PRX D

DIGITAL SWITCHING SYSTEM

PHILIPS

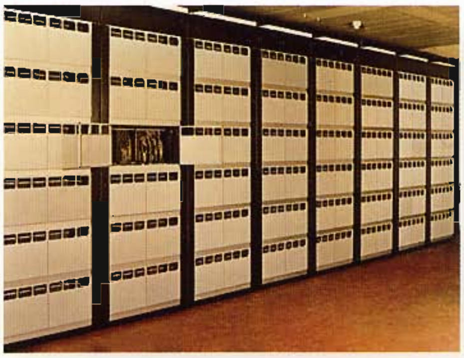
PHILIPS Telecommunications

Contents

1. Introduction

General

The past few years have seen extremely rapid advances in the technology of microelectronics, particularly the development of LSI and VLSI logic elements. The availability of high-reliability microprocessors, solid-state memories, and a wide variety of application-oriented LSI devices designed to operate under microprocessor control has made economically feasible the employment of distributed intelligence and a very high level of functional modularity. Improved system flexibility, manageability in engineering, manufacturing and operational terms, optimized hardware/software relationships, further size reductions and many other advantages can now be achieved at a reasonable cost.
The PRX/D represents a major step forward in the realisation of the benefits of contemporary and future digital technology.



PRX/D trunk exchange

Advantages of digital technology

With the transposition of speech into a digital form it becomes possible to transmit signals in 'time slots', which can be multiplexed and transmitted on a common transmission link. Indeed the relationship between digital transmission (PCM) and digital switching is self-enhancing: an increase in the number of digital transmission systems increases the economic viability of digital switching, which necessarily makes the implementation of digital transmission systems still more favourable.

The decreasing cost of the logic elements used in digital switching equipment, and the increasing adoption of PCM transmission systems, will eventually favour the implementation of digital switching, particularly at the trunk exchange level.

The unification of digital switching and digital transmission will result in greatly improved speech quality, since a digital signal is essentially immune to crosstalk and noise, and facilitate the transmission of data over the same network.

Other tangible advantages of digital switching are short call-set-up time and the ability to economically design practically non-blocking switching networks.

PRX/D system organization

The design philosophy applied to the PRX/D is based on the two principal requirements of administrations in today's rapidly changing telephony environment: the need for smooth, economical growth as networks expand and subscriber needs change; and the ability to implement new technologies as they become economically feasible. To realise these objectives a modular design is employed throughout the PRX/D system structure. Complete system functions are realised on one or more printed circuit cards which simply plug into easily handled connective frames.
A frame containing cards constitutes a module, and these are installed into shelved cabinets and interconnected as appropriate by front-access cable connectors.

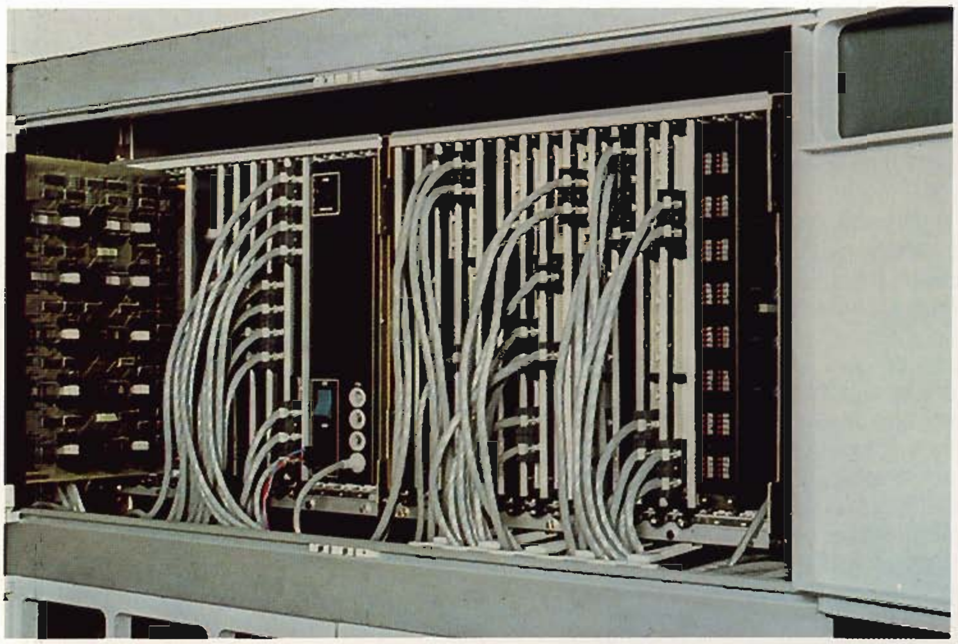
The use of distributed microprocessors to control discrete network domains considerably simplifies software organization and by implementing the CCITT programming language CHILL the software is rendered insensitive to hardware evolution.

The switching network not only switches speech channels but in addition establishes control channels between the dispersed microprocessors and the central processing system, facilitating the implementation of remote concentrator stages.

Two types of central processing system are available in the PRX/D family of exchanges: TCP18 and TCP36. These processing units provide a range of control capacity to cover the requirements of the different exchange sizes in the most economical way. The central control facility typically performs the high-intelligence functions, such as call processing and coordination, while the dispersed microprocessors perform simple repetitive tasks, such as signal reception and generation.

2. System Features

The adoption of a dispersed control configuration, with its implications in software implementation, and the general equipment practice employed in the PRX/D system structure has many important advantages:



Cabinet shelf with connectorised modules

- Considerably reduced floor space requirements due to the microminiaturization of the PRX/D components; the elimination of separate interface units between the switch and the transmission equipment; and the ability to assemble cabinets back-to-back.

- Full connectorisation of the system, and the easily handled equipment frames, considerably simplifies installation procedures.

- Low power consumption due to the use of specially designed Low-power Current-mode Logic (LCL) integrated circuits.

- The software modularity ensures that software faults will be confined and not corrupt the entire system.

- The hardware of the functional units can be kept simple, since it is directly controlled by a microprocessor which performs all the necessary logical and diagnostic functions.

- The central processing system and the dispersed microprocessors interface on a software-to-software basis with the central control software modules corresponding directly to switching network functions.

- The high level of hardware independence simplifies the selection of both hardware and software modules from the available system functions, and facilitates the generation of exchange software.

- Functional units can be assembled and tested as complete entities prior to delivery to the exchange site, significantly shortening installation and commissioning time.

- Modules representing telephony functions can be added or changed in accordance with traffic requirements or new service needs at any time, with no influence on existing facilities.

- Capability of being configured to function at any level in the network, or at more than one level in a combined exchange.

- Capability of expansion in rational increments from low to high traffic-handling capacities, simply by the addition of switching stages and peripheral control domains.

- Remote supervision of exchanges from a centralized operations and maintenance centre.

- Capability for working in either 24 or 30 channel digital transmission networks.

3. Exchange Organization

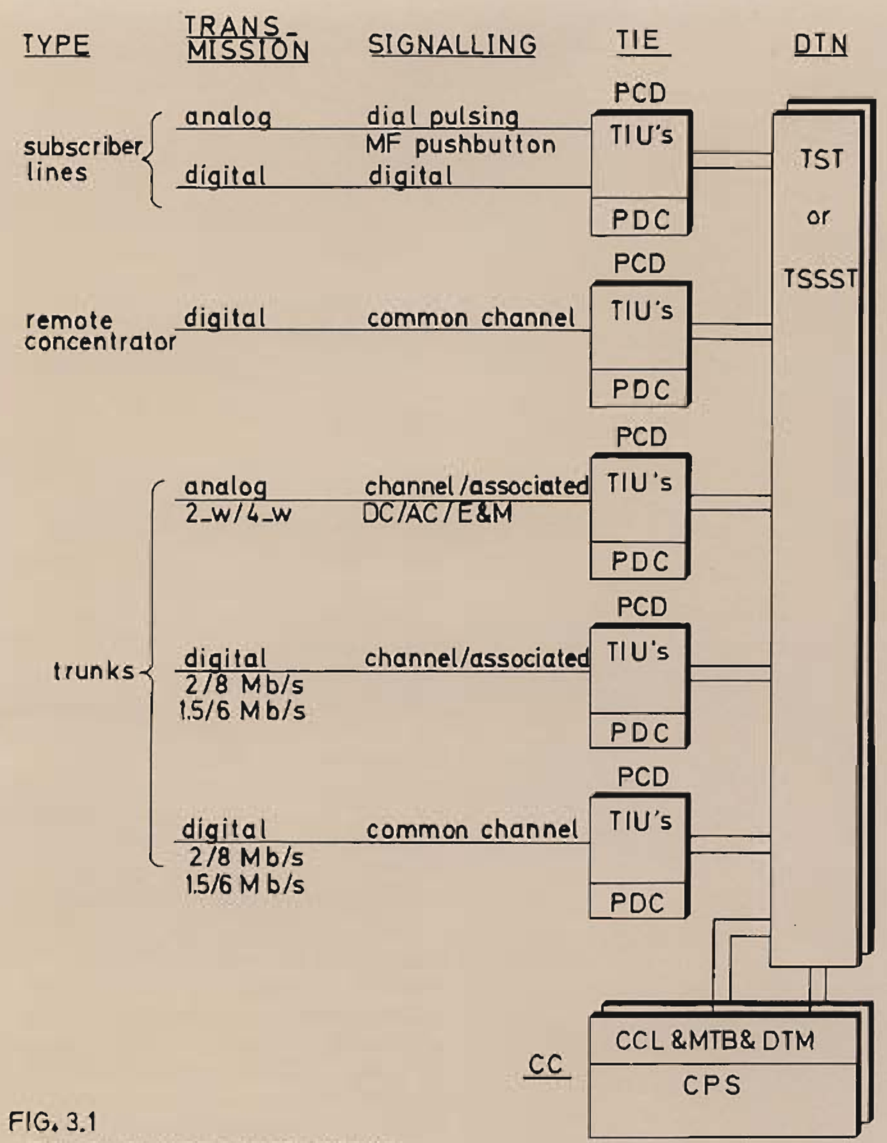


FIG. 3.1
PRX-D SYSTEM STRUCTURE

The basic structure of the PRX/D is illustrated in fig. 3.1. There are essentially three categories of subsystem that constitute the PRX/D. These are:

- Terminal Interface Equipment (TIE)
- Digital Trunk Network (DTN)
- Central Control (CC)

Terminal Interface Equipment (TIE)

The Terminal Interface Equipment (TIE) provides the external circuit interfaces, appropriate to the transmission environment, and associated signalling and services facilities. Subscriber lines and trunks, analogue and digital, and digital links from remote concentrators, are therefore connected to the TIE.

The TIE processes the inputs, in accordance with their nature, producing either primary multiplexes of 2048 kbits/s or second order multiplexes of 8192 kbit/s. In addition the TIE handles all types of channel associated signalling. Common channel signalling is routed via the TIE to the Message Transfer Buffer.

The TIE consists of a compilation of Peripheral Control Domains (PCD's), the number and functional role depending upon the specific interface requirements.

A PCD is essentially a self-supporting group of Terminal Interface Units (TIU's), consisting of Circuit Terminal Units (CTU's), a Signalling and Services unit (SAS), a Peripheral Domain Switch (PDS), and a Peripheral Domain Controller (PDC). See fig. 3.2.

Subscriber line terminations and inter-exchange trunks are connected to CTU's to which digit receivers and digital tone generators, grouped in the SAS, are assigned. The PDS is used to establish connections within the PCD for speech channels, tones and digit reception. The PDC stores the necessary data required for call set-up and call status and transposes the telephone signals into logic levels, and vice versa. This basically autonomous unit can be repeated for further system expansion in which case an additional digital switching network is required to provide interconnections between the PCD's.

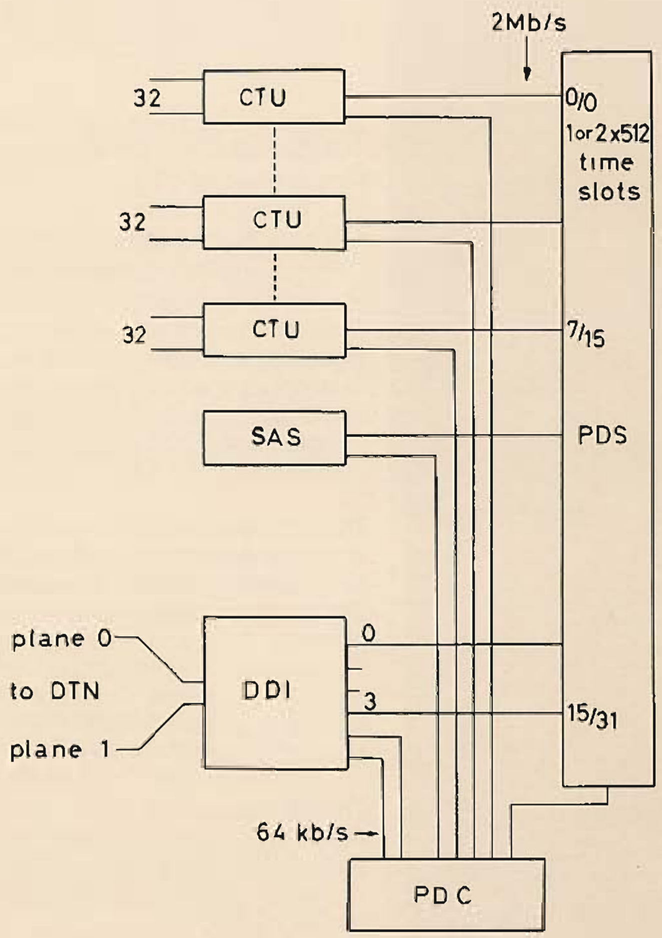


FIG. 3.2 PERIPHERAL CONTROL DOMAIN (PCD)

Circuit Terminal Units (CTU's)

There are essentially three types of CTU:
- Subscriber Line Interface Unit SLI)
- Analogue Trunk Interface Unit (ATI)
- Digital Trunk Interface Unit (DTI).

In a medium to large exchange a PCD will typically contain one type of CTU, whereas in smaller exchanges a PCD may contain a variety of CTU's.

Subscriber Line Interface Unit (SLI)
The SLI connects subscriber lines, analogue and digital, to the PRX/D. A SLI consists of four cards and provides terminations for 32 subscriber lines. Two SLI's can be accommodated in an 18 pitch module frame.

Analogue Trunk Interface Unit (ATI)
The ATI connects analogue trunks to the PRX/D. An ATI accommodating 32 junctor circuits and associated codecs consists of four or six cards depending upon the signalling protocol.

Digital Trunk Interface Unit (DTI)
The DTI is used to connect 30 or 24 channel PCM line systems to the PRX/D. A DTI, for use with 30 channel PCM systems, consists of four Exchange Terminal (ET) cards each of which is dedicated to one PCM circuit.

Signalling and Services Unit (SAS)
The SAS contains the signalling devices required as a complement to the CTU's. The SAS consists of multifrequency senders and receivers, and tone generators. The tone generators are for the generation of subscriber audible tones. The multifrequency senders and receivers consist of registers which can be used alternately as a sender or a receiver. The multi-frequency tones are stored, in digital form, in the memory of the PDC. Additional facilities, such as conference calls, may also be realised in the SAS.

Peripheral Domain Switch (PDS)
The PDS is a non-blocking time switch for 16 PCM 30/32 systems with 512 interconnectable channels. When used in a PCD, 4 of the 16 2.048 Mbit/s systems are reserved for connecting the PDS, via a collocated interface card to the DTN. The DTN Interface Card (DDI) multiplexes the 4 2.048 Mbit/s systems into an 8.192 Mbit/s system as required for through connection through the DTN. If the PDS is used as the only switching element in a small autonomous exchange it serves for setting up all connections between subscribers.

Peripheral Domain Controller (PDC)
The PDC consists of a microprocessor card and a memory card, both of which may be duplicated for availability reasons. The principal function of the PDC is to translate telephone information peculiar to the PCD into standardized messages for communication with the CC, and vice-versa. Thus the PDC controls the line/trunk circuits, signalling procedures, call-time supervising, and the PDS.
The PDC permits the establishment of a devolved control structure: the PDC performing the time-consuming repetitive telephony functions while the CC performs the high-intelligence functions such as: call processing, resource management, etc. This devolved control structure simplifies software provisioning by establing clearly defined functional boundaries within the CC software.

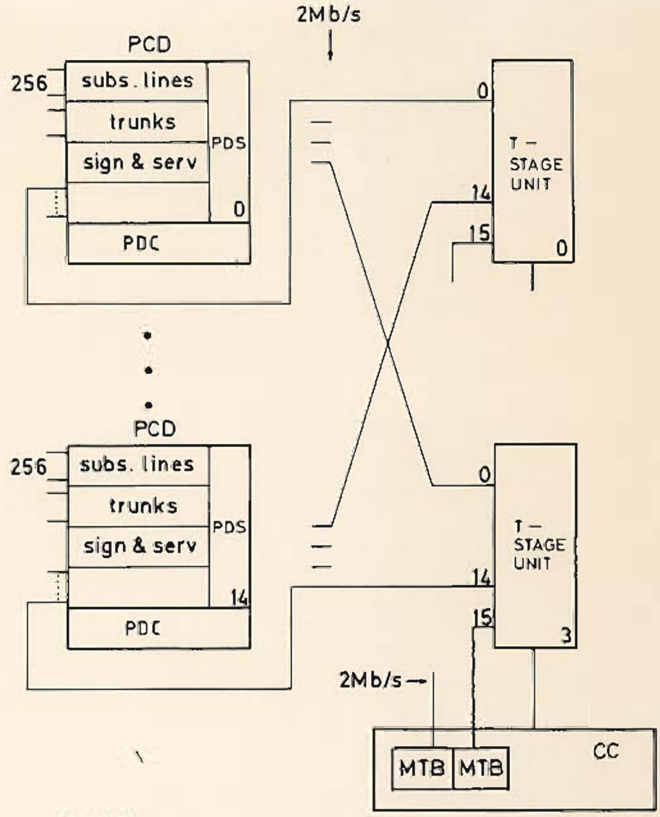


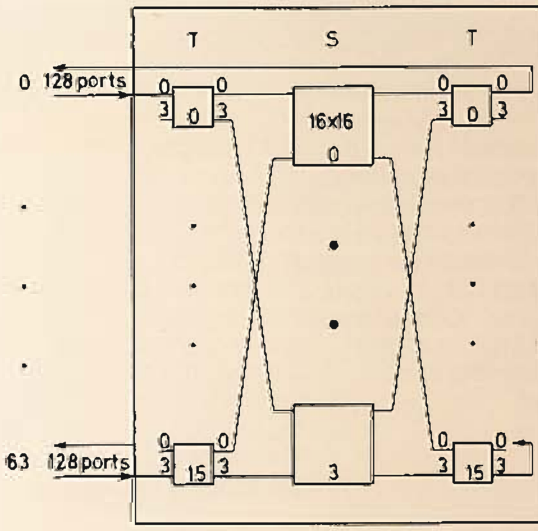
FIG. 3.3
SMALL EXCHANGE 4000 SUBSCRIBERS

Three types of DTN switch assemblies are available:
1) A switching network for small to medium exchanges with a maximum capacity of 4,000 subscribers. This DTN consists of a single time stage comprising four time-stage units. See fig. 3.3.
2) A switching network for medium to large exchanges providing 8192 channels. This DTN has an explicit time-space-time structure comprising 2 x 16 time-stages (4 x 8 Mbit/s) and four space-stages (16 x 16) symmetrically wired as depicted in fig. 3.4.
3) A switching network for large exchanges providing 65,536 channels. This DTN has an explicit time-space-space-space-time structure comprising 2 x 128 time-stages and four triple space stage arrays as depicted in fig. 3.5.

Digital Trunk Network (DTN)

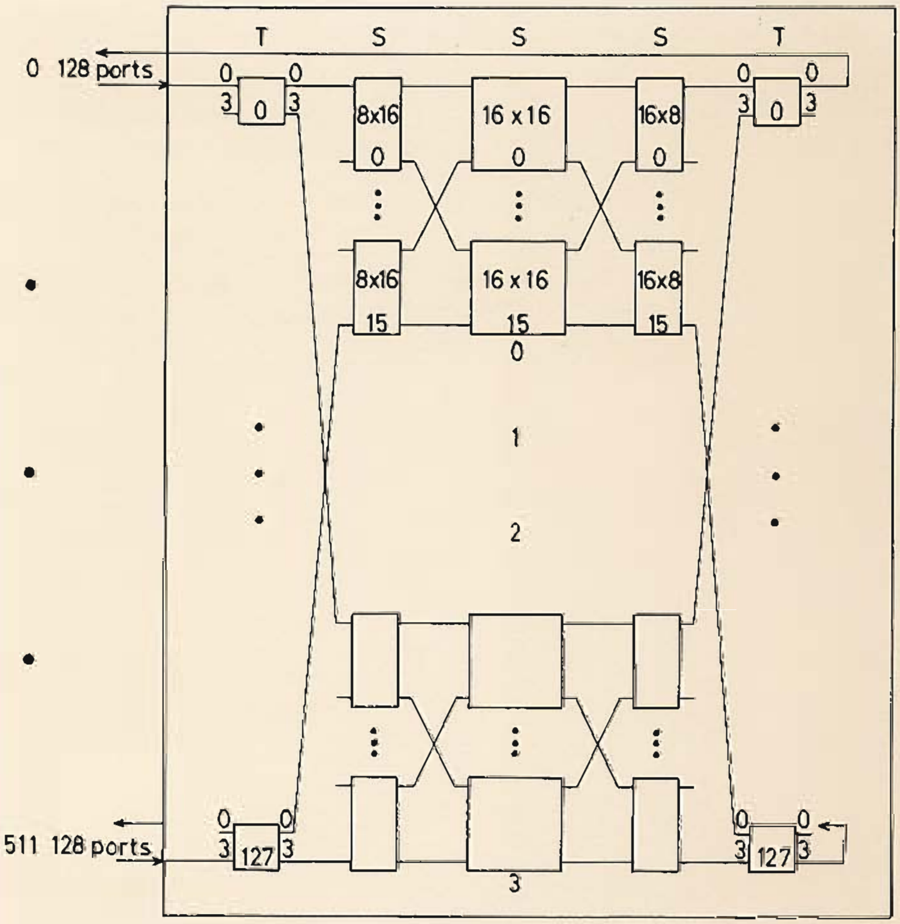
For all but the smallest exchanges, where a PCD or a number of PCD's form the switching network, a DTN providing additional switching elements is required. Depending on the size of the exchange the DTN consists of time switches or a combination of time and space switches.

The time switches serve to interchange time-slots. Incoming PCM words are sequentially written into a buffer memory and subsequently read out during a preselected time-slot.
The space switches, consisting of a matrix of electronic cross-points, serve to switch the time-slots through space.



Capacity: 8192 duplex ports
$P_{blocking}$: $< 10^{-5}$ at 0.8 Erlang per port

FIG. 3.4
DIGITAL TRUNK - LINK NETWORK DTN (TST)



Capacity: 65 536 duplex ports
Blocking: $< 10^{-5}$ at 0,8 Erlang per port

FIG. 3.5
DIGITAL TRUNK-LINK NETWORK DTN(TSSST)

The time-space-time types of DTN are for availability reasons fully duplicated and are controlled and supervised by a duplicated marker. The single time stage DTN for small exchanges is not duplicated but operates in a load sharing mode such that in the event of failure of one time-stage unit the remaining three can sustain the full load.

The time-stage units consist essentially of time-slot memories for buffering the various channels, and control memories for controlling the read-in and read-out of time-slots to and from the time-slot memories. In addition the time-stage units distribute timing and alignment signals to the PCD's. Similarly the space switch contains control memories to effect the switching through space of time-slots. These control memories are also serviced by the marker.

Central Control (CC)

The CC provides exchange administration facilities, and consists of the following duplicated systems:
- Central Processing System (CPS)
- Message Transfer Buffer (MTB)
- Central Clock (CCL)
- DTN Marker (DTM)

Central Processing System (CPS)

The optimal use of microprocessors and associated memory elements throughout the PRX/D system structure results in a substantial reduction in the processing requirements of the CPS. Thus, it has been possible to utilize the CPS's; TCP18 and TCP36, which have been proved in operation with the PRX/A. The deloading of the CPS, effected by the PDC's, results in a substantial improvement in the call capacities of the processing units. The TCP 18, which can be used in either a single or multicontrol configuration, can handle up to 40 calls per second. The more powerful multiprocessor TCP 36 can handle traffic volumes up to 250 calls per second. These CPS's employ duplicated processors and memories in an instruction-synchronous, dual-compare mode to ensure the high system availability required in telephone switching applications.
The TCP 36 is programmed in accordance with the CCITT high level language CHILL. The use of this machine independent language results in improved software reliability, supported checking possibilities at compile time, and improved understandability and maintainability, facilitating customer involvement in the generation of exchange software.

Message Transfer Buffer (MTB)

The MTB acts as an interface between the CPS and the PDC's. It translates the format and speed of the received information in accordance with the particular requirements of the respective communicating processors.

Central Clock (CCL)

The CCL provides timing and alignment signals to the PCD's via the DTN. A block-diagram of the clock distribution system is given in fig. 3.6. The CCL consists of duplicated clock generators, a clock measuring unit, and an optional clock reference unit. The clock generators, operating in a phase-synchronised mode, supply the PCD's with the required timing signals, i.e. 8,192 kHz sine waves and 4 kHz alignment pulses.
The two clock generators and the clock measuring unit contain voltage-controlled quartz oscillators with a nominal frequency of 8,192 kHz and a stability of one part in 10^{10} per day. The outputs of the three oscillators are continuously compared, and a majority decision is taken if a fault occurs. A switchover from one clock generator to the other is made in such a way that phase discontinuities are prevented.
The clock generators can be supervised by a clock reference unit which may contain either a caesuim reference clock or inter-exchange synchronisation facilities to reduce frame slip to one slip per 70 days.

DTN Marker (DTM)

The DTM acts as an interface between the CPS and the address generators of the DTN. It translates the information received from the CPS into byte form for transfer over 64 kbit/s channels, routed to the DTN address generators.

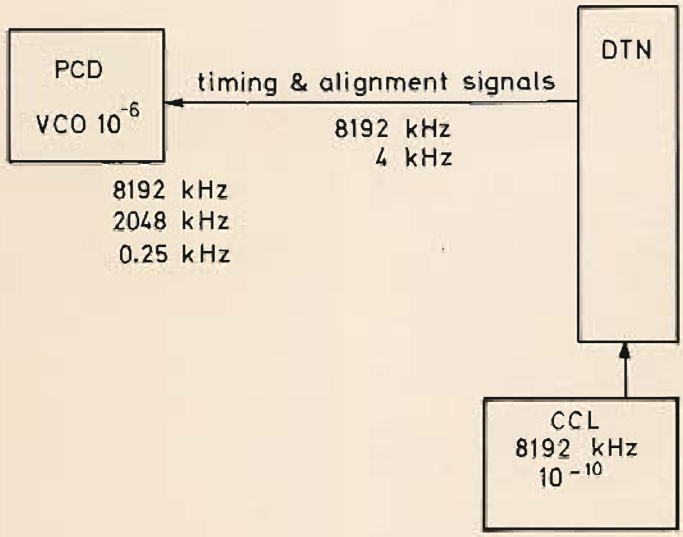


FIG. 3.6
DISTRIBUTION OF TIMING & ALIGNMENT SIGNALS

Control Channels

The CPS communicates with the PDC's in the PCD's via 64 kbit/s control channels. As these channels are identical to the speech channels, the switching network is utilized to gain access to the PDC by the formation of semi-permanent connections. Not only does this mechanism facilitate the utilization of remote concentrator stages, but additionally facilitates the adoption of common channel signalling system CCITT No. 7. The control channels are grouped together in clusters of 128 for transmissions through the 8Mbit/s switching network. The switching network switches the individual channels in a preassigned time-slot.

All the control channels are connected to the Message Transfer Buffer (MTB), which temporarily stores, and subsequently converts, messages derived from the CPS into a 64 kbit/s bit stream. The messages are a compilation of 8-bit bytes comprising an address, check bits and the actual information.

Exchange Configurations

There are in essence four primitive exchange types with overlapping application boundaries. Augmenting these basic types is remote concentrator which by virtue of the local call completion facility can function as a small autonomous exchange.

The exchange configurations for up to 1,000 and 4,000 subscribers are illustrated respectively in figs. 3.7 and 3.3. The smaller of the exchanges, fig. 3.7, is essentially a maximum of four PCD's connected to a microprocessor CPS. The PDS's of the PCD's constitute the switching network and are interconnected by means of 2 Mbit/s digital paths. The PCD's are connected to the CC via 64 kbit/s digital paths.

The 4,000 subscriber exchange, fig. 3.3, includes a time-stage DTN. A maximum of 15 PCD's can be connected, via 2 Mbit/s digital paths, to a DTN comprising of four time stage-units. The DTN then has one remaining 2 Mbit/s digital path which is used for communicating with the CC.

The larger exchanges, for dealing with high traffic capacities, are configured using the T-S-T and T-S-S-S-T DTN's described previously and illustrated in figs. 3.4 and 3.5 respectively. The T-S-T DTN can be connected to a maximum of 63 PCD's via a duplicated 8 Mbit/s digital path. Similarly with the T-S-S-S-T DTN a maximum of 508 PCD's can be connected. The PDC's of the PCD's are connected to the CC via semi-permanent digital switching network paths (64 kbit/s).

Depending upon the traffic load, the CPS required for these network configurations can be the TCP 18 (mono and multi-control) or the TCP 36 multi-processor.

The remote concentrator, illustrated in fig. 3.8 is essentially a PCD with the DDI, required for connecting a PCD to the 8 Mbit/s DTN, removed and replaced by exchange terminals.

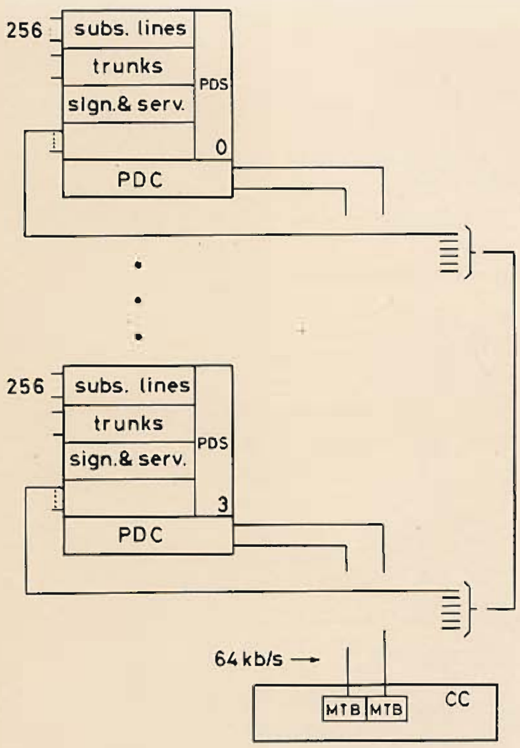


FIG. 3.7
SMALL EXCHANGE 1000 SUBSCRIBERS

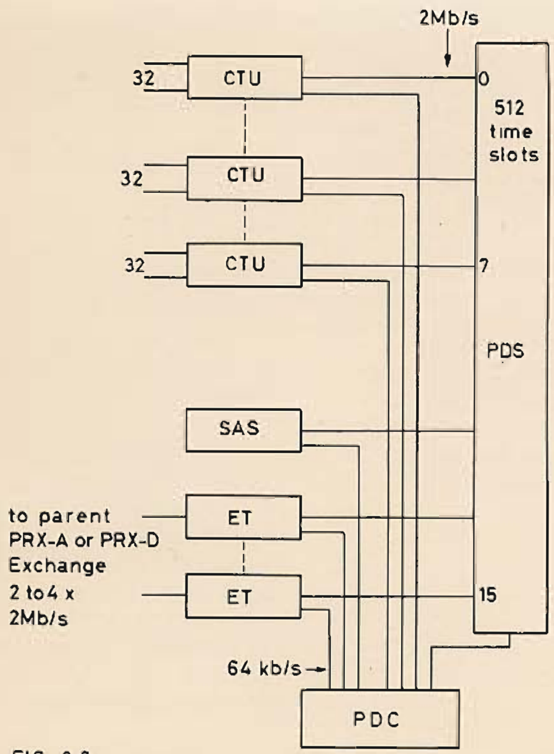


FIG. 3.8
REMOTE CONCENTRATOR
FOR 256 SUBSCRIBER LINES

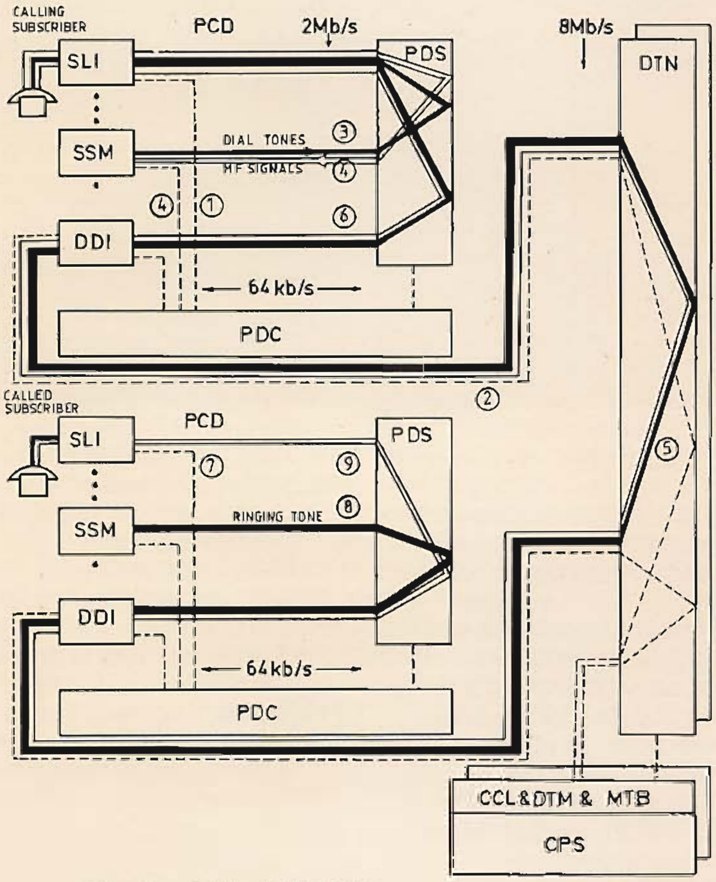


FIG. 3.9 CALL HANDLING

Call Handling (See fig. 3.9)

The following section outlines the basic operating principles within a PRX/D exchange for establishing an intra-exchange connection.

The calling subscriber lifts the hand-set. The associated Subscriber Line Interface Circuit (SLIC) correspondingly applies an alerting signal to the PDC ①.

The PDC transfers information pertaining to the calling subscribers terminal designation to the CPS via a semi-permanent connection within the DTN ②.
The CPS evaluates the subscriber status and forwards a through-connect instruction to the PDC ②.
The PDC then establishes a digital connection, via the PDS, between the tone generator, in the signalling and services module, and the calling subscriber, supplying dial tone ③.

When the subscriber commences dialling the PDC disconnects the dial tone and effects a digital connection between the calling subscriber and the PDC, via the digit receiver in the SAS, for the reception of the numerical information ④.
The PDC subsequently forwards the numerical data to the CPS, via the control channel, for evaluation ②.
The CPS then establishes a connection, via the DTN, between the calling and called subscriber's PCD's ⑤.
The CPS then instructs the PDC of the calling subscriber to release the connection between the multi-frequency receiver and the calling subscriber and to establish a digital connection, via the PDS, between the calling subscriber and the set-up digital path in the DTN ⑥.
The CPS then instructs the PDC pertaining to the called subscriber to apply ringing tone to the called subscriber ⑦, and establish a connection between the tone generator of the called subscribers PCD and the established digital link so that the calling subscriber receives ringing tone ⑧.

The called subscribers PDC recognizes the off-hook condition of the handset and correspondingly releases the digital connection between the tone generator and the established digital link and subsequently establishes a connection between the called subscriber and the digital link via the PDS ⑨. The calling and called subscribers are hence connected.

4. Software

The software organisation of the TCP18 has been used and well proven in several years experience in SPC exchanges. Descriptions of the TCP18 software are available in various publications and therefore the software description given here is restricted to that of the TCP36, which has been developed with the experience gained from the TCP18 software.

All operational programs and data are located in a central memory, accessible by a number of Central Control processor pairs for concurrent operational execution. Due to this organisation the call load can be distributed equally over several processors, avoiding processor function dedication and the related complicated load control. Each part of a call process can be executed on any Central Control processor that becomes available. Communication between the Central Control and the Peripheral Domain Microprocessors is on a message basis, the Peripheral Domains having autonomous control over execution of telephony oriented functions. Some low-level software functions (common system interrupt answering, system configuration switching, etc.) are executed by a dedicated processor (MPR) because the associated hardware is connected to that processor. The software for PRX/D is written in CHILL, the high level language for SPC systems recommended by the CCITT.

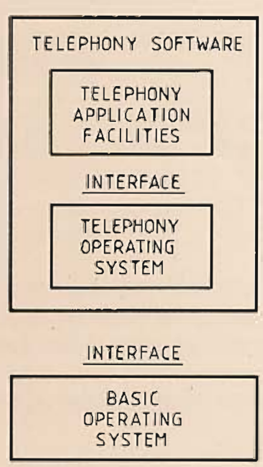


FIG. 4.1 SOFTWARE STRUCTURE

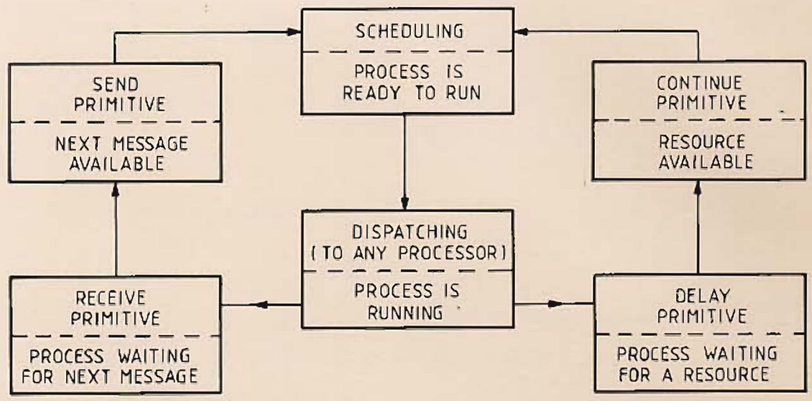


FIG. 4.2 PROCESS MANAGEMENT

Software structure

The operational software comprises two major subsystems, namely: the Basic Operating System (BOS) and the Telephony Software package, with a virtual machine interface between the two (see Figure 4.1).
Due to the virtual machine interface, the application of CHILL for the Telephony Software package program design and the integration of CHILL program and data concepts into the Executive of the BOS, independence from the processing machine used and portability of the Telephony Software package is achieved. The Telephony Software package consistst of a Telephony Operating System (TOS), which converts the general features of the BOS to a specifically telephony oriented environment, and a collection of Telephony Application Facilities (TAF).

Basic Operating System (BOS)

BOS consists of a collection of facilities for managing the central control hardware and software resources and for providing a virtual machine environment for the telephony software package.
BOS itself is designed to be fully independent from the telephony application of the system.

Although the majority of the BOS software modules are written in CHILL, the highly frequently used modules are implemented in assembly code. In addition, some of the very frequently used procedures are programmed directly in firmware (i.e. chaining procedures).
The most important facilities provided by BOS are:

- **Store management** consisting of a set of primitives to control free store and a set of facilities to control a number of pre-allocated pools, in order to avoid additional overheads for call processing.

- **Process management** comprising the primitives for process state control, process message communication and process synchronisation.
Process management also comprises the procedures for scheduling and dispatching (see fig. 4.2).
Processes in the system are organised in different classes; call processing, man/machine transactions, etc., to which processing capacity is assigned by means of a time slicing mechanism available per processor. This method guarantees processing capacity for each class on each processor.
Each processor that becomes available autonomously selects the task with the highest priority scheduled within the class to which that processor is devoted at that moment.

• **Time services** containing a set of primitives providing, in conjunction with process management, the facilities for process initiation on date and time, delayed scheduling and watchdog timing.

• **Input/Output message handling** comprising the facilities to control the message flow to and from the Peripheral Domains. This service works in conjunction with a set of software primitives in the MPR processor, controlling the DMA/Message Communication Channel hardware.

• **Protected data updating,** including facilities to synchronise all processors in the event of a major data-base modification. The preparation of such a modification can be performed by any processor, but since the actual execution requires the memory access to be blocked for all processors it is controlled by the configuration control processor (MPR).

• **Central Control and Message Communication Channel maintenance** consisting of the software facilities responsible for: test control and automatic and manual configuration control of the duplicated central control and message communication channel, alarm and conditioning reporting, control of the suspicion mechanism to distinguish hard faults from transient faults, etc.

These facilities operate in conjunction with a set of first-line primitives for error localisation, error isolation, configuration switching and test which are executed under control of the MPR processor.
A block diagram of this package is shown in fig. 4.3.

• **Man/Machine device and transaction control** containing the software facilities for the control of maximum 16 man/machine service positions (local and/or remote). The language and dialogue procedures used are in accordance with the CCITT recommendation for Man/Machine Language (MML). Transaction Control supervises the man/machine dialogue, assembles system reports and performs the command analysis, providing a general internal system boundary to the telephony software package. In this manner the command execution and report generation facilities within the telephony package are made independent of the actual organisation of the man/machine environment.

• **Software Configuration Management** comprising a set of facilities for initial and overlay loading, repair (on-line replacement of software modules) and extension (on-line addition of software modules). These facilities are strongly supported by the object code structure which has the following characteristics:
  • Each module is fully relocatable and is entered through one entry in the system catalogue. Modules with more than one entry have a small sub-catalogue as part of the module.

  • The use of absolute pointers in modules is minimised to a large extent and where this cannot be avoided the information for pointer (re)calculation is saved to allow such calculations to be performed in the event of module replacements.

Telephony Software Package

The main functions of this package are:
• Call processing
• Traffic management, i.e. observation, route control, etc.
• Switching network supervision and maintenance, including network error handling, configuration switching, test access and diagnostic facilities.

The telephony software, which is written in CHILL and operates in an environment provided by the BOS, consists of an operating system called TOS (Telephony Operating System) and a collection of function-related call processing and traffic management facilities, known collectively as the Telephony Application Facilities (TAF).

The TOS system converts the general features of the BOS to a specifically telephony oriented environment and is responsible for the management of the switching network hardware and software resources, the management of the exchange data-base and for providing a set of standard call processing facilities (i.e. route analysis, charging, etc.).

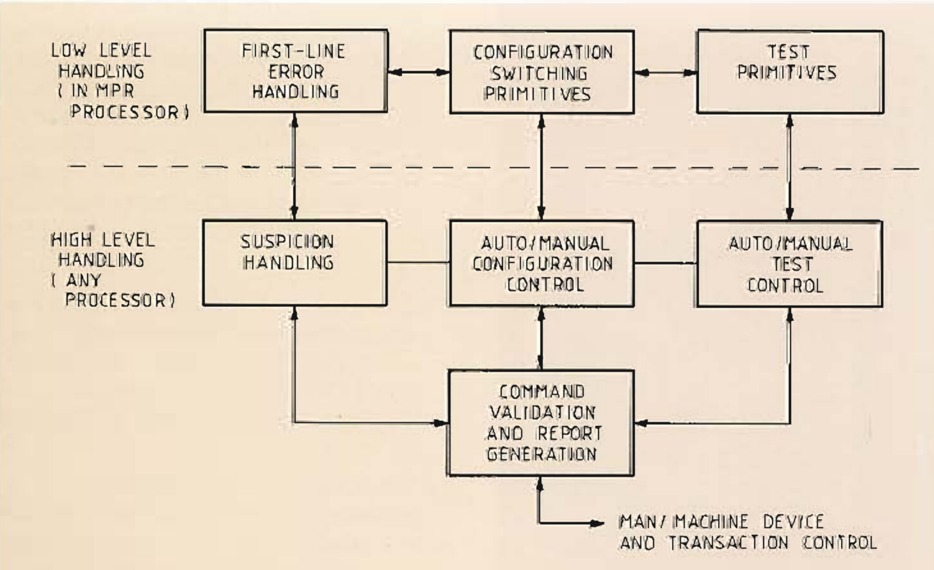


FIG. 4.3 MAINTENANCE SOFTWARE

Frame Construction

The individual functional modules of the PRX/D system are assembled in mechanical frames with a standard height and depth and variable width. Although a frame may be any width up to the maximum 38-pitch (0.8-inch pitch) width of a shelf, the majority are either 12, 18 or 9 pitches wide, with 17, 11 and 8 card positions respectively. Interconnections between printed-circuit cards are made by back-panels which incorporate a 4- or 8-layer printed-circuit board and power rails to distribute secondary voltages for the power supply.

Cabling

The cabling between modules of the PRX/D system, and from the system to the main distribution frame is fully connectorised. Cables are manufactured to the required lengths, and may be installed in cabinets and shelves whether or not the frames are in place. One of the results of microminiaturization is a high density of connection points on individual printed-circuit cards. To prevent congestion in the plug-to-plug cabling throughout the system, a new, optimized family of connectors and cables has been developed. The family includes a slender, 6mm-diameter cable containing eight miniature coaxial cables, and a VF cable of the same diameter which incorporates eight 0.4mm pairs. To simplify the installation of the many VF pairs in overhead cable ducts to the MDF, eight of the 6mm VF cables are combined into a larger cable containing 64 pairs.

Power Distribution (See fig. 5.2)

The 48 volt battery voltage of the exchange is distributed throughout the equipment bays by an integrated system of bus-bars and cabling.
The bus-bars act as the primary voltage source for an equipment bay and are located in the columns at the end of the equipment bays. From the column bus-bars power is distributed within the bay by cables which terminate in fuse units that can be inserted in a cabinet adjacent to the functional modules.
Within a cabinet, power is distributed by cables which are plug connected to the front of DC/DC converters and PCB's.
The input/output isolated converters are designed to operate with a primary voltage as low as 39 volts. This is an important feature since a small low cost exchange battery, fluctuating within wide tolerances, can be used. In order to supply relay-sets of the D.C. signalling type with a more stabilised voltage the corresponding functional modules are served by a separate group of fuse units and column bars for which booster equipment is inserted between the bus bars and the battery.

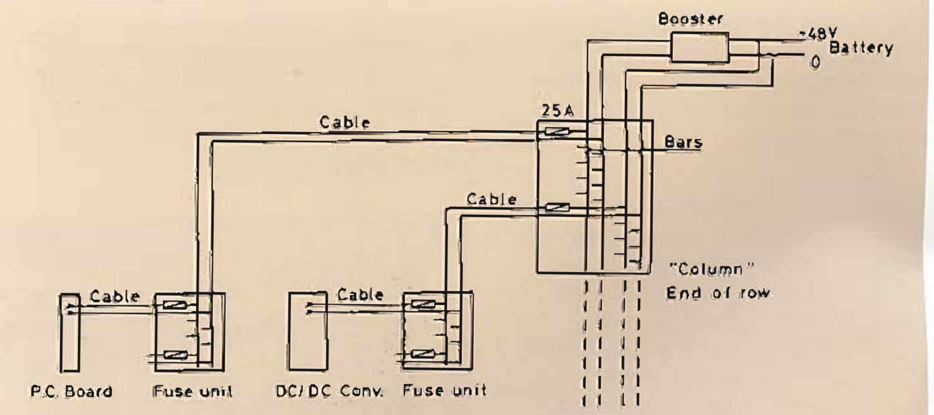


FIG. 5.2 POWER DISTRIBUTION.

6. Management and Maintenance

Management and maintenance in SPC systems is performed through the medium of a man/machine communication centre. The man/machine communication centre comprises input/output devices capable of producing output messages to inform the operator of any changes in status of the operating system and of converting commands input by the operator into machine language for implementation by the system. These devices are connected to the operating machine via data highways, enabling them to be located locally or remotely.
The dialogue between operator and system is conducted in a standard, CCITT recommended, Man/Machine Language (MML).

In first generation SPC exchanges the man/machine communication centre was in the form of a control desk, situated in the same area as the operating system and manned by management and maintenance personnel responsible for the exchange operation, following the traditional pattern as established by experience with conventional exchanges (see Figure 6.1). It was rapidly discovered that the superior logic power of SPC systems and increased reliability of components used did not warrant full-time resident staff and remote devices could be connected to operate in parallel with the control desk. The organisation of a resulting extended local management and maintenance facility is illustrated in Figure 6.2.

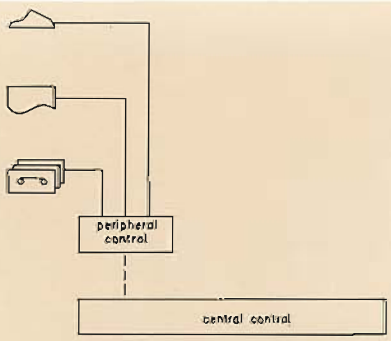


FIG. 6.1 PRIMARY LOCAL MANAGEMENT AND MAINTENANCE FACILITIES

If the remote devices from several exchanges are sited in one location, a central management and maintenance centre is formed, with the resultant saving in manpower.
If instead of devices dedicated to each individual exchange, the input/output interfaces of each exchange are linked to a processor in the management and maintenance centre via medium or high speed data links, a reduced set of devices is required. The data communication links so formed are also faster and more efficient. A primary local and central management and maintenance facility so formed is shown in Figure 6.3.

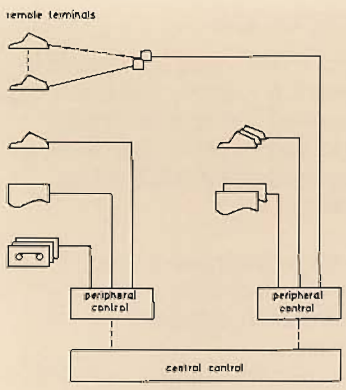


FIG. 6.2 EXTENDED LOCAL MANAGEMENT AND MAINTENANCE FACILITIES

The primary centre may be extended by adding remote devices and interconnecting other such centres to form an extended local and central management and maintenance facility (see Figure 6.4).

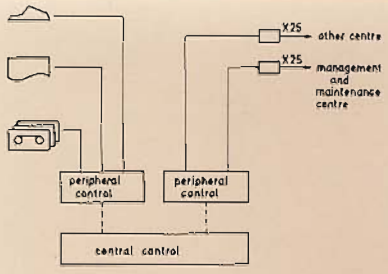


FIG. 6.3 PRIMARY LOCAL AND CENTRAL MANAGEMENT AND MAINTENANCE FACILITIES

The final sophistication of the management and maintenance facilities is the establishment of a management and maintenance centre connected to all exchanges in a telephone district via medium or high speed data links and also connected to remote sub-centres via medium or high speed data links. The remote sub-centres may be situated where they are of most use, at a maintenance depot, for example, or even at the residences of maintenance staff. The organisation of a central management and maintenance configuration is shown schematically in Figure 6.5.
The tasks that can be performed using a management and maintenance centre are summarized here.

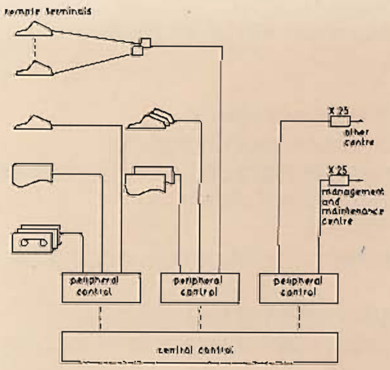


FIG. 6.4 EXTENDED LOCAL AND CENTRAL MANAGEMENT AND MAINTENANCE FACILITIES

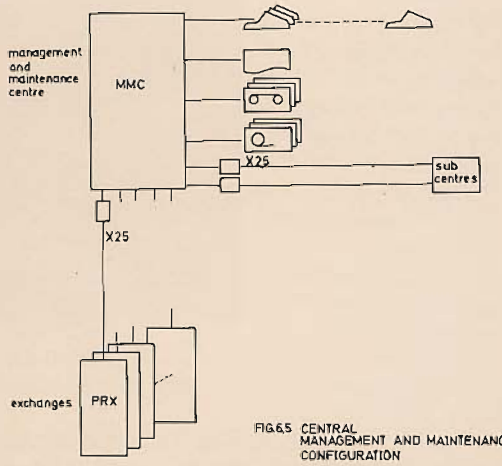


FIG.6.5 CENTRAL MANAGEMENT AND MAINTENANCE CONFIGURATION

Management

The management functions can be divided into three categories; network supervision, traffic observation and subscriber functions.

• **Network Supervision,**
Network Supervision includes such items as:
- Putting equipment into service
- Removing equipment from service
- Temporarily blocking trunks and equipment for maintenance purposes
- Recording status data
- Recording traffic statistics
- Assigning directory numbers
- Trunk group re-assignment
- Assigning zoning and call charging
- Assigning alternative routing
  etc.

• **Traffic Observation,**
Traffic Observation includes:
- Observation of subscriber behaviour
- Measurement of peak traffic conditions
- Determination of performance data by,
  • observation of real traffic
  • observation of engineered loading.
  etc.

•**Subscriber Functions**
Subscriber-Functions include such terms as:
- Entering subscriber line data
- Recording subscriber line data
- Recording call charge data
- Modification of subscriber facilities
- Malicious call identification
  etc.

Maintenance

There are three areas applicable to maintenance, namely: the Exchanges, Software and Subscriber Lines.
The tasks within each area differ, as can be seen from the following summaries.

• **Exchange Maintenance**
This can be classified under preventive and corrective maintenance.
Preventive maintenance includes:
- Routine testing of equipment
- Routine testing of trunks
- Registration of interface data
- Recording of status data
  etc.

Corrective maintenance includes:
- Testing
- Diagnosis
- Fault clearance
- Memory dumps
- Switching over to alternative equipment
- Specifying alternative routing to by-pass faults
  etc.

• **Software Maintenance**
This includes:
- Exchange software updates
- Security of program and data modifications in the exchange memory
- Data transmission between data memories
- Removal and reloading of exchange software
  etc.

• **Subscriber Line Maintenance**
This includes:
- Investigation of subscriber's complaints
- Testing and measuring subscriber loops from the exchange
- Testing and measuring subscriber loops from the subscriber's premises
- Routine tests of subscriber lines
- Switching recorded announcements on and off
- Registering blocked subscribers
  etc.

Although the realisation of centralized management and maintenance facilities has been made possible by the advent of SPC techniques, the facilities so provided do not need to be restricted to SPC exchanges. Conventional exchanges can be integrated into the central management and maintenance facility by the addition of some equipment, to form substantial savings in maintenance costs.

Glossary of Abbreviations

ATI – Analogue Trunk Interface Unit

BOS – Basic Operating System

CC – Central Control

CCL – Central Clock

CPS – Central Processing System

CTU – Circuit Terminal Unit

DDI – Domain to DTN Interface Unit

DTI – Digital Trunk Interface Unit

DTM – DTN Marker

DTN – Digital Trunk Network

ET – Excharge Terminal

MTB – Message Transfer Buffer

PCD – Peripheral Control Domain

PDC – Peripheral Domain Controller

PDS – Peripheral Domain Switch

SAS – Signalling and Services Unit

SLI – Subscriber Line Interface Unit

TAF – Telephone Application Facilities

TIE – Terminal Interface Equipment

TIU – Terminal Interface Unit

TOS – Telephony Operating System

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