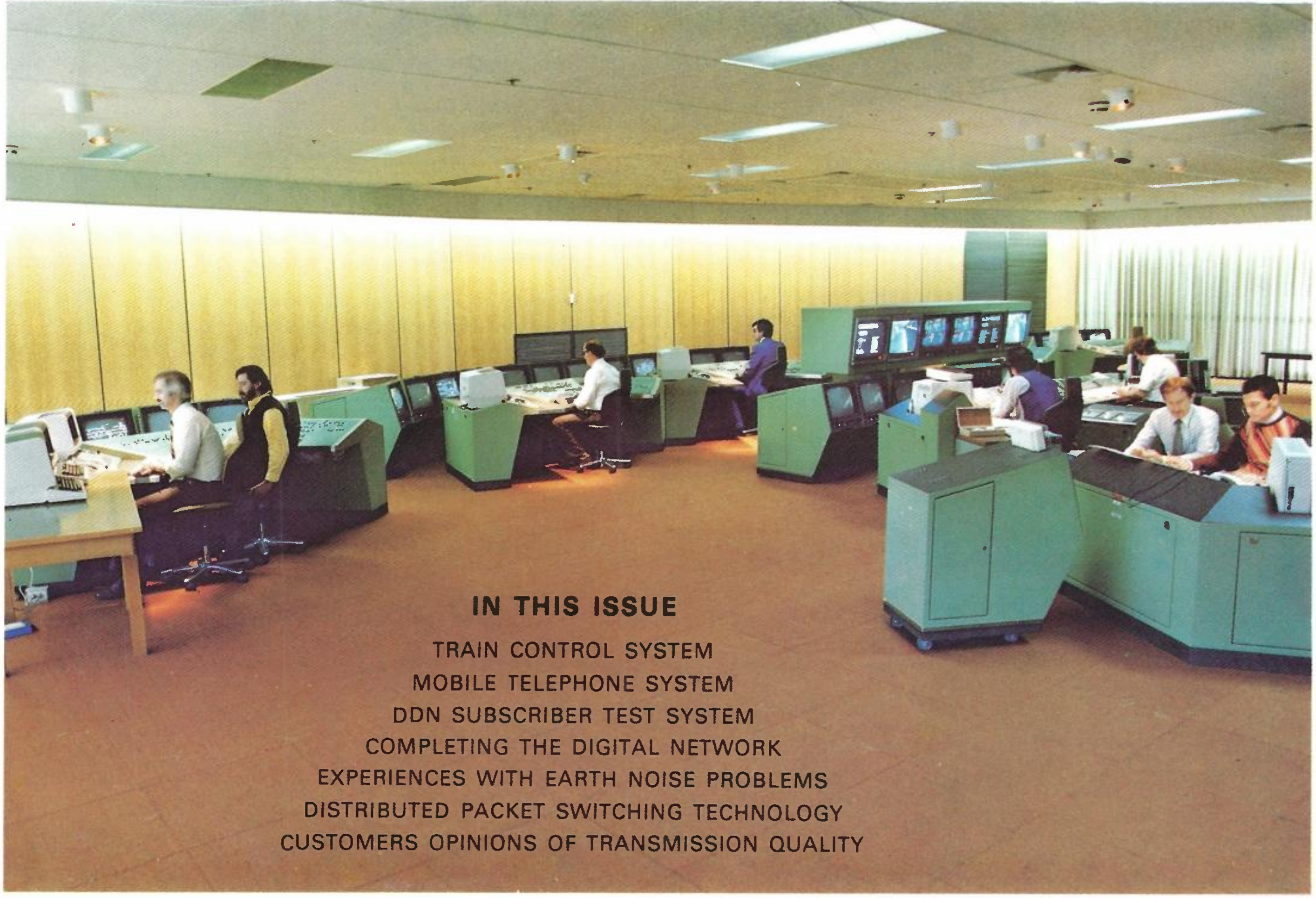
Volume 32, No. 1, 1982

the telecommunication journal of Australia



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TELECOMMUNICATION SOCIETY OF AUSTRALIA

The Society Reporter

Volume 32 No. 1
supplement

Here is the first issue of 'The Society Reporter'.

This supplement to the Telecommunication Journal of Australia will bring you news of topical and programmed society events in all States and of the people involved in running your Society.

The Reporter is supplied in this form so that you can conveniently separate it from the Journal for your ready reference while its contents are current, or possibly to pass it on to a potential new member to kindle an interest in the Society's affairs.

THE TELECOMMUNICATION SOCIETY IN TASMANIA

ACTIVITIES DURING 1981/82

Following the AGM held in April 1981 the pace for Society activities was set with a most informative lecture on Australian Antarctic operations by Graeme Manning of the Antarctic Division.

Lectures were held at two-monthly intervals in Hobart and at four-monthly intervals in Launceston and Burnie.

The lecture programme for 1981/82 was:

JUNE Rod Palmer from Commercial Services Department, Headquarters, lecture on Small Business Systems at Hobart, Launceston and Burnie.

AUG Inspector Maurice Massie from Tasmanian Police on Search and Rescue at Hobart.

OCT Martin Turner, Commercial Services Department, Headquarters, spoke on Videotex at Hobart, Launceston and Burnie.

DEC Commodore Kevin Williams of the Derwent Sailing Squadron spoke on his experiences at the Americas Cup to the Hobart group.

FEB Mike Balderston from Engineering Division, Headquarters, lectured on the Australian National Satellite system.

The lectures, on a wide variety of topics, were most interesting to members, and the lecturers are to be complimented on their high standard of presentation.

Forthcoming activities are based on the Annual General Meeting to be held on 7 April 1982 at the Freemasons Hotel in Hobart at 7.30 p.m.

All members and friends, and those interested in becoming members, are welcome.

The meeting will be followed by a talk to be given by John Addison of the Engineering Secretariat, Hobart, on his recent 12 month trip overseas.

The 1982/83 lecture programme will be published following the AGM and indications are that the lectures will be of the same high standard as in 1981/82.

Highlights of the Victorian Division

Membership

Membership records have been of concern. Therefore, a computer record has been established. Agents have been provided with a print out of members in their area and are returning marked copies for record amendments.

Membership statistics:

December	1981	1980
TSA Subscribers	1650	1630
ATR Subscribers	180	167

General Meetings

Five general meetings were held in 1981 together with a country lecture tour and a special lecture held at LaTrobe University. The meetings held were:

February, Business Development, Mr E. R. Banks.
April, ISDN, Mr R. J. Vizard.
June, Going Commerical, Mr G. L. Crew.
August, Data Service Initiatives, Mr J. Gerrand.
October, Developments of Viodetex Services in Australia, Mr W. M. Turner.

The country lecture was on New Paging Systems, by Mr B. Robinson and Mr W. Dickson. The special lecture at LaTrobe was on Technology trends in Telecommunication Components, by Mr P. S. Jones.

A special effort was made in 1981 to contact District Managers and staff responsible for arranging facilities for the country lectures. The chairman, Mr. Hugh McCall, visited two of the lecture centres with the "New Paging System" lecture team. As a result of these contacts a change will be made in the country lectures in 1982. Instead of visiting 8 centres with one lecture this year we will have two lecture teams each visiting 6 centres (that is there will be 12 lecture centres) with the timing of the lectures arranged so that staff of adjoining districts who are located within reasonable distance can have the opportunity to hear the two lectures. This year the country lectures will be on SULTAN and Outback TV.

The 1981 lectures were organised by Mr Ern George. He has also arranged the 1982 program.

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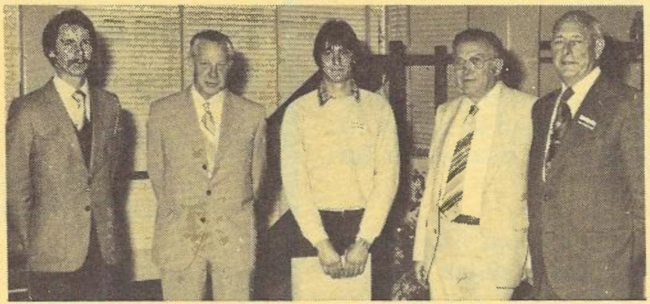
John Stribley Telecom Training Centre, 41 Pirie Street	225 6647

PEOPLE in the news

PRIZES FOR TRAINEES IN VICTORIA



Victoria's President, Hugh McCall (second from right) after presenting the award to Mr R. Horton (centre) was joined by Messrs G. Smith, Supervising Engineering Training, C. Hosking, Chief State Engineer, and J. Snow, Principal, Tooronga Training School.

The Society presented prizes for Trainees of the 1980 year in Victoria. Mr Hugh McCall presented awards on behalf of the Society at the Tooronga Training School to: Mr D. E. Thom, Distinction in Achievement in the Telecommunication Trainee Scheme, and Mr R. J. Horton, Distinction in Achievement in Module Courses. The awards were an inscribed medallion, a Certificate, and one year's membership of the Society.

ERIC LEDIN REVISITS AUSTRALIA

Eric Ledin, a retired senior engineer from L. M. Ericsson, Sweden, will pay a sentimental call on VicRail during his visit to Australia in March. Eric was project leader in 1935 for the installation of a 700-line, 500 Point, automatic telephone exchange for VicRail, a pioneering project in Australian telecommunications. Some older members of the Society may remember that Mr Ledin presented a paper 'The Victorian Railways New Telephone Exchange' to the Postal Electrical Society on the 11th March 1935. The Telecommunication Journal having not yet been established at that time, the paper was therefore published in The Electrical Engineer and Merchandiser of May 1935.

To mark the visit, Mr Ledin will be awarded honorary membership of the Telecommunication Society of Australia.

NORM STREET RESIGNS

During 1981 the Victorian Secretary Mr N. Street resigned.

For many years Mr L. Kilborn and Mr N. Street have assisted lecturers in the presentation of slides. They have also arranged lighting and sound for lectures. In 1981 Mr Kilborn converted this experience into a valuable paper as a record of procedures to be followed at the H. C. Sleigh theatrette.

The society thanks Norm Street for his service.

Mr Andrew Robertson who, with the able assistance of Mr Mun Chin, has established a computer file of the Society's members, has accepted the position of Secretary.

NEW CHAIRMAN — VICTORIA

Mr Hugh McCall has just completed his two year term as Chairman of the Victorian Committee. The State Manager, Mr P. R. Brett, has appointed Mr L. Bennett as the new Chairman. The Society thanks Mr McCall for his enthusiastic leadership of the Victorian Division during his term of office.

PLESSEY HOSTS REUNION

Many past and present members of the Society were present at a reunion of executives, hosted recently by Plessey Australia.

Plessey has the largest group of individual members of the Society, outside Telecom.

The photograph of the guests shows, seated, left to right, Colin Fleming, retired Plessey executive, Gordon Martin, Telecom's acting Chief General Manager, Maurice Dunstan, Plessey management services executive, Eber Lane, the last Director-General of the Australian Post Office before Telecom Australia was formed.

Standing, left to right, are Phil Crosby, retired Plessey executive, Jack Curtis, Telecom's first Managing Director, Ken Douglas, NSW State Manager for Telecom, Charles Taylor, former General Manager, Engineering, Telecom, Clive Smith, Director, Posts and Telegraphs, NSW of 25 years ago, Bill Schmidt, OTC General Manager, Jim Hutchinson, former Director, Posts and Telegraphs NSW, Bill Pollock, Telecom's Managing Director, Tom Skelton, former Director, Posts and Telegraphs, NSW, Walter Fielder-Gill, General Manager, Plessey Australia and formerly Supervising Engineer, metropolitan service, NSW PMG Department.

PIN UP

FORTHCOMING EVENTS

Queensland Lecture Program

The Queensland Division committee has looked to a wide variety in the range of lecture topics programmed to appeal to members' interests. Here is the program of lectures to be presented in Brisbane during 1982:

- FEBRUARY 23 — Tuesday, 12.30 pm, Telecom Theatrette Annual General Meeting "Small Business Systems for the 80's" — R. G. Plamer.
- MARCH 16 — Tuesday, 7.30 pm, Visit to Hoyts Theatre Complex.
- APRIL 20 — Tuesday, 12.30 pm, Telecom Theatrette "Packet Switching from the Customer's Viewpoint" — D. Jeffreys
- MAY 12 — Wednesday, 6.15 pm, Telecom Theatrette "Communications for the Commonwealth Games" — T. F. Steer (Joint Meeting with IE (Aust) and IREE hosted by TSA).
- JUNE 22 — Tuesday, 12.30 pm, Telecom Theatrette "Automatic Call Distributors" — T. Bartels.
- JULY 21 — Wednesday, 6.15 pm, Room 313, Axon Building, University of Queensland "Fibre Optical Communications — Device and System Capabilities" — Dr K. S. Tucker (Joint Meeting with IE (Aust) and IREE hosted by IE (Aust)).
- AUGUST 24 — Tuesday, 12.30 pm, Telecom Theatrette "Remote Area Television (RATV)" — V. L. Cavallucci.
- SEPTEMBER 14 — Tuesday, 12.30 pm, Telecom Theatrette "Leopard" — P. J. Chippendale.
- OCTOBER 13 — Wednesday, 6.15 pm, Telecom Theatrette "Public Automatic Mobile Telephone System" — J. Boland and K. Phillips. (Joint Lecture with IE (Aust) and IREE hosted by IREE).
- NOVEMBER 23 — Tuesday, 12.30 pm, Telecom Theatrette "Videotex" — L. Cunningham.

South Australia's Lecture Program

- **5 APRIL**
  Visit to Codan Pty Ltd, Newton
- **7 JUNE**
  Natural Disaster Planning in Telecom
- **2 AUG.**
  Impact of Digital Techniques on Communications
- **4 OCT.**
  Forecasting of Customer Demand in Telecom
- **6 DEC.**
  Call Charge Recording

Lectures are held in Chapman Hall, 11 Bagot Street, North Adelaide at 7.30 p.m.

KEEP UP

WITH THE LATEST

JOIN

THE TELECOMMUNICATION SOCIETY OF AUSTRALIA

VICTORIAN LECTURE PROGRAMME 1982

- **5 April.** New Paging Systems
- **21 June.** Role of Financial Policy in Corporate Planning.
- **9 August.** Telecoms Capital Investment Policies and Practices.
- **11 October.** Directory Assistance Services.

Location: H. C. Sleigh Theatre, 1st Floor
Cnr. Queen and Bourke Sts.,
Melbourne.

Time: 4.30 p.m.

THE TELECOMMUNICATION JOURNAL OF AUSTRALIA

ISN 0040 2486

Volume 32 No. 1, 1982

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Editorial

THE RELEVANCE OF THE TELECOMMUNICATION SOCIETY IN TODAY'S INDUSTRY

The Telecommunication Society of Australia, grew from the need to keep people within the emerging telegraph industry (C. 1870), informed of general movements in the technology within that industry.

The Society, whose members now come from Telecom, Government Departments, manufacturers, consultants and academic institutions, answers this need today, by presenting lectures, organising seminars and by publishing journals and monographs.

Within this framework, The Telecommunication Journal of Australia, has recorded the change from fundamental telegraphy to include telephony, radio, TV, satellites, digital transmission, computer control and informatics. Today however, the definitive listing of change has become difficult as the traditional understanding of the field of telecommunications converges with that of computer technology.

The present challenge for the Society is to maintain an effective media for explaining the technology, now moving in so many diverse directions, and the Journal's part must aim at providing a broad level of understanding without becoming over involved in scientific detail.

The role of the Society, and therefore its Journal, has by necessity changed over the years but the need has not diminished. The future relies on the acceptance of the professional challenge to all technologists within the industry, to ensure that as the pace accelerates towards commercial goals, the need to record, explain and examine the related technology, is not lost.

This issue of the Journal illustrates the breadth of the relevance of the Society today as it covers papers from the latest thinking in digital technology, to earth noise problems — a 'bread and butter' subject for many field engineers.

As a further step towards maintaining a relevant position within the industry, the Society has introduced, in this issue of the Journal, The Society Reporter. This feature is designed to keep all members informed on what is happening within the Society, in all States.

GUEST EDITOR

R. K. McKINNON
CHIEF SERVICES ENGINEER
TELECOM AUSTRALIA
AND
CHAIRMAN
COUNCIL OF CONTROL
TELECOMMUNICATION SOCIETY
OF AUSTRALIA

DPS25: Distributed Packet Switching Technology for the AUSTPAC Network.

M. J. HARRISON, M.I.E. Aust.

Telecom Australia has announced the selection of the French Company SESA as the contractor for the establishment of the AUSTPAC network. This paper presents an overview of the packet switching technology to be delivered by SESA for implementation of AUSTPAC.

INTRODUCTION

The background and network plan for the national packet switching service (AUSTPAC) were outlined in a previous article (Ref. 1). The purpose of this paper is to provide an overview of the technology (system features, hardware and software) selected for implementation of the AUSTPAC network.

The DPS25 packet switching system, designed and manufactured by SESA (Societe d'Etudes des Systemes d'Automation) of France has been selected to implement AUSTPAC. SESA in conjunction with Standard Telephones and Cables (STC) Pty Ltd of Australia will provide all equipment and services for the initial network detailed in Reference 1. Expansion of the network will be carried out by trained Telecom Australia staff installing DPS25 equipment supplied by SESA.

The design and development of the DPS25 system incorporates the significant experience gained by SESA in their turnkey implementation of the TRANSPAC packet switching network for the French Post and Telecommunications Administration, and the operational DPS25 networks of the European Space Agency, French Railways Board, and the Luxembourg PTT.

DPS25-OVERVIEW

The DPS25 packet switching system has been designed to accommodate a wide variety of data communications applications and traffic types.

In DPS25, architecture is the key to providing the range of interfaces and facilities, flexibility, cost effectiveness and management functions necessary for a public data network.

The basic architectural concepts are:

- separation and distribution of operations, control and communication functions.
- multi microprocessor hardware configuration.
- layered communications software.
- use of a limited number of hardware components.

These architectural concepts are layers built one on top of the other some consisting exclusively of software and others of hardware and software. The top layer of the DPS25 system is the network and its various components.

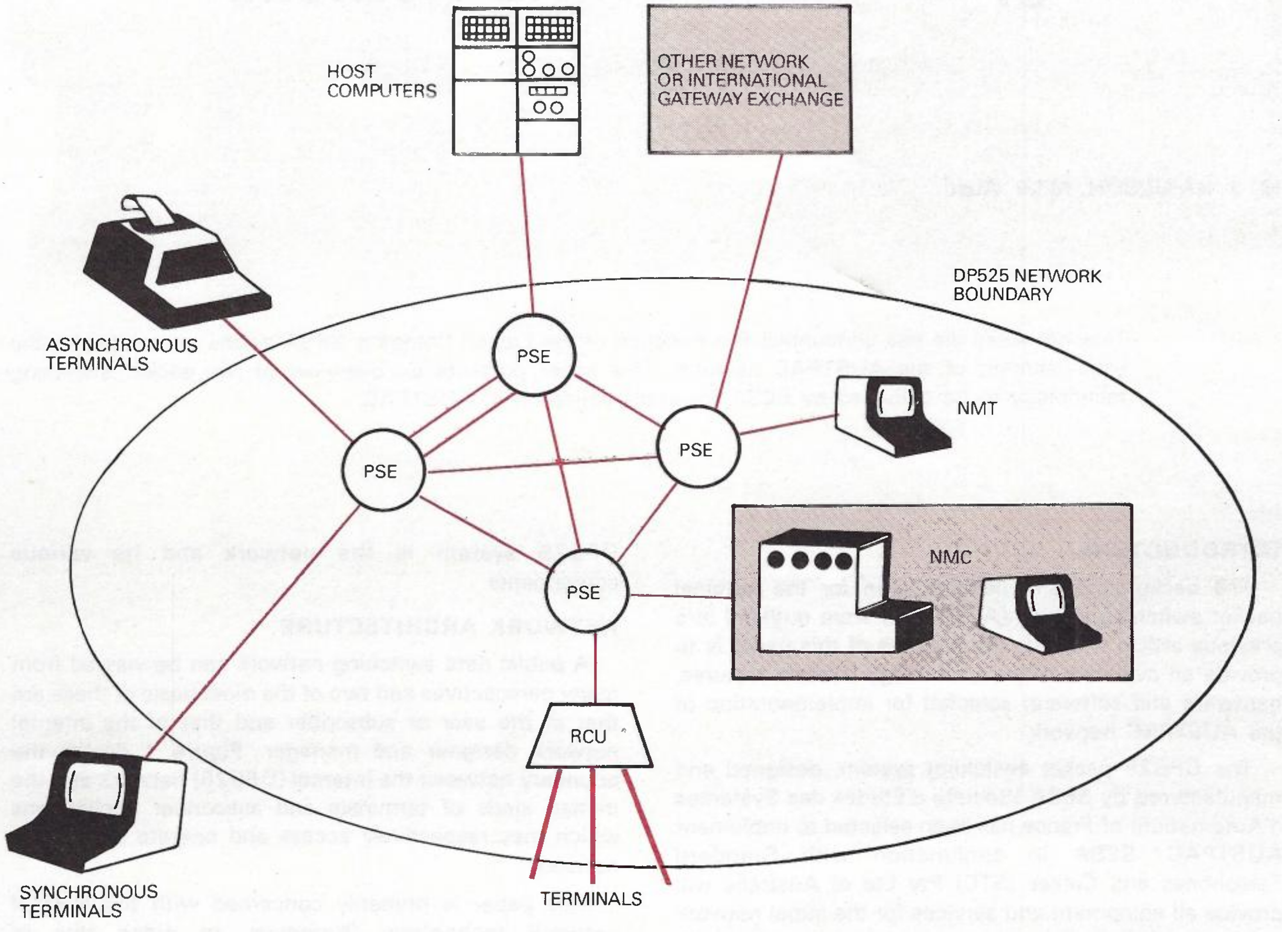
NETWORK ARCHITECTURE

A public data switching network can be viewed from many perspectives and two of the most basic of these are that of the user or subscriber and that of the internal network designer and manager. **Figure 1** details the boundary between the internal (DPS25) network and the myriad kinds of terminals and subscriber applications which may respectively access and operate across the network.

This paper is primarily concerned with the internal network technology. However, to place this in perspective a brief view of the important subscriber and other networks interfaces available in the DPS25 system is required, and these are:

- for asynchronous terminals (eg. teletype compatible) the character mode interface is provided which complies with the CCITT Recommendations X.28, X.3 and X.29.
- for synchronous terminals (eg. Visual Display Units and host computers) the packet mode interface is provided which complies with the CCITT Recommendation X.25.
- for the IBM3270 class of synchronous terminals the block mode interface is provided which complies with the relevant IBM standards.
- for connection to other packet switching networks the CCITT Recommended X.75 protocol is provided.

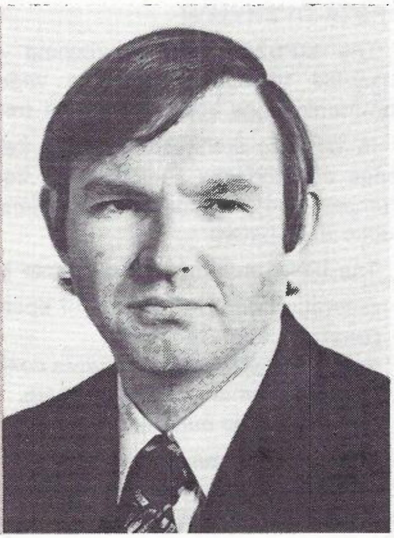
Within the DPS25 network boundary depicted in Figure 1 is the node or Packet Switching Exchange (PSE). This is the main switching element performing transit and local switching. To obtain the high transmission utilisation provided by the packet switching technique the network interface should be as close as possible to the subscriber terminals. In DPS25 a part of a PSE can be distributed or extended to perform concentration and local protocol conversion. This Remote Concentration Unit (RCU) can be located anywhere in relation to its parent PSE provided data transmission (9.6Kbit/s to 48Kbit/s) facilities are available.



PSE — PACKET SWITCHING EXCHANGE
RCU — REMOTE CONCENTRATION UNIT
NMC — NETWORK MANAGEMENT CENTRE
NMT — NETWORK MANAGEMENT TERMINAL

Fig. 1. DPS25 Network

M. JOHN HARRISON joined the PMG's Department in 1963 as a Technician-in-Training and then obtained a Trainee Engineer position in 1967 which enabled the completion of an Associateship in Communication Engineering at the Western Australian Institute of Technology in 1969. He then spent 2 years as an Engineer Class 1 in external and internal plant areas in the West Australian Administration before joining the Telegraph and Data Engineering Branch at Headquarters working on the CUDN project. In 1975 he joined the Data Planning Branch at Headquarters as an Engineer Class 4 working on the automation of the public Telegram Service, and then later as Engineer Class 5 in charge of Telex network planning. He is currently the Product Engineering Manager, Packet Switching Network Group, in the Data Services Sub-Division at Headquarters.



Overall co-ordination and operation of the network is carried out through a separate computer acting as a Network Management Centre (NMC) in conjunction with the distributed management functions in PSE's. The facilities of the NMC are made available through local terminals directly connected to the NMC or to any point in the network through Network Management Terminals (NMT) connected to PSE's.

FUNCTIONAL ARCHITECTURE

Prime DPS25 system design objective was to separate the operation control and communications functions into distinct stand alone units to provide a high performance/cost ratio over a wide range of system configurations, while at the same time making the system as flexible as possible. In this case flexibility means the ability to tailor the system to the required mix of switching power and termination capacity.

The physical implementation of the design objective can be seen on examining the functional architecture of a DPS25 node. **Figure 2** outlines the separation and distribution of the main functions namely:

- management (node supervision and monitoring)
- signalling (call establishment and routing)
- switching and communications (eg. line protocols such as X.25)

These functions are implemented in separate hardware modules (ie. Executive Unit — EU, Signalling Unit — SU and Group Unit — GU).

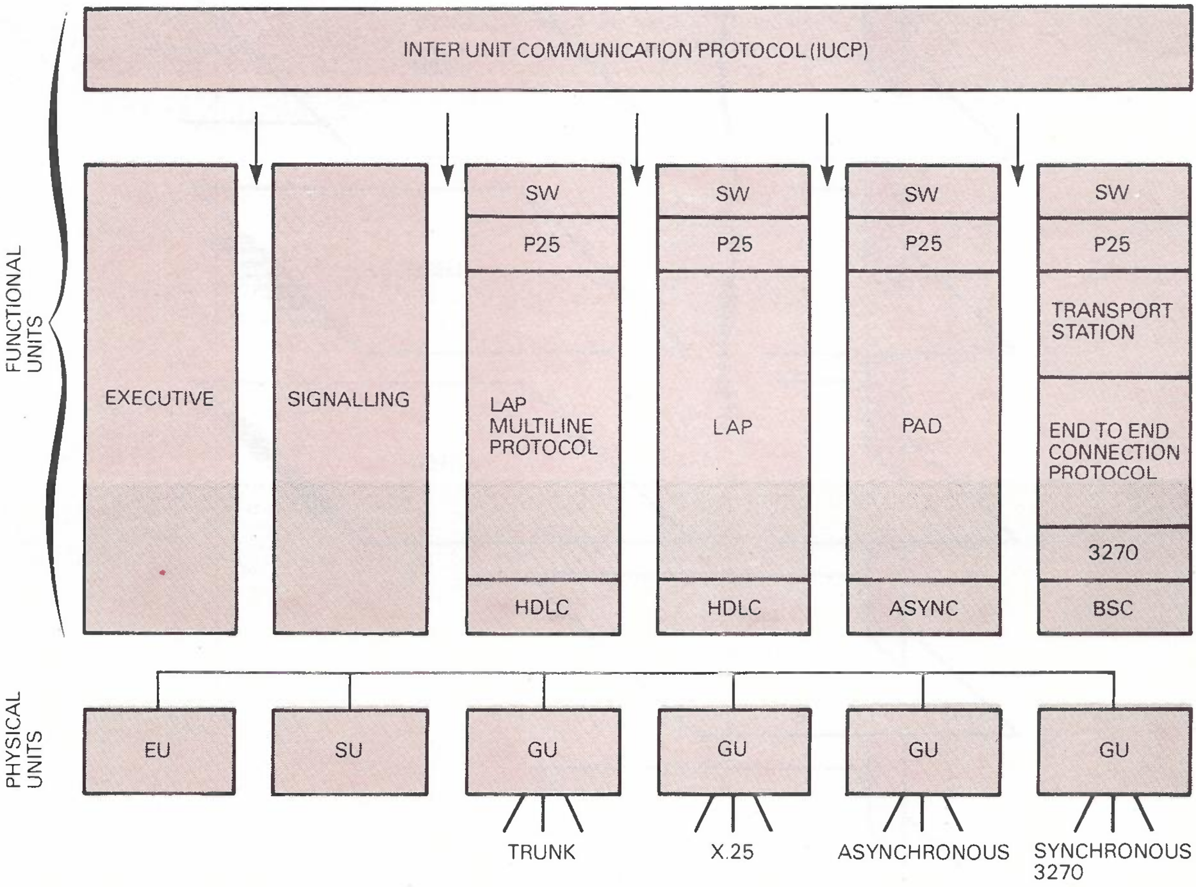
Communication between the modules is carried out through the Inter Unit Communication Protocol (IUCP). This protocol enables a communication path to be established or cleared between any pair of functions implemented in the units. The IUCP is based on the X.25 LAP-B protocol which provides flow control and data security for unit to unit transmission.

Executive Unit (EU)

Central control of the operation of the IUCP within a PSE resides in the EU. The other main functions of the EU are:

- supervision of PSE units (in service, standby etc)
- high level transport communication control (PSE to PSE, PSE to NMC)
- collection of call charging data
- subscriber and trunk line management
- subscriber facilities management
- traffic generation services

The traffic generation facility enables a subscriber to perform some self testing of his connections to the DPS25 network. By calling a designated network number a subscriber may request, through the data field of the



EU — EXECUTIVE UNIT
SU — SIGNALLING UNIT
GU — GROUP UNIT
SW — SWITCHING SOFTWARE
P25 — X.25 PROTOCOL SOFTWARE (PACKET LEVEL)

Fig. 2. DPS25 Node Functional Architecture

call request packet, use of the traffic generation, absorption and echo services.

Signalling Unit (SU)

The establishment termination and routing of virtual calls is the prime function of the SU. The basic signalling packets of call request, call accepted, clear request, clear confirmation, restart and restart confirmation are processed by this unit in the management of virtual calls. Additional functions performed by the SU are collection of trunk and local link traffic statistics and measurement of the utilisation of internal resources such as memory buffers and logical channels.

Group Unit (GU)

Direct interfacing to a dedicated group of local or trunk transmission lines and the switching of traffic between lines are the main functions of the GU. Interfacing includes the three main levels of X.25 (physical, frame and packet levels) as well as the packet assembly and

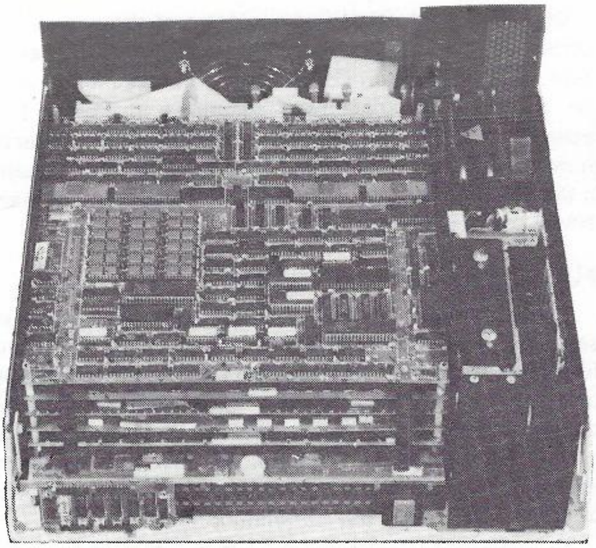


Fig. 3. Data Technology Module - DATEM

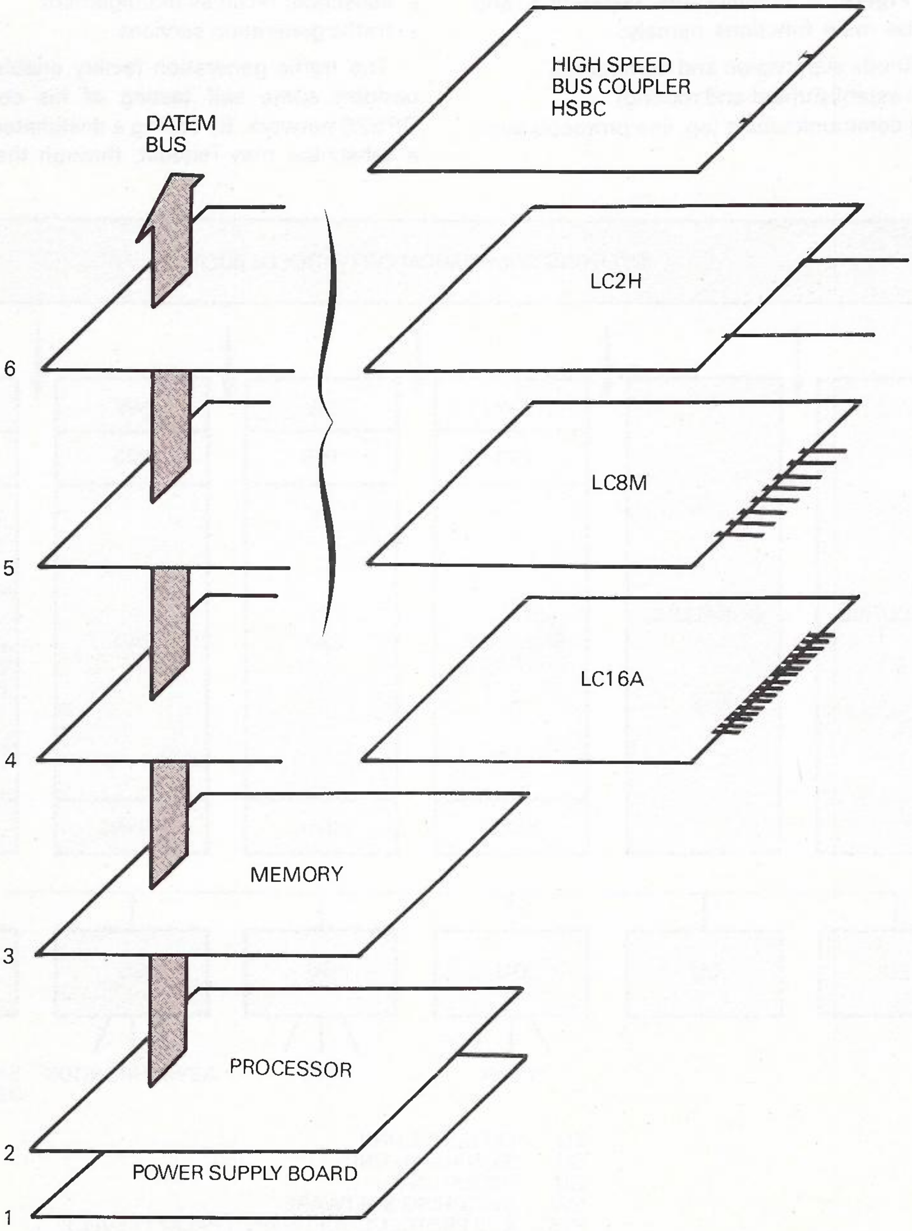


Fig. 4. DATEM Structure

disassembly (PAD) function for character mode terminals. Handling the internal trunk multi-line protocol, interfacing remote concentration units as well as emulation for the IBM 3270 protocol is also carried out in the GU.

DATA TECHNOLOGY MODULE (DATEM)

The basic hardware building block in which the functions of the DPS25 system are implemented is the DATEM (**Figure 3**). The DATEM has been designed to be used as a stand alone module (eg. remote concentration unit) or to be organised as a large number of modules, such as in a switching node. It uses microprocessor (ZILOG Z80) technology extensively and has similar overall dimensions (43 x 43 x 17 cms) to a modem.

The multi microprocessor architecture (**Figure 4**) of a DATEM is organised around an internal bus on which are connected:

- A power supply board (inputs 220VAC or 48VDC)
- A central processor board (Z80 microprocessor)
- A memory board which contains 64 to 256 kbytes of RAM memory
- One to three line controller boards, some of which have their own micro-processor and memory
- An optional inter-DATEM coupler board (HSBC) for high speed (8Mb/s) control and interconnection of DATEM units in a packet switching exchange
- An optional Winchester Disc coupler.

Line Control Interface

A DATEM module may contain one, two or in the case of a stand alone module, three of the following line control interface boards:

- LC8M — for eight full or half duplex medium speed (up to 9.6 kbit/s) synchronous or asynchronous lines. This interface board is used in the AUSTPAC network for the connection of medium speed (2.4 kb/s, 4.8 kb/s and 9.6 kb/s) synchronous terminals such as visual display units and smaller computers.
- LC16A — for 16 full or half duplex (up to 9.6 kb/s) low to medium speed asynchronous lines. This interface board is used in the AUSTPAC network for connection of the low speed (50 b/s to 1200 b/s) asynchronous class of teletype compatible terminals which may access the network via the public telephone network or direct data transmission circuits.
- LC2H — for two full or half duplex high speed (up to 72kb/s) synchronous lines. This interface board is used in the AUSTPAC network for internal and international network trunks operating at 48 kb/s and the connection of high speed customer computers.

The two line interface boards LC8M and LC16A have their own onboard microprocessor (Z80A), memory (64 kbytes RAM) and DMA interface with the internal DATEM bus.

The LC2H line interface board has a higher speed onboard microprocessor (Z80B), 64 kbytes of memory and high speed line interface based on a bit slice microprocessor (AMD2900).

All of the line control parameters such as transmission mode, character length and line speed are software programmable.

Software for the processor, memory and line cards (X.25, PAD, 3270) is tele-loaded from the main external disc storage controlled by the EU.

Software

An essential requirement for the development and maintenance of complex, real time communication switching software is a sound design and documentation methodology. For the DPS25 system SESA have employed an in house methodology called MELUSINE. MELUSINE is basically a documentation system which provides an initial framework and an ongoing vehicle for system design and monitoring of progress. The MELUSINE system levels cover the whole spectrum of development documentation including functional specification, detailed analysis, operating documentation and software listings.

DPS25 software is largely written in the ZILOG PLZ/SYS language which has many similarities to high level languages such as PASCAL. PLZ/SYS is however not a general purpose language, it has been specifically designed for efficient implementation of modest sized programs for micro computer systems. The standard PLZ/SYS software such as compilers, and filing and operating systems have been augmented by SESA developed utility software for simulation, tracing and patch management.

PSE — DESCRIPTION

PSE Hardware

As outlined in **Figure 5** DATEM's are configured in several different ways to build up a PSE. The hardware modules are interconnected by the Inter Module Link (IML). In high capacity PSE's, such as are used in AUSTPAC, this IML consists of a dual bus operating at a maximum rate of 8Mbit/s. Conventional data communications circuits operating at 48Kbit/s can be used to link RCU's to a local PSE, with the remote units having exactly the same subscriber facilities as local units within a PSE. Up to three RCU's can be linked together at the same location to concentrate traffic onto a single transmission link to a PSE.

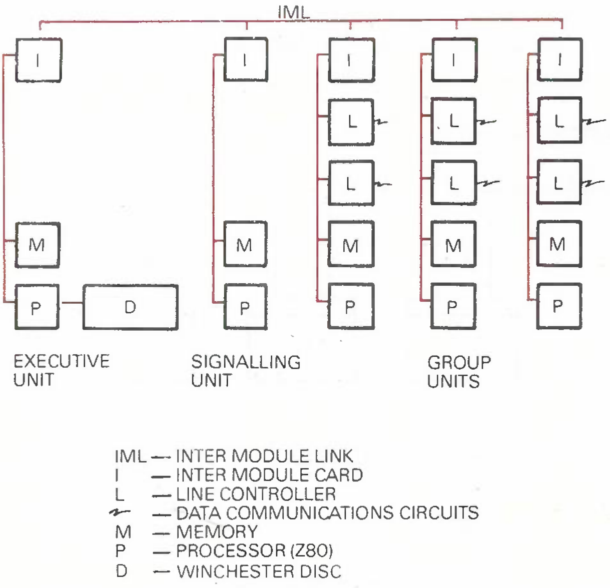


Fig. 5. PSE Hardware Structure

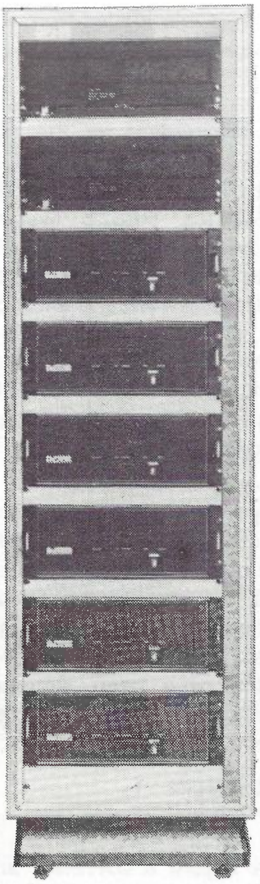


Fig. 6. Typical DPS25 PSE Rack including one executive, one signalling, one common back-up unit, three group units, and disk units for the executive and common back-up unit.

The maximum configuration of a PSE consists of 40 DATEM's in 5 racks. A typical single rack of equipment including an executive, signalling, common back-up unit, and three group units is illustrated in **Figure 6**.

A PSE always contains at least one EU and depending on the call establishment rate, one or more SU's. The number of GU's in a PSE depends on the number of asynchronous and synchronous terminations, and their traffic generation characteristics.

Reliability

Redundancy within a DPS25 node can be organised (see **Figure 7**) to suit a wide range of reliability requirements. Control units (EU, SU) can be backed up (hot standby) by a single unit (E/SU) able to assume the role of an EU or SU as required. A set of GU's, with the same line interfaces and communications protocols, can be backed up by a separate group unit with the lines of the failed unit able to be switched to the back-up unit. The available redundancy — which may be specified as $^1/_N$ where N is the number of backed-up units and N is equal to or less than 7.

Maintenance

Within a PSE the basic replaceable unit is a DATEM. In the event of a fault occurring, the combined supervision and test facilities of the EU and NMC indicate on terminals at the NMC or remote NMT's, the faulty DATEM unit. No special tools are required for the removal **(Figure 8)** of the DATEM from a PSE rack as it is simply a matter of removing the front retaining screws, sliding out a drawer and unplugging the bus and line interface cables. Removal of these cables does not interfere with the other units of the PSE or subscriber modem connections.

A spare DATEM with the same board configuration is then inserted in the cabinet drawer and the cables reconnected. On powering up the unit the hardware automatically performs self testing, and final placement into service is carried out via NMC commands. The removed faulty module is connected to an external disc unit containing basic GO/NOGO software which locates the faulty board within the DATEM and displays this information via a front panel of LED's. The board is then replaced and the DATEM is now ready to act as a replacement unit for further faults.

NETWORK MANAGEMENT SYSTEM

The management functions of the DPS25 network are implemented by the network management systems which are distributed between PSE's and NMC's. The main functions of an NMC are detailed in **Figure 9**.

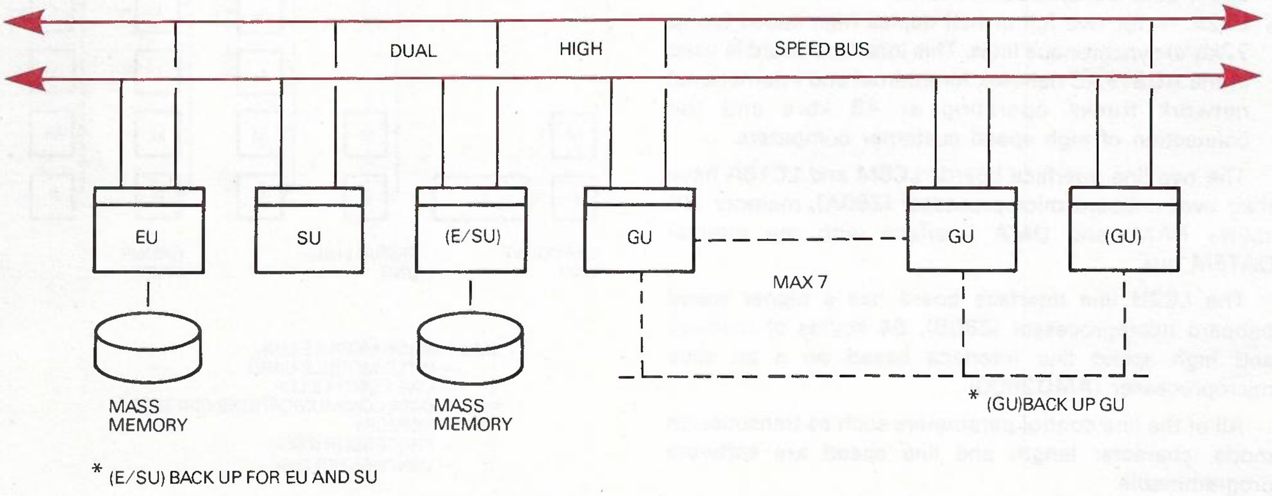


Fig. 7. PSE Redundancy of Modules

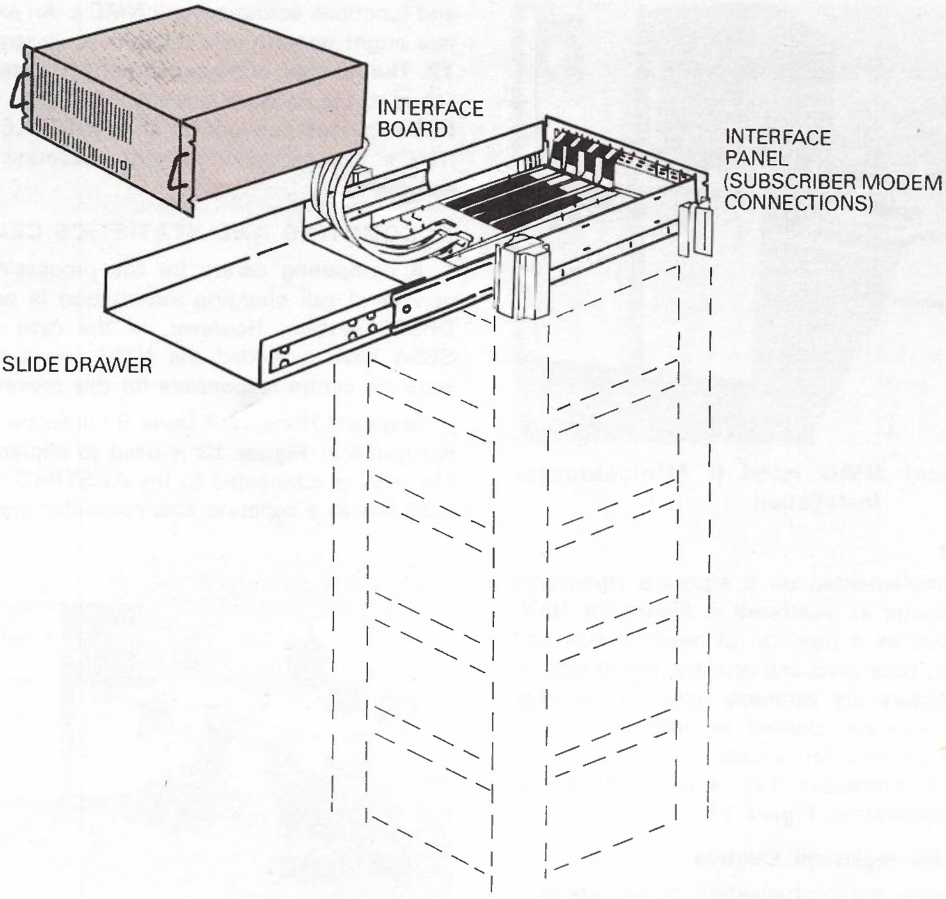


Fig. 8. Removal of Rack Mounted DATEM

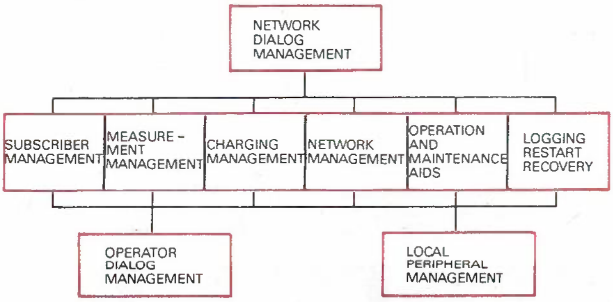


Fig. 9. Network Management Functions

NMC Functions

Each function is composed of several subfunctions, which are activated by communications from the operator console, or the arrival of event generated information from the network requiring specific action.

Network Dialog Management refers to the connection of an NMC to the network via an X.25 link and the management of data exchanges between PSE's and NMC functions and remote network management terminals and NMC applications.

Subscriber Management includes the maintenance of a central database of subscriber parameters, defining technical characteristics (eg. line speed, protocol, etc) and user facilities subscribed to such as reverse charging and closed user group.

The management of measurements includes network traffic and service quality as well as detailed monitoring of PSE resources such as memory and switching capacity.

Call charging information is first generated in the originating PSE and transferred to the NMC for safe storage. Processing of this information to produce customer billing information is carried out on computing equipment separate from the DPS25 network. In the case of AUSTPAC however this billing centre is provided as an integral part of the network (see ASC description).

The network management function of an NMC includes the logging and processing of all alarm and failure reports from PSE's in the network. Management of all software for the network including individual software configurations for each PSE in the network is carried out under the network management functions. This ability to remotely load, add to, modify and delete any part of the PSE software and system tables is a particularly powerful operational and maintenance capability of the DPS25 network.

Tests for subscriber lines and network links and the monitoring of these lines and links are all provided by the operation and maintenance aids function. These maintenance aids can all be invoked on local NMC or remote NMT terminals.

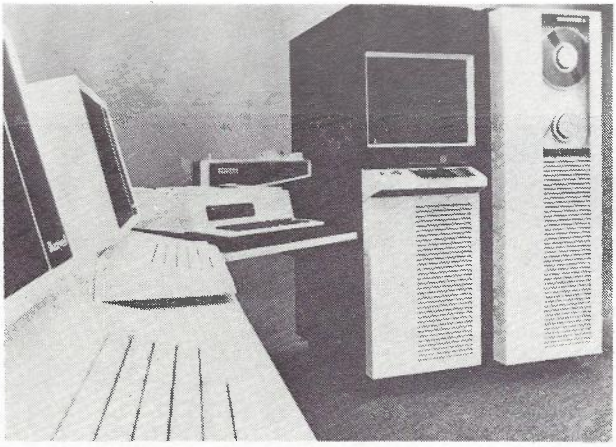


Fig. 10. Typical NMC level 6 Minicomputer Installation

NMC Hardware

An NMC is implemented on a standard Honeywell Level 6 minicomputer as illustrated in **Figure 10.** NMC configurations vary as a function of network size and include disk units, tape units and printers. Visual display units and teleprinters are normally used for network operation tasks and are classed as remote or local devices. Remote devices can access the NMC via the network using a protective key system. A typical configuration is detailed in **Figure 11.**

Distribution of Management Centres

In large networks the centralisation of management functions may present loading and security problems particulary for a single NMC. The DPS25 system provides the ability to distribute the network management load and functions across several NMC's. An example of how this might operate in a network is illustrated in **Figure 12.** The number of management computers that can be linked to the network is restricted only by the number of PSE's in that network. In the AUSTPAC network two NMC's are provided to give automatic back up as required.

ACCOUNTING AND STATISTICS CENTRE (ASC)

A computing centre for the processing of network generated call charging information is not part of the DPS25 system. However, in the case of AUSTPAC, SESA have extended the NMC concept to include a separate centre responsible for this processing function.

Standard Honeywell Level 6 hardware similar to that illustrated in **Figure 13** is used to implement the ASC. The ASC is connected to the AUSTPAC network via an X.25 link as a separate host computer that is able to set

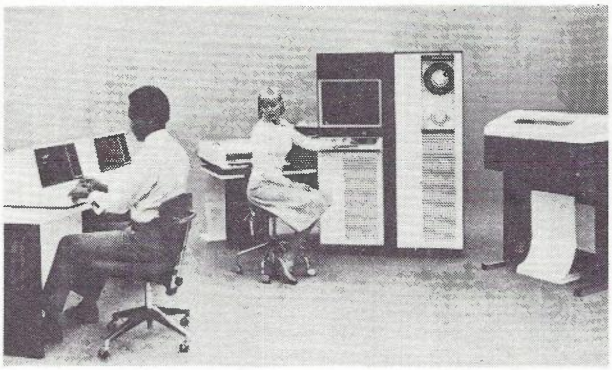


Fig. 13. Typical ASC Level 6 Minicomputer Installation

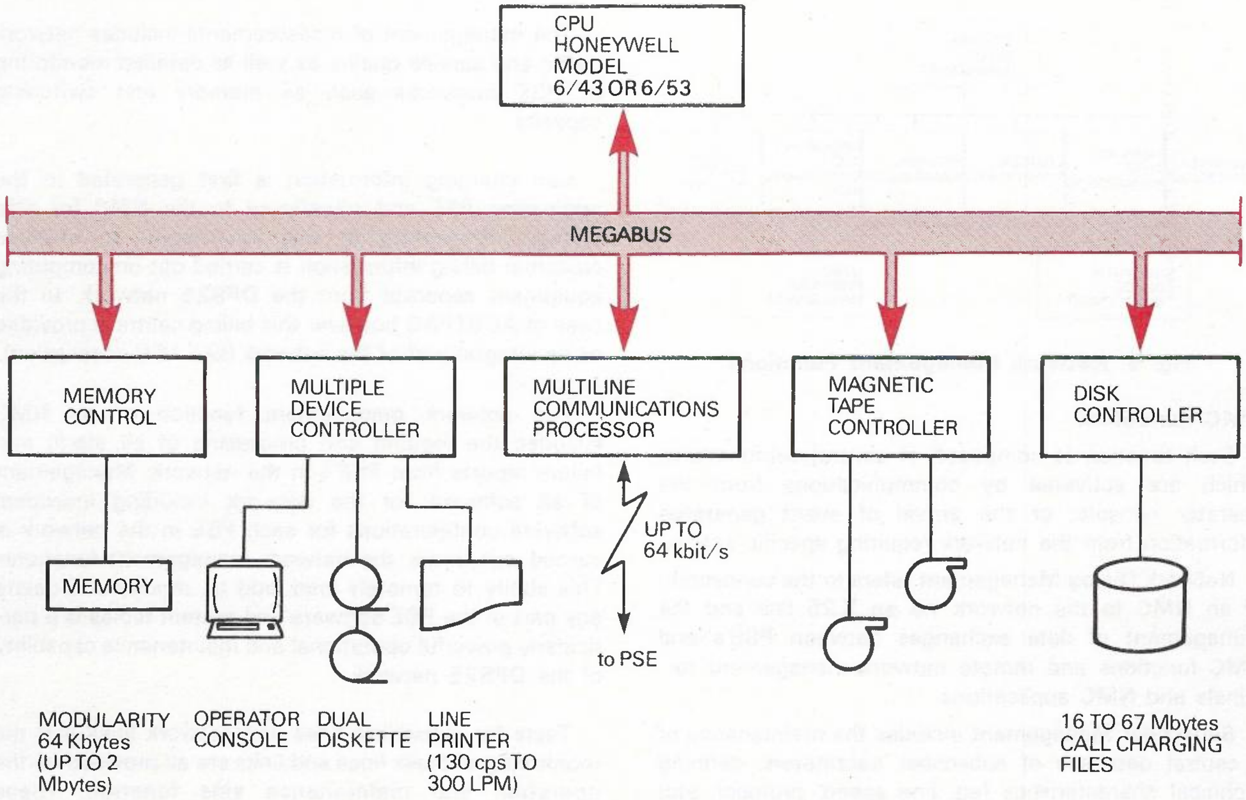
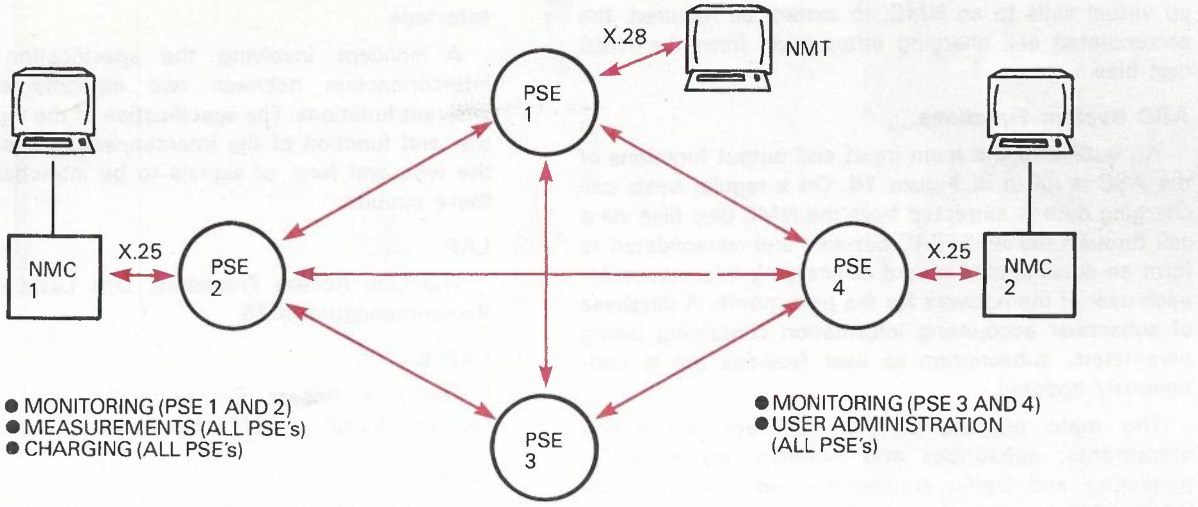


Fig. 11. NMC — Typical system configuration



- REPORTS AND ALARMS TRANSMITTED THROUGH VC, PVC, USING A HIGH-LEVEL PROTOCOL
- REMOTE ACCESS TO NMC FUNCTIONS THROUGH NMT
- CCITT COMPLIANT MAN-MACHINE LANGUAGE (Z311 to Z359)

Fig. 12. NMC — Network Management Operation

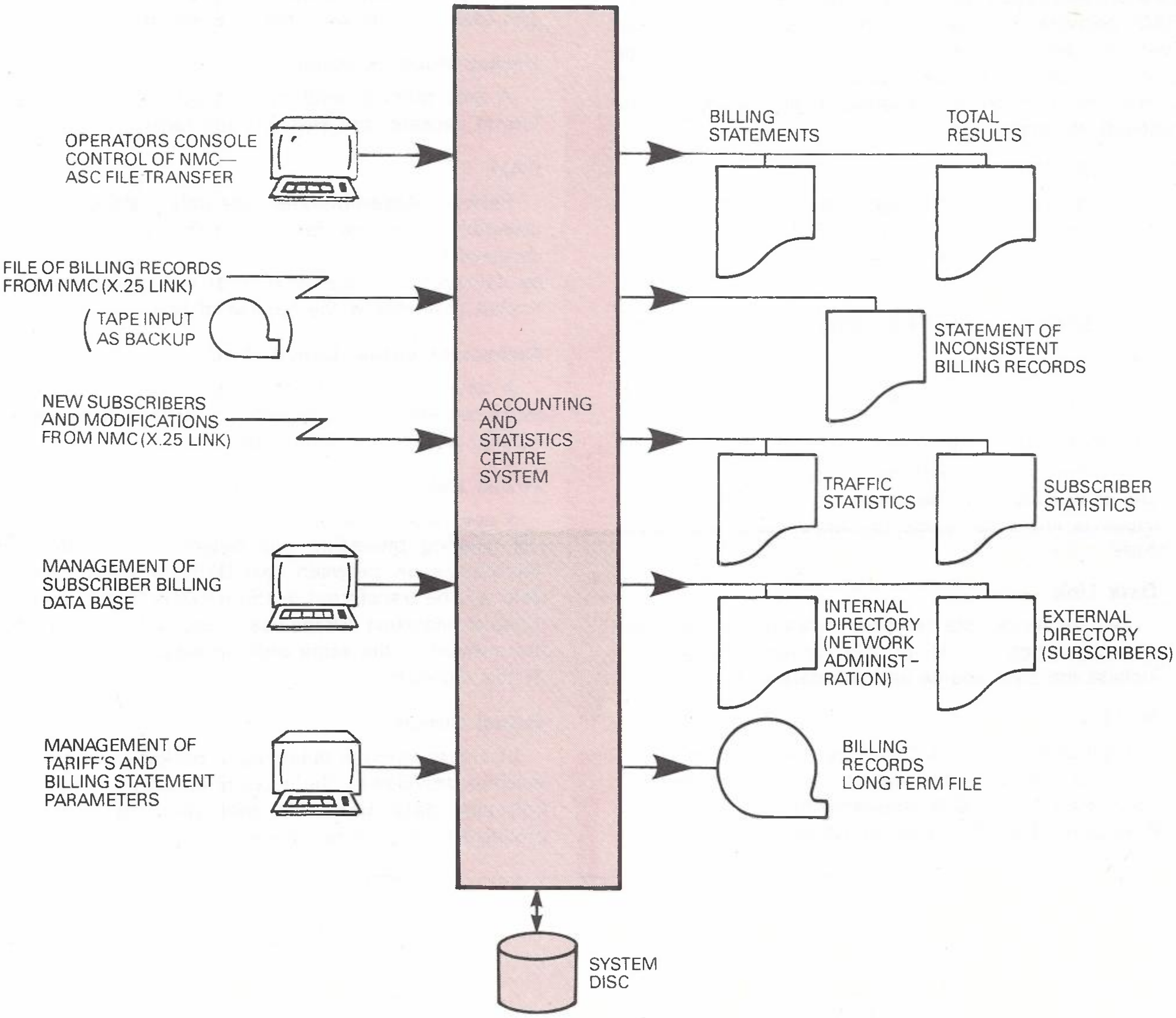


Fig. 14. Accounting and Statistics Centre Functions

up virtual calls to an NMC, to extract as required, the accumulated call charging information from the NMC disc files.

ASC System Functions

An outline of the main input and output functions of the ASC is given in **Figure 14.** On a regular basis call charging data is extracted from the NMC disc files via a call through the AUSTPAC network and consolidated to form an accumulated record of charging information for each user of the network for the past month. A database of subscriber accounting information containing billing parameters, subscription to user facilities etc is continuously updated.

The main outputs of the ASC are the billing statements, subscriber and network statistics for marketing and traffic engineering use, and directory information.

CONCLUSION

This paper has presented a brief overview of the DPS25 packet switching technology selected for implementation of the AUSTPAC network.

The DPS25 system is very well suited to meet Telecom Australia's objectives in establishing the AUSTPAC network because of the considerable packet switching system experience which it embodies and its powerful ability to be economically and flexibly configured to meet an expected highly variable data network demand.

REFERENCES

1. M. J. HARRISON, "Network Plan for AUSTPAC — The Australian National Packet Switching Network", Telecom Journal of Australia, VOL 31, No. 1, 1981, page 28.

GLOSSARY OF PACKET SWITCHING TERMS

BSC

Binary Synchronous Data Link Control procedure.

Character-mode Terminal

A terminal which receives and transmits characters one after another in the stop-start mode. The DPS25 supports character mode terminals using the ASCII code.

Data Link

Two or more data terminal installations and their interconnecting circuit. In this context, it does not include the data source and the data sink.

HDLC

High Level Data Link Control procedure specified by the International Organisation for Standardisation (ISO). Part of HDLC is applicable to the Link Access Procedure of CCITT Recommendation X.25.

Interface

A concept involving the specification of the interconnection between two equipments having different functions. The specification of the type, quantity, and function of the interconnecting circuits, and the type and form of signals to be interchanged via those circuits.

LAP

The Link Access Procedure, Link Level of CCITT Recommendation X.25.

LAP B

The Link Access Procedure Balanced mode, a revision of LAP of CCITT Recommendation X.25.

Packet

A group of binary digits, including data and call control signals, switched as a composite whole. The data, all control signals, and possible error control information are arranged in a specific format.

Packet Level (Level 3)

The packet format and control procedures for the exchange of packets containing control information and user data between the DTE and the DCE.

Packet-Mode Terminal

A data terminal equipment which can control and format packets, and transmit and receive packets.

PAD

Packet Assembly/Dis-assembly. Packet disassembly is a user facility which enables packets destined for delivery to a start-stop mode terminal to be delivered in character form at the applicable rate. Packet assembly is the reverse of this.

Permanent Virtual Circuit (PVC)

A user facility in which a permanent association exists between two DTEs which is identical to the data transfer phase of a virtual call.

Virtual Call

A user facility in which a call set-up procedure and a call clearing procedure will determine a period of communication between two DTEs in which user's data will be transferred in the network in the packet mode of operation. All the user's data is delivered from the network in the same order in which it is received by the network.

Virtual Circuit

In a data network operating in packet mode, those facilities provided by the network for transferring data between data terminals that emulate facilities provided by a physical connection.

The Digital Data Network Subscriber Test System

C. T. BEARE B.E.(Hons.), B.Sc, PhD., G. ROSAMILIA Dip. Electronic E, Dip. E.E. and D. GIBBS B.E.(Hons.), BSc.

Significant improvement in service restoration times will be possible with the Digital Data Service. This is due to the ability to rapidly isolate faults in individual customer networks and thus alert the correct maintenance personnel. To achieve this, a special purpose Subscriber Test System has been jointly developed by Telecom and AWA for use in the Digital Data Network. This system is microprocessor based, integrated within the DDN main centres and operated from the Special Service Restoration Centres (1107 Centres). This paper describes the role, operation and design of the system.

INTRODUCTION

The Digital Data Network (DDN) is the name given to the synchronous digital multiplex and transmission network being implemented in Australia to support a range of dedicated data transmission services to be marketed as the Digital Data Service (DDS). A detailed description of the DDN was given in a previous article (Reference 1).

Responsiveness in customer service provision and restoration has been recognised from the beginning as the key factor in the success of the Digital Data Service. For this reason, a centralised Subscriber Test System (STS) has been integrated within the DDN. This support system is extremely powerful. It allows the operator to monitor and test all elements of any customer network carried on the DDN. Specifically, the operator can:

- monitor the status of any multiplexed digital link (alarm status, availability, error performance);
- test and inject signals at the multiplexed link level;
- monitor the status of any customer link (alarm status, idle state, presence of active customer data, controlled interface mode of operation, use of loopback facility by customer, etc);
- set up loopbacks at various points in the customer network (i.e. at the Data Circuit-terminating Equipment (DCE)/Data Terminal Equipment (DTE) digital interface;
- inject and monitor test patterns on this looped circuit to check performance (in terms of error rate, % error-free seconds, % availability, etc);
- inject test patterns towards any DCE;
- monitor test patterns generated at any DCE.

The STS will be normally operated from a VDU console in the Special Service Restoration Centre (SSRC) or 1107 Centre, where it is available for use upon first customer contact with Telecom following a suspected fault on a customer network. This gives the operator the ability to accurately and quickly assess the status of an individual customer service from a central location without the need to visit the customer's premises.

Alternative operation will be possible from the DDN Maintenance Control Room (MCR) located in the DDN main centre. The Maintenance Control Room is the focal point for the DDN network operation in the State or main centre area. The locations associated with this two-level maintenance approach are illustrated in **Figure 1**.

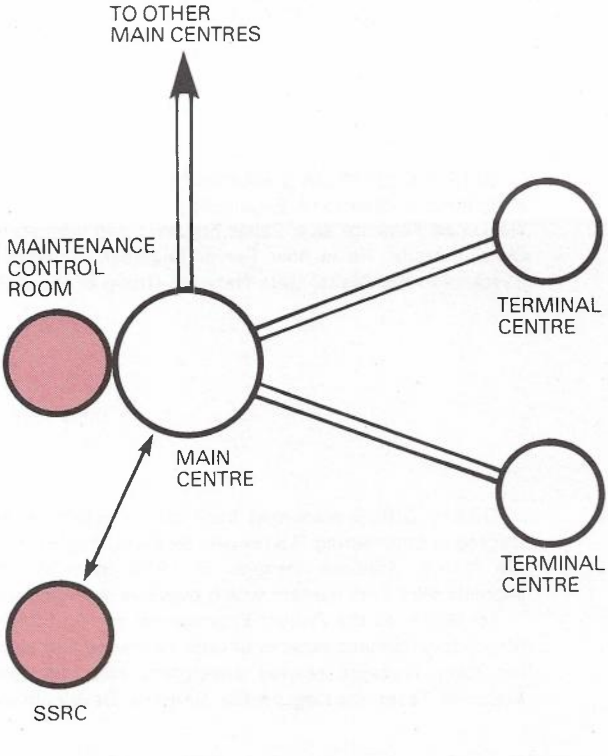


Fig. 1: DDN Network Management Centres

The Subscriber Test System (**Figure 2**) consists of:

- a common equipment panel rack mounted in the DDN main centre;
- individual Data Access Equipment (DAE) installed in every transmission link entering and leaving the main centre. The Data Access Equipment consists of individual units rack mounted in panels;
- two VDU consoles (one in the MCR and one in the SSRC) connected to the common equipment via 1200 bit/s data modems.

The following section considers the subscriber end of a DDS, introduces the concept of a maintenance entity and compares the STS with an ideal system for fault isolation. The STS is then described as seen by the operator and its use on a hypothetical customer network is illustrated.

Finally, the hardware and software design of the STS is described and future developments are outlined.

THE ROLE OF THE STS IN DDN OPERATIONS

The restoration of all multiplex equipment and multiplexed transmission links is the responsibility of the main centre staff. The SSRC staff are responsible for restoration of services arising from any fault which arises in any part of the Digital Data Service affecting only the one subscriber. In this area the DDN uses a loopback technique to help isolate faults. This works in the following manner.

Each customer service on DDN is carried within DDN at a higher rate called the enveloped rate (Reference 1). Thus for example, a 2400 bit/s service is carried within DDN at 3200 bit/s. The extra information making up the enveloped rate is formed within the DCE by adding a ***status*** bit and a ***framing*** bit with every 6 bits of customer data. It is this status bit which is used by the STS to enable loopbacks to be set up at various locations in the customer network without losing transparency to customer data. For example, to initiate a loopback in a DCE the STS does the following to the customer data stream (via the Data Access Equipment):

- the status bit is changed from ON (valid customer data being carried) to OFF (network code-word being carried).
- the six customer information bits are overwritten by the appropriate loopback code-word which is transmitted 16 consecutive times.

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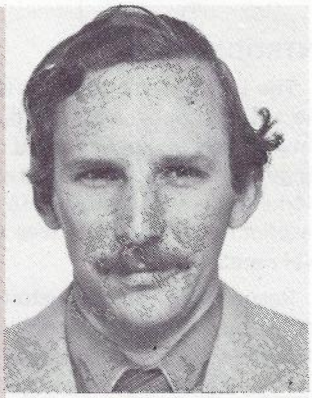
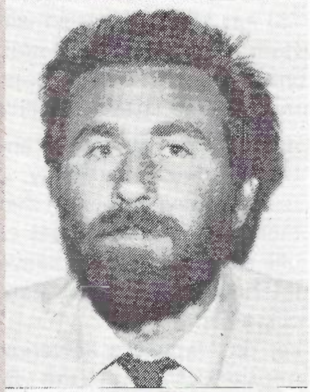
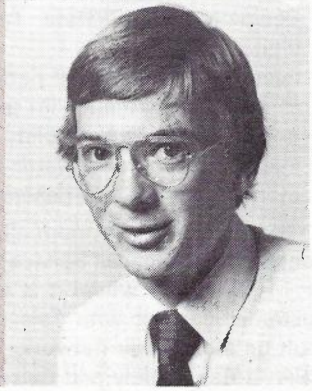


GERRY ROSAMILIA graduated from Swinburne Institute of Technology with a Diploma in Electronic Engineering (1972) and Electrical Engineering (1974). He joined Telecom as a Cadet Engineer and worked initially in Telegraphs and Data, Victoria. He is now Senior Engineer, Network Operations and Support Systems in the Digital Data Network Group of the Data Division Headquarters.



DARYL GIBBS graduated from the University of Adelaide with an Honours Degree in Engineering (1978) and Bachelor Degree in Science (1977). He joined the A.W.A. Ashfield complex in 1979 to work on the development of a sophisticated Test System which overlays the Australian Digital Data Network.

Mr Gibbs, as the Project Engineer for the Test System has been responsible for all development aspects of both hardware and software for the System and for other Network related equipment and has co-ordinated with Telecom Australia Team working on the Network Development.



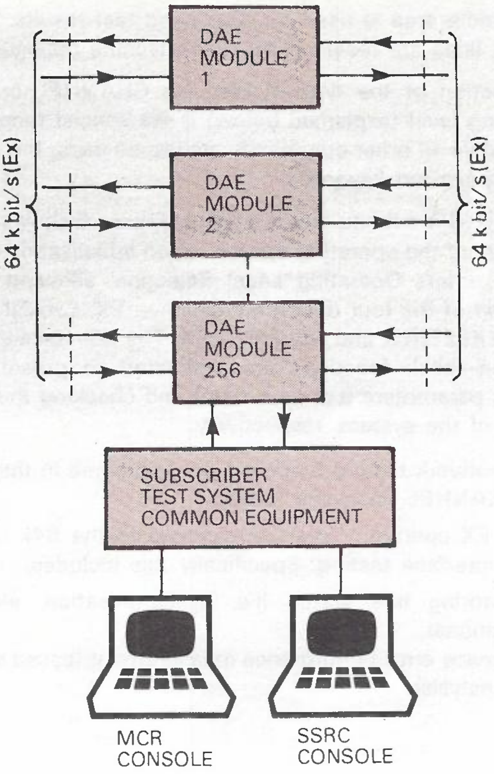


Fig. 2: Subscriber Test System Configuration

- the code-word is recognised by the DCE (after 8 consecutive correct code-words with status bit OFF are received) which simultaneously transmits an acknowledgement message back to the STS and then initiates the loop.

A similar procedure is followed to release the loop. Different code-words are used to set up loopbacks at different locations in the network. By injecting a test pattern on a looped circuit and monitoring the received signal, the STS can detect performance deterioration in the looped part of the circuit.

That section of the circuit relating to a single service is shown in Figure 3, where the concept of a maintenance entity is illustrated. A maintenance entity is defined as that clearly identifiable section or part of the customer service for which one maintenance group is uniquely responsible.

Five maintenance entities have been highlighted in **Figure 3:**

- the DTE — Maintenance responsibility belongs with the customer
- the DCE — Maintenance responsibility belongs with Datel maintenance staff
- building cable — Maintenance responsibility belongs with operations district field staff
- distribution cable — Maintenance responsibility belongs with operations district lines staff
- multiplexer line module — Maintenance responsibility belongs with exchange maintenance staff.

An ideal centralised test system should be able to uniquely locate the fault to one of these maintenance entities.

As described earlier, the DDN has in-built loopbacks which can be accessed from the STS. Through the use of these remotely activated loopbacks, the STS can isolate the fault to one of three areas:

- the DTE;
- the DCE, the building cable, or the distribution cable;
- the multiplexer line module.

Given that a simple test at the customer's premises can prove a DCE faulty or otherwise, then a close to ideal fault sectionalisation and isolation system has been achieved.

In addition to DDS trouble-shooting, the other role of the STS is the acceptance-testing of new (large) customer networks upon installation, prior to official handover.

OPERATING THE STS

In the design of the man-machine interface a number of operational requirements were considered desirable:

- the ability to directly select the type of test best suited to solving the problem;
- provision for continually informing the operator of the progress of the testing cycle;
- provision for warning the operator if any test will interfere with normal customer traffic;
- use of a simple man-machine protocol.

The command repertoire and screen overlays are designed to provide maximum status information relating to a DDS, while streamlining the test set-up procedure.

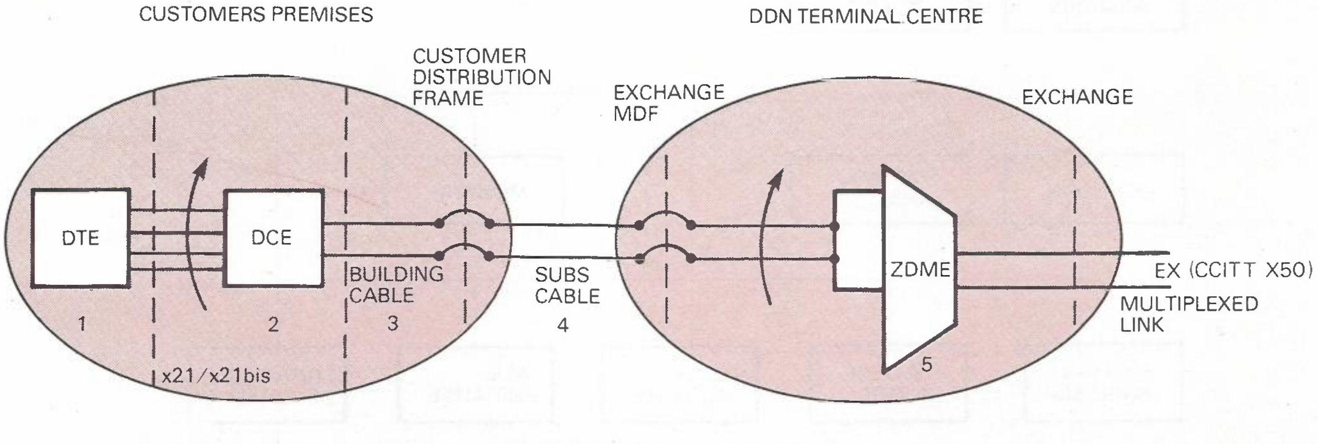
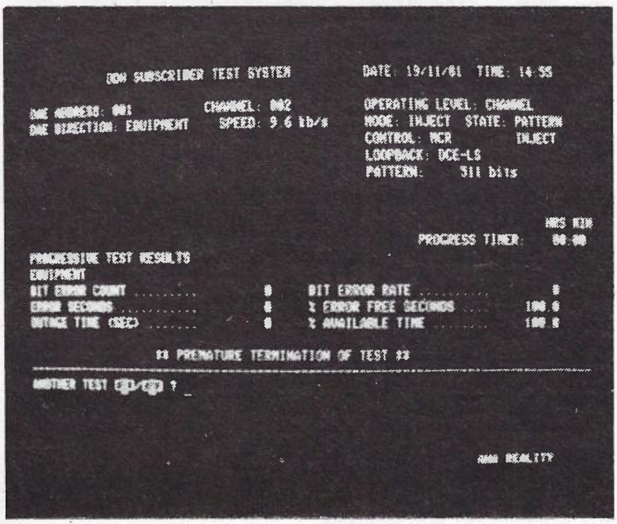


Fig. 3: Maintenance Entities

Figure 4 shows a typical display on a standard 25 line x 80 character video display. The top area is used to display operating level, DAE address, channel number, speed, mode (inject/monitor) and test pattern injected.



```
          IDN SUBSCRIBER TEST SYSTEM          DATE: 19/11/81  TIME: 14:55

DAE ADDRESS: 001          CHANNEL: 002        OPERATING LEVEL: CHANNEL
DAE DIRECTION: EQUIPMENT    SPEED: 9.6 kb/s   MODE: INJECT  STATE: PATTERN
                                              CONTROL: MCR         INJECT
                                              LOOPBACK: DCE-LS
                                              PATTERN:     511 bits

                                                                  HRS MIN
                                                  PROGRESS TIMER:   00:00
PROGRESSIVE TEST RESULTS
EQUIPMENT
BIT ERROR COUNT .........        0    BIT ERROR RATE ..........        0
ERROR SECONDS ...........        0    % ERROR FREE SECONDS ....    100.0
OUTAGE TIME (SEC) .......        0    % AVAILABLE TIME ........    100.0

          ** PREMATURE TERMINATION OF TEST **
------------------------------------------------------------------------
ANOTHER TEST (Y/N) ? _

                                                     AWAIT REALITY?
```

Fig. 4: VDU Display

The middle area is used for displaying test results. The bottom lines are reserved for man-machine dialogue.

Selection of the type of test, i.e. CHANNEL or EX operating level (explained below) is via special function keys, while all other commands are issued using the normal (typewriter) keyboard.

The STS is a menu driven system. **Figure 5** shows the structure of the operating system. Upon initialisation, the system enters Operating Level Selection, allowing the selection of the four operating levels — EX, CHANNEL, HOUSEKEEPING and SELF-CHECK. The house-keeping and self-check functions are dedicated to presetting various parameters (i.e. time/date) and checking the integrity of the system, respectively.

All network testing functions are contained in the EX and CHANNEL operating levels.

The EX operating level corresponds to the 64k bit/s digital interface testing. Specifically this includes:

- monitoring line status (i.e. synchronisation, alarm conditions);
- in-service error performance measurement (based on F bit analysis);

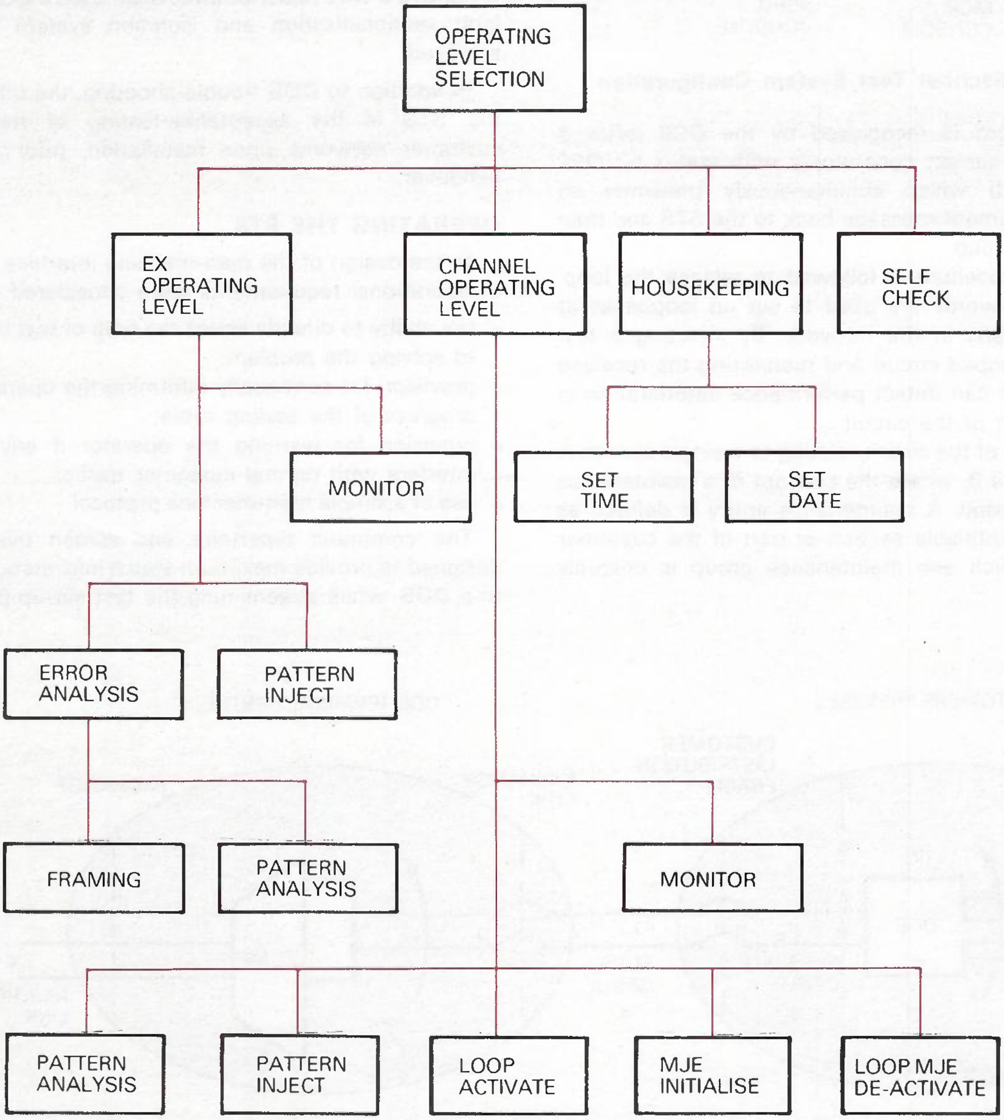


Fig. 5: Software Flow Chart

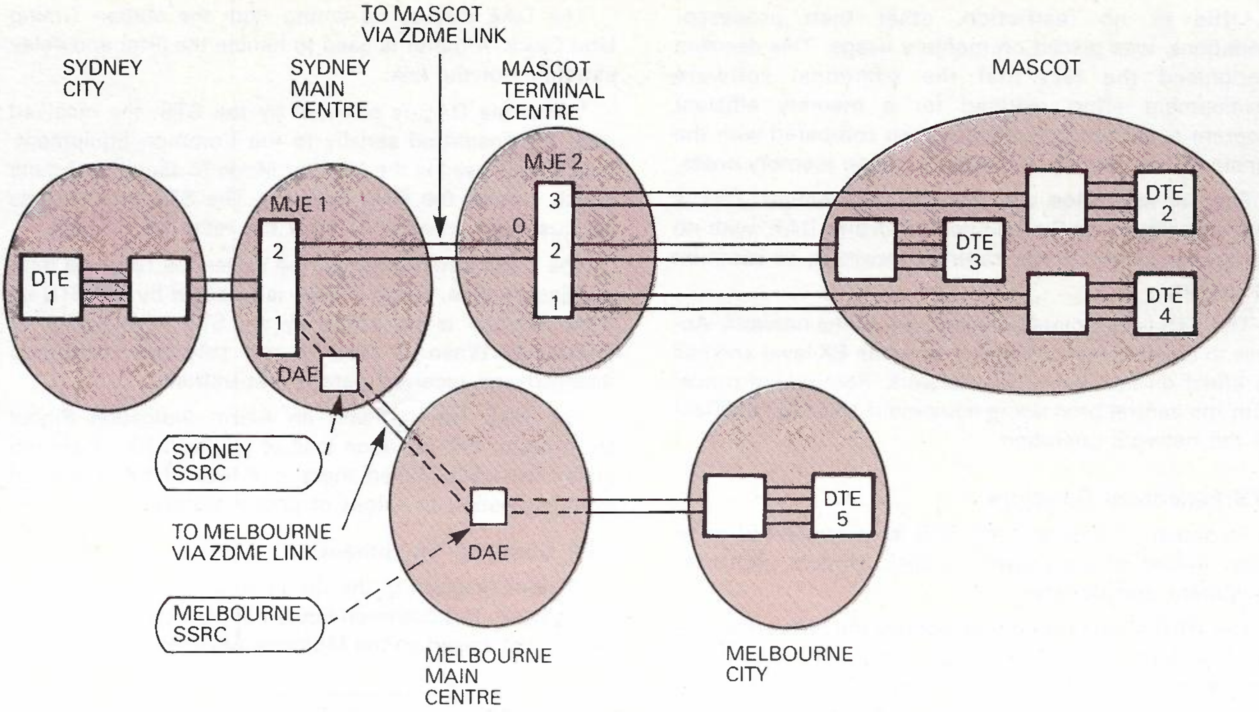


Fig. 6: Typical Multi-point Network

- injecting test pattern data and measuring % availability and % error-free-seconds (EFS).

The CHANNEL operating level is used for testing DDS services. This level comprises:

- monitoring the status of customer channel data flow (live data, network control data including, alarm conditions and code-words);
- initialising multijunction equipment (MJE) for test purposes;
- activating/deactivating loopbacks;
- injecting pseudo-random (test) data and measuring % availability and % EFS.

The principal user of the STS system is the SSRC operator. The majority of testing will result from DDS customer difficulties and fault reports. Therefore, it is anticipated that testing will be short-term (less than 10-15 minutes duration), and frequent, especially when the number of services in operation increase.

Upon receiving a customer complaint, the SSRC operator can check the integrity of the end to end data service, fault sectionalise and identify the malfunctioning equipment. The operator can then immediately inform the customer of the estimated time to restore service.

Prior to handing the service back to the customer, the operator can verify that it meets the performance criteria.

Customer networks comprise one or more point to point and/or multipoint services. As the latter is the more complex to maintain, the operation of the STS as applied to a DDS multipoint service will be described in the following example.

Consider a fault in the customer multipoint network of **Figure 6,** in particular a problem with the DTE No. 4 drop. Access to the customer channel is obtained by inputting the DAE address, channel number and speed. Then the following sequence of operations occur:

System Response	**Operator Response**
Inject or monitor?	Inject
Direction?	Equipment
Point to point or multipoint?	Multipoint
MJE No.?	MJE No1, connect channel 1 to 2
Channel 1 to 2 OK	MJE No 2, connect channel 0 to 1
Channel 0 to 1 OK	Loopback (DCE No 4)
Loop OK) Loop NOT OK)	

In the case where the loop is activated (Loop OK), the % availability and % EFS can be measured and the customer informed that no problem exists. In the case where the loop is not activated (Loop NOT OK), a number of testing options are available to the SSRC operator to determine whether the problem is caused by:

- multijunction equipment (MJE) malfunction;
- junction, subscriber or building cable discontinuity;
- or DCE malfunction.

This example shows that the STS can be used firstly, to confirm that a problem exists and secondly, to pinpoint the cause.

STS DESIGN

Introduction

The system is designed to be highly modular in both hardware and software. The STS can be considered as a series of modules with well defined tasks which involve a mixture of hardware and software. Communication between modules exists, and involves the passing of data through centrally located modules.

Little or no restriction, other than processor limitations, was placed on memory usage. This decision recognised the fact that the additional software development effort required for a memory efficient program could not be justified when compared with the constantly decreasing and already cheap memory costs.

Ease of expansion was a basic requirement. This is achieved simply by the addition of further DAE, with no change necessary to the central processing or common equipment.

The STS is completely transparent to the network. Access to a subscriber channel is from the EX level and has no effect on the rest of the network. Removal of power from the central processing equipment also has no effect on the network operation.

STS Functional Structure

As shown in Figure 2 the STS is comprised of three major pieces of equipment — DAE Module, Common Equipment and Console.

The DAE Module is connected into the network at the EX (64 bit/s digital exchange interface) level. One module is required for each EX stream. The modules are mechanically mounted in panels of eight modules. The minimum STS configuration contains one DAE panel, the maximum contains thirty two. The DAE Modules are interconnected in parallel on a bus enabling one EX to be accessed at a time.

The STS Common Equipment contains the processing system and interfacing hardware to DAE Modules.

Two VTE-6 consoles provide the man machine interface. The STS is not a time share system. Only one console at a time can be used as an input device, but both consoles display the same output information. The consoles may be located either locally at the exchange itself or at remote centres.

Data Access Equipment DAE — 64k

A DAE Module consists of two identical DAE printed board assemblies (PBA). The module gives the Common Equipment access to the 64k bit/s data, as well as the facility to replace some or all of this data. **Figure 7** demonstrates the procedure by which this is achieved.

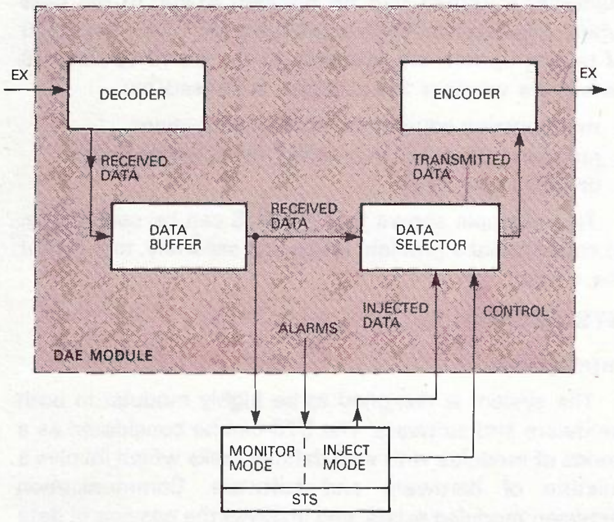


Fig. 7: DAE Block Diagram

The DAE derives its timing from the station Timing Unit Clock. A buffer is used to handle the jitter and delay variations of the link.

When the DAE is selected by the STS, the received data is transmitted serially to the Common Equipment. This data is used in the Monitor Mode to align the circuits which control the Data Selector. The STS also detects various alarm conditions from the received EX data.

The transmitted data can be either the received data or injected data. When a DAE is selected by the STS its Data Selector is controlled by the STS Inject Mode of operation. When a DAE is not selected, control is disabled and received data is transmitted.

The DAE will transmit an Alarm Indication Signal (AIS) alarm (all 1s) upon loss of received EX. A station alarm will occur when there is a loss of EX, a loss of synchronisation or a loss of power supply.

STS Common Equipment

A block diagram of the Common Equipment is shown in **Figure 8.** The Common Equipment is a three processor system set, based on the Motorola 6802 microprocessor.

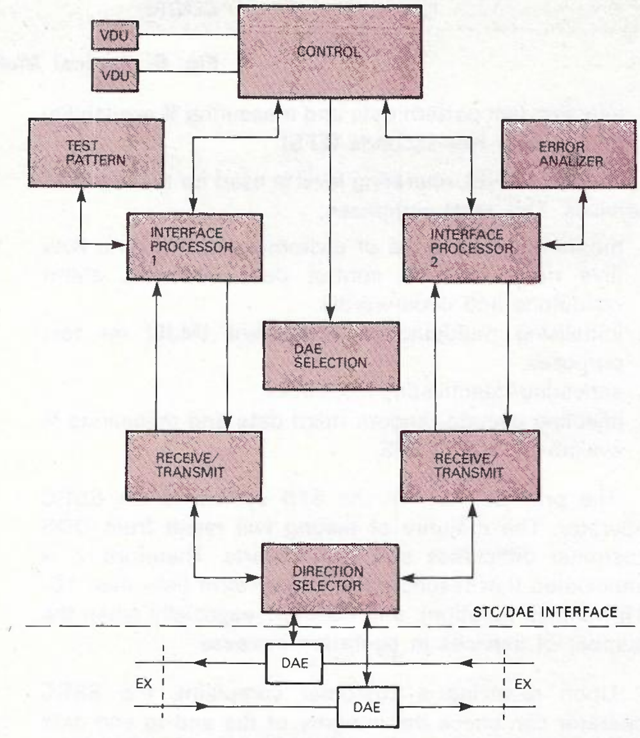


Fig. 8: STS Common Equipment Block Diagram

Two distinct categories of processing work exist. Firstly there are the simple repetitive functions which do not require any great analytical capability. A good example of this category is the generation and analysis of test pattern data. Another example is the detection of the predescribed data words and the monitoring of alarm conditions on the EX stream. All this processing is handled by the Interface Processors, the program size of each being about 2K bytes of machine language.

Functions which are performed less frequently, but which require complex analytical treatment form the second category. Examples include the analysis of test results, the input-output to the consoles, and the system

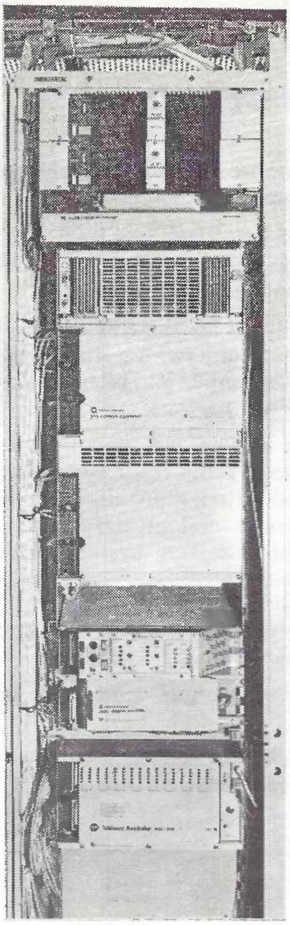


Fig. 9: **STS Installed in Type 72 Rack, showing, (top to bottom) Power Converters, STS Common Equipment, Service Panel, Dual Modem and DAE Panel.**

self-check. These are realized in a single central Control Processor, still based on the 6802 micro-processor, but with a more extensive program and data storage area than the Interface Processors. The program is stored in 26K bytes of ROM and the data area occupies 1K bytes of RAM. Of the program, 90% was written in a high level structured language, the remaining in machine language.

FUTURE DEVELOPMENTS

Two areas are currently being developed. This first is to include 2048 kbit/s data access and incorporation of a PX monitor level. The second is to allow indirect addressing. At present the STS is addressed by DAE number, but a memory lookup table is being incorporated to allow optional addressing via the multiplexed link numbering scheme (eg M HMKD LOND L003/4/5).

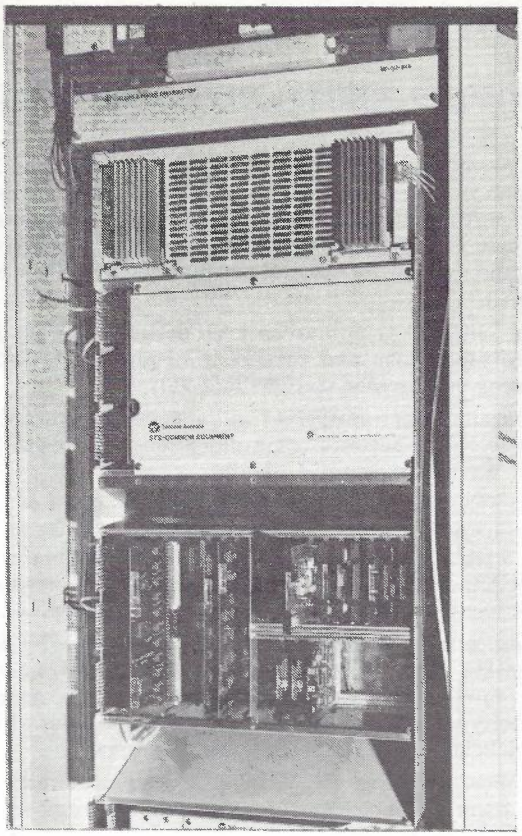


Fig. 10: **STS Common Equipment (one cover removed)**

A significant area of future development will be the extension to multi-user and multi-test system access. For example, the one VDU console might be used to access many STS (one or more of which may be in remote locations), as well as accessing other computer-based systems (eg RASS or the Supervisory Alarm System). Multiple access to the one STS or at least to the one set of DAEs might also be considered.

REFERENCES

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In Brief

DAMPIER-PERTH PIPELINE COMMUNICATIONS SYSTEM

In November 1981 an agreement was executed by Telecom Australia and the State Energy Commission of Western Australia (SECWA) which provides for Telecom to supply and construct a dual communications system along the route of the natural gas pipeline from Dampier to Perth.

The SECWA communications system will enable remote supervision and control of all pipeline facilities including compressor stations and valves.

A parallel Telecom system will also be constructed to enhance public network communications services to the North West of Western Australia.

The SECWA system will comprise primarily a 44 hop backbone 300-channel microwave radio-relay system in the 7.5 GHz frequency band. The system terminates at SECWA facilities in Karratha and Perth. The repeaters are co-located with pipeline compressors and valves.

There will be 11 spur radio paths in the 900 MHz and 1800 MHz bands to provide communications from the main microwave system repeaters to some nearby electricity substations and to those pipeline valves which do not have co-located microwave repeaters.

Duplicated polling 450 MHz radio systems (similar to subscribers' radio concentrator systems) are proposed to supervise a number of more closely spaced pipeline valves in the Perth metropolitan area.

A comprehensive VHF mobile radio network will provide coverage of the whole pipeline route to assist pipeline operations and maintenance.

Terminal facilities for the SECWA system include a telemetry system, orderwires, direct telephone links, PAX and PABX networks and teletype and facsimile terminals on the PAX network.

The Telecom system will comprise a 43 hop, 900-channel microwave radio-relay system in the 6.7 GHz frequency band. Repeater sites, antenna support structures, antennas and primary power plant will be shared with the SECWA system. The system will terminate in the Karratha and Wellington telephone exchanges. Facilities will be included for non-priority TV and data-above-voice transmission as well as a number of wayside subscribers' radio services.

A 6.7 GHz 900-channel spur will be provided to Geraldton.

Both the SECWA system and the mainline Telecom system are programmed for completion in November 1984.

THE ANZCAN SUBMARINE CABLE

The ANZCAN System is an undersea telecommunications cable system linking Australia, New Zealand and Canada over a 14,000 km route via Norfolk Island, Fiji and Hawaii. The system will provide 1380, 4 KHz telephone circuits simultaneously.

The project involves 14 nations and will cost about $400 million in total. The system is scheduled to be designed, manufactured and installed by August 1984.

The system will include 1000 underwater repeaters, almost half of which will be manufactured in Australia (STC Sydney). Each repeater will be manufactured to precise standards such that they will have a maintenance free life of more than 25 years (by comparison, satellite repeaters are required to last about seven to eight years).

To fill the order, the manufacturers will employ a new air conditioned factory in Sydney which includes an environmental clean area providing a degree of cleanliness greater than that of surgical operating theatres.

Australia's part in this project will bring it to be only the fifth western nation with the technology to manufacture complex electronic repeaters and allows this country to be considered in the future for involvement in further submarine cable projects, and the manufacture of electronic equipment for the domestic satellite and certain defence projects.

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- **ISSUED FOR COMMENT**

DR 82022 — INTRUDER ALARM SYSTEMS

Completing the Digital Telecommunications Network

R. A. COURT B.Sc., B.E. (Hons.), M. Eng. Sc., M.I.E.E.E. and N. J. GALE B.E. (Elec.)

Digital technology is moving rapidly into the junction and trunk portions of the telecommunications network. However the digital network cannot be completed without the inclusion of the customers' network, i.e. that area which lies between the customer's premises and the local exchange. This paper examines the use of digital transmission in this area as well as the associated aspects of signalling, control and interfacing. Network evolution and overseas developments are also briefly discussed.

INTRODUCTION

The growing influence of digital technology is being felt in many areas of the telephone network. The use of digital line transmission systems on junction routes and the introduction of stored programme control (SPC) exchange systems in Australia is a reflection of a world wide trend which also includes high capacity digital trunk systems and fully digital switching centres. One area which up to now has remained aloof from these changes is the customers' network, which for the sake of this paper is that part of the telecommunications network which lies between, and includes, the customer's premises and his local exchange.

For reasons which will be described later, the use of digital transmission and switching techniques in the customers' network is currently being studied by a significant number of telecommunications administrations and manufacturers of systems, equipment and devices. Interest has accelerated over the past few years and it is probable that digital advances in this area will be of major importance in the future development of Telecom Australia.

This paper is a general introduction to the subject of digital transmission in the customers' network. By this we mean the possible future extension of digital transmission to the majority (perhaps 90-95%) of customers. This differs from the interim establishment of small special services networks to serve the needs of the business community. Such special networks may well be operated using conventional techniques employing data modems and four wire transmission. The techniques and systems discussed in the following sections are quite distinct and are being developed to serve the household telephone as well as the needs of large and small businesses.

ATTRACTIONS OF DIGITAL TECHNIQUES

The major attraction of applying digital techniques to the customers' network is that the network which results has the ability to gain access to a wide range of non-voice services in an efficient manner. To date, such services have largely been provided by separate networks. For example, the world wide telex network operates independently of the telephone network and several circuit switched and packet switched data networks are now in operation overseas. Investment in the customers' network (including exchanges and cables) constitutes some 60% of Telecom Australia's fixed assets [1]. Thus there is considerable economy to be gained in using it as a common network to provide access to voice, telex, data and other services [2].

The growing use of digital transmission and switching systems is producing a convergence of telecommunications and computer technology. This convergence will be complete when a single integrated network is able to provide a range of services. The infrastructure for such a network will be provided in Australia as digital systems are introduced. A decision to continue telephony network development on integrated digital network (IDN) principles has already been taken by Telecom.

In order to proceed a further stage along the path to an integrated services digital network (ISDN) it will be necessary to add more sophisticated control and signalling to the existing network. The introduction of digital transmission in the customers' network forms an essential part of this process [3]. Although the exact nature of ISDN evolution and operation is yet to be defined it is expected that as investigations continue into digital telecommunications, emphases will change, particular applications will become clearer and the form of the ISDN will emerge.

As well as showing a growing interest in a "unified network" as a source of added revenue from new services, proponents of digital customers' networks suggest that the use of digital techniques may eventually lead to a more economical network for telephony alone. This conclusion is largely based on the consequent simplification of exchange and telephone interfaces and on the inevitable decline in costs for large scale integrated circuits.

Other potential advantages include the use of pair gain systems such as digital multiplexers and concentrators which will increase the utilization of the cable network. An improvement in voice transmission quality [4] resulting from digital transmission is also expected.

THE TRANSMISSION PROBLEM

The most significant technical difficulty in providing digital services to the customer is the choice of transmission technique. The initial question in this respect is, what transmission medium should be used? To answer this, it is important to note that the customers pair cable network (main and distribution) represents almost 20% of Telecom Australia's fixed assets (≃ $2,000,000,000). As will be seen shortly, the increased bandwidth of digital transmission means that conventional transmission techniques cannot be used on pair cable. The replacement of the pair cable network with a wideband medium such as optical fibre or coaxial cable, or the installation of more pair cable to use four wire transmission are both very expensive prospects. This suggests that a new transmission method or methods should be found to utilize the pair cable network for digital transmission at the required bit rates.

The choice of bit rate is itself an open question. It is constrained to some extent by the choice of transmission medium and on the other hand, dictated by the requirements of the services which are to be provided. At a minimum, voice services are needed and this currently requires 64 kbit/s to be transmitted. It is possible that this bit rate may reduce as technology improves, although digital networks are tending to develop using 64 kbit/s as a basic unit and this rate may remain as a standard. As well as the basic voice service, and high speed services which could use the 64 kbit/s, there are other needs including a variety of slower speed services, required in parallel with the voice service, and an appropriate signalling component. The trend has been to consider that 80 kbit/s will be an overall rate (i.e. 64 + 16). However there has been a recent move to add the capability for a second 64 kbit/s service and consequently 144 kbit/s has been mooted. This issue remains to be resolved but it will be clear from what follows that, if the pair cable network is to be used as the transmission medium, the higher the bit rate the greater will be the transmission problem. Looking further ahead, it is possible that video services may be a future requirement and this would demand the use of wideband media instead of pair cable.

TRANSMISSION METHODS

The transmission method or methods to be used must be capable of operating simultaneously in both directions (i.e. full duplex) on a single pair of wires. The analogue telephone of today works in just this way [5], however the wider bandwidth of the corresponding digital signals (at least 20 times greater) makes such transmission a much more difficult task. Several methods have been proposed as solutions to the problem and they are described in this section.

Before looking at the transmission methods it is important to consider the distances over which these

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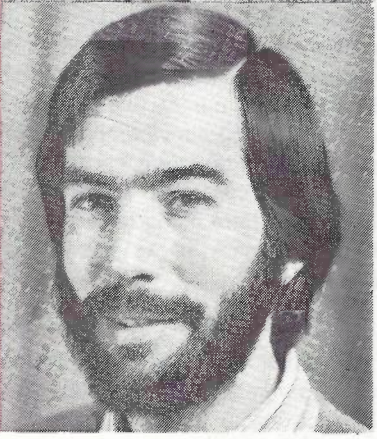
NORMAN J. GALE joined the Australian Post Office in 1970. He has worked on a range of SPC switching projects in the Switching and Signalling Branch at the Research Department. In 1979/80 he provided technical liaison for industry research contracts to investigate the potential for, and problems of, digital subscriber lines. Lately he has been involved in joint studies with Transmission Branch, Research, on the provision of integrated telecommunication services on cable TV, coaxial cable and optical fibre networks.



methods must operate. Depending on the implementation strategy the distance may be as short as from pillar to customer or as long as from exchange to customer. **Table 1** shows the exchange to customer distances in a number of countries. The pillar to customer distances are of the order of 1-2 km.

Country	Ref.	Distance between Exchange and Customer (km)
Australia	[6]	< 5 (95%)
Denmark	[7]	< 4 (97%)
France	[8]	< 4 (95%)
Japan	[9]	< 7 (99%)
Norway	[10]	< 4 (93%)
U.K.	[11]	< 5.5 (98%)
Italy	[12]	< 3 (95%)

Table 1: Comparison of Distances from Exchange to Customer.

It can be seen from these figures that a transmission distance of 4-5 km will be required to serve the desired number of customers. The Australian network appears to be longer than most and this may prove to be a significant problem.

The transmission methods which have been proposed include extensions of the conventional analogue hybrid [5]. The wider bandwidth of the digital signals, leads to a far greater variation in the input impedance of the customers line than that faced by today's hybrid. The variation is caused by the change with frequency of the characteristic impedance of the wires making up the line. This is complicated by the mixture of wires that can make up one line. A typical customer's line is shown in **Table 2**.

Section		Length (m)	Type (mm)	Size (pairs)
Exchange	1	96	.40 PEIUT	1800
	2	119	.40 PIUT	1200
	3	297	.40 PIUT	800
	4	484	.64 PIUT	400
Cabinet	5	252	.64 PIQL	300
Pillar	6	317	.51 PIQL	100
	7	89	.40 PEIUT	30
Customer	8	20	.90 PEIUT	drop wire

PE	polyethylene	UT	unit twin
P	paper	QL	quad local
I	insulated		

Table 2: Typical Customer's Line

The result of this variation is that it is not possible to obtain adequate separation of the two directions of transmission using a fixed impedance to balance the customer's line, as is the case in the conventional hybrid. Several hybrids have been proposed which adapt the balancing impedance to follow the changes in the line [13]. However transmission distances of only 1-2 km have been obtained using these techniques on uniform lines [14]. As can be seen in Table 2 customers' lines are often far from uniform. This makes it unlikely that such hybrids will find much use in practice unless the distances involved are very short.

To overcome the problems caused by the wider bandwidth of the digital signal three major methods are being examined, namely; digital hybrid/echo cancellers, burst transmission and frequency separation. These will now be looked at in turn. Another technique called dispersion separation [15] has been proposed, but has received little attention because of inherent problems when operating on short lines.

Digital Hybrid/Echo Canceller

As well as the imperfect separation resulting from the hybrid, other problems result from discontinuities (e.g. changes in wire gauge) on the line. **Figure 1** illustrates the situation.

A transmitted signal T(t) would ideally not appear in the receiver. However because the hybrid H is not perfectly balanced some energy will leak through. In addition discontinuities on the line (see Table 2) will cause energy transmitted towards the exchange to be reflected back to the customer's receiver. Both the leakage signal and the reflections may be considered as echoes of the transmitted signal which will interfere with the reception of the signal from the other end of the line. To overcome this problem an echo canceller may be used as shown in **Figure 2**.

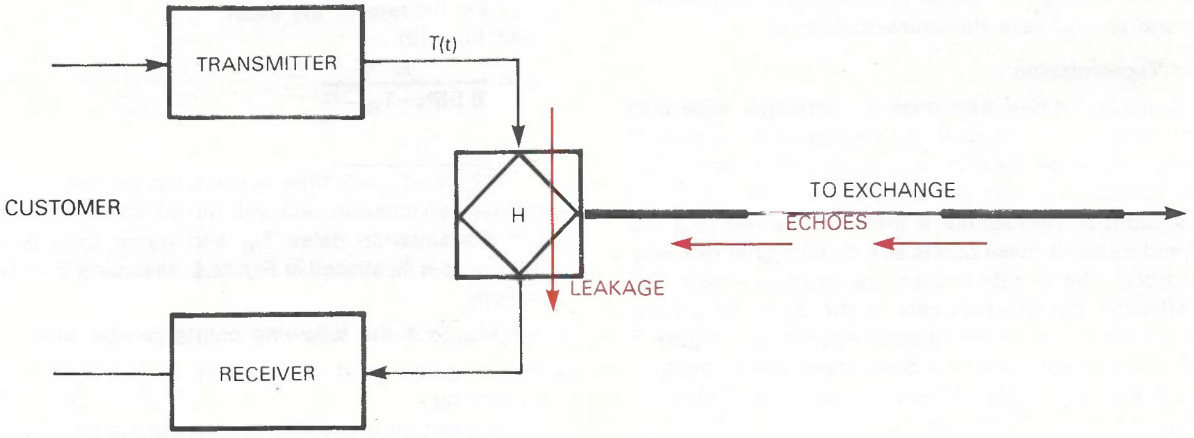


Fig. 1. Echoes on a Customer Line

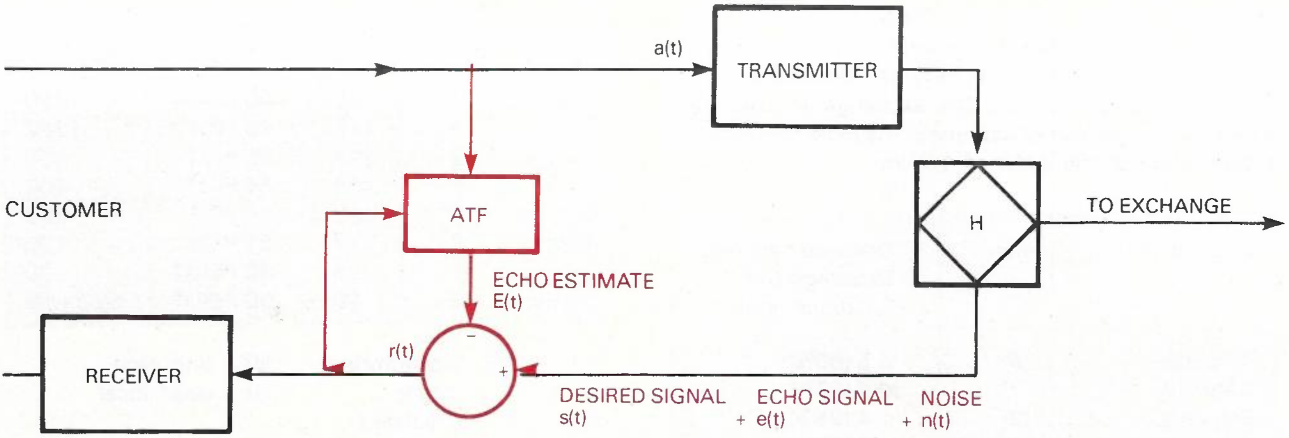


Fig. 2. Echo Canceller

An adaptive transversal filter (ATF) [16] is used to produce an estimate of the echo path. This estimate E(t) is subtracted from the received signal which contains the desired signal s(t), the echo signal e(t) and a noise signal n(t). This subtraction results in r(t), where

$$r(t) = s(t) + n(t) + e(t) - E(t) \qquad (1)$$

The key to the operation of echo cancellers is that the error $[e(t) - E(t)]$ can be directly expressed as a function of r(t) and the digital stream to be transmitted a(t). Note that both r(t) and a(t) are inputs to the ATF. Given this relation, echo cancellers attempt to minimize the error by adapting the filter coefficients using various algorithms. For a more detailed description of digital echo cancellers readers are recommended to [17].

Echo cancellers may have to provide at least 45 dB of cancellation for satisfactory operation e.g. s(t) may have been attenuated 40 dB by the time it reaches the receiver while the echo may be less than 10 dB down on the transmitted level. A ratio s(t) : e(t) of 15-20 dB is required for acceptable error performance.

A number of realizations of echo cancellers are currently under study and are mentioned later along with other systems under development. These developments have been encouraged by two factors. Firstly, because they are digital, echo cancellers of this type are well suited to manufacture using very large scale integration (VLSI) techniques, regardless of the complexity of the device. Secondly the subscribers' lines are relatively short and the echo responses themselves correspondingly short thus easing the design constraints in comparison with end to end data transmission circuits.

Burst Transmission

The second major transmission technique separates the two directions by allocating different times to each. It is known either as burst or ping-pong transmission. The basic method is to take the input digital stream (e.g. 80 kbit/s, store it, reassemble it into short bursts (e.g. 10 bits) and transmit these bursts at a much higher rate (e.g. 256 kbit/s). The bit rate of these bursts must ensure that the effective transmission rate is the same or greater than the input rate or information will be lost. **Figure 3** illustrates the operation of a burst transmission system. There is also a variation of the burst technique called the interleaved burst technique [18] but this will not be discussed in this paper.

Assuming an input rate of 80 kbit/s, the period of one bit is 12.5 μs. A burst contains N bits and therefore the period of a burst at the input rate is 12.5N μs. In this period a burst must be transmitted from one end to the other, and because operation is full duplex, a burst must also be sent and received in the opposite direction. Any repetition period longer than 12.5N μs will result in information being lost, since in this time the transmitter is assembling the next burst of N bits from the input data stream.

This means (from **Fig. 3**)

$$12.5\ N = 2T + 2W + I + G \qquad (2)$$

where

$$\left.\begin{array}{ll} T & \text{is the transmission delay} \\ W & \text{is the duration of the burst} \\ I & \text{is the idle time} \\ G & \text{is the guard time} \end{array}\right\} (\mu s)$$

I is a variable quantity making up for the variation in T with different line lengths. The minimum value of I is G when the line length is a maximum for the particular system. At this point $T = T_m$ (i.e. maximum transmission delay)

$$\text{i.e. } 12.5N = 2(T_m + W + G) \qquad (3)$$

also, assuming no extra bits are added to the burst

$$W = \frac{N}{r} \qquad (4)$$

where,

r is the bit rate of the burst
and from (3)

$$r = \frac{N}{6.25N - T_m - G} \qquad (5)$$

i.e. if $\frac{N}{6.25N - T_m - G}$ MHz is the burst bit rate, then the effective transmission rate will be 80 kbit/s for a maximum transmission delay T_m and guard time G. This relationship is illustrated in Figure 4, assuming G = 0, for simplicity.

From **Figure 4** the following points can be seen

- For a given N it is possible to increase T_m by increasing r
- For a given r it is possible to increase T_m by increasing N

Although on the surface it appears that this transmission method is capable of meeting any distance requirements, in practice this is not always so, as shown in the next section.

Many burst transmission systems are currently being studied and because they are digital they are also well suited to manufacture using VLSI techniques.

Frequency Separation

Frequency separation is a third method under study in several laboratories. It assigns a different frequency band to each direction of transmission. The different bands are obtained by either modulating one direction (e.g. using Single Side Band techniques) using a suitable carrier frequency or by using different line codes [19] in each

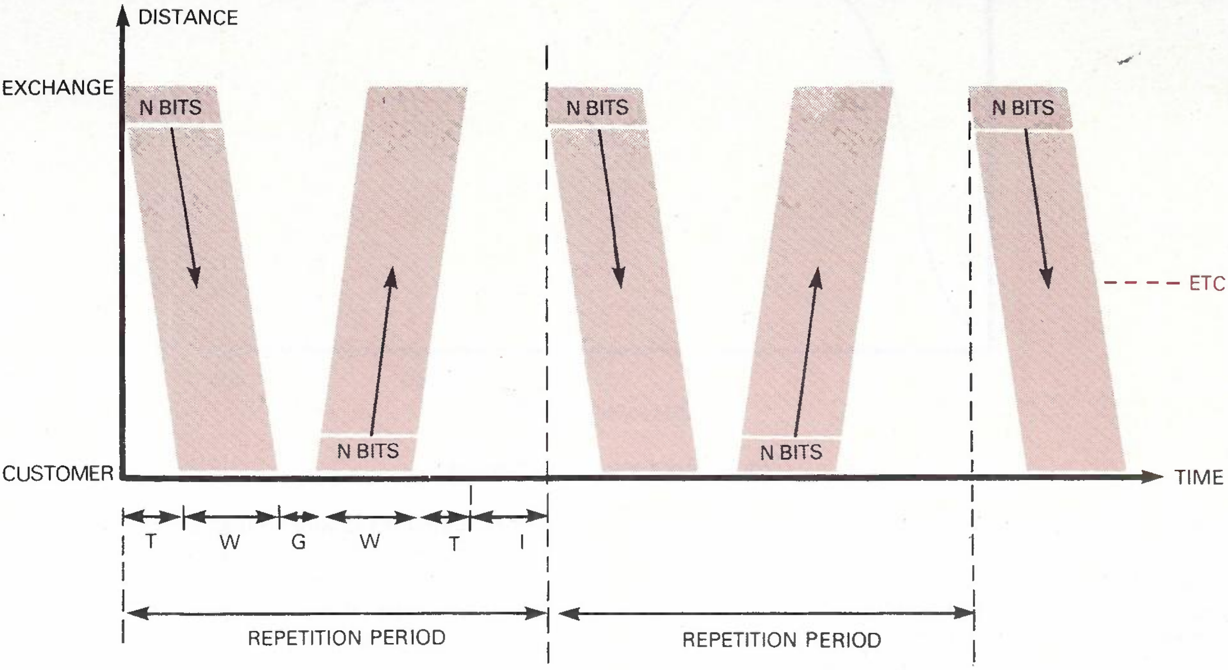


Fig. 3. Burst Transmission

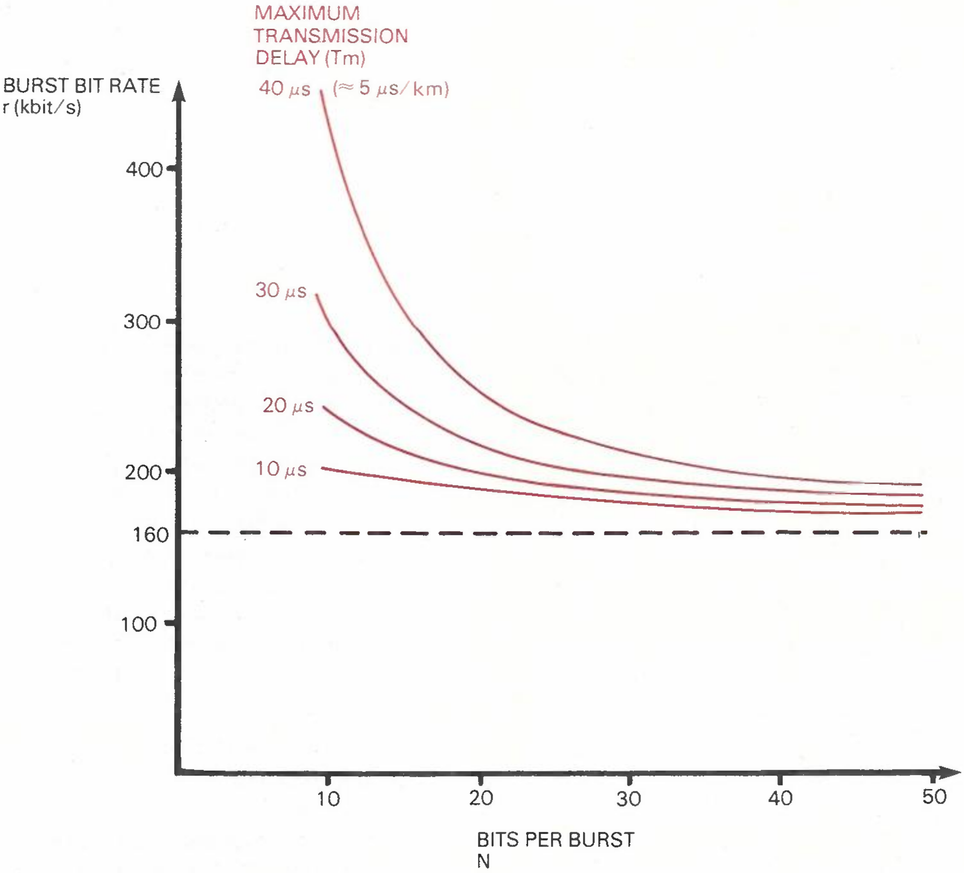


Fig. 4. Maximum Transmission Delay For Burst Transmission

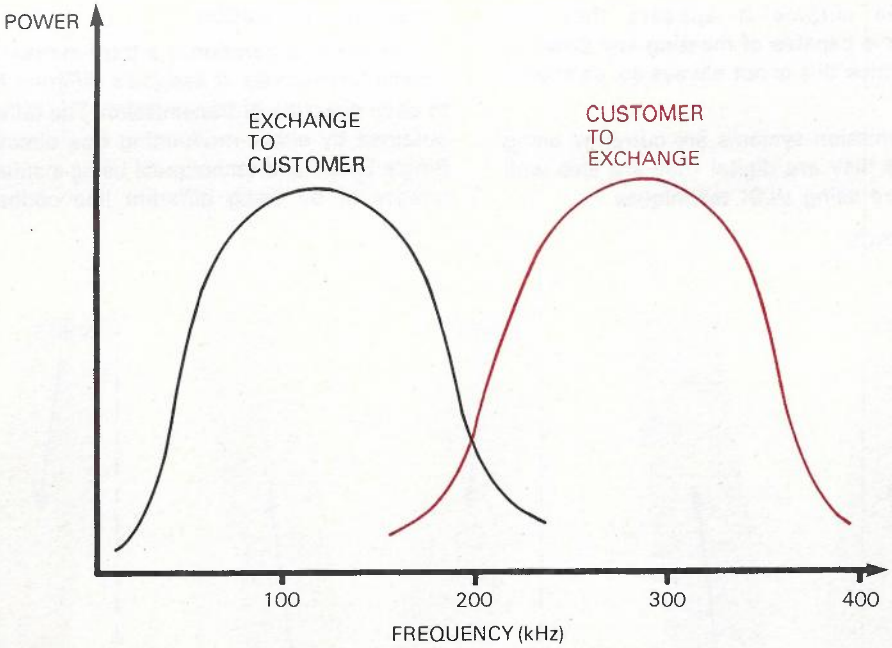


Fig. 5. Frequency Separation

direction with different power spectra. In either case the spectra of the two directions will overlap (**Figure 5**), and because of the variation between transmit and receive levels (up to 40 dB), careful filtering will be required for complete separation. The need for filters which may not be suitable for integration appears to be the reason why comparatively few frequency separation systems are under study.

TRANSMISSION LIMITATIONS

The transmission methods which have been discussed are intended to operate on pair cables at much higher frequencies than those for which the cables were designed. It is therefore essential to examine the limitations on transmission distance imposed by the customers' cable network on these methods. The following eight limitations have been identified and will be examined with respect to their effects on the three main transmission methods.

The limitations are:

- Attenuation,
- Near End Crosstalk (NEXT),
- Far End Crosstalk (FEXT),
- Impulse Noise,
- Multiples (Bridged taps),
- Gauge Changes,
- Compatibility,
- Radio Frequency Interference.

Attenuation

The basic and unavoidable limitation is the attenuation resulting from transmission through a lossy medium. The reduction in signal-to-noise ratio which follows and its manifestation as a reduction in error performance places a maximum value on the gain of equalizers used to counteract the shape of the cable's attenuation/frequency characteristic.

Although attenuation in pair cable is well understood and well documented [20], information on noise levels in customers networks is very limited and only estimates of the attenuation limit are ever quoted. A conservative transmission limit is a line length with an attenuation of 40 dB at the edge of the frequency band used for the transmission method.

Figure 6 illustrates the effect of attenuation on the burst transmission method. This is a plot of burst bit rate (r kbit/s) versus maximum possible transmission delay ($T_m \mu s$) derived from equation (5), assuming G = 0. Two curves have been drawn, one for a 10 bit burst (N = 10) and one for a 20 bit burst (N = 20).

Also plotted are the 40 dB attenuation limits for 0.40 mm and 0.64mm PIUT cables. For these curves, the transmission delay for the distance at which the attenuation reaches 40 dB has been plotted against frequency. This assumes the edge of the frequency band is numerically equal to the bit rate. The points of intersection of the two sets of curves are the maximum distances which can be reached with the particular burst lengths and the particular cable types. Customers' lines are made up of a mixture of cables and the actual attenuation limit is probably somewhere between the two which are shown. It is easy to see, from Figure 6, that the theoretical advantages of gaining extra transmission distance by increasing r or increasing N cannot be fully utilized in a practical network.

Attenuation increases with frequency and therefore the frequency separation method, which requires a wider bandwidth than the other two methods is at a disadvantage in this respect. Conversely echo cancellers require by far the smallest bandwidth of the three and will be least affected.

Near End Crosstalk (NEXT)

Near end crosstalk is the result of electromagnetic coupling between pairs in the same cable. As illustrated in **Figure 7** the disturbing NEXT energy travels in the opposite direction to the disturbing circuit. Near end crosstalk attenuation, NEXTA (dB), is the difference

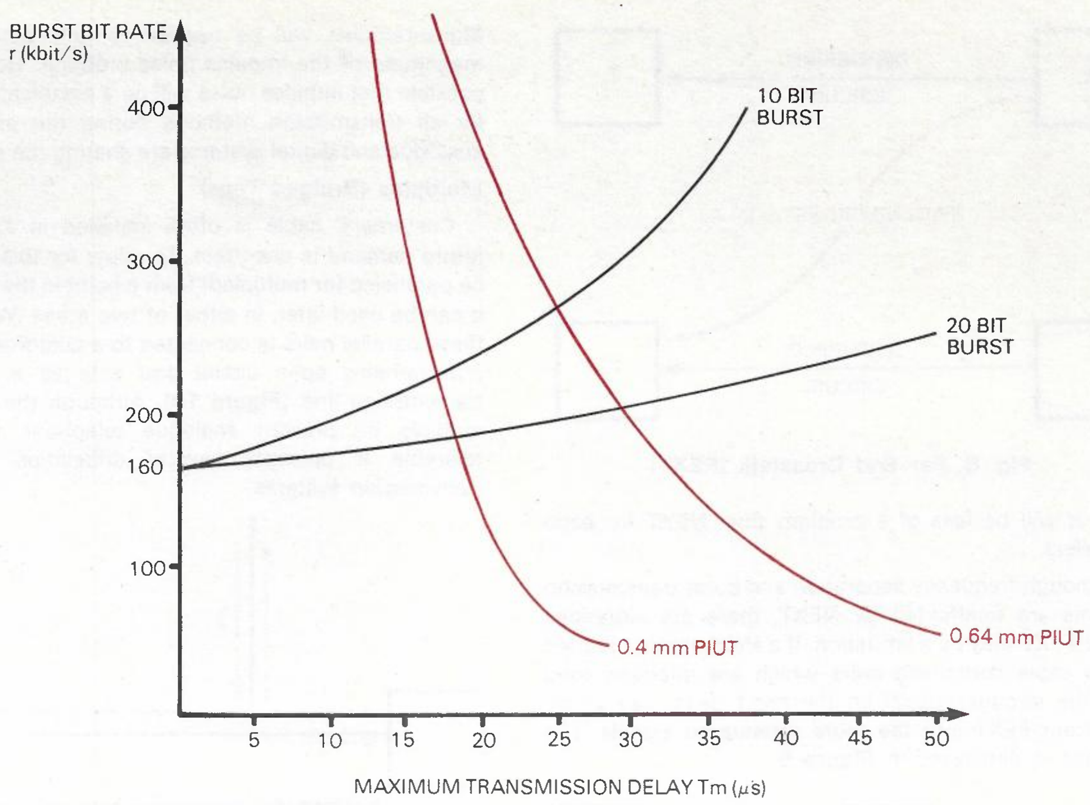


Fig. 6. Effect of Attenuation On Burst Transmission

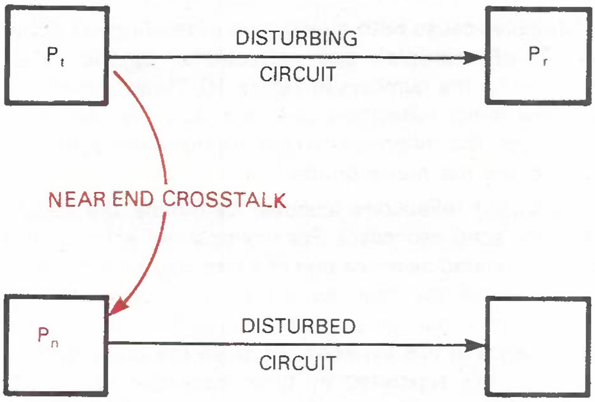


Fig. 7. Near End Crosstalk (NEXT)

between the power transmitted by the disturbing circuit, Pt, and the disturbing power received by the disturbed circuit, Pn, (i.e. NEXTA (dB) = Pt − Pn). NEXT resulting from all the pairs in a cable is a complex problem and can only be treated in statistical terms [21,22]. However it is sufficient to note that NEXTA between any two similar circuits at any one frequency is a random variable with mean m(dB) and standard deviation s(dB). As frequency increases m decreases at ≃15 dB/decade while s remains almost constant. This decrease in m means that the problems caused by NEXT increase with frequency.

Small corrections to NEXTA predictions are necessary because of the effects of reflections from mismatched terminations and discontinuities on the line.

An extensive measurement programme is needed to quantify the levels of NEXT to be found in actual networks, however it is expected to be a limitation for echo cancellers. Since echo cancellers operate simultaneously in both directions, and with both directions in the same frequency band, the disturbing signal will interfere with the desired signal at the receiver. NEXT will not be a limitation for burst transmission since bursts may be synchronised so that all exchange transmitters operate together so no signal will be received when NEXT disturbances are present. NEXT should also not cause problems for frequency separation because different frequency bands are used in each transmission direction.

Far End Crosstalk (FEXT)

Far end crosstalk is also the result of electromagnetic coupling between pairs in the same cable. In this instance the disturbing energy travels in the same direction as the disturbing circuit as shown in **Figure 8.** The far end cross-talk ratio, FEXTR (dB), is the difference between the power level of the desired signal received by the disturbing circuit, Pr, and the disturbing power level received by the disturbed circuit, Pf, (i.e. FEXTR (dB) = Pr − Pf). As was the case with NEXT the FEXT resulting from all the pairs in a cable is a complex problem [21]. The FEXTR between any two similar circuits at any one frequency is a random variable with mean M(dB) and standard deviation S(dB). M decreases ≃20 dB/decade with frequency and 10 dB/decade with length while S remains almost constant. Thus FEXT problems increase both with frequency and length.

FEXTR predictions must also be corrected for the effects of reflections.

Measurements are required to determine the influence of FEXT in the customers' network. However because the disturbing FEXT power is attenuated by the length of the

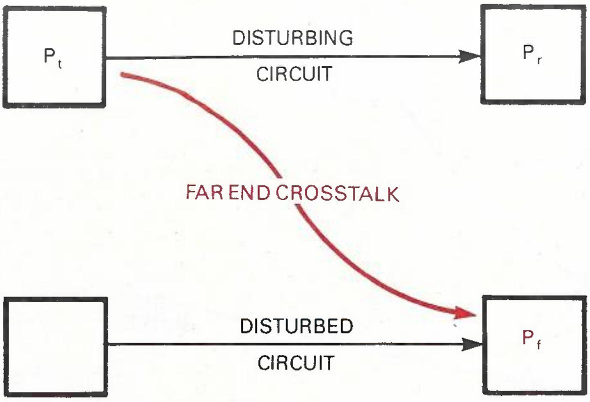


Fig. 8. Far End Crosstalk (FEXT)

cable it will be less of a problem than NEXT for echo cancellers.

Although frequency separation and burst transmission systems are unaffected by NEXT, there are situations where FEXT may be a limitation. If a short cable is jointed into a cable containing pairs which are relatively long then the stronger signal on the short pairs may cause significant FEXT into the more attenuated signals. The situation is illustrated in **Figure 9.**

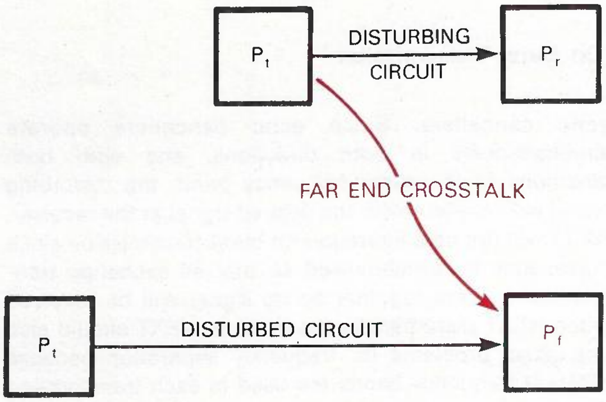


Fig. 9. FEXT From Strong Signal Into Weak Signal

This situation is under study and several solutions which adjust the receive or transmit level or both have been suggested [23].

Impulse Noise

Impulse noise is a result of FEXT and NEXT from switching events at either end of the line. Sources such as dial pulses, reversals and switching of ring tone must be considered. Impulse noise is not a well understood phenomenon but it is known to have a very wide spectrum. The wider the receiver bandwidth the greater the susceptibility of the system will be to impulse noise.

Measurements will be needed to fully determine the magnitude of the impulse noise problem. However it is possible that impulse noise will be a significant limitation for all transmission methods during the period when analogue and digital systems are sharing the same cable.

Multiples (Bridged Taps)

Customers' cable is often installed in areas where future demand is uncertain. To allow for this a pair may be paralleled (or multipled) from a point in the line so that it can be used later, in either of two areas. When one of these parallel pairs is connected to a customer the other arm remains open circuit and acts as a stub on a transmission line (**Figure 10**). Although the effect of a multiple on present analogue telephone systems is tolerable it presents several difficulties for digital transmission systems.

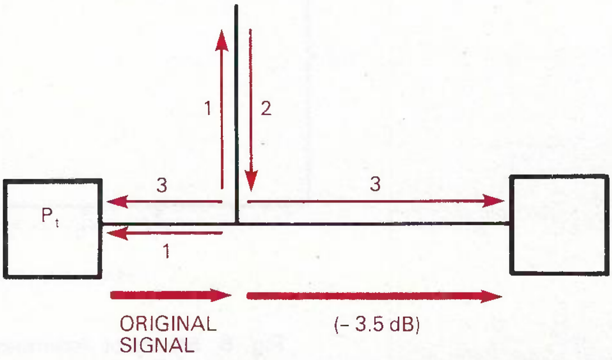


Fig. 10. Reflections From Multiple

Multiples cause both attenuation of the original signal (≃ 3.5 dB/multiple) and reflections, in the order indicated by the numbers in Figure 10. Those shown are only the initial reflections [24] but they are the most significant. The reflections which are both backward and forward are the major problem.

Backward reflections (echoes) determine the design limits for echo cancellers. For example, an echo from a multiple located near one end of a line may be more than 30 dB above the required signal. At least 45 dB of cancellation should be provided to ensure adequate error performance in this situation. Because the burst method directions are separated by time, backward reflections will not be a problem ie the reflections will have died away before they can interfere with a burst from the other end. The magnitude of the reflection may be a difficulty for frequency separation. Although the echo and the desired signal are in different frequency bands, there will be some overlap. This means that the receive filters will require stopbands with very high rejection because of the difference between the transmit and receive levels.

Forward reflections are a problem for all techniques particularly if the length of a multiple approaches that equivalent to half a bit period. The forward reflection will

Bit Rate (kbit/s)	Worst Case length (km)	First Forward Reflection at Point of Multiple (dB)	First Backward Reflection at Point of Multiple (dB)
200	0.5	−12.7	−9.5
80	1.1	−19.5	−9.5

Table 3: Effect of Multiples

then cause the maximum intersymbol interference to the following bits. This worst case problem increases with frequency as shorter multiples become significant with correspondingly less loss. **Table 3** shows the worst case lengths of multiples and the magnitude of the reflections on 0.40 mm PIUT cable. It should be noted that Australia has one of the few networks which contains multiples, and some form of equalization will be required at the receiver to overcome the forward reflections [9].

Gauge Changes

It is common for customers' lines to contain a number of changes in wire gauge (e.g. Table 2). The effect of these discontinuities is to cause backward reflections and a small amount of attenuation. The effect of the reflections is the same as the backward reflections from multiples although the mismatch between the gauges, and consequently the magnitude of the reflections, increases as frequency decreases.

A gauge change from 0.4 mm to 0.90 mm is often found at the customers drop wire and the result of this is a reflection of −14dB for 80 kbit/s transmission. At the end of a 40 dB line, an echo canceller should provide at least 40 dB cancellation to overcome this echo.

Compatability

The NEXT and FEXT problems described previously were a result of many systems of the same type (i.e. the customers digital system) using the same cable, however other transmission systems may use the same cable as the digital systems which have been described. The amount of crosstalk from and into these other systems must also be considered [25]. The maximum output power of the digital subscriber system is controlled by the allowable crosstalk into other systems. Conversely the minimum output power is controlled by the allowable crosstalk power from other systems.

Radio Frequency Interference

The final limitation is radio frequency interference (RFI). This is electromagnetic coupling from external sources into the subscribers line. Potential sources are power lines, train and tram lines and lightning. Problems with long wave broadcasting exist in Europe but not in Australia. It is difficult to assess the magnitude of the RFI problem and measurements are necessary. However exactly what measurements should be made and how to do them is a study in its own right.

THE CUSTOMER'S NETWORK CONNECTION

Providing a digital transmission path between customer and exchange is only part of the task of realizing a digital customers' network. This section of the paper discusses the signalling, control and interfacing aspects of such a network. In particular, support of voice and non-voice services on a digital distribution network requires that:

- information interchange standards be established,
- a versatile customer signalling system be defined,
- equipment interfaces and functions be defined,
- the differing performance requirements for voice and non-voice services be defined,
- methods of interworking between existing networks and an integrated services network be determined, and
- suitable telephone plans for digital parallel and extension telephones be developed.

An overview of CCITT studies related to these topics is given in [26].

Information Interchange

A digital link to the customer allows a totally new scheme for transferring signalling and other information between the customer terminal and exchange to be developed.

Indeed part of the motivation to introduce digital techniques is derived from the substantial improvement in signalling flexibility which may be achieved. In such a network the customer's terminal equipment has the potential of growing into a private network in its own right and signalling to the exchange increases in complexity as a result. Careful design of an information interchange scheme is therefore important and any scheme chosen must be flexible and open-ended.

The following types of information have been identified by the CCITT [27] as needing transmission to the terminal equipment, in order to support the wide range of services that will use an Integrated Services Digital Network (ISDN). The bit rates described refer primarily to the customer bit rate. In the ISDN itself 64 kbit/s is expected to be used as a standard transmission rate for switching or interexchange working.

- **v-information** corresponds to digitally encoded voice, coded for transmission at 64 kbit/s as in present PCM equipment (type v1) or at a submultiple of 64 kbit/s (8, 16 or 32 kbit/s), type v2. A further alternative of high quality voice transmission at 64 kbit/s using new coding rules is foreseen (v3 information type).
- **d-information** includes data transmission at rates up to 64 kbit/s.
- **s-information.** A separate digital channel will be provided on the ISDN customer line to handle control of call set up. s-information refers to the customer signalling information carried on this channel, at rates up to 16 kbit/s.
- **p-information.** Because s-information does not uniformly load the transmission capacity of the signalling channel there will be spare capacity on this channel for low rate data transmission, to be interleaved with signalling information. p-information rates are yet to be defined.
- **w-information** uses a grouping of 64 kbit/s channels, nx64, with n less than 3.
- **u-information** (Wideband information). The signalling arrangements (s-information) for the ISDN service are also expected to control access to wideband service information rates, which will correspond to levels of the PCM hierarchy (for example, 2, 8, 34 or 140 Mbit/s).

In order to simplify the design of transmission equipment the above information types are condensed into a more limited number of channel types. One possible combination of these is as follows:

- B-channel a 64 kbit/s channel, to carry v, d or w-information.
- B′-channel — a channel operating at a submultiple of 64 kbit/s, to carry d or v2 information.
- D (delta) channel — to carry s, p and possibly telemetry information, at 8 or 16 kbit/s.

The B′ channel owes its definition partly to the bit rate limitations expected from 2-wire transmission. Channel types for u-information are not yet defined.

Whilst the above definitions seek to provide a general framework for ISDN service development it must be expected that initial implementations will provide only a particular subset of above channels and information types. As an example, **Figure 11** illustrates one method of providing B, B′ and D channels within an overall 80 kbit/s service rate.

Fig. 11. Possible Framing Format

where

D	The signalling or delta channel carries type s signals and may also carry type p — signals provided that this does not degrade the signalling performance of the channel.
B′	A spare data channel carrying type d or v2 signals.
b1-b8	A basic digital channel carrying type v signals or type d signals.

Customer Signalling

The signals required by the customer (the content of the s-information listed above) depend on the types of services to be carried on the digital connection and have yet to be defined.

Two broad approaches may be taken. The signalling channel may be used to continuously monitor physical contacts such as push buttons or telephone hook states and transfer the raw state information to the exchange for interpretation. Alternatively, the terminal may form messages itself, such as call request and address messages which could be sent on the signalling channel in packet form. It is conceivable that both approaches to signalling could be taken within the one network, thus tailoring signalling complexity to terminal intelligence.

Interface Specification

A multifunction terminal having access to a number of different services (such as telephony, packet switched data, and circuit switched data) introduces a significant increase in terminal complexity. This requires clearly defined interfaces in the local network, to allow existing as well as new equipment from different manufacturers to be used and interchanged in such units as data terminals, digital concentrators, multiplexers and PABXs. The introduction of digital transmission on the customers line gives rise to at least two new functions at the customers premises, namely: network termination and network conversion. At the exchange end a new function, line termination (LT), is provided. **Figure 12** illustrates the proposed interfaces in the customers' network. The definition of these new functional blocks is a matter of continuing international debate through the CCITT.

The line termination (LT) for example contains equipment to support two way digital transmission in the local network. Where this is a two wire network the equipment may support burst mode, digital hybrid or frequency separation methods as previously described. The transmission method, bit alignment and synchronisation methods and coding technique must be totally independent of the signalling formats and other system parameters, in order to allow design of terminal equipment to proceed independently of line transmission equipment. LT also handles power feeding.

At the customers premises Network Termination (NT1) provides line transmission functions similar to those of LT and also provides maintenance functions such as test loops. Network Conversion (NT2) provides functions which may include protocol handling, switching and multiplexing in some cases. The interface labelled S is a proposed interconnect standard for new ISDN services. For existing service types such as X.25 data terminals (DTE) an additional function, that of bit rate and protocol conversion (TA), must be provided.

The definition of functional modules and interfaces, particularly those at the customers premises, is essential to realize the full advantages of an integrated network and to be able to accommodate a range of intelligence in customer terminals.

Performance Requirements

The required network performance for voice and non-voice services is quite different with respect to such parameters as call set up time, delay tolerance, errors and call holding times. Each service may have differing critical parameters and various services may require differing values of the same parameters. As a result the determination of performance objectives for networks and parts of networks (e.g. the customer network) is a complex problem.

Figure 13 shows some of the constraints on an Integrated Network.

Network Interworking

Mention has already been made of the need for an ISDN to interwork with existing networks. An ISDN can be introduced over a period of time once an adequate proportion of the telephony network has been equipped with digital transmission, or could be introduced separately. In the meantime separate networks such as the packet switching data network can be established to meet customers immediate needs for this type of data service. Future decisions would be necessary to determine which services will continue to be served by separate networks and which will be merged into an ISDN.

The need to interwork with existing networks will be a continuing requirement and will have a marked influence on integrated network architecture.

Telephone Plans

The design of a new standard telephone to take advantage of digital transmission in the local network is several years away. Nevertheless some experimental digital telephones are currently in operation and at least one public field trial using digital telephones is already being undertaken.

A number of problems have yet to be adequately solved for the digital telephone. The variety of telephone plans possible with the analogue telephone for extension and parallel working are not so easily implemented for digital telephones. One solution is to implement a digital conference bridge in the telephone. Other approaches

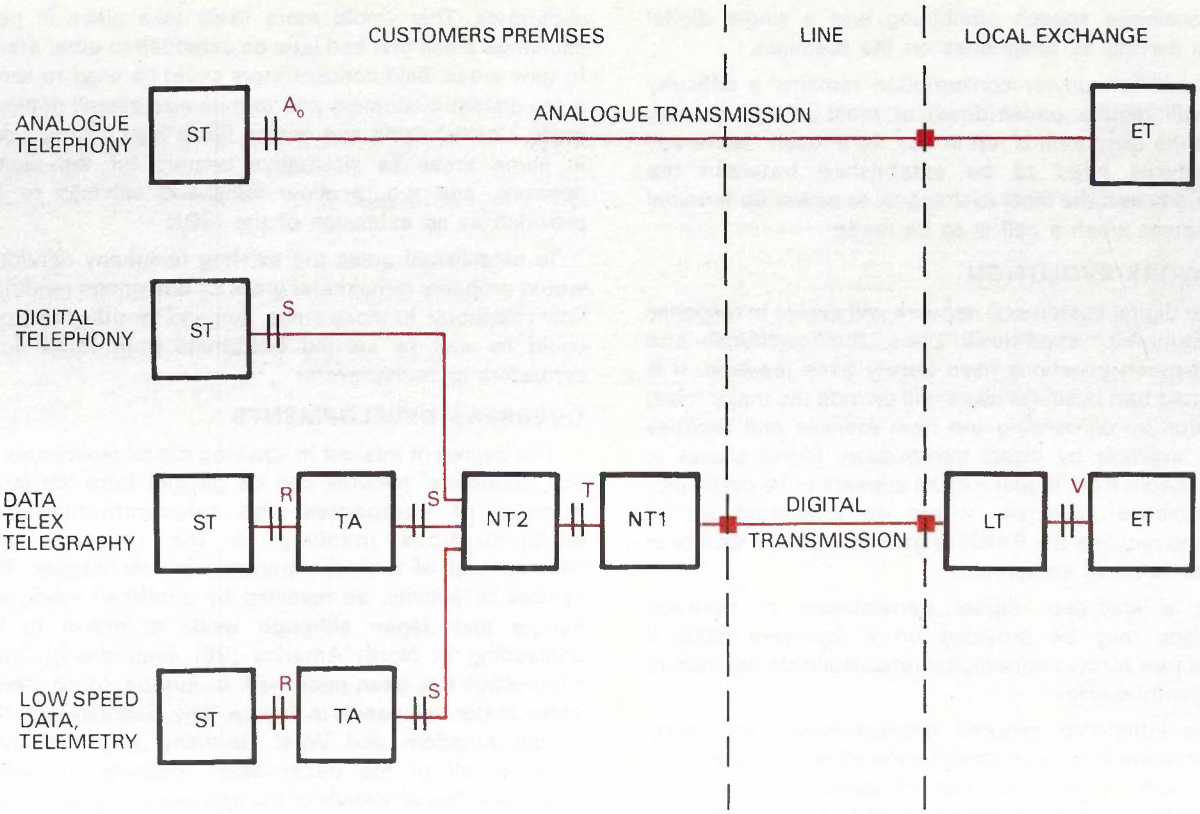
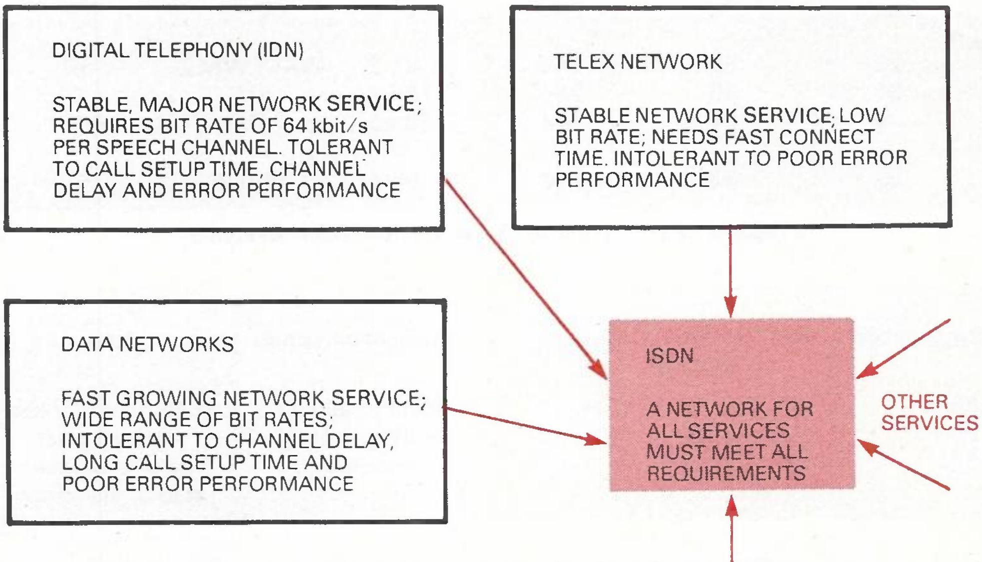


Fig. 12. Interfaces in the Customer's Network

ST — Customer Terminal
LT — Line Transmission Termination function
ET — Customer Line Exchange Termination
NT1 — Network Termination function, including LT functions
NT2 — Network Conversion functions
R — Interface to existing terminals
S — Terminal Interface
T — Network Interface
V — Exchange Interface
Ao — Interface to Analogue phone
TA — Bit Rate and Protocol Conversion


DIGITAL TELEPHONY (IDN)

STABLE, MAJOR NETWORK SERVICE; REQUIRES BIT RATE OF 64 kbit/s PER SPEECH CHANNEL. TOLERANT TO CALL SETUP TIME, CHANNEL DELAY AND ERROR PERFORMANCE

TELEX NETWORK

STABLE NETWORK SERVICE; LOW BIT RATE; NEEDS FAST CONNECT TIME. INTOLERANT TO POOR ERROR PERFORMANCE

DATA NETWORKS

FAST GROWING NETWORK SERVICE; WIDE RANGE OF BIT RATES; INTOLERANT TO CHANNEL DELAY, LONG CALL SETUP TIME AND POOR ERROR PERFORMANCE

ISDN

A NETWORK FOR ALL SERVICES MUST MEET ALL REQUIREMENTS

Fig. 13. Network Requirements To Be Met By An ISDN

use analogue speech combining and a single digital codec serving all telephones on the premises.

In addition power consumption remains a difficulty and will require power-down of most of the circuitry when the telephone is not in use. As a result "wake-up" procedures need to be established between the telephone and the local exchanges, to power up terminal equipment when a call is to be made.

NETWORK EVOLUTION

The digital customers' network will evolve in response to economic conditions once the technical and specification questions have largely been resolved. It is expected that business users will provide the major initial stimulus by demanding the new services and facilities made available by digital transmission. Digital access to the network from digital PABXs appears to be particularly attractive especially where an integrated set of services requires the PABX to gain access to a variety of distant terminal equipment.

As a stop-gap, digital transmission to business premises may be provided on a four-wire basis if techniques for two-wire digital reticulation do not mature sufficiently quickly.

The integrated services network based on digital transmission in the customer's network would most likely begin with a small number of services with access provided to packet-switched and other data networks via gateway exchanges.

Such a network could grow using multiplexers and concentrators in local exchange buildings until an initial potential market was satisfied. A telecommunications administration might then take a series of decisions to transfer services to the new network and gradually dismantle existing separate networks.

Integration of network services will take place over an extended time period. At a later stage, digital telephony and data based services would be offered to residential customers. This would more likely take place in new exchange areas first and later be extended to other areas. In new areas, field concentrators could be used to serve more distant customers and to minimize overall network costs. Coaxial cable and optical fibres may also be used in some areas as alternative bearers for the digital network, and would allow wideband services to be provided as an extension of the ISDN.

In established areas the existing telephony network would probably remain and grow for customers requiring only telephony. In these areas, demand for other services could be met by serving customers from ISDN concentrators or multiplexers.

OVERSEAS DEVELOPMENTS

The degree of interest in applying digital techniques to the customers' network can be gauged from the large number of companies and telecommunications administrations involved in the research and development of two-wire transmission techniques. The centres of activity, as revealed by published work, are Europe and Japan although work is known to be proceeding in North America [28] even though little information has been published. In Europe, more than a dozen major companies in France, Italy, Scandanavia, the United Kingdom and West Germany are developing some or all of the transmission methods discussed previously. Not all details of the systems being developed have been revealed however**Tables 4 and 5** give the major parameters of some of the systems. The relative number of burst systems (5) and echo cancellers (3) shown in the Tables is an indication of the popularity of the two techniques at this time. This, in turn, is indicative of the only recent upsurge of interest in echo cancellers and it is possible that the balance may alter.

As can be seen from the tables there is a large variation in the system parameters. This suggests that at this early stage of development there is no clear indication to the final solution and a range of techniques

Organisation	Ref.	Input Rate (kbit/s)	Burst Rate (kbit/s)	Burst Length (bits)	Line Code [29, 30]	Delay Limit (km)	Attenuation Limit
SAT	8	80	256	96+4	5B-6B	17	40 dB at 60 kHz
CSELT	12	80	240	8+2	WAL1,WAL2	4	Not given
Siemens	31	80	256	16+2	AMI	7.5	Not given
ECL	9	64	144	128+2	AMI	5.5	46 dB at 72 kHz
GEC	32	88	256	8+4	WAL2	3	Not given

Table 4: Parameters of Burst Transmission Systems

Organisation	Ref.	Input Rate (kbit/s)	Line Code [29, 30]	Attenuation Limit	Note
Philips	33	96	WAL2	40 dB at 96 kHz	EBN canceller has created great interest because of ease of realization.
EBN	34	80	Diphase	40 dB at 80 kHz	
SEL	35	80	AMI	not given	

Table 5: Parameters of Echo Canceller Systems

and parameters may be needed to provide adequate coverage.

Concurrently with the development of transmission methods, administrations in at least six countries (France, Denmark, Italy, Sweden, West Germany and the United Kingdom) are conducting or sponsoring extensive field trials. These will use either specially designed test networks or selected subscriber lines in the actual networks. They will include trials of transmission, switching and terminal equipment as well as measurements aimed at characterizing the cable networks with respect to the limitations outlined previously. It is expected that some of the results from these trials will be published in the near future.

CONCLUSION

Completion of the digital connection to the customer offers significant opportunities to improve telecommunications services in Australia and to contain the costs of separate network development. Amongst the questions yet to be answered are the definition of suitable interfaces in the local network; definition of an adequate signalling scheme; methods of providing the variety of telephone plans now available with analogue telephones; and the selection of transmission techniques suited to the Australian distribution network. In view of current plans to provide a separate Digital Data Network and a packet switching data network (AUSTPAC) in Australia, considerable planning will be needed to ensure that the development of an Integrated Services Digital Network is compatible with those plans and with the future development of the telephony network.

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In Brief

INTRODUCTION OF AXB20 TELEX EXCHANGES INTO THE AUSTRALIAN NETWORK

The L. M. Ericsson Stored Program Controlled (SPC) AXB20 telex system has been selected by Telecom Australia to provide for the future expansion of the Australian telex network. The initial field exchange will be commissioned, in Melbourne, early in 1982. Further exchanges are scheduled for commissioning in Brisbane and Sydney during 1983/84. Studies are also being conducted to determine when AXB20 exchanges should be provided in Adelaide and Perth.

The technology of the AXB system is the same as that of the AXE system ie. the mechanical design, central processor unit, installation engineering, and language of the system software is basically identical.

The AXB20 system is a significant advance over the present ARB/ARM crossbar switching system in that it is electronic, has stored program control, and utilises a solid state digital switchblock providing for both customer and trunk terminations. The switchblock provides a full availability non-blocking switching path between any two bothway inlets. It is expected that each exchange will cater for in excess of 20,000 customers. Considerable exchange floor space savings are also achieved since the system is much more compact than the existing electro-mechanical crossbar system.

The introduction of the AXB20 system makes possible significant improvements in present customers facilities, such as the automation of handling conference/broadcast calls, and the introduction of some new facilities such as "Call Duration Advice" (CDA), ie. chargeable time on clearing, and automatic insertion of date and time.

The automatic conference/broadcast facility will be made available to all national telex customers, after the Melbourne AXB20 exchange is commissioned. Customers using the automatic conference/broadcast facility can obtain access to the "Group Address Facility". They can also obtain access to "CDA" and "time and date" when using the conference/broadcast facility.

The "Group Address Facility" greatly simplifies the setting up of a conference or broadcast call by the customer. The customer can call up to 16 "B" parties using a simple code, eg. G1, instead of entering the wanted numbers one at a time. The system can automatically verify that all called numbers are available or inform the calling party of those unavailable, before connection takes place.

The growth of the Australian telex network, since its introduction in 1966, now requires that 6 digit numbering be introduced as the availability of numbers in the 5 digit ranges is becoming critical in some States. All customers directly connected to AXB20 exchanges will have a six digit number commencing with the digit 1 eg. Victorian number ranges 13XXXX and 15XXXX will apply to customers connected to the Melbourne AXB20 exchange. The introduction of 6 digit working for ARB/ARM exchanges is not necessary, or planned, at this time.

All manual assistance traffic will still be handled by the existing manual assistance centres. A manual assistance facility is available with the system but it has not been purchased at this time.

The AXB20 system provides other features which will assist in improving service to all customers in the telex network. The system provides automatic supervision of signalling and transmission on all calls passing through the exchange. Alarms are printed out in the exchange whenever set limits are exceeded. Therefore the service experienced by customers on local, incoming and transit calls is continuously monitored.

The system regenerates all signals passing through it. This will enable the relaxation of some transmission limits, insofar as customers connected to the AXB20 exchange are concerned.

The reliability and maintainability of the system is improved by duplication of the common control and switching equipment down to the customer interface level. On line diagnostic programs continuously check the exchange switching performance. Any malfunction of the equipment causes automatic removal of the faulty equipment from service and, if necessary, a changeover to the standby side of the system.

No further ARB/ARM equipment will be installed in States that have an AXB20 exchange commissioned, ie. all future expansion of capacity in the particular State will be taken up using AXB20 type equipment.

It is not intended that AXB20 will replace existing ARB/ARM installations in the near future. The intention is to provide new facilities to existing ARB/ARM customers via AXB20 exchanges. Appropriate charges will be applied for the use of new facilities not presently available in the existing network.

Telephone Transmission Quality: Customers' Opinions. Part 1.

R. G. KITCHENN B.Sc(Eng.), C.Eng., M.I.E.E. and R. P. KILLEY B.E.E.

Part 1 of this paper describes the design, conduct and results of a sampling experiment involving more than 3000 volunteer telephone customers in greater Melbourne. Customers' opinions were solicited about the transmission quality of the telephone connections over which they were interviewed. Correlation of opinions with the known transmission conditions for each connection yielded 'laws' by which customers' opinions could be predicted, given the overall reference equivalent of the connection and the line-noise level experienced by the customer. Part 2 describes how the 'laws' were applied to realistic models.

TRANSMISSION — OBJECTIVE AND SUBJECTIVE

The wide range of telephone facilities already technically and economically available (and the promise of more in the future) perhaps tends to over-shadow the ultimate and essential requirement of a telephone customer: the ability to converse easily with another telephone customer. No matter what other electronic magic he can command, the customer's satisfaction with his telephone service will always be dominated by its ability to provide effortless exchange of voice messages.

It is necessary, therefore, for a telephone administration to know the relationship between the objectively measurable (calculable) performance of its telephone network and the opinions of customers about that performance. This is a statistical relationship, in that the range of transmission conditions experienced by customers is rather large, and a given transmission condition may elicit a wide range of opinions over many customers. Moreover, customers' opinions will vary with time: Opinions will depend on customers' expectations, and expectations are influenced by related developments in society. An increase in the level of customers' expectations may occur with the passage of years.

Australian laboratory experiments in 1966 (Ref. 1) examined the effect of changing loss alone, with fixed line and room noise, and concluded

- that the received speech volume yielded by the Australian limiting telephone connection of about 33dB overall reference equivalent (ORE) would be rated as 'too faint' by more than 80% of telephone users, and
- there was a preferred ORE of about 9dB.

Data from these experiments were incorporated into telephone network models to yield estimates of customers' adverse opinions under current and possible future planning rules (Ref. 2).

These studies did not explore the combined effects of transmission loss and noise, but in the past decade, much work has been done internationally to determine the subjective results of these principal (and other) determinants of satisfactory performance, notably in the USA (eg. Refs. 3,4) and the UK (eg. Refs. 5,6). These studies included laboratory experiments and call-back interviews to administrations' employees on their business extension telephones. No tests are known in which the opinions of 'real' customers, speaking on their own telephones, were sought during a conversation or a test connection; it was therefore decided to conduct such tests, to obtain the opinions of Australian telephone subscribers.

TOWARDS A PILOT STUDY

The decision to go beyond laboratory simulations and to seek the required planning data through field tests was made to encompass a wider range of telephoning experience and skills, more realistic ambient noise conditions and if possible an exposure to a sample of the personal distractions and stress conditions that sometimes apply in real telephoning situations. It was of course realised that a substantial sample size would be needed and that there would be many practical difficulties.

In view of the extensive alternative-routing used in the Australian network it was decided that the test calls would need to be placed by interviewers located at the customers' terminal exchanges. In placing their calls the interviewers would use equipment which would provide simulations for the calling party and junction-plant components of the test connections. The test connections would then be extended through the terminal exchange and over the customer's line to the telephone at the customers' residential or business location.

Each interview would concern only one (loss/noise) transmission condition, would last about ten minutes and would follow a structured format. Prior to the interview each participating customer would receive a sealed booklet containing a set of questions with multi-choice answers. The interviewer's role would be complex in that he/she would need to provide the spoken material on which the customers' assessment would be made, encourage participation and understanding and record the results of the test. (In fact, the interviewers would also be called upon to give their own opinion of each test situation). The method would therefore provide clearly presented written material for the customer's consideration, the direct involvement of both the interviewer and the customer and the availability of a telephone channel for the rapid and positive return of the replies. It would consequently include aspects of both telephoned and mailed market-research-interview techniques with the unusual feature that the quality of the interviewer's telephone call would be the subject being researched.

In view of these complexities and the highly statistical nature of the overall problem, it was decided firstly to conduct an in-house pilot study to test both the feasibility of the scheme and various detailed aspects of the technique. A consideration of anticipated variance indicated that the actual project would require a sample of 3000 interviews and it was decided to proceed with a pilot study of one-tenth of this size.

Three hundred participants for the pilot study were obtained through a random selection from the employees connected to the Telecom Australia Headquarters PABX. This PABX (03 - 630 XXXX) is located in the Russell telephone exchange building and serves extensions in some fifteen buildings throughout the Melbourne Central Business District. The pilot study was conducted late in 1977 and details of it were submitted to CCITT Study Group XXII in May 1978 (Ref. 7).

The pilot study gave a clear indication that the method was essentially sound and that a full-scale study would produce worthwhile results. Many detailed operating aspects were tested during the pilot study and particular checks were made for sensitivity towards different interviewers and different methods of presenting the question material in the issued booklets. As part of the assessment procedure, an observer was posted at the "customer's end" during 50 of the interviews. Two interesting results from his observations are shown in **Tables 1 and 2.**

CONDUCTING THE SURVEY

General

The achievement of some 3000 interviews over test connections to volunteer customers located in their homes or places of business necessitated detailed

RON G. KITCHENN (right) graduated from London University in 1948, during his service in the Engineer-in-Chief's Office of the United Kingdom Post Office, where his main experience was in the development, installation and maintenance of transmission-related plant, and as a lecturer.

Joining the Australian Post Office in 1951, he spent four years in N.S.W. associated with broadcasting transmitters and studios.

Headquarters service has included work in radiocommunications and h.f. broadcasting, in the trunk aspects of systems planning, and, since 1960, in transmission planning aspects of the national network. At the time of the work described in this paper, he was responsible for the determination of transmission performance objectives for Telecom Australia services. At the request of the Australian National Commission for UNESCO, he served the 1973/74 biennium on the latter's specialist Education Committee.

He is a past contributor to the Journal and to the work of the C.C.I.T.T., for which he has been Special Rapporteur for studies on the transmission characteristics of circuits in the switched international network and on stability, echo and noise. He was Vice-Chairman of C.C.I.T.T. Study Group XVI for the 1976-79 study period, and will retire from Telecom Australia in mid-1982.

RUSSELL KILLEY (left) joined the Australian Post Office as a Cadet Engineer in 1951. After graduating at the University of Melbourne as a Bachelor of Electrical Engineering in 1954 he worked in a number of planning, construction and operational areas in the Victorian Administration. In 1973 he transferred to the Transmission Planning Branch at Headquarters where he was concerned with the development of transmission performance objectives for the national telephone network. He is currently an Engineer class 4 with the Transmission Network Design Branch of the Development Division, Headquarters.

Noise level dB (A)		Percent in this class
Less than	40	6
	40 - 44	40
	45 - 49	26
	50 - 54	18
Greater than	54	10

Table 1 — Customer's Ambient Noise Level — Pilot Study

Observer's opinion of handset position	Percent in this class
Satisfactory for speaking and listening	32
Unsatisfactory for speaking/ satisfactory for listening	18
Satisfactory for speaking/ unsatisfactory for listening	12
Unsatisfactory for speaking and listening	28

Table 2 — Customers' Handset Position — Pilot Study

attention to many points. Of these, four stood out as key items:

- — the recruitment of the volunteer customers
- — the selection and training of the interviewers
- — the design and construction of the test equipment and
- — the design of the "multi-choice" questionnaire booklet.

The Volunteers

Several alternative arrangements for different parts of the project were considered but in each case it was apparent that the design of the project would be heavily influenced by the solution chosen for the first of the four key items — the recruitment of the volunteers. Consideration of the public relations aspect was obviously important and led to a decision that the potential participants would be indeed volunteers and would generally not be directly solicited by mail or telephone. After considering a number of alternatives it was decided to tie the recruitment of the volunteers to a field promotion of modern telephone instruments and other terminal equipment. This would result in a sharing of the costs while the attractions of the promotional display could be used to obtain the interest of potential volunteers.

Fig. 1 — Promotional Display and Recruitment Centre

The equipment used for the promotional display and recruitment centre is shown in **Figure 1.** The large walk-through caravan contained the display of terminal equipment and included facilities for processing sales and other inquiries. As indicated by the sign on its roof the smaller caravan was used for the Telephone Call Survey. It will be noticed that the arrangement shown in **Figure 1** also included a free-standing explanatory sign **Figure 2.**

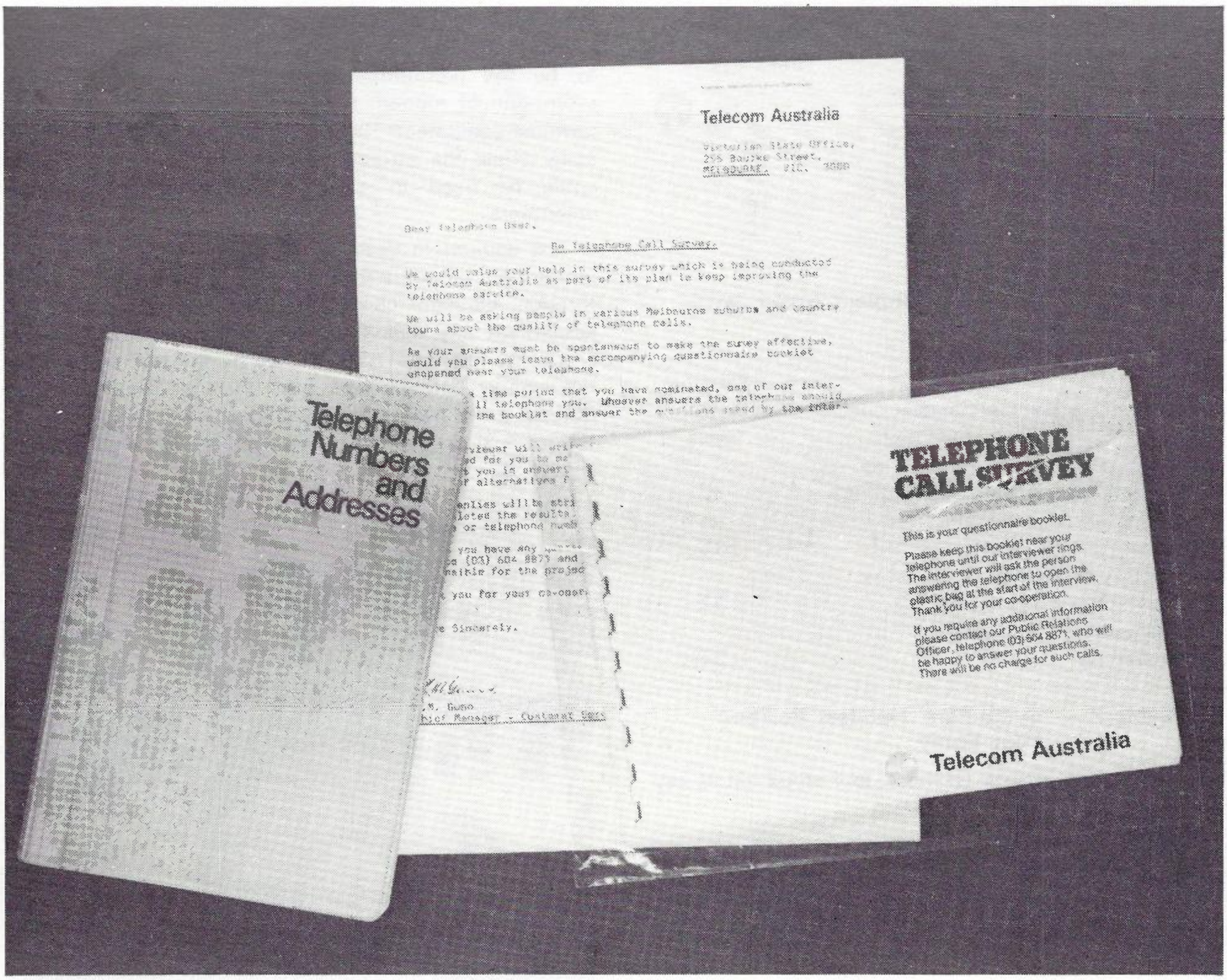
Fig. 2 — Volunteer-Recruitment Sign

Volunteers' details were recorded at the smaller caravan and they were given the material shown in **Figure 3**. This consisted of:

- an explanatory letter.
- the questionnaire booklet in a sealed envelope.
- the gift — a presentable and useful Telephone Numbers and Addresses book.

The promotional display and recruitment centre was set up for approximately a week at a time at each of nine shopping centres in the greater Melbourne area. The nine locations were chosen to achieve a balanced socio-economic coverage. In order to obtain an increase in the business and industrial content of the survey, permission was obtained to undertake some limited direct soliciting in these particular areas.

As indicated on the cover of the questionnaire booklet, the actual interviews were not necessarily conducted with the household representative volunteering at the recruitment centre but rather with the person who happened to answer the telephone when the call was placed. In an attempt to increase the probability of including participants who worked during office hours the



This is your questionnaire booklet.

Please keep this booklet near your telephone until our interviewer rings. The interviewer will ask the person answering the telephone to open the plastic bag at the start of the interview. Thank you for your co-operation.

If you require any additional information please contact our Public Relations Officer, telephone (03) 604 8871, who will be happy to answer your questions. There will be no charge for such calls.

Fig. 3 — Volunteer's Survey kit

tests that were made to residential locations were placed between 1 pm and 9 pm.

The Interviewers

As mentioned, the interviews' role was a complex one. In fact, it was realised at an early stage that the success of the survey would be heavily dependent on the quality of the interviewing. Although the body of the interview was structured, the introductory phase allowed ample scope for the interviewer to apply his/her skill in establishing pleasant and co-operative contact with the customer. In addition to their attention to the points mentioned earlier, the interviewers were required to carefully control both their diction and the manner in which they held their telephone handsets.

In view of its importance it was decided to contract the interviewing component of the project to a firm of market-research consultants employing professional telephone interviewers. As a consequence, the training requirement was achieved through a relatively simple familiarisation exercise of mock-up interviews.

The Test Equipment

The test calls were placed from the customers' terminal exchange using equipment that simulated the calling party and junction plant components of the connections. The extent of the simulated and real components of each test connection is shown in **Figure 4a.**

The possibility of selecting participants having subscriber-lines of a common cable-gauge (at each exchange) was considered. This would have allowed a simple line-current measurement to obtain the information needed to determine the customer's send reference equivalent (SRE) and receive reference equivalent (RRE). However, the decision to obtain the participants in the manner described earlier precluded this approach, and it was necessary to obtain the customer's line details (gauges and distances) for each interview from office records. The determination of the type of telephone instrument at the customer's end was achieved by asking the customer to make an identification from a series of sketches which were included in the questionnaire booklet.

The general arrangement of the test equipment in an interview connection is shown in **Figure 4b.** It will be seen that the interviewer's console provides for a choice from two calling-party subscriber-lines (zero and limit-length artificial-line), a choice from five simulations of junction-cable loss and from three values of line noise (a total of 30 combinations). The selection of a set of parameters (calling-party line, junction loss and line noise) occurred automatically each time a call was

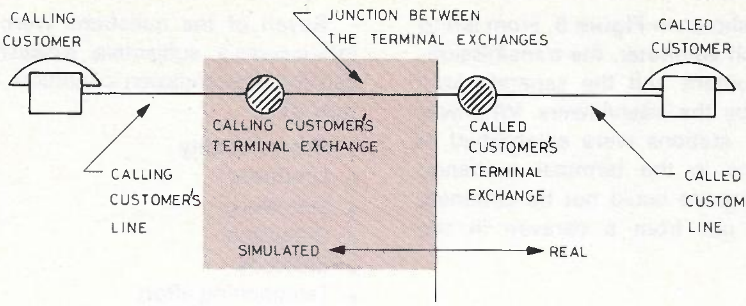
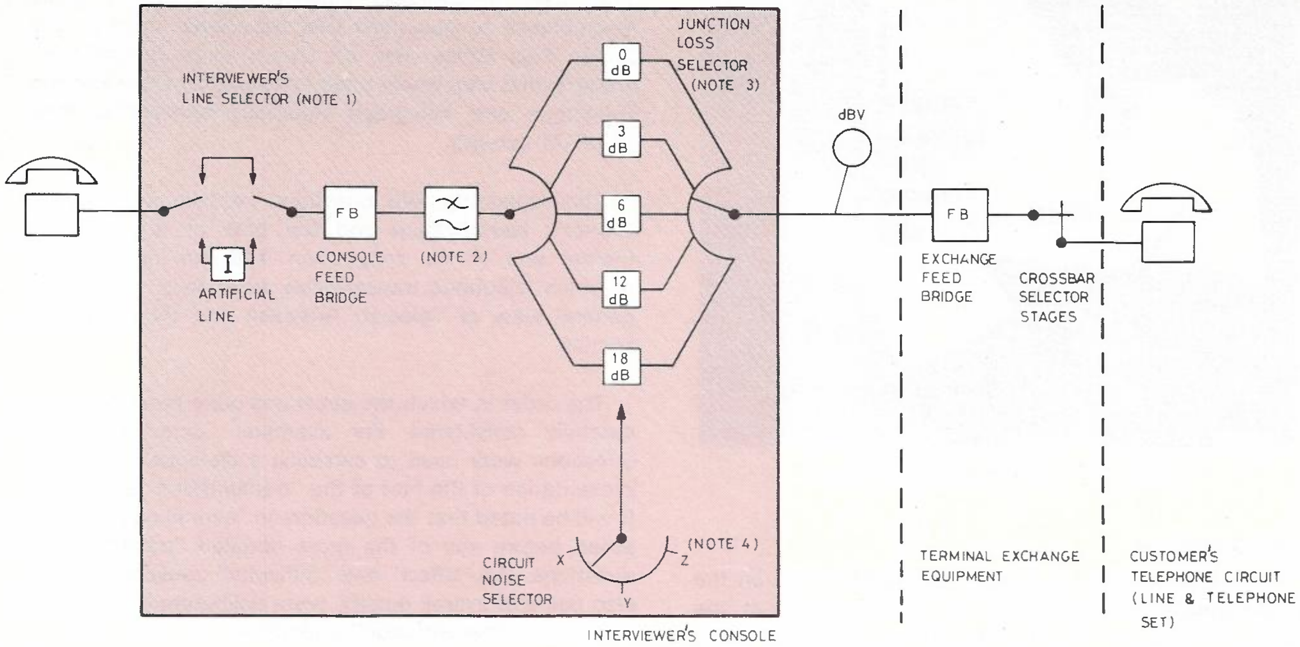


FIG 4(a) EXTENT OF THE SIMULATION.



NOTES

1. INTERVIEWER'S LINE SELECTION: ZERO LINE OR ARTIFICIAL LINE (1150 OHMS 0·4mm UNLOADED - 273 OHM/km, 45nF/km).
2. LOW PASS FILTER: SIMULATION OF ATTENUATION/FREQUENCY DISTORTION OF 0·64mm JUNCTION CIRCUIT (LOADED 88mH AT 1830m SPACING).
3. JUNCTION LOSS SELECTION: 1200 OHM ATTENUATOR PADS.
4. CIRCUIT NOISE SELECTION: WHITE NOISE, BAND LIMITED 0·3 - 3·4 kHz, THE CONDITIONS X, Y, AND Z CORRESPOND TO NOMINAL NOISE LEVELS OF -70 dBmp, -60 dBmp, AND -50 dBmp AT THE TERMINAL EXCHANGE FEED BRIDGE.

FIG 4(b) DETAILS OF INTERVIEW CONNECTION.

Fig. 4 — Simulated Connection

placed. The selection was pseudo-random with an allowance made for the expected distribution of customers' RRE and was aimed at achieving a uniform distribution of ORE. In order to avoid the possibility of bias during the interview (and as the interviewers' opinions of the transmission conditions were sought) the numerical display indicating the selected combination of parameters was not illuminated until the call was terminated. As shown in Figure 4b, each console included a calling-party feed-bridge and a low-pass filter to simulate the attenuation/frequency distortion of loaded junction cable. The interviewer's telephone had a standard 802-type circuit and handset.

Measurements were made of the customers' speech-voltage levels at the terminal exchange. These measurements were made using the British Post Office Speech Voltmeter Type 5B Mark II (Ref. 8). A locally designed directional-coupling device was developed from an earlier design (Ref. 9) to allow the use of this voltmeter at a two-wire terminal exchange. Two speech voltmeters were kindly lent to the Commission for the survey by the British Post Office Research Department. A further two instruments were built-up by our Research Laboratories from information provided by the British Post Office.

In order to allow test calls to be placed simultaneously from several exchanges four interviewers' consoles were constructed by the Telecom Workshops. An example of an interviewer's station is shown in **Figure 5.** From left to right this shows the speech voltmeter, the transmission-parameter selection equipment and the separate key-pad/telephone unit used by the interviewers. Wherever possible the interviewers' stations were established in reasonably quiet locations in the terminal exchange buildings. Where suitable space could not be obtained, the testing was carried out from a caravan in the exchange yard.

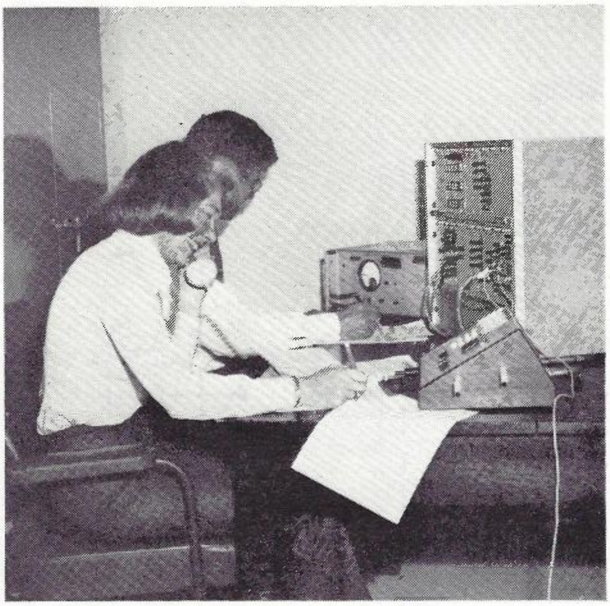


Fig. 5 — Interviewer's Station

The Questions

The structured part of each interview centred on the questionnaire booklet given to the volunteers at the recruitment centre. This was issued in a sealed but transparent envelope, with a view to making the responses more spontaneous than would have been the case if the questions had been previously studied. In the event, the interviewers believed that the envelopes were being genuinely opened for the first time in about 80% of cases. The notes that were visible on the cover of the sealed booklet asked that it be placed near the telephone ready for the interviewer's call. A note inside the booklet assured the participants of anonymity.

The booklet contained seventeen questions. Eight of these were sought to establish a profile of the interviewee and his/her environment. They covered:

- Occupation
- Age and sex
- Details of any hearing difficulty and hearing-aid usage.
- The interviewee's opinion of the strength of his/her telephoning voice.
- Location — residential, business etc., individual office, large office etc.
- Room noise — interviewee's opinion of level and source.
- Telephone usage on local, trunk and overseas calls.
- Lifestyle — interviewee's opinion of his/her social standing.

A summary of the responses to several of these questions is set out in **Annex 1**.

Seven of the questions were used to establish the interviewee's subjective assessment of the randomly selected transmission condition. These were directed in turn at:

- Overall quality
- Loudness
- Line Noise
- Distortion
- Sidetone
- Telephoning effort
- Telephoning Difficulty

Details of the first two and the last of these topics are given in a following Section. In many cases these questions were closely related to questions that have been used in overseas studies. Many bear a close resemblance to questions that have been used by the British Post Office (Ref. 6). Others were derived from material that was kindly made available by the American Telephone and Telegraph Company concerning their TELSAM surveys.

The remaining two questions concerned the interviewer's identification and the type of telephone at his/her end of the connection, and the interviewee's previous telephone transmission experience and his/her general view of Telecom Australia and the telephone service.

The order in which the questions were presented was carefully considered. For example, "personal-profile" questions were used to establish a dialogue before the presentation of the first of the "transmission" questions. It will be noted that the question on "overall quality" was asked before any of the more detailed "transmission" questions. The "effort" and "difficulty" questions, which also concern overall quality, were deliberately put at the end of the "transmission" questions.

The Data

In addition to the four key-items mentioned earlier, particular attention had to be given to the collection of the data obtained during the survey. From the recording viewpoint each test progressed through four steps:

— the signing-on at the recruitment centre.
— the actual telephoned interview.
— the speech-level measurement during the interview.
— the subsequent record-search for the subscriber-line details.

Forms prepared for each of these steps were stapled together as the information was built-up. Each test-call consequently led to a single assembly of papers ready for direct conversion to an 80-column punched card. The make-up and application of these cards is discussed later and in **Annex 2.**

The simultaneous generation of forms at the shopping-centre recruitment point and at up to three terminal-exchange testing centres called for the continuous services of a courier. The assembly of the forms was arranged so that the dissociation of the original recruitment sheet could be taken as a final step to achieve the promised degree of anonymity.

PROCESSING THE DATA

General

The data for each interview were coded as an 80-digit entry in a file 'RECOD' as described in Annex 2.

Subsequent processing yielded a file 'OUTPUT' **(Annex 3)** which recorded for each interview calculated values of:

- SRE, RRE of customer's subscriber circuit
- ORE in each direction
- noise level at each end
- impedance-mismatch losses
- 'junction' loudness loss
- customer's speech level while active.

For the three questions considered in this article, further processing correlated customers' opinions from 'RECOD' and the derived results from 'OUTPUT'. For each multi-choice question this yielded the percentages of opinions attributable to each 4dB cell of ORE. For example, for the question 'How good?', which had five possible responses, the result for the 163 customers represented in the 4dB cell centred on 20dB ORE with a noise level of -59dBmp(0) was:

Excellent	:	19.6% E
Good	:	49.1% G
Fair	:	21.5% F
Poor	:	8.6% P
Intolerable	:	1.2% I

Manipulation of such figures allowed coarser classifications to be examined as a function of ORE and noise; for example, per cent poor-plus-intolerable (% (P+I) : 9.8% in the above example).

Reference Equivalents

'True' reference equivalents, which are measures of sending, receiving and overall loudness performance, are determinable only by protracted subjective tests in a laboratory situation (Refs. 10,11).

In this survey it was necesary to assign SRE and RRE to each sample subscriber circuit and to each interviewer's telephone circuit; then to take account of the inserted loss and derive a 'summed' overall reference equivalent (SORE) in each direction of transmission.

'True' reference equivalents were known for the 300- and 800- type telephones (Ref. 12) and objective laboratory tests enabled estimated values to be assigned to other telephones. These data enabled the nominal zero-line values of SRE and RRE of all telephones to be expressed as a function of direct feed current:

$$\text{SRE} = (A + BI + CI^2)\ \text{dB}$$
$$\text{RRE} = (D + EI)\ \text{dB}$$

where A, B, C, D and E were constants for a particular type of telephone (for average-efficiency transducers) and I was the feed current in mA.

The volume performance of the four interviewers' telephone sets and feed circuits were each measured objectively. These had a known feed current under all test connections, so each could be assigned fixed values of SRE and RRE.

The 'reference equivalent' or loudness loss of each of the randomly-chosen simulated interexchange circuits was calculated as a function of its measured performance at 14 frequencies by the method described in Ref. 13.

The SORE in each direction was then calculated as the sum of the respective SRE, RRE and line loudness loss, plus correction factors which accounted for impedance mismatches at the interfaces between subscriber and simulated interexchange circuits.

Noise

Three values of noise level at 10 dB intervals were applied at the mid-point of each simulated interexchange circuit; thus a common noise signal appeared at each end of the test connection. For convenience in relating to similar international data, the noise level at each end had to be expressed in normalized form: the level which would appear at the terminals of a telephone circuit having an RRE of OdB. This was calculated for each direction of transmission from the noise-level setting, mismatch loss at 800 Hz, and the RRE of the telephone. This normalized unit is described here as dBmp(O).

Distribution of Samples

The design of the random-selection process was intended to distribute values of ORE reasonably evenly over the range, and to assign the three possible noise sources with equal probability. **Table 3** shows the result.

The 3-dimensional Model

The important questions to be answered by the survey were of the form: for a given ORE and noise level, what percentage of customers would give a specified opinion? (eg. 'excellent', 'too faint', 'difficult to converse', etc). There were two independent variables (ORE, noise) and one dependent variable (percentage of customers or interviewers expressing a given opinion).

The distribution of noise level, referred to a listener's end with RRE = OdB is shown in Table 4.

ORE (dB) / Towards	<4	4 to <8	8 to <12	12 to <16	16 to <20	20 to <24	24 to <28	28 to <32	32 to <36	36 to <40	40 to <44
Customers	4.48	5.54	11.06	12.54	11.99	9.02	10.91	13.78	8.76	12.82	0.10
Interviewers	1.22	4.22	6.36	11.51	10.91	12.92	20.95	18.80	11.06	2.05	0.00

Table 3 — Distribution of ORE — % of 3127 Samples

dBmp(O) / Towards	>-80	-80 to -75.1	-75 to -70.1	-70 to -65.1	-65 to -60.1	-60 to -55.1	-55 to -50.1	-50 to -45.1	> -45
Customers	0	0.1	8.99	23.98	10.07	24.4	8.83	23.54	0.10
Interviewers	0	0.0	11.13	22.03	14.23	20.12	10.27	22.23	0.0
Group	1 (C=32.97) (I=33.16)				2 (C=34.47) (I=34.35)		3 (C=32.47) (I=32.05)		

The distribution falls clearly into three groups, corresponding to the three 10dB-spaced levels of injected noise (Table 5).

Table 4 — Distribution of Noise Level — % of 3127 Samples

Towards	Level of noise power (dBmp(O))					
	Group 1		Group 2		Group 3	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
Customers	-49.4	1.3	-59.4	1.4	-69.4	1.3
Interviewers	-48.7	2.6	-59.1	2.7	-68.7	2.7

Table 5 — Level of Mean Noise Power.

The general problem was therefore to find an analytical description of the surface above the ORE/noise plane (**Figure 6**) which best fitted the opinion data at each of the three noise levels.

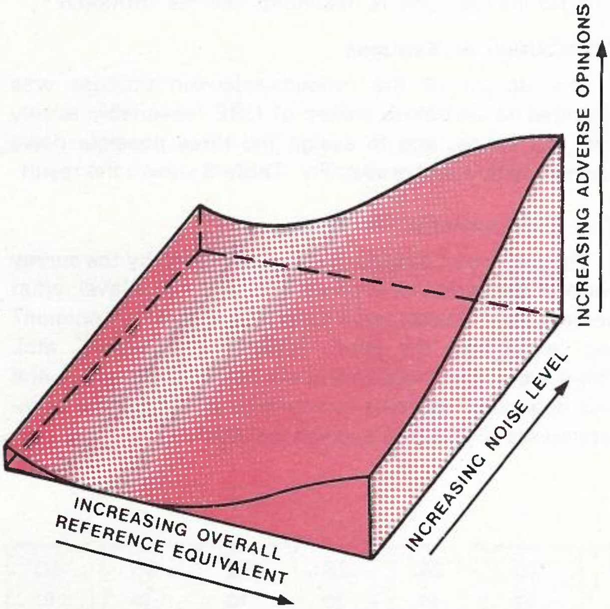


Fig. 6 — 3-dimensional Surface: Opinions/Noise/ORE

To maximise the information obtained from the data, the latter were divided into two overlapping cell-sets at 2dB centres, each 4dB wide, along the ORE scale. Thus the cells labelled '12 dB ORE' would include data for ORE between 10 and 14 dB; those labelled '14 dB ORE' would include data for ORE between 12 and 16dB. This process also enabled the number of samples per cell to be kept reasonably high.

Thus the input to the surface-fitting process was 20 sets of %-vs-ORE data at each of 3 noise levels: 60 data points.

An orthogonal-fit program ORFIT was devised which would produce a polynomial

$$\% = f(L,N) \text{ where } L = \text{ORE}, \quad N = \text{Noise},$$

and in which the number of terms in the polynomial could be specified in advance. From an examination of the raw data, and a knowledge of the expected trend of the results, it was decided that eight terms would be more than adequate, rising to the third power in L and to the first power only in N.

The program was therefore set to yield the constants C_1 to C_8 which were attached to the various products of L and N in the following polynomial:

$$\% = C_1L^3N + C_2L^2N + C_3LN + C_4N + C_5L^3 + C_6L^2 + C_7L + C_8$$

By rearranging the polynomial it was possible, for a given value of % and L, to determine the corresponding value of N to produce 'contour' curves of constant percentage.

PRINCIPAL RESULTS

Scope

This article describes only three of the many outputs provided by the survey:

- percent ("poor" + "intolerable")
- loudness preferences
- percent difficulty

The percent ("poor" + "intolerable") opinions (% (P+I)) derive directly from Question 8 of the questionnaire. Other measures may be derived from the responses (eg. percent ("excellent" + "good") or mean opinion score (MOS) and standard deviation). Such measures are being used in current studies of the data, but the authors suggest that an easily-understood numerical indicator of customer dissatisfaction is to be preferred when communicating objectives to management and to the public.

The opinions on loudness (Question 9) were available for each of the three noise levels. However, for the purpose of this article it is sufficient to combine the results as a broad indicator of customers' preferences when ORE is the only variable to be considered.

The third output — 'percentage difficulty' — also meets the criterion associated with % (P + I). In their responses to Question 14, customers and interviewers were requested to answer 'yes' or 'no' to the question 'Did you have any difficulty in talking to or hearing me during this interview?'. If the answer was 'yes' the respondent was asked to describe the difficulty, and the response was recorded exactly as stated by the subject. The 'percent difficulty' scores (%D) were derived from those respondents answering 'yes' to Question 14, but without regard to the reported nature of the difficulty.

% (P+I) Opinions

Question 8 ('How good') was the first of the transmission-related questions to be answered by the interviewee, who had the five possible responses noted earlier. The best-fit surface relating % (P + I) to ORE and noise is shown in the form of 'contour' diagrams for customers' opinions in **Figure 7** and for interviewers' opinions in **Figure 8.**

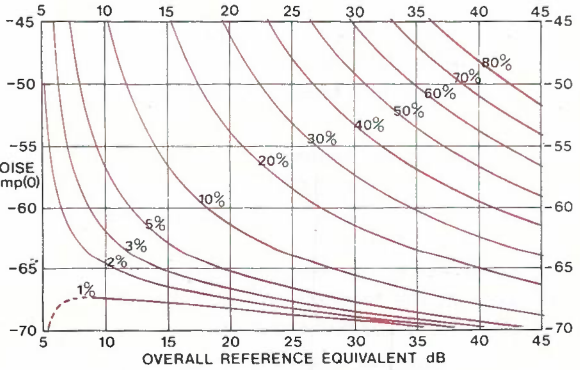


Fig. 7 — Contours: %(P+I) — Customers

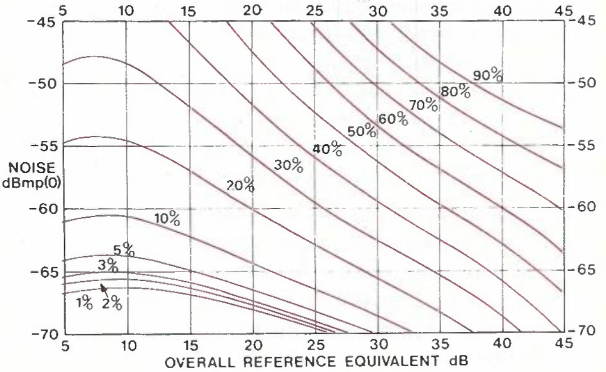


Fig. 8 — Contours: %(P+I) — Interviewers

Significant differences will be noted between these two Figures, the most important of which is that for any given ORE/noise combination, interviewers' adverse opinions are greater than those of customers. For example, at a reasonably 'good' connection with ORE = 15dB and noise = -60 dBmp(O), we have:

Customers : 7.5% (P+I)
Interviewers : 14.4% (P+I)

Reasons for this are discussed later.

Loudness Preferences

Question 9 of the survey was labelled "How Loud?" in the questionnaire booklet. The interviewee was requested to judge the loudness of the interviewer's voice over the test connection and classify it as one of:

1. much louder than preferred
2. louder than preferred
3. preferred
4. quieter than preferred
5. much quieter than preferred

Categories 1, 2, 4 and 5 may all be regarded as adverse opinions; their sum is illustrated in **Figure 9** for both customers and interviewers. Category 3 is similarly illustrated in **Figure 10.** The curves in both figures are derived from opinions for OREs lying within ±1dB of the indicated values; the best-fit curves take account of the numbers of samples found in the ±1dB slots. For any ±1dB slot, the samples include approximately equal numbers of connections having the three noise levels.

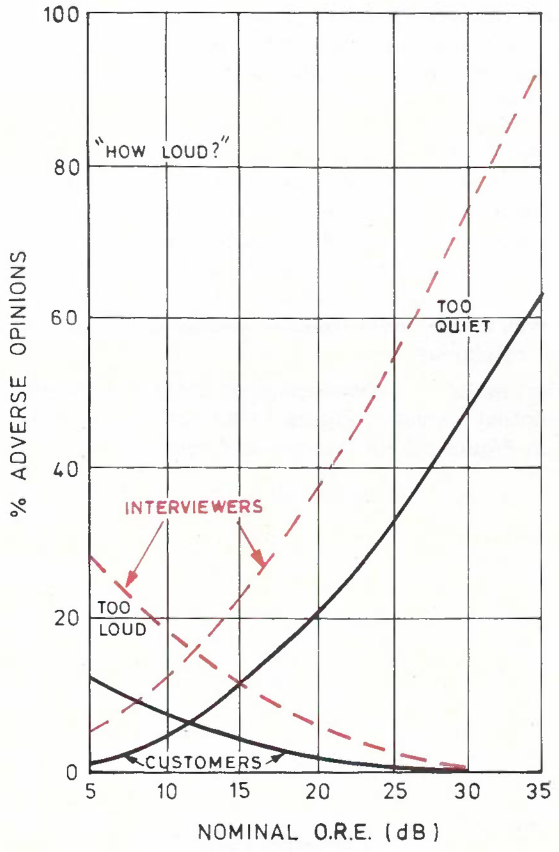


Fig. 9 — Adverse Opinions — Loudness

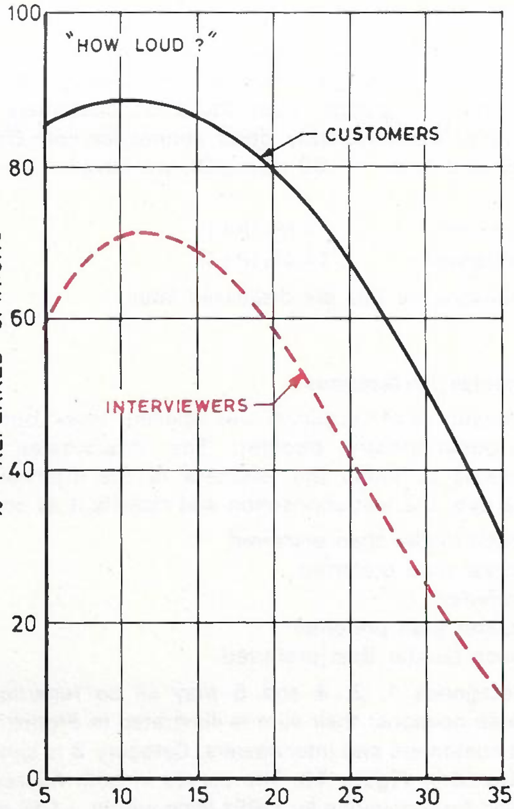


Fig. 10 — 'Preferred' Opinions — Loudness

Again, there is a significant difference between the levels of opinions expressed by customers as a class and interviewers as a class: the interviewers were more critical. However, the ORE at which adverse opinions are a minimum and that at which the 'preferred' opinions are at a maximum does not differ between customers and interviewers.

%D Opinions

An analysis of the reasons given by interviewees who answered 'Yes' to Question 14 (Any difficulty?) reflects the design and scope of the experiment rather than a significant conclusion: about half said that the received voice was too faint and about half complained that the line was noisy. There were, of course, combinations of these categories.

The results — without assigning causes — are shown as 'contour' curves in **Figure 11** for customers' opinions and in **Figure 12** for interviewers' opinions.

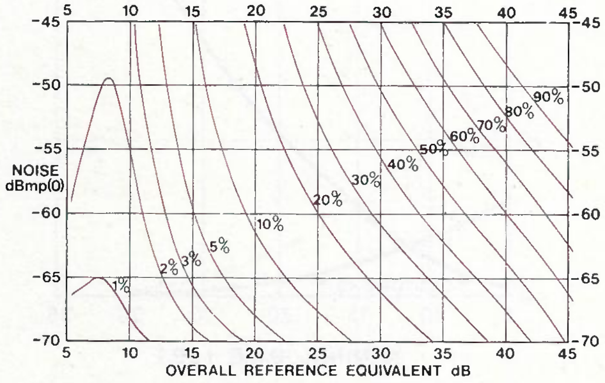


Fig. 11 — Contours: %D — Customers

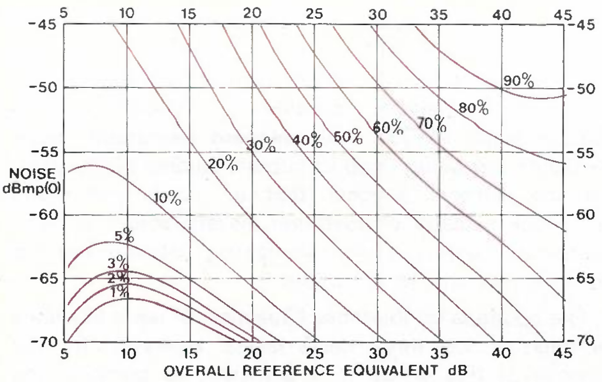


Fig. 12 — Contours: %D — Interviewers

Again, interviewers were more critical. For example, for the connection of 15dB ORE and noise level of -60dBmp(O) cited above:

Customers	: 5.1%D
Interviewers	: 12.5%D

Reasons for this are discussed later.

It will be noted that the %D curves (but not the % (P+I) curves) tend to confirm the preference for values of ORE in the region just below 10dB: a value rather lower than that corresponding to the preferred received loudness.

WHOSE OPINIONS?

A significant aspect of the above results (and others, not described in this article) is the consistently higher level of adverse opinions registered by interviewers for any given combination of ORE and noise, compared with that registered by interviewees, deemed to represent general customers.

In seeking the reasons for this difference, we make the following observations:

- The received volume and intelligibility are dependent not only upon ORE, but also on other factors outside the control of the telephone administration. These include:

— vocal level of the speaker

— placement of the speaker's lips relative to the telephone mouthpiece (which may be affected in part by the level of sidetone).

— effectiveness of the seal between ear and telephone earpiece at the respondent's end.

— quality of the speaker's diction.

- The vocal levels of interviewers were not controlled, but the number of interviewers was few, and their individual vocal levels could be assumed to remain substantially constant over a series of interview sessions. In the aggregate of customers' opinions, the effect of variation in vocal level could be expected to be small. There would, of course, be an expected general increase in vocal level as higher OREs were encountered, for both interviewers and customers.
- The vocal levels of customers were not controlled and could be expected to vary widely over the large number of customers involved. Interviewers' opinions attributable to a given ± 1dB slot of ORE would be influenced by possibly a different vocal level on each connection.
- The placement of interviewers' lips relative to the

telephone mouthpiece was well controlled. Although these people were professional telephone interviewers, the need for correct handset attitude was stressed in the training sessions, and interviewers were observed in action during interviews, so that corrective action could be taken if necessary. We may be confident that customers' adverse opinions were not affected by deficiencies in the interviewers' use of the telephone handsets.

- The placement of customers' lips relative to the telephone mouthpiece was not controlled; neither was there any reference to this topic by the interviewers in conversation with customers. During the pilot survey (Ref. 7), the handset attitude of 50 "customers" was observed (Table 2); of these 26 (56%) were judged to be unsatisfactory for speaking. Such observation was not possible in the main survey but we may be confident that a very high proportion of customers spoke with the mouthpiece of the telephone well removed from its optimum position, thus adding to the effective ORE of the connection. This can occur through carelessness, or by a subconscious action to reduce the level of the speaker's sidetone. To the extent that this occurred, interviewers' adverse opinions of a given connection could be expected to be greater than those of customers.
- Some indication of a systematic difference in the vocal levels of inteviewers as a class and customers as a class might be expected from an examination of speech-voltage measurements of each, even though these may be masked by different values of mouth-to-mouthpiece distance. The survey yielded a speech-voltage measurement of the customer's voice signal for every interview. Speech-voltage measurements were also made for some interviewers on some interviews. However there were insufficient samples of interviewers' speech-voltages to draw a reliable comparison between the two classes of signal.
- The professional interviewers as a class would undoubtedly exhibit more favourable characteristics in respect of enunciation, voice inflexion and rate of delivery than customers as a class. Such conscious care observed by a talker renders the listener's task much easier, and for a given ORE/noise condition would yield a lower adverse-opinion score than that resulting from a careless talker.
- Interviewers as respondents would be giving opinions about the quality of voice signals received from a population of customers who could not be expected to be conscious of, or equipped with special skills for, careful voice production. The listening effort required from interviewers on this account is likely to be greater than that required from their customer respondents on the same connection, thus leading to a higher level of adverse opinions from interviewers.
- Qualitative opinions such as those in the questionnaire are always based on a respondent's personal values and expectations. For example, a customer whose previous telephoning experience was exclusively over poor-quality connections requiring considerable conversational effort may nevertheless believe such experience to be the norm and might register satisfaction on a test connection of comparable quality: his expectations are low. On the other hand, a customer with a more favourable telephoning experience would use that as a reference to decide that the same connection was decidedly unsatisfactory: he would register an adverse opinion because of his higher expectations.

The interviewers, as a class, are likely not only to have had a favourable past experience, but also to have greater expectations of the quality of telephone service by which they earn their living. In this sense, interviewers' opinions might be a more valid expression of business-customers' opinions than those of the bulk customer sample. This view needs to be validated by comparison of selected sub-samples of customers' opinions.

Taking account of the above observations, we are led to the tentative conclusion that interviewers' opinions may be a more realistic description of perceived network performance than the gross customers' opinions described in this article because they

— are based on signals resulting from the vocal levels and telephone-holding habits of a realistic range of telephone customers and
— are likely better to represent the expectations of frequent and business users of the telephone network.

However, more work is necessary to validate this conclusion.

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ANNEX 1 — ASPECTS OF POPULATION INTERVIEWED

3148 interviewees surveyed from 16 terminal exchanges in Melbourne suburbs:

Interviewees — Age and Sex

Age Group	Percentage of Total Sample	
	Female	Male
Less than 15 years	0.5	0.3
15-24	6.6	4.4
25-34	16.0	7.2
35-44	17.8	8.0
45-54	11.3	5.1
55 and over	12.0	10.8
	64.2	35.8

Interviewee's Location

	Percentage
Residential (incl. business services located in residences)	92.3
Commercial	3.8
Retail	3.1
Industrial	0.7
Other	0.1
	100.0

Interviewee's Opinion of Ambient Noise Level

	Percentage
Very noisy	3.2
Noisy	20.1
Neither noisy nor quiet	28.8
Quiet	36.8
Very quiet	11.1
	100.0

Interviewee's Recollection Of Telephone Usage*

1. Local Calls: number per week

	Percentage
Less than 10	26.7
10-49	56.4
50 or more	16.9
	100.0

2. Trunk Calls: number per week

	Percentage
Less than 3	67.9
3-6	16.7
7 or more	15.4
	100.0

3. Overseas Calls: number per year

	Percentage
Less than 3	86.5
3-6	9.0
7 or more	4.5
	100.0

* Calls included those made and received by interviewee at any telephone.

ANNEX 2 — SAMPLE DATA FROM FILE 'RECOD'

Corresponding data were collected for 3148 different customers

COLUMN	CODE	SAMPLE VALUE	MEANING
1	SERVTP	P	A 'basic' non-business service
2-4	EX	288	The Melbourne exchange with prefix 288: Burwood
5-7	SEQ	021	The 21st sample taken on Burwood exchange
8	GAUGE 1	9	The subscriber line is in 4 sections. Starting from the telephone end, they are: 15 m. of 0.9 mm diameter 2065 m. of 0.4 mm diameter 423 m. of 0.51 mm diameter 310 m. of 0.64 mm diameter
9	GAUGE 2	4	
10	GAUGE 3	5	
11	GAUGE 4	6	
12	GAUGE 5	-	
13-16	LENGTH 1	15	
17-20	LENGTH 2	2065	
21-24	LENGTH 3	423	
25-28	LENGTH 4	310	
29-32	LENGTH 5	-	
33	PHONE	C	400-type telephone: wall or table.
34	OCC	A	The interviewee is female, aged over 55 years, and describes her occupation as 'home duties'.
35	AGE	F	
36	HEAR	C	She has no hearing difficulty and uses no hearing aid.
37	HEAR 1	N	
38	HEAR 2	N	
39	STRV	C	She judges the loudness of her 'telephone voice' to be about average.
40,41	LOC	A1	Her telephone is in a kitchen, lounge or family room —
42	RNOIS	E	— which is very quiet
43	HGOODC	B	She judges the quality of this conversation to be 'good', with
44	HLOUDC	C	the loudness of the interviewer's voice at her preferred level.
45,46	LNOISC	A1	She notices no other noises or sounds from her telephone.
47	HUMAN	A	The interviewer's voice sounds quite natural, with no distortion,
48,49	SIDET	AN,	and she cannot hear her own voice through the telephone as she speaks.
50	EFORTC	A	She is able to conduct the conversation with complete relaxation and no effort is required.
51	DIFFC	N	She has no difficulty in talking to or hearing the interviewer.
52,53	HOFTL	1B	She uses a telephone for local calls between 5 and 9 times a week.
54,55	HOFTT	2A	She uses a telephone for STD calls within Australia less than once a month
56,57	HOFTO	3A	She uses a telephone for overseas calls less than once a year.
58	LSTYLE	C	She regards herself as 'ordinary middle-class'
59,60	ID1	AC	The interviewer's initials were 'A.C.'
61	HGOODI	B	The interviewer rated the quality as 'good', and the loudness
62	HLOUDI	C	of the customer's voice was at his preferred level.
63	LNOISI	G	He noticed a humming or buzzing sound on the line.
64	EFORTI	B	In conducting the conversation, he found attention was necessary but no appreciable effort was required.
65	DIFFI	N	He experienced no difficulty in talking to or hearing the customer.
66	SPIMP	A	The interviewer judged that the customer had no apparent speech
67	LANG	A	impediment, and had no apparent difficulty with the English language.
68	CONSOL	2	The interview was conducted via technical console No.2, which, by automatic random selection, provided:
69	ILINE	0	— a zero-distance subscriber line for the interviewer,
70	LOSS	4	— a simulated loaded junction circuit of nominal loss 3dB, and
71	NOISE	0	— an injected noise in both directions of -70 dBmp.
72	HSET	K	The interviewer's 800-type handset had its characteristics listed in file K.
73,74	ID2	DC	The technician making the measurements of speech level had
75	INST	2	initials 'D.C.', and used Speech Voltage meter No.2 to make the following measurements.
76 to 80	SVC	-23.6	The average of 5 readings of the customer's active speech level was -23.6 dBV.

Each file entry in RECOD (see Annex 2) is processed in program CUSOP to yield values of sending, receiving and overall reference equivalents for a particular sample connection.

The customer's telephone and feed method are identified, the feed current calculated from line date, and the sending and receiving reference equivalents of the telephone instrument for the particular feed condition are calculated.

The transmission characteristics of each section of the subscriber line are calculated at 14 frequencies and matrix-multiplied to yield an equivalent single network, the loudness loss ("Richards insertion loss") of which is calculated. In the process, the impedances at interfaces are calculated to permit later determination of mismatch losses.

The 14-frequency admittance matrix of the simulated junction is known, as are the corresponding characteristics of the particular technical console, interviewer's line and handset. The junction data are matrix-multiplied with the customer's line data, and an overall reference equivalent calculated for each direction of transmission.

The inserted noise level from RECOD is applied to the calculated receive reference equivalents of the customer's and the interviewer's subscriber circuits to yield a normalized noise level for each direction of transmission.

Program CUSOP yields a file OUTPUT which has an entry corresponding to every entry in the input file RECOD. Correspondence is established via the exchange and sequence codes, combined here as IDENT. Below are the output data corresponding to the RECOD entry described in Annex 2.

CODE	VALUE	MEANING
IDENT { EX	288	The Melbourne exchange with prefix 288: Burwood.
SEQ	021	The 21st interview conducted from Burwood.
SORE 1	6.3	The summed overall reference equivalent from interviewer to customer was 6.3 dB
SORE 2	8.6	The summed overall reference equivalent from customer to interviewer was 8.6 dB
NC	-67.6	The noise level at the customer's end was -67.6 dBmp(O)*
NI	-66.3	The noise level at the interviewer's end was -66.3 dBmp(O)*
		* where (O) indicates referral to a receiving reference equivalent of O dB. These values were from the common noise level of -70 dBmp applied (see Annex 2).
TR1	88	Transmission rating o towards customer
TR2	92	Transmission rating o towards interviewer
		o according to an A.T. & T formula; of secondary interest here.
SREI	4.7	Sending and
RREI	-3.3	receiving reference equivalents (dB) of the interviewer's subscriber circuit.
ILJ	3.5	The 1200-ohm/1200 insertion loss of the simulated junction at 800 Hz, in dB.
SREC	7.8	Sending and
RREC	-2.0	receiving reference equivalents (dB) of the subscriber circuit
CFX1	0.0	Correction factor ** towards subscriber (dB)
CFX2	0.6	Correction factor ** towards interviewer (dB)

** SORE1 = SREI + ILJ + RREC + CFX1
SORE2 = SREC + ILJ + RREI + CFX2
The correction factor takes account of actual impedance mismatch losses at the interfaces of subscriber and junction sections in the connection.

Computer Based Train Control System for Melbourne

J. HONT B.E. (Hons.) M.I.E. Aust.

An integral part of the Melbourne Underground Rail Loop (MURL) project in upgrading the suburban railway network is the introduction of centralized control of the signalling of the Melbourne electrified area, as well as the introduction of centralized voice communications and control and monitoring of ancillary services in the loop tunnels.

This article outlines some of the background as to the purpose of the loop and the signalling control system, and presents some of the operational facilities of the control system and their implementation.

INTRODUCTION

General

Melbourne is a city fortunate in having an extensive suburban railway network. However this network is a radial one, concentrating most of the traffic through Flinders Street and Spencer Street stations. These stations have been the centres of congestion for trains, and for pedestrians alighting or boarding the trains.

The underground loop is solving these congestion problems, by allowing the trains which terminate their journeys in the city to be effectively turned around through the loop, without any unnecessary delay at platforms, and by allowing passengers a choice of a further three stations for boarding and alighting, located around the loop. Two of the four tunnels are now operational, along with one of the three new stations, Museum.

Train traffic congestion had been caused by the large number of trains terminating their journeys at the two city stations as a result of the imbalance of originating and terminating traffic between the eastern and western sides of Flinders Street Station. Many trains were required to wait for free platforms before being able to berth at Flinders Street or Spencer Street, and then depart in the opposite direction. This type of traffic required the train crews to walk the length of the trains, thus having the trains occupy platforms for a relatively long time, or having changeover crews stand by, ready to take over the trains on arrival. A relatively minor delay or other problem was then often able to severely disrupt the progress of many trains, resulting in delays especially in the Flinders Street yard area.

With only two city stations, and Flinders Street Station handling most of the suburban passenger traffic, there was substantial pedestrian congestion inside the station area, as well as in the nearby streets.

Control of Railway Signalling

The traditional method of controlling trains in a railway network, including the Melbourne suburban network, is by means of controlling the signals and points from numerous manned signal boxes distributed through the network. Generally, signal boxes are located at major or junction stations, as part of the station complex. Coordination between these signal boxes is mainly achieved by the use of telephones and the use of a special bell code system.

To realize the full potential of the new Melbourne Underground Rail Loop however, a computer based remote control and supervisory system JZA715 is being installed by L. M. Ericsson Pty. Ltd.

This system will readily allow the Area Controllers a complete overview of the total traffic situation in their whole line group, whereas previously a signalman's view of the network was limited by the extent of his local display diagram, which was usually one station area. Thus the area controllers will be better equipped to make traffic handling decisions, and to minimize the effects of any disturbances to traffic. Further, since the operations controllers will also be equipped with colour VDU's, they will be more effective in their role, coordinating the various area controllers.

A major feature of the system is the "train describer" facility, whereby signalling control staff can conveniently follow the progress of the trains through the network by means of identifying train descriptions (numbers) which are displayed to them.

The central equipment is being installed and tested at the new Melbourne Metropolitan Train Control Centre, (METROL). As well, the local control panels located at the various signal boxes are being replaced by remote concentrators, linked to the central equipment by telephone cable, employing phase shift modulation and time division multiplexing (TDM) techniques.

The centre will initially control the signalling of the whole inner suburban area, not just the underground loop. It is planned to ultimately control the whole of the Metropolitan network from Metrol.

SYSTEM OVERVIEW

Interworking with the Railway Signalling Network

JZA715 system interfaces to the railway signalling network by means of distributed field stations (concentrators) located at signal boxes. **(Fig. 1).** State detectors in the various local field objects, namely points, signals and track circuits are wired from these objects to interlocking relay logic, also located in the signal boxes. The interlocking logic provides the safety feature that is an inherent requirement in railway systems whereby potentially conflicting train routes will not be permitted to be set up. That is, once a train route has been set, the interlocking logic will exclude a conflicting route being set.

Orders to the field objects emanate from the system and are checked by the interlocking logic for their executability from a safety viewpoint. If an order is executable, the interlocking logic then activates the relevant driving mechanism.

However, most features of the logic of the relay interlockings are simulated in the computer, so that commands can be pretested for their executability before being transmitted to the field. Commands that are determined to be not executable are held back in the computer, until field conditions change so that the commands will be able to be executed. This pretesting function ensures that all commands that are issued are actually carried out, which is particularly important in Train Describer Automatic Routing (TDAR) operation.

Indications to and orders from the central computer are conveyed by the TDM links mentioned above. Indications, once processed by the computer, are presented to the operators on colour visual display units (VDU's), by colouring a grey coloured track diagram with different colours representing the various states of the objects. For example, an unoccupied track circuit is represented by a grey track symbol which becomes green when a route is set over it, showing the reserved path, and becomes red when the track circuit is occupied by a train. In general, in order to minimize clutter on the VDU pictures, object symbols are coloured grey, the dullest colour available, when the objects are in their normal or neutral state.

Objects that are in an active operating state have symbols coloured red, green, yellow etc., while faulty devices are marked with white symbols, the brightest colour on the VDU.

System Structure

The system is divided into function oriented subsystems as follows:

- — the control and indication system
- — the transmission system
- — the train describer system
- — the automatic routing system
- — the passenger information system
- — the train location recording system

The above subsystems are divided into block modules, which are also function oriented. A customer with a specific installation can choose his own list of function blocks from a function catalogue to fulfill his specific requirements. Each subsystem is implemented by means of both hardware and software and usually includes a number of inter-related modules. Each program module comprises a number of programs. All communication between subsystems and between program modules is carried out using standard procedures on a program bus.

The JZA715-system is based upon the PDP11-family of computers under the operating system RSX11-M. Discs are used for the storage of programs, data and the logging of required events. The configuration is a dual computer system with all peripherals arranged such that they can be accessed from each computer.

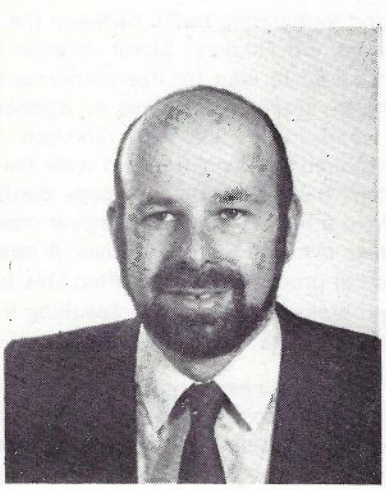
Each computer system is totally independent of the other, ensuring high availability. One computer operates in a "hot stand-by" mode, so that it is constantly updated and therefore prepared to immediately take over in the event that the on-line computer malfunctions.

Because of its large geographical extent and the high density of its traffic, the controlled area has been divided into two, each of these two areas being controlled by an independent dual system. Hence, in fact, four computers will be used to control the Melbourne network.

JOHN HONT graduated in Electrical Engineering at Monash University in 1970. After a short time in the Research Laboratories of the PMG's Department, he took up a position with Siemens AG of Munich, West Germany, where he participated in the design of a new processor for the control of EWS series telephone exchanges.

He re-joined the PMG Research Laboratories in 1974 in the Switching and Signalling Branch, working on digital system design and implementation. In 1977 he moved to the Engineering Department of Telecom to work in the National Support Centre for 10C Trunk Exchanges.

In 1978 Mr Hont joined L. M. Ericsson Pty. Ltd. to work on the contract awarded by the Melbourne Underground Rail Loop Authority. This work included 18 months in Sweden with the parent company, working on facilities specifications and design. Currently, he is the Engineering Manager in the Railway Signalling Systems department.



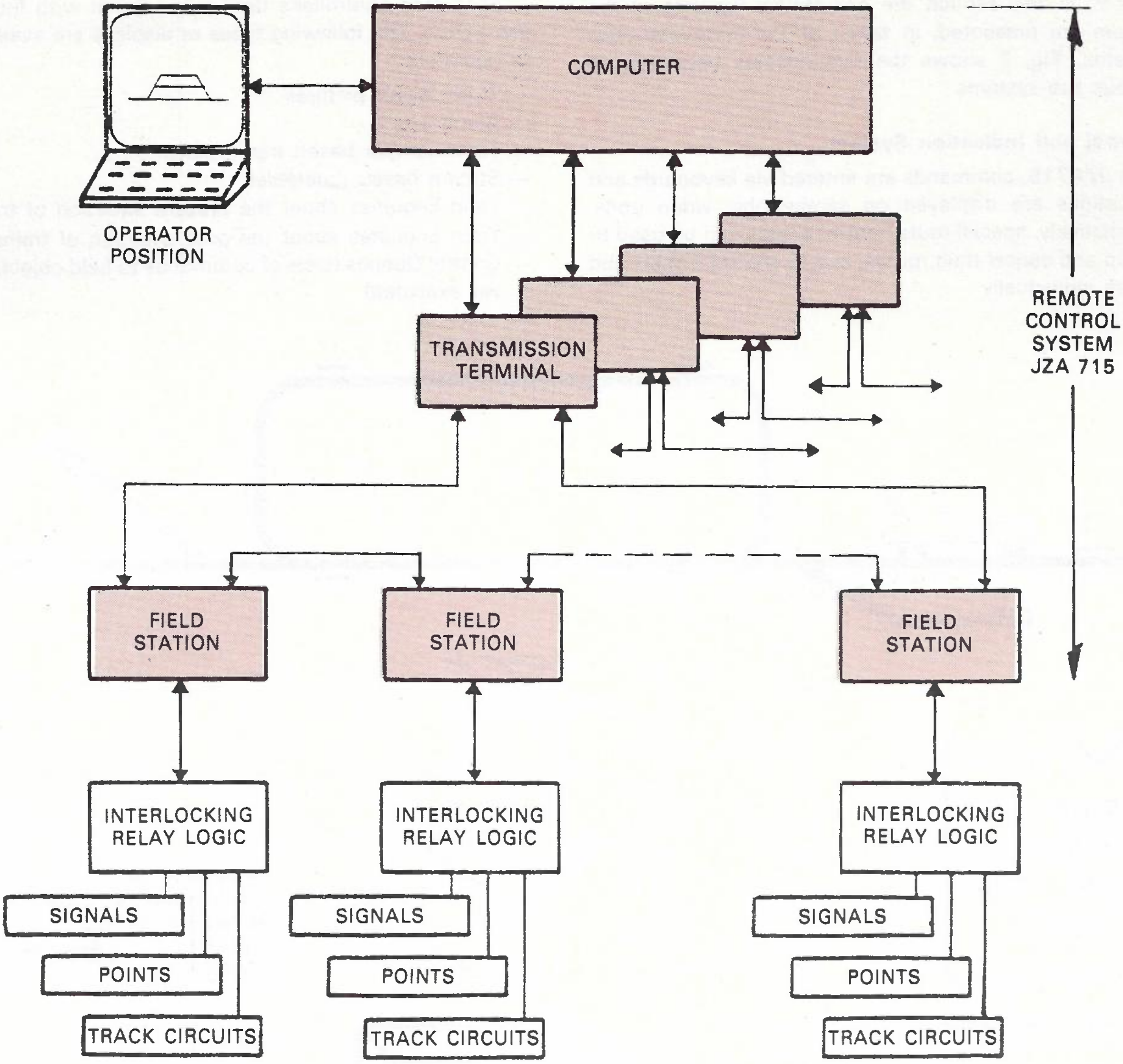


Fig. 1. Control System Hardware

The modular structure of input and output hardware modules in the JZA700-family, of which system JZA715 is a part, makes it possible to provide only the amount of equipment that is required at each location. When a new station is added to the system or when new objects are added at a station, only the corresponding hardware modules are added without any change in the wiring in the older parts.

JZA715 also incorporates data generation aids that assist in the preparation of application-oriented data and documentation.

Operation

The inner suburban Melbourne network will be controlled by five Area Controllers, one controller for each of the following line groups:

— Clifton Hill
— Burnley
— Northern
— Caulfield
— Sandringham (including St. Kilda and Port Melbourne lines).

In addition to these there are about 30 operators of various classifications that can access the central computers to obtain information about the location of trains, time tables, or technical data such as a summary of signalling equipment failures. Most of these operators are located at METROL, but some are located at Victorian Railways Head Office at Spencer Street.

When a train enters the controlled area, it is allocated a train description (number), which is entered automatically or by a signalman using a terminal located at the boundary of the controlled area. The JZA715 system then tracks this number in computer memory "berths", moving the number from berth to berth as the train progresses through the area. The train number contents of the berths are displayed to the operators at METROL as part of the track diagrams on the colour VDU's. The numbers are also used internally by the system to initiate automatic functions.

SYSTEM FEATURES

Whereas the previous section outlined the environment, system structure and operation of the system, in this section the operational features of the system are presented, in terms of the functional sub-systems. **Fig. 2** shows the relationships between the various sub-systems.

Control and Indication System

In JZA715, commands are entered via keyboards and indications are displayed on semigraphic video units. Alternatively, special route control panels can be used to set up and cancel train routes, and to control signals and points individually.

Each area controller's desk is equipped with four or five VDU's. The following types of displays are available to operators:

- — Track layout pictures
- — Alarm List
- — Train number based traffic plans
- — Station based timetables
- — Train Enquiries about the present situation of trains
- — Train Enquiries about the past situation of trains
- — Control Queues (Lists of commands to field object, not yet executed)

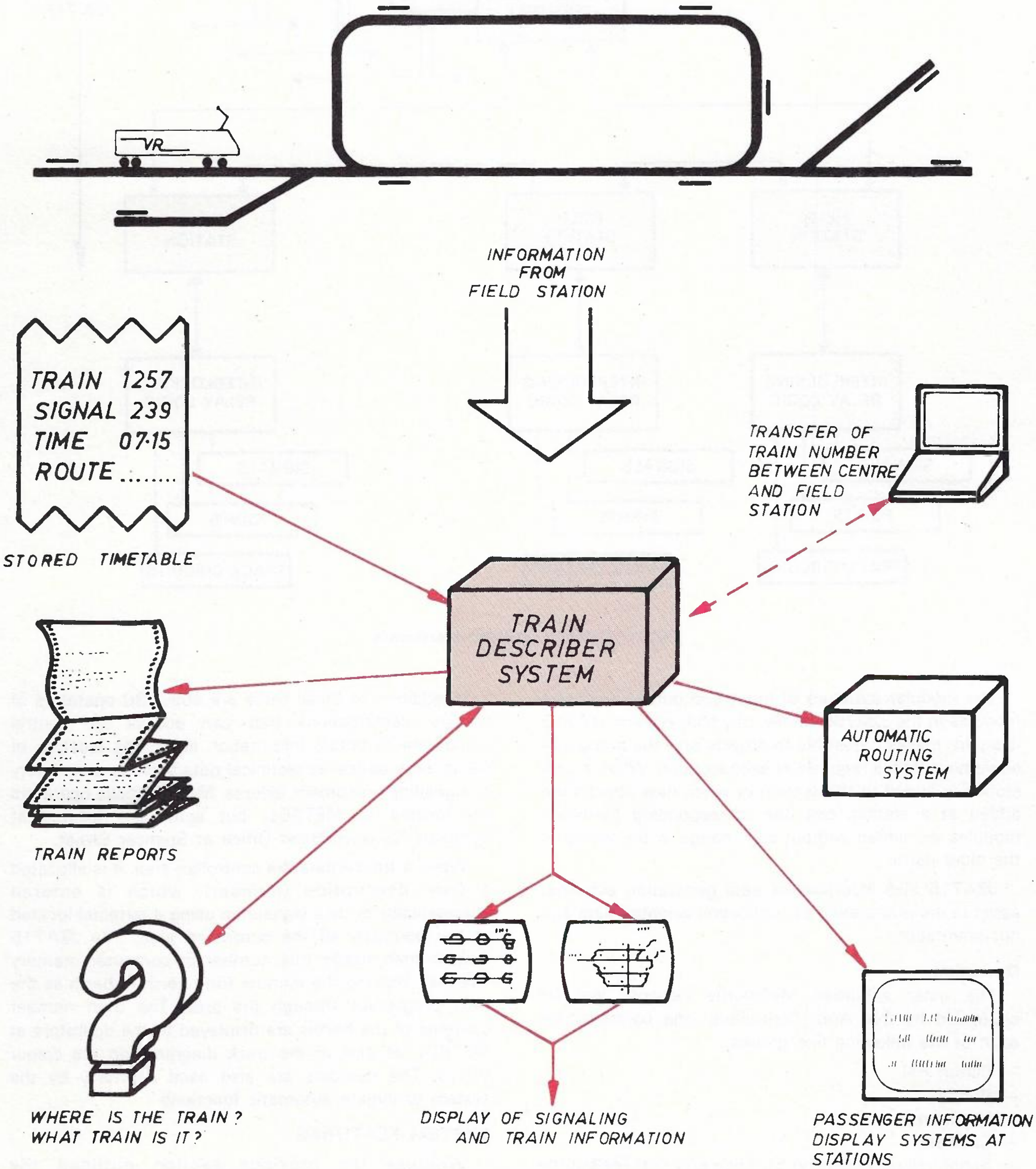


Fig. 2. System Features

Of the above, the text lists, plans and tables can be displayed on monochrome as well as on colour VDUs.

To facilitate the work of the area controllers, provision has been made for the operator to enter and queue a number of conflicting route setting controls, each to be executed in turn, after the passage of a train.

Route setting can also be automatic on the basis of train numbers ie, TDAR.

Transmission System

The transmission system is used for fetching status information from the relay interlocking plant or sending controls to the interlocking plant. The transmission system is also used to send information to and from other connected equipment, such as passenger information display equipment, and monochrome VDU's located several kilometres from METROL at the fringe of the controlled area, which are used to enter the train numbers for trains entering the area.

JZA700 field station equipment is used for the connection to relay-based local interlocking plants. This equipment, based on Ericsson BCH mechanics, is specifically designed for use in railway applications, where high noise immunity is a prerequisite, but can also be used for other remote control applications.

The various field stations are distributed throughout the network and are usually situated at the stations in the interlocking relay rooms, or in separate cabinets at wayside locations. Along each railway line, the stations are interconnected by twisted pair telephone cable.

At each field station the transmission line is interrupted and connected to the line inputs of the field station. In this way all field stations on the transmission line are in series. The field stations (and the METROL-transmission unit) are designed to function as regenerative repeaters for messages passing through the field station on the way to other field stations.

The loop configuration allows two access paths to each field station, promoting high availability. In normal operation, the upper switch shown in **Fig. 3a** is closed, and the lower switch is open.

If a malfunction occurs at a station, which affects the transmission system, the operator can bypass it by giving a bypass command. **(Fig. 3b).** The bypassed station may then be controlled locally, either manually or with automatic equipment. The rest of the system continues to operate as before.

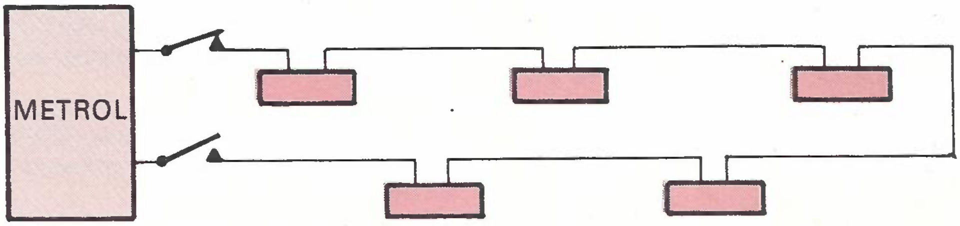


Fig. 3a. Normal Transmission Line Configuration

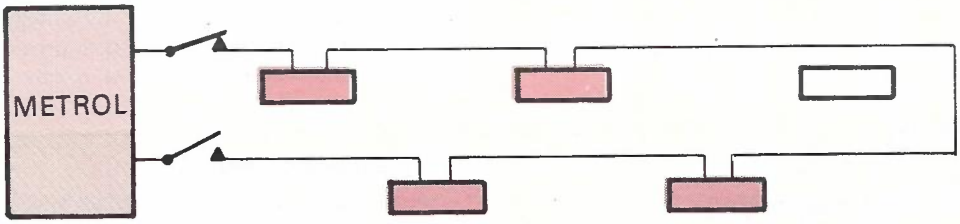


Fig. 3b. A Faulty Field Station is by-passed

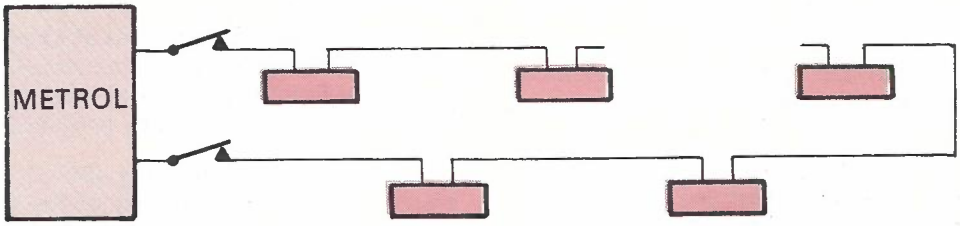


Fig. 3c. A Faulty line section is isolated

Fig. 3. Transmission Line Configurations

Similarly, a fault in a section of a transmission line can be isolated by means of a line disconnect command from the operator. When this is done the diversion path switch is closed as shown in the lower part of **Fig. 3c.**

Special DC signalling, initiated from the control centre, is used to effect field station bypass and line disconnect operations from neighbouring stations to failed field stations or line sections.

Phase modulated data transmission is used between the JZA700 field stations, with a speed of 1200 bit/s, requiring a bandwidth of 30-2500 Hz. The attenuation between the two stations should normally not exceed 11 dB. The transmitted level is normally 0 dBm.

Each bit in the transmitted message consists of two parts, a positive and a negative half cycle, using the technique of phase shift modulation.

One positive half-cycle followed by one negative half-cycle is used to transfer a binary one. To transmit a binary zero, a negative half-cycle followed by positive half-cycle is used **(Fig. 4).** Each transmitted character is detected twice in the receiving station, once half way through the first half cycle and subsequently half way through the second half-cycle. Detection must take place correctly during both half-cycles if the receiving station is to regard it as correct. The zero transition between the half-cycles is used to synchronize the receiving unit.

Further protection against error is provided by the transmission of a parity bit for each 16 message bits transmitted, and the use of message acknowledgements and retransmission procedures.

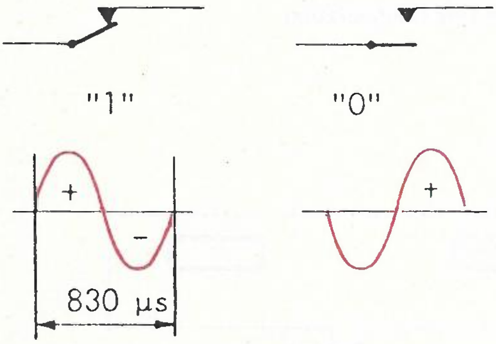


Fig. 4. Transmission Modulation

Train Describer System

The train describer system is used to facilitate the work of the operators by identifying trains on the video units and also by providing a base for automatic route setting, automatic passenger information by train numbers, and automatic train reporting.

Within the train describer system, the movements of trains are simulated by moving the train numbers between train number berths.

Each berth comprises a number of words in the computer memory. There is at least one berth for each section of track controlled by a signal. Movement of train numbers from berth to berth is controlled by signalling information obtained from the interlocking.

Also included in the train describer system is the facility to request:

- the position of a particular train
- the number of a train at a particular signal
- the listing of the positions of all trains currently in the system

Train Describer Automatic Routing (TDAR)

This feature relieves the area controllers of routine tasks. TDAR is based on the train describer system. When a train approaches a signal showing "stop", the system looks at the traffic plan stored in the computer memory. This traffic plan specifies the routes that are to be established for the train. The traffic plan also specifies the conditions that are to be fulfilled in this connection, such as departure times, dependency on other trains, etc. **(Fig. 5).**

Passenger Information Display System (PIDS)

This system issues controls calling for the changing of platform signs. The controls are sent via the transmission system to the passenger information display controllers at the various stations.

PIDS information is selected automatically on the basis of train numbers. For each train number, there is a table in the traffic plan containing the correct PIDS information.

During unusual traffic situations, PIDS displays can be operated manually from the operators' keyboards in METROL.

Automatic Train Reporting

The subsystem is implemented by recording the identifying numbers of trains passing the specified reporting points, and the difference between the actual passing time and the timetabled passing time at these reporting points. This recording, on a magnetic disc, can then be searched in various ways to provide the required historical information on VDU or printer.

Data Generation Aid

A data generating aid is used as an off-line facility to fill in the tables containing application-specific data. Data of this type is typically traffic plan data, the geographical arrangement of field objects (track circuits, signals, points etc.), VDU picture layouts, field object characteristics.

CONCLUSION

In a similar way to other areas of information handling technology, computers and communications are playing a very significant role in railway signalling by providing aids and facilities to operating personnel.

With the introduction of the JZA715 remote control system, and with the opening of the remaining loop tunnels and underground stations, Melbourne can look forward to a smoother and more efficient railway network.

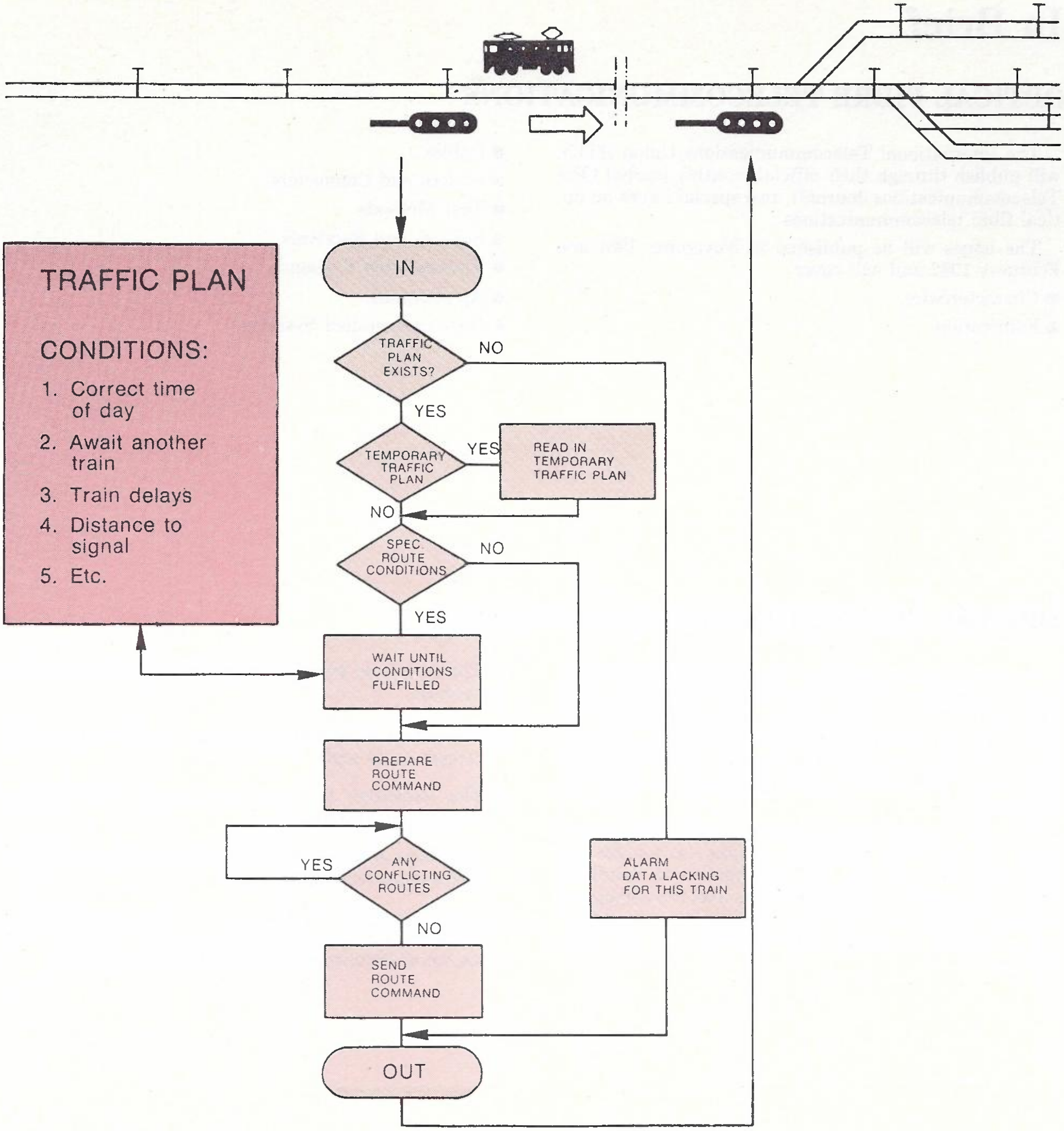


Fig. 5. Train Describer Based Automatic Routing

In Brief

OPTICAL FIBRE TELECOMMUNICATIONS

The International Telecommunications Union (ITU), will publish through their official monthly journal (The Telecommunications Journal), two special issues on optical fibre telecommunications.

The issues will be published in November 1981 and February 1982 and will cover

- Characteristics.
- Fabrication.
- Cables.
- Splices and Connectors.
- Test Methods.
- Sources and Receivers.
- Transmission Systems.
- Applications.
- Data on Installed Systems.

DIGITAL TELEVISION STUDIO STANDARDS

Study Group II (Television Broadcasting) of the CCIR, has unanimously adopted the first recommendation that will lead to the standardisation of video signals and equipment in television studios of the future. The new standard is based on digital technology and will bring the advantages of computer-type techniques to television production.

The new standard will be substantially the same in both 525 line and 625 line systems except for the difference in field rate. It only applies to television production studios, and there are no plans to change the existing standards of the signals radiated from transmitters. Viewers' existing receivers will not be made obsolete.

The long-term benefits of the new standard are likely to include.

- The potential for lower equipment costs because of the economies of scale
- The potential for improvements in international programme exchange.
- A greater international exchange of information on operational techniques.
- A reinforcement of the ideal of common technical solutions by international agreement, acting as a source of encouragement for future agreements.

FULLY FREQUENCY SYNTHESIZED FM MOBILE RADIO TRANSCEIVER

A fully, frequency synthesised FM mobile radio transceiver, which is perhaps the first to be designed and manufactured in Australia, has been launched.

The development was aided by a project grant to Plessey from the Australian Industrial Research and Development Incentives Board.

Characteristics of the new range of transceivers include the following.

- Frequency synthesized to eliminate individual channel carrier frequency crystals.
- At UHF, band width for both transmitter and receiver is greater than 10MHz wide.
- Exact frequencies are selected by a PROM (Programmable Read Only Memory).
- Frequency stability is better than +0.0005% of carrier frequency in the temperature range -10°C to +60°C.
- Capacities of up to 400 channels can be achieved.
- Data transmission speed of 1200 bps.
- Receiver intermodulation better than -80db (EIA).
- Selective calling, vehicle identification, frequency scanning (including a priority channel) and programmable continuous tone coded squelch are available.

Telecom's MTS

Integration with The Australian Telephone Network

P. DARLING, B.Sc., B.E.

Changes in the telephone network have been made in order to introduce the new Mobile Telephone Service (MTS) and this paper discusses the integration techniques necessary to enable MTS subscribers to call and be called by any telephone subscriber, in Australia or overseas, with access to the network. It covers the methods of access to and from the Mobile Control Centre to the telephone network, the originating and terminating classifications available to MTS subscribers, the signalling used on calls to and from MTS subscribers and the charge recording techniques with the service.

In addition, the numbering plan used for MTS and the routing and charging requirements for calls to MTS subscribers are outlined.

INTRODUCTION

The MTS which has been introduced in Sydney and Melbourne has been described in other Telecom Journal articles (Refs 1-4). This service is fully integrated with the Australian telephone network, and thus the international network.

An MTS subscriber with the correct access category can call any other subscriber connected to the national and international network. Similarly any network subscriber with access to STD can call an MTS subscriber directly.

INTERFACE TO THE SWITCHED NETWORK

General

The MTS equipment for use in Australia is based on a two-wire switch requiring a four-wire to two-wire interface on the radio side of the Mobile Control Centre (MCC).

Because of the special nature of the service, different arrangements from those at normal telephone exchanges are required. The MCC, although similar to a network exchange, is not required to handle all the network analysis and signalling of a normal local exchange.

In order to connect MTS, an ARE-11 Interfacing Exchange (IE) is provided in each city to perform the functions of receiving and routing traffic outgoing from the MCC (as well as performing barring analysis, etc.)

The ARE-11 IE may also route terminating traffic for MTS to the MCC, or this traffic may route directly from a higher order switching centre, eg the Main Exchange. In Melbourne and Sydney, the MCC's are installed at Windsor and Haymarket respectively co-located with the ARE-11 IE.

The following are the main features of the interface (see **Fig. 1**):

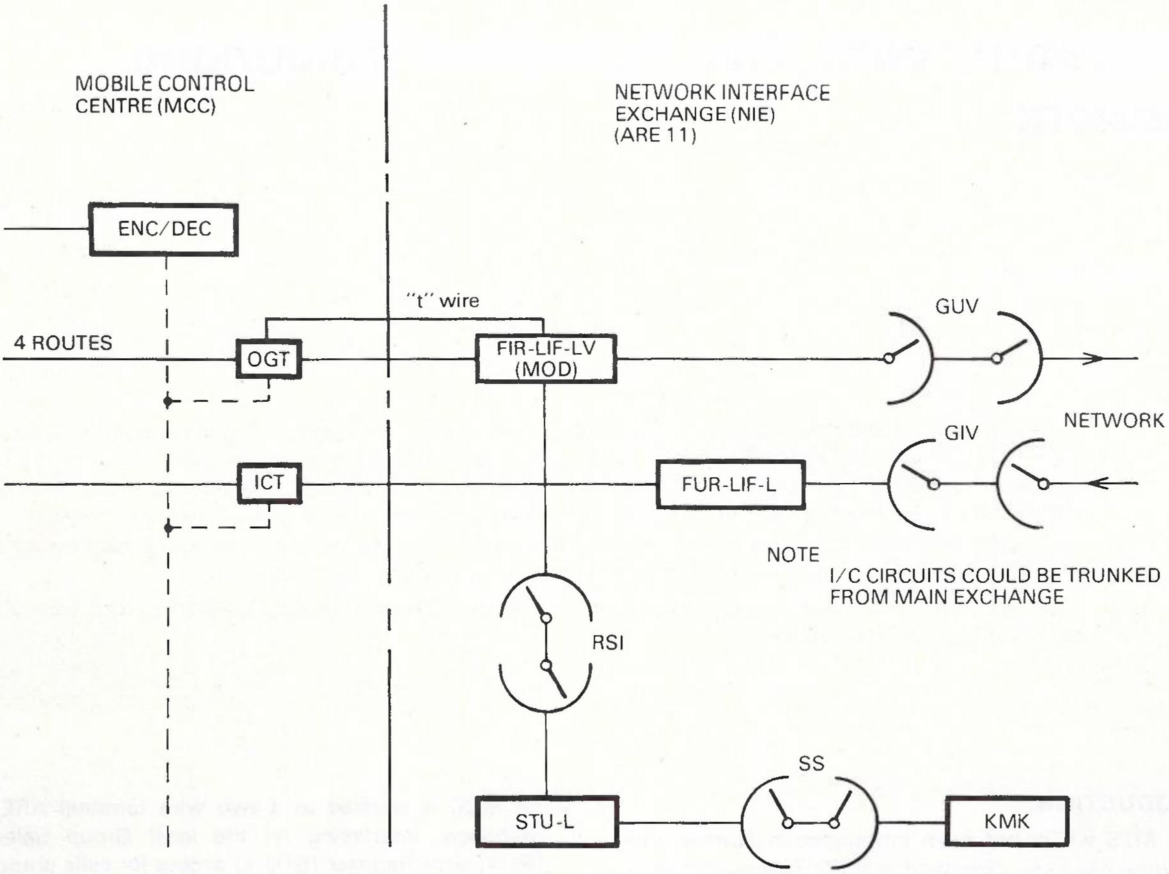
- The MCC is trunked to a two wire terminal ARE-11 exchange, interfacing on the local Group Selector (GUV) with Register (STU-L) access for calls outgoing from the MCC.
- On calls from a mobile subscriber to the telephone network, standard Voice Frequency Push Button Telephone (VFPBT) signalling is used from the MCC to the IE to forward the required number.
- There are a number of routes between the MCC and the IE for originating traffic, each corresponding to one originating category.
- All network analysis, barring and routing for originating calls is done by the IE.
- On calls from the network to a mobile subscriber, standard Multi Frequency Code (MFC) compelled information signalling is used from the network to the MCC.
- The MCC maintains an Interception Store for mobile subscribers and allows standard interception facilities.

Outgoing from MTS to the Network

The procedure for calls from the MTS to the network is as follows. The method of obtaining access to the MCC is described in Ref 3.

Signalling: Line Signalling between the MCC and IE uses the Loop Disconnect (L type) inter-exchange signalling scheme. Meter pulses are passed back from the IE to the MCC on the "t" wire and are incorporated in the Call Charge Record (CCR) at the MCC.

An additional signal, the Network Timeout Signal, is required by the MCC from the IE to indicate that normal network time supervision has taken place. This signal, which allows the MCC to minimise radio channel usage, is passed on the "t" wire associated with each outgoing circuit.



ABBREVIATIONS

ENC/DEC	ENCODER/DECODER
FIR	INCOMING JUNCTION CIRCUIT
FUR	OUTGOING JUNCTION CIRCUIT
GUV/GIV	GROUP SELECTOR STAGES
ICT	INCOMING TRUNK CIRCUIT
OGT	OUTGOING TRUNK CIRCUIT
RSI	REGISTER FINDER INCOMING
STU-L	LOCAL REGISTER

KMK	TONE RECEIVER
SS	TONE RECEIVER SENDER

"t" WIRE INDICATES TIME OUT CONDITION TO MCC

Fig. 1: Interconnection MCC to ARE-11 Terminal Exchange.

When the IE is ready to receive digits from the MCC, dial tone is sent to the MCC in the normal fashion. This tone is not heard by the MTS subscriber and is used as an inter-office signal only. The MCC detects the dial tone and then forwards the digits of the called subscriber to the IE using non compelled multifrequency signalling (Touchfone 12 standard).

Subscribers Originating Classification: Information on the originating classification of a mobile subscriber is passed to the MCC during call set-up. The MCC selects one of the four outgoing routes to the IE based on this classification. Each route carries traffic with the same originating classification, and all the inlets for the route are marked at the IE with the appropriate category. Thus

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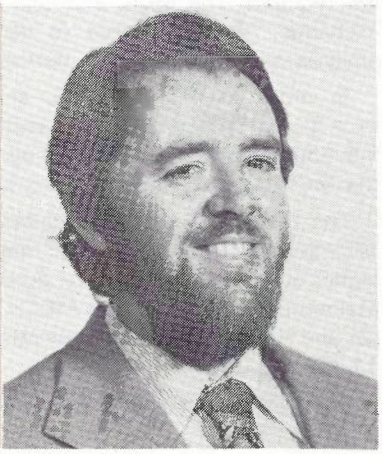
In 1974 he was promoted to a position in Telephone Switching Planning in the Engineering Department, Headquarters. Mr Darling now heads the Communications and Network Facilities Section in that Branch, which is responsible for the planning of network based facilities and the interconnection of systems such as the MTS. He is the Australian co-ordinator for CCITT Study Group XI (Telephone Switching and Signalling).



selection of the route indicates to the IE the originating classification of the calling subscriber.

The routes and the associated access categories, are given in **Table 1**.

ROUTE	ALLOWABLE ACCESS				NOTES
	LOCAL	TRUNK OPERATOR	STD	ISD	
Route 1	YES	YES	YES	YES	Unrestricted (Note 1)
Route 2	YES	YES	YES	NO	Barred ISD
Route 3	YES	NO	NO	NO	Local Access (Note 2)
Route 4	YES	YES	NO	NO	Barred ISD, STD

Table 1 — Access Categories.

Note 1: ISD charging is by multimetering pulses passed back from the ISD charging centres. A CCR record is available from the MCC LCCR Tape. Ring Back Price is not available.

Note 2: Analysis is based on the IE. "Local" allows access to local fixed network subscribers but not other MTS subscribers.

Incoming from the Network to MTS

The procedure for a call from a subscriber in the network to an MTS subscriber is as follows.

Signalling: Line signalling uses the Loop Disconnect (L-type) inter-exchange signalling scheme. Standard MFC-M information signalling is used to transfer the number of the called subscriber and send back information on the subscriber's status.

Subscribers Terminating Classifications: These are maintained by the MCC for all MTS subscribers served by the MCC. The terminating classifications possible are given below:

Category 1: Ordinary Telephone
Category 2: Disconnect Time Supervision before Answer
Category 3: Incoming Calls Non-Chargeable
Category 4: B Party Control
Category 5: B Party Control, Incoming Calls Non-Chargeable
Category 6: B Party on Interception

Normally, subscribers will have the Category 1 "ordinary telephone" option, although Category 4 will be available on request to special customers who require call tracing. Category 6 is used by an MTS subscriber requiring the interception facility. Categories 2, 3 and 5 will normally not be used.

Interception: The MCC will maintain an interception store for both "local" MTS subscribers (based in the same area) and "roaming" MTS subscribers (based in another MTS area). The full facilities of the proposed Centralised Interception Service will be available to MTS subscribers.

Access to the interception store is via a dedicated number in each 10 000 numbering range, marked as "B Party on Interception" to limit access. Setting, removal from interception and auditing, follows standard procedures using the appropriate MFC signals.

Interception store setting will be done on an area by area basis. Placing a subscriber on interception at Melbourne would have no effect on the status in Sydney, for example. If it was also desired to place the service on interception when roaming to Sydney, a separate access to the Sydney MCC would be necessary.

CALL CHARGING

Call charge recording for MTS will be provided by Local Call Charge Record (LCCR) equipment associated with the MCC. Call details recorded on the LCCR system for later processing at a data centre, are computed from the receipt of multimetering pulses provided by the network, and includes such information as:

- Full national number of called subscriber.
- Time and date of call start (speech channel seizure).
- Time called party answered.
- Time and date of disconnection.
- Call type (MFC Group 2 signal).

Calls from subscribers in the local service area to an MTS subscriber will be charged at a selected trunk rate rather than unit fee to reflect the nature of the service. Normal trunk rates will apply on trunk distance calls to MTS with the selected trunk rate being the minimum charge.

NETWORK NUMBERING AND ROUTING (Refer Fig 2)

The Mobile Telephone Service has been established using a previously reserved code in the national numbering scheme, 007.

A mobile subscriber may be called in his home service area by dialling a 3-digit access code plus the 6-digit number unique to the mobile subscriber, eg:

MTS ACCESS CODE	MOBILE SUBSCRIBERS NUMBER
007	CD EFGH

The CD digits determine the particular MTS exchange (and radio service area), and are allocated on a regional basis.

eg Call to Melbourne subscriber in home area dial 007 plus 33XXXX.

When the subscriber is in a foreign service area, callers will dial a 6-digit foreign area access code plus the 6-digit mobile subscriber's number. The additional 3 digits of the access code are necessary for the correct routing of the call to the foreign service area. (This "roaming" facility wil not be offered initially), eg

FOREIGN AREA ACCESS CODE	MOBILE SUBSCRIBERS NUMBER
007 CD 0	FG HIJK

The foreign area access code is made up of 007 plus the first two digits of the foreign service areas listed number range (eg 21) plus digit 0. The digit 0 is used by the network to indicate that the call is from a roaming subscriber, and to send the correct digits into the MCC.

eg Call to a subscriber in a foreign serivce area

(Melbourne subscriber in Sydney) dial 007210 plus 33X-XXX.

NETWORK CHANGES FOR MTS

Routing and charging changes have been made in the network to allow for access by network subscribers to MTS. The network requirements for MTS introudction are outlined below.

Terminal Exchanges — Routing and Charging.

- Allow access on code 007 (Barred STD subscribers do not have access).
- Mark 007 as multimetering.
- Route 007 to trunk exchange (direct or via tandem).
- Mark 007 as requiring cyclic storage (12 digits).

NOTE

Provision of cyclic storage (digit storage to accept 12 digits) at ARF exchanges with Register Local Provincial (LP) and Local Metro (LM) equipment for code 007 is to enable access to 'roaming' MTS subscribers.

Transit Exchanges — Routing.

- Originating Tandems
  - — Route code 007 to trunk exchange.
- Minor Switching Centres
  - — Route 007 to Main Switching Centre.
  - — Mark 007 as requiring cyclic storage (12 digits).
- Secondary Switching Centres
  - — Route 007 to Main Switching Centre.
  - — Mark 007 so that the transit register remains connected until 0 + 5 digits have been sent to the next exchange.
- Main Switching Centre
  - — Mark Code 007 for storage of 12 digits.
  - — Route calls to other main switching centres as shown below. At the destination main switching centre, the code is to be given Number Unobtainable (NU) tone until the MTS switching centre is established.

0071 - Spare (NU tone)
0072 - New South Wales
0073 - Victoria
0074 - Spare (NU tone)
0075 - Spare (NU tone)
0076 - Spare (NU tone)
0077 - Queensland
0078 - South Australia
0079 - Western Australia
0070 - Tasmania

CONCLUSION

Using the signalling, trunking and the network numbering that have been described in this article, calls to and from MTS subscribers can be made. While the MTS is new to Telecom's customers, and uses many novel techniques, it still functions as a standard part of the telephone network.

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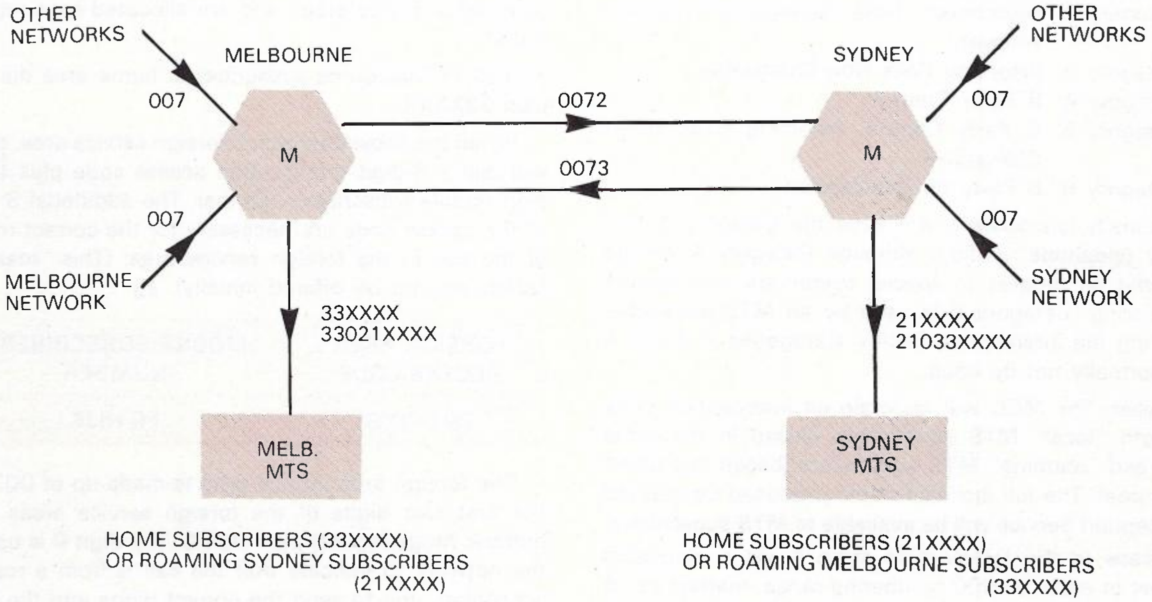

Fig. 2: MTS Network Numbering and Routing.

Telecom's MTS

The Mobile Control Centre

K. C. PHILLIPS B.E.

The Mobile Control Centre (MCC) is the heart of the Mobile Telephone Service. This centre provides the signalling and interface to the Telecom network and to the speech and control radio channels of the system as well as the switching between them. Additionally the charge recording and fixed equipment system maintenance and monitoring is provided in the MCC.

The Mobile Control Centre consists of a stored program control space division switching system to which regional processing in the form of micro processor controlled peripheral devices has been added.

This paper describes the functions performed by and the equipment used in the Mobile Control Centre.

INTRODUCTION

The Mobile Control Centre is the heart of the Telecom Mobile Telephone Service. One MCC is provided for each 120-channel MTS installation with initially one in Melbourne (Windsor Exchange) and one in Sydney (Haymarket Exchange).

The MCC is based on the Nippon Electric Company standard local switching exchange type ND20 (Ref 1) and, as configured for the Mobile Telephone Service, is designated MS2E. The ND20 system, being stored program controlled, has a considerable capacity for adaptation to include the special functions required for the mobile service. In addition to the ND20 adaptation to achieve the MS2E system, intelligent peripheral devices under microprocessor control have been employed to carry out some of the repetitive, less complex tasks involved in mobile signalling, signal strength determination and test call generation.

The block diagram of the MCC is shown in **Fig. 1** with the accompanying **Table 1** giving an explanation of the abbreviations used in the diagram and generally in this paper. The principal features and parameters of the MCC are listed in **Table 2.** A system overview to the MTS and operations on typical calls is given in Ref. 2. A description of the network interfacing and numbering and charging arrangements of the system is in Ref. 3. This paper provides details of the specific hardware and some aspects of the software of the MCC and as such should be read in association with Ref. 2 and 3.

FUNCTIONS OF THE MOBILE CONTROL CENTRE

The MCC provides the following main functions in the MTS:

- Switching incoming and outgoing trunks connecting the telephone network to radio channels.
- Control of signalling
  - — MFC from network on mobile incoming calls
  - — VF push button to network on mobile outgoing calls
  - — BCH data to mobiles.
- Sending of tones and voice announcements to land subscribers.
- Detecting and recording of call details and writing of call charge records on magnetic tape.
- Storing and checking validity and category of mobile subscribers.
- Storing and use in call connection of system data such as:
  - — Number of base stations
  - — Channels available in each base station
  - — Numbers of trunks in each route
  - — Busy free state of trunks devices and switch lines.
- System management and man machine communications.

MOBILE CONTROL CENTRE HARDWARE

Switchblock and Trunks

The MCC is built around a dual 3-stage trunk line network (TLN) switchblock. This switchblock provides the connection from the network incoming and outgoing trunks (ICT and OGT) and the radio channel connecting both way trunks (BWT).

As well, the switchblock is used to connect the signalling, tone and voice announcement devices to the incoming and outgoing trunks at appropriate times of a call. The devices and their uses are:

IRT	The Incoming Register Trunk provides MFC signalling for mobile terminated calls employing associated MFC oscillators and tone receivers.
OST	The Outgoing Sender Trunk provides the VF push button signalling used on mobile originated calls employing associated VF oscillators and dial tone detection circuitry.
RBT	The Ring Back Tone Trunk provides ring tone to land subscribers while a responding mobile is being rung on a mobile terminating call.

BTT	The Busy Tone Trunk connects "number unobtainable" tone to land subscribers who attempt to call an invalid mobile. Busy tone is provided on a call to a busy but valid mobile by the originating exchange in response to the called subscriber state MFC signal.
ANT	The Announcement Trunk provides connection of a recorded announcement advising land callers if a valid mobile is turned off or out of range.
AAT	The Automatic Answer Trunk provides answer and connection to tone generator and level detection circuit (TARS or TCARS) for transmission and switching test calls.

The switchblock and all trunks mentioned above employ two-wire transmission. As well the connection to the Telecom network from ICT and OGT employs two-wire transmission. A more detailed description of this network interface may be found in Ref 3.

The other use for the switchblock is to provide a connection from the radio channel BWT to the Encoder/Decoder devices. The Encoder/Decoders (E/D) are microprocessor controlled devices used to provide the data signalling between the MCC and the mobile. The types of data conveyed are:

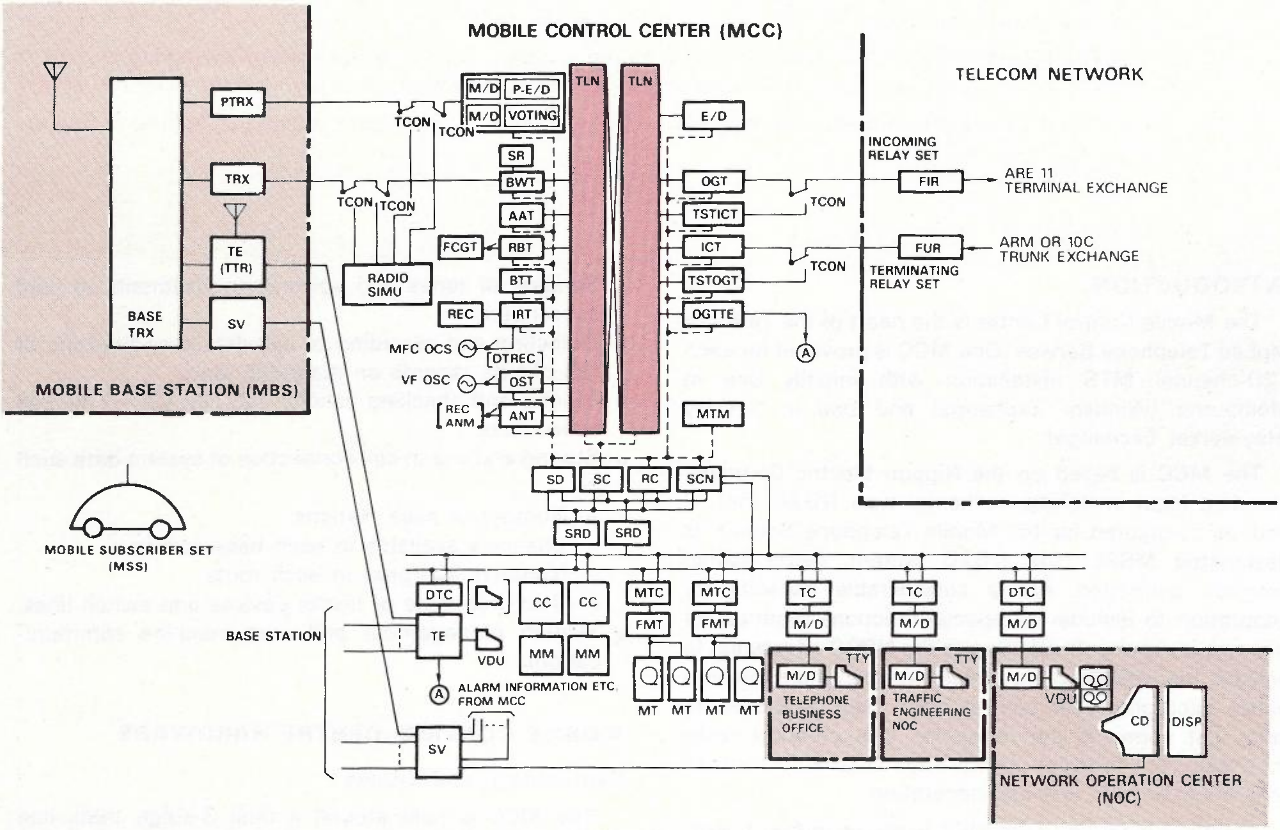

Fig. 1 — Mobile Control Centre

KEVIN PHILLIPS joined the Australian Post Office as a cadet engineer in 1962 and following graduation from University of N.S.W. in Sydney worked in Metropolitan Exchange Installation in N.S.W.

In 1970 he was granted a Confederation of British Industries Scholarship working with GEC Telecommunications, Coventry, England. From 1974 as Engineer Class 3 he worked on the large Pitt ARF and later Pitt IOC installation projects.

In 1980 he joined Switching Design Branch H.Q. in the newly created Development Division, Sydney Office. Projects undertaken there include the MTS, High Capacity Radio Paging and Directory Assistant Automatic Call Distributor.

AAT — Automatic Answer Trunk — Terminates test calls

ANT — Announcement Trunk — Connects voice announcement to the land subscriber when a call is made to a mobile which is off or out of range

BTT — Busy Tone Trunk — Sends number unobtainable tone when a call is made to an invalid mobile.

BWT — Both Way Trunk — Connects to radio channel.

CC — Central Control The control processors for the MCC.

CD — Control Desk Supervisory and alarm display at operations centre

DTC — Data Transmission Controller 1200 baud controller for VDU and test equipment

E/D — Encoder/Decoder — Codes and decodes signals to and from the mobiles.

FMT — Formatter — Ancilliary controller for magnetic tapes.

FCGT — False and Cross Ground Trunk — Checks for faulty TLN paths.

ICT — Incoming Trunk — Connects 2-wire mobile terminating calls from trunk exchange.

IRT — Incoming Register Trunk — Register for MFC signalling on mobile terminating call

MBS — Mobile Base Station — Location of transmitters and receivers. There is one for each radio zone.

MM — Main Memory — Program and data store.

M/D — Modulator Demodulator Modem — Code and decode data to be sent to a remote site.

MFC OSC — MFC Oscillators — Tone sources for MFC signalling

MSS — Mobile Subscriber Set — Transceiver fitted to vehicle.

MTC — Magnetic Tape Controller — Interface to reload and charge data tape drives.

MTM — Master Timer — Hardware pulse and time of day clock for CC.

OGT TE — Outgoing Trunk Test Equipment — Connects test calls generated by TTR

OGT — Outgoing Trunk — Connects 3-wire (2-wire speech) mobile originating calls to ARE exchange.

OST — Outgoing Sender Trunk — Sends VF push button signals on mobile originated calls after detection of dial tone.

P E/D — P channel Encoder/Decoder — Codes and decodes signals sent on the paging channel.

PTRX — P Channel Transmitter Receiver Duplicated transmitter for P channel one per base station.

RBT — Ring Back Trunk — Sends ring tone to land subscriber

REC — Receivers for MFC — Tone receivers for MFC signalling

RC — Relay Controllers — Interface and driver for magnetic latching relays in trunks.

RADIO SIMU — Radio Simulator — Simulates base station and mobile for internal MCC test calls.

SC — Switch Controller — Interface and driver for magnetic latching reed matrix in TLN.

SCN — Scanner — Scans and reports relay states of trunks and E/Ds.

SD — Signal Distributor — Interface for fast signal relays in trunks and E/Ds.

SRD — Signal Receiver and Distributor — Interface between high speed processor and slower peripheral buses — provides peripheral address decoding

SR — Signal Receiver — Receives signal indicating mobile has hung up.

SV — Supervisory Equipment — Communication and display of radio and MCC equipment alarms and status.

TLN — Trunk Link Network — 3-stage 2-wire reed switch network.

TCON — Test Connector — Intercepts normal path for test calls.

TST OGT ICT — Test Incoming/Outgoing Trunk — For MCC test call connection.

TC — Transmission Controller — 300 baud controller for VDU or teletype.

TRX — Transmitter Receiver — A or S channel transmitter and receiver one per channel.

TE — Test Equipment — Microprocessor controlled test call generator and system test apparatus.

TTR — Test Transmitter Receiver — Base station located mobile used for test calls.

TTY — Teletype — Keyboard printer terminal.

VDU — Visual Display Unit — HP2645A keyboard display station with cartridge tape for man/machine communication.

Table 1 — Explanations of Abbreviations to Fig. 1.

- Request dialled number
- Mobile "dialled" number
- Mobile identity
- Channel to be used
- Instruction to ring mobile
- On/off hook mobile status

The balance of data signalling between the MCC and the mobile occurs on a dedicated paging of P-channel. There is duplicated P-channel equipment including a duplicated data link for each base station. The P-channel encoder/decoder is a similar microprocessor controlled device to the E/D's mentioned above. The P-channel E/D has associated with it a separate processor controlled device to provide decoding of the signal strength information. This signal strength information is sent by each base station when a mobile responds on a land generated call. The relative signal strength of the mobile at each base station is thus available to allow the MCC to select a channel with the highest signal strength for the call. This process is termed voting and the equipment, voting equipment.

The P-channel and voting equipment has no connection to the switchblock but communicates directly with the Central Control (CC).

Peripheral Devices

The switchblock and trunks are controlled by the central control processors through four types of peripheral devices. These devices provide an interface between the high speed processor bus and the slower speed of the switchblock equipment. The devices and their functions are:

- **SD** The Signal Distributor provides the interface and driving for the time critical relays in the trunks. Included are MFC and VF tone connection and communication of mobile codes towards the encoder/decoders.
- **RC** The Relay Controller provides the interface for the slower speed relay operations in the trunks. The relays driven are magnetic latching types.
- **SC** The Switch Controller provides driving and interface for the magnetically latching switchblock.
- **SCN** The Scanner latches the state of the trunk and signalling device relays and makes these available to the central control.

All peripherals are provided on a needs +1 basis so that the failure of any one device will not affect exchange performance. The system software on detection of a faulty device issues an order to switch in the standby and informs operations staff of the fault.

Central Control

The central control processors and their individually associated main memory provide control of the MCC and to a large extent control over the MTS system. The processors and main memory are duplicated for reliability and normally operate in microcode synchronism, that is they execute each part of each instruction at exactly the same time. The results of the execution of the two processors is compared by stand alone hardware circuitry. This circuitry forces recovery action when differences are detected.

Although the two processors are operating together only one is active in sending switchblock, trunk and device orders to the peripheral devices. In this way the standby processor's main memory is kept up to date with program permanent and transient data and it is instantly available to take over should the active processor or its memory become faulty.

An individual processor can control the system on its own (single mode) to allow diagnosis or repair to be carried out on a faulty processor. This single mode operation is also useful in allowing new system programs or program changes to be made. The new program or changes can be inserted in the standby processor's main memory while the other processor continues call handling. The new program can then be introduced with minimum call handling disruption by forced changeover of the active/standby state of the processors.

The processors are implemented using 2900 series bit slice devices with four bit slices giving a 16-bit word. The ROM based microcode provides 180 instructions. Many of these are extensive instructions adapted for

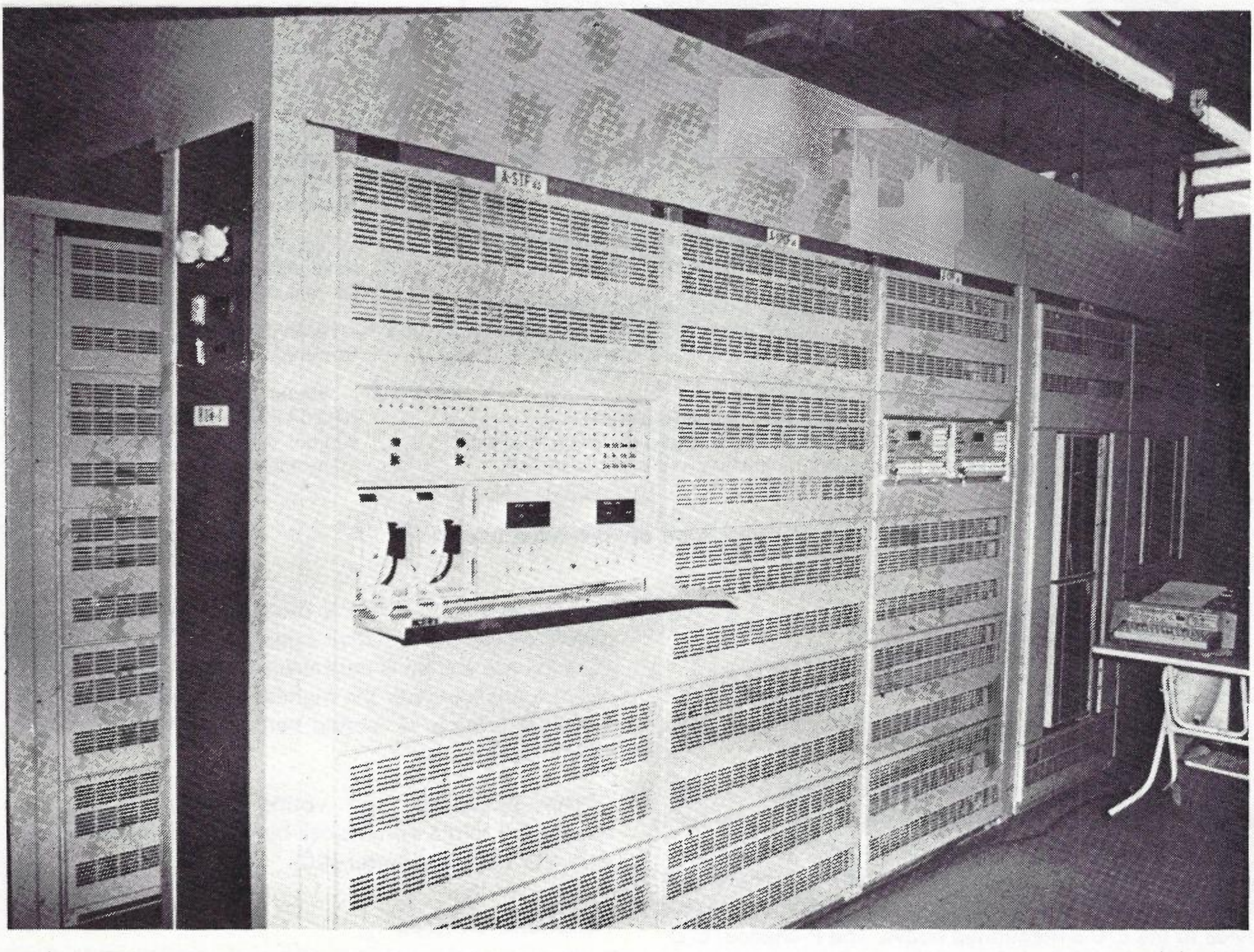

Fig. 2 — A view of one of 3 rows of equipment comprising an MCC installation. Frames from left are:- (1) Alarm Panel and Radio Simulator, complete with two mobile handsets, (2) Speech Path Control, (3) Central Control, with two processor consoles visible and (4) (5) Magnetic Tape Electronics and Tape Drives.

Space division magnetic reed relay switch, dual 3 stage 2 wire network.

RAM resident stored program control.

Duplicated synchronously operating central processors.

16 bit, bit slice based processors with individual 640K dynamic RAM main memory.

120 channels maximum 500 MHz band

Approximately 4000 subscribers with:
— 0.025 erlang/subscriber in busy hour
— mobile to land 75% of calls
— land to mobile 25% of calls

Information signalling
— MFC mobile terminating calls from network
— VF push button mobile originating calls to network
— FSK 300 bit/second split phase to mobile.

L1 line signalling with addition of 3rd wire for metering and time control on mobile originated calls

Charging via local call charge recording on magnetic tape

15 frames (racks), each 2100mm x 987mm x 540mm (h x w x d)

Area 64 square metres (see Fig. 2).

Power consumption, 6 kw at 52V d.c.

Table 2 — Principal Features of the Mobile Centre.

manipulating the system's particular office and call data structures. The average instruction execution time is 2.54 micro seconds. The main memory has a maximum capacity of 1024 kilo words (16 bits plus 1 parity bit). The equipped capacity is 640 kilo words. The memory employs 16K bit dynamic MOS RAM devices.

Input/Output Devices

The input/output for the MCC is achieved through the following devices:

DTC The Data Transmission Controller provides 1200 baud full duplex communication for the Network Operations Centre (NOC) VDU and the Test Equipment (TE).

The NOC VDU provides the main communication between the operations staff and the MCC. This VDU can execute any of the system commands. As well this HP 2645A VDU employs an integral dual cartridge tape drive used for "recent change" data storage (see section describing System Software).

The TE has a VDU connected directly to it which is capable of inputting commands to direct the TE and commands to the MCC system.

The TE DTC link is used to convey system commands entered on this VDU and to send instructions on test call connections required by the TE.

TC The Transmission Controller provides 300 baud communication for the subscriber data teletype and the traffic engineering teletype.

The subscriber data teletype is limited to input of commands and output of data relevant to changes and status of mobile subscribers. Similarly the traffic engineering teletype is limited to traffic measurement request commands and output.

MTC Two magnetic tape controllers are employed for the four reel-to-reel magnetic tape drives provided in the system. The tapes are used for charge data, recording, system load and reload, and traffic engineering data recording.

Charge data is recorded on one drive only with a second drive on standby should the first fail or the tape fill up. Mobile originated and terminated calls which proceed to having a speech channel assigned are recorded on the tape in blocks of 16.

The system reload tape is permanently mounted on a drive and is available for system recovery in the event of program contamination. The 4th drive is used occasionally for traffic engineering data recording and as a standby.

Supervisory and Test Equipment

The MCC has extensive software based hardware fault detection, switchover (to standy device) and diagnostic facilities. An alarm display panel and audible alarms are provided locally in the MCC. The more important MCC alarm indications along with those from the base station equipment are transmitted by data signalling supervisory (SV) equipment to the MTS Operations Centre. Test calls can be made internally within the MCC by use of the radio simulator which simulates the functions of the base station and mobile. Commands are provided to enable testing of any channel with any ICT or OGT using this device.

Overall test calls generated from a Test Transmitter/Receiver TTR located at each base station are possible to a single outgoing test trunk (OGT TE). These tests are set up from microprocessor controlled test equipment and while capable of detecting some MCC faults, are essentially checks on the radio section of the MTS.

MOBILE CONTROL CENTRE SOFTWARE

System Software

The total system software and data occupies 640K, 16 bit words divided as follows:

Program	416 K
Office and call data	160 K
Correction area and spare	64 K

Approximately 80% of the programs are written in Assembler language, with the remaining 20% in PLC, a structured high level communications oriented language.

The MCC generic sources are basically those of the ND20 system. These provide the software for all the exchange switching, signalling input output fault recovery and diagnostics. To these have been added programs for MTS operation such as voting, mobile signalling, channel allocation and programs providing for the particular Telecom network signalling, charge data format and operations requirements.

The program structure is highly modular with strict control placed on data transfers between larger blocks of code to limit data corruption and system disruption caused by program contamination. Because the microprogram is ROM resident the opportunity has been taken by the system designers to implement many of the previously defined and commonly used assembly language macro instructions into the instruction set. This adaptation of the CC's instruction set has resulted in considerable processor occupancy savings.

The system software and data is initially loaded and backed up in the exchange by a magnetic tape. In the event of irrecoverable program contamination the system initiates a reload of the program and data. As well, the data changes, such as new subscriber registrations, made since the back up magnetic tape was created, are stored as they are entered on a cartridge tape associated with the system VDU. These "recent changes" are automatically loaded into the system following a reload.

Support Software and Software Production

The system sources are held on IBM3330 disk. Cross assembly, compilation, linkage and system tape production are carried out on an IBM 370/158 computer installation owned by ICI Australia in Melbourne. The software production is controlled from, and the printed output directed to, a Terminet 9610 remote batch terminal located in Sydney using a 1200 baud dial up link.

The IBM based support, software required for software production and comprising a suite of 8 programs, was supplied, along with the system software sources, by NEC. Because of the effort and computer time involved in a complete system tape production and debugging, minor system changes and software corrections are inserted by direct changes to the object code (patches). These are verified in a model of the MCC before being inserted by on line command into the working systems. A new reload magnetic tape is then made by copying the altered memory content to tape (system dump). A corresponding source code alteration is also made so that the change is included in any subsequent new system assembly.

Much of the exchange dependent data, office data, and all the subscriber dependent data can be altered by on line command in reasonably easily understood command formats. These changes can be carried out by operating or installation staff.

Peripheral Software

The software for the microprocessor controlled peripheral devices is much less complex than the system software. Typically the device control programs are around 4 K bytes (8 bit 8085 and 8080 processors are used) and are ROM resident. This software is treated almost as an extension of the device hardware logic. No backup for reload is needed and no software support or production facilities are maintained by Telecom.

CONCLUSION

By the relevant application of new technology and the use of stored program control it has been possible to produce a cost effective and flexible automatic mobile telephone system. The use and flexibility of stored program control in the MCC has allowed the Japanese designed system to be adapted relatively easily to meet the particular signalling, charging and maintenance requirements imposed by the Telecom network and operating procedures and, as well, it should allow improved customer facilities to be later added to this premium service.

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Telecom's MTS

Equipment and Manufacture

M. MORISHIMA. B.E.E., M.I.E.C.E. (Japan)

Nippon Electric Co. Ltd. has long been engaged in research and development of mobile telephone systems. Following their successful tender for the Australian systems, NEC Australia Pty. Ltd. manufactured the equipment to specifications set by Telecom Australia. The system, which operates in the 500 MHz band, consists of a Mobile Control Centre (MCC), the Mobile Base Station (MBS) equipment, the Mobile Subscriber Sets (MSS) and Supervisory (SV) and the system Test Equipment (TE) for maintenance. This paper describes the System configuration, performance and the manufacture of the Mobile Subscriber Sets.

INTRODUCTION

In September 1981, the automatic Mobile Telephone Service (MTS) was commissioned in Melbourne by Telecom Australia. This was followed by a similar service in Sydney.

NEC has long been engaged in research and development of Mobile Telephone Systems and has delivered them to Kuwait (since 1971), Egypt (1974, 1975) Saudi Arabia (1978), Nippon Telegraph and Telephone Public Corporation (HCMTS) in Japan and now Telecom Australia (Melbourne, Sydney).

The system provides a medium capacity service (4000 - 8000 users), is completely automatic and is capable of extension to incorporate a high capacity radio paging service.

The MTS system has been manufactured for Telecom Australia under contract, by NEC Australia.

THE MOBILE TELEPHONE SYSTEM

The basic parameters and features of the system are described in Ref. 1. For convenience in development, the overall system can be considered as having the following sub-systems or discreet technologies.

- Switching
- Radio
- Supervisory

In terms of hardware systems, the overall system comprises:

- Mobile Control Centre (MCC) (Ref. 1 and 5)
- Mobile Base Stations (MBS) (Ref. 1)
- Mobile Subscriber Sets (MSS) (Ref. 1)

SYSTEM DEVELOPMENT

The MTS is an integrated system, (Switching, Radio and Supervisory) with the following new technologies (Ref. 2,3) being fully exploited:

- Mobile exchange technique including, network configuration and tracking exchange
- Link control technique, including connection control
- Radio transmission technique, including data transmission, error correction and frequency diversity
- Efficient radio frequency utilization technique, radio zone configuration, frequency synthesis and multiplexing
- Mobile terminal technique, safety and convenient operation

In the development of the Mobile Telephone System, NEC has utilized the skills available from several specialist divisions of the NEC organization (See **Fig. 1**).

MOBILE CONTROL CENTRE EQUIPMENT

Ref. 5 describes the MCC in detail. The MCC equipment (**Fig. 2**) is a stored programme controlled (SPC) switching system based on the NEC Type ND20 system and equipped with additional encoding and decoding and mobile radio zone strength monitoring (voting) equipment. The MCC equipment has the following characteristics:

- Outgoing and Incoming Trunk (OGT) (ICT) Junctors to connect the MCC to the telephone networks.
- Digital signalling is used as control data transmission with the following characteristics.
  300 bps Manchester Code (Ref. 1)
  1500 + 200 Hz Sub-carrier FSK (Ref. 4).
- A maximum of 120 individual radio channels are connected to Both Way Trunks (BWT's) junctors. These can be connected to any of the OGT's or ICT's via the two-stage switch network (TLN). As well these channels can be connected via the TLN to the data signalling Encoder/Decoder (E/D).
- A duplicated Central Control (CC) is incorporated which can be operated by synchronous or separate modes, plus the Main Memories (MM) whose capacity is 1,024 kilowords and are also duplicated.
- Voting or 'Hand off' equipment so that the MCC can change the channel allocation in the middle of a call when a mobile moves from one zone to another.

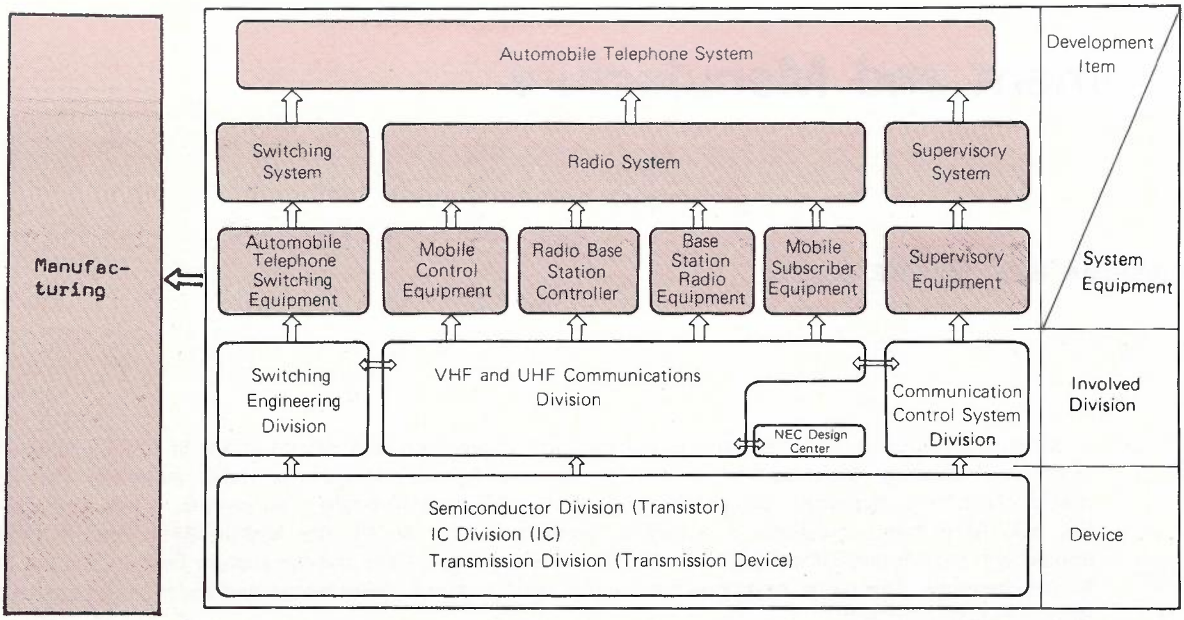

Fig. 1: Mobile Telephone System Development Organization

- Man/machine communication equipment allowing operating staff to monitor the performance and the state of the system.
  This communication is carried out either locally, or via a 1200 bit/second modem from a remote location using VDU based terminals. These same VDU terminals with cassette tape attachments are employed to re-load subscriber status changes in the event of a system failure which affects the dynamic random access main memory of the centre.
- Magnetic Tape (MT) units for local call charge recording on a single entry basis. Data is recorded for each call, on the set up time, calling and called mobile numbers, and the number of multi-metering pulses received.
- Software based on the standard NEC ND20 switching system. This being easily realized as the ND20 program systems consist of many program function modules which can be optionally linked to each other to provide a wide variety of features.

That is, each module is characterized as follows:

- Function division
- Logic interface
- Decentralized data assignment

Fig. 3 shows software system growth of the MCC. About 60% is used for network switching function, 25% for MTS control, the remaining 15% being available for radio paging facilities.

- Facility options for a radio paging service in addition to its use for MTS, thus economizing on the total MCC cost when both MTS and Radio Paging are required at the same control site.
  It is only necessary to add Paging Data Transmission Controllers (PDTE) and special software to establish the integrated mobile and paging exchange system, as shown in **Fig. 4**.
- Testing Facilities consisting of a radio simulator which provides two test mobile telephone circuits for internal outgoing / incoming / hand-off and manual connections, without any interface with radio links and/or the operational interface exchange.

MANUFACTURE OF MCC

The MCC equipment consists of 15 frames and was manufactured at NEC Australia Pty. Ltd.

The manufacturing method used is similar to that used in the production of the Mobile Subscriber Set. (Described later, refer to Fig. 17, Fig. 18).

Each module in the equipment is of a plug-in type to facilitate maintenance. Connection to each frame uses cable with multipin connectors to ease the installation task.

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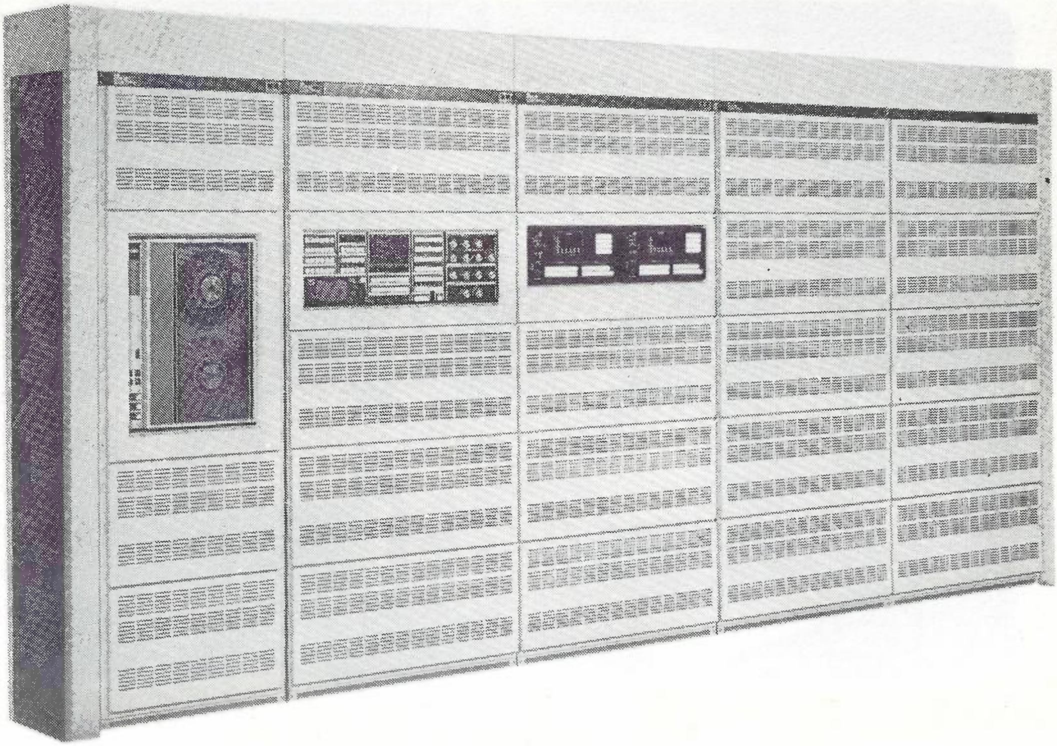


Fig. 2: Mobile Control Centre Equipment

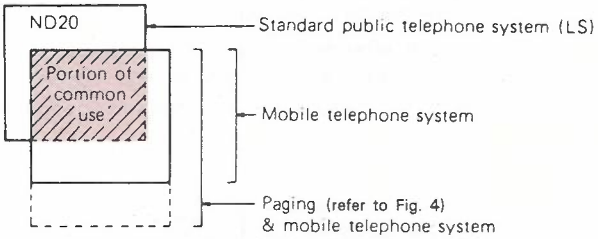


Fig. 3: Software System Growth

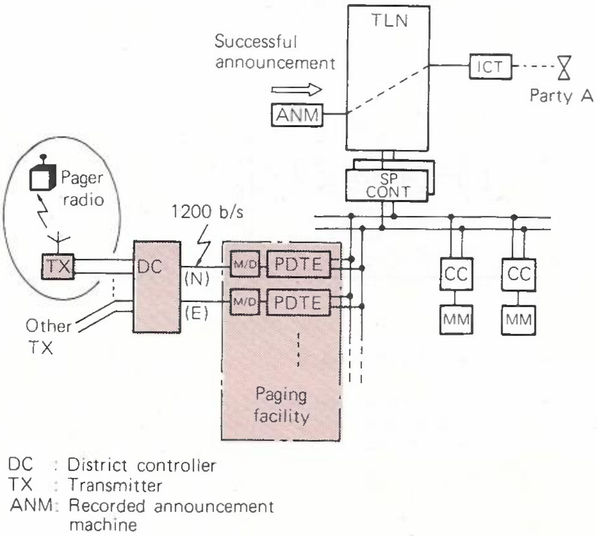


Fig. 4: Radio Paging Facility Addition

In order to minimize onsite testing, NEC carried out system test between the MCC and the radio equipment (Mobile Base Station, Mobile Subscriber Set) at their Melbourne factory **(Fig. 5)**.

MOBILE BASE STATION EQUIPMENT

The mobile base stations consist of transmitters, receivers, a transmitter multiplexer, antenna, supervisory and test equipment. All electronic units have been constructed using fully solid state components and the extensive use of integrated circuits has reduced the number of components thus assuring a high reliability and miniaturized size. The output power amplifier is also fully solid state.

Each panel is of a plug-in type to facilitate easy maintenance. Furthermore, the design permits all operations required for maintenance to be made from the front panel.

All equipment has been manufactured at NEC Australia Pty. Ltd. using similar techniques to those described for the MCC and the MSS (Refer to Fig. 17, Fig. 18).

Transmitting Equipment

The transmitting equipment is divided into two categories; one is that used for Speech Channels (S-CH) or for Access Channels (A-CH) and the other is that used for the Paging Channels (P-CH). However, with the exception that frequency stabilities are different, their electrical characteristics are nearly the same. The P-CH employs a redundant configuration, consisting of main and standby units.

The equipment consists of a transmitter unit, power supply unit and control unit and, in the case of a transmitter used for the paging facilities, a P-CH repeater unit with the function of converting the signal from subcarrier FSK to direct FSK, is added. The equipment used for Speech or for Access channels is shown in **Fig 6**. This equipment has four channel transmitters incorporated.

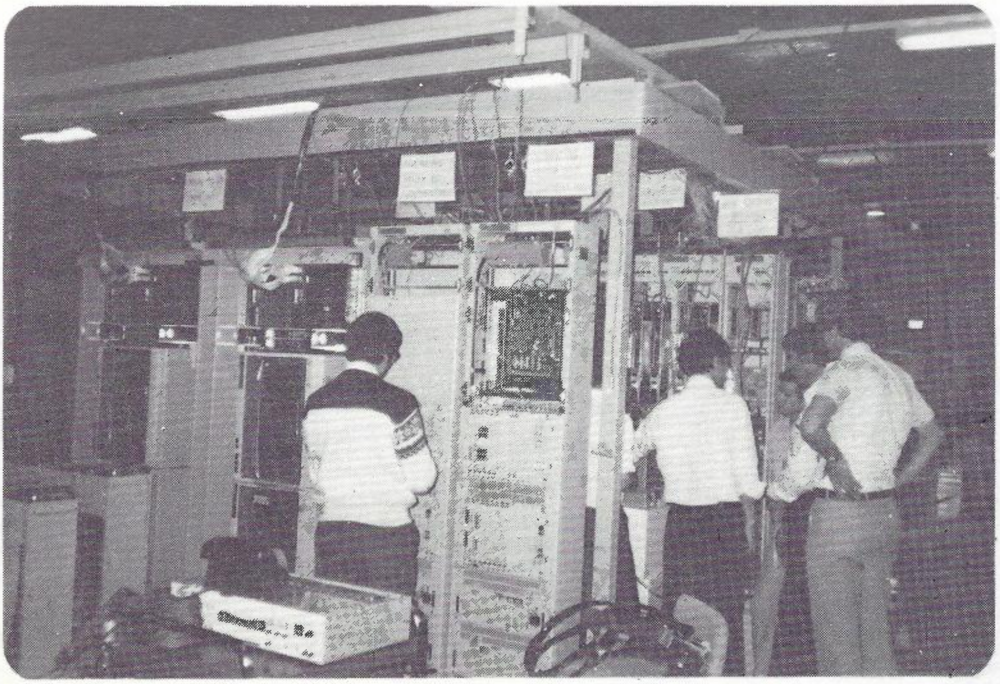
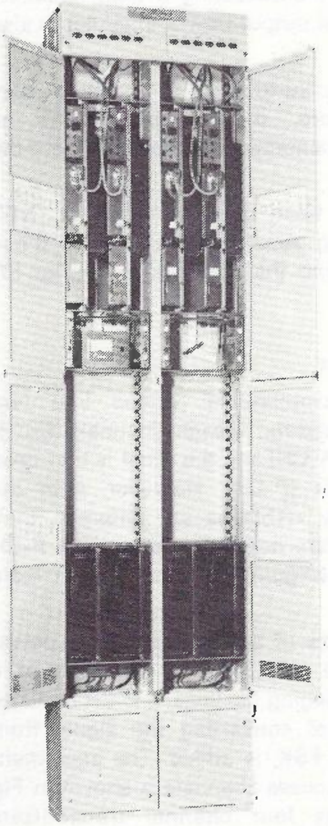


Fig. 5: System Test

The transmitters do not use a multiplying circuit but have a direct oscillation of about + 27 dBm from a high output Voltage Controlled Oscillator (VCO). They provide the required frequency stability by comparison with a reference oscillator through a phase lock loop thus achieving a high Carrier to Noise value.

The Output from the VCO is applied to a power amplifier unit where it is amplified to 25W. The modulation circuit uses a Voltage Controlled Crystal Oscillator (VCXO) as a reference oscillator for the phase loop and also serves as a modulator.

The voice signal, after passing through the compressor circuit which prevents deterioration of the Signal to Noise (S/N) ratio, such as caused by a sudden change in



S/A-CH TX

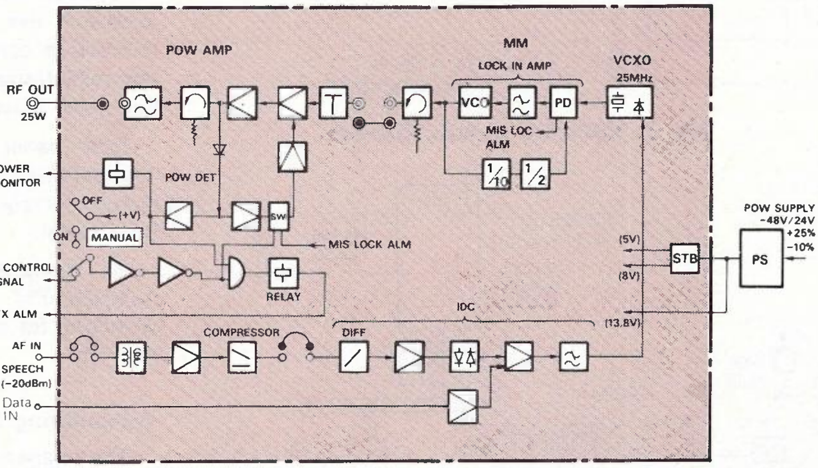
2,100mm (H)
520mm (W)
240mm (D)

150kg/FRAME
FOR 4CH

TX OUTPUT 25W
FREQ. STABILITY
$\pm 4.5\times10^{-6}$

PHASE MODULATION
±3.0kHz FREQ DEVIATION
FOR STANDARD MOD.

POWER DRAIN 150W/1CH



A-CH (1) SETTING UP A RADIO PATH WHEN CALL IS ORIGINATED FROM MSS.
(2) OPERATING AS A SPEECH CHANNEL WHEN ALL THE SPEECH CHANNELS ARE BUSY.
S-CH (1) TRANSMITTING A SPEECH SIGNAL.

Fig. 6: Base Station Transmitter S/A-CH

electric field strength due to fading, etc., passes through an Instantaneous Deviation Control (IDC) circuit and a splatter filter and is hence fed to the VCXO.

The digitized signalling information, after conversion into direct FSK by the P-CH repeater, is supplied to the VCXO input after passing through a DC amplifier circuit and a splatter filter.

Receiving Equipment

The receiving equipment is divided into two categories:

(1) basic equipment to which two units are provided for the paging channels, a maximum of 14 channels being available for use as speech or access channels.

(2) extension receiving equipment having a maximum of 16 channels (used as S-CH or A-CH).

The same receiver type is used for all channels and it is possible to connect a maximum of three extension receiving equipments to the basic equipment.

In order to improve reliability of the P-CH, parallel operation is provided. The receiving equipment consists of a paging unit, an access unit, a speech receiver unit, power supply unit, and antenna multiplexer. In the case of the P-CH, a carrier monitor that has a function for frequency conversion of field strength information for remote monitoring, is added. The basic receiving equipment is shown in **Fig. 7.**

The antenna multiplexer allows the use of a single antenna for receivers up to a maximum of 64 channels and compensates for distribution loss by the common amplifiers. The amplifiers used have a low noise figure and low intermodulation distortion, and are operated in parallel in order to improve reliability. A system diagram of the receiver is shown in **Fig. 8.**

This receiver has no RF amplifier stages, a low intermodulation distortion and a quadrature detector in the demodulation circuit giving a completely adjustment-free system, including the IF stage. A median value method has been employed for electric field strength detection plus an expander with a two-to-one characteristic in the audio frequency speech path.

The receiver transmits to the MCC a tone signal with variable frequency in the band 0.3 - 0.6 kHz in accordance with the electric field strength information. A 5 pps signal is also sent to the MCC as a voting request when the input electric field drops below a set value (10 dBu). In addition, this receiver has an 8-bit parallel input for designating an optional speech channel receiver as an access channel.

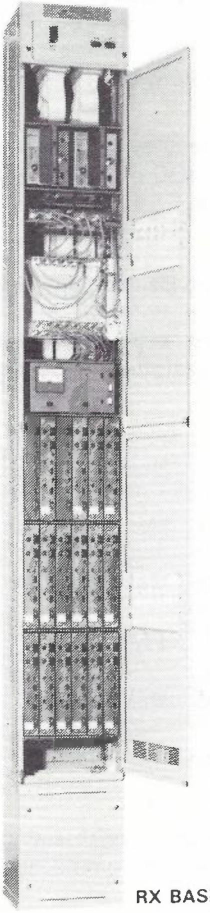
Supervisory and System Test Equipment

Because of the nature of the overall system it is considered necessary to detect and correct promptly, any faults that might occur during call connection in addition to monitoring equipment performance. The performance in each equipment item is monitored by the supervisory system but any fault that might appear during call connection is monitored by automatically generated test calls.

System Outline

The supervisory system block diagram for the mobile telephone system is shown in **Fig. 9** and consists of two parts:

- Supervisory System



RX BASIC FRAME

2,100mm (H)
260mm (W)
240mm (D)

90kg/FRAME
FULLY EQUIPPED

RX SENSITIVITY
1μ V FOR S/N 20dB

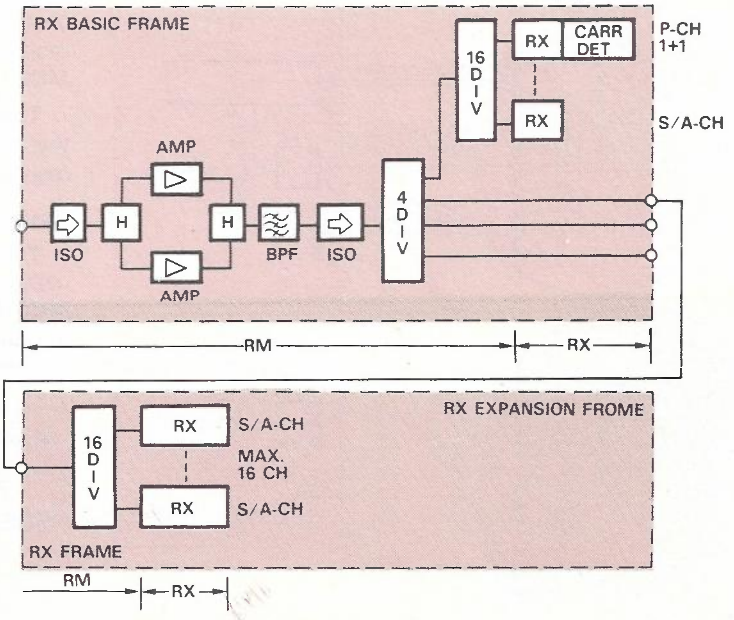
ADJACENT CH SELECTIVITY
70dB

INTERMODULATION
75dB

HUM AND NOISE
50dB

POWER DRAIN
COMMON CIRCUITUS
15W/FRAME

RX CH 3.1W/CH



P-CH RX 1+1.	DATA RECEPTION FROM MSS RF RECEIVE LEVEL INFORMATION TO MCC
A-CH RX	DATA AND VOICE RECEPTION FROM MSS
S-CH RX	TONE AND VOICE RECEPTION FROM MSS VOTING REQUEST TO MCC

Fig. 7: Base Station Receiver

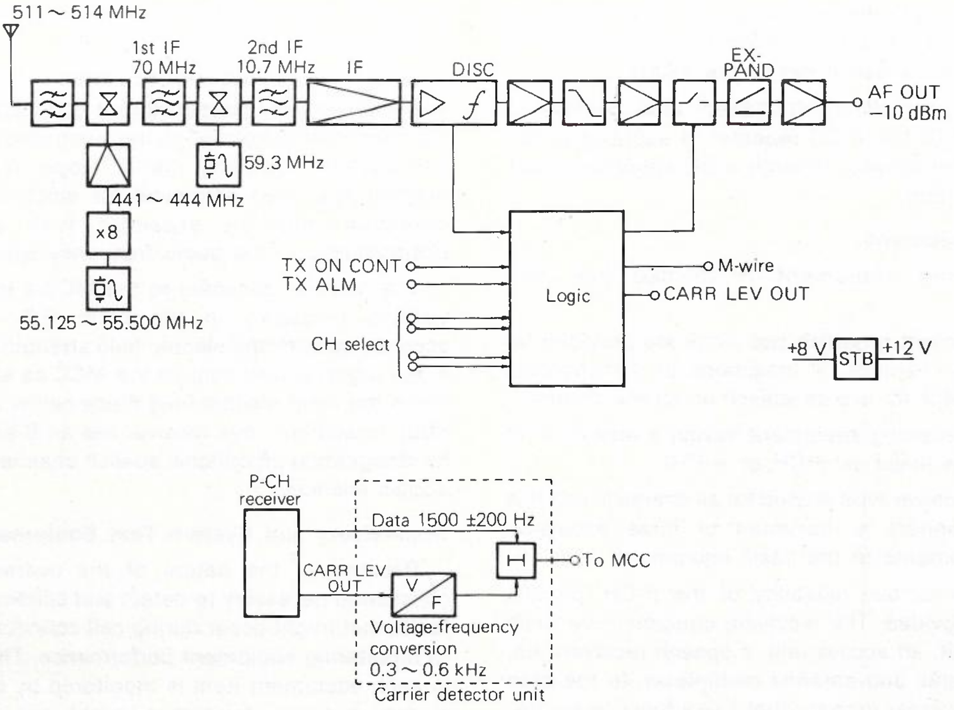
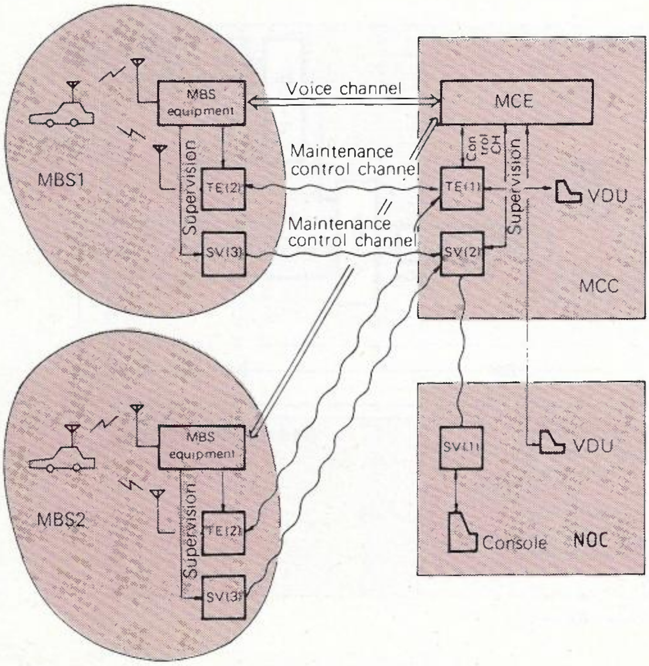


Fig. 8: Receiver Block Diagram

Control lines connect each MBS and the Network Operating Centre (NOC) to the MCC. The NOC supervises each MBS and the MCC. The MCC displays the status of the various items of MBS equipment.

The NOC also displays on a console the status of various MBS and MCC equipment, specifically taking the system economy into consideration.



MBS	Mobile base station
MCC	Mobile control center
NOC	Network operation center
SV (1)	Supervisory equipment
SV(2)(3)	Supervisory equipment
TE (1)(2)	System test equipment
VDU	Video display unit

Fig. 9: Supervisory System

- Test System

Control lines connect each MBS to the MCC. The system TE includes a MSS similar to that installed in vehicles, allowing for simulation of originating calls and terminating calls between the MCC and the MBS. The characteristics of the MBS transmitter-receiver are monitored by the control commands from the TE at the MCC.

These monitoring functions are executed by entering the commands at the VDU for the NOC or MCC. Test results are displayed on these VDU's.

Supervisory System and Radio Test System

Table 1 shows the number of supervised stations and individual items. Signal transmission between MBS-MCC-NOC is performed by a 50 bit/s FSK. An independent FSK frequency is assigned to each monitored station.

Supervision	Item	Number
MBS Supervision	Stations	Max 10 MBSs
	Supervised Items	Max 96/MBS
MCC Supervision	Stations	1 MCC
	Supervised Items	Max 16/MCC

Table 1. Supervision

Test System

The test system facilities provided for channel testing are shown in Table 2. The channel test connection concept is shown in **Fig. 10**.

- Channel Test
  - Manual Test
    - Originating call connection test
    - Terminating call connection test
    - Terminating call test and characteristic measurement test
  - Automatic Test
    - Originating call connection test
    - Terminating call connection test
    - Terminating call test and characteristic measurement test

Table 2. Test List.

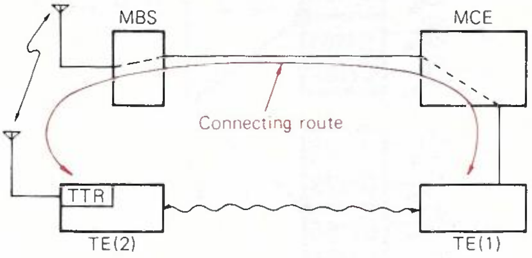


Fig. 10: Test Connection Concept

Manual Test

Manual test is performed for the localization of an alarm by the ordinary call processing, for failure complaints from the subscriber, or for recovery confirmation. Maintenance personnel can perform the connection operation test and voice channel level check by specifying the radio zone, voice channel, etc.

- Connection Test
  This test is segregated into two categories, the originating call connection and terminating call connection. Maintenance personnel issue commands for each test from the VDU.

The MCC system test equipment performs the voice channel reservation to the Mobile Control Exchange (MCE). If it is an originating call, it causes the test mobile unit mounted on the MBS system test equipment to originate a call by means of the remote control. This originated call signal is led to the MCC system test equipment by the MCE. During this processing, the sequence is displayed on the VDU. Therefore, if the connection fails, the sequence in which the failure cause is located can be detected.

- Characteristic Test
  This test performs test connection of a voice circuit by the incoming call connection. Then it performs the following measurements:
  - — Does the upward voice channel level satisfy the specification?
  - — Does the downward voice channel level satisfy the specification?
  - — Does the MBS transmitter output satisfy the specification?
  - — Does the MBS receiver limiter current satisfy the specification?

Sequential Automatic Test

For a routine test, the test system automatically selects channels one by one, and performs each test described above sequentially. Paramaters, such as intervals between channels, are designed to be selected by maintenance personnel.

Transmitter Multiplexer (TM)

Up to 16 transmitters and 64 receivers can be multiplexed on a single antenna. **Fig. 11** shows a 16-channel TM system.

Antenna

Two types of antennas (see **Fig. 12**) are employed. The most common is a colinear 8 stack array with an omni-directional radiation pattern and a 9dB gain. (Fig. 12a).

For applications requiring directional radiation characteristics, a 3-element corner reflector is used with a main beam gain of 9dB (Fig. 12b).

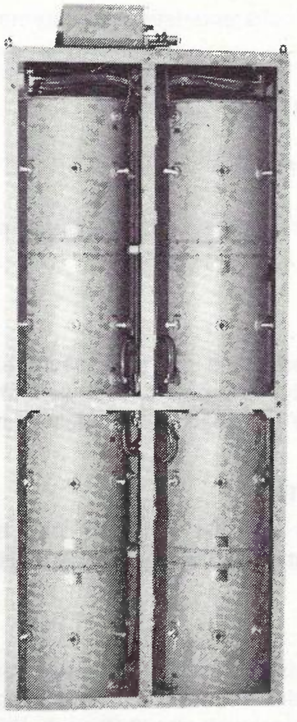
MOBILE SUBSCRIBER SET

The Mobile Subscriber Set (MSS) consists of an antenna, a transceiver/logic unit and a control unit (refer to **Fig. 13**). The antenna is normally mounted on the rear mudguard, or the roof of the car, the transceiver/logic unit mounted in the boot and the control unit installed in the passenger compartment — usually in a centre console or under the dashboard. Power is supplied from the vehicle's battery directly to the transceiver/logic unit. Power is turned on and off by operating the control unit control lock key.

Transceiver/Logic Unit

The transceiver unit is composed of a duplexer, transmitter, receiver and synthesizer, its block diagram is given in **Fig. 14**. The transmitter output power is 10 watts (nominal). The transmitter is provided with a frequency modulator for digital signalling and an equivalent phase modulator for the audio signal. The transmission frequency is obtained by mixing a signal from the frequency synthesizer and the VCO in the exciter as a result, excellent spurious signal level (80dB) and carrier-to-noise ratio (80dB) are obtained. The synthesizer is capable of generating frequencies for transmitting and receiving signals for 120 channels, and generates a frequency for any desired channel under control of the logic unit.

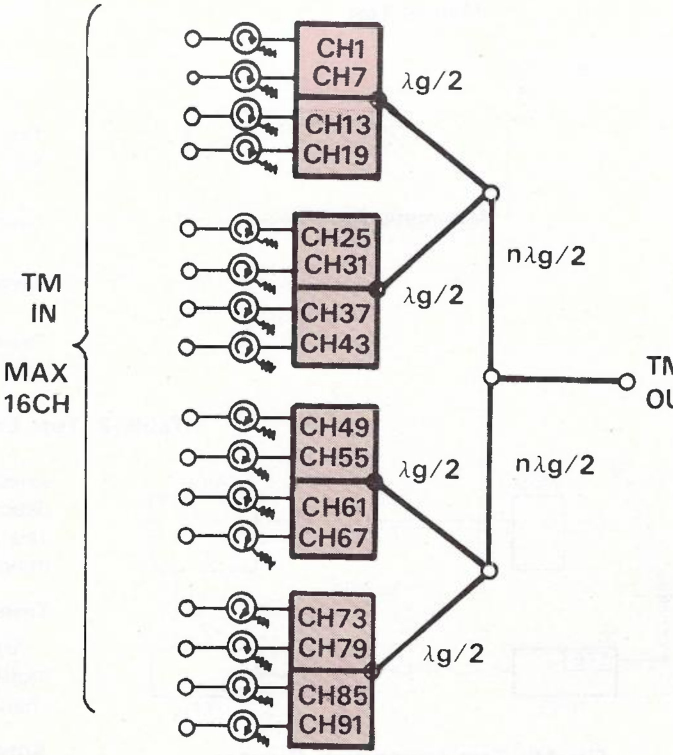
The VCO, which is an important circuit element of the frequency synthesizer, employs a hybrid integrated circuit using a high-dielectric substrate. Thus, it has high Q and



2,400mm (H)
(2,600mm)
1,040mm (W)
500mm (D)

300kg/FRAME

TM 16/16 CH DUPLEXER



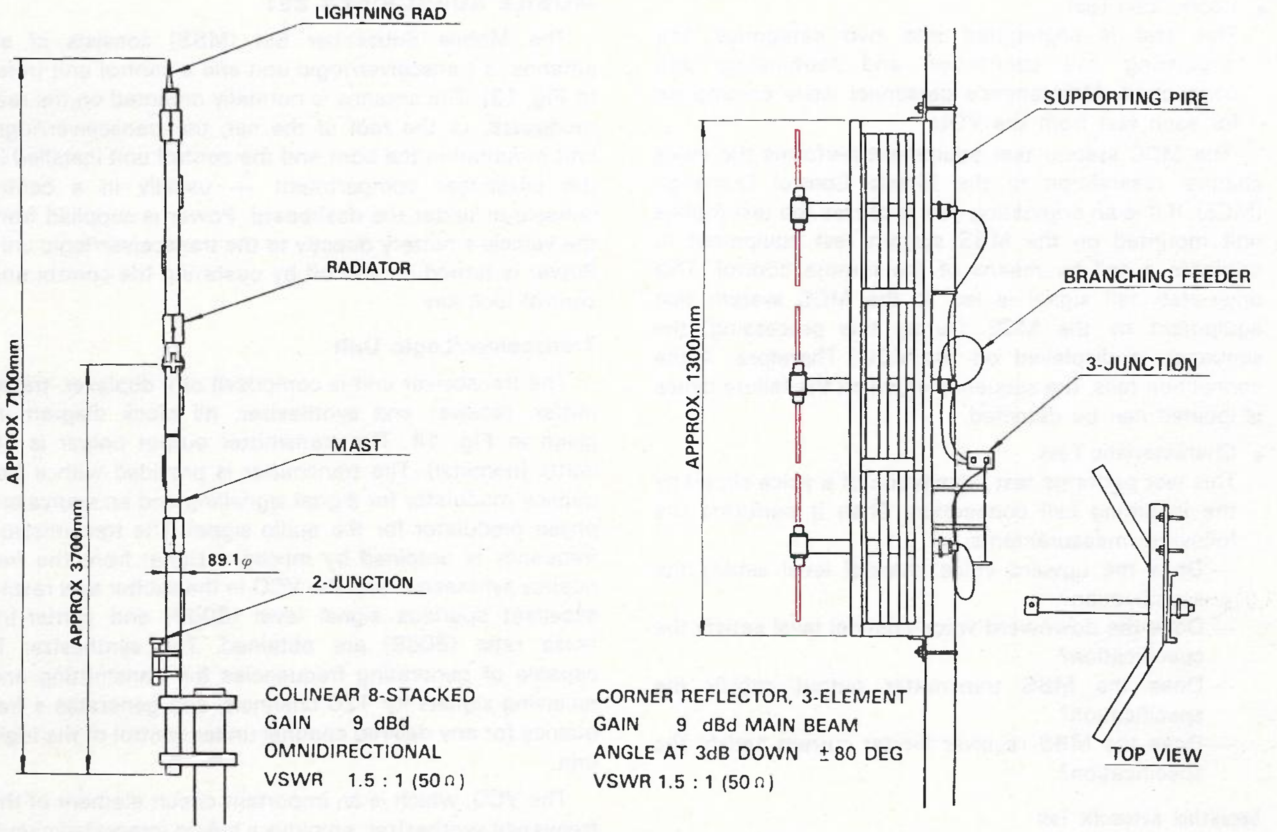
150kHz SEPARATION
LOSS TMIN-TMOUT 3.0dB
TM IN TREMINAL COUPLING 40dB
INTERMODULATION 42dB
VSWR 1.2 : 1 TM INPUT
2.0 : 1 TM OUTPUT
0°C ~ +50°C

$$\lambda g = \frac{\lambda}{\left\{1 - \left(\frac{\lambda}{\lambda c}\right)^2\right\}^{1/2}}$$

λ = WAVELENGTH

λc = 1.3λ

Fig. 11: Transmitter Multiplexer (TM)



COLINEAR 8-STACKED
GAIN 9 dBd
OMNIDIRECTIONAL
VSWR 1.5 : 1 (50Ω)

CORNER REFLECTOR, 3-ELEMENT
GAIN 9 dBd MAIN BEAM
ANGLE AT 3dB DOWN ±80 DEG
VSWR 1.5 : 1 (50Ω)

Fig. 12: Base Station Antenna

RF CH COPACITY : 120 CH BY DIGITAL FREQUENCY SYNTHESIZER

CH SPACING : 25 kHz

DUPLEX SEPARATION : 10 MHz

POWER SOURCE : DC+13.6V (NEGATIVE GROUND)
STANDBY 1.5A
CONVERSATION 6.5A

TRANSMISSION BAND : 0.3 - 3.4kHz

TX OUTPUT : 10 W
SPURIOUS EMISSION : 75dB
FREQUENCY STABILITY : ± 4.5ppm

MODULATION : PM FOR VOICE, Δf ± 3kHz
FM FOR DATA, Δf ± 4.5kHz

TX S/N : 50dB

RX SENSITIVITY : 1μV EMF FOR S/N 20dB

ADJACENT CH SELECTIVITY : 70dB

INTERMEDULATION : 73dB

RX S/N : 50dB

MICRO COMPUTOR CONTROLLED LOGIC PROCESSING
COMPANDER FOR BETTER SPEECH QUALITY

Fig. 13: Mobile Subscriber Set (MSS)

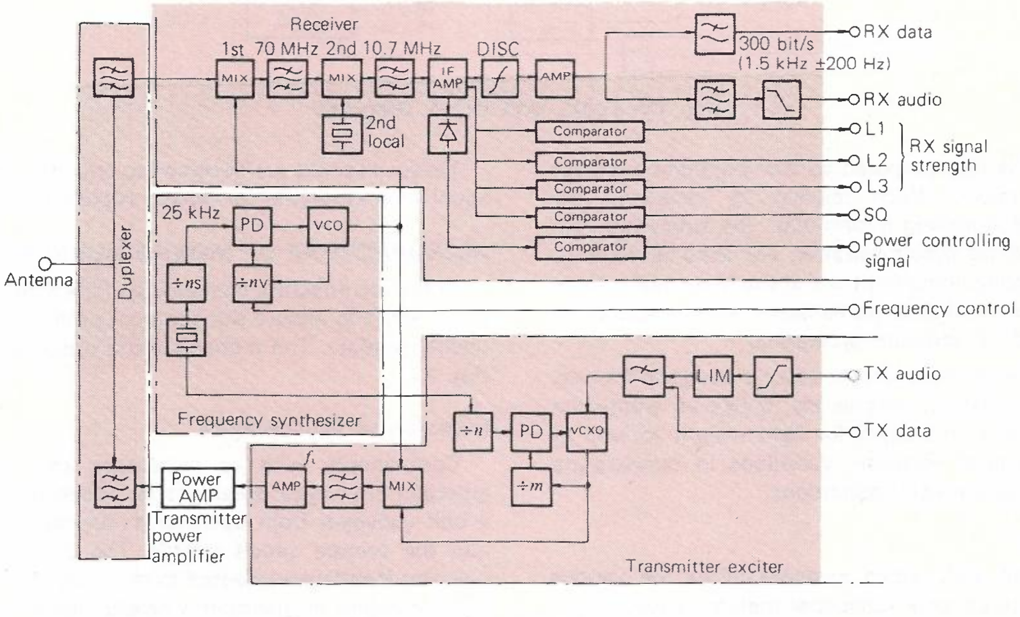


Fig. 14: Transceiver Unit Block Diagram

excellent vibration resistance. The oscillation frequency of the VCO is directly used for the local frequency of the transmitter and receiver. As the variable divider of the frequency synthesizer is of a pulse swallow type, it is capable of directly dividing at 500 MHz.

The receiver sensitivity is 1 uV emf (20dB S/N). To prevent intermodulation, no RF amplifier is used before the first mixer. The receiver has a frequency demodulator for digital signalling, a phase demodulator for audio signals and three field strength indicators. The duplexer is made of high-dielectric material and comprises a transmitting filter and a receiving filter.

The logic unit functions include reception of signalling information and generation, transceiver unit control, control unit supervision and control, and sequence control. A functional block diagram of the Logic Unit is shown in **Fig. 15**. The logic unit accommodates a uPD8085 8-bit micro-processor, three mask ROMs (uPD8355) and one RAM, (uPD8155). The mobile identification number is stored in a programmable ROM on the logic unit.

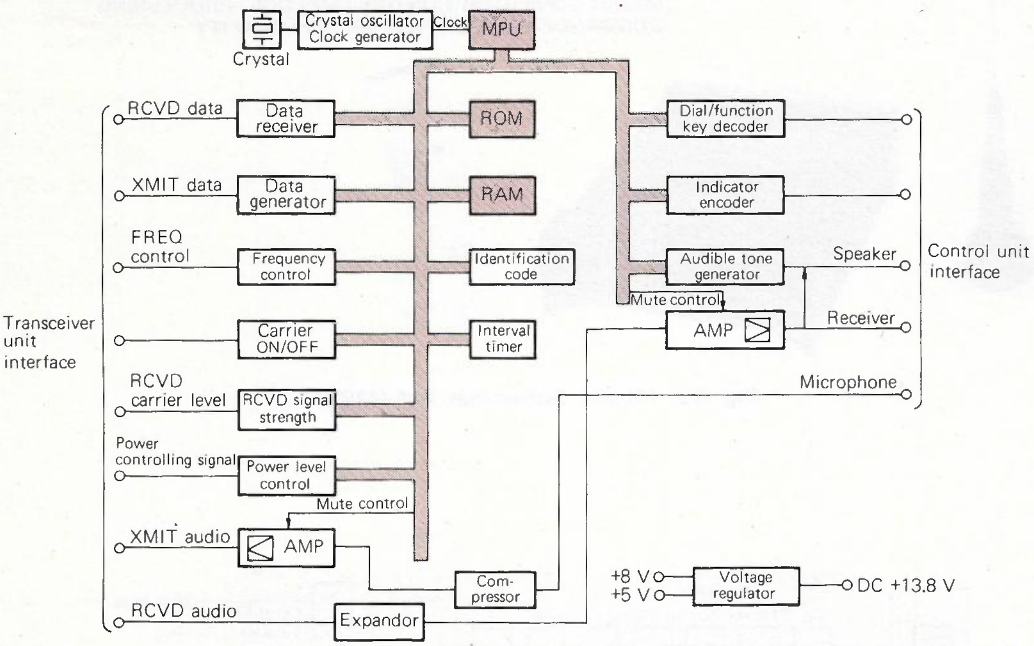


Fig. 15: Logic Unit Block Diagram

The ROM is also prepared so that origination classes can be identified. With respect to reception and generation of signalling information, the subcarrier FSK decoding and bit synchronization are accomplished by suitably designed equipment whilst the Manchester Code decoding and serial data transmission and reception are accomplished by software processing.

The transceiver/logic Unit housing is designed for easy handling, mountability and safety. It has an aluminium diecast structure, H-shaped for light weight as well as resistance against vibration, variations in temperature and other environmental conditions.

Control Unit

The control unit, which accommodates the various functions required for a subscriber making or receiving a call, is installed at a location where it is easy to operate with due consideration to man-machine interface. The control unit (**Fig. 16**) is composed of a dial-in-handset, a cradle, and an optional auxiliary call alert unit. It includes a dial key pad, a dialled number display, a microphone and receiver, and various controls and indicators.

The standard audio input level for the microphone is 94dB SPL (Sound Pressure Level). The optimum value of receiver output level is set at around 96dB SPL to obtain a good sound articulation, even if the ambient noise level is 70dB.

The handset is controlled by a 1-chip micro-computer. The auxiliary call alert is used for connecting an auxiliary incoming call indicator such as the vehicle's horn or headlights, to alert the mobile subscriber of an incoming call when he is in the vicinity of the vehicle.

Antenna

Two main types in use are:

- Rear mudguard mounting: ½ + ¼ λ antenna with a gain of 4.5 dB.
- Roof mounting: ½ + ¼ λ antenna with a gain of 2.5 dB.

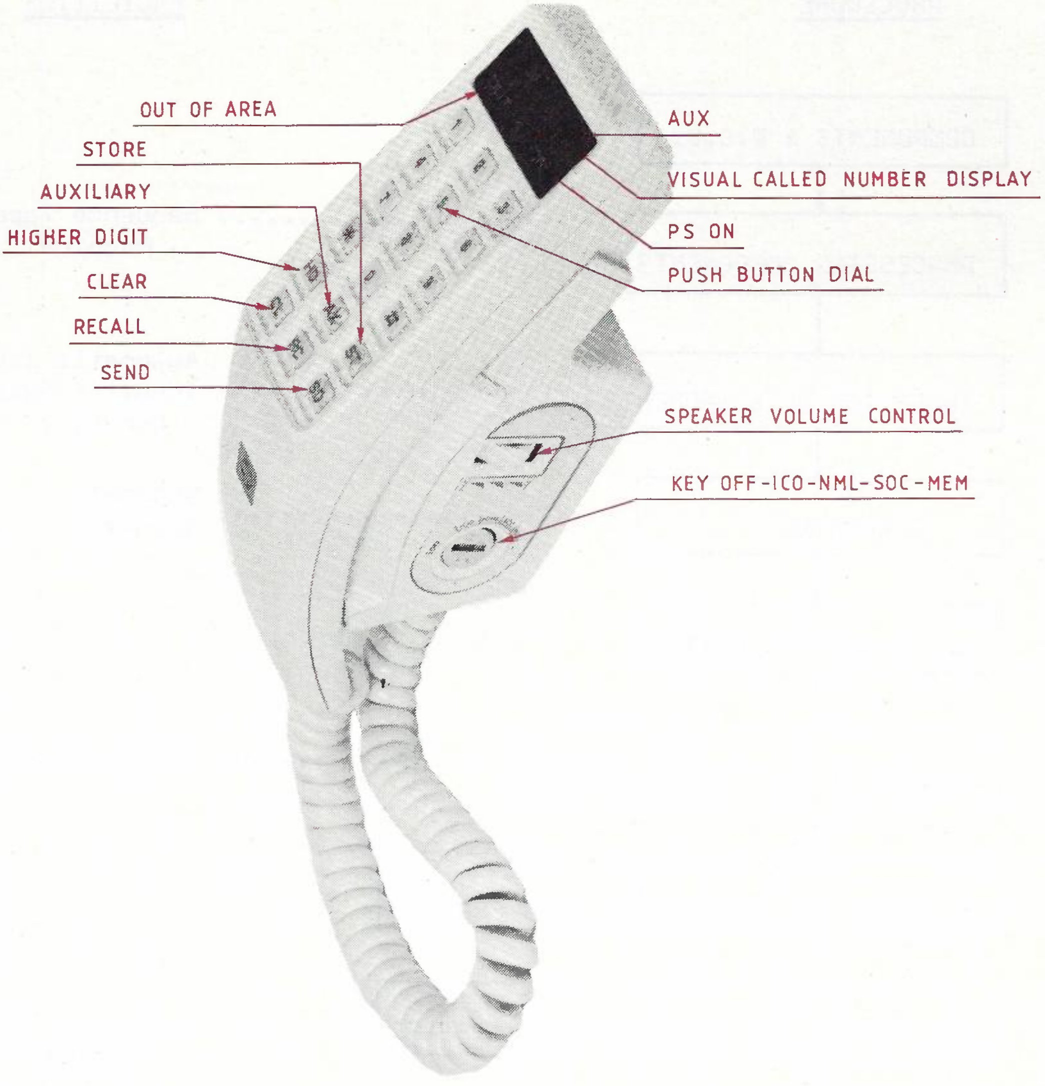
These antennas are designed to provide approximately equal field strengths for typical vehicle installations.

MANUFACTURE OF MOBILE SUBSCRIBER SET

In the manufacture and testing of the MSS, NEC made every effort to ensure the constant production of a high quality product. The manufacturing process is shown in **Fig. 17**.

Insertion of Components

Components such as capacitors and resistors are arranged in a logical sequence on a tape which is fed via a belt conveyor from operator to operator for insertion into the printed circuit boards. The components each operator inserts are selected to minimize insertion errors. At completion of insertion a careful visual inspection is carried out.



CONTROL HEAD

Fig. 16: Mobile Subscriber Control Unit

Insertion of integrated circuits requires care in handling. Thus the use of a micro-processor controlled Integrated Circuit (IC) insertion machine is made which is controlled by program on punched paper tape.

Soldering Process

The soldering processes are arranged to meet Telecom's soldering specification and is shown in **Fig. 18,** with the flux used, carefully chosen to be of low activity and hence to avoid any corrosion problems.

After initial fluxing, the printed circuit board is preheated to ensure a proper flow of solder, especially through plated holes. The board is then wave soldered to hold components in position and avoid movement during the lead cutting operation. High speed rotary cutting blades **(Fig. 19)** cut the component leads to the specified length without lead bending. Some cooling has occurred at this stage so the printed circuit board is re-fluxed and reheated.

The board is flow soldered to cover all the bare ends of the component leads and to give a high quality final solder finish. Upon completion it is brushed clean and carefully inspected for defects.

Assembly and Post Soldering

Some special components are not suitable for the automatic soldering process (e.g. crystals, filters, components to be mounted on top of board). These are inserted and soldered by hand.

The board is assembled into the individual assembly with the necessary plugs and mechanical parts.

Alignment and Testing

A technician performs the alignment of the board in accordance with a set down procedure with performance parameters of the board checked by specially designed test instrumentation **(Fig. 20).**

The majority of faults are detected at this stage; those found are repaired and the board retested. For quality control purposes, a percentage of units is also tested at high and low temperatures.

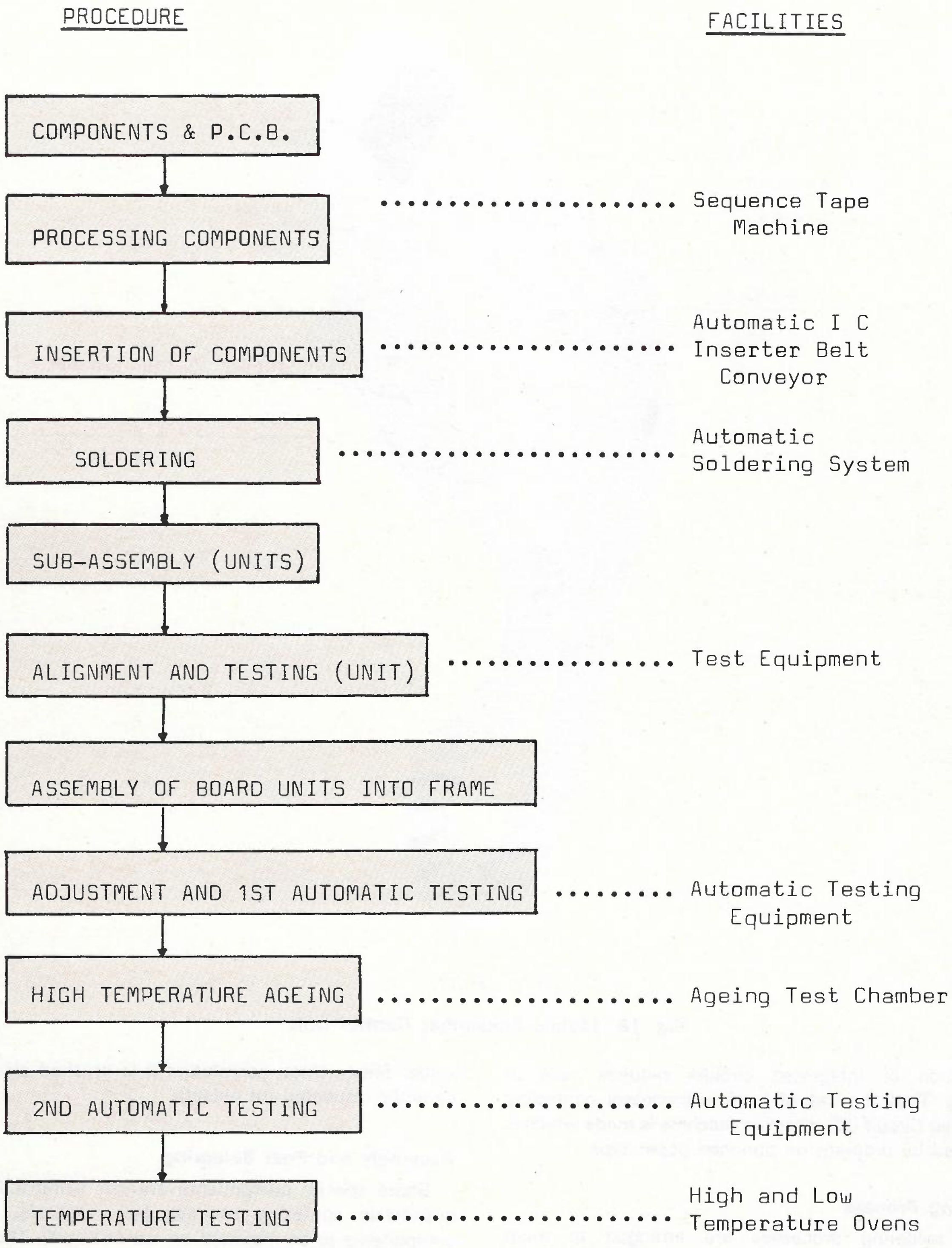


Fig. 17: Manufacturing Flow of Mobile Subscriber Set

First Overall Performance Test

The aligned and tested board units are assembled into the frame together with mechanical parts. Some adjustment depending upon interaction between boards is made at this stage. The unit is fully tested for electrical performance (**Fig. 21**) by automatic test equipment with any defective units diagnosed and repaired by the appropriate alignment technician. A printout of results is attached to each unit.

High Temperature Ageing

Because of the statistical probability that any component failure is most likely to occur in the first few hours of operation, the Mobile Subscriber Sets are subjected to an ageing process to detect such failures by operating the unit at 60°C for a period of 48 hours with the transmitter automatically cycled on and off.

Second Overall Performance Test

After any faults occurring in the ageing process have been rectified, the unit is again subjected to a full electrical performance test. For quality control purposes, a percentage of units is again tested at high and low temperatures.

CONCLUSION

This paper has described the configuration, performance and manufacture of an economical mobile telephone system. Advanced technology has made it possible to produce a cost effective and flexible mobile telephone and additional radio paging system for an increasingly mobile society.

This system has, to date, been delivered to Melbourne, Sydney and to Mexico-City.

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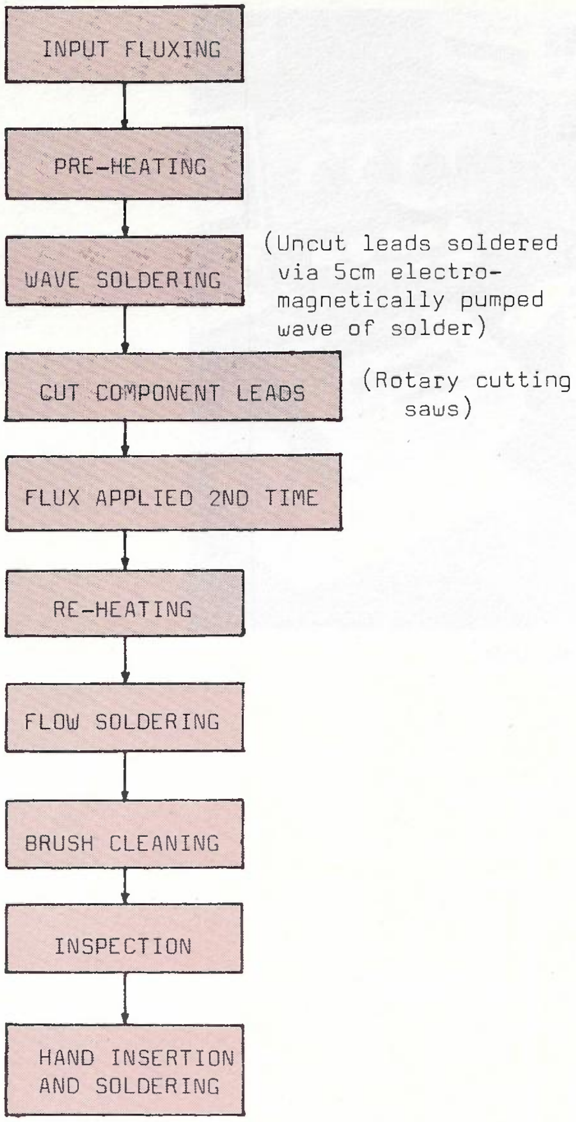

Fig. 18: Soldering Process Flow

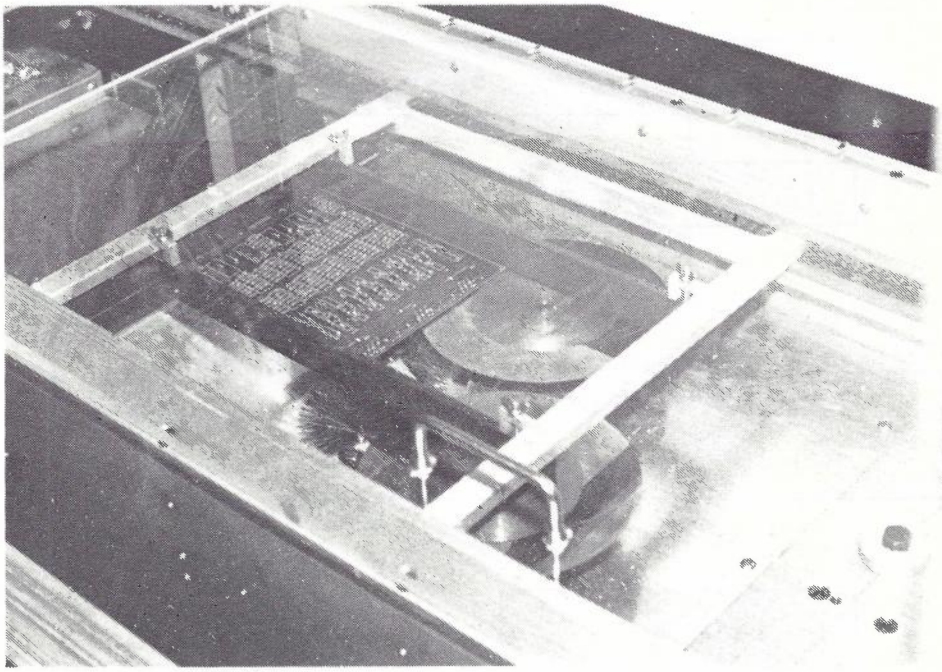

Fig. 19: Lead Cutting of Automatic Soldering

Fig. 20: Testing of Logic Unit

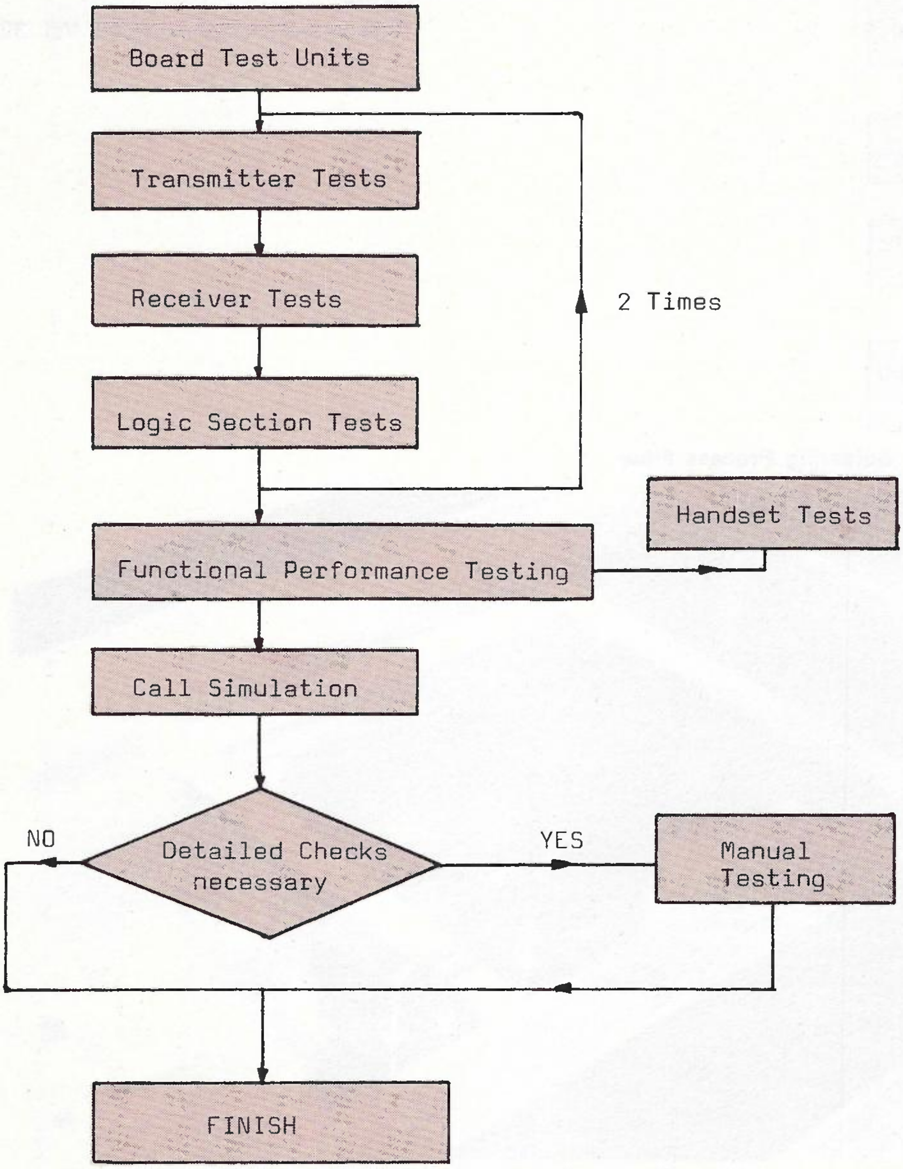

Fig. 21: Mobile Subscriber Set Testing Flow

Some Experiences with City "Earth Noise" Problems

E. G. WORMALD, F.I.E. Aust., F.A.C.S.

The investigation of complaints from customers about noise on their lines is a perennial problem. This article explains the basis of a particular class of noise problem and how some related complaints were cured in Sydney city around 1976-79. Limitations of the method are indicated.

INTRODUCTION

It appears that complaints about noise interfering with telephone conversation have occurred ever since the earliest public exchanges.

In recent years a substantial proportion of noise complaints from Sydney city customers has had in common the symptoms of "hum-like" and "evident only on exchange-to-extension calls" (through a PBX, either PMBX or PABX). Their cause has been an AC difference of potential between the Telecom earth on the customer's premises and Telecom earth at the parent public exchange, acting on an impedance unbalance in the through connection to produce loop noise.

How the potential difference arises, why it creates noise, and how such problems have been traced and cured are explained. The cure has its limitations, which are discussed.

Terminology:

Earth potential — The electric potential at the connection point to an earthing system, relative to ultimate earth (sometimes called the "remote body of earth" ie the conductive core of this planet). An ideal earth would have zero earth potential in all circumstances including the passage of large currents to its earth connection, but all practical earths are non-ideal, having non-zero resistance to ultimate earth.

Although earth potential can have a DC component, in this paper only AC is considered, because of its capability for interfering with the quality of telephone conversations.

Loop Noise — Nominally balanced line pairs are used between customer and exchange, with loop-mode transmission of telephony. Most noise sources couple equally to both legs of a line (ie longitudinally, sometimes called "common mode") and departure from ideal balance is necessary if they are to generate a loop ("differential mode") component capable of interfering with conversation. Except for long lines or identifiable leakage faults, it is unusual for a line by itself to be unbalanced enough to cause complaints. Otherwise, the usual source of unbalance problems is equipment in the transmission path, and the noise source acting on the unbalance to create interference is usually the earth applied to the PBX equipment.

WHY EARTH PBXs?

Telecom equipment is conventionally connected to earth for several purposes including circuit operation and protection. Some designs of PBX (as an extreme instance, the CB Extension Switch) can function quite well without any local connection to earth. However, the use of earth paths for circuit operation usually simplifies the design task in its signalling and control aspects, and facilitates fault-finding. There can be benefits for over-voltage protection in case of lightning or commercial supply surges, and (telephonic) noise alleviation. (Earth is applied to the 50V power supply's positive pole: originally chosen to reduce the electrolytic corrosion of relay windings.)

"Earth" as a Noise Source

In the city it is usual to find an appreciable potential difference (p.d.) between earth points in different buildings (or even within the one building). This is due to noise currents from various sources traversing the small but non-zero resistances between them. Consequently, earth at a customer PBX is often noisy relative to earth at its parent exchange.

The currents generating these earth p.ds come mostly from the supply authority's commercial 3-phase (4-conductor) distribution. In such systems neutral currents occur in at least two ways:

(a) The loads on the phases are seldom in exact balance, and the resultant out-of-balance current is carried by the neutral conductor.

(b) Among others, the triple harmonics (3rd, 6th, 9th, etc.) are generated in quantity by (non-linear) devices such as fluorescent lights. These add up directly in the neutral, from each phase. These components often predominate in noise problems because both the ear and telephone receivers are more sensitive to these frequencies than to the lower fundamental frequency.

A customer's neutral current is provided with its own conductor for return to the substation, developing a p.d. along its (non-zero) resistance as it flows. (See **Fig. 1**.) In the usual Multiple Earthed Neutral (MEN) system, each end of the conductor is earthed, so that the customer's supply earth potential is the phased (vector) sum of the neutral feeder p.d. and the substation earth potential. The latter is determined by the resistance of the substation's earth and the phased sum of all its neutral currents. As well as the contributions from customers, for whom there is, in effect, an earth path in parallel with this neutral feeder, the substation earth usually carries the out-of-balance component of the high voltage transmission line serving the substation.

Similar conditions apply at the exchange, except that close coupling between supply earth and Telecom earth is unavoidable (and often deliberate). The resultant extensive combined electrode system (including an array of cable sheaths extending for miles) helps to keep its earth potential low.

In many circumstances, Telecom earth at a PBX is closely coupled to the local supply earth. Whenever this occurs, the PBX-to-exchange earth p.d. is usually substantial, and line circuit unbalance is enabled to generate loop noise.

For any particular installation, the magnitude of the inter-earth potential difference can be readily measured by using an AC voltmeter and an otherwise spare (good) pair between customer site and exchange. With the pair earthed locally at either end, the p.d. appears between earth and the pair at the opposite end. The meter should be insensitive to DC to avoid false results. A multimeter on a power/output scale (which utilises an inbuilt series capacitor) is usually convenient. Typically 0.5—10 Volts are read for any large city building. Psophometric weighting may be necessary if interference capability is to be assessed.

Ways of Earthing a PBX

The provision of customer's Telecom earth for a PBX has usually followed one of four practices:

(a) An earth conductor back to the exchange, isolated from all earths other than that at the parent exchange end. This conductor has been the exchange cable sheath, bunched pairs within the cable or a PVC-insulated power cable run in the duct with the exchange cable. This keeps customer earth close to exchange earth potential, but the arrangement is suspect in its protection capability as indicated later.

Note that the use of lead-sheathed cable in possibly wet ducts does not necessarily remove it from this category. Usually the earth resistance to sheath of such a run exceeds 100 ohms which is too high (compared with the few ohms back to the exchange earth) for the

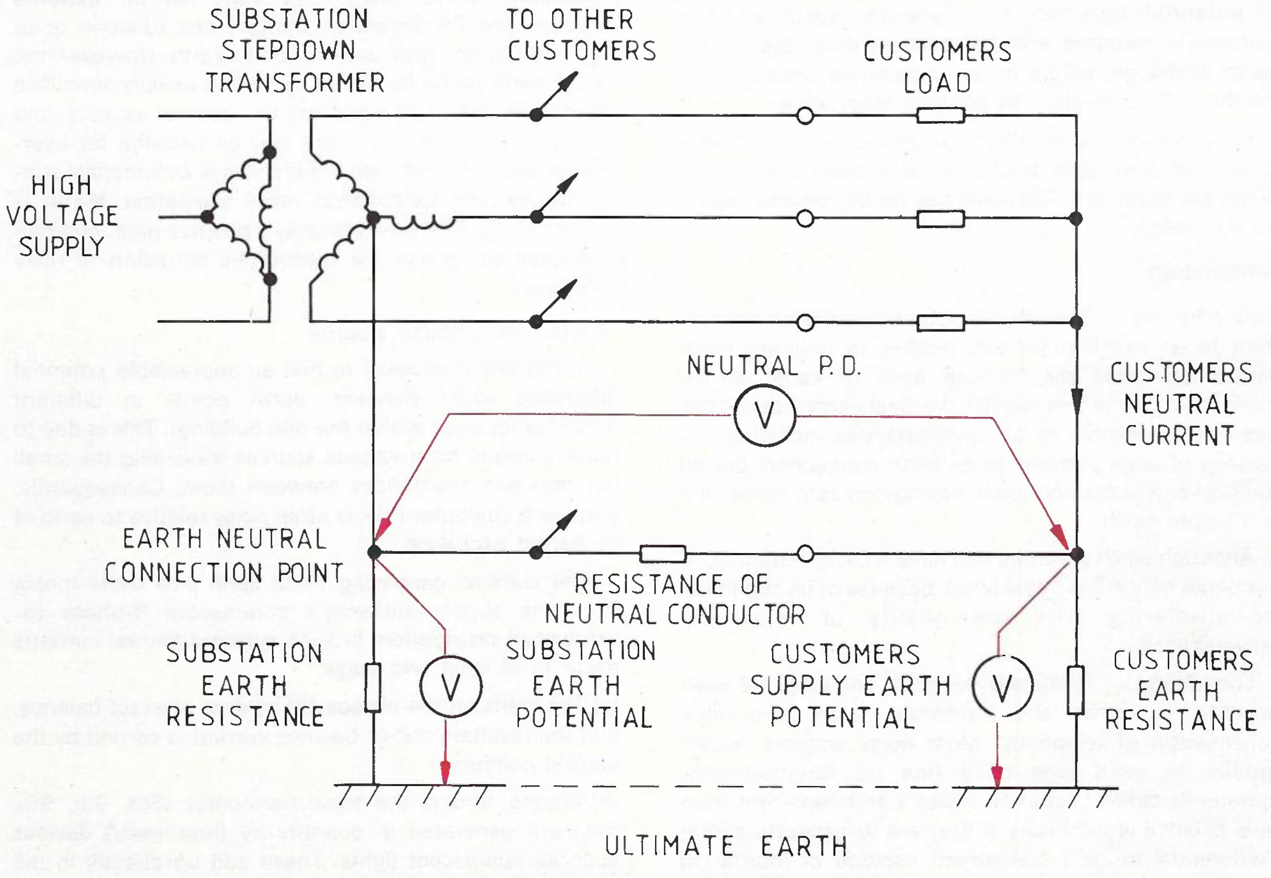

Fig. 1 Customers Supply 'Earth' Potential
(= Substation EP + Neutral p.d., as shown)

development of any substantial earth potential on the sheath.

(b) Buried stakes or plates hopefully well separated from other earth conductors on the same site (seldom used in Sydney city). In practice, it is usually difficult to avoid closer coupling between Telecom and supply earth electrodes by comparatively low-resistance horizontal paths through soil than by remote earth through vertical paths. Building steel is invariably tied to supply earth and with deep footings often approximates to a cage around any practicable Telecom electrode location on the site. The resultant Telecom earth potential is close to that of supply earth.

(c) A combination of (a) and (b), ie a conductor back to the exchange earth also provided with its own earth electrode(s) on customer premises (also not frequent in Sydney city). The earth potential achieved is somewhere between (a) and (b) depending on the ratio of the resistance of the local earth to that of the exchange earth feed. Close to the exchange and with an inefficient electrode system, the effect is as for (a); at the end of a long cable and with Telecom and supply electrodes in a damp pocket of soil, the effect is for (b). Others are intermediate.

(d) A connection to supply earth, with or without Telecom electrodes. Note that any Telecom electrodes here are virtually only a parallel extension of the MEN electrode system on the same site, and consequently have little practical effect on the situation. Note also that this style of connection is often achieved inadvertently, as described later, and that the earth potential resulting from the practice is not usually affected by also connecting the Telecom cable sheath to the composite earth.

WHY THE EARTH POTENTIAL DIFFERENCE CREATES NOISE

Noise current is driven along both legs of the exchange line by the earth noise potential difference acting on the line longitudinal resistance and the longitudinal series impedance at exchange and PBX (see **Fig. 2**). Unbalance in the line or associated equipment will develop a noise loop voltage capable of interfering with conversation. The situation may be summarised as:

$$e_N = e_E \cdot Z_U / Z_C$$

where e_N is the loop (noise) voltage caused by the unbalance impedance (lumped equivalent) Z_u carrying the longitudinal noise current e_E / Z_C ie the inter-earth noise voltage e_E divided by the longitudinal line circuit impedance Z_C in which it flows.

Those concerned with noise measurement often find it convenient to work in terms of a circuit's "coefficient of sensitivity", defined as

$$C_S = e_N / e_E.$$

From the foregoing relationship it is easily shown that also

$$C_S = Z_U / Z_C.$$

As a matter of interest, the maximum acceptable value of C_S is usually specified as 0.01 for the sort of situation dealt with here.

How to Control Such Noise

The foregoing relationship indicates that an objectionable value of e_N may be reduced by one or more of the following actions:

(1) Reduce Z_U. This can be very effective. For instance, line capacitors in the PBX transmission bridge sometimes drift in value or suffer low insulation resistance, or relay windings suffer from shorted turns. Attention to this factor is particularly indicated when it is found that some exchange lines are worse than others, or that there are also reports of crackling or scratchy noises, low transmission and/or wrong numbers.

However, it is often found that the unbalances are diffuse and not directly treatable.

(2) Increase Z_C. This can be used as a palliative, usually by inserting bifilar-wound inductors in exchange lines. Despite their low insertion impedance, such devices have a high series longitudinal impedance which adds into Z_C, and can be very effective. They are also costly and can pose difficulties in accommodation, wiring and testing.

It is aggravating that in practically all cases where this

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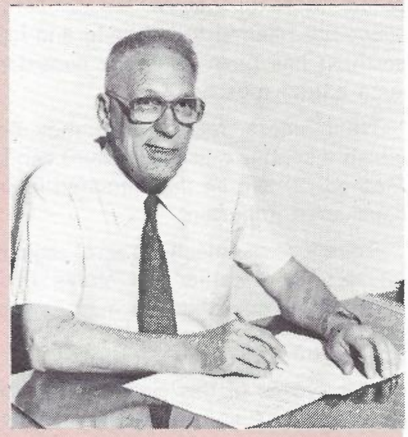
In 1960 he went to industry, designing equipment and systems for three different companies until he rejoined the PMG's Department in 1975 as Engineer Class 1. After working on PABXs, long line equipment and local exchange switching in Sydney City Field Engineering, he has been Supervising Engineer, Operations Support Systems in the NSW Design & Practices Branch since May 1980.

He has numerous published papers, mostly on equipment design, computing and traffic engineering. "A Traffic Distribution Recording Project" won the 1959 Electrical Engineering prize of the Institution of Engineers, Aust.



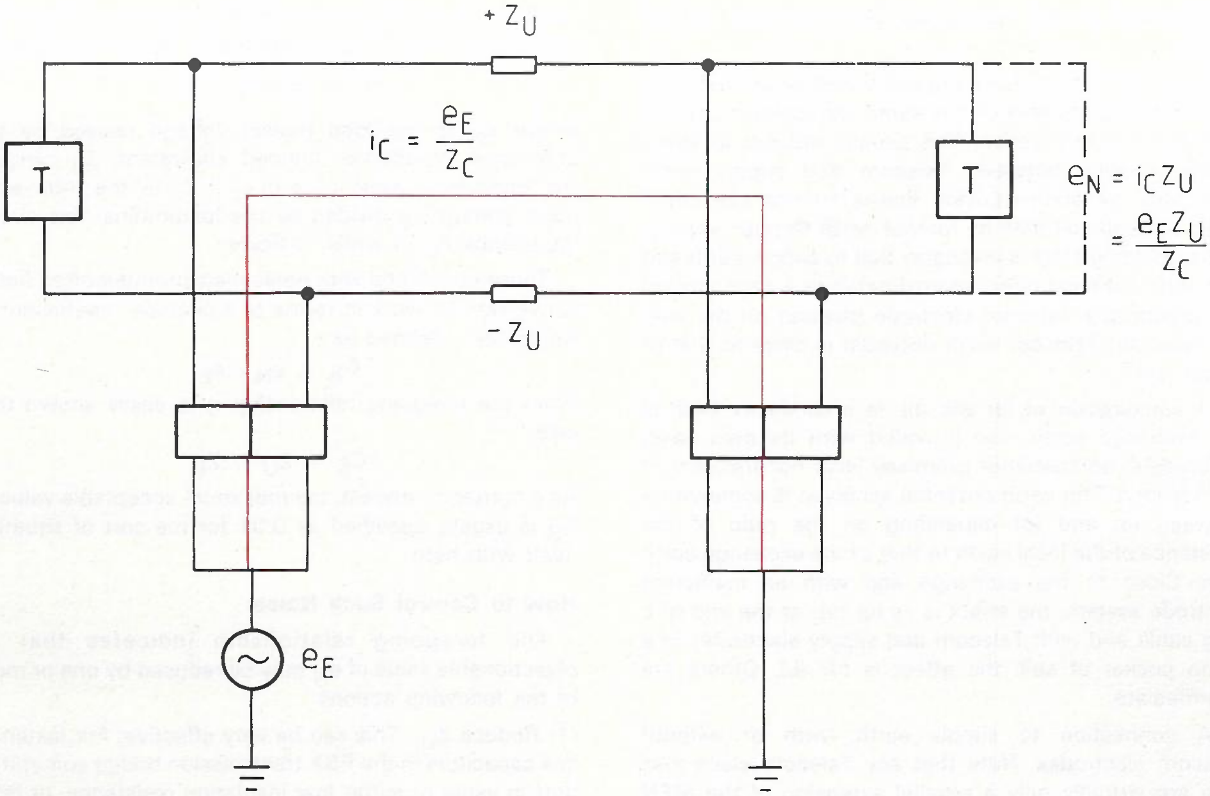


Fig. 2 Conversion of Earth p.d. To Loop Noise
e_E drives i_C through Z_C (The Common Mode Impedance), ie develops e_N across Z_U

sort of noise problem exists, the design of the PBX has lowered Z_C into the troublesome range by a poor choice of transmission bridge. Transformer-type bridges easily provide longitudinal isolation with consequently high Z_C. It is the author's opinion that inferior arrangements should not be designed into new equipment.

(3) Reduce e_E. This also can be very effective. Its use is contentious as it involves decoupling the customer's Telecom earth from his supply earth. Until recent times, such coupling occured in various ways but was seldom deliberate. Indeed, isolation was specified in S.A.A. wiring rules and some Engineering Instructions, but not others. More recently (with particular regard to the safety viewpoint relating to lightning and high potential rise of earth) it has been generally considered better to bond such earths together.

Nonetheless, reducing e_E may be the only way in which a serious noise complaint can be silenced quickly. Method (2) can be implemented later where bonding is considered important.

To reduce e_E (ideally to zero) requires the arrangement (a) described earlier in "Ways of Earthing a PBX", although as described (c) may approximate (a).

Procedure

It is typical of this class of fault that (for a variety of reasons) the first few complaints from PBX extensions are not successfully treated. Usually there is an eventual written complaint listing a large number of affected extensions and calling for urgent action.

Ideally, this has taken the form of:

(i) Locate and cure any identifiable faults causing unbalance in exchange lines or associated equipment.

This may cure the complaint, but otherwise —

(ii) Ensure that the Telecom earth path back to exchange earth is intact.

(iii) Locate any contacts between Telecom earth and supply earth, and isolate them. These are often inadvertent and obscure.

A first step towards (ii) and (iii) has been to measure AC in the sheath of the exchange cable near its entry to the PBX. See Appendix "A" regarding instrumentation, which usually shows current in the range of 0.5 to 10 Amps. Zero indicates either an open cable sheath path or zero earth potential at the PBX. The latter unusual possibility could be eliminated if necessary by the spare-pair voltage reading described earlier. The more usual open sheath has been located by using "HIND" (High Impedance Noise Detector — see Appendix "B") and has invariably been due to a faulty screen-bonding connection in one or more joints involving moisture-barrier cable. When continuity back to the exchange exists, the potential difference between the earths (say 2V) applied to the cable screen resistance (say 1 ohm) produces a substantial AC current (2 Amps in this example). Such current is an indicator of the situation but not usually a direct producer of noise.

By moving along the cable towards the PBX, careful and successive measurements pinpoint the source(s) of the cable current. As the culmination of the work, actual insulation of the found current-paths has usually involved comparatively little effort, but the resultant sudden removal of a worrying noise can be quite rewarding.

Investigations

A typical instance was when PMBX customers on either side of the southern end of Phillip Street reported hum/noise problems. The cable serving the area from Martin Plaza showed 1 Amp of AC, branching to 2 Amps and 3 Amps at a joint along the street. Tracing the major current to another joint showed 3 Amps and 5 Amps in the fingers. The 5 Amp cable entered a nearby building, where 5 Amps on one side of a wall through which it passed became zero on the other side. Investigation showed that steel-wool packing had been used as a basis for the plaster around the lead-sheathed cable, and that this also contacted some earthed (steel) electrical conduits within the wall. Replacement of the steel-wool by insulating material considerably alleviated the hum situation, which was cleared up after similarly tracing and eliminating the currents noted in other branch cables.

Elsewhere, a government department had a hum problem with their PABX for many years. In the course of time the interference level had increased with the electrical consumption within the building and the use of modern non-linear devices, until conditions were verging on intolerable for exchange line calls. The AC voltmeter test (described earlier) showed 1.5V between local earth and parent exchange earth. As a first step the customer was asked to insulate all light fittings, conduit and switch housings from the PABX racks on which they were mounted. After this the current-measuring technique was applied, and pointed to the lead-sheathed extension cables as the remaining cause of the problem. They were found to traverse under-floor steel ducts and runways which contacted supply earth in numerous places, and they also contacted PABX earth when passing over the top of the MDF. The problem was cleared by slipping insulating sheet between them and the MDF ironwork.

A new tower-office building was found to have 15 PMBX'S with objectionable hum/noise on exchange calls. This was traced by similar methods to contact between the fixing bolts of the building MDF (located in its basement) and structural steel within the wall. Normality was restored by applying insulating bushes and washers to the fixing bolts through the MDF ironwork to which the Telecom earth cable connected. It was also necessary to locate and rectify a faulty inter-screen bond at one joint in the street cable, in order to obtain an effective earth on the building MDF from the exchange. The steel core of the building formed part of the Supply Authority's MEN system and in consequence was about 1.0V AC away from exchange earth.

A PABX on the 17th floor of another building had exchange line hum problems. It was found that the exchange-to-Telecom earth p.d. was tolerable in the basement of the building but not on the 17th floor, despite the substantial copper cable up the riser shaft connecting them. It turned out that the building MDF and the 17th floor IDF each had their ironwork (to which the riser earth cable was bolted) accidentally connected to the core of the building (through fixing bolts) at points about 1.5 Volts apart. There were about 3 Amps traversing the cable, whose arc frightened the technician who broke the circuit.

The foregoing are the most interesting of about 10 incidents treated in the course of three years. It is noteworthy that all had capacitor-type feeds in exchange/extension calls.

SUMMARY

Neutral current from the commercial electricity supply system usually causes an AC potential difference to exist between the Supply Authority earth at any large city building and the Telecom earth at the exchange serving that building. The same p.d. may appear between Telecom earths. If impedance unbalances which act to derive loop-noise interference from such a p.d. cannot be removed or nullified economically and quickly, relief may be obtained by reducing the p.d. Related questions are examined.

Typical incidents in Sydney City have been described. It seems probable that similar problems occur in other closely developed areas where the technique described may be helpful also.

APPENDIX "A" — "CLAMMETER"

The work involved in taking frequent readings of cable (sheath) current was greatly simplified by the use of an ammeter with an openable magnetic core, allowing a current to be measured without breaking its path. No suitable commercial tong-type ammeter could be found — those with tongs large enough to close around our largest street cable (close to 100 mm diameter) required 10 Amps or more for an observable indication.

The device used nicknamed 'Clammeter" for clamp-ammeter, uses a demountable current transformer with an amplified meter. Its core consists of a double stack of U and I power transformer laminations bolted together to form an openable hollow square. A coil of about 120 turns is wound on one limb and encapsulated in polyester putty for protection and water-proofing. A small instrument box is attached by a 2-wire lead. It contains a quad operational amplifier micro-circuit to raise the level of the voltage induced across the coil by current in a cable through the closed core, and to "idealise" diode-rectification of the signal before application to a 50 mm square 50 uA analog meter. There is a switch to select the gain for meter ranges of 5 and 50 Amps full-scale, a "read" push-button to minimise discharge of the small 9V battery, and a L.E.D. indicator that the battery voltage is adequate.

The accuracy is within ± 30% for 50 Hz, which is adequate for the task despite its pronounced non-linearity of scale. There is a natural emphasis of higher frequencies up to at least 1KHz, which is regarded as an approximation to psophometric weighting.

APPENDIX "B" — "HIND" (HIGH IMPEDANCE NOISE DETECTOR)

As a noise control measure or for other reasons it is sometimes necessary to be sure that the sheath or screen of street cables is electrically continuous. External lead sheaths are no problem, but some cables have an outside plastic sheath, notably the "moisture-barrier" types with polythene extruded over an aluminium screen. Their screen continuity depends on correct installation of a bond-wire from screen to screen inside each joint. Such bonds are not normally accessible either visually or electrically, so that the occasional imperfect installation is difficult to identify.

If the city, a good bond may be confirmed by a non-zero "clammeter" reading, as sheath current cannot pass an open circuit. On the other hand, zero current near a joint does not necessarily indicate that it is faulty. There may be an open circuit elsewhere.

In such circumstance a cable test set known as "HIND" (High Impedance Noise Detector) has proved valuable. (Note that it is likely to be superseded by a more readily available commercial device which operates on the same principle.) Using capacitive probes and an amplifier with an input impedance of at least 100 megohms, HIND is capable of sensing the potential difference between the physically inaccessible aluminium screens inside the polythene sheath on either side of a joint in moisture-barrier sheathed cable. If the screens are well bonded electrically, the p.d. should be low but if the bond is faulty the p.d. is usually many tens or hundreds of milli-volts because of noise induction effects.

Note that HIND can indicate a good joint as faulty if the screen carries enough AC current to generate an abnormal voltage drop across the bond. Thus HIND is only used where the "clammeter" indicates no screen current. Anyway, if screen current exists the bond is intact and the use of HIND is unnecessary.

In Brief

FIRST AXE EXCHANGE AND AOM GO INTO SERVICE

On 1 November 1981 Telecom Australia cutover the first AXE exchange in Australia. The exchange is located at Endeavour Hills, an expanding outer metropolitan suburb of Melbourne. The new AXE exchange is a 4000 line installation and replaced three existing portable exchanges. AXE is the latest SPC exchange produced by L. M. Ericsson and offers sophisticated facilities for the customer and for Telecom Australia. The Endeavour Hills installation is fitted with an analogue group selector stage but all future AXE exchanges will be installed with a digital group selector stage and as such will form the basis of an integrated digital network (IDN).

In conjunction with the AXE installation at Endeavour Hills, the first AOM installation was also placed in service at Clayton in Victoria. The AOM is an L. M. Ericsson designed message switching system which is connected to the AXE exchange by a data link. The AOM will switch messages and record transactions between Network Operations Centres (such as the Maintenance Centre, NPAAC, etc.) and any exchanges which are connected to it. The AOM will form part of a total "Operations Network" development.

Telecommunications in the United Kingdom

GRAHAM McMORRIN

INTRODUCTION

The demand for telephones in Britain has grown at an astonishing rate ever since they were introduced just over 100 years ago.

The country now has the world's fourth biggest telephone network after the United States of America, Japan and West Germany.

After the Post Office opened its first telephone exchange in Swansea, Wales, in 1881 the number of telephones rapidly increased.

In those days the instruments were bought under licence from the British agent of the Bell America company. Several other companies then started to offer alternative systems and even before the end of 1881 the need for a comprehensive national system became obvious.

Accordingly, the Post Office took responsibility for all long distance calls, although private companies continued to operate under licence from the Government until 1912. The post Office took most of them over, though one or two remained independent the most notable at present being the Hull Telephone Company.

GROWTH

The growth of the telephone network continued at a fast pace. In 1950 Britain had 5.2 million telephones, which rose to 7.4 million in 1958. The total went sharply to 12.1 million in 1968. The trend continued through the 1970s and by 1981 the country had 28 million phones.

This rate of growth together with radical changes in technology created a need for change and reorganisation at the top, and led Parliament to pass the Post Office Act of 1961. This gave the Post Office more autonomy and separated its finances from the Treasury. In 1969 the Post Office was established as a State corporation and its operations gradually became those of a commercial enterprise.

In 1977, a Government-sponsored review committee recommended separation of the mail and telecommunications businesses — a move supported by the Post Office Board and most of the trade unions. This separation was formally completed in October 1981 with the passing of the British Telecommunications Act. British Telecom thus came into being with the aim of consolidating its role as one of the world's biggest telecommunications organisations.

DIGITAL SERVICE

At the centre of British Telecom's strategy is technology for the future: the creation of a single multi-purpose network capable of simultaneously carrying all kinds of communication — speech, text, data or pictures — from customer to customer in digital form. Information is transmitted as rapid on/off pulses of electricity or light instead of a continuous electrical signal as with today's analogue equipment.

Providing the brains for the new network are System X exchanges while its nerve system, carrying the nation's communications, will increasingly involve optical fibres.

Messages will be sent as pulses of light along hair-thin strands of glass as British Telecom builds up a comprehensive optical fibre network. Fibres are made from glass so pure that a sheet 6 km thick would be as transparent as an ordinary window.

British Telecom is now engaged in providing a range of new digital services for customers. The keynote is flexibility, and the most appropriate methods will be used — including microwave links from customers' premises. Satellites will also bring specialised services to business customers using small dish aerials.

SYSTEM 'X'

Computer controlled exchanges of the System X type are now going into service offering better speech quality, greater reliability, and high-speed connections. Advanced techniques such as voice guidance — actual spoken messages — will help the customer to use new "star" services for diverting calls to another number, setting up alarm calls or holding three-way conversations.

Modern microchip technology, with few moving parts, ensures that the noise, crossed lines and wrong numbers sometimes associated with much of the older equipment still in service are almost totally eliminated.

At Baynard House, London, the first System X exchange has been operating successfully since June 1980. It handles a million calls a month between 40 London exchanges and the call-failure rate has shrunk dramatically to less than one in 10,000. A local System X exchange is also in service and the first long distance exchange will open shortly.

FIBRE OPTICS

By linking the new generation electronic exchanges with optical fibre cables, British Telecom wil give the network greater potential. Optical fibres can transmit far more information than conventional metal cables, quickly and efficiently. Light, easy to handle optical cables handle the same amount of information as a metal cable 10 times thicker. A pair of fibres in use today can carry 2000 simultaneous conversations. The potential for further development is great.

British Telecom has already begun work on Britain's optical fibre network. At least 100,000 km of fibre will be installed by 1990.

The new network will enable the process of computerisation and automation to be dramatically expanded. Computer will talk to computer just as easily as today's telephone can be connected with any other.

MESSAGE SERVICE

Through British Telecom's Prestel — believed to be the world's largest viewdata service — more than 12,000 individuals and organisations have instant access to a wealth of information. The system links a domestic television set, suitably modified, to central computers through the telephone.

Customers can call up around 200,000 pages of constantly updated information at the touch of a few buttons.

An electronic mail service has already been introduced in London as a prelude to national coverage. This service allows a customer to send a message to any other Prestel user by depositing it with the central computer. The addressee will be told there is a message waiting when next using Prestel. Touching a button then calls up the message on to the screen.

Prestel technology has already been sold to West Germany, Austria, Hong Kong, The Netherlands, Switzerland, Italy and Belgium.

SUBMARINE SYSTEMS

Developments in telecommunications technology are having a worldwide impact. Optical fibres, digital transmission and System X exchanges are the backbone of Britain's national system — and they also play an important role in bringing nearer the concept of the "global village".

Internationally, major developments are underway in both undersea cable and satellite technologies.

British Telecom is a partner in 41 submarine systems and will have a share in three more by 1984.

SATELLITES

Extensive use will be made of global, regional and domestic satellites. An important step in business communications is the introduction of satellites capable of working to aerials of 5m or less in diameter, mounted on or near business premises. These would offer services such as "fast fax", high-speed data transfer or video-conferencing. By 1984, British businessmen will have access to such a system covering the whole of Europe.

INTERNATIONAL

A sizeable proportion of Britain's international telephone traffic will be switched digitally by the second half of this decade. Full digital service will be available by then to most of Europe, North America and Japan.

An international digital exchange will open in London in 1984. Computer controlled equipment will considerably improve the efficiency and economy of international telex by the mid to late 1980s.

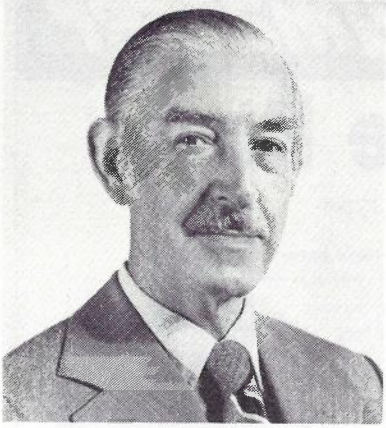
COMMERCIAL OBJECTIVES

British Telecom is well equipped to meet increased competition. It aims to establish Britain as a first choice communications centre for companies world-wide. National administrations can also benefit from the expertise of Telconsult — British Telecom's impartial consultancy service.

The magnificent television coverage in July 1981 that" took the pageantry of the marriage of Prince Charles, Prince of Wales, and Lady Diana Spencer, at St Paul's Cathedral, London, all round the world depended upon equipment installed by British Telecom. The organisation mounted its largest outside broadcast operation to transmit pictures via satellites. Two technicians are pictured on a rooftop near St Paul's erecting microwave aerials used to transmit the pictures. British Telecom provided links for Britain's two television services and 100 television companies from other coutries.

PERSONALITIES

RON KITCHENN RETIRES



Mr R. G. KITCHENN recently commenced a period of long service leave from Telecom Australia pending his retirement in mid-1982 after some 30 years of service.

Ron Kitchenn is remembered particularly by the Telecommunication Society of Australia because of his 13 years as General Secretary of the Society. Ron was originally appointed Secretary of the Postal Electrical Society of Victoria in 1958, then in its 50th year of existence, at a time when the 23-year-old Telecommunication Journal of Australia was ailing through lack of readers and contributors.

Ron quickly observed that although the Journal had had a national name ever since publication commenced in 1935, drew papers from all over Australia, and was widely distributed overseas, it was produced by a Victorian Society with no formal interstate connections. Proposals were therefore made to change the base, function, and name of the Society to a national one and to obtain support from the top levels of the Postmaster-General's Department in all States.

It was decided to modernize the Journal to attract both readers and advertisers and as a consequence the circulation was lifted by 175% in the following two years.

The Telecommunication Society of Australia took over from the Postal Electrical Society of Victoria and was formally constituted in October 1959; Ron Kitchenn became its General Secretary at that time.

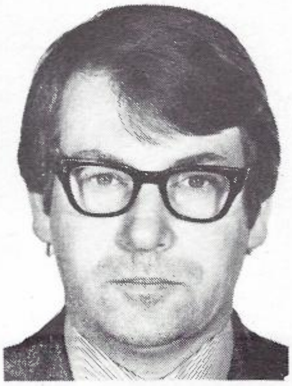
Under his guidance the Journal was placed on a sound financial footing and its world-wide reputation greatly enhanced. A few years later the sister Journal, "Australian Telecommunication Research" was founded to publish the more academic papers of the Society.

When Ron relinquished his post as General Secretary in 1972 the Victorian State Committee awarded him a Life Membership in appreciation of his contributions to the Society.

Ron has been a frequent contributor to the Journal and is a co-author of a paper appearing in the current issue, where further information on his work as a telecommunications engineer may be found.

The Society offers its best wishes to Ron for many happy and fulfilling years in retirement.

CHANGES IN THE BOARD OF EDITORS



Mr A. CARUANA (left) is retiring from the Telecom Journal's Board of Editors. Since 1978 he has been the editor specialising in radio topics.

Our thanks are due to Aldo for the meticulous attention he has devoted to promoting and editing articles from this subject area. He set an example in this regard too, by contributing, as a co-author, the article on the World Administrative Radio Conference in Volume 29 No. 2.

Aldo's place on the board has been filled by Mr L. J. DERRICK (right) who also has written for the Journal, on radio subjects.

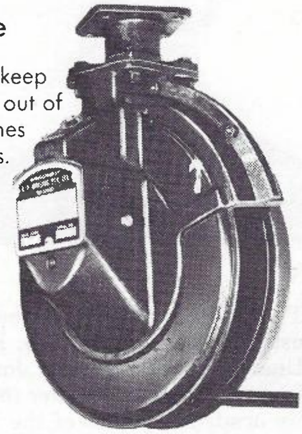
Laurie was the author of 'Multicoupler Performance Specifications' in Volume 28, No. 2 and 'The Telecom Tower Radio Functions and Specification' in Volume 31, No. 2.

Together Aldo and Laurie very competently handled an editorial task of some magnitude in co-ordinating the content of all the articles in Volume 31, No. 2, on the Telecommunications Tower, Canberra.

Readers can be assured that the radio and broadcasting editorship is still in good hands, as we welcome Laurie to the position.

Mr ROD REYNOLDS has joined the Board of Editors to look after the editing and author assistance functions for papers dealing with network transmission and also for technology research and productivity innovation.

Rod is a Supervising Engineer with the Line Transmission Equipment Construction Branch at Telecom H.Q. and was the author of a paper on 'Near End Crosstalk' in Volume 30/2.



The Telecommunication Journal of Australia

ABSTRACTS: Vol. 32, No. 1

DPS 25: DISTRIBUTED PACKET SWITCHING TECHNOLOGY FOR THE AUSTPAC NETWORK; M.J. Harrison; Telecom. Journal of Aust., Vol. 32, No. 1, 1982, page 3.

Telecom Australia has announced the selection of the French Company SESA as the contractor for the establishment of the AUSTPAC network. This paper presents an overview of the packet switching technology to be delivered by SESA for implementation of AUSTPAC.

THE DIGITAL DATA NETWORK SUBSCRIBER TEST SYSTEM; C.T. Beare, G. Rosimilia and D. Gibbs; Telecom Journal of Aust., Vol. 32, No. 1, 1982, page 13.

Significant improvement in service restoration times will be possible with the Digital Data Service. This is due to the ability to rapidly isolate faults in individual customer networks and thus alert the correct maintenance personnel. To achieve this, a special purpose Subscriber Test System has been jointly developed by Telecom and AWA for use in the Digital Data Network. This system is microprocessor based, integrated within the DDN main centres and operated from the Special Service Restoration Centres (1107 Centres). This paper describes the role, operation and design of the system.

COMPLETING THE DIGITAL TELECOMMUNICATIONS NETWORK; R.A. Court and N.J. Gale; Telecom Journal of Aust., Vol. 32, No. 1, 1982, page 21.

Digital technology is moving rapidly into the junction and trunk portions of the telcommunications network. However the digital network cannot be completed without the inclusion of the customers' network, i.e. that area which lies between the customer's premises and the local exchange. This paper examines the use of digital transmission in this area as well as the associated aspects of signalling, control and interfacing. Network evolution and overseas developments are also briefly discussed.

TELEPHONE TRANSMISSION QUALITY: CUSTOMER'S OPINIONS, Part 1; R.G. Kitchenn and R.P. Killey; Telecom Journal of Aust., Vol. 32, No. 1, 1982, page 35.

Part 1 of this paper describes the design, conduct and results of a sampling experiment involving more than 3000 volunteer telephone customers in greater Melbourne. Customers' opinions were solicited about the transmission quality of the telephone connnections kover which they were interviewed. Correlation of opinions with the known transmission conditions for each connection yielded 'laws' by which customers' opinions could be predicted, given the overall reference equivalent of the connection and the line-noise level experienced by the customer.

COMPUTER BASED TRAIN CONTROL SYSTEM FOR MELBOURNE; J. Hont, Telecom Journal of Aust., Vol. 32, No. 1, 1982, page 49.

An integral part of the Melbourne Underground Rail Loop (MURL) project in upgrading the suburban railway network is the introduction of centralized control of the signalling of the Melbourne electrified area, as well as the introduction of centralized voice communications and control and monitoring of ancillary services in the loop tunnels.

This paper outlines some of the background as to the purpose of the loop and the signalling control system, and presents some of the operational facilities of the control system and their implementation.

TELECOM'S MTS: INTEGRATION WITH THE AUSTRALIAN TELEPHONE NETWORK; P. Darling; Telecom Journal of Aust., Vol. 32, No. 1, 1982, page 57.

Changes in the telephone network have been made in order to introduce the new Mobile Service (MTS) and this paper discusses the integration techniques necessary to enable MTS subscribers to call and be called by any telephone subscriber, in Australia or overseas, with access to the network. It covers the methods of access to and from the Mobile Control Centre to the telephone network, the originating and terminating classifications available to MTS subscribers, the signalling used on calls to and from MTS subscribers and the charge recording techniques with the service.

In addition, the numbering plan used for MTS and the routing and charging requirements for calls to MTS subscribers are outlined.

TELECOM'S MTS: THE MOBILE CONTROL CENTRE; K.C. Phillips; Telecom Journal of Aust., Vol. 32, No. 1, 1982, page 61.

The Mobile Control Centre (MCC) is the heart of the Mobile Telephone Service. This centre provides the signalling and interface to the Telecom network and to the speech and control radio channels of the system as well as the switching between them. Additionally the charge recording and fixed equipment system maintenance and monitoring is provided on the MCC, which consists of a stored program control space division switching system to which regional processing in the form of micro processor controlled peripheral devices has been added. This paper describes the functions performed by and the equipment used in the Mobile Control Centre.

TELECOM'S MTS: EQUIPMENT AND MANUFACTURE; M. Morishima; Telecom Journal of Aust., Vol. 32, No. 1, 1982, page 67.

Following their successful tender for the Australian Mobile Telephone System, NEC Australia Pty. Ltd. manufactured the equipment to specifications set by Telecom Australia. The system, which operates in the 500 MHz band, consists of a Mobile Control Centre (MCC), the Mobile Base Station (MBS) equipment, the Mobile Subscriber Sets (MSS) and Supervisory (SV) and the system Test Equipment (TE) for maintenance. This paper describes the System configuration, performance and the manufacture of the Mobile Subscriber Sets.

SOME EXPERIENCES WITH CITY "EARTH NOISE" PROBLEMS; E.G. Wormald; Telecom Journal of Aust, Vol. 32, No. 1, page 81.

The investigation of complaints from customers about noise on their lines is a perennial problem. This article explains the basis of a particular class of noise problem and how some related complaints were cured in Sydney around 1976-79. Limitations of the method are indicated.

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POLICY. The Journal is issued three times a year (February, June and October) by the Telecommunication Society of Australia. The object of the Society is to promote the diffusion of knowledge of the telecommunications, broadcasting and television services of Australia by means of lectures, discussions, publication of the Telecommunication Journal of Australia and Australian Telecommunication Research, and by any other means.

The Journal reports on the latest developments, both technical and commercial, in telephony, radio and TV and is distributed to professional engineers, executives and technical staff engaged in the planning, marketing, installation and operation of telecommunication services in Australia and overseas, also to manufacturers in this field, government departments, universities and consultants.

The Journal is not an official journal of the Australian Telecommunications Commission. The Commission and the Board of Editors are not responsible for statements made or opinions expressed by authors.

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Information on how to prepare and submit manuscripts and contributions for the Journal is available from members of the Board of Editors.

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IN THE NEXT ISSUE
OF
TJA

- NATIONAL DIRECTORY ASSISTANCE
- MOBILE TELEPHONE SERVICE
- TRANSMISSION SURVEY
- DIGITAL FACSIMILE
- VIDEOTEX


Clip Base
Clip Top
Track