic programs basically changed the serving of the LSRH from first in-first out (FIFO) to last in-first out (LIFO). The IOS also incorporates pushout and time-out strategies for calls placed in the LSRH. The main objective of IOS is to allow the ESS to serve the maximum number of good calls possible during an overload condition while expending a minimum amount of real time for calls having a low probability of completion. For example, calls originated by customers not waiting for dial tone prior to dialing (discussed in paragraph 2.49) have a low probability of completion. During an overload condition, dial tone delays occur which tend to perpetuate and increase the severity of the overload when the LSRH is serviced using the FIFO service method. With the FIFO method, when the LSRH becomes full, line scanning is stopped. Thus, with the FIFO service strategy, when an office approaches an overload condition, system performance and customer service is rapidly and severely degraded.

2.51 The Improved Overload Strategy (using LIFO with pushout and time-out) improves system performance and customer service during an overload condition. Attributes of the IOS are as follows:

- Improved call completions during overloads
- More modest dial tone delays during overloads
- Quicker recovery from outages
- Decrease in sensitivity to load fluctuations and surges
- Sensitive to customer behavior.

2.52 Using LIFO with pushout and time-out, there are four possible dispositions of a line service request.

(1) The service request is served immediately; ie, dial tone delay is essentially zero.

(2) The service request is served after waiting in the LSRH for some period of time less than 20 seconds.

(3) The service request in the LSRH times out in 20 to 30 seconds and is removed from the LSRH.

(4) The service request is pushed out of the LSRH.

> ***Note:*** Line scanning is resumed on those LENs that were previously in the LSRH but were removed due to either pushout or time-out. These LENs have an equal chance with other LENs of being served first.

2.53 Implementation of the IOS is as follows:

(1) When an off-hook signal is detected by line scanning, the request is placed in the LSRH and waits for a dial tone connection. As the originating load increases, the line scanning rate is decreased; however, line scanning is not stopped (as was previously done with FIFO).

(2) Central control unloads a certain number of line equipment numbers (LENs) from the LSRH on a LIFO basis and connects each LEN to a customer digit receiver (CDR). Dial tone is given and (for discussion purposes) service is assumed complete. (The exact details of call completion are irrelevant for this description.)

(3) When the LSRH is full, which can occur during heavy loads, the next arriving line service request will push out the line service request in the last position of the LSRH. When a request is pushed out, the LEN is placed back on line scanning and can reenter the system.

(4) Each request in the LSRH is timed. If a request has remained in the LSRH for 20 to 30 seconds, the request is removed from the LSRH and the LEN is placed back on line scanning. At this point, the service request has an equal chance with other service requests of being served first.

Line Load Control

2.54 Line Load Control (LLC) is available to provide some degree of control over line originations during periods when service has been severely degraded. Unlike the Automatic Overload Controls which are inherent in the system operation, LLC is selected by maintenance and/or traffic personnel. LLC has the capability to control the line load distribution by temporarily denying originating service to lines in nonessential line groups during a measured overload. The degree of control is determined by the extent and persistence of the overload. While attempting to alleviate the overload, LLC also assures service to essential lines.

2.55 Two conditions are required for Line Load Control to be active: (1) Line Load Control must be enabled and (2) a measured overload (based on dial tone speed tests and network blocking) must be occurring for Line Load Control to be active.

> ***Note:*** To prevent ambiguity, the terms "enable(d)" and "active" are defined as follows. When enabled, Line Load Control is not denying service to any lines, but can deny service if network blockage limits are exceeded and/or dial tone speed test failures occur. When active, Line Load Control has been enabled and is actively denying service to some or all nonessential lines.

DESCRIPTION

3. USER OPERATION

CUSTOMER

3.01 During an overload condition, customers may experience delays in receiving dial tone, depending on the severity of the overload condition. When Line Load Control is actively denying service during an overload condition, some or all nonessential lines (depending on the severity and duration of the overload) will not receive dial tone.

TELEPHONE COMPANY

A. Overload Detection

3.02 Various methods are used to detect office overload conditions. Indicators are provided to aid traffic and maintenance personnel to recognize an overload condition. An overload condition may occur because of either system problems or heavy traffic, as discussed in paragraphs 2.05 through 2.11.

Automatic Overload Controls

3.03 Overloads are generally classed as hardware, software, and real-time overloads. The system inherently monitors its operations and work load to detect an overload condition. During the transition period from a nonoverload state to an overload state, and during the overload state, Automatic Overload Controls operate to smooth the system work load and to alleviate the overload condition. Generally, when heavy traffic or system problems adversely affect the system hardware, software, or real-time resources, a central control real-time overload condition occurs regardless of the specific cause or type of overload.

3.04 Detection of an overload condition depends on the overload source. An overload condition may be manifested by any of the following conditions:

- Long E-to-E cycle times
- Long input-output times
- Full hoppers/buffers
- Failure to seize idle registers
- Failure to seize idle equipment
- Failure of network path hunts
- Dial tone speed test failures
- High level of system activity in one or more areas (ie, originating calls, incoming calls, processor occupancy, etc).

Line Load Control

3.05 During an extreme situation, such as an emergency or disaster, traffic may become so great that the Automatic Overload Controls cannot alleviate the overload condition and service will be severely degraded. For such an extreme situation, Line Load Control is available to provide some degree of control over originations from nonessential lines.

B. TTY Messages

3.06 For a detailed description of TTY input and output messages, refer to item B in Part 18.

Output Messages

Automatic Overload Controls

3.07 TOC01 and TOC02 output messages contain overload data for the various overload conditions and status data for traffic controls. The TOC01 and TOC02 messages differ in that the TOC01 message is used to initially report serious overload conditions, while the TOC02 message is used to report less serious conditions and/or to periodically report persisting abnormal conditions. The TOC01 message is accompanied by a major or minor alarm and by a bell at the traffic TTY.

3.08 There are other output messages (TC15, LC01, and LC02), based on the overload condition, which may be recognized by statistical data evaluation of system outputs. For example, the TC15 quarter-hour traffic report is useful in evaluating the traffic load. Other items which may be considered include:

- Quarter-hour plot of E-to-E cycle times
- The number of originating and incoming calls processed
- Dial tone delays
- Line scans.

3.09 The 15-minute traffic data is transmitted to the maintenance and traffic TTYs on any clock quarter-hour when one or more of the following conditions exist:

(a) Receiver queue overload has existed for some interval during the last 15 minutes.

(b) Line Load Control is on.

(c) The maintenance or traffic TTY has requested the traffic data.

Line Load Control

3.10 An LC01 output message is printed due to a change in the status of Line Load Control. For example, an LC01 message is printed when:

(a) The first group(s) of nonessential lines has been denied service.

(b) All groups of nonessential lines have been restored to service.

3.11 The LC02 output message prints the present state of the LLC scan mask in response to the input message LLC-MASK-PRINT.

Input Messages

Automatic Overload Control

3.12 The TTY input message TOC-STATUS is used to request a print (TOC02 output message) of the traffic and overload control status.

3.13 Maintenance and traffic personnel may turn the printing of the traffic data on or off by means of the following TTY input request:

- LS-QUARTER-M,ON. (Maintenance on request)
- LS-QUARTER-M,OF. (Maintenance off request)
- LS-QUARTER-T,ON. (Traffic on request)
- LS-QUARTER-T,OF. (Traffic off request).

Line Load Control

3.14 LLC-MASK-PRINT is used to request the LC02 output message which contains the present state of the LLC scan mask.

3.15 LLC-INH is used to inhibit Line Load Control. LLC-ALLOW-ON is used to manually enable Line Load Control. LLC-ALLOW-AU is used to place Line Load Control in the automatic mode. Line Load Control modes are discussed in paragraphs 3.26 through 3.34.

C. Indicators

3.16 Lamps are provided on the MCC alarm, display, and control panel (Fig. 9) to indicate the following:

- Receiver overload condition—***RCVR OVLD*** lamp
- Central control overload condition—***CC OVLD*** lamp
- Dial tone speed test failures—***DT DEL*** lamp
- Line Load Control enable state—***LLC ENAB*** lamp.

Note: The ***OG LOAD CONTROL*** and ***INC LOAD CONT*** lamps are associated with Network Management.

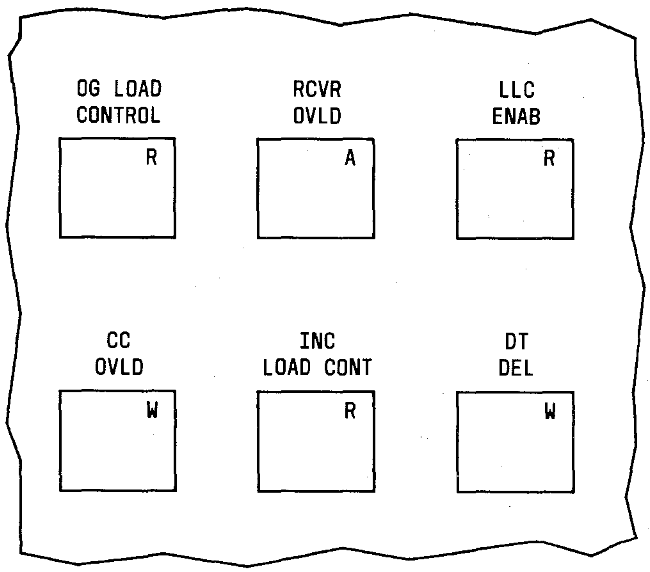


Fig. 9—Overload Indicators at the MCC Alarm, Display, and Control Panel

Automatic Overload Controls

3.17 The ***RCVR OVLD*** lamp is lighted when a receiver queue overload condition occurs. Also, for this condition, an audible alarm is sounded and a TOC01 message is immediately printed on the maintenance and traffic TTYs. On the next quarter-hour and each succeeding quarter-hour thereafter, TC15 and TOC02 messages providing overload data are printed.

3.18 The ***CC OVLD*** lamp is lighted when the E-to-E cycle time becomes excessive. When a CC overload occurs, a TOC02 message is printed on the maintenance and traffic TTYs to provide data concerning the overload.

Line Load Control

3.19 The ***DT DEL*** lamp is lighted whenever a 3-second dial tone speed test fails or whenever Line Load Control is denying originating service to one or more groups of nonessential lines.

3.20 The ***LLC ENAB*** lamp is lighted when Line Load Control is enabled in either the automatic or manual mode.

> ***Note:*** Whenever the ***LLC ENAB*** lamp is lighted, Line Load Control may or may not be denying originating service to one or more groups of nonessential lines, depending on the results of dial tone speed tests and network blockage measurements.

D. Automatic Overload Controls

3.21 Automatic Overload Controls are inherent in the system design and operation, as discussed in Part 2. No manual actions are required for the Automatic Overload Controls. When hardware, software, and/or real-time overload conditions are detected, system operations are automatically altered to alleviate the overload condition.

E. Line Load Control

Determining the Need for Line Load Control

3.22 The consequences of Line Load Control (LLC) should be carefully considered since LLC has the capability to control the load distribution by temporarily denying originating service to lines in nonessential line groups. The degree of control is determined by the extent and persistence of the overload. LLC also assures originating service to essential lines.

3.23 Before deciding on a particular course of action when an overload occurs, all system indications should be considered. The lamp indicators at the master control center (MCC), in conjunction with the TTY output messages, can be used to evaluate an overload condition. The TOC01, TOC02, TC15, LC01, and LC02 output messages provide direct indications as well as statistical data to aid in recognizing and evaluating various overload conditions. Refer to item B in Part 18 for a detailed description of the messages. Items to be considered during an overload condition include:

- Long E-to-E cycle items
- Full hoppers/buffers
- Failures to seize idle equipment
- Failures of path hunts
- Dial tone speed test failures
- Time of day in relation to the busy hour.

3.24 The occurrence of a receiver overload condition does not alone justify the need for manually selecting the LLC ON or LLC AUTOMATIC mode, since such action, while insuring service to essential lines, may deny service to nonessential lines. When LLC is active, service to nonessential lines, which may already be degraded due to the overload condition, is made considerably worse. For example, when a receiver queue overload does occur, Automatic Overload Controls have already caused permanent-signal, partial-dial (PSPD) timing to be decreased, thereby reducing the receiver holding time. Also, if not already in progress, dial tone speed tests are initiated. ***Therefore, if LLC is enabled and a receiver queue overload occurs, LLC may start denying service to nonessential line groups because of dial tone speed test failures caused by peaked traffic. LLC is available to improve and assure originating service to essential lines during prolonged and/or extreme overload conditions. Calls originating from nonessential lines may be either temporarily delayed or denied when LLC is active.***

3.25 As with receiver queue overloads, a CC overload condition does not alone justify the need for LLC. A CC overload condition may be caused by system problems (such as equipment failures or software problems) or heavy traffic, which reduce real-time availability for call processing. Increasing processing demands, as indicated by longer E-to-E cycle times (decreasing real-time availability), can cause a CC overload condition. LLC may or may not alleviate a CC overload condition. ***A CC overload condition should (in nonemergency situations) be alleviated without the need for LLC, since the Automatic Overload Controls delay and eliminate tasks and control the rate and number of trunk and line originations that are accepted and processed during a particular time period.***

3.26 It is not possible to prescribe the exact conditions for selecting Line Load Control. Line Load Control may be placed in one of three modes which are (1) OFF, (2) ON, and (3) AUTOMATIC. The selective use of LLC should follow local procedures established by the telephone company. It is strongly recommended that LLC ***not*** be left in the ON mode during times when no emergencies exist.

> ***Note:*** To provide uniform service to all lines, Line Load Control should not be left in the ON or AUTOMATIC mode during periods of normal machine operation. Preferential treatment should be restricted to disaster or emergency situations. For hours when there is no local or remote plant maintenance coverage or traffic coverage, the AUTOMATIC mode is appropriate.

LLC Mode Selection

3.27 The appropriate LLC mode (OFF, ON, or AUTOMATIC) is selected using either the maintenance or traffic TTYs. No line groups are denied originating service unless LLC is enabled in either the ON or AUTOMATIC mode and a measured overload (based on dial tone speed test failures or a measured network overload) is occurring. The terms "enable(d)" and "active" as used for LLC are defined in paragraph 2.55.

3.28 LLC may be placed in the OFF mode by using the LLC-INH input message. LLC may be placed in the manual ON mode (manually enabled) by entering the LLC-ALLOW-ON message. LLC may be placed in the AUTOMATIC mode using the LLC-ALLOW-AU message. Note that in the AUTOMATIC mode, LLC is enabled and disabled automatically by the system according to extended dial tone speed test failures. Indicators associated with LLC are the LC01, LC02, TOC01,and TOC02 output messages and the dial tone delay and the Line Load Control indicator lamps on the system status panel.

LLC OFF Mode

3.29 The LLC OFF mode is selected using the LLC-INH message. In the OFF mode, LLC is inhibited (disabled) and cannot deny originating service to any lines regardless of dial tone speed test failures or network failures which may occur. When LLC-INH is selected, a TOC02 message is printed indicating that LLC is off.

LLC ON Mode

3.30 When the LLC-ALLOW-ON message is entered, LLC is immediately enabled. When enabled, the ***LLC ENAB*** lamp is lighted, a major alarm is sounded, and a TOC01 message is printed indicating that LLC is on (enabled). After LLC is enabled, the system administers Line Load Control according to calculations based on the results of 3-second dial tone speed tests and network overload measurements. Dial tone speed tests are performed every 4 seconds (unless inhibited) and the network overload status is determined every 3 minutes by measuring the extent of network path blockage (incoming matching loss) occurring on incoming calls. LLC either allows or denies originating service to one or more nonessential line groups based on the results of dial tone speed tests and network blockage. Three successive 3-second dial tone speed test failures or 10-percent network blockage for a 3-minute interval will cause LLC to remove dial tone service from one-half of the nonessential lines currently able to receive dial tone service. Three more successive 3-second dial speed test failures or another 3-minute period with 10-percent or greater network blockage will result in another 50-percent decrease in the remaining number of nonessential lines served. After four such decreases in service for nonessential lines, all nonessential lines are denied dial tone service.

3.31 When LLC is active, originating service is denied to one or more nonessential line groups depending on the degree and persistence of network blockage and dial tone speed test failures, which are indicative of a service overload condition. When LLC starts denying service, an LC01 message is printed. As the overload subsides, LLC gradually restores originating service to all lines. When originating service is denied on the basis of network blockage, LLC will not restore any line group during the 3-minute interval but will deny additional nonessential line groups based on 3-second dial tone speed test failures. If the network blockage is less than 10 percent after 3 minutes, the line group denied originating service for the longest time is restored following a successful dial tone speed test. For each successful dial tone speed test thereafter, LLC restores service to another line group. When originating service is denied on the basis of 3-second dial tone speed test failures, LLC restores service to the nonessential line group that has been denied service for the longest period each time a dial tone speed test is successful. When originating service has been restored to all lines, an LC01 message is printed and LLC is no longer active; however, LLC remains enabled in the ON mode.

LLC AUTOMATIC Mode

3.32 The AUTOMATIC mode is selected using the LLC-ALLOW-AU message. When this mode is selected, a TOC02 message is printed indicating the mode selected and the enable status, which may be either OFF or ON.

3.33 LLC is automatically enabled only when extended dial tone speed test failures occur. For extended dial tone speed testing, when a regular 3-second test fails, the test on that line is extended an additional 8 seconds (maximum). Thus, the total maximum time for an extended dial tone speed test is 11 seconds. Since the extended tests start as regular 3-second dial tone speed tests, the extended tests occur at the same rate (one every 4 seconds). The criterion for failing regular dial tone speed tests is still a 3-second dial tone delay. Regardless of extended testing, there are 900 3-second dial tone speed tests per hour. Traffic counts are recorded for the number of dial tone speed tests which exceed the 3-second and 11-second criteria.

3.34 LLC is automatically enabled (ON) when three successive extended dial tone speed test failures occur. When LLC is enabled, the ***LLC ENAB*** lamp is lighted, a major alarm is sounded, and a TOC01 message is printed. After being enabled in the AUTOMATIC mode, LLC is administered using the 3-second dial tone speed tests and network blocking measurements as discussed in paragraphs 3.30 and 3.31. As the service overload subsides, originating service is restored to nonessential lines until LLC is no longer active. Also, in the AUTOMATIC mode, LLC is automatically disabled (OFF) when all nonessential line groups have been restored to service and a service overload no longer exists. LLC remains in the AUTOMATIC mode until another mode is selected using the appropriate TTY message, LLC-INH (OFF) or LLC-ALLOW-ON (manual ON).

LLC Deactivation

3.35 LLC gradually restores service to nonessential lines as the service overload subsides. When service has been restored to all nonessential lines and a service overload does not exist, LLC is not active. If LLC is in the manual ON mode, LLC remains enabled until another mode is selected. If LLC is in the AUTOMATIC mode, LLC is enabled (ON) and disabled (OFF) automatically by the system based on extended dial tone speed tests.

3.36 The input message LLC-INH inhibits LLC. If LLC-INH is entered when LLC is active (denying service), LLC is disabled and inhibited and originating service is restored to all lines.

> ***Note:*** If dial tone speed tests are inhibited, LLC is also inhibited.

Evaluation of LLC Effects

3.37 The number of nonessential lines returned to service after LLC has been activated is an indication of how much the service overload has subsided. To determine the number of line groups which are being permitted or denied originating service, the input message LLC-MASK-PRINT is typed in at the maintenance or traffic TTYs. This message requests a printout of the present state of the LLC scan mask word. See items A(6) and B(2) in Part 18 for a complete description of the LLC mask. An LC02 output message is printed indicating the number of line groups being served and/or denied. The results of the LC02 printout and other indicators (ie, the overload indicator lamps, TOC01, TOC02, and LC01 output messages) may be used in evaluating an overload condition to aid in determining when the system should be returned to normal. Table C is a summary of LLC modes, conditions, and indicators.

TABLE C

LLC SUMMARY

MODE SELECT TTY INPUT MESSAGE	LLC MODE	DIAL TONE SPEED TEST (DTST) FAILURES	LLC STATUS	INDICATOR LAMPS		RELATED TTY OUTPUT MESSAGES	REMARKS
				DT DEL	LLC ENAB		
LLC-INH	Off	No Affect	Inhibited	Off or On	Off	TOC02	LLC not enabled or active; all lines have originating service.
LLC-ALLOW-ON	ON	3-sec DTST< 3	Enabled	Off	On	TOC01	LLC enabled but not active; no service overloads based on DTST and network blockage. All lines have originating service.
		3-sec. DTST< 3	Enabled and Active	On	On	TOC01, LC01, TC15	LLC actively denying originating service to one or more nonessential line groups based on the degree and persistence of the service overload.
LLC-ALLOW-AU	AUTOMATIC (OFF)	11-sec. DTST< 3	Not Enabled or Active	Off or On	Off	TOC02	In AUTOMATIC mode, LLC is either OFF or enabled (ON) automatically based on extended DTST failures.
	AUTOMATIC (ON)	11-sec. DTST> 3	Enabled, not Active	On	On	TOC01	LLC is automatically enabled after three successive extended DTST failures; however, LLC is not active until three successive 3-second DTST failures occur or network blocking exceeds certain limits.
		3-sec. DTST> 3	Enabled and Active	On	On	TOC01, LC01, TC15	

4. SYSTEM OPERATION

HARDWARE

4.01 Not applicable.

OFFICE DATA STRUCTURES

A. Translations

4.02 Not applicable.

B. Parameters/Call Store

Note: For detailed set card, parameter, and call store information, refer to items C(1) and C(2) in Part 18.

Automatic Overload Control

4.03 The LSRH (call store table HLR) is built with set card LRH. LRH indicates the quantity of LSRH entries. Prior to the 1E6 generic program, the permitted range was 8 through 16,000 and the reasonable range was 8 through 56. The LSRH does not exist in the 1E4 and 1E5 generic programs. With the Improved Overload Strategy in 1E6 and later generic programs, the permitted range is 256 through 1024 and the reasonable range is 256 through 672.

4.04 One call store word is used for the variable A6MAX5. The content of call store word A6MAX5 is used to control the unloading rate of entries in the LSRH and TSAH. One fixed generic program word specifies the maximum value for A6MAX5.

Line Load Control

4.05 Parameter word L4ESSL, built with set card EVL, specifies the fraction of total line groups (verticals) in the office that are marked as essential. The fraction of line groups specified as essential may be either 1/16, 1/8, 3/16, or 1/4. A value of one specifies 1/16, two specifies 1/8, three specifies 3/16, and four specifies 1/4. A value of one is recommended to specify one line group (vertical 4) as essential.

4.06 Parameter word L4LLCS, built with set card LLCS, specifies the state of Line Load Control after system reinitialization. A value of zero specifies that Line Load Control be off, one specifies the automatic state, and three specifies the on state. A value of zero is recommended to cause Line Load Control to be placed in the off state after system reinitialization.

FEATURE OPERATION

4.07 Office Overload Controls consist of Automatic Overload Controls (inherent in the system design and operation for hardware, software, and real-time overloads) and Line Load Control.

4.08 The basic strategies for hardware and software overloads are (1) try another way, (2) queue, (3) try again later, and (4) do not serve the call. For real-time overloads, the strategies are to delay and/or eliminate work. These strategies are effected during system operations by certain programs which include:

- Call processing programs
- Executive control programs
- Maintenance control program
- Emergency action facility
- Automatic overload control program
- Traffic measurements programs
- Queue administration programs.

For a detailed description of these program functions, refer to items A(2) through A(6) in Part 18.

4.09 When active, Line Load Control temporarily denies originating service to one or more nonessential line groups based on the degree and persistence of a service overload. A service overload condition is determined by the results of dial tone speed tests and network blockage (incoming matching loss) measurements. For a description of dial tone speed tests, incoming matching loss measurements, office overload procedures, and Line Load Control, refer to items A(7) through A(10) in Part 18.

A. Hardware Overload

4.10 Hardware overload occurs when the quantities of engineered hardware items are insufficient to meet existing traffic demands. Hardware overload conditions are generally classified into three areas:

(1) Service circuit overload

(2) Outgoing and 2-way trunk overload

(3) Network overload.

The detection of busy and/or blocking conditions occurs in the call processing client programs of the system.

Service Circuit Overload

4.11 When a call encounters a service circuit busy condition, queueing is usually done for the particular type of service circuit. An exception is that queueing is not done for transmitters. Transmitters are subject to preemption after a waiting period for start pulsing signals exceeding 4 to 5 seconds. Table D indicates those service circuits for which a queue is provided and the type of queue. If a queue does not already exist for the particular circuit, one is established, with this call being the first entry. Otherwise, the call is loaded into the existing queue. During the period of time that the queue exists, the service circuit idle list head cell is marked to inhibit seizures of idle equipment by calls not on the queue. Queue unloading occurs whenever a service circuit becomes available. The queue is unloaded sequentially (ie, the first call queued is unloaded first).

4.12 Special actions occur when there is a shortage of receivers. The first entry on a receiver queue causes permanent-signal, partial-dial (PSPD) timing to be decreased. Normal PSPD timing is 16 to 24 seconds. Decreased PSPD timing causes the maximum receiver holding time for incoming trunks to be decreased. When a receiver overload occurs, permanent signal (PS) timing is reduced to 10 to 15 seconds and partial dial (PD) timing is reduced to 5 to 10 seconds.

4.13 If a call fails to seize a customer dial receiver, the call is placed on a queue and a receiver preemption request is made. This request will free a receiver being used only for supervision of an outgoing call during outpulsing. The call associated with the preempted receiver is then supervised by a special line ferrod scan.

4.14 When a receiver queue is established, a 100-second timer is started. If the queue overflows, a check is made to determine if the queue has existed for at least 100 seconds; if so, a receiver queue overload exists and office personnel are alerted via the following indications:

(a) The ***RCVR OVLD*** lamp at the MCC is lighted.

(b) A TOC01 output message containing overload data and traffic control status is printed on the maintenance and traffic TTYs. An audible

TABLE D

SERVICE CIRCUIT QUEUES

SERVICE CIRCUIT	QUEUE TYPE
Customer Dial Pulse Receiver	Fixed
Customer Receiver for ***TOUCH-TONE***® Dialing	Fixed
Trunk Receiver	Linked PMT
Regular Ringing Circuits	Linked Register
Special Ringing Circuits	Linked Register
Coin Control Circuits	Linked Register
Hi Tone	Linked Register
Low Tone	Linked Register

alarm is sounded and a bell rings at the traffic TTY(s).

(c) A TOC02 output message, which also contains overload data and traffic control status, is printed on the maintenance and traffic TTYs every 15 minutes if the overload persists.

(d) Also, if not already in progress, the TC15 quarter-hour traffic report is activated to report traffic and overload measurements.

Outgoing and 2-way Trunk Overload

4.15 If an outgoing call fails to find an idle trunk in the primary group, successive alternate groups are tried until either an idle trunk is found or until all alternate groups are exhausted; in which case, overflow tone is given.

4.16 Certain trunk groups in an office can be designated as toll protected, and certain lines can be designated as toll essential. If the toll network protection program is activated via a TTY input message, only toll essential lines are permitted to access toll protected trunks. An attempted seizure of a toll protected trunk by a nontoll essential line will result in overflow tone being given to that line.

Network Overload

4.17 Network blockage conditions can cause a network overload. On an incoming call, if blocking on all possible paths occurs on the network path hunt from the incoming trunk to the terminating line, the trunk is given overflow; otherwise, the call is completed. On an outgoing call, if an idle trunk is found but the network path hunt blocks, another idle trunk and path are hunted. If blocking occurs the second time, the procedure is repeated once more. A third failure results in overflow being given to the originating line. An exception is network blockage experienced when connecting to a customer dial receiver. In this case, queueing (blocked dial tone queue) is done for an idle path. The blocked dial tone queue is unloaded every 2 seconds until the blockage is cleared or the customer(s) abandons.

> ***Note:*** If the system is in a real-time overload, blocking retrials of trunk hunts are eliminated.

4.18 Every 3 minutes a count is made of the incoming matching loss failures to reserve talking paths for incoming calls. Incoming matching loss failure counts are one of the measurements used for Line Load Control.

B. Software Overload

4.19 Various software items in the system are engineered according to the expected traffic load in the office during the average busy hour. A software overload exists when the demand on one or more of these items exceeds the supply or engineered capability. Engineered software items include the various system hoppers, call registers, and peripheral order buffers (POBs). Software overloads are handled by the call processing programs, executive control program, and the automatic overload control program. The strategies used for software overload controls are to eliminate nonessential tasks, to delay certain deferrable tasks, and to queue for particular software items. For discussion purposes, software is classified as either nonhopper type or hopper type software.

Nonhopper Overload

4.20 Some types of registers are engineered on a one-to-one basis with hardware; thus, if the hardware is available, so is the register. If registers (which are not engineered on a one-to-one basis with hardware) are not available, the call which made the request for the register is restored to a previous state and placed on a queue for the required software. Software items for which queueing is used are listed in Table E.

> ***Note:*** When queueing is done for a call requiring trunk-to-trunk memory (TTM), a transmitter and outpulsing register are held for the call while on the TTM queue. Therefore, sufficient trunk-to-trunk memory must be available; otherwise, service may be seriously affected.

Hopper Overload

4.21 Hoppers are engineered to hold various numbers of entries. When a hopper fills up, hopper overload exists. Hopper overloads are handled differently in non-SP and SP offices. In a non-SP office, input-output work is accomplished via input-output programs, as previously discussed; whereas, input-output work in an SP office is handled by the SP. In a non-SP office, when an input-output program loads an entry into a hopper and finds the hopper full, a

TABLE E

SOFTWARE QUEUES (NONHOPPER)

SOFTWARE ITEM	QUEUE TYPE
Regular Ringing Register	Linked Register
Local Coin Overtime Register	Linked Register
Coin Zone Register	Linked Register
CAMA Register Port 0	Linked Register
CAMA Operator	Linked Register
AMA Output Buffer	Linked Register
Peripheral Order Buffer	Linked Register
Trunk-to-Trunk Memory (TTM)	Linked Register

direct transfer is made to the automatic overload control program to alleviate the overload condition.

4.22 In an SP office, the SP is unable to administer hopper overloads except for the LSRH. Therefore, except for LSRH overflows, the SP must request (via a K-level interrupt) that the automatic overload control program administer the hopper overload.

SP Hopper Overload

4.23 When the SP is unable to make a hopper entry because the hopper is full, the hopper is considered overloaded. The automatic overload control program, resident in the CC, must administer all hopper overloads (except for the LSRH) occurring in the SP. The SP obtains the immediate attention of the CC for a hopper overload condition by generating a K-level interrupt. When a K-level interrupt is generated because of a hopper overflow, all SP work is stopped. The SP hopper overflow condition is administered by the CC, which causes the SP work to be resumed after administering the overflow condition.

4.24 The CC has access to the entire SP call store and all of the SP registers. After a K-level interrupt, the automatic overload control program determines which hopper overflowed. The last entry in the overflowed hopper is inspected to determine the source of the entry. In most cases, the automatic overload control program restores the memory associated with the hopper entry to the previous state (prior to overflow). After restoring the SP memory, the CC restarts the SP. The SP is usually restarted at the end of the current job (which resulted in overflow) since additional attempts could be made by the SP to load new entries, thus producing additional overflows. A request is made to unload the hopper in interject.

Non-SP Hopper Overload

4.25 Generally, if the input-output program which caused the hopper overflow looks for only one type of report and loads only one hopper, the remainder of the input-output job is skipped. If the input-output program looks for more than one type of report or loads more than one hopper, it is continued. The input-output jobs temporarily bypassed are listed in Table F, which also shows overload actions for the various hoppers. The general philosophy is to force another attempt to load the hopper and to request that the hopper be unloaded in interject.

4.26 The automatic overload control program contains hopper unloading routines for the LSRH and TSAH. The hopper unloading routines for generic programs prior to 1E6 are discussed separately, followed by a description of the Improved Overload Strategy implemented in 1E6 and later generic programs.

TABLE F

HOPPER OVERLOAD ACTIONS

HOPPER	INPUT-OUTPUT JOBS BYPASSED	INTERJECT UNLOADING PRIORITY	SUCCESSIVE OVERLOADS POSSIBLE
Abandon Interdigital Time-out	None	6	Yes
Centrex Key (Note 1)	None	9	Not Likely
Dial Pulse Transmission	None	11	Yes
Hit Scan Result	None	13	Yes
K-Level Interrupt (Note 2)	N/A	Not Unloaded in Interject	N/A
Line Ferrod Disconnect	None	15	No
Line Service Request (Non-SP)	(Note 3)	Not Unloaded in Interject	No
Miscellaneous Scan (TSJR)	None	10	Yes
Multifrequency	None	1	Yes
Release Dial Tone	None	7	Yes
Revertive Digit Reception	None	2	Yes
Revertive Digit Transmission	None	8	No
Ring Tip	None	12	No
Step-by-Step	None	3	No
TOUCH-TONE® Service	None	4	Yes
Trunk Dial Pulse Reception	None	5	Yes
Trunk Seizure and Answer	None (Note 4)	14	Yes

Note 1: Only offices with Centrex service have a Centrex key hopper.

Note 2: Only SP offices have a K-level interrupt hopper.

Note 3: Prior to the 1E4 generic program, line scanning was bypassed. The LSRH does not exist in the 1E4 and 1E5 generic programs. In 1E6 and later generic programs, a LSRH overload cannot occur since the Improved Overload Strategy incorporates a LIFO with pushout and time-out philosophy.

Note 4: Prior to the 1E4 generic program, line, trunk, and master scanning jobs were bypassed.

Note: Prior to the 1E4 generic program, the LSRH is unloaded on a FIFO basis. During a heavy traffic load or real-time overload, the LSRH can overflow causing line scanning to be temporarily suspended and originating service to be degraded. In the 1E4 and 1E5 generic programs, the LSRH is not used. Line service requests are processed immediately after a service request is detected by line scanning. Requests not able to be processed due to an overload condition are ignored. In 1E6 and later generic programs, the Improved Overload Strategy (with a LIFO, pushout, and time-out strategy) is used for the LSRH. The Improved

Overload Strategy prevents the possibility of a LSRH overflow and maintains some degree of originating service.

Regulation of TSAH and LSRH Unloading Rate

4.27 Regulation of the TSAH and LSRH unloading rate is done by the automatic overload control program. Adjustments to the unloading rate limits are made according to central control overload conditions. In non-SP offices with 1E4 and 1E5 generic programs that do not use a LSRH, the automatic overload control program service request adjustments are applied during line scanning. The limits are decreased (to a minimum) as long as overload conditions persist, and they are increased gradually (to a maximum) when overload conditions subside. This regulation smooths the rate at which trunk and line service requests are presented for call processing and helps to preclude real-time overloads.

4.28 Prior to CTX-6, there were no controls for regulating the TSAH unloading rate. In CTX-6 and later generic programs, controls (based on the existing LSRH unloading controls) for the TSAH unloading are provided. This incoming trunk overload control applies only to non-step-by-step calls. There are no direct overload controls for incoming step-by-step calls; however, the incoming trunk overload control indirectly compensates for incoming step-by-step traffic by placing constraints on other types of trunk traffic. Basically, the incoming trunk overload control limits the number of incoming trunk seizures which will be processed each time the TSAH is unloaded. When the number of trunk service requests exceeds the limit, excess requests are queued until time becomes available for further processing. The limit is variable and decreases when E-to-E cycle time becomes excessively long.

4.29 The overall traffic acceptance rate is used to limit both incoming and originating traffic, with incoming traffic given priority. Adjustments to the unloading rate limits are made according to overload conditions. The value of the limits is based on a call store variable (A6MAX5).

Administration of A6MAX5

4.30 The contents of the call store word A6MAX5 control the rate at which entries are unloaded from the TSAH and LSRH. The variable A6MAX5 varies dynamically as a function of E-to-E cycle time. When a real-time overload does not exist, A6MAX5 is equal to its maximum value specified in the generic program. Maximum values specified are 224 in an SP office and 160 in a non-SP office. These values are the same for all generic programs.

4.31 When the E-to-E cycle time becomes excessive (last 3 E-to-Es >5.04 seconds), the automatic overload control program decreases the value of A6MAX5 by one-sixteenth (1/16) of its current value. At this point, a minor overload exists based on the E-to-E cycle time. The value of A6MAX5 is continuously decreased at 3-second intervals as long as the E-to-E cycle time remains excessive (ie, minor or major overload).

> ***Note:*** The contents of A6MAX5 cannot go below a value of 15.

4.32 The value of A6MAX5 is increased by 1/16 of its current value when the average E-to-E cycle time decreases to less than 1.68 seconds as measured over a 5.04-second period. The value is continuously increased until A6MAX5 reaches its maximum value (ie, SP office = 224; non-SP office = 160).

Unloading the TSAH and LSRH

4.33 The unloading of the TSAH and LSRH are base level class C and class D tasks, respectively. Base level operations are discussed in paragraphs 2.30 through 2.37. It is important to note that there are two class Cs between each class D. (Refer to Fig. 7.) Each D-to-D cycle begins with the first class C following a class D and therefore has the form C-C-D. The number of service requests which may be processed during each class is determined as follows:

- First class C—The number of trunk seizures which may be processed is 1/32 of A6MAX5 plus one.
- Second class C—The number of trunk seizures which may be processed is 1/32 of A6MAX5 plus one, plus any remaining counts left from the first class C.
- Class D—Prior to the Improved Overload Strategy, the number of line service requests which may be processed is equal to the number of counts left over from the two preceding class Cs plus one. In this manner, even if the

count already equaled the maximum due to the incoming traffic, one line origination is still processed. With the Improved Overload Strategy, the number of line service requests which may be processed is equal to the number of counts left over from the two preceding class Cs plus four, thus permitting a minimum of four line originations to be processed.

4.34 The equation for the trunk and line service requests accepted for processing during one D-to-D cycle, in the form C-C-D is (1/32 A6MAX5+1)+(1/32 A6MAX5+r+1)+(rc+1 or rc+4)

where r = remaining counts from the first class C and

rc = total remaining counts from both class Cs. The maximum value of A6MAX5 is 160 for a non-SP office and 224 for an SP office.

Note: Variable A6MAX5 is decreased by 1/16 of its current value every 3 seconds during a minor or major overload to a minimum of 15. After an overload subsides, A6MAX5 is increased by 1/16 of its current value until the maximum value is reached.

4.35 This implementation method insures that incoming traffic is given priority over originating traffic. This is desirable since more time and equipment is invested in an incoming call as compared to an originating call. This method also lessens the possibility of propagating an overload condition to other offices.

LSRH Unloading Administration

4.36 The contents of A6MAX5 control the rate at which entries are unloaded from the LSRH during base level class D as discussed in paragraphs 4.27 through 4.34. When an entry is removed from the LSRH, the originating line is connected to dial tone. If a customer dial receiver (CDR) is not available, the service request is placed on a CDR queue until a CDR is available. CDR queueing is discussed in paragraphs 4.11 through 4.14. In addition to the unloading rate during class D, no more than the number of hopper entries specified by A6MAX5 may be unloaded within 5 seconds. When that number is reached, LSRH unloading is suspended for the remainder of the current 5-second time period. The 5-second limit guarantees that an excessive number of entries will not be allowed to be processed during periods of short E-to-E cycle times and/or light incoming traffic.

4.37 Prior to the Improved Overload Strategy, when LSRH unloading is suspended, new line service requests continue to be loaded into the LSRH. In such a case the LSRH could overflow. LSRH overflows are handled entirely by the SP in an SP office. In a non-SP office, since the LSRH is not unloaded in interject, line scanning is temporarily suspended. Supervision is reset for the line causing an LSRH overflow, and LSRH loading is stopped until space is available. With the Improved Overload Strategy, the LSRH cannot overflow and line scanning is not suspended.

TSAH Unloading Administration

4.38 A count is kept of the number of seizures processed each time the TSAH is unloaded during each class C visit. This count is compared to the current per-visit limit which specifies how many seizures may be processed. The limits are established as discussed in paragraphs 4.33 and 4.34. When the count of the number of trunk seizures processed equals the limit, the remaining entries in the TSAH are put on the incoming overload control queue.

4.39 During periods of heavy incoming traffic, the incoming overload control queue helps to maintain a high-call-completion rate by reducing the possibility of a TSAH overflow. In offices with generic programs prior to 1E4, when the TSAH overflows, line scanning, trunk scanning, and master scanning are temporarily suspended to prevent successive overloads, and a request is made to unload the TSAH in interject. In offices with 1E4 and later generic programs, scanning continues but any attempts to load the TSAH hopper are inhibited.

Incoming Overload Control Queue Unloading

4.40 The incoming overload control queue is unloaded during base level class C visits. Class C is the same class in which the TSAH is unloaded. Therefore, the limit on the number of trunk seizures processed from each class C visit is applied to the sum of the numbers processed from both the hopper and the queue. Because of this, the relative order of these two tasks is very important.

4.41 When the length of the queue is short (Q-length $<$ 16 $\times$ current processing limit), the queue is served before the hopper. This forces more calls through the queue. However, a "first in-first out" order is maintained and, because the queue is relatively short, no incoming calls are delayed excessively.

4.42 When the incoming overload control queue reaches a length that is 16 times the number of seizures which may be processed in a class C visit, the hopper is served before the queue. This is done to prevent excessive delays when the queue is long. When the queue is long, the time an incoming call remains on the queue becomes excessive and results in sender time-outs and customer abandons. Since all incoming calls will be going through the queue when incoming traffic is very heavy, a high percentage of all incoming calls will be experiencing time-outs and abandons. This results in a significant decrease in the call-completion rate and inefficient call processing. By serving the hopper first, those calls which are processed have a shorter sender-holding time. Shorter sender-holding times reduce sender time-outs and customer abandons, thus increasing the call-completion rate. When the queue length causes a reversal of the order of service from queue first to hopper first, a TOC02 message is printed on the traffic, maintenance, and network management TTYs. The message will continue to be printed every 15 minutes until the condition no longer exists.

4.43 When the incoming overload control queue is unloaded, the entry unloaded will be the entry which has been there the longest period of time. The incoming overload queue is a linked path memory for trunks (PMT) queue. Since the time on the queue may be quite long, it is possible that a call unloaded from the queue may have abandoned or the originating office sender may have timed out while the call was on queue. Therefore, before processing a call unloaded from the incoming overload queue, a directed trunk scan is performed for the associated trunk to determine if that trunk is still off-hook. If the directed scan shows that the call unloaded from the queue has gone on-hook or sender time-out has occurred, the trunk is restored to the idle state. If the directed scan shows the trunk is in the off-hook state, the queue unloading routine will load the trunk network number (TNN) and the master scanner number (MSN) or trunk scanner number (TSN) into the appropriate register and return control to call processing.

Improved Overload Strategy

4.44 Prior to the Improved Overload Strategy, when an off-hook was detected, the LEN was placed in the LSRH until the processor could service the request. During class D of base level, the processor would remove LENs on a FIFO basis (according to the algorithm using A6MAX5). The LENs would be connected to CDRs and given dial tone. If a CDR was not available, requests were placed on a CDR queue for the next available CDR. When a CDR became available, requests in the CDR queue would be served on a FIFO basis. If the CDR queue was filled, visits to the LSRH would cease. Furthermore, in non-SP offices, line scanning was performed in base level in such a way that the number of times lines were scanned would drop linearly with load. In fact, when the LSRH was full, line scanning would cease in both SP and non-SP offices. Thus, there were three major sources of delay for service to a dial tone connection: the scanner, the LSRH, and the CDR queue.

4.45 The No. 1 ESS was very sensitive to traffic under heavy loads. That is, as the load increased to the point where dial tone speed test failures occurred (ie, dial tone delay exceeded 3 seconds) a slight further increase in traffic would result in essentially all line originations experiencing dial tone delay. Furthermore, as the processor attempted to process the increasing load and retries from partial dials, calls would drop, line scans would plummet, and recovery would take a relatively long period of time with a significant decrease in the traffic load. These factors caused a new strategy to be developed to improve customer service and system performance during heavy loads and overload conditions.

4.46 The Improved Overload Strategy essentially consists of LIFO servicing of the LSRH (with pushout and time-out mechanisms), the elimination of the CDR queue as a source of delay, and the maintenance of the line scanning rate at a high level. These last two points imply that all delays to dial tone will appear at the LSRH and not at the CDR queue or line scanner where they cannot be controlled.

4.47 The Improved Overload Strategy is in effect continuously. With the Improved Overload Strategy, when a line service request is detected and entered in the LSRH, there are four possibilities:

(1) The request is (essentially) served immediately.

(2) The request is served after spending less than 20 seconds in the LSRH.

(3) The request is buried in the LSRH and eventually pushed out.

(4) The request is buried in the LSRH and eventually timed out.

4.48 When an off-hook is detected, the LEN is placed in the LSRH. During base level class D, the central control (CC) checks to determine if CDRs or slots in the CDR queue are available. (The CDR queue now has an effective length of one.) If so, the CC removes LENs from the LSRH (one at a time on a LIFO basis) and connects each of them to a CDR or places, at most, one LEN per class D in the CDR queue. During base level class D, the CC removes LENs up to a certain maximum (determined by the algorithm using A6MAX5 discussed in paragraphs 4.27 through 4.37) or until a LEN is placed in the CDR queue. When the CDR queue is occupied, the CC does not serve the LSRH on that occurrence of class D. When the CC does serve the LSRH, the CC will attempt to remove a minimum of four LENs during one class D visit, but will stop when the CDR queue is active.

4.49 During normal traffic loads, requests in the LSRH are served (essentially) immediately without experiencing dial tone delays. As the traffic load increases, new requests are loaded in the LSRH and are unloaded on a LIFO basis. This causes older service requests to "age" in the LSRH until either served, timed out, or pushed out. Requests aging in the LSRH are checked every 10 seconds via a class E job. If a request is found to have been in the LSRH for 20 to 30 seconds, the request is removed from the LSRH and the LEN is placed back on line scanning. At this point, a service request from the timed-out LEN has an equal chance of being served first.

4.50 During very heavy traffic loads, the LSRH may become completely filled. In this event, the LEN in the last slot of the LSRH is pushed out by the next arriving request. The pushed-out LEN is placed back on line scanning and has an equal chance of being served first.

> ***Note:*** In an SP office, when the LSRH is full, the SP is not stopped by the CC (as was done prior to the Improved Overload Strategy), but the scanning rate will decrease somewhat with load. However, even under extreme loads the scanning delay is negligible.

4.51 It is important to note that with the Improved Overload Strategy, a relatively long LSRH is used. The LSRH is sized at either roughly twice the number of CDRs or 256, whichever is greater, up to a maximum of 1024. The actual length of the hopper was initially determined by deciding what magnitude of traffic would be allowed into the system and then calculating how large the hopper should be so that it would require at least 20 seconds for a request to be pushed out. This implies that the time-out mechanism is the governing factor because even under heavy loads very few requests will actually get pushed out. Thus, the time-out mechanism is equivalent to a dynamic hopper size.

4.52 With the Improved Overload Strategy the processor can operate nearer to the figure of 100-percent-normalized load. By definition, the 100-percent-normalized load would consume all available real time. Moreover, the processor can efficiently handle peaks in traffic above 100-percent occupancy for some period of time without producing a major degradation in service.

> ***Note:*** The No. 1 ESS "capacity" is determined by setting the minimum E-to-E level (EMIN) beyond which service would degrade. Prior to the 1E6 generic program, EMIN has been set at 3500 for an SP office. However, all available real time is not consumed at 3500 E-E cycles. The Improved Overload Strategy has allowed the EMIN value to be lowered from 3500 to 3000 in an SP office thus increasing the processor capacity. The CC-only office EMIN value of 2300 is not affected by the implementation of the IOS and continues to realistically reflect office capacity.

C. Real-Time Overload

4.53 A real-time overload occurs when heavy traffic or system problems create so much work the central control is not able to complete its tasks within a certain time period. The automatic overload control program automatically attempts to alleviate a real-time overload by controlling the unloading rate of the line service request hopper (in non-SP offices) and the trunk seizure and answer hopper. The automatic overload control program also causes system tasks which are not critical to be postponed or eliminated. Such actions are based on traffic measurements or on direct measurements of the average time required for the central control to cycle through all base level classes A through E (known as the E-to-E cycle time). Base level operations and E-to-E cycle time are discussed in paragraphs 2.30 through

2.37. Central control real-time overloads are classed as (1) a heavy load, (2) a minor overload, and (3) a major overload.

> ***Note:*** The Improved Overload Strategy reduces the probability of real-time overload occurrences during periods of increasing or heavy traffic.

Heavy Load

4.54 A heavy load exists in an SP office when less than 2000 E-to-E cycles occur during a 5-minute period. A heavy load exists in a non-SP office when less than 1200 E-to-E cycles occur during a 5-minute period. When a heavy load is detected, the automatic overload control program causes restore verify (RV) and false cross and ground (FCG) tests to be inhibited. A TOC01 or a TOC02 message is printed indicating a heavy load condition. For an initial change of state, a TOC01 message is printed, accompanied by three rings of the traffic TTY bell, and a minor alarm is sounded. For a continuing heavy load state, a TOC02 message is printed every quarter-hour. These messages also indicate tests that are inhibited. After the heavy load has subsided, the RV and FCG test are resumed. In an SP office, a heavy load no longer exists after 2150 E-to-E cycles occur during a 5-minute period. In a non-SP office, a heavy load no longer exists after 1300 E-to-E cycles occur during a 5-minute period.

Minor Overload

4.55 A central control minor overload exists when the time required for three consecutive E-to-E cycles exceeds 5.04 seconds (ie, average of last three E-to-E cycles> 1.68 seconds). When a minor overload occurs, the ***CC OVLD*** lamp is lighted and a TOC01 or TOC02 message is printed to indicate a minor overload. A TOC01 message is printed for an initial overload condition and a TOC02 message is printed for a continuing overload condition. During a minor overload, the automatic overload control program reduces the unloading rate of the trunk seizure and answer hopper and the line service request hopper to reduce the central control processing load. The RV and FCG tests are also inhibited. These actions are taken to increase real-time availability for the central control to complete its work within an acceptable time period; thus the objective is to decrease the average E-to-E cycle time to less than 1.68 seconds by eliminating and delaying work. If the minor overload persists, the trunk seizure and answer hopper and the line service request hopper unloading rate is further reduced every 3 seconds (to a minimum rate). These unloading rates are discussed in paragraphs 4.27 through 4.43. As the minor overload subsides, the TSAH and LSRH unloading rates are gradually increased to a maximum value and the RV and FCG tests are resumed. When the real-time overload no longer exists, the ***CC OVLD*** lamp is extinguished.

Major Overload

4.56 A central control major overload exists when the time required for three consecutive E-to-E cycles exceeds 8.04 seconds (average of last three E-to-E cycles> 2.68 seconds). A major overload can occur even though minor real-time overload controls exist, because a surge in traffic may not manifest itself as an excessive real-time demand for a few seconds after the influx has occurred. For example, a significant amount of call processing time is required after the last digit is dialed and the call is given ringing. Therefore, during the first few seconds, the overload is initially detected as a minor overload. If the traffic demand is such that the real-time demand continues to increase during a minor overload, a major overload can occur.

4.57 When a major overload occurs, the same actions (if not already in effect) are taken as for a minor overload. The TSAH and LSRH unloading rates are reduced, the RV and FCG tests are inhibited, and the ***CC OVLD*** lamp (if not already on) is illuminated. A TOC01 or TOC02 message is printed indicating a major overload. Blocking retrials of trunk hunts are inhibited. In an SP office, unloading the LSRH is stopped. In a non-SP office having a generic program prior to 1E6, line scanning is stopped to increase real-time availability for call processing. Line scanning is not stopped in No. 1 ESS offices equipped with 1E6 and later generic programs since the Improved Overload Strategy uses the LIFO (with time-out and pushout strategy).

4.58 Recovery from a major overload results in gradual restoration of processing work presented to central control. As the real-time overload subsides, the major overload becomes a minor overload until no further real-time overload conditions exist. Recovery actions for an overload condition are accomplished in reverse order. Nonessential tasks which were suspended are restored. The unloading rate of the TSAH and LSRH is gradually increased and the RV and FCG tests are resumed. The ***CC OVLD*** lamp is extinguished when no major or minor overload exists.

Real-Time Trigger of Emergency Action Phase

4.59 When the central control does not complete one E-to-E cycle within 14 seconds, it is unlikely that any actions of the automatic overload control program can alleviate the condition since a system failure has probably occurred. Therefore, when one E-to-E cycle has not been completed within the last 14 seconds, an emergency action (EA) phase is initiated. The purpose of an EA phase is to restore the system to an acceptable operating condition.

4.60 While an EA phase is in progress, nothing except reinitialization and auditing is performed. All maintenance interrupt levels except levels A, B, and certain J-level tasks (in non-SP offices) are inhibited during the EA phase. When an EA phase occurs, an EA02 output message is printed on the local and remote maintenance TTYs. The output message indicates which number phase is running and gives a code corresponding to the condition causing the phase. For a description of the EA facility, refer to item A(6) in Part 18.

D. Line Load Control

4.61 Line Load Control (LLC) provides a means of assuring originating service to essential lines during an overload condition by temporarily denying originating service to some or all nonessential lines. When active, LLC permits continuity of service to as many nonessential lines as possible and does not affect established calls or incoming calls. The three LLC modes (OFF, ON, and AUTOMATIC) are described in paragraphs 3.26 through 3.34. The associated ***LLC ENAB*** and ***DT DEL*** lamps are discussed in paragraphs 3.19 and 3.20. A summary of LLC is contained in Table C.

4.62 Overloads in the processor or in the network can cause degradation of originating service due to either excessive dial tone delay time or excessive blocking on incoming path hunt failures. The system recognizes originating service degradation by measuring the degree and persistence of dial tone delays (based on dial tone speed tests) and the amount of incoming matching loss (network blocking) failures occurring. When LLC is enabled in either the manual or automatic mode, either excessive dial tone speed test (DTST) delays or excessive incoming matching loss failures cause LLC to temporarily deny originating service to some or all nonessential lines, based on the degree and persistence of the overload. Once active, LLC denies and restores originating service to nonessential lines according to the results of DTST and incoming matching loss measurements. If some, but not all, nonessential lines are being temporarily denied originating service, originating service is temporarily denied to the nonessential line groups on a rotating basis. This allows all nonessential lines to have originating service for some periods of time. As the measured overload subsides, originating service is gradually restored until all lines have originating service.

Line Group Classification and Assignment

4.63 Generally, lines which may be required during an emergency may be designated as essential lines. Lines classified as essential are assigned to designated concentrator levels of the line link network (LLN). Up to 4 of the 16 verticals in the line scanner matrix may be designated as essential verticals and used for the assignment of essential lines. Each vertical represents a line group. The number of verticals can be expressed as a fraction (1/16, 1/8, 3/16, or 1/4) of the total line terminations in the office. The fractions can also be specified as a percent (6.25, 12.50, 18.75, or 25.00) of the total number of line terminations.

4.64 Parameter L4ESSL (specified by set card EVL) contains the number of essential verticals and which verticals are marked essential. The number of essential verticals designated may be from one to four. Verticals 0, 4, 8, and 15 of each line scanner row are possible essential verticals. The number of essential verticals specified determine which verticals are marked as essential. See Table G. L4ESSL contains a one in each bit position corresponding to the essential verticals which are not to be denied originating service when LLC is active. Refer to Fig. 10 for the data formats for the number of essential verticals designated. Each of the positions (corresponding to a particular vertical) containing a zero allows that vertical to be treated as nonessential when LLC is active.

Line Scan Mask

4.65 When LLC is active, one or more of the nonessential line groups are denied originating ser-

TABLE G

DESIGNATED ESSENTIAL VERTICALS

NO. OF ESSENTIAL VERTICALS	PART OF TOTAL VERTICALS		VERTICALS MARKED ESSENTIAL
	FRACTION	PERCENT	
1	1/16	6.25	4
2	1/8	12.50	8, 4
3	3/16	18.75	15, 8, 4
4	1/4	25.00	15, 8, 4, 0

vice by means of a 16-bit scan mask in call store. The bit positions correspond to the verticals in the office. A one in a particular bit position allows that corresponding vertical to be scanned. A zero inhibits scanning of that vertical. For example, a zero in bit position "n" of the scan mask disables the "n"th vertical in all line scanners of the office.

> ***Note:*** The designated essential verticals (Fig. 10), as specified by L4SSL, cannot contain a zero. Each of the nonessential verticals can contain an entry of one or zero, depending on the overload conditions.

4.66 The 16-bit scan mask is updated as the measured overload varies. When LLC is active, LLC determines every 4 seconds if the scan mask should be updated. The type of updating depends on the originating traffic load in the office and the time elapsed since the last update. The line scan mask is updated to:

- Reduce the number of nonessential line groups served

15			12	11			8	7			4	3			0
0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0

A. FORMAT FOR ONE ESSENTIAL VERTICAL

15			12	11			8	7			4	3			0
0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0

B. FORMAT FOR TWO ESSENTIAL VERTICALS

15			12	11			8	7			4	3			0
1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0

C. FORMAT FOR THREE ESSENTIAL VERTICALS

15			12	11			8	7			4	3			0
1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1

D. FORMAT FOR FOUR ESSENTIAL VERTICALS

NOTE:
OFFICE VERTICALS CORRESPOND TO POSITIONS 0 THROUGH 15. AN ENTRY OF ONE SPECIFIES THAT VERTICAL AS ESSENTIAL. UP TO FOUR VERTICALS MAY BE SPECIFIED AS ESSENTIAL.

Fig. 10—Data Format for Designated Essential Verticals

- Rotate the nonessential line groups served
- Increase the number of nonessential line groups served.

4.67 A printout of the line scan mask, which indicates the verticals currently being allowed and denied originating service, can be obtained at the maintenance or traffic TTYs by typing the input message LLC-MASK-PRINT. An LC02 output message containing a 16-bit representation of the verticals being allowed and/or denied originating service is printed. Ones in the LC02 printout represent verticals (line groups) which are allowed dial tone service. Zeros indicate line groups which are being denied dial tone service. An LC01 message containing the same information is automatically printed on the traffic TTYs when the first line groups are denied and again when all line groups are restored.

LLC Enable

4.68 No line groups are denied originating service unless LLC is enabled, either manually or automatically, and a measured overload is occurring. LLC mode selection and enablement is described in paragraphs 3.22 through 3.34. LLC is administered according to calculations based on the results of 3-second DTSTs and incoming matching loss (network blockage) measurements. DTSTs are performed every 4 seconds. Incoming matching loss is determined every 3 minutes by measuring the extent of network blockage affecting incoming calls.

Reducing Nonessential Line Groups Served

4.69 Three successive 3-second DTST failures cause LLC to remove originating (dial tone) service from 50 percent (rounded to the next 1/16) of the nonessential line groups currently able to receive dial tone. Similarly, if network blocking measurements indicate at least 10-percent blocking of incoming calls, LLC acts the same as for three 3-second DTST failures. Another three successive DTST failures or another 3-second period with greater than 10-percent blocking will result in a 50-percent (rounded to the next 1/16) decrease in the number of nonessential lines still served in an office. A total of four decreases will result in originating service being temporarily denied to all nonessential lines. Items 1 through 5 of Fig. 11 depict the quantity of nonessential line groups denied originating service based on DTST failures. Items 7 and 8 depict the reduction of nonessential line groups based on network blockage.

Note: Only one line group is classified as essential for the purpose of Fig. 11.

Increasing Nonessential Line Groups Served

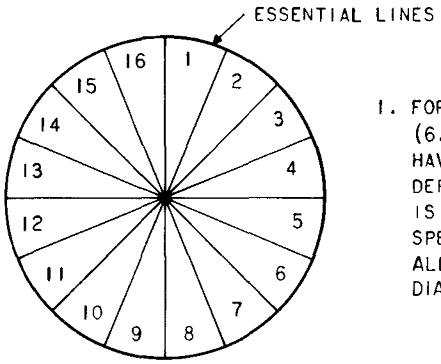
4.70 When originating service is temporarily denied on the basis of network blockage, LLC will not restore any line group being denied originating service during the 3-minute interval; however, LLC may increase the number of line groups denied originating service based on DTST failures. If the network blockage is less than 10 percent after 3 minutes, the line group denied originating service for the longest time period has originating service restored following a successful DTST. For each successful DTST thereafter, LLC restores originating service to another nonessential line group.

4.71 When originating service is temporarily denied on the basis of DTST failures, LLC restores originating service to the nonessential line group that has been denied the longest each time a DTST is successful.

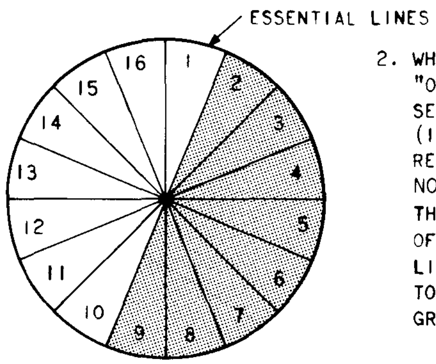
4.72 In either case (DTST failure or network blockage), when a nonessential line group is restored to service, the first three DTSTs are not relevant if they fail. Thus, when a nonessential line group is restored, five consecutive DTST failures are possible without a further reduction in the nonessential line groups served. If the sixth DTST passes, originating service is restored to another nonessential line group. If the sixth DTST fails, 50 percent of the nonessential line groups in service will be denied service. Items 6 and 9 in Fig. 11 depict nonessential line groups being restored. Originating service is gradually restored in this manner until all nonessential line groups have originating service.

Rotating Nonessential Line Groups Served

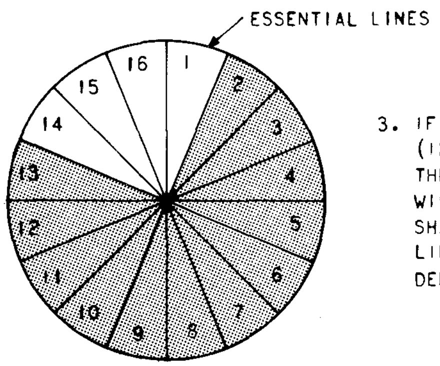
4.73 Once per minute a check is made to determine if some, but not all, of the nonessential line groups are receiving originating service. If so, the two nonessential line groups that have had originating service for the longest period of time are denied originating service, and the two nonessential line groups that have been denied originating service for the longest period of time are given originating service. If only one line group is being denied, then that line group is either rotated or restored. Since line group rotation is accomplished once per minute and one line group may be restored for each successive



1. FOR EXAMPLE, AN OFFICE WITH 1/16 (6.25%) OF THE OFFICE LINES HAVING ESSENTIAL SERVICE IS DEPICTED AT LEFT. WHEN THE OFFICE IS OPERATING WITHOUT DIAL TONE SPEED DELAY OR NETWORK BLOCKAGE, ALL 16 LINE GROUPS CAN RECEIVE DIAL TONE.



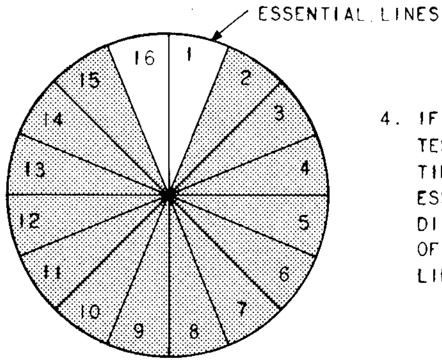
2. WHEN THE LLC FEATURE IS IN THE "ON" MODE, THREE SUCCESSIVE 3-SECOND DTS TEST FAILURES (11 SECONDS ELAPSED TIME) WILL REMOVE DIAL TONE FROM 50% OF THE NONESSENTIAL LINES ROUNDED UP TO THE NEXT 1/16 (6.25%) OF THE OFFICE. IN THIS EXAMPLE 8 LINE GROUPS ARE BEING DENIED DIAL TONE. SHADED AREA REPRESENTS LINE GROUPS DENIED DIAL TONE.



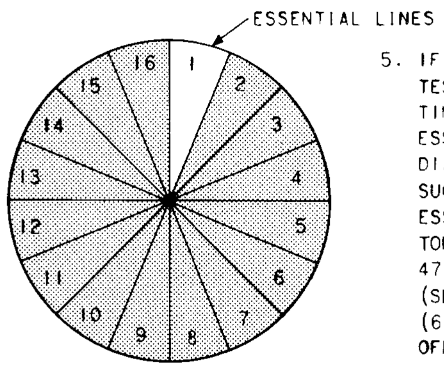
3. IF THE NEXT THREE DTS TESTS FAIL, (12 SECONDS ELAPSED TIME) 50% OF THE REMAINING NONESSENTIAL LINES WILL BE DENIED DIAL TONE. THE SHADED AREA (75% OF THE OFFICE LINES) REPRESENTS LINE GROUPS DENIED DIAL TONE.

NOTE.

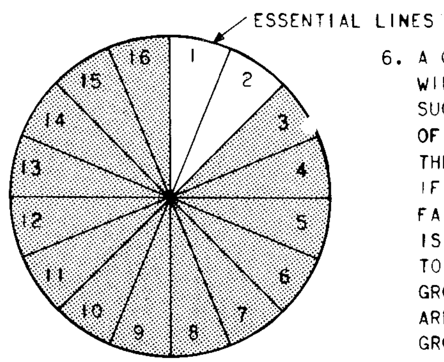
THE NUMBERS 1 THROUGH 16 REPRESENT THE LINE GROUPS ASSIGNED TO THE 16 VERTICALS IN AN OFFICE. THE LINE GROUP NUMBERS ASSIGNED DO NOT REPRESENT OR CORRESPOND TO THE PARTICULAR OFFICE VERTICALS. FOR THIS FIG., ONE LINE GROUP (1) IS CLASSED ESSENTIAL; THE REMAINING ARE NONESSENTIAL.



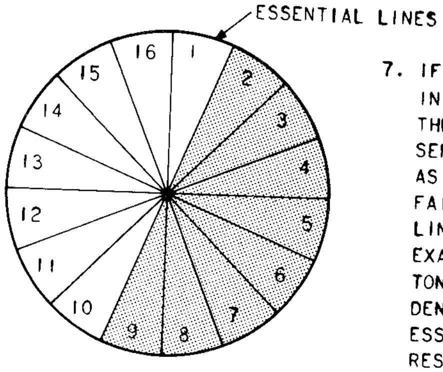
4. IF THE NEXT THREE SUCCESSIVE DTS TESTS FAIL, (12 SECONDS ELAPSED TIME) 50% OF THE REMAINING NON-ESSENTIAL LINES WILL BE DENIED DIAL TONE. THE SHADED AREA (87.5% OF THE OFFICE LINES) REPRESENT LINE GROUPS DENIED DIAL TONE.



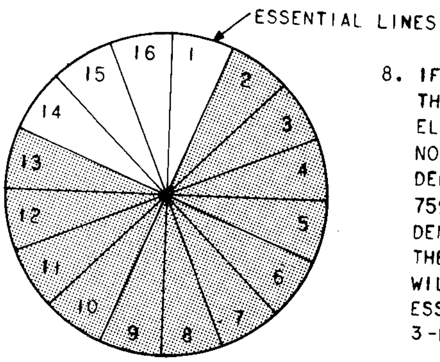
5. IF THE NEXT THREE SUCCESSIVE DTS TESTS FAIL, (12 SECONDS ELAPSED TIME) THE LAST GROUP OF NON-ESSENTIAL LINES IS ALSO DENIED DIAL TONE. THUS, IN FOUR SUCCESSIVE DECREASES, ALL NON-ESSENTIAL LINES ARE DENIED DIAL TONE IN A TOTAL ELAPSED TIME OF 47 SECONDS. ONLY ESSENTIAL LINES (SEE NONSHADED AREA) OR 1/16 (6.25%) OF THE OFFICE IS BEING OFFERED DIAL TONE.



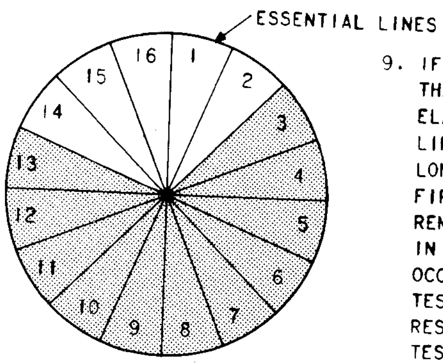
6. A GROUP OF NONESSENTIAL LINES WILL BE RESTORED WITH EACH SUCCESSFUL DTS TEST. WHEN A GROUP OF LINES IS RESTORED, THE NEXT THREE DTS TESTS ARE NONRELEVANT IF THEY FAIL. THUS, SIX CONSECUTIVE FAILURES, FOLLOWING A RESTORAL IS NECESSARY TO DENY DIAL TONE TO 50% OF THE NONESSENTIAL GROUPS IN SERVICE. THE UNSHADED AREA "2" DEPICTS THE FIRST LINE GROUP RESTORED TO SERVICE FOLLOWING THE FIRST SUCCESSFUL DTS TEST.



7. IF 10% NETWORK BLOCKAGE OCCURRED IN AN OFFICE WITH 1/16 (6.25%) OF THE OFFICE LINES HAVING ESSENTIAL SERVICE, THE RESULT IS THE SAME AS THREE SUCCESSIVE DTS TEST FAILURES. 50% OF THE NONESSENTIAL LINES, (8 LINE GROUPS IN THIS EXAMPLE) ARE BEING DENIED DIAL TONE SERVICE. WHEN DIAL TONE IS DENIED BASED ON BLOCKAGE, NON-ESSENTIAL LINE GROUPS WILL NOT BE RESTORED DURING THE 3-MINUTE INTERVAL.



8. IF THE NETWORK BLOCKAGE IS GREATER THAN 10% AFTER THREE MINUTES OF ELAPSED TIME,50% OF THE REMAINING NONESSENTIAL GROUPS WILL BE DENIED DIAL TONE SERVICE. THUS, 75% OF THE OFFICE LINES ARE NOW DENIED DIAL TONE AS DEPICTED BY THE SHADED AREA. AGAIN, DIAL TONE WILL NOT BE RESTORED TO ANY NON-ESSENTIAL LINE GROUP DURING THE 3-MINUTE INTERVAL.



9. IF THE NETWORK BLOCKAGE IS LESS THAN 10% AFTER THREE MINUTES OF ELAPSED TIME, THE NONESSENTIAL LINE GROUP DENIED DIAL TONE THE LONGEST WILL BE RESTORED WHEN THE FIRST DTS TEST IS SUCCESSFUL. THE REMAINING GROUPS WILL BE RESTORED IN A LIKE MANNER WITH EACH OCCURRENCE OF A SUCCESSFUL DTS TEST. WHEN THE FIRST GROUP IS RESTORED A MAXIMUM OF FIVE DTS TESTS MAY FAIL, BUT THE SIXTH DTS TESTS IS USED TO DETERMINE WHETHER TO DENY OR RESTORE. THE UNSHADED AREA "2" DEPICTS THE FIRST LINE GROUP RESTORED.

Fig. 11—Line Load Control Results

DTST (accomplished every 4 seconds), the probability is that a single line group being denied service will be restored to service before the time occurs for rotation. Rotating the nonessential line groups served is accomplished by updating the line scan mask.

4.74 When line groups are rotated, the number of DTSTs not relevant is six. On this basis, nine successive DTST failures would have to occur before additional nonessential line groups would be denied originating service immediately following rotation of line groups. Rotation actions always apply when at least two nonessential line groups are being served and at least two nonessential line groups are being denied. If this is not the case, certain actions are modified as mentioned in paragraph 4.73 for one line group being denied. If all nonessential line groups are either served or denied, it is not necessary to rotate any nonessential line group.

4.75 Some of the conditions and actions resulting from possible combinations of network blockage measurements and DTST results are summarized in Table H. In Table H, the number of nonessential lines denied and restored columns indicate the update actions required for the 16-bit scan mask word.

> ***Note:*** The numbers in these two columns ***do not*** indicate the absolute number of nonessential lines being served or denied at any given time.

CHARACTERISTICS

5. FEATURE ASSIGNMENT

5.01 Office Overload Controls are provided on a per office basis.

6. LIMITATIONS

OPERATIONAL

6.01 Not applicable.

ASSIGNMENT

6.02 For Line Load Control, a maximum of 1/4 of the line groups may be classed as essential. Refer to paragraph 4.05.

7. INTERACTIONS

STATIC

7.01 Not applicable.

DYNAMIC

7.02 Office Overload Controls attempt to preclude and alleviate system hardware, software, and real-time overloads. There can exist, under certain conditions, a limited interaction between Automatic Overload Controls and Line Load Control, since dial tone delays are one of the criteria for Line Load Control. When Line Load Control is enabled, Line Load Control actively denies and restores originating service to nonessential line groups based on dial tone speed tests and incoming matching loss measurements. Dial tone delays may be experienced due to either Automatic Overload Controls or heavy traffic. Dial tone delays may be caused by a delay in hopper unloading or a delay in processing. Sources of dial tone delays are listed in Table I. Line Load Control may be activated if Automatic Overload Controls delay either hopper unloading or entry processing.

7.03 If dial tone speed tests are inhibited (using input message DT-INH), Line Load Control is inhibited. If Line Load Control is on, the ***LLC ENAB*** lamp is extinguished. Also, a major alarm is sounded and a TOC01 output message is printed. If Line Load Control is actively denying service, all nonessential line groups being denied are restored to service. If Line Load Control is off when the input message is entered, a TOC02 output message is printed.

7.04 The Automatic Overload Controls interact with the Network Management Dynamic Overload Controls. For a detailed description of Network Management, refer to item A(1) in Part 18. The Dynamic Overload Controls (DOC) monitor the length of various queues that are administered by the automatic overload control program. When the length of these queues exceeds established thresholds, machine congestion (MC) signals are sent to subtending offices. The MC signals cause the subtending offices to route traffic away from the office experiencing congestion. The system criterion is to send an MC1 signal when the receiver attachment delay exceeds 1.2 seconds and to send an MC2 signal when the receiver attachment delay exceeds 2.4 seconds. The overload state in conjunction with the length of the incoming overload control and receiver queues is used to predict the receiver attachment delay. The queue entry thresholds for DOC signals generated by Network Management are given in Tables J, K, and L.

8. RESTRICTION CAPABILITY

8.01 Input message LLC-INH is used to inhibit Line Load Control. Refer to paragraph 3.15. Also, if dial tone speed tests are inhibited (using input message DT-INH), Line Load Control is inhibited. Refer to paragraph 7.03.

INCORPORATION INTO SYSTEM

9. INSTALLATION/ADDITION/DELETION

9.01 Installation/addition/deletion procedures are not applicable to Office Overload Controls.

9.02 Set cards EVL and LLCS are required for Line Load Control. Refer to paragraphs 4.05 and 4.06.

10. HARDWARE REQUIREMENTS

10.01 Not applicable.

11. SOFTWARE REQUIREMENTS

Note: This part contains cost factors and determination of quantities. Central Office Equipment Engineering System (COEES) Planning and Mechanized Ordering Modules are the recommended procedures for developing these requirements. However, for planning purposes or if COEES is not available, the following guidelines may be used.

MEMORY

A. Fixed

11.01 The following memory is required for Office Overload Controls:

(a) The ***base generic program (program store)*** requires approximately 110 words.

(b) ***Fixed parameters (program store)*** require one word for the maximum value of A6MAX5.

(c) One ***compool defined word (call store)*** is required for the variable value of A6MAX5.

B. Conditional

11.02 The following memory is required in an office:

(a) One ***program store*** word is required for parameter L4ESSL (built via set card EVL) to specify the essential verticals.

(b) One ***program store*** word is required for parameter L4LLCS (built via set card LLCS) to specify the state of Line Load Control after a system reinitialization.

Note: For parameter and set card engineering, refer to items C(1) and C(2) in Part 18.

C. Variable

11.03 Not applicable.

REAL TIME IMPACT

11.04 Table M contains the approximate real-time overhead cycle cost estimates applicable to Automatic Overload Control. Three additional cycles are added to every trunk seizure processed by the system. Every entry which is not processed immediately, but which must go through the queue, will consume approximately 75 additional cycles. Additional time is also required on each class C and D visit to determine the number of entries to be unloaded and to decide whether to process entries in the incoming overload queue before the trunk seizure and answer hopper or the hopper before the queue.

11.05 Line Load Control real-time overhead cycle costs are approximately:

(a) LLC ON or AUTOMATIC mode (enabled)—75 cycles every 4 seconds

(b) LLC active—250 cycles every 4 seconds.

11.06 The cycle times for the No. 1 ESS are as follows: 5.5 microseconds (0-percent speedup), 5.24 microseconds (5-percent speedup), or 5.0 microseconds (10-percent speedup). Clock speedup is available with 1E7 and base restarts of the 1E6 generic programs.

TABLE H

LINE LOAD CONTROL ACTIONS

TIME FOR NETWORK OVERLOAD CALCULATION	TIME FOR ROTATION	(NOTE 1) NETWORK OVERLOADED	(NOTE 2) RESULT OF DTST	DTST FAILURE RESULTED IN CONTROL OVERLOAD (NOTE 3)	NUMBER OF NONESSENTIAL LINES DENIED AND/OR ROTATED	NUMBER OF NONESSENTIAL LINES RESTORED OR ROTATED (NOTE 4)	CORRECTION TO NONRELEVANT DTST COUNT (NOTE 5)
ONCE/3 MIN	ONCE/MIN		ONCE/4 SEC		N=NUMBER SERVED		
Yes	Necessarily Yes	Yes	†	†	N/2* + 2	2	+6
Yes	Necessarily Yes	No	Failure	Yes	N/2* + 2	2	+6
Yes	Necessarily Yes	No	Failure	No	2	2	+6
Yes	Necessarily Yes	No	Success	Can't Occur	1	2	Zero, Then +6
No	Yes	†	Failure	Yes	N/2*+2	2	+6
No	Yes	†	Failure	No	2	2	+6
No	Yes	Yes	Success	Can't Occur	2	2	+6
No	Yes	No	Success	Can't Occur	1	2	Zero, Then +6
No	No	†	Failure	Yes	N/2*	0	None
No	No	†	Failure	No	0	0	None
No	No	Yes	Success	Can't Occur	0	0	None
No	No	No	Success	Can't Occur	0	1	Zero, Then +3

* Fractional results are rounded up to next integer.

† Answer can be yes or no without affecting resulting actions due to other conditions.

Notes:

1. Network Overload: Every 3 minutes (the average holding time of a call) a calculation is made to see if 10 percent or more of the incoming calls to an office experienced network blocking on the talking path during the last 3-minute period. If they have, the office is considered to have a network overload for the purpose of LLC during the next 3-minute period.

2. If dial tone delay exceeds 3 seconds during a dial tone speed test (DTST), the DTST is a failure. An indicator, which tells whether or not the last DTST succeeded, is updated every 4 seconds. This indicator is examined by line load control (LLC) every 4 seconds.

3. If three consecutive relevant DTST failures occur, LLC decreases the number of nonessential line groups served by one-half. Four such reductions result in temporary denial of orginating service for all nonessential line groups.

4. Each successful relevant DTST causes originating service to be restored to the (one) nonessential line group which has been denied for the longest period of time. If the network is overloaded, no line group is restored. Every minute, the two nonessential line groups denied the longest are rotated with the two served the longest.

5. Nonrelevant DTST: While a line group is denied originating service, a backlog of originations may build up in the group. Restoration of the group can produce a surge of originations causing dial tone delay. This surge does not represent the steady state load of the office, so the first three DTSTs following restoration of a group are considered nonrelevant for LLC purposes. (The nonrelevant DTST count is kept in L4NRDT. If nonzero, the count is decremented by one following each DTST.)

TABLE I

SOURCES OF DIAL TONE DELAY

CAUSE	RESULT
Trunk Seizure and Answer Hopper Overload Real-Time Overload CC Overload	Failure to Scan (Note)
Limited Unloading Rate CC Overload Emergency Action Phase	Hopper Unloading Delay
Queueing for a Receiver Queueing for a Network Path Queueing for a POB Queue Overflow	Entry Processing Delay

Note: In generic programs prior to 1E6 without the Improved Overload Strategy, line scanning was stopped during a major overload. In 1E6 and later generic programs (with the Improved Overload Strategy), line scanning is not stopped.

12. DATA ASSIGNMENTS AND RECORDS

TRANSLATION FORMS

12.01 Not applicable.

RECENT CHANGES

12.02 Not applicable.

13. TESTING

13.01 Not applicable.

14. OTHER PLANNING TOPICS

14.01 A value of one is recommended for set card EVL to specify one line group as essential for Line Load Control. A value of zero is recommended for set card LLCS to cause Line Load Control to be placed in the off state after system reinitialization.

14.02 To provide uniform service to all lines, Line Load Control should be inhibited (off) during periods of normal operation. Preferential treatment should be restricted to disaster or emergency situations. During periods when there are no plant maintenance or traffic coverage, the automatic mode is appropriate.

ADMINISTRATION

15. MEASUREMENTS

15.01 Traffic measurements related to the Office Overload Controls feature are listed in Table N. The TC15 output message contains the current data for these measurements. The TC15 output message is printed every quarter-hour when an overload condition exists or when requested by the input message LS-QUARTER. For detailed descriptions of the traffic measurements listed in Table N, refer to items A(11) and C(3) in Part 18.

16. CHARGING

AUTOMATIC MESSAGE ACCOUNTING

16.01 Not applicable.

TABLE J

INCOMING OVERLOAD QUEUE

OVERLOAD	DOC SIGNAL	THRESHOLD
No overload	MC1	33
No overload	MC2	66
Minor overload	MC1	19
Minor overload	MC2	38
Major overload	MC1	9
Major overload	MC2	18

TABLE K

MF RECEIVER QUEUE

DOC SIGNAL	THRESHOLD
MC1	Q length >40% of number of MF receivers
MC2	Q length >80% of number of MF receivers

TABLE L

DIAL PULSE AND REVERTIVE PULSE RECEIVER QUEUE

DOC SIGNAL	THRESHOLD
MC1	Q length >24% of number of DP/RP receivers
MC2	Q length >48% of number of DP/RP receivers

UNIFORM SERVICE ORDER CODES

16.02 Not applicable.

SUPPLEMENTARY INFORMATION

17. GLOSSARY

Automatic Overload Control—This term refers to the Overload Protection and Control features designed, engineered, and automatically incorporated in system operations. Automatic overload controls for hardware, software, and real-time resources are inherent in system operations.

Base Level—The term "base level" refers to the operational level in which the central control accomplishes the majority of its work. Call processing is done in interrupt level L, known as base level.

Buffer—The term "buffer" refers to an area in memory used to temporarily store orders (output data) until they are executed.

Hopper—The term "hopper" refers to an area in memory used to temporarily store request entries (input data) until the entry can be processed.

Interject—A class of work, higher than any of the priority classes within base level.

Overload—An overload is a condition that occurs when there is an excessive demand for system resources available. Hardware, software, and real time are system resources.

Queue—A queue is an area in memory used to record a waiting list of work which temporarily cannot be completed or to record a list of entries which cannot be loaded into a hopper because the hopper is full.

18. REFERENCES

A. Bell System Practices

(1) Section 231-090-305—Network Management Feature—2-Wire No. 1 and No. 1A Electronic Switching Systems

(2) Section 231-045-100—Operational Software Control Structure—Software Subsystem Description—2-Wire No. 1 and No. 1A Electronic Switching Systems

(3) Section 231-045-155—Queue and General Purpose Software Subsystem Description—2-Wire No. 1 and No. 1A Electronic Switching Systems

(4) Section 231-045-165—Measurement Software Subsystem Description—2-Wire No. 1 and No. 1A Electronic Switching Systems

(5) Section 231-045-200—Maintenance Control Software Subsystem Description—2-Wire No. 1 and No. 1A Electronic Switching Systems

(6) Section 231-045-245—System Performance Software Subsystem Description—2-Wire No. 1 and No. 1A Electronic Switching Systems

TABLE M

AUTOMATIC OVERLOAD CONTROL AND INCOMING OVERLOAD CONTROL REAL-TIME CYCLE COSTS

DESCRIPTION	CYCLES REQUIRED
Every trunk seizure: cycles required to determine if seizure must be placed on the queue.	3
Every trunk seizure placed on the queue: cycles required to administer traffic count and place the call on the queue.	30
Every class C: cycles required to calculate number of incoming trunk seizures to be unloaded this visit	4
Every class C: cycles required to determine if hopper or queue is to be unloaded first.	6
Every trunk seizure taken off the queue: cycles required to remove the call from the queue.	30
Every trunk seizure taken off the queue: cycles required to perform a directed scan to determine if trunk timed out or abandoned while on queue.	15

(7) Section 231-070-710—Dial Tone Speed Delay Network Administration—No. 1/1A Electronic Switching Systems

(8) Section 231-070-715—Matching Loss Network Administration—No. 1/1A Electronic Switching Systems

(9) Section 231-070-760—Office Overload Procedures Network Administration—No. 1/1A Electronic Switching Systems

(10) Section 231-070-805—Line Load Control Network Administration—No. 1/1A Electronic Switching Systems

(11) Section 231-070-510—Traffic Measurements—Quarter Hour Network Administration—No. 1/1A Electronic Switching Systems

(12) Section 759-100-000—Subject Index—Central Office Equipment Engineering System (COEES)—Business Information System Programs

(13) Section 759-100-100—General Description—Central Office Equipment Engineering System (COEES)—Business Information System Programs.

B. TTY Input and Output Manuals

(1) Input Message Manual IM-1A001, No. 1 Electronic Switching System

(2) Output Message Manual OM-1A001, No. 1 Electronic Switching System.

TABLE N

TRAFFIC MEASUREMENTS

ITEM MEASURED	TYPE	CODE	EQUIP GROUP OR OFFICE COUNT NO.
Originating Calls	PC	005	014
Incoming Calls	PC	005	015
Incoming Matching Loss	PC	005	016
DP Dial Tone Speed Tests	PC	005	017
TT Dial Tone Speed Tests	PC	005	018
DP Dial Tone Delays	PC	005	019
TT Dial Tone Delays	PC	005	020
Intraoffice Calls	PC	005	031
Intraoffice Calls	OVFL	005	032
Blocked Dial Tone Queue	PC	005	078
Blocked Dial Tone Delay	PC	005	087
Main Program Cycles ("E to E")	PC	005	126
Line Scan Completion	PC	005	127
Tandem Call Attempts	PC	005	131
Tandem Call Attempts	OVFL	005	132
Incoming Overload Control Queue	PC	005	148
Incoming Overload Control Queue	USAGE	005	150
Tandem First Failure to Match	PC	005	202
Incoming First Failure to Match	PC	005	205
MF Receiver Attachment Delay Recorder Test	PC	005	217
MF Receiver Attachment Delay Recorder Delays	PC	005	220
DP Receiver Attachment Delay Recorder Tests	PC	005	223
DP Receiver Attachment Delay Recorder Delays	PC	005	226
RP Receiver Attachment Delay Recorder Tests	PC	005	229
RP Receiver Attachment Delay Recorder Delays	PC	005	232
Preprogram Controls Affected Calls	PC	005	233
Flexible Controls Affected Calls	PC	005	234
Code Block Affected Calls	PC	005	236
Peripheral Order Buffer Queue	PC	005	376

C. Other Documentation

(1) Parameter Guide PG-1—2-Wire No. 1 Electronic Switching System

(2) Office Parameter Specification PA-591001, No. 1A Electronic Switching System

(3) Translation Guide TG-1A.