NO. 2 ELECTRONIC SWITCHING SYSTEM
OPERATIONAL FEATURES
SERVICE OVERLOADS AND INTERRUPTS

CONTENTS PAGE

FIGURES

TABLE PAGE

1. GENERAL

1.01 This section describes the service overloads and interrupts associated with the No. 2 Electronic Switching System (ESS) and the resultant effects on customer service. Further it discusses the intricacies of machine overload control and, of particular interest to the network administrator, highlights the effects that overloads and interrupts have on traffic data.

1.02 Whenever this section is reissued, the reason for reissue will be listed in this paragraph.

2. DESCRIPTION

2.01 The maximum call processing capacity for No. 2 ESS is dependent upon the small, but finite, amount of real time that is required by the central processor to perform the tasks required to process a call. The central processor becomes overloaded when the volume of requests for service is such that the time allocated for processing is exceeded. The more calls in a transient or nontalking state, the longer the base level scan. (Consult Dial Facilities Management Practice, Division H, Section 10d(3), Program Organization). Excessively long base level scans will result in an equipment time-out which causes the active control unit to switch to the standby control unit.

OVERLOAD CONTROL PROGRAM

2.02 The base level scan, during which call processing, maintenance, and routine work operations are performed, is normally initiated every

100 milliseconds (or more precisely, the minimum length of a base level scan is 100.08 milliseconds). The various tasks are classified into two categories: ***nondeferrable*** and ***deferrable. Deferrable time*** during which deferrable tasks (ie, audits, detection tests and call store updating) are performed, is referred to as ***periodic deferrable time*** (PDT). The ***nondeferrable*** operations include those functions which must be performed during each base level scan, regardless of the call volume being processed. These include:

(a) Dispatching of supervisory inputs to new or previously assigned transient call records (see 2.04)

(b) Accessing transient call records in order to perform all the work required to advance each call to the next state, at which time it must await customer or system action

(c) Performing necessary maintenance functions, such as, processing teletypewriter signals and traffic measurements.

An overload control program is entered once each base level scan, just ahead of the deferrable maintenance programs, which are the last programs entered on the base level scan. Upon completion of all nondeferrable (call processing) work operations, a check is made to determine whether 100 milliseconds have elapsed. If not, deferrable routine work operations (ie, audits, call store updates, control unit detection tests, etc) are performed for the balance of the 100 millisecond base level scan. The base level scan will exceed 100 milliseconds whenever there is more work in the nondeferrable area than can be completed in this time. (See Fig. 1.) The overload control program monitors the time being taken for call processing during each base level scan; its initial function is to calculate the length of the scan in the terms of the timed or 25 millisecond interrupts (IØ25 interrupt program) that have occurred from the beginning of the scan to the point where the overload program is entered.

2.03 The program then compares the current scan length to the previous maximum; if the current scan is longer than the previous maximum, it is stored as the new maximum. If the current scan exceeds 100 milliseconds, the deferrable routine work operations are not performed during this scan, and the next base level scan is initiated.

2.04 A transient call record (TCR) is associated with each active nontalking call in the system. It consists of eight call store words and controls the progress of the call from origination until an answer signal has been received and the connection is placed in a talking state. Call store may contain from one to four transient call record blocks, depending on the number of call store modules installed. Each transient call record block contains 64 or 70 transient call records, depending on the call store layout selected.

2.05 The first word of each TCR is called a progress mark. It contains the address of the program used by the central processor to reinitiate the processing of a call during each base level scan (or main program loop). The main program inquires as to whether there is any new information associated with the call. If the status of the call is unchanged, the same progress mark is left in the TCR, and the next TCR is accessed. When new information is indicated, the program acts on that information and generates any output which is required. If the completion of this action changes the state of the call, a new progress mark is written into the TCR to reflect the new state.

2.06 The overload control program acts to defer work operations which require considerable processing time. ***A deferral may be defined as the delay of a nondeferrable task during a certain time period. It should not be confused with a deferrable routine work operation which occurs at the end of the base level scan,*** as described above. The work items subject to deferral are identified by certain progress marks in each transient call record, and each item requires 10 milliseconds or more of processor time to complete. These work items are:

(1) Connecting dial tone

(2) Connecting of ringing and audible ringing tone

(3) Connecting a transmitter to an outgoing trunk

(4) Connecting an incoming trunk to a receiver.

2.07 During the base level scan, a hardware timer is activated in the central processor at the start of each TCR block scan. If a TCR block scan is not completed within 320 milliseconds

(.320 seconds), the active central processor will switch to the standby processor. To avoid such a switch during normal call processing, each TCR block scan is timed (by a software timer.) Once 175 milliseconds have elapsed, all TCRs remaining in this block, which contain a progress mark indicating a work item that may be delayed, are skipped during this base level scan. Separate program actions assure that individual calls will not experience permanent deferral. A simplified flow diagram of the overload control program is shown in Fig. 2.

OVERLOAD INDICATORS

2.08 The overload control program causes the overload lamp (amber), on the maintenance center frame control and display panel, to light when the number of call processing deferrals in a base level scan is nonzero and the lamp is not already lit. The lamp is extinguished when the count returns to zero.

2.09 A second overload condition is determined by dial tone speed tests (DTSTs) which are performed every 4 seconds. Every 100 seconds the traffic program determines the number of DTST failures in the last 16 tests performed. (A DTST failure results when a random customer selected by the traffic program for the DTST has failed to receive dial tone within three seconds.) Ten or more failures out of the 16 tests is an indication that the system is experiencing an overload condition. At this point, the program will activate dynamic service protection (DSP) unless the telephone company has denied it (see 2.20). An output message, indicating the status of DSP, is printed on both the network administration (traffic) and maintenance TTYs. If DSP has been activated, the DSP lamp located on the maintenance center control and display panel will light and a major alarm will sound. DSP is deactivated when the number of dial tone speed test failures is less than 7 out of the 16 tests being checked.

CENTRAL PROCESSOR BASE LEVEL PROGRAM AND CALL DEFERRAL MEASUREMENTS

A. Quarter Hourly (Q) Schedule

2.10 There are several measurements available in the No. 2 ESS which may be used to determine the effect of carried load on service performance. They are recorded on the quarter hourly or Q schedule. This is a fixed collection of 14 load service measurements including dial tone speed test (DTST) results, line and trunk origination totals, incoming matching loss parameters and system overload measurements. These measurements always contain data collected during the 15-minute period ending with the last quarter hour. The counts collected on this schedule are added to totaling registers each clock quarter hour. The totaling registers accumulate quarter hour totals for hourly (H or C schedules) and plant schedules. (The accumulating registers from which the counts are taken are reset to zero when the data are transferred to a teletypewriter buffer for a scheduled printout). The Q schedule items are listed in the Translation Guide, TG-2H, Division 10, Traffic Measurements, and in Bell System Practice 232-120-301, Traffic and Plant Measurements. A sample printout is shown in Fig. 3.

2.11 The recorded information is printed out by both the network administration and network maintenance TTYs on the quarter hour for any of the following reasons:

(a) If scheduled by the traffic work table (TWT), an area in memory used to specify the time of day by clock hour and quarter hour and the day or days of the week during which traffic work operations are to be performed. Network administration and network maintenance TTYs can be scheduled independently.

(b) If the number of dial tone speed tests performed during the last quarter hour was not equal to 225 (1 every 4 seconds).

(c) If the number of dial tone speeds test failures was greater than 4.

(d) If the system was in, or indicated that it should be implementing, dynamic service protection (DSP) at the quarter hour (see 2.19).

(e) If the system was in overload (deferrals occurring) at the quarter hour.

B. Load Service Measurements (LSM)

2.12 The LSM schedule contains the same measurements as the Q schedule except that the measurements contain data collected from the last clock quarter hour to the time of printout. A sample of the LSM schedule printout is shown in

Fig. 3. This schedule is printed upon TTY request or when a transient initialization occurs.

2.13 With reference to Fig. 3, the contents of the Q and LSM registers are printed horizontally on two lines (Q1, LSM1 to Q10, LSM10 on line 1 and Q11, LSM11 to Q14, LSM14 on line 2). Those registers which would tend to indicate an overload condition are:

(a) Q3, LSM3 and Q4, LSM4 - The former is a count of the DTST failures on dial pulse receivers, while the latter is a count of the DTST failures on TOUCH-TONE® receivers.

(b) Q11, LSM11 - These registers maintain a count of the number of base level scans. A decrease in this value from the previous reading is an indication of increased load. A maximum value of 8993 with every 4th or 5th reading of 8992 could be observed during normal idle or light load periods since the minimum length of a base level scan is 100.08 milliseconds.

(c) Q12, LSM12 - These registers record the total number of times that the timed, 25 millisecond interrupts occurred ***during the nondeferrable (call processing) portion*** of the base level scan. This measurement can be used to determine the total length ***of the nondeferrable portion*** of all base level scans by taking the product of it and 25 milliseconds (.025 seconds). The average scan length, in milliseconds, is defined as

$$\frac{(Q12)(25)}{Q11}$$

During idle machine conditions (periods of light load), there may be very little, if any, input supervision of transient call record work to be performed during the base level scan. Under these conditions, it is possible that this work can be completed in less than 25 milliseconds with the result that a count of zero will be indicated for this scan. This is due to the fact that the 100 millisecond base level scan is normally synchronized to the 25 millisecond interrupt program and starts immediately after an interrupt. A normal count of 300 to 400 may be expected during light load periods. The maximum value which could be experienced would be 35,972. An extremely heavy load requiring continuous nondeferrable work during each base level scan could theoretically produce such a reading.

(d) Q13, LSM13 - These registers measure the maximum number of 25 millisecond interrupts occuring ***in the nondeferrable portion*** of any one base level scan. This measurement is principally an indication of the maximum call processing peakedness which occurred during the measurement period. It can be used to determine the length of the longest base level scan measured by 25 millisecond interrupts during ***the nondeferrable portion*** of the scan. (Length, in milliseconds, = Q13 × 25 milliseconds) A nominal value of one or two interrupts may be expected during light loads. A maximum of 60 interrupts, limited by generic time-out features may be experienced. Any readings higher than 16 will usually be an indication that excessive service activity is involved. A reading of 16 would equate to a base level scan of 16 × 25 milliseconds or 400 milliseconds.

(e) Q14, LSM14 - This measurement represents the time spent doing ***deferrable*** tasks; it has been referred to earlier as ***periodic deferrable time*** (PDT). Specifically, it represents the real time remaining in the base level scan once fixed overhead tasks (scanning for supervisory inputs, accessing call records, making usage measurements), variable overhead tasks (system monitors), and the tasks required to process calls offered to the system (detection of originations, setting up path connections, detection of call terminations etc.) have been completed. It should be evident that PDT increases as the result of a decrease in call volume. The reading is valid only if the system remained in synchronism during the measurement period and the audits (programs that locate inconsistencies between different memory records in call store and attempt to correct them) did not have to run in a priority mode. If the reading exceeds 9999, the measurement should be ignored because one or both of the above conditions have not been satisfied. For readings less than 9999 division by 100 yields the percent of time spent ***in the deferrable portion*** of the base level scan.

Example: If Q14, LSM14 = 6667, the percent of time spent ***in the deferrable portion***

(PDT) of the total base level scans during the last 15 minutes equals 6667/100 or 66.67% (or 10 minutes out of the last 15 minutes).

*For offices with the LO-1 generic program, Q14 is valid only for Issue 4.6 and higher.

C. Hourly-Busy Hours (H) and Hourly-Non Busy Hours (C)

2.14 The office total (OFT) measurements section of the H or C schedule consists of a group of 50 registers (60 registers for EF-1) which provide measurements for each type of call originated in the office. It can be assigned to either the H or C schedule but not both. OFT1 through OFT10 which correspond to Q1 through Q10 (and, for EF-1 only, OFT51 through OFT54 which correspond to Q11 through Q14) are updated every 15 minutes from the Q schedule registers.

SERVICE INTERRUPTS

2.15 If the No. 2 ESS is failing to process calls properly, the system automatically attempts to restore complete service by taking emergency actions. If automatic emergency actions fail, manual procedures are implemented. The program is forced to a known fixed location and restarted to provide an orderly return to the beginning of the base level scan. The restart process is called initialization.

> ***Note:*** Initializations with a level count of 4 or more cause a major alarm to sound. Level counts 5 and 6 can be manually initiated at the emergency action panel (EAP) located on the maintenance center frame. Consult BSP 232-113-301, System Initialization Procedures, for procedures involving manual initialization.

2.16 The level count is zeroed after 1024 base level scans have successfully elapsed since the last initialization.

2.17 With reference to Table A, three different types of system initialization will affect traffic and/or plant measurements. Since the network administrator's link to the system and a means by which service is gauged are traffic measurements, an understanding of the following types of initialization is vital.

- ***Stable Clear Initialization***—Most traffic and plant registers are declared stable in call store. This implies that these registers can only be cleared by a manually requested stable initialization. Whenever a stable initialization occurs and clears all traffic and plant registers, a clear (CLR) message is printed on the network administration and maintenance TTYs to indicate that the action has taken place.

- ***Transient Clear Initialization***—All service circuit, trunk, PBX and junctor group measurements are transient in call store. Thus, the registers for these measurements are cleared by a transient initialization. The call store copy of the traffic work table (TWT) is also cleared. Whenever this initialization occurs the load service measurements (LSM) schedule is printed on the network administration and maintenance TTYs. Following restoration of the date and time clock by maintenance personnel, the call store copy of the TWT is updated by the program store copy.

- ***Recent Change Clear***—A recent change initialization, which clears the recent change area of call store, also produces a transient initialization.

TRAFFIC OVERLOAD CONTROLS

A. Dynamic Service Protection (DSP)

2.18 Dynamic service protection provides continuity of originating service to essential lines during those periods when the machine's capability of handling origination requests is exceeded. The objective is to give preferential service to critical customers (class A) during emergency situations when general overall service has been degraded. When DSP is active, class A lines are scanned continuously every 25 milliseconds while the remaining lines (class B) are looked at only during alternate 25 millisecond (or 50 millisecond) periods. Additionally, if lines are blocked from selecting a digit receiver, no class B lines will be allowed to select a receiver until at least one class A line has succeeded.

2.19 DSP is a program controlled function; however, the telephone company has the option to either allow or deny implementation. This option is exercised by input messages entered at either

the network administration (traffic) or maintenance TTYs. Due to the unique operational features of DSP, ***it is recommended that this feature be denied in attended or monitored offices.*** Consult Dial Facilities Management Practices Division H, Section 10d(1), Dynamic Service Protection, for activation procedures and the consequences of implementation.

> ***Note:*** Following any stable clear initialization, with LO-1, Issue 4.6 and EF-1, Issue 3.4, the system will automatically deny DSP and set dial tone speed test failures to zero. In offices with earlier generic programs, DSP is automatically allowed. Therefore, the deny message must be inputted on either the network administration or maintenance teletypewriter to prevent the activation of DSP.

3. REFERENCES

3.01 The following sources may be consulted for additional information concerning service overloads and interrupts in the No. 2 ESS:

1—Translation Guide, TG-2H, Division 10, Traffic Measurements.

2—BSP 232-103-101, Call Processing Description

3—BSP 232-113-301, System Initialization Procedures

4—BSP 232-120-301, Traffic and Plant Measurements

5—PD-2H011, Initialization Program

6—PD-2H116, Traffic and Plant Measurement Program

7—PD-2H135, Overload Control Program

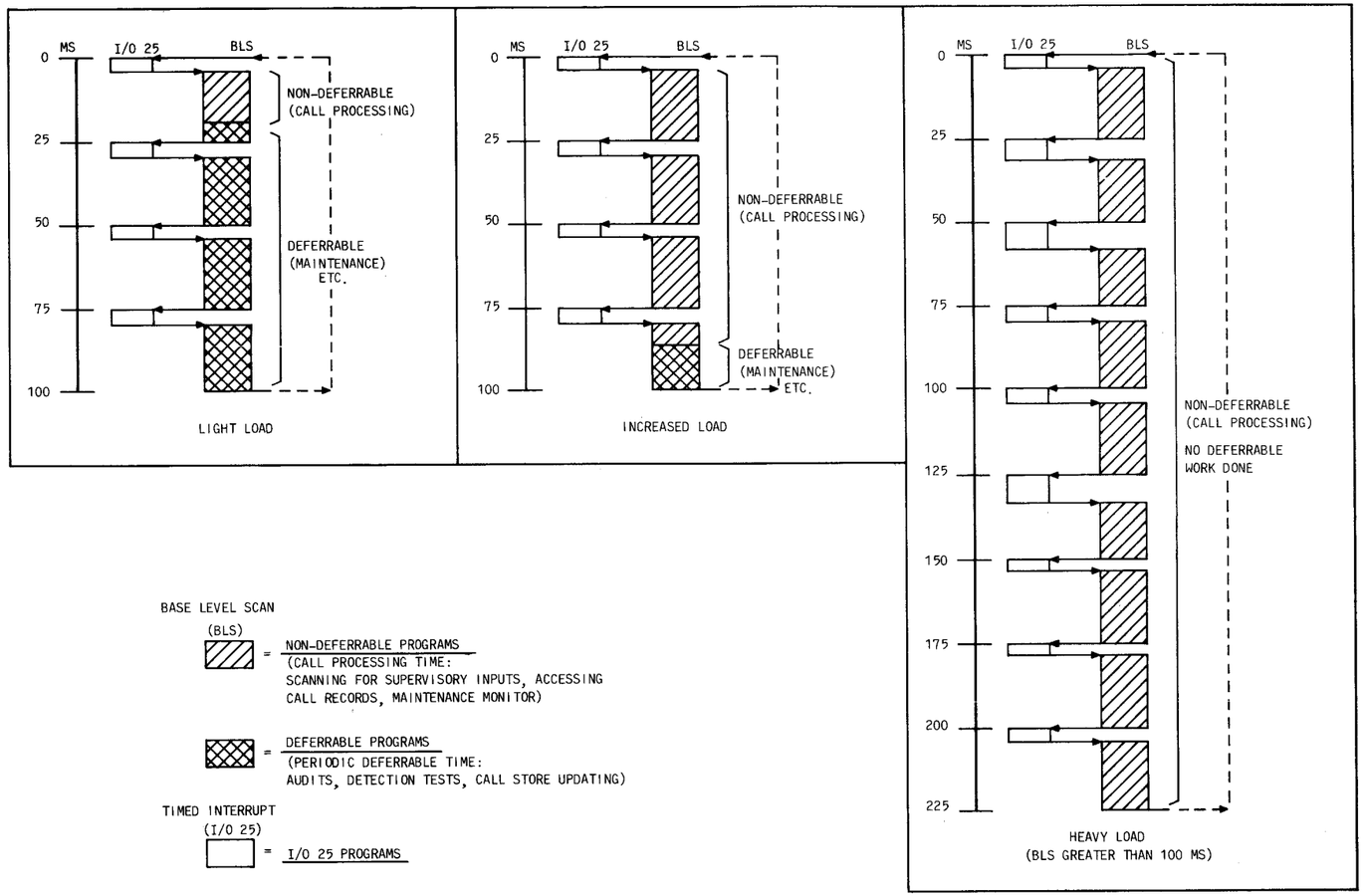

Fig. 1—Program Response to Increased Load

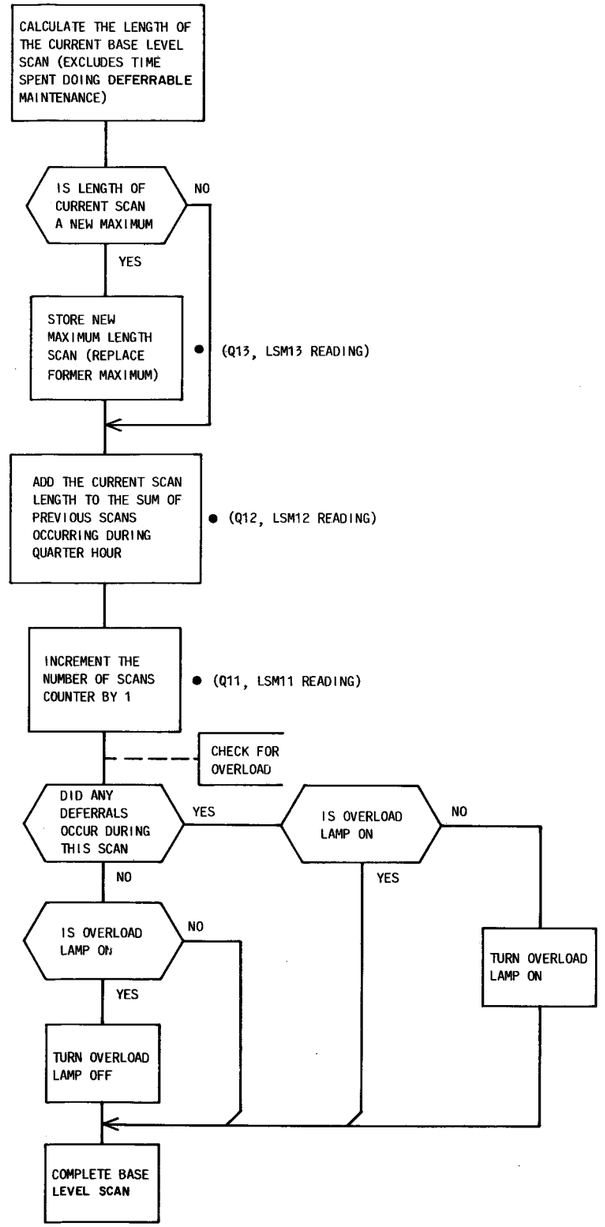

Fig. 2—Overload Control Program

Q SCHEDULE PRINTOUT

```
15  T1  PR  Q      MON  1-26  0945-01  312  554
                1    2    3     4    5       6    7    8    9   10
               11   12   13    14    0       0    0    0    0    0
END     PR  TRF    MON  1-26  0945-09  312  554
```

LSM SCHEDULE PRINTOUT

```
58  TI  PR  LSM    MON  1-26  0958-16  312  554
                1    2    3     4    5       6    7    8    9   10
               11   12   13    14    0       0    0    0    0    0
END     PR  TRF    MON  1-26  0958-34  312  554
```

Fig. 3—Examples of Quarter Hourly (Q) and Load Service Measurements (LSM) Schedule Printouts

TABLE A

SYSTEM INITIALIZATIONS

TYPE INITIALIZATION	SOURCE REQUESTED	LEVEL COUNT	EFFECT ON CALL PROCESSING
Nominal (no memory cleared)	Automatic	1	Fails all sending originating registers (ORs)
Partial clear	Automatic	2	Partially clears areas of call store
		3	Same as level count 2 except more drastic
Emergency audit	Automatic	4	• Idles all peripheral order buffers (POBs) • Idles all transient call records (TCRs) except designated TCRs which are checked for correctness • Idles ORs* • Idles all transient terminal memory records (TMRs)* • Restores all line ferrods to enable customer origination • Restores system network map *Except those associated with designated TCRs
	Automatic and manual	5	Same as level count 4; occurs only if 4 does not complete
Transient clear	Automatic and manual	6	• Zeros all transient data except TCRs and transient TMRs • Forms a list of customer lines involved in TCRs • Idles all TCRs • Sets up a special POB to restore customer line ferrods upon resumption of call processing on those lines that were involved with a TCR • Calls in a TMR audit to zero transient TMRs, a line status bit (LSB) audit to reconstruct line status bits for stable calls and a network audit to rebuild the network map based on stable calls • Call store copy of the traffic work table (TWT) is cleared • LSM schedule printed on traffic and maintenance TTYs (call store copy of TWT restored using program store copy)
Recent change clear	Manual	6	• Clears recent change data such as service orders, customer-originated changes to custom calling features, traffic and plant measurements • Disables calls in transient state causing an emergency audit • Performs transient clear initialization *Note:* A backup tape of service order information should be available when a recent change clear is initiated to restore data following the initialization.

TABLE A (Cont)

SYSTEM INITIALIZATIONS

TYPE INITIALIZATION	SOURCE REQUESTED	LEVEL COUNT	EFFECT ON CALL PROCESSING
Stable clear	Manual	6	• Clears all of call store except recent change area • Idles all trunks and service circuits • Restores all idle line ferrods after resumption of call processing • Causes network administration and maintenance TTYs to print out that all traffic, plant, and performance measurements have been lost • With LO-1, Iss. 4.6 and EF-1, Iss. 3.4, after any stable clear initialization, dynamic service protection (DSP) is defined (Prior to LO-1, Iss. 4.6 and EF-1, Iss. 3.4 DSP is allowed)
Recent change and stable clear	Manual	6	• All calls are disconnected • Zeros all transient data • Zeros all recent change data in call store • Zeros all stable data in call store and initializes the physical equipment