"DMS-1*" DIGITAL MULTIPLEX SYSTEM

TRAFFIC CONSIDERATIONS

1. GENERAL

1.01 DMS-1 is a digital subscriber carrier concentrator system. Its main components are a Control Concentrator Terminal (CCT) at the central office and one or more Remote Concentrator Terminals (RCT) connected by one or two DS1 lines. Use of this system reduces the outside plant requirement for subscriber lines.

1.02 This section describes the different system configurations and options which affect traffic capacity and subscriber access, and the protection features which are provided to minimize service interruption if a system fails. Traffic capacity graphs, to be used as guides for loading the system, are provided for some of the more probable system configurations. Traffic operation of the system is described. The interterminal communication cycle is indicated, and some typical call progressions are followed. Finally, a description is given of the traffic measurements which are carried out by the optional traffic measurement circuit pack. The information obtained from these measurements is used to monitor system performance, and to ensure an acceptable grade of performance while optimizing system utilization.

1.03 *Reason for Reissue:* To add new and revised information. Since this is a general revision, changes are not marked by margin arrows.

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2. EQUIPMENT CONFIGURATIONS

2.01 Three independent factors determine the equipment configuration:

(a) the number of RCT ($\leqslant 4$)

(b) the number of working DS1 lines ($\leqslant 2$)

(c) the number of subscriber lines terminated on the system ($\leqslant 256$).

2.02 Up to four RCT may be connected in tandem to the same CCT. The subscribers connected to all RCT compete equally for the free channels on the DS1 lines. The number of RCT affect traffic capacity only when the local link option is provided.

2.03 One or two working DS1 lines connect the CCT to the RCT. Two working lines are generally required when the number of subscriber lines exceeds 128 to ensure that the objective level of blocking is not exceeded.

2.04 The maximum number of subscriber lines terminated on a DMS-1, using an arbitrary combination of circuit packs, equals the sum of the products of the number of subscriber lines terminated on each type of plug-in times the number of that type of plug-in installed in the system. Normally this number is 256 (the product of 64 single-party or universal cards, times four loops per plug-in). These plug-ins are installed in eight shelves. The shelves may be distributed among RCT in any combination. The 32-loop capacity of any one shelf may not be shared among RCT.

> *Example:* Assume a DMS-1 system with 45 single-party plug-ins (4 loops per plug-in), 15 universal plug-ins (4 loops per plug-in), and 4 coin-line plug-ins (2 loops per plug-in). Then the total number of loops which may be terminated on the system is equal to:
>
> $(45 \times 4) + (15 \times 4) + (4 \times 2) = 248$

3. OPTIONS

3.01 Two system options affect the traffic capacity of the system:

(1) the priority/dedicated option;

(2) the local link options.

3.02 In addition, DMS-1 provides three optional protection arrangements for different system configurations:

(1) automatic line-protection switching;

(2) RCT bypass and loopback;

(3) channel reassignment.

The system options and protection features are described in this part. The effect of the options on traffic measurements are described in Part 6.

A. Priority/Dedicated Option

3.03 If priority or dedicated service is required for a subscriber line(s), the QPP406 single-party office line card for the line is replaced by a QPP411 priority/dedicated line card. Either priority or dedicated mode of operation can then be selected by a switch on the QPP411 faceplate, either during installation or later as required. Installation of a QPP411 causes all four subscriber lines served by that line card to operate in either the priority or dedicated mode, depending on the settings of the individual line switches on the faceplate. Normal operation mode is not possible on any of the four subscriber lines once the QPP411 priority/dedicated line card has been installed.

3.04 *Dedicated.* In dedicated operation, one of the DS1 line channels between the CCT and the RCT is permanently assigned for use of a single subscriber line, instead of being assigned on a first-come, first-served basis. However, the seizure signal from the CCT to the switching equipment still follows the off-hook signal from the RCT assigned to the dedicated line. Because one DS1 channel is permanently assigned to a single line, traffic capacity for the nondedicated lines is reduced.

3.05 *Priority.* In the priority mode, system operation is normal whenever one or more DS1 channels between the RCT and CCT are unoccupied at the time of seizure by the station on the priority line. In cases where all DS1 channels are busy, seizure by the station on the priority line or a terminating call for that station causes traffic on the priority line to replace the nonpriority traffic on one of the busy DS1 channels. The line connection which is replaced by the priority traffic is broken.

B. Local Link Option

3.06 The local link option provides the capability of connecting two lines terminated on the same RCT directly at the RCT, thus freeing channels to the CCT for traffic to elsewhere in the network. When the system is engineered with only one DS1 line, and the local link option is provided, 12 local links are available. When the system is engineered with two DS1 lines, 24 local links are available. The system capacity per line increases as the proportion of local link traffic increases. The local link circuits are shared between all RCT on a first-come, first-served basis.

3.07 Local links are detected by inserting a tone into the terminating line and searching for it in the other DMS-1 channel. This tone is heard by the terminating and possibly by the originating subscriber. To minimize the number of times the tone is heard by a subscriber, the operating company may select an option which enables the local link only under high-traffic conditions. When this option is used, the local link operation is enabled only when 36 or more external channels are occupied on a 2-digroup system, or when 16 or more channels are occupied on a single-digroup system. On a 2-digroup system with one digroup failed, local link operation is permanently enabled, independent of the option selected.

3.08 If the option which enables local link only under high-traffic conditions is selected, the maximum traffic capacity is reduced by about 15 percent. However, the remaining capacity should be sufficient in most DMS-1 applications. If, however, the capacity is not sufficient, the option should not be selected; that is, the local link should be left permanently enabled.

3.09 There are three constraints on channel availability for local-link assignment to occur.

(1) There must be four unassigned channels available; one for the initial originating call to the switching office, one for the return terminating call to the called subscriber, and two more for the local link assignment.

(2) The two local-link channels required after the initial call sequence must be adjacent (e.g., channels 16 and 17).

(3) The first available local-link channel must be even numbered, the second is then odd numbered (starting from channel 0 through 23).

3.10 Local link switching is not provided between RCT. Therefore, when equipped with local link, the number of RCT will have an effect on the available traffic capacity. Traffic capacity can be maximized by consolidating equipped lines onto the smallest feasible number of RCT. Only those RCT with sufficient intra-RCT calling need be equipped with the local link option.

C. Protection Options

3.11 *Protection Switching.* Two types of DS1 line protection switching may be used with DMS-1. Both types are provided on the same protection switching circuit packs.

(a) If the DS1 lines are terminated with LD-1 type repeaters (QRY6A, QRY7A, QPP436, or QPP437), the DMS-1 protection switching option can be used.

(b) If the digital lines are terminated with repeaters other than LD-1 types, the protection switching system recommended by the manufacturer of the type of line in use can be used.

In either case, the protection switch transfers traffic from the failed to the protection DS1 line. The protection switching arrangement may be 1-for-1 for a small DMS-1 system, or 1-for-2 for a larger system.

3.12 *Bypass and Loopback.* For systems with distributed RCT, an RCT bypass and loopback option (manual, or manual and automatic) may be installed. When this option is provided, failure of one RCT does not affect service at other operating RCT. Automatic bypass is activated by RCT failure, and connects the RCT preceding the failed RCT to the RCT following, thus disconnecting the failed RCT from the line. Should all DS1 lines fail at any point, loopback is activated (if the loopback option is used). At the second to last RCT, the DS1 lines are looped at the RCT output. If service is not restored, the procedure is repeated at the third from last RCT, and, if necessary, at the RCT closest to the CCT until service has been restored.

D. Reassignment

3.13 Should service not be restored by a protection switch or bypass, all traffic on the failed DS1 line is reassigned to the empty channels on the good DS1 line. If channel space is insufficient on the working DS1 line to totally reassign the failed subscriber lines, the remaining subscriber lines are disconnected. Any priority/dedicated channels on the failed DS1 line are reassigned to a priority/dedicated position on the working DS1 line.

4. INTERTERMINAL COMMUNICATION CYCLE AND CALL PROGRESS

A. Interterminal Communication

4.01 System operation is completely controlled by the system processor in the CCT. Status is monitored by scanning registers in the CCT and RCT, and comparing their present status with their status at the last scan. When a change in status is detected, the processor initiates the appropriate signaling to cause any required operations in the CCT, RCT, or both. The communications of message between the terminals is done by coding the required information into the digital signal once every 1.5 ms. Each message requires at least three redundant 1.5 ms cycles to ensure error-free transmission.

4.02 Under normal operating conditions, the entire cycle takes 160 to 250 ms. Cycle time exceeds 250 ms only under very unusual circumstances. Assuming a system wholly composed of single-party lines and 48 originations in one scan period into a system carrying no traffic, the cycle time may increase to 600 ms.

B. Originating Call Sequence

4.03 When a call is originated by a DMS-1 subscriber, the off-hook is detected by the line circuit at the RCT. The subscriber line status is passed back to the CCT which initiates the assignment of a channel between the RCT and CCT and closes the line appearance at the CCT. This closure is interpreted by the switch as a call for service and dial tone is returned. From this point until disconnect, the call is processed normally by the switch. When the DMS-1 customer disconnects, the system immediately opens the CCT line appearance. The switch interprets the opening of the line as a disconnect. Two seconds later, to protect against spurious interruptions, the line is disconnected from the DMS-1 channel.

C. Terminating Call Sequence

4.04 When a call terminates on a DMS-1 line, ringing is detected by the CCT line circuit, a channel is set up betweeen CCT and RCT, and ringing is applied to the subscriber line from the RCT. When the subscriber answers, the off-hook is detected at the RCT and the call is handled as an originating call from that point onwards. As with originating calls the channel connection between the RCT and CCT is not removed until 2 seconds after the DMS-1 subscriber disconnects. If the subscriber does not answer, the channel connection is removed within 7 seconds after the last ringing signal. The delay avoids assigning and disconnecting channels on each ringing signal.

D. Local Link Call Sequence

4.05 A local link call originates just as any other originating call. The switch connects it to another DMS-1 appearance, and from that point onward, the call is processed as a terminating call. Immediately after a voice connection has been established through the switch, however, a single tone of up to 450 ms duration is injected into the called subscriber's connection at the CCT. If the tone is detected on any other DMS-1 channel, the two associated subscriber lines are connected at the RCT, and the DS1 channels connecting them from the

RCT to the CCT are disconnected. The line connection at the CCT is not removed, so that the central office connection is maintained. When either customer disconnects, there is a waiting period of 2 seconds (to protect against spurious interruptions) before the local link is disconnected at the RCT, and the line closure at the CCT is removed.

4.06 When a system is equipped for local link detection, all terminating calls are checked, except as described in 3.08 through 3.10. If more than one termination occurs in any scan cycle, only one is checked. Furthermore, no other termination, even if detected in a subsequent scan cycle, is checked until the first local link detection attempt for the first call is complete.

5. TRAFFIC CAPACITY

5.01 Blocking in the system occurs at two points. The first point is on each line shelf, where 32 subscriber lines have access to 24 channels. Each of the 24 channels may be directed through the buffer and drivers to one of digroup A or digroup B, or local link A or B. Once a channel has been assigned to digroup A, that channel is no longer available on the same line shelf for assignment to digroup B or local link. However, on any other line shelf, the same channel can be assigned to digroup B or local link A or B, but not to digroup A. The second point of blocking is at the interface between the line shelves and the digital lines or local links, where 24 channels from each line shelf have access to the 24 channels on each of digroups A and B and local links A and B.

Example: If heavy traffic on line shelf 0 has used up all 24 channels on digroup A, traffic on all other line shelves would compete for the 24 channels on each of digroup B, and local links A and B.

5.02 Total system Average Busy Season Busy Hour (ABSBH) traffic capacity is given in Fig. 3 for various criteria, and similarly Fig. 2 gives the traffic capacity in terms of 4 High Week (the 4 busiest weeks of the year). The traffic capacity in these charts includes the effect of the pseudo-full access system. No further adjustments are required

when loading the system unless some lines are dedicated. All charts indicate traffic capacity for one-RCT system configurations as follows:

(a) 256 subscriber lines in a system with two DS1 lines.

(b) 128 subscriber lines in a system with two DS1 lines.

(c) 256 subscriber lines in a system with only one DS1 line. (This curve indicates the capacity of a fully loaded system when one DS1 line fails and a protection line is not available.);

(d) 128 subscriber lines in a system with only one DS1 line.

(e) 256 subscriber lines in a system with two DS1 lines: local link enabled when 36 or more external channels occupied.

(f) 128 subscriber lines in a system with one DS1 line: local link when 16 or more external channels occupied.

Note: The charts show capacities with local link threshold at 0 channels unless otherwise noted.

Terminating calls blocked, and originating calls delayed, jointly present the limiting conditions on traffic capacity. Therefore, for any combination of incoming and outgoing traffic, the ABSBH capacity of these configurations is given as a function of the ratio of local link traffic to total traffic for 0.1 percent blocking ABSBH, and for 0.5 percent blocking in the busiest hours of each of the 4 High Weeks. Any combination of subscriber lines can be assigned to a DMS-1, limited only by the maximum number of terminated lines and the minimum allowable traffic capacity per main station.

Example: A 128 subscriber line system with one DS1 line and 20 percent local link traffic is to be loaded to give 0.1 percent ABSBH blocking. Then, from Fig. 3, 575 ccs may be assigned to the system.

5.03 If any subscriber lines are dedicated, traffic capacity for the remaining lines should be derated by 2 percent for every dedicated line.

5.04 At high intra-RCT calling rates, the capacity of dual-digroup system serving 256 subscriber lines is greater than that of a system serving 128 subscriber lines. This results from the high calling rate (> 11 ccs/line) required on the 128-line system to produce any blocking at all. This high calling rate forces more intense competition for the exit channels of each shelf, thus decreasing the traffic capacity from each shelf at any blocking probability.

5.05 To determine system capacity as described requires the availability of local link ccs. Local link ccs includes only traffic carried on local links between subscribers connected to the same RCT. Local link ccs therefore excludes,

(a) ringing and dialing traffic associated with local link calls, and

(b) calls between subscribers connected to the same RCT which are blocked from the local link (e.g., due to no channels available between the RCT and CCT).

5.06 To obtain local link ccs data, the traffic measurement option (QPP434) must be installed. If QPP434 is not installed, but an estimate of intra-RCT traffic from some other source is available (including dialing, ringing, and blocked local link call traffic), Fig. 2 and 3 may be used as follows:

(1) calculate the ratio of intra-RCT traffic to total traffic;

(2) decrease the result by 15 percent to obtain an estimate of local link traffic alone;

(3) enter the graphs of Fig. 2 or 3 as applicable, and determine traffic capacity.

Example: A 256 subscriber line system with two DS1 lines is to be loaded to give 0.1 percent ABSBH blocking.

Total Traffic	= 1225 ccs
Intra-RCT Traffic	= 210 ccs
Intra-RCT ratio	= 0.17
Local Link ratio	= 0.85 × 0.17 = 0.145
Traffic Capacity (from Fig. 3)	= 1325 ccs

5.07 If the local link option is not installed in the system, the traffic capacity of the system is
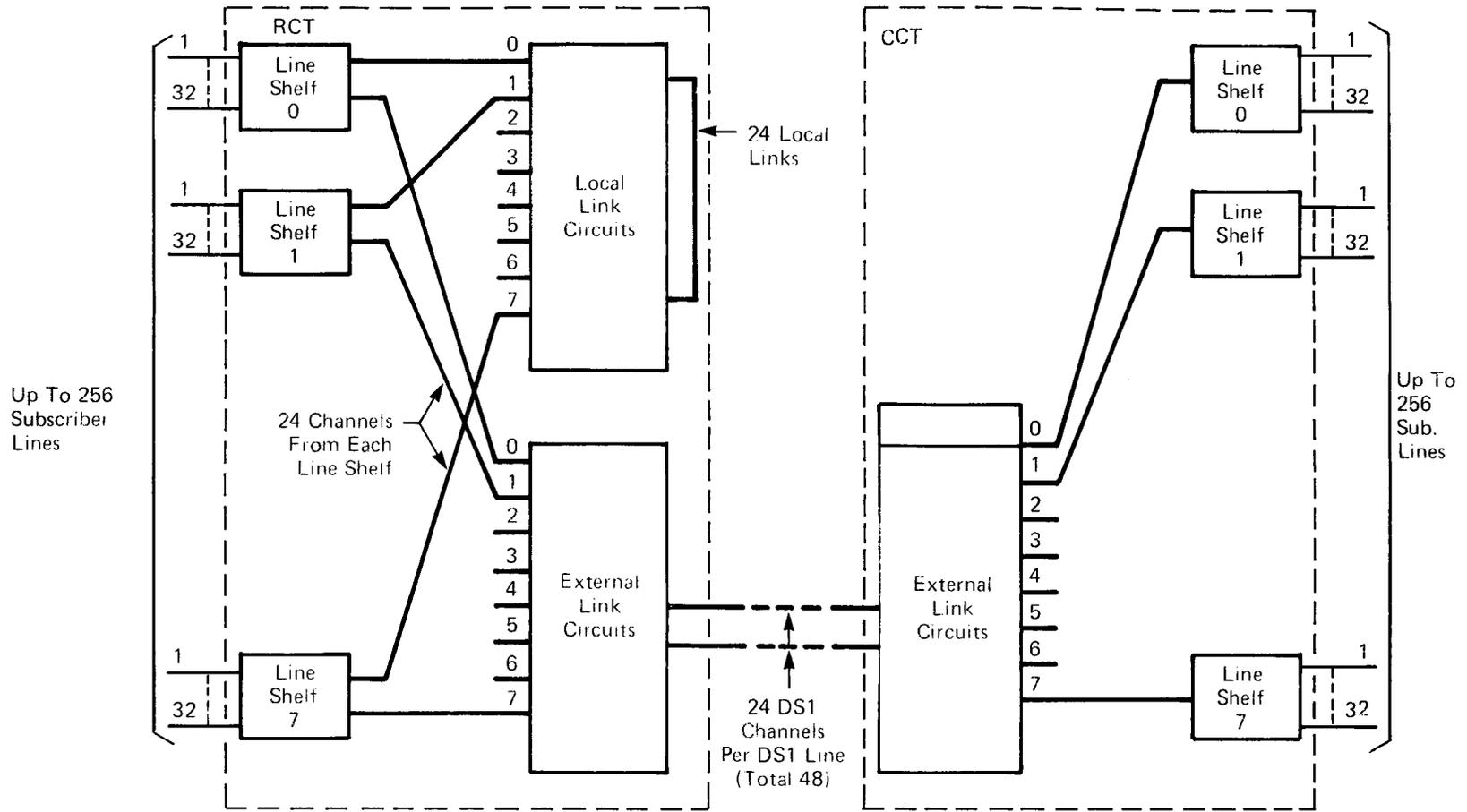
$$T = T_o (1 - 0.1I)$$

where

T_o = traffic capacity at 0 percent local link traffic

I = Ratio of Intra-RCT traffic to total traffic.

Example: A 256 subscriber line system with two DS1 lines, no local link option, and 15 percent intra-RCT calling is to be loaded to give 0.5 percent blocking (four high week). Then, it can be loaded to

$$1250 [1-(0.1 \times 0.15)] = 1231 \text{ ccs}$$

Traffic Flow In A DMS–1 System With 256 Subscriber Loops,
Two DS–1 Lines and 24 Local Links

Fig. 1 – DMS-1 Traffic Flow

Fig. 2 — **Traffic Capacity at 0.5 Percent Blocking (4 High Week)**
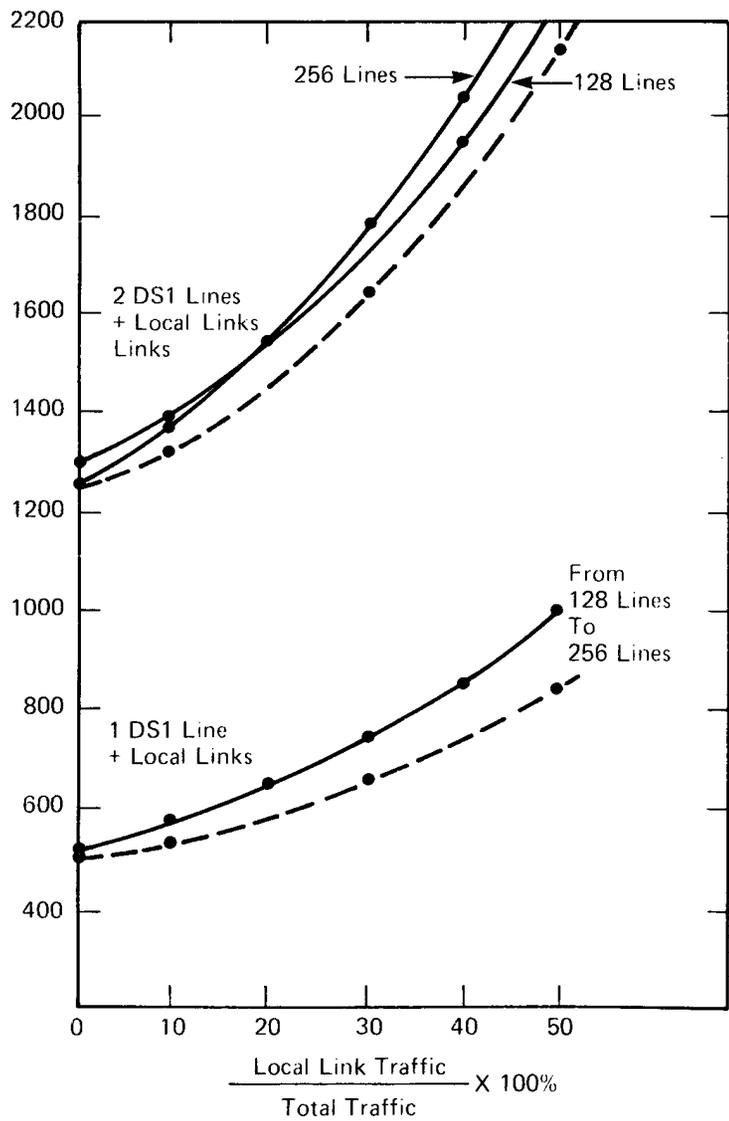
Legend:

————————— Local Link Permanently Enabled

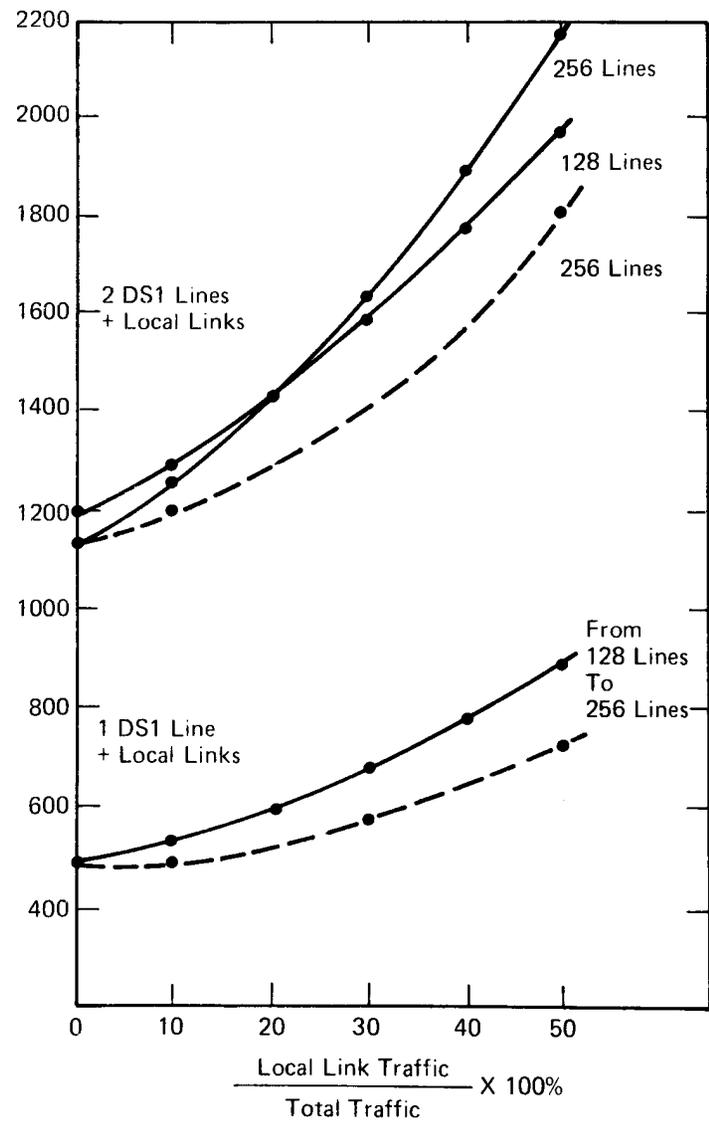— — — — — Local Link Enabled In High Traffic Only

Fig. 3 — **Traffic Capacity at 0.1 Percent Blocking (ABSBH)**

5.08 Traffic capacity of other system configurations can be extrapolated with reasonable accuracy. Capacity of distributed systems can be approximated as a one-RCT system carrying the weighted average of the intra-RCT traffic on all RCT. If traffic measurement option is provided, the local link ccs provides this weighted average directly.

Example 1: A distributed system with two DS1 lines is to be engineered for 0.1 percent blocking ABSBH, with subscriber line distribution as follows:

(a) *RCT 1.* 96 subscriber lines; 114 main stations; 11.5 percent intra-RCT traffic.

(b) *RCT 2.* 64 subscriber lines; 70 main stations; 15 percent intra-RCT traffic.

(c) *RCT 3.* 32 subscriber lines; 38 main stations; local link not provided; 15 percent intra-RCT traffic.

Because only intra-RCT traffic figures are available, equivalent local links ratios must be determined:

(a) *RCT 1.* 11.5 percent intra-RCT traffic is equivalent to (0.115 × 0.85) or 9.8 percent local link traffic.

(b) *RCT 2.* 15.5 percent intra-RCT traffic is equivalent to (0.15 × 0.85) or 12.8 percent local link traffic.

(c) *RCT 3.* Because local link is not provided, the local link traffic ratio is 0 percent.

Because the system is to be loaded to 0.1 percent blocking ABSBH, the data required can be obtained from Fig. 3.

Total subscriber lines = 192

Total main stations = 222

Weighted local link traffic = (0 × 32 + 0.128 × 64 + 0.098 × 96)/192 = 0.092

Capacity at 9.2 percent local link (256 subscriber lines) = 1255 ccs

Capacity at 9.2 percent local link (128 subscriber lines) = 1300 ccs

Capacity at 9.2 percent local link (192 subscriber lines)

= 1300— |(1300—1255) × (256—192)/(256—128)| = 1278 ccs

Capacity/subscriber line = 6.7 ccs

Capacity/main station = 5.8 ccs

Example 2: The system of example 1, this time equipped with the traffic measurement option, is to be engineered for 0.5 percent blocking (four high week). The traffic option registers 11 percent local link ccs. Then the traffic capacity of the system at 11 percent local link traffic is as follows:

NO. OF SUBSCRIBER LINES	CCS
256	1400
128	1430
192	1415

Capacity/subscriber line = 7.4 ccs
Capacity/main station = 6.4 ccs

6. TRAFFIC MEASUREMENTS

6.01 Two versions of the traffic measurement circuit pack are available:

(a) *QPP434A* with counters mounted on the faceplate of display of traffic data; and

(b) *QPP434B* without counters on the faceplate.

In both circuit packs, measurements of eight traffic parameters are provided, with an output for each function which can be used to operate external 14-type counters. On each output, the signal provided is a 100-ms contact closure to ground for each increment of the counter.

6.02   The parameters measured are:

(a) originating peg count,

(b) terminating peg count,

(c) total ccs (including local link),

(d) total local link ccs,

(e) high hourly ccs,

(f) all channels busy occurrences,

(g) terminating calls blocked,

(h) originating calls delayed.

6.03   *Originating Peg Count.* A 5-digit counter is incremented every time a channel from the RCT to the CCT is established. Therefore, this counter indicates the number of calls (including intra-RCT calls) which originate from DMS-1 main stations on nondedicated lines and which are preceded by an on-hook period of at least 2 seconds. Dedicated lines register an origination only when first dedicated.

6.04   *Terminating Peg Count.* A 5-digit counter is incremented every time a channel is set up from the CCT to the RCT. Therefore, the counter indicates the number of incoming calls (including intra-RCT calls) to DMS-1 main stations on nondedicated lines which reach the point of ringing, and which are preceded by an on-hook period of at least 2 seconds at the terminating station. The effect of dedicated lines on this measurement is similar to that described for the originating peg count. Note that intra-RCT calls are counted as one originating and one terminating call.

6.05   *Total CCS.* A 5-digit counter records the sum of the times that each channel is in use (including local link).

> *Note:* All dedicated lines are considered to be permanently in use, and thus contribute 36 ccs each to the total.

6.06   *Total Local Link CCS.* A 5-digit counter records the sum of the times that the local link channels are in use. Therefore, this register accumulates the ccs associated with the conversations carried. Ringing and dialing are carried by the external digital line and thus are not included. Therefore, 2 ccs are registered, one for the originating, and one for the terminating party, for each 100 seconds that a local link is in use.

> *Note 1:* Local link traffic is defined as conversation time between subscribers served by the same RCT. It does *not* include conversations between two subscribers served by different RCT.

> *Note 2:* When local link is enabled under high-traffic conditions only, the local link ccs indication does not include potential local links which might have been set up, if local link had been permanently enabled. Thus the indication in this case, cannot be used in any of the traffic calculations described in this practice. Only those local link ccs measurements made when the local links are permanently enabled may be used.

6.07   *High Hourly CCS.* A 6-digit counter displays the maximum ccs (including local link) occurring in any 60 minute period between resets. The counter is reset manually at the CCT, and the 60 minute periods are measured from the time of reset. A lamp is provided which lights when power to the QPP434 is interrupted. Should power be interrupted, the high hourly ccs reading becomes invalid. The lamp, therefore, indicates that the counter data is invalid and the reset button should be pressed to clear the counter.

> *Example:* If the counter is reset at 7:51, then the next two 60 minute periods will be 7:51 through 8:51, and 8:51 through 9:51.

6.08   *All-Channels-Busy Occurrences.* One 5-digit counter records the number of times that all channels on the DS1 line(s) are in use. It does not record instances when no internal channels are available from the line shelf to the local or external link circuits. (This first stage of blocking is described more fully in 5.01.)

6.09   *Terminating Calls Blocked.* One 5-digit counter records the number of incoming calls which occur while all the channels on the DS1 line(s) are busy. In addition, a count may be caused by the unavailability of an internal channel from the DS1 line interface to the required shelf.

6.10   *Originating Calls Delayed.* One 5-digit counter records the number of calls which must wait 3 seconds or more before a channel is assigned and the call is connected to the central office.

7.   TRAFFIC ASSIGNMENT

7.01   Since the probability of a call being blocked on each line shelf is negligible with 24 channels for 32 subscriber lines, there are no restrictions on the number of multiparty lines that may be assigned to each line shelf. However, to limit the number of subscribers that would lose service from line shelf common equipment failure (buffer, line power converter), it is recommended that the total number of subscribers be distributed approximately equally over the installed line shelves.