An Emergency Fire Telephone System

by

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Design and Development of
an Emergency Fire Telephone System
for the
Cape Town City Council
by
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for the
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at
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Cape Town City Council
Electricity Department
Test and Metering Branch
Computer Section

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Declaration.

I declare that this thesis is my own, unaided work.
It is being submitted in partial fulfillment of the requirement for the Masters Diploma in Technology.
It has not been submitted before for any Diploma or examination at this or any other Techikon.

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Date: 29th February 1988.
Acknowledgements.

Without the guidance, support and assistance of the following persons, this thesis may never have materialised.

The Cape Town City Council, in particular Mr. M.J. van Rensburg, Assistant City Electrical Engineer (Test and Metering Branch), for giving me the opportunity to do this project.

The members of the Computer Section (test and Metering Branch), for their contribution, guidance and support.

A special word of appreciation to my wife Engela for her loving support.
The project entails designing and installing an emergency fire telephone system (EFTS) for the 23 storey Cape Town Administrative Civic Centre.

The original system, with its mostly analogue circuitry, has no documentation available, is difficult to maintain and has become unreliable. After considering alternative systems the most economical option was to expand the original system by adding more extension telephones and to redesign the control section.

The new EFTS briefly operates as follows:

The status of ninety six extension telephones, installed at the emergency exits on each floor, are displayed on a mimic status display which both operators can monitor. Any emergency call can be identified by a green flashing LED and a distinctive bleep. The LED indicates the exact position and number of the telephone in the building. Each operator has a keypad and a two digit numeric display fitted to his telephone.

The operator can immediately answer incoming calls by pressing the queue button. Calls queue on a first in first out basis. The number of the extension telephone will be displayed on a numeric display. The operator can also select the extension he wishes to contact, by dialling the extension number on the keypad.

The EFTS consists of nine rack mounted printed circuit boards. A Microcomputer
board, made up of a Motorola MC6809 microprocessor, six 6821 PIAs, 2 kilobyte RAM, up to 16 kilobyte ROM and a watchdog timer controls the EFTS.

Two Telephone Controller boards process voice signals and generate logic control signals for the CMOS voice switching circuitry on the Multiplexer Monitor boards.

Six Multiplexer Monitor boards switch the two operators to any of the ninety six extension telephones and continuously monitor the extension telephone lines for faults and handset statuses. Noise and over voltage line protection is provided.

The multiplexing of the 192 LEDs on the Mimic Status Display is controlled by the Microcomputer board.

An unusual principle used in this design is the combination of low frequency AM and audio to affect communication.

Two uninterruptable power supplies provide user independence from mains.

Software used for the EFTS is written in 6809 Assembly Language. A Real time interrupt controls the Mimic Status Display. Operator actions are interfaced with the program logic by means of hardware interrupts.
**Opsomming.**

Hierdie tesis behels die ontwerp en installasie van 'n telefoon noodkommunikasiestelsel in die 23 verdieping Kaapstad Administratiewe Burgersentrum.

Die oorspronklike stelsel, wat meestal analog-stroombane gebruik, beskik oor weinige dokumentasie. As gevolg hiervan is stelselfonderhoud moeilik en is die stelsel onbetrugaar. Nadat verskeie alternatiewe stelsels ondersoek is met inagneming van verskeie faktore was die mees ekonomiese uitweg die uitbreiding van bestaande stelsel deur die byvoeging van 42 addisionele telefoonuitbreidings en die vervanging en herontwerp van die beheerstelsel.

Die nuwe telefoon noodkommunikasiestelsel behels die volgende:

Ses en negentig telefoonuitbreidings is by die nooduitgange op elke vloer aangebring. Die stand van elke telefoon word aangedui op 'n paneel met die uitleg van die gebou daarop. 'n Flikkerende LED, wat die posisie van die telefoon in die gebou aandui, dui die noodoproep aan. Die twee operateurs se telefoone is elk toegerus met 'n 4 x 4 sleutelbord en tweesyfervertooneenheid.

Die operator beantwoord inkomende oproepe deur die Q-sleutel te gebruik. Hierdie faciliteit koppel inkomende oproepe out-
omaties in volgorde deur die eerste-in-eerste-uit metode. Die operator kan ook kies met watter telefoonuitbreidings hy in verbinding wil tree deur die uitbreidingsnommer te skakel op sy sleutelbord.

Die stelsel bestaan uit nege rakgemonteerde stroomkaarte en word beheer deur 'n Motorola 6809 mikro-rekenaar. Die mikrorekenaarkaart bestaan uit ses randheid koppelstukke (E.PIAs), 2 kilogroep leeskrifte, 2 tot 16 kilogroep elektries-programmeerbare-leeuwe en 'n waaktydreëllaar.

Twee telefoonbeheerkaarte prosesseer die stemkseine vir die stelsel. Beheerseine, wat deur die skakelbordkaarte gebruik word, word ook hierop verwerk.

Ses telefoonvertakskakelkaarte skakel die twee operateurs deur na enige van die 96 telefoonuitbreidings. Die status van al die telefoonlyne word gedurigdeur gemonitor vir fouttoestande sowel as die status van telefoonheerstukke (d.i. of die heerstuk opgelig is of dan nie).

Die telefoonstandvertoonpaneel se 192 LEDs word op 'n tyddeel begin en aangedryf.

Die stelsel gebruik 'n ongewone modulasietegniek vir die klank. Beide lae frekwensie amplitudemodulasie en suier oudio word gebruik.

Twee nie-onderbreekbare kragbronne word gebruik vir kragvoorsiening.

Motorola 6809 saamstelbare is gebruik om programmatuur vir die stelsel te ontwikkel. 'n Reëltyd onderbreekse beheer die stelselfunctiestandvertooneenheid. Alle datakop-
pelling tussen gebruikeraksies en die stelselprogrammatuur geskied d.m.v. apparaatuuronderbreekseine.
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Chapter I.

INTRODUCTION.

A practical solution to the problem of designing and selecting the most suitable emergency communication system can be obtained by the careful consideration of various factors of which only six will be discussed in this chapter.

I.1 The importance.

Fires in high rise buildings spread rapidly and can be very fierce especially when spreading via lift shafts and ducts which make perfect ventilators. Evacuating people from the building should be controlled to promote safety and to reduce panic situations, while fire fighting activity should be coordinated throughout different areas in the building.

Because public buildings are prime targets for sabotage and terrorism, the evacuation procedure should remain secret. Therefore appropriate in situ communication and instructions should be issued during evacuations or emergencies.

I.2 The Requirements.

In order to control emergency situations it stands to reason that the communication system should be reliable and uncomplicated with good audio quality.

The system should allow the operator to communicate clear instructions to different locations in the building, to give and receive regular reports of conditions at specific locations and the progress of specific events and to supplement information for improved overall security.

The efficiency of an emergency telephone system depends on its ease of use and on the proficiency of the operator. An uncomplicated system requires less intensive training and thereby saves time and cost while ensuring the effective operation of the system.
An Emergency Fire Telephone System.

Introduction.

In order to keep system downtime to a minimum, the system design has to incorporate simple and easy maintenance. Full documentation has to be provided.

The users have to be consulted to determine desirable user features. Clearly defined and well understood user requirements will improve the quality and efficiency of the end product.

Security, evacuation and life support communication systems provide private communication which will help constrain panic situations.

1.3 The Location.

The EFTS is used in the 23 storey Cape Town Administrative Civic Centre. Fire telephone extensions are located at the emergency escapes on every floor. The Control Centre, located in the basement of the building, directs all communication to the various locations throughout the building.

Fig. I.1. Functional Block Diagram.
An Emergency Fire Telephone System.

Introduction.

I.4 Various communication systems available.

Use of video and voice provide the most elaborate communication. The visual and verbal contact ensure that the control centre is fully informed.

Video signals require a wide band transmission line. Suitable video equipment and transmission lines are very expensive.

Voice communication may be provided in different forms.

Two way communication can be realized in many different ways.

I.4.1. UHF radios provides full two way communication as well as mobility. Reliability is enhanced because of independence from use of cabling as transmission lines. Correct selection of operating frequency limits RF attenuation caused by the steel structure of the building.

Multiple channel radios allow simultaneous communication. Should secrecy be important the audio signals can be scrambled.

I.4.2. A standard balanced telephone line system provides good audio quality, is reliable and not expensive considering its performance.

In terms of transmission lines, a balanced line telephone would be the most suitable, since cabling is simple and relatively cheap. However cabling impose a reduced reliability during fires.

Depending on the communication control required (see block diagram, figure I.1), a suitable exchange can be implemented, whether digital, relay or standard switching techniques are used.

I.4.3. A high quality intercom system is another option. Either telephone handsets or loudspeakers can be used. A low cost system will use small 50 mm high impedance loudspeakers at all locations. Impedance matching transformers may be used as necessary. Relatively good voice quality is possible.
An Emergency Fire Telephone System.

Introduction.

Low signal levels are associated with low impedance transducers. Amplification of both received and transmitted voice signals will therefore be required. Methods of powering these amplifiers via the two signal lines complicate the design. Additional cabling for power make the design more expensive than a balanced line telephone system.

Handsets provide for more private communication than loudspeakers.

I.4.4. One way communication will certainly be the cheapest option. This can be accomplished using voice communication or other means.

In fact the most common building evacuation systems are one way communication systems. A 100V PA amplifier would drive loudspeakers mounted at suitable locations throughout the building.

Since the earliest times visual (nonverbal) signals have been used for communication. A very basic form is to use strategically placed labelled indicator lamps. More elaborate communication using alpha numeric displays can be used to display text messages.

I.5. The operation of various systems.

I.5.1. UHF radio communication.

Handheld UHF two way radios provide a very effective communications network. See figure I.2 for a proposed system.

A base station will be installed at the Control Centre to provide not only communication control, but also a more powerful transmitter to effect communication to any point within the building and the near proximity. The base station can have an antenna mounted in a suitable area to provide full coverage of the building. A suitable emergency repeater station can provide the same features.

The Handheld radios are kept in suitable positions were security staff or those responsible for evacuation can obtain
An Emergency Fire Telephone System.

Introduction.

them. These radios will remain on a trickle charge to keep them fully operational.

Spare battery packs can be used on a rotational basis. While security staff use the handheld radios daily, some batteries will be on charge while other are used in the radios. This ensures that radios are tested and operational and spare fully charged batteries are available at all times.

A suitably located repeater station will ensure good communication throughout the building between all radios. The additional cost of this will outweigh the improved performance of the radios. Also, lower powered radios may then be used.

![Diagram of mobile handheld radios and repeater station](image)

Mobile Handheld radios used throughout building.

![Diagram of UHF radio communication](image)

Fig.I.2. UHF radio communication.

1.5.2. A balanced line telephone system.

This system requires separate or its own cable paths but can serve as a backup to an existing PABX telephone system. If special care is taken in routing the cabling, the risk of fire damage to the cabling can be reduced substantially.
An Emergency Fire Telephone System.

A telephone exchange which meets the system requirements will be installed in the Control Centre. The exchange operator controls the flow of communication manually.

I.5.3. An intercom system.

A two way intercom system will provide a similar service than that of a balanced line telephone system. Instead of using standard telephone units, a simple box with a small 50 mm loudspeaker and a line transformer is provided. A button on the box will provide a call facility.

The hardware cost of the intercom system is substantially less when using loudspeaker units instead of telephones. Cabling costs will be more or less the same for both systems.

Should an amplifier be required at each loudspeaker, this can be powered by providing DC on the lines. A hybrid network in the amplifier separates the DC from the audio signals.

![Diagram of intercom system]

**Fig.I.3. Intercom system.**

Switching of intercoms at the Control Centre exchange may be done using switches, relays or electronic switching (i.e. CMOS analogue switches). Indication of selected intercoms is indicated by the switch position, i.e. switches remain in a centre position until activated. Incoming calls are indicated by a LED.
An Emergency Fire Telephone System.

Introduction.

Should handsets instead of loudspeakers be required, the design remain basically the same.

I.6. Circumstantial and budget limitations.

I.6.1. The original system.

This system has been in use since the commissioning of the building. It requires only one operator to communicate with fifty four extension telephones.

Unique to the design of the original system is the special PYRO cabling used to provide telephone cabling which will withstand the high duct temperatures in cases of fire. This cabling has a solid copper outer core. The individual conductors are isolated from the outer core by means of a powdery substance which withstands very high temperatures before the isolation breaks down.

The high cost of the PYRO cabling has necessitated minimization of the number of wires per extension telephone. Therefore only one wire per extension telephone is used. The copper outer core, which forms an earth return path, is used as the second conductor. This forms an unbalanced line condition requiring more complex termination of the lines.

No documentation is presently available for the original system and therefore several design details are unknown. The modulation technique used for communication between the extension telephone and the Control Center is an unusual technique.

![Fig.I.4. Extension Telephone Block Diagram.](image)
An Emergency Fire Telephone System.

Introduction.

The voice signal between the extension telephone and the Control Centre use amplitude modulation of which the carrier frequency is 14 kHz. The voice signal between the Control Centre and the extension telephone uses normal audio.

I.6.2. Existing cabling has to be used.

Since so much has been invested in the cabling of the original system, the new system will have to utilize the existing cabling which places many limitations on the new design.

The number of extension telephones have to be increased to ninety six. The additional extension telephones will use identical cabling in order to provide equivalent safety and performance.

I.6.3. Modulation technique used in existing system.

The low carrier frequency used causes several problems.

An audio bandwidth of 300 to 3400 Hz is used. With a carrier frequency of 14 kHz the lower side band will be at 10 600 Hz (14 000 - 3400). Very good filtering will be required if high gain amplifiers are required in the extension telephone.

From the extension telephone block diagram (figure I.4) it can be seen that a feedback loop is formed. The hybrid network, the earpiece and mouthpiece of the handset forms the feedback paths under non-ideal conditions. This will require careful attention.

I.6.4. Limited budget.

UHF radios: For an effective system a minimum of fifteen handheld radios will be required as well as a base station and a repeater station. This would be too expensive for a conservative budget.

Balanced telephone system: The replacement of at least fifty four existing telephones as well as the acquisition of new balanced line twisted pair cabling would be uneconomical.
Introduction.

Standard telephone equipment: A limited budget will not allow for the cost of a new system.

Intercom System: The cost of this system will be equal to the cost of a new EFTS installation. New telephone line cables will have to be installed and the present investment in cabling and extension telephones forfeited.

1.7. A practical solution.

Retaining the 54 existing extension telephones, adding 42 new extension telephones with the same cabling and redesigning and replacing obsolete control equipment would be the most viable and economical solution.

New features of the expanded system will be:

- A second operator at the Control Centre.
- First in first out (FIFO) queuing of extension telephones awaiting a response from the Control Centre.
- Real time line proving of all the extension telephone lines.
- A mimic display panel to indicate the status of the EFTS, i.e. both the status of all extension telephones and the condition of all the extension telephone lines.
- An uninterruptable power supply.
Chapter II

DESIGN CONSIDERATIONS.

The philosophy of design of the EFTS is considered in this chapter. Technical design detail is discussed in a later chapter.

II.1 System Block Diagram.

The EFTS is divided into several functional blocks. These are:

1. Microcomputer Board.
2. Telephone Controller Board.
4. Status Display.
5. Operator Telephones.
6. Power Supplies
7. Subrack and associated hardware.

A short description of some of the functional blocks are given.

The telephone controller board processes all audio signals, generates and controls the ring tone, and generates several logic control signals for the multiplexer monitor boards.

The primary function of the multiplexer monitor board is to switch the voice signal between an operator telephone and an extension telephone. It also monitors the extension telephone handset statuses and the extension telephone lines for faults.

The status display displays extension telephone handset and extension telephone line statuses. LEDs are used as indicators.

The operator telephones control the communication. The extension telephone is always the slave of the operator telephone. Each operator telephone consists of a handset, cradle switch, keypad and two digit 7 segment display.
An Emergency Fire Telephone System.

Design Considerations.

Status display

Operator Telephone No. 0

Operator Telephone No. 1

Microcomputer Board

Telephone Controller Board

MM 0 MM 1 MM 2 MM 3 MM 4 MM 5

Sixteen extension telephones are connected to each MM.

**MM: Multiplexer Monitor Board**

Power Supplies
- Input: 60V DC
- Output: +5V
  +24V

Fig. II.1. System Block Diagram.
II.2 Microcomputer Board.

A few years ago we were still amazed by the four function hand held calculator. The microcomputer is applied more than ever for sequential and logical control applications. Often it is cheaper to exploit the potential of the microcomputer than using discrete designs.

To provide the required control facilities for this project, a microcomputer offers an economical and versatile solution. A similar discrete logic EFTS design is more complex, the component count is much higher, and the system less reliable compared to moderate component count microprocessor controlled designs. Design time, constructional simplicity and operational flexibility of the microcomputer design far outweigh that of discrete designs.

Various tasks are controlled by the microprocessor:

- Continuous monitoring of telephone lines for faults.
- Continuous monitoring of telephone handset statuses.
- Displaying the extension telephone handset and line statuses.
- Executing of operator keyboard commands.
- Controlling of the audio switching.
- Ringing the extension telephones.
- Queuing of incoming calls.
- Testing the system.

A Motorola EXORCISER development system is available and consequently the powerful Motorola 6809 microprocessor is used in the new design. MPL, a high level language developed for the Motorola, is well suited for development of the software. 6809 Assembler will only be used where necessary.
An Emergency Fire Telephone System.

Design Considerations.

II.2.1 Microcomputer Input/Output Requirements.

Sixteen extension telephones are connected to each MM.

MM = Multiplexer Monitor Board

Fig. II.2. System Block Diagram with input/output lines.
An Emergency Fire Telephone System.  

Design Considerations.

II.2.1 Microcomputer Input/Output Requirements.

The block diagram shows the number of input/output lines required to control various tasks on the different boards. The input/output lines on the Microcomputer Board are utilized as follows:

(i) 6 - Status display: ROW lines  
(ii) 32 - Status display: COLUMN lines  
(iii) 10 - Operator Keyboard data and strobe lines  
(iv) 16 - Operator Displays  
(v) 9 - Phone switching control lines  
(vi) 5 - Status Selection control signals  
(vii) 3 - Ring tone control lines  
(viii) 2 - Cradle status lines  
(ix) 8 - Status data bus  

91 Total number of i/o lines

Since both software and hardware requirements determine the allocation of the input/output ports, the final grouping of the input/output lines is indicated in the Appendices.

Timing for the status display multiplexing is derived from the onboard real time interrupt. A multiplexing frequency greater than 30 Hz provide a flicker free status display. An interrupt period of 5 ms provide a 33 Hz display refresh frequency (6 columns x 5 ms = 30 ms).

(i). The mimic status display data is routed from the microcomputer board to the status display board on the ROW and (ii) COLUMN lines.

(iii). The strobe lines of the operator keyboards are connected to the microprocessor interrupt lines. When an operator depress a key, an interrupt is generated which reads the keyboard data. (viii). Similarly, a change in operator handset status generates an interrupt which supervises continuing processes, e.g. when the handset is replaced all commands are cleared.
(iv). The operator keyboard and display data between the microcomputer board and the telephone controller board is routed via the Kybd and OpDsp lines.

(v). The Phone switching lines control the switching of the voice signals between the extension telephones and the operators.

(vii). Two of the ring lines are used to ring extension telephones. The third line controls the operator alarm.

(ix). The status data bus routes the telephone handset and line statuses to the microcomputer board. (vi). The status control lines control status data flow on the status data bus.

II.3 Telephone Controller Board.

The TCB processes all audio signals, generates and controls the ring tone, and generates several logic control signals for the multiplexer monitor boards.

![Telephone Controller Functional Block Diagram.](image)

The main purpose of the audio section is to provide clear communication between the operators and the extension telephones.
An Emergency Fire Telephone System.

Design Considerations.

Figure II.4. Basic Audio and Voice Switching Block Diagram.

Operator communication is explained by the above block diagram, figure II.4. Audio is amplified and processed in the Audio Processing block. Switching the voice signal between an operator and a selected extension telephone is controlled by the switching block. Both operators may be switched to any one of 96 extension telephones — totaling 192 switching nodes. Also see Fig. II.5.

The AM carrier frequency is 14 kHz. Reduction of the frequency spectrum is achieved by band limiting the audio to between 300 Hz and 3300 Hz. This frequency band is determined by the original extension telephones, and can therefore not be altered. See the chapter on the hardware for a full description.

The operator telephone is interfaced to the Audio Voice Processing block with a hybrid network. The hybrid network prevents the microphone signal reaching the earpiece and also blocks the DC supplied to the telephone handset from the audio circuitry.

Electrically standard telephone handsets are used for the extension telephones. The voice signal from the extension telephones to the operator telephones use amplitude modulation. Normal audio is used from the operator telephones to the extension telephones. Power to the extension telephones, each having an amplifier and modulator, is delivered via the same telephone lines.

Figure II.5. Extension Telephone Block Diagram.
Inducement of noise into the audio circuitry was foreseen because of interference introduced by the monitoring of the status data lines. See section II.4 on the Multiplexer Monitor boards for a description of the status monitoring.

When the status of a data latch is read by the microcomputer the impedance of the corresponding window comparator circuitry changes minutely thereby introducing noise into the audio circuitry. The frequency of the noise introduced is proportional to the frequency at which the status is read.

The 96 extension telephone lines are effectively all paralleled at the 192 CMOS switches. This loading effectively reduces the input impedance of the analogue switches. The lower input impedance can generate a limited amount of crosstalk between the CMOS switches whilst in their "off" state. The high frequency of the AM signal, 14 kHz and the sidebands, introduce additional crosstalk.

The status of each extension telephone line is monitored by two window comparators. The high input impedance of the voltage comparators have negligible loading on the low impedance telephone lines.

The low "on" resistance of the analogue switches (150 Ohm) cause little signal degradation. The high "off" resistance of the analogue switches result in minimal cross talk between channels.

A ring tone is generated both for the operator and the extension telephone. To aid quick cognizance in the busy Control Room the ring tone differs entirely from that of the G.P.O. telephones. The ring tone is switched to:

- the extension telephone operator 0 is ringing, or
- the extension telephone operator 1 is ringing, or
- the operator telephones/audible alarm.

Due to the common earth return path of unbalanced telephone lines merely one switch per extension telephone is required. CMOS analogue switches effect a compact and reliable switching arrangement.
An Emergency Fire Telephone System.

Design Considerations.

Figure II.6 indicates the switching of the 96 voice signals to the two operators. Each operator may be connected to any one of the 96 extension telephones with one proviso: both the operators may never concurrently be connected to the same extension telephone. Excessive signal degradation will result from loading a line.

<table>
<thead>
<tr>
<th>96 extension lines</th>
<th>96 point Switching Matrix</th>
<th>Operator 1</th>
<th>Operator 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. II.6. Audio switching matrix.

II.4 Multiplexer Monitor Boards.

The primary function of the multiplexer monitor board is to switch the voice signal between an operator telephone and an extension telephone. It also monitors the extension telephone handset statuses and the extension telephone lines for faults.

The power requirements of an extension telephone is such that with the extension telephone handset replaced, the power drawn is approximately 10 mA, and with the handset lifted approximately 7 mA.

The extension telephone is powered from a 24 volt source via 1200 Ohm series resistor. When a handset is lifted the line voltage is approximately 10V. With the handset replaced the line voltage rises to approximately 12V.
An Emergency Fire Telephone System.

Design Considerations.

The effect of the line resistance is not taken into consideration in above calculation.

Line voltages outside these parameters indicate the presence of line faults (figure II.8). Two voltage comparator windows are set up. The one window checks between 20 and 12 volt, the other between 12 and 8 volt. The selected window voltages give the most consistent and reliable results.

While ringing, the extension telephone power consumption rises and the line voltage drops to below 8V and fault status monitoring is disabled to inhibit false alarms.
II.5 Status Display.

Extension telephone line fault statuses and handset statuses are indicated on the Status Display using red and green LEDs respectively.

The display of 192 different statuses requires too many microcomputer input/output lines and therefore LEDs are multiplexed to conserve microcomputer i/o lines.

The 192 indicators are divided into six rows of thirty-two columns each. Each extension telephone has two statuses associated with it, namely handset and fault statuses. The handset statuses are numbered from 0 to 95 and the fault statuses from 96 to 191. Also see figure II.9.

<table>
<thead>
<tr>
<th>Telephone No</th>
<th>Handset status No</th>
<th>Fault status No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 32</td>
<td>0 - 31</td>
<td>96 - 127</td>
</tr>
<tr>
<td>33 - 64</td>
<td>32 - 63</td>
<td>126 - 159</td>
</tr>
<tr>
<td>65 - 96</td>
<td>64 - 95</td>
<td>158 - 191</td>
</tr>
</tbody>
</table>

LEDs may be steady or they may blink. A flashing fault LED indicates a new extension telephone line fault which has not been acknowledged by the operator (the audible alarm is activated if both operator handsets are down). A fixed (non-flashing) fault LED indicates a fault which has been acknowledged by the operator (the audible alarm is de-activated by the acknowledgement made by the operator).

When an operator is connected to an extension telephone the corresponding LED is steady. The green LED flashes when the operator rings an extension telephone of which the handset is down. As soon as the extension telephone is lifted the green LED stops flashing. The corresponding green LED will also flash when an extension telephone is lifted to call the operator.
An Emergency Fire Telephone System.

Design Considerations.

**Fig. II.9. Mimic numbering.**

<table>
<thead>
<tr>
<th>No</th>
<th>Extension Telephone number</th>
</tr>
</thead>
<tbody>
<tr>
<td>St</td>
<td>Extension Telephone status number</td>
</tr>
<tr>
<td>Phone</td>
<td>Extension Telephone status indicator (green)</td>
</tr>
<tr>
<td>Fault</td>
<td>Extension Telephone fault status indicator (red)</td>
</tr>
</tbody>
</table>

In the mimic status display each row transistor sources thirty two column transistors. A LED is enabled when the row transistor and the corresponding column transistor is enabled.

Whenever a row transistor and any of its associated column transistors are enabled, the corresponding LEDs are enabled. In this way, instead of using 192 row and column control lines, only 38 lines are used to control the 192 LEDs.

The row transistors are selected for worst case conditions. This occurs while executing a lamp test, then all the column transistors for each row are on. The maximum instantaneous current to a row is $32 \times 25 \text{ mA} = 800 \text{ mA}$. 

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An Emergency Fire Telephone System.

The column transistors each enable only one LED, i.e. source a maximum of 25 mA. Row transistors therefore require a higher power rating than that of the column transistors.

Each row transistor is successively enabled for 1 ms every 6 ms. Switching transistors are used for this purpose. The optically less efficient green LEDs are driven harder than the red LEDs - 50 mA as opposed to 25 mA (instantaneous current).

II.6 Operator Telephone.

The operator telephones control the communication. The extension telephone is always the slave of the operator telephone. Each operator telephone consists of a handset, cradle switch, keypad and two digit 7 segment display.

The operator telephone two-digit-readout displays the extension telephone number entered by the operator on the keypad, or the number which he is ringing, or the number which he is connected to.

The operator telephone uses standard unmodified balanced line audio circuitry.

A 16 key keypad is used. The 4x4 keypad matrix (8 lines) is encoded on the TCB to four data lines in addition to a strobe line (5 lines). The encoded data (TCB) is connected to the Microcomputer Board. See figure II.2 for the I/O lines.

Sixteen data lines are used to output operator display data from the microcomputer to the operator numeric displays – eight lines per operator display. The operator display data is decoded by two BCD to seven segment decoder/drivers in the operator telephone housing.

A red operator telephone is used, making its use as emergency telephone more obvious.
An Emergency Fire Telephone System.

Design Considerations.

Fig. II.10. Operator Telephone Block Diagram.

II.7 Power Supplies.

The main power source is a 60V battery supply. The voltage may increase to some 72V when the batteries are charged. Switching power supplies are most suitable for such varying supply voltages.

The project specifications require all telephone circuitry to operate from a 24V source. Logic circuitry operates at 5 volt.

Fault status monitoring circuits require reference voltages for the window comparators. Three voltages (8V, 11V and 14V) are supplied with minimal current source.

II.8 Subrack and associated hardware.

Console equipment is made up of the operator telephones and the mimic status display. The subrack, including the rack mounting frame, Main Distribution Frame (MDF) and the cable termination, is separated from the console equipment and installed in a different location.

The operating environment influences operator efficiency. Ease and simplicity of use of the EFTS is of prime importance.
Therefore operator involvement should be as simple as possible. Only basic operations are required. Operator training is given to familiarize them with all operational features.

Similarly the status display is made simple and clear. Correlation of the telephone number with the telephone position within the building is facilitated by using a mimic display.

Care is taken to ensure that the operator position relative to the status display is such as to make viewing and operation most efficient. Unnecessary operator movement is minimized by correct placement of the operator telephone on the operator console.

Since the status display is legible and bright, changes in lighting conditions will not affect the visibility and clarity of the EFTS displays.

Frequent emergency exercises ascertain thorough testing of the system.

The particular rack equipment is selected for easy maintenance of the system and for its robust construction. The rack size is determined by the standard used for telephone equipment by the Cape Town City Council.
NOTE: Please refer to the detailed circuit diagrams in the Appendix.
III.1 MICROCOMPUTER BOARD.

Please refer to drawing SK3818, sheet 10, in the Appendix for the microcomputer board circuit diagram.

The Microcomputer Board is designed as a multipurpose single board computer (microcomputer board). Not all the possible options are utilized in the EFTS application. The microcomputer board is specifically designed to provide a large number of parallel input/output lines. No serial communication is provided. Two kilobytes of RAM is provided and two to sixteen kilobytes of EPROM.

Six PIAs provide 96 input/output lines. An additional 22 control lines are available. These lines are all connected to the edge connectors of the printed circuit board.

A real time interrupt can be obtained by connecting a divided clock signal to any one of the PIA CAO lines. Additional timing signals may be derived from the same frequency divider.

A hardware watchdog circuit provides an automatic reset of the system should any software or hardware failures interfere with timing loops. The watchdog may be disabled if so required.

A reset switch provides a controlled restart for the microcomputer board.

III.1.1 6809 Microprocessor

Please refer to drawing SK3818, sheet 10, in the Appendix for the Microcomputer circuit diagram.

A Motorola MC6809 microprocessor (U3) controls the single board computer. A 4MHz ceramic resonator acts as external parallel resonator to an on-chip oscillator to generate the bus timing signals, E and Q. The ceramic resonator is used in preference to
An Emergency Fire Telephone System.

Hardware Description.

the more expensive crystal. A 4MHz oscillator frequency provides an effective 1 MHz bus frequency. (The E bus timing signal is a quarter of the clock frequency).

The NMI, IRQ and FIRQ lines are tied high, but the IRQA and IRQB lines from each of the six PIAs can be wire-ORed to the desired interrupt line of the 6809. The PIA Allocation tables in the Appendices provide full detail on which interrupt lines are used.

III.1.2 EPROM (U4)

By making appropriate links, the user has the option of using a 2k, 4k, 8k or 16k EPROM in the U4 socket. In this application a 2732 EPROM is used. See the Microcomputer Board circuit diagram in the Appendices for which link to set to facilitate the use of the 2732.

III.1.3 RAM

Static RAM (U5) used is 2k x 8 at locations $0000 to $07FF.

III.1.4 Clock Divider

The CD4020 (U1) 14 bit binary counter divides the 1MHz system clock. One of the divider outputs may be connected to the CA1 line of PIAOA (U10) to generate a real time interrupt to the microprocessor. Connecting the divide by $2^{14}$ pin to CA1 will generate an approximately 16 ms interrupt. During the initialization PIA0 needs to be configured to generate an interrupt when CA1 is toggled.

PIAO has to be initialized with the CA2 line as an input to generate an interrupt. See the RESET, PIAOA initialization routine in the Source Code Listing for more detail.

III.1.5 Address Decoding

Address decoding is accomplished by using a decoding PROM (U6) and a three-to-eight decoder (U7). The binary output from the decoding PROM is decoded by a three to eight decoder which selects the desired memory chip.
III.1.6  PIA's (U10 - U15)

Six 6821 PIA's are available to the user. Each PIA provides two 8 bit programmable i/o ports and four handshaking lines. The IRQA and IRQB lines of the PIA's may be wire-ORed to the microprocessor interrupt lines.

See the PIA Allocation table in the Appendices for the appropriate wire-ORed IRQ lines. The CA lines used as inputs to generate IRQ's are labeled: TIMER, KYSTRB0, KYSTRB1, CRADLO and CRADL1.

The output of the divider (U1) is connected to CA1 of PIA0. PIA0 is programmed to generate an interrupt to the microprocessor (IRQA line) with the CA1 line. The interrupt service routine causes CA2 to be toggled in order to retrigger the watchdog timer.

All the PIA i/o lines are connected to the edge connector.

III.1.7  Watchdog (U9, U17)

The watchdog circuit consists of a dual monostable IC (U9) and a 555 (U7) set up as an astable multivibrator. At power-up, or after pressing the system RESET button, monostable B provides a 100 ms RESET pulse. The start-up routine takes CA2 (PIA0) low until a pulse is received from the divider circuit connected to CA1. The PIA is programmed so that CA2 goes high as well as generate an interrupt on IRQA when CA1 goes low. The interrupt service then cause CA2 to reset again (goes low).

Monostable A is continually re-triggered during normal operation of the system. Should a hardware or software fault occur and the interrupt is not serviced, monostable A times out and the astable (IC17) is activated which then provides a string of RESET pulses. The watchdog can be inhibited by strapping the RESET pin of monostable A to ground.
III.1.8 Edge Connector

Port A, Port B and the control lines of each of the six PIA's (CA1, CA2, CB1, CB2) are connected to the two 64 pin edge connectors (labelled A and B respectively). Each edge connector has two rows of 32 pins (a and c respectively e.g. PIA3, the eight bits of PA0 - PA7 are connected to pins B c9 - B c2 respectively).

The Microcomputer Board connector pinouts are tabled in the Appendices.
HARDWARE

III.2 TELEPHONE CONTROLLER BOARDS:

Please refer to drawing SK3818, sheet 1 and sheet 2, in the Appendix for the Telephone Controller Board circuit diagrams.

The Telephone Controller board consists build of:

Logic circuitry composed of:

- Keyboard encoder
- Status addressing
- Multiplexer addressing

and,

Analogue circuitry composed of:

- Audio circuitry; AM demodulator, filters
- and amplifier and Ring generator
- Reference voltage power supplies

Initially it was attempted to design a single printed circuit board incorporating all the above functions which served both operators concurrently. This approach was prevented because too many control lines had to be connected to the edge connectors and could not be achieved using the available printed circuit board manufacturing equipment.

Each Telephone Controller Board (TCB) serves one operator. Two identical TCBs are used (i.e. TCB0 and TCB1) and duplicate logic and analogue circuitry exist. However, the reference voltage and ring tone generator on TCB1 are not used and not connected to the backplane.

Even though the TCB's are functionally identical, the boards may only be interchanged once links on the TCBs are correctly set up for the particular board position in the rack.
An Emergency Fire Telephone System.

Status Selection.

Audio Selection.

The bracketed numbers indicate the number of wires per function.

Fig. III.1. Telephone Controller Block Diagram.

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An Emergency Fire Telephone System.

Hardware Description.

Figure III.1 indicates the fundamental functions of the TCBs. An elementary description is given below.

The keyboard encoder encodes the operator 4x4 keyboard array. The data is output to the microcomputer board with the necessary control signals.

The majority of the logic control signals for the audio multiplexer I.C.s and the status data latches, situated on the Multiplexer Monitor cards (MM), is generated on the TCBs.

The line statuses of extension telephones are monitored on the multiplexer monitor boards. The status selection logic signals control data flow on the 8 bit status bus between the status data latches on the MM's and the microcomputer board. The CARD SELECT signals select one of the six MM's. The BYTE SELECT lines then selects one of four data latches on the selected MM. Status data may then be read by the microcomputer board.

Three logic signals are used for the audio processing. The three lines control the ringing of the two extension telephones selected by the operators and the operator audible alarm.
An Emergency Fire Telephone System.

Hardware Description.

The control of the multiplexer I.C.s on the MM's is shown in the Audio Selection portion of figure III.1. Each operator’s extension telephone is addressed separately by the microcomputer board. The address data for a particular extension telephone multiplexer I.C. is latched before the address data is further decoded by the 4-to-16 decoders. The MUX lines select a multiplexer IC on one of the MM's. The PHON lines connect the operator voice signals to a particular extension telephone on the selected multiplexer IC.

III.2.1 Keyboard Encoder

A 74C922 (U6) 16-Key keyboard encoder, used in a standard configuration, encodes the 4x4 keypad. The strobe line (KYSTRB) goes high with every key depression. Key debouncing is performed by the encoder chip. The auto-repeat facility is not used.

III.2.2 Status Addressing

The five status address lines output from STSEL (PIA4A) are grouped as follows:

- b0, b1 - STMXA - Status Mux Address
  selects one of four data latches on the Multiplexer Monitor boards

- b2, b2, b3 - STCRDSEL - Status Card Select
  selects one of the six Multiplexer Monitor boards

Also see figure III.2.

Bits b2 - b4 are decoded by a 3-to-8 decoder (74LS138, U8) to obtain eight Status Card Select (STCRDSEL) lines. Only six of the eight Status Card Select lines are used, i.e. one STCRDSEL line per Multiplexer Monitor board.
An Emergency Fire Telephone System.

Hardware Description.

The STCRDSEL line selects one of the six Multiplexer Monitor cards.

STATSEL control word bits b0 and b1 are decoded to obtain four chip select lines (STMXA, Status Multiplexer Address) by the 2-to-4 line decoders (74LS139, U7). The STMXA lines enable one of four status data latches on a Multiplexer Monitor board if the corresponding STCRDSEL is enabled. STMXA lines are bussed to all the Multiplexer Monitor boards.

---

Fig. III.3. Status card select decoding.

---

Fig. III.4. Status address multiplexer decoding.

Each of the STMXA lines selects one of the possible four multiplexer I.C.'s on the Multiplexer Monitor Board which are enabled by the STCRDSEL line.
An Emergency Fire Telephone System.

Hardware Description.

STATSEL Control Word

```
7 6 5 4 3 2 1 0
```

CRDSEL (3) (2) MUXSEL

3 to 8 Decoder

2 to 4 Decoder

STCRDSEL 0 to 7

STMUXA 0 to 3

Fig. III.5. Status Decoding Block Diagram.

If STCRDSEL is enabled, STMUXA selects one of four tri-state data buffers.

Status data latches

```
latch 0  latch 1  latch 2  latch 3
```

STMXA 0

STMXA 2

STMXA 2

STMXA 3

STCRDSEL n --> 2-to-4 decoder <-- STMXA

Status Address decoder:

Fig. III.6. Addressing the Status data latches on the MN.
To summarize again, using figure III.6. The status data of a MM is selected by enabling the STCRDSEL (STCRDSEL n in the diagram for that card). STMXA selects one of the four data latches. The selected data latch routes the line statuses, established by the window comparators, to the single board computer via the status data bus.

III.2.3  Multiplexer Addressing

Extension telephone number data is output from PIA3B to the two Telephone Controller Boards. Each Telephone Controller Board latches the extension telephone number addressed to it. On each board the 74LS374 (U1) tri-state octal D-type flip flop latches the extension telephone number data. The latch enable line is controlled by the most significant bit of PIA3B (PSEL line).

The latch enable strobes for the two boards are generated on the first Telephone Controller Board by one of the 3-8 decoders of the 74LS139 (U9). By making the appropriate links on both Telephone Controller boards the latch enable signals are connected to the data latches.

Figure III.1 shows the relationship between the control lines of the MMs and TCBs. Also refer to the complete circuit diagram in the Appendices of the MM Board.
An Emergency Fire Telephone System.

Hardware Description.

TTT data stable
XXX data indeterminate

PSEL b0 - b6
PSEL b7
STROBE

Operator 0 multiplexer addressing

IPHON and STMXA

data correctly latched

PSEL b0 - b6
PSEL b7
STROBE

Operator 1 multiplexer addressing

IPHON and IIMUXA

data correctly latched

Fig. III.7. Multiplexer Control Timing Diagram.

The timing diagrams in figure III.7 reveal the relationship between the control signals. The PSEL b0 - b6 lines contain the telephone number data, whereas b7 determines to which the extension telephone is connected. Once the PSEL data has stabilized, the selected data latch is strobed (STROBE) to latch the data on the PSEL b0 - b7 lines.
III.2.4  **Multiplexer Addressing and Control Word (CNNCT).**

Fig. III.9. Multiplexer Addressing and Control Word (CNNCT).

If b7 of CNNCT is zero Operator 0 audio multiplexers are selected. When b7 is set, Operator 1 audio multiplexers are selected.
An Emergency Fire Telephone System.  

The I PHON line enables the Multiplexer Monitor Board's audio multiplexers for Operator 0. The multiplexers are addressed by the I MUXA lines.

III.2.5 Links

See the Telephone Controller Board circuit diagram.

First Telephone Controller Board: TCBO
Connect CS0 to CS
PSEL CS to CS1

Second Telephone Controller Board: TCB1
Connect PSEL CS to CS

links

P  P  \rightarrow  3 \text{ to } 8  \rightarrow^* \rightarrow^* \rightarrow \text{CS to 1st TCB}
P  S  b  \rightarrow  \text{decoder}  \rightarrow^* \rightarrow^* \rightarrow \text{PSEL CS to 2nd TCB}

CS - Chip Select

Fig. III.8. Phone select decoding.

III.2.6 Voltage Translators

The Multiplexer I.C.s operate from a 14V supply voltage. The logic control signals (IPHON, IIPHON and MUXA), which originate from 5V circuits, are translated to the higher voltage levels using 7407 open collector buffers (U3, U4, U5).

III.2.7 Audio Circuitry

Voice signals on the MUX audio line contains both audio and AM signals. AM is used from the extension telephone to the operator telephone. Normal audio is used from the operator to the extension telephone.
The 14kHz AM signal is filtered by a high pass filter, U12, and then demodulated. The demodulator signal losses are minimized by applying a 0.6 V offset to the demodulation diode. The demodulated signal is filtered and amplified by a band limited audio amplifier (U11a). The 680pF capacitor of U11a shunts the internal pole-splitting capacitor of the LM381 to limit the frequency to 6kHz (See Bibliography for more detail). The band limited audio is output to the operator telephone via the hybrid circuit.

The audio from the operator telephone to the MUX line is amplified by an LM381 inverting frequency compensated AC amplifier, U11b, with a high frequency cutoff at 5kHz. The LM381 is used in the suggested special bias, low noise configuration.

The impedance matching of the hybrid network is adjusted with 1k cermet potentiometer. Proper adjustment of the hybrid impedance ensures minimal feedback between the operator microphone and earpiece.

### III.2.8 Buzzer

A 556 dual timer circuit generates the ringing tone. Refer to the full circuit diagram of the TCB, SK3818 sheet 2, in the Appendix. Transistors T1, T2 and T3 switch mercury wetted relays to connect the ringing tone to MUX0, MUX1 and the operator audio alarm respectively. The operator alarm is mounted on mimic status display board.

Mercury wetted relays were used because of its high reliability.

The mercury wetted relays have internal back e.m.f. diodes.
III.2.9 Reference Power Supplies

Minimal current is supplied by the four reference power supplies since they are primarily reference voltages to the Multiplexer Monitor Boards. U12 (LF351, high pass filter) and the analogue multiplexer (CD4051, U17 to U20) I.C.s on the Multiplexer Monitor Boards are powered by the +14V supply.

Standard LM317 voltage regulator circuits are used. The voltages used are:

+8 volt - for short circuit faults
+12 volt - for extension telephone handset statuses
+20 volt - for open circuit faults
III.3 MULTIPLEXER MONITOR BOARD

Please refer to drawing SK3818, sheet 3, in the Appendix for the detailed circuit diagram of the multiplexer monitor board.

Each Multiplexer Monitor board (MM) multiplexes voice signals and monitors telephone lines for sixteen extension telephones. Six MM's are used in the EFTS.

The voice signals of the 96 extension telephones can be switched to the two operators. There is one requirement: both operators may not simultaneously be connected to the same extension telephone.

The two Operator 0 multiplexers (U17, U19) are addressed by OP#0 BSEL and enabled by OP0 CS0 or OP1 CS1. Operator 1 multiplexers (U18, U20) are addressed by OP#1 BSEL and enabled by OP1 CS0 or OP1 CS1. These control signals are derived from the two Telephone Controller Boards.

One microfarad capacitors on each of the extension telephone lines block the DC on the extension telephone lines from the multiplexer I.C.s. The signal that is switched by the CMOS analogue switch contains no DC component.

The voltage of the line switched by the CMOS switch may not exceed the power supply voltages. Line protection is provided to clamp the extension telephone line voltages to ensure that these parameters are not exceeded.

Noise and voltage spikes on the extension telephone lines are clipped by clipping diodes on every line.

To simplify printed circuit board layout and to make maintenance easier all the voltage comparator circuits are physically identical. Consequently only three of the four comparators in each quad voltage comparator package (LM339) are used to promote efficient circuit board layout.

Each extension telephone line is monitored for open circuit and short circuit faults. The LEDs, mounted onboard the multiplexer
An Emergency Fire Telephone System.

Hardware Description.

monitor board, display the extension telephone statuses. The on-board LEDs are provided as a maintenance aid. The outputs of the window comparators are buffered by four status data latches (74LS373, U22, U23, U24, U25).

The STATUS bus outputs the statuses, established by the window comparators, to the microcomputer board subsequent to STAT BYT and STCRDSEL lines being enabled. Refer to figure III.11.

HHH data stable
xxx data indeterminate

<table>
<thead>
<tr>
<th>STMXA b0 - b1</th>
<th>xxxxxHHHHHHxxxxxx (or STAT BYTE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>STCRDSEL</td>
<td></td>
</tr>
<tr>
<td>STATUS bus</td>
<td>xxxxxxxHHHxxxxxx data only valid during STCRSEL</td>
</tr>
</tbody>
</table>

Fig. III.11. Status Control Timing Diagram.

The extension telephone handset status is determined by measuring the line voltage. When the handset is lifted the line voltage exceeds +12 V (green LED enabled). With the handset down the line voltage is less than +12 V (green LED disabled).
An Emergency Fire Telephone System. 

Hardware Description.

16 Extension telephone lines

![Diagram of 16 Extension telephone lines]

Voice Handset Status lines (16)
Fault Status lines (16)

Status Card Select
(8)
(8)
(8)
(8)

Status Byte Select
(16) Voice lines to/from Extension telephones

MUX0 Address Logic

MUX1 Address Logic

Voice MUX Addresses

8 to 1 Mux

8 to 1 Mux

8 to 1 Mux

8 to 1 Mux

Operator 0

Voice line

Operator 1

Voice line

STCRDSEL - Status Card Select. STATBYT - Status Byte Select.

Fig. III.12. Multiplexer Monitor Board Block Diagram.
III.4 MIMIC DISPLAY

Positioning of LED's on the Mimic Display indicate the relative positions of the extension telephones throughout the CTACC. Only 74 extension telephone of a possible 96 are indicated on the present Mimic display.

The 192 LED's are grouped into six ROWs of thirty two COLUMNs each. Whenever a ROW is enabled, the corresponding 32 COLUMNs may be enabled to display the extension telephone statuses.

High efficiency LEDs are used for good legibility. The less bright green LEDs are driven at their maximum instantaneous current of 25 mA to compensate for their lower intensity.

NOTE: LED's on the Mimic display should never be allowed to be switched on unless they are multiplexed. The LEDs dissipate maximum power while being multiplexed and will be destroyed if switched on perpetually.

The LEDs are continually multiplexed. Only when a fault occurs on the microcomputer board will the multiplexing be terminated. The fault may be cleared by resetting the Computer Board. Should this not restore the multiplexing the EFTS must be switched off and the Computer Board checked.

The operator audio alarm, mounted on the status display printed circuit board, is generated on Telephone Controller Board 0. The piezo electric buzzer is pulsed with a 5 V DC voltage to facilitate invoking the operator alarm.

Flashing red LED's indicate new faults. Steady (non flashing) red LED's indicate faults that have been accepted.

Green LED's indicate extension telephone statuses. When flashing it could mean:

The extension telephone handset is replaced and the operator is ringing him.
An Emergency Fire Telephone System.

Hardware Description.

The extension telephone handset has been lifted. The call will be queued and the operator connected to him at a later stage.

A steady green LED indicates that an operator is connected to an extension telephone.

Should both a red and green LED be on (flashing or steady), an open circuit fault condition exists on the line of the extension telephone.

The table given below may be used to obtain the ROW and COLUMN numbers of the green and red LEDs.
An Emergency Fire Telephone System.

Hardware Description.

Row and Column matrix of LEDs.

<table>
<thead>
<tr>
<th>GREEN</th>
<th>RED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column Row 0, Row 1, Row 2</td>
<td>Column Row 3, Row 4, Row 5</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
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<td>30</td>
<td>30</td>
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<tr>
<td>31</td>
<td>31</td>
</tr>
<tr>
<td>32</td>
<td>32</td>
</tr>
</tbody>
</table>

|     |     |     |     |
| 33 | 34 | 35 | 36 |
| 37 | 38 | 39 | 40 |
| 41 | 42 | 43 | 44 |
| 45 | 46 | 47 | 48 |
| 49 | 50 | 51 | 52 |
| 53 | 54 | 55 | 56 |
| 57 | 58 | 59 | 60 |
| 61 | 62 | 63 | 64 |
| 65 | 66 | 67 | 68 |
| 69 | 70 | 71 | 72 |
| 73 | 74 | 75 | 76 |
| 77 | 78 | 79 | 80 |
| 81 | 82 | 83 | 84 |
| 85 | 86 | 87 | 88 |
| 89 | 90 | 91 | 92 |
| 93 | 94 | 95 | 96 |
| 97 | 98 | 99 | 100|

Telephone no. 56: the green LED is in ROW 1 and COLUMN 2.
Telephone no. 38: the red LED is in ROW 4, and COLUMN 6.

Fig. III.13. LED Row and Column Matrix Table.
III.5 OPERATOR TELEPHONES

Please refer to drawing SK3818, sheet 6, in the Appendix for the detailed circuit diagram of the operator telephone.

Standard Siemens Master 111 telephones are used for the operator telephones. The rotary dials are replaced with 4x4 keypads. The two digit seven-segment displays, with the associated driver circuitry, have been added to the units.

A D-25 connector terminates the operator display ribbon cable to the microcomputer board. Voice lines are connected to pins 24 and 25 of the same connector.

The operator telephone circuit diagram drawing SK2818 Sheet 6 is provided in the Appendix. A wiring schedule is also supplied, see: the "Operator Telephone to Telephone Controller Board" and "Backplane Wiring" wiring schedules.

III.6 EXTENSION TELEPHONE

Please refer to drawing SK3818, sheet 7, in the Appendix for the detailed circuit diagram of the operator telephone.

The audio design philosophy of the system has been largely determined by the original design of the extension telephones. Communication from the extension telephone to the operator telephone use AM. A 14 kHz carrier frequency is used.

Each extension telephone is powered by the single extension telephone line and the ground return telephone line provided by the PYRO cable (+24 V with 1 200 ohms series resistor). When the extension telephone handset is down, receiver gain is increased to facilitate the a loud ring tone. When the handset is down, power consumption is reduced such that the line voltage increases to approximately 13.5 V.

The microphone signal is amplified by IC2 (pin1). IC1 (pin 7) provides the carrier. The carrier signal is modulated with the audio signal of IC2 (pin 7) in the transformer (LT60). IC2 (pin 7) is configured in a low pass filter mode in order to reduce the
high frequency content of the audio signal. The microphone characteristics automatically reduce the low frequency content in the signal.

The received audio signal is buffered with the IC1 (pin1) audio amplifier. This has a low pass filter in its input stage to filter out the carrier frequency. When the handset is replaced, switch S2 increases the earpiece volume by increasing the feedback level.

The switch S1 determines the extension telephone filtering characteristics during the high gain operation.

### III.7 POWER SUPPLIES

DC Power for the system is provided by two VERO MONOVOLT GK60 switching supplies which operates from a DC source which varies between 24 V and 72V.

The power supplies were selected for worst case operating conditions.

i. All LEDs are illuminated on the Status display and on the Multiplexer Monitor Boards. A maximum of 32 LEDs are on at a time on the Status Display and 96 LEDs on the Multiplexer Monitor Boards.

ii. One operator display with all segments of the two digits illuminated.

iii. The audio alarm active.

iv. The normal power supply requirements of the eight boards in the rack.
An Emergency Fire Telephone System. Hardware Description.

Power requirements are:

<table>
<thead>
<tr>
<th>Component Description</th>
<th>Voltage</th>
<th>Current</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extension Telephones (96X)</td>
<td>+24V</td>
<td>0.012A</td>
<td>1.200A</td>
</tr>
<tr>
<td>Operator Telephones (X2)</td>
<td>+24V</td>
<td>0.020A</td>
<td>0.04A</td>
</tr>
<tr>
<td>Mimic Status display (32X)</td>
<td>+5V</td>
<td>0.030A</td>
<td>0.960A</td>
</tr>
<tr>
<td>Multiplexer Monitor (x6)</td>
<td>+12V</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-12V</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+5V</td>
<td>0.640A</td>
<td>3.2</td>
</tr>
<tr>
<td></td>
<td>+24V</td>
<td>0.200A</td>
<td>1.2</td>
</tr>
<tr>
<td>Telephone Controller (x2)</td>
<td>+12V</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-12V</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+5V</td>
<td>0.300A</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>+24V</td>
<td>0.040A</td>
<td>0.08</td>
</tr>
<tr>
<td>Single Board Computer</td>
<td>+5V</td>
<td>-</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Worst case total power requirements:

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Current (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>+5V</td>
<td>6.3</td>
</tr>
<tr>
<td>+24V</td>
<td>2.6</td>
</tr>
</tbody>
</table>

The +12V and -12V is derived from the +24V supply. It is used for the voltage comparator circuits.

The power supplies used are:

+ 5 V at 12 A, and
+24 V at 2.5 A.

Since these worst case considerations are not possible, the +24V @ 2.5A power supply power rating would not be exceeded.

### III.8 BACKPLANE WIRING

The complete wiring schedule is given in the Appendix. Bussing is clearly indicated by the names given to all functions in the wiring schedule in the Appendices.

Point to point wire wrapping is used. A heavier gauge wire is used to make allowance for high currents of the power supply lines.
Chapter IV

SOFTWARE DESCRIPTION

Please refer to the 'Software module description' and the 'List of Variables' for a list of mnemonics used in the software.
Chapter IV

SOFTWARE DESCRIPTION

IV.1 Software Background

A high level language such as MPL is generally well suited for applications such as this one.

The Motorola EXORCISER compiles the MPL source code into 6809 Assembler modules. The object modules, whether originally Assembler or MPL, are linked together by the 6809 Linker to form the object code.

The available MPL compiler is an upgraded version of the 6800 Motorola MPL compiler. The advanced addressing modes of the 6809 microprocessor had not been implemented into this 6809 Motorola MPL Compiler. Some MPL routines compiled into very inefficient Assembler code because some powerful 6809 instructions were not exploited.

Since the mimic status display LEDs are multiplexed the software is time dependent. Data to the Status Display has to be updated every 5 ms in order to provide a flicker free display.

The Status display interrupt service routine interspaces normal processing. The Status display service call is the highest priority task, and is invoked by a 5 ms real time interrupt. The execution time of the Status display interrupt service routine \( t_{mimic} \) has to be as short as possible to allow the maximum time for other processing \( t_x \) to be done.

Figure VI.1 shows this concept graphically. If \( t_{mimic} \) is too long, insufficient time remains for normal processing.

---

Fig. VI.1. Interrupt Timing.
I had completed most of the software using MPL before hardware became available to test the software interface efficiency. The display routine written in MPL executed in approximately 4000 clock cycles. Less than 1 ms remained for normal processing when the 5 ms interrupt is used — this was not acceptable.

Comparing the compiled MPL with the Assembler was easy since the compiler generates Assembler. From this compiled MPL it became clear that the available MPL was not optimized for the 6809 microprocessor. In the case of the Display service routines the optimized Assembly language code executed in only 400 clock cycles as compared with the 4000 of the MPL.

Assembler and MPL use different programming methods and philosophies. Parameter passing between Assembler and MPL routines proved to be difficult. Assembler counters decrement to zero and MPL counters, e.g. DO loops, where the count variable increments from the start to the stop parameter. It was decided to rewrite all software in assembly language.
IV.2 Introduction.

Nassi-Shneiderman flow charts are used to document program logic. Its format aids structured programming and promotes more compact documentation than conventional flow charting.

The flow charts are included at the end of this chapter.

Included with the software listing in the Appendix is a pseudo high level language used to aid description of the program logic.

An overall perspective of the software is best obtained by studying both the IRQP and MAINP routines. IRQP is the main interrupt handler. MAINP is the main controlling routine subsequent to system initialization.

All data is input via interrupts. Operator and user action invoke IRQP which call the necessary interrupt service routines to pass data via system status flags (in SYSTAT, the system status word) to the main program, MAINP. The main program responds only to changes in the system status flags (or changes in the telephone statuses). The status flags are set or cleared by the interrupt service routines.

Subsequently the main program checks the system status flags and executes the appropriate service routines. Once the service routines have been completed the system status flags are checked again. The program flow of the MAINP program is exclusively determined by the system status flags.

Figure IV.2 pictorially present the relationship between the interrupts, the extension telephone statuses and the main program (MAINP). Hardware interrupts interface the operator cradle statuses, operator keypads and the mimic status display with the software. If necessary the interrupt handling routines set or clear flags in the system status word (SYSTAT) during execution. Subsequently control is returned to the MAINP.

Each time MAINP is activated the extension telephone statuses are checked. The mimic status display data update, operator numeric displays, operator alarm and the ring tone are all controlled by MAINP.

The MAINP execution is interrupted only by the hardware interrupts. These interrupts interface to the MAINP only via the system status flags (SYSTAT, FNCST0 and FNCST1). The main program executes iteratively and the program flow is solely determined by the system status flags.
The EFTS software can be divided into two main sections:

- Interrupt driven routines, and
- Main program

All the software is written in 6809 assembly language and totals approximately 2100 bytes in length.

IV.3 Interrupt Driven Routines.

Hardware interrupts invoke IRQP, the main interrupt handler. The interrupt routine disables all further hardware interrupts. IRQP identifies the origin of the interrupt and then calls the appropriate interrupt service routines. Interrupts are re-enabled upon completion of the interrupt service routines, when program control is resumed by the main routines (MAINP).

When an interrupt is invoked by the onboard clock (5 ms), the two counters, MSEC and IRQCNT, are decremented. MSEC is a presettable counter and used by the DELAY-routine. IRQCNT determines the flashing period of the LEDs - when zero, IRQCNT is preset to FLSHTM.

The Cradle interrupt pass appropriate parameters to CRDLP, the cradle interrupt service routine. A keyboard interrupt invokes
An Emergency Fire Telephone System.

Software Design.

the KYBX routine, the operator keyboard service routine, which read and then decodes keyboard data.

IV.3.1 Interrupt Priorities (IRQP)

The periodic real time interrupt (the interrupt period is selected by jumpers on the Computer Board) has the highest interrupt priority and the highest recurrence rate. The operator telephone cradle switches have the next highest priority because of their vital function: it cancels all system command modes. Keyboard action has the lowest priority.

highest priority ...... 1 ms real time interrupt
Operator 0 cradle interrupt
Operator 1 cradle interrupt
Operator 0 keypad interrupt
Operator 1 keypad interrupt

lowest priority ......

The interrupt flags are reset by their appropriate service routines.

IV.3.2 Mimic Status Display

The mimic status display is multiplexed at fixed regular intervals (IRQCNT) to provide a flicker free constant intensity display. The 192 LEDs are grouped into 32 columns of 6 rows. Data is output to one row at a time - each row has 32 LEDs. The 6 rows of 32 columns of LEDs therefore require 30 ms to refresh.

Flashing and steady (non flashing) LED statuses are stored in two 24-byte arrays: FLSH & COLBUF. The arrays respectively indicate flashing or steady LEDs. The first 12-bytes (96-bits) of each array represent handset statuses and the next 12-bytes represent fault statuses.

The MIMIC service routine is invoked only by the real time interrupt. Upon entry all ROW's are disabled. Before enabling the next row (one of six rows) the 32-bits (4-bytes, 4 PIA's) of column data is output to the columns.

Multiplexing is executed in one of two modes:

- Lamp test active, or
- Normal multiplexing
When the lamp test flag (LAMPM) in SYSFLG is set, all Columns are enabled to turn on all the LEDs.

The flash bit (FLASHB) in SYSFLG determine the status of the flashing LEDs. When set the flashing LEDs are on, and when cleared, the flashing LEDs are off. The flashing LEDs are turned on and off by negating the status of FLSHB at the flashing period (FLSHTM).

If the flash bit (FLASHB) is cleared, only COLBUF data is output to the COLUMNS. When the flash bit is set, COLBUF & FLASH data is logically ORed before outputting the data to the COLUMNS, thereby turning on the flashing LEDs as well as the steady LEDs.

IV.3.3 Keypad Routine (KYBX and KYBRDP)

Operator keypad activity invokes the IRQP main interrupt service routine which then calls the KYBX interrupt service routine. KYBX has lowest priority of the interrupt service routines. Upon completion of the keyboard service routine the interrupt flag is cleared enabling further interrupts.

Operator 0 keypad (KYBRDO) uses the least significant nibble (4 bits) of the keypad PIA (KYBRD), and the operator 1 keypad (KYBRD1) the most significant nibble. Depending on which keypad initiated the interrupt the KYBRD code is masked and the relevant keypad code stored in KYBINP buffer.

The keypad codes stored in KYBINP is decoded by the KYBRDP subroutine. Decoding by KYBRDP is accomplished on three levels.

Level 1

Unnumbered key - No action taken.
Lamp Test code - Set Lamp Test flag in SYSTAT.
Alarm Accept code - Set Alarm Accept flag in SYSTAT.
Clear code - Set the Clear flag in SYSTAT.

Level 2

If the Audio flag is set and the cradle is down all other codes are ignored.

If the operator telephone cradle is up, then:

Ring code - Set Ring flag in SYSTAT.
Queue code - Set Queue flag in SYSTAT.

Level 3

Decode the numeric keys and display the numbers on the operator numeric display.

Level 1 keypad codes are actioned irrespective of the operator telephone cradle status. Level 2 codes are executed only if the Audio flag (in FNCST) is set and the operator telephone cradle is up. Level 3 codes can only be executed if the keycode is not Level 1 or Level 2 code.

After this the program control is returned to IRQP.

Keypad decoding table:

<table>
<thead>
<tr>
<th>Function</th>
<th>Code</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>6 lowest</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>8</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Function</th>
<th>Code</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>A</td>
<td>6 lowest</td>
</tr>
<tr>
<td>0</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>L</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>A</td>
<td>B</td>
<td>2</td>
</tr>
<tr>
<td>C</td>
<td>F</td>
<td>5</td>
</tr>
<tr>
<td>Unmarked</td>
<td>E</td>
<td>0 highest</td>
</tr>
<tr>
<td>Q</td>
<td>D</td>
<td>4</td>
</tr>
<tr>
<td>R</td>
<td>C</td>
<td>3</td>
</tr>
</tbody>
</table>

Fig. VI.3. Keypad decoding table.
IV.3.4 Cradle Procedure (CRDLP)

The cradle procedure has the second highest priority of the interrupt service routines. Any change in operator cradle status invokes the CRDLP service routine.

First the operator telephone cradle status is determined. If the operator handset is lifted no further action is taken and program control is returned to IRQP.

If the operator handset is down, the AUDIOM and RINGM flags of the function status word are tested. When the AUDIOM flag is set the audio line between the operator and the extension telephone is disconnected. If the RINGM flag is set ringing of the extension telephone is stopped.

Consequently all status flags of that operator are cleared. Lastly, the operator numeric display is cleared. Program control is then returned to IRQP.

Note: When the cradle is down, the cradle status at PIAOB is low (logic 0).

IV.4 Main Programs

IV.4.1 Main Program (MAINP)

The Main Program (MAINP) executes in an iterative loop. It's execution is diverted only by the five hardware interrupts.

The status of a specific operator is represented by flags in the function status word (FNCST0 and FNCST1 for operator 0 and operator 1 respectively).

The program flow of MAINP is determined by the mode flags in the function status words (FNCST0 for operator 0 and FNCST1 for operator 1). When no mode flags are set, MAINP resets the watchdog and checks the extension telephone statuses for changes in status. MAINP invoke routines associated with the mode flags.

<table>
<thead>
<tr>
<th>Mode_flag</th>
<th>Description</th>
<th>Routine called</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACKM</td>
<td>Acknowledge</td>
<td>ACKP</td>
</tr>
<tr>
<td>LAMPM</td>
<td>Lamp Test</td>
<td>LAMPM</td>
</tr>
<tr>
<td>RINGM</td>
<td>Ring</td>
<td>RING</td>
</tr>
<tr>
<td>QM</td>
<td>Queue</td>
<td>QP</td>
</tr>
<tr>
<td>CLRM</td>
<td>Clear</td>
<td>CLRP</td>
</tr>
<tr>
<td>AUDIOM</td>
<td>Audio mode</td>
<td>Status only</td>
</tr>
<tr>
<td>RINGING</td>
<td>Ringing active</td>
<td>Status only</td>
</tr>
</tbody>
</table>

During execution of a procedure called by MAINP, flags in FNCST0 and FNCST1 may be set and/or cleared in order to invoke other appropriate procedures.

**IV.4.2 Watchdog (WTCHDG)**

At power up the Watchdog timer is disabled for approximately 4,5 seconds. During normal processing the watchdog timer has to be reset every 10 ms, otherwise the watchdog timer resets the system.

The watchdog timer is reset when the CA2 line of PIAO is toggled by the watchdog routine, WTCHDG.

**IV.4.3 Test for Status Changes (TSTCHNG)**

This routine checks the handset and line statuses of the 96 extension telephones.

A change from low to high in extension telephone handset status sets the particular bit representing that extension telephone in the mimic data buffer (STBUFO and STBUF1). The operator audio alarm is then activated to inform the operator of the incoming call.

A change from high to low in status clears the particular bit in both the FLSH and COLBUF data buffers. Both the flashing and steady LEDs are turned off.

When the handset status changed from low to high QPHON adds the telephone number to the queue. If the handset status changed from high to low QPHON deletes the telephone number from the queue.
IV.4.4 Make Buffer (MAKBUF)

This routine alternately buffers all the extension telephone statuses in one of the data buffers, STTBUF and STBUF1 (24 bytes each).

A change in extension telephone status is reflected by a difference between the two data buffers. This difference is detected by TSTCHG when it compares the two data bases.

Momentary open circuit faults on the lines necessitate debouncing of the fault statuses. The faults are caused when fumbling the extension telephones handsets when they are lifted or replaced.

IV.4.5 Ring Procedure (RINGP)

This routine rings an extension telephone when the ring mode flag (RINGM) is set.

When you ring an extension telephone an audio multiplexer connects the voice signal to the extension telephone. Should the extension telephone handset be lifted no ring tone is required. If the extension handset is down the ring tone is enabled and the ring tone can be heard at both the operator telephone and the extension telephone. When the handset is lifted the ringing is terminated.

The RINGM flag is cleared when the ringing is terminated.

Before ringing an extension telephone two tests are done:

Two operators may never simultaneously be connected to the same extension telephone. Should the one operator dial the extension telephone the other operator is connected to, the other operator is disconnected from that extension telephone. The latter caller is connected to the extension telephone. The other operator's numeric readout is cleared to indicate that his call has been terminated.

The second test executed checks that a valid extension telephone number is dialled, i.e. the number is zero or is not
greater than the maximum number allowed (96 for the present implementation). When an invalid number is dialled ringing is aborted and program control is immediately returned to MAINP after clearing the operator numeric readout.

A valid extension telephone number is decoded and stored in the ring buffer for the particular operator. The operator telephone voice circuit is connected to the dialled extension telephone and the audio flag is set in the function status word. If the extension telephone handset is not lifted the LED corresponding to the extension telephone number starts flashing. The operator telephone voice circuit is connected to the dialled extension telephone and the audio flag is set in the function status word. The ringing flag is set and the ring flag remains set in the function status word.

The dialled extension telephone is checked to see if the handset has been lifted. Until such time as the handset is lifted or the call is terminated, the extension telephone is disabled.

Replacing the operator handset or pressing the C-key will terminate the Ring function.

IV.4.6 Alarm Acknowledge (ACKP)

The ACKP routine servers two main functions:

The operator audio alarm is silenced

A new fault is acknowledged by turning the flashing fault LEDs on permanently until the fault is cleared and/or the system reset.

The fault LEDs stop flashing when the fault statuses in the FLSH data buffer are cleared. The fault LEDs turn on (steady) by logically ORing the FLSH fault data with the COLBUF column data. The ORed data is stored in the fault status section of COLBUF.

The acknowledged faults are indicated by steady red LEDs on the mimic status display. These LEDs are enabled via the normal MIMIC routine.
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IV.4.7 Clear Function (CLRP)

This routine terminates all functions of the operator and is equivalent to replacing the operator handset.

The clear routine clears the Clear flag in the appropriate function status word (FNCST0 or FNCST1) and then branches to the cradle down routine (CRDLDW) which is part of the cradle procedure (CRDLP). The CRDLDW routine terminates all operator functions.

IV.4.8 Lamp Test (LAMPP)

The lamp test routine has two functions. All the LEDs on the Status display and all the operator readout segments are all turned on.

LAMPP indirectly control the LEDs by setting the lamp test flag in the appropriate function status word (FNCST0 or FNCST1). The LEDs are then enabled by the MIMIC interrupt service routine.

Before enabling all the segments on the operator readout the data displayed on the operator readout is buffered. All the segments are enabled for the lamp test by outputting "88" to the readout. Once the lamp test has been completed the lamp test flag is cleared and the operator readout data restored to its values prior to the lamp test.

The operator who invoked the lamp test may terminate the lamp test by lifting and replacing his handset. Replacing of the handset clears the function status flags and so terminate the MIMIC lamp test.

IV.4.9 Queuing Routines

Queuing routines are subdivided into four routines:

- Testing the presence of an extension telephone number in the queue.
- Adding an extension telephone number to the queue.
Deleting an extension telephone number from the queue.

Ringing the extension telephone number at the top of the queue.

Queuing data is stored in a linked list. Each extension telephone number uses two bytes. Therefore all linked list table offsets and pointer values are double that of the telephone number.

Each telephone number data element is made up of two bytes: "prev" and "next". The pointer value to the telephone number data element is therefore double the value of the telephone number. See figure VI.4.

When a telephone number is not in the queue both its pointer values are $00_{16}$.

Queuing Example:

Refer to Figure VI.4. In this example the extension telephone at the top of the queue is number 9 ($12_{16}$). FRSTNO points to $12_{16}$ (double the value of number 9). The "prev"-byte of extension telephone number 9 points to $00_{16}$, which means there is no telephone number prior to this one in the queue.

The 'next'-byte of extension telephone number 9 is $04_{16}$, and points to extension telephone number 2.

The 'next'-byte of extension telephone number 2 is $18_{16}$, and points to extension telephone number 12.

The "next"-byte of telephone number 12 (pointer value $18_{16}$) is $00_{16}$. This implies that there is no next telephone in the queue and that it is the last telephone in the queue.

Telephone number 12 is the last extension telephone number in the queue for two reasons. The pointer to the next location is $00_{16}$, and LASTNO also points to it.

The "prev"-byte of telephone number 12 (pointer value $18_{16}$) points to $04_{16}$, or extension telephone number 2.
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Telephone number 2 pointers indicate that the previous telephone number in the queue is at location $12_{16}$, which is extension telephone number 9. The next extension telephone number in the queue is at location $18_{16}$, which is telephone number 12 ($0C_{16}$).

<table>
<thead>
<tr>
<th>tel. no.</th>
<th>pointer value</th>
<th>Linked list prev</th>
<th>next</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ 0</td>
<td>+ 00</td>
<td>* 00</td>
<td>+</td>
</tr>
<tr>
<td>1</td>
<td>+ 2</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>2</td>
<td>+ 4</td>
<td>12</td>
<td>* 18</td>
</tr>
<tr>
<td>3</td>
<td>+ 6</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>4</td>
<td>+ 8</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>5</td>
<td>+ A</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>6</td>
<td>+ C</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>7</td>
<td>+ E</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>8</td>
<td>+ 10</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>9</td>
<td>+ 12</td>
<td>00</td>
<td>04</td>
</tr>
<tr>
<td>10</td>
<td>+ 14</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>11</td>
<td>+ 16</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>12</td>
<td>+ 18</td>
<td>04</td>
<td>00</td>
</tr>
<tr>
<td>13</td>
<td>+ 1A</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>14</td>
<td>+ 1C</td>
<td>00</td>
<td>00</td>
</tr>
</tbody>
</table>

These two bytes are not used.

FRSTNO

12

LASTNO

18

Fig. VI.4. Example of queue in operation.

IV.4.10 Check Queue: (CHKQ)

The routine checks the Queue for the presence of a specified Telephone number. There are four possibilities:

i. The extension telephone number is not in the queue. On completion of the routine, the A-register contains SFF.

ii. The extension telephone number is in the queue and it is linked to other extension

telephone numbers. A test is made to see whether these pointers are present. If these are present, the A-register contains the extension telephone number on completion of this test. If the test fails, a third test is done.

iii. The number checked may be the only number in the queue. Such a number if not linked to any other numbers and is therefore both the first and last extension telephone number in the queue. FRSTNO, the pointer to the first extension telephone number in the queue, is tested for correspondence. If the test is true, the number is the FRSTNO and the A-register will contain the extension telephone number on exit. If false, the A-register will contain $\text{SFF}$.  

iv. The extension telephone number is the last extension telephone number in the queue. The test in (ii) will locate this number. Since it is only linked to a previous extension telephone number in the queue, no numbers follow it. Test (iv) is a special case of test (ii).

IV.4.11 Add to Queue (ADDQ)

The routine adds an extension telephone number to the queue. There are two possibilities:

i. The queue is empty. The extension telephone number to be added will be the first extension telephone number in the queue.

FRSTNO points to the first extension telephone number entry in the queue.

ii. The queue is already in use. The extension telephone number is added to the end of the queue.
The last extension telephone number in the queue now becomes the second last in the queue by making its "next"-byte point to the new last entry.

The extension telephone number added to the queue becomes the LASTNO, and its "previous" byte points to the extension telephone number that has become the second last in the queue.

IV.4.12 Delete from Queue (DELFQ)

The routine deletes the selected extension telephone number from the queue. CHKQ must be invoked before calling DELQ to ensure that the number to be deleted is present in the queue. Three possibilities exist for program control.

i. The extension telephone number to be deleted is the first number in the queue, i.e. FRSTNO. The second extension telephone number now becomes the FRSTNO, and the "previous" and "next"-bytes of the extension telephone number to be deleted is cleared.

ii. The extension telephone number to be deleted is somewhere in the queue, but not the FRSTNO or LASTNO. The "previous"-byte of the extension telephone number following the to-be-deleted extension telephone number is made the same as the "previous"-byte of the to-be-deleted extension telephone number. Also, the "next"-byte of the extension telephone number preceding the to-be-deleted extension telephone number is made the same as the "next"-byte of the to-be-deleted extension telephone number. Then the "previous" and "next"-bytes of the to-be-deleted number is deleted. The to-be-deleted extension telephone number are now deleted from the queue.

iii. The extension telephone number to be deleted is the LASTNO. The "next"-byte of the second last extension telephone number
in the queue is cleared. The "previous" and "next"-bytes of the last extension telephone number in the queue is cleared and LASTNO made to point at the second last entry in the queue. The old LASTNO is now deleted.

IV.4.13 Ring Top of Queue (QP)

This program rings the extension number at the top of the queue simply by pressing the Q-key.

If there are no telephone numbers are in the queue when the Q-key is pressed program, control is resumed by MAIN?

If the queue is in use, FRSTNO is decoded and displayed on the operator readout. The extension telephone number is further decoded and appropriate parameters passed to RINGP. RINGP is then executed i.e. RINGP rings the extension telephone as if the extension telephone number was dialled from an operator keypad.
IV.5 System Software Flow Charts

IF PERIODIC INTERRUPT THEN DO
  DECREMENT MSEC COUNTER
  DECREMENT IRQCNT COUNTER
  IF IRQCNT ZERO THEN DO
    EQUATE IRQCNT TO FLASHTIME (FLSHTM)
    INVERT FLASH (FLSH) FLAG IN SYSTEM FLAG (SYSFLG)
    IS LAMP TEST FLAG SET
  END
ELSE
  IF FLASH FLAG SET THEN
    ENABLE ALL COLUMNS
  ELSE
    OUTPUT:  COLO = COLBUF (NCOLM)
    OR FLSH (NCOLM)
    DECREMENT NCOLM
    COLBUF (NCOLM) TO COLO
    DECREMENT NCOLM
    COLO = COLBUF (NCOLM)
    OR FLSH (NCOLM)
    DECREMENT NCOLM
    COLBUF (NCOLM) TO COL1
    DECREMENT NCOLM
    COL1 = COLBUF (NCOLM)
    OR FLSH (NCOLM)
    DECREMENT NCOLM
    COLBUF (NCOLM) TO COL2
    DECREMENT NCOLM
    COL2 = COLBUF (NCOLM)
    OR FLSH (NCOLM)
    DECREMENT NCOLM
    COLBUF (NCOLM) TO COL3
    DECREMENT NCOLM
    COL3 = COLBUF (NCOLM)
    OR FLSH (NCOLM)
    IF NCOLM = 0 THEN DECREMENT NCOLM
    IF NCOLM = 0 THEN
      NCOLM = 23
    NROW = MASK (NROW)
    DECREMENT NROW
    IF NROW = 0 THEN
      NROW = 5
    IF ANY CRADLE IS SET THEN THEN
      IF CRADLE 0 IS SET THEN
        PASS PARAMETER = 0
        CALL CRADLP (CRADLE PROCEDURE)
      ELSE
        CALL CRADLP (CRADLE PROCEDURE)
      END
    ELSE
      IF ANY KEYBOARD FLAG IS SET THEN
        IF KYBO IS SET THEN
          GET KEYBOARD Inputs FROM KYBRD
          PIA & STORE IN KYBINP(0)
          CALL KYBRDP (KEYBOARD PROC)
        ELSE
          GET KEYBOARD Inputs FROM KYBRD
          PIA & STORE IN KYBINP(1)
          CALL KYBRDP (KEYBOARD PROC)
        END
      END
      RETURN FROM INTERRUPT
    END
  END
ELSE
  IF NCOLM = 0 THEN DECREMENT NCOLM
  NCOLM = 23
  ROW = MASK (NROW)
  DECREMENT NROW
  IF NROW = 0 THEN
    NROW = 5
  IF ANY CRADLE IS SET THEN Then
    IF CRADLE 0 IS SET THEN
      PASS PARAMETER = 0
      CALL CRADLP (CRADLE PROCEDURE)
    ELSE
      CALL CRADLP (CRADLE PROCEDURE)
    END
  ELSE
    IF ANY KEYBOARD FLAG IS SET THEN
      IF KYBO IS SET THEN
        GET KEYBOARD Inputs FROM KYBRD
        PIA & STORE IN KYBINP(0)
        CALL KYBRDP (KEYBOARD PROC)
      ELSE
        GET KEYBOARD Inputs FROM KYBRD
        PIA & STORE IN KYBINP(1)
        CALL KYBRDP (KEYBOARD PROC)
      END
    END
  END
END
NOTE:  COLBUF (13) = FLASH (1)
       COLBUF (23) = FLASH (11)
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IF NONE OF THE CRADLE’S HAVE BEEN PUT DOWN THEN
RETURN FROM SUBROUTINE

RESET CRADLE IRQ’S

IF AUDIO OR RING MODE FLAGS ARE SET THEN
DISABLE LED OR PHONO CONNECTED TO : JSR CHGLED
DISABLE OPERATOR RINGING : JSR BUZZR
DISCONNECT AUDIO FROM EXTENSION : JSR AUDIO

DISABLE OPERATOR CONNECTED TO : JSR CHGLED
DISABLE OPERATOR RINGING : JSR BUZZR
DISCONNECT AUDIO FROM EXTENSION : JSR AUDIO

CLEAR KYBUF (OP#) (KEYBOARD BUFFER)
CLEAR OPERATOR DISPLAY : JSR LINKP
CLEAR FUNCTION STATUS FLAGS
RETURN FROM SUBROUTINE

GET KYBINP (OP#) (KEYBOARD INPUT)

DO CASE

UNNUMBERED

NUMBER 0 - 9

KEY

LAMP TEST

ALARM ACCEPT

CLEAR

RING

SET LAMP

SET ACKM

SET CLRM

SET RINGM

MAKE OLD LSD

NEW MSD

ADD NEW DIGIT

DISPLAY DATA :

LINKP

RETURN FROM SUBROUTINE

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<table>
<thead>
<tr>
<th>Software Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>An Emergency Fire Telephone System.</td>
</tr>
</tbody>
</table>

**DO FOREVER**

<table>
<thead>
<tr>
<th>CLEAR IRQ MASK</th>
</tr>
</thead>
<tbody>
<tr>
<td>RESET WATCHDOG</td>
</tr>
</tbody>
</table>

**DO CASE (FNCST (OPRN2))**

<table>
<thead>
<tr>
<th>RINGM</th>
<th>ACKM</th>
<th>QM</th>
<th>CLRIM</th>
<th>LAMP</th>
<th>CHG</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLG</td>
<td>FLG</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JSR</td>
<td>JSR</td>
<td>JSR</td>
<td>JSR</td>
<td>JSR</td>
<td>JSR</td>
</tr>
<tr>
<td>RING</td>
<td>ACKP</td>
<td>QP</td>
<td>CLR</td>
<td>LAMP</td>
<td></td>
</tr>
</tbody>
</table>

**RESET WATCHDOG (WATCHDOG)**

**INVERT OPRNO (OPERATOR NO. 0 OR 1)**

**TEST FOR STATUS CHANGES : TSTCHG**

### CHANGE STATUS BUFFER NO.

<table>
<thead>
<tr>
<th>GET ACTIVE STATBUF ADDRESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>JSR MAKEBUF</td>
</tr>
<tr>
<td>MAKE NEW STATUS BUFFER</td>
</tr>
</tbody>
</table>

**DO MUXNO = 23 TO 0**

**IF THERE IS A CHANGE IN STATUS THEN**

**FIND BITNO OF CHANGED BIT**

**FIND NEW STATUS OF CHANGED BIT**

**IF NEW STATUS OF BIT = 1**

**NO**

**IF MUXNO ≤ 11 (PHONE) THEN**

**GET PHONO NO O CHANGED STATUS**

**HAS HANDSET BEEN LIFTED**

**YES**

**PUT PHONE IN Q**

**NO**

**DELETE PHONE FROM Q**

**NO FROM Q**

**SET LED FLASHING**

**LED OFF**

**TURN FLASHING**

**IF MUXNO = 11 (PHONE) THEN**

**GET PHONO NO O CHANGED STATUS**

**PUT PHONE IN Q**

**DELETE PHONE FROM Q**

**NO FROM Q**

**SET LED OFF**

**TURN FLASHING**

**IF MUXNO ≤ 11 (PHONE) THEN**

**GET PHONO NO O CHANGED STATUS**

**HAS HANDSET BEEN LIFTED**

**YES**

**PUT PHONE IN Q**

**DELETE PHONE FROM Q**

**NO FROM Q**

**SET LED OFF**

**TURN FLASHING**
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**LAMFP**

- Output "88" to operator display
- Delay for TSTIME (Test Time)
- Restore operator display
- Clear lamp test flag in FNCST (OP#)

**CLRP**

- Clear all flags in FNCST (OP#)
- Clear operator display

**ACKP**

- Make all flashing 'fault' LED's steady
- Stop buzzer ringing

**RINGP**

- If same phono rung as other op then
  - Return
- If RNGNG flag is not set then
  - Set RNGNG flag
- If phono is not valid then
  - Return
- Flash green LED
- Connect OP# phone to phono
  - JSR Audio
- Ring phono
- If phono has been answered then
  - Stop ringing
  - Clear RNGNG flag
  - Make green LED steady
- Return
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ARD CODING:

KEYBOARD & LAYOUT:

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>ACK</td>
<td>CL</td>
<td>LAMP</td>
<td>DIAL</td>
<td>RING</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

KEYBOARD CODES:

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>C</td>
<td>E</td>
<td>F</td>
<td>B</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Chapter V

OPERATOR INSTRUCTIONS

V.1 CONTROL CENTRE

V.1.1 Incoming Calls

The audio alarm sounds and a flashing green LED on the Mimic indicates the calling Extension telephone.

The operator lifts a telephone handset. This cancels the audio alarm.

Press the Q-key to connect to the incoming call. The flashing green LED turns on permanently and the numeric readout displays the Extension telephone's number.

The operator telephone is now connected to the Extension telephone.

The operator terminates the call by either replacing the handset or pressing the C-key.

In the case of queued calls, first terminate the present call (C-key) before connecting to the next in the queue (Q-key).

Once a call is terminated, the operator may directly ring any Extension telephone or connect to the next Extension telephone in the queue.

NOTE: No audible alarm sounds when any one of the operator handsets have been lifted. Should the operator replace his handset before all the incoming calls have been answered, the audio alarm will NOT sound again, however the green LED will remain flashing as long as the Extension telephone handset remains lifted.

Once the audio alarm has been silenced and the operator handset replaced, the audio alarm will sound again until another Extension telephone handset is lifted.

V.1.2 Outgoing Calls

Lift the operator handset and enter the Extension telephone number on the keypad. Press the R-key (RING) to ring the Extension telephone.
The green LED, corresponding to the Extension telephone, will flash while the Extension telephone is ringing.

When the Extension telephone is answered, the green flashing LED stops flashing and becomes steady. Communication may now proceed.

The operator replaces his handset or presses the C-key to terminate the call. The green LED then turns off.

NOTE: Only the operator can terminate a call.

Replacing the Extension telephone handset will not terminate a call. After replacing the Extension telephone handset the operator telephone voice signals will be amplified to an extra high volume level until the operator terminates the call.

V.1.3 FAULT CONDITIONS

When a fault occurs the corresponding red LED flashes. If neither of the operator handsets are lifted the audio alarm sounds.

Press the A-key to acknowledge and silence the alarm. The flashing red LED stops flashing and turns on permanently.

The operator reports the fault to the Technical Staff.

NOTE: Intermittent audio alarms may be eliminated by lifting an operator handset off the cradle.

No audio alarms can sound with the operator handset lifted and incoming calls may so be missed.

V.2 EXTENSION TELEPHONE

V.2.1 To make a call.

The caller lifts the handset and waits for the Control Centre operator to answer. After conversing the handset is replaced.

V.2.2 To receive a call.

The Extension telephone will ring. When the handset is lifted the ringing terminates. The user may now converse with the Control Centre operator.
V.3 LAMP TEST

When the L-key is pressed all the LED's and the numeric readout of the one operator telephone are turned on.

The operator numeric readouts may be tested independent from the mimic status display by pressing the black button on the operator telephone.

V.4 GENERAL

When in doubt press the C-key. This has the same effect as replacing the handset which cancels all previous commands and keyboard entries.

The only two operator functions that can be executed with the handset on the cradle are the Lamp test and Alarm acknowledgement.

The two operators cannot simultaneously communicate with the same Extension telephone. The call may be interrupted by the second operator by him dialling the same extension telephone number. The first operator will then be cut off.

A lamp test is automatically executed after power up or after system reset.
Chapter VI.

SYNOPSIS.

It is good practice to determine whether the design attained the original objective.

The following factors restrained attainment of the original goal:

The restrictive budget curbed more ingenious solutions.

The modulation technique used restricted the remodeled design and the resulting audio quality.

Few failings have been found in the present design beyond those originating from the alluded restraints.

The modulation technique used, i.e. using both AM and audio, resulted in an inferior audio quality.

In order to obtain the required gain in the audio circuitry the audio and AM bandwidths had to be restricted regardless of the effect.

The hybrid network and amplifier circuit has been adjusted to operate marginally below the point of oscillation where positive feedback results. Even so, sometimes the volume has been found to be insufficient, or oscillations have resulted.

The use of dedicated filtering ICs is probably the most economical way to improve the audio quality. Superior filtering characteristics are possible with these devices. Research has found it to be relatively costly. One Chebychev filter IC costs approximately the same as the microcomputer board would cost to manufacture. At least three of these devices would be required – once again fluked by the budget.

A practical issue has been overlooked regarding the queuing of incoming calls. The person at the extension telephone has no indication that an operator has in fact received his call. Some discernible form of acknowledgment would be a distinct enhancement.
Substituting the red and green LEDs with single dual color LEDs will aesthetically enhance the Mimic display even though the dual colour LEDs are more expensive than two single colour LEDs.

Personally I would have preferred using standard balanced line telephones. This would have been a viable solution if the previous extension telephones were discarded. However, the previous system had to be expanded, and could not be replaced.

Ultimately the EFTS can be regarded as economical, durable and reliable and uncomplicated with a reasonable audio quality.
A. APPENDICES.


The Emergency Fire Telephone System provides communication between various selected places, distributed throughout the Cape Town Administrative Centre (CTACC), i.e. from the tower block, the podium, and the foyer, to the Security Control Centre on the first floor in the podium block.

The system has the following facilities:

- Communication from the control centre to an Extension telephone, with ring capability.
- Communication from the Extension telephone to the control centre, also with ring facility.
- Simultaneous two way communication is provided between one operator at the control centre and an Extension telephone.
- Line monitoring of all Extension telephone lines for short circuit and open circuit detection.
- Line status and fault status indication of all Extension telephones.
- An operator can only communicate with one Extension telephone at any one time. An Extension telephone is selected by means of a two digit telephone number dialled on the Operator telephone.
- Ring and Clear facilities are provided on the Operator keyboard.
- The "ring" and "fault" statuses of all Extension telephones are displayed.
An Emergency Fire Telephone System.

Telephone circuitry is designed to operate on a nominal 24V supply.

A.1.1 System Layout.

A.1.1.1 Extension Telephones.

The Extension telephone receives a normal audio signal from the Operator telephone and amplifies it. However, the signal from the Extension telephone to the Operator is an A.M. signal with a 14 kHz carrier frequency.

Each of the Extension telephones is provided with an unbalanced wire pair: one is the ground line, and the other carries the audio, the A.M. voice signals, and the 12V power.

A.1.1.2 Rack and Console.

The line monitoring boards multiplex the speech lines and monitor each of the Extension telephone lines. Each Extension telephone is addressed by a specific code which connects the Extension telephone to the Operator telephone. The line statuses are monitored and output to the status display boards.

Speech processing is accomplished by demodulating the A.M. voice signal from the Extension telephone and amplifying it to the Operator earpiece. The Operator microphone signal is amplified and directly output to the Extension telephone.

A.1.2 The Improvements.

The original system had become unreliable and no circuit diagrams or documentation were available for system maintenance.

The system required expansion for improved utilization. The original fifty-four Extension telephones had to be increased to ninety-six. With the additional Extension telephones a second operator decrease operator workload under emergency conditions.

Answering multiple calls on a FIFO basis necessitated a queueing facility. New incoming calls would be queued when the operator
was busy with a call, and he would then not be distracted by new calls.
A.2 Software Module Description.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RESET</td>
<td>System Initialization.</td>
</tr>
<tr>
<td>FMSB</td>
<td>Find most significant bit.</td>
</tr>
<tr>
<td>VALBIT</td>
<td>Determine value of specified bit within a byte.</td>
</tr>
<tr>
<td>SETBIT</td>
<td>Sets/Clears specified bit within a byte.</td>
</tr>
<tr>
<td>IRQP</td>
<td>Interrupt priority determining service routine.</td>
</tr>
<tr>
<td>MIMIC</td>
<td>Mimic display control: interrupt driven routine.</td>
</tr>
<tr>
<td>KYBRDP</td>
<td>Keyboard decoding procedure: Interrupt service routine.</td>
</tr>
<tr>
<td>CRDLP</td>
<td>Cradle procedure: Interrupt service routine.</td>
</tr>
<tr>
<td>LINKP</td>
<td>Operator readout procedure.</td>
</tr>
<tr>
<td>KYBX</td>
<td>Operator keyboard procedure.</td>
</tr>
<tr>
<td>MAINP</td>
<td>Main procedure.</td>
</tr>
<tr>
<td>WCHDGD</td>
<td>Watchdog reset routine.</td>
</tr>
<tr>
<td>TSTCHG</td>
<td>Tests for changes in Extension telephone statuses.</td>
</tr>
<tr>
<td>MAKBUF</td>
<td>Debounces and reads Extension telephone statuses into status buffers.</td>
</tr>
<tr>
<td>CHGLED</td>
<td>Changes/Sets mimic LED statuses: off/flash/on.</td>
</tr>
<tr>
<td>ACKP</td>
<td>Alarm acknowledge routine.</td>
</tr>
<tr>
<td>LAMPP</td>
<td>Lamp test procedure.</td>
</tr>
<tr>
<td>DELAYP</td>
<td>Delay procedure: real time interrupt.</td>
</tr>
<tr>
<td>DELAYR</td>
<td>Delay procedure: repetitive loop.</td>
</tr>
<tr>
<td>RINGP</td>
<td>Ring extension telephone procedure.</td>
</tr>
<tr>
<td>QP</td>
<td>Ring extension telephone at top of the queue.</td>
</tr>
<tr>
<td>AUDIO</td>
<td>Dis/connect an Extension telephone from/to an operator.</td>
</tr>
<tr>
<td>PHDCOD</td>
<td>BCD telephone no. to bit and byte code.</td>
</tr>
<tr>
<td>PHECOD</td>
<td>Phone number encode: Byte and bit code to BCD phone number.</td>
</tr>
</tbody>
</table>
An Emergency Fire Telephone System.

Appendices.

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>STROBE</td>
<td>Strobes Extension telephone address into Telephone Controller Board data latch.</td>
</tr>
<tr>
<td>BUZZR</td>
<td>Operator and/or Extension telephone ring controller.</td>
</tr>
<tr>
<td>DECBIN</td>
<td>BCD to binary conversion.</td>
</tr>
<tr>
<td>CHKQ</td>
<td>Checks for Extension telephone in queue.</td>
</tr>
<tr>
<td>ADDQ</td>
<td>Adds Extension telephone to queue.</td>
</tr>
<tr>
<td>QPHON</td>
<td>Queueing control routine: section of TSTCHG.</td>
</tr>
</tbody>
</table>
A.3 List of Variables.

<table>
<thead>
<tr>
<th>Name</th>
<th>Bytes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYSFLG</td>
<td>1</td>
<td>System Status Flag</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b1: FLASH-ON</td>
</tr>
<tr>
<td>FNCST0</td>
<td>1</td>
<td>Function Status Word, Operator 0.</td>
</tr>
<tr>
<td>FNCST1</td>
<td>1</td>
<td>Function Status Word, Operator 1.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b7: ACKM</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b6: LAMPW</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b5: RINGM</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b4: not used</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b3: QM</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b2: CLRM</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b1: AUDIOM</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b0: RINGNG</td>
</tr>
<tr>
<td>BUFNO</td>
<td>1</td>
<td>Active Status Buffer number: 0 or 1, used as pointer.</td>
</tr>
<tr>
<td>BUFADD</td>
<td>2</td>
<td>Status Buffer Address: Contains address of STTBUF or STBUF1.</td>
</tr>
<tr>
<td>MSEC</td>
<td>1</td>
<td>Real Time Interrupt counter; max of $9999.</td>
</tr>
<tr>
<td>IRQCNT</td>
<td>2</td>
<td>Interrupt Counter; counts to FLSHTIM before reset.</td>
</tr>
<tr>
<td>KYBUFO</td>
<td>2</td>
<td>Keyboard 0 Data Buffer.</td>
</tr>
<tr>
<td>KYBUF1</td>
<td>2</td>
<td>Keyboard 1 Data Buffer.</td>
</tr>
<tr>
<td>NCOLM</td>
<td>1</td>
<td>Mimic COLUMN counter.</td>
</tr>
<tr>
<td>NROW</td>
<td>1</td>
<td>Mimic ROW counter.</td>
</tr>
<tr>
<td>BYTNO</td>
<td>2</td>
<td>Extension Telephone decoder: byte pointer, BYTNO, BYTN1.</td>
</tr>
<tr>
<td>BITNO</td>
<td>2</td>
<td>Extension Telephone decoder: bit pointer, BITNO, BITN1.</td>
</tr>
<tr>
<td>STTPTR</td>
<td>2</td>
<td>Status pointer: STTSTR, STPTR1.</td>
</tr>
<tr>
<td>OPRNO</td>
<td>1</td>
<td>Operator number pointer; 0 or 1.</td>
</tr>
<tr>
<td>KYBINP</td>
<td>2</td>
<td>Keyboard input code.</td>
</tr>
<tr>
<td>STTBUF</td>
<td>1</td>
<td>Status Buffer 0.</td>
</tr>
<tr>
<td>STBUF1</td>
<td>1</td>
<td>Status Buffer 1.</td>
</tr>
<tr>
<td>COLBUF</td>
<td>24</td>
<td>Column data buffer for Mimic: Mimic LED status.</td>
</tr>
<tr>
<td>FLSH</td>
<td>24</td>
<td>Flash data buffer for Mimic: flashing LED status.</td>
</tr>
<tr>
<td>FRSTNO</td>
<td>1</td>
<td>First number in queue.</td>
</tr>
<tr>
<td>LASTNO</td>
<td>1</td>
<td>Last number in queue.</td>
</tr>
<tr>
<td>QUE</td>
<td>192</td>
<td>Queue tables.</td>
</tr>
<tr>
<td>TSTCNT</td>
<td>192</td>
<td>Debounce counter table.</td>
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</table>
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A.4 PIA Allocation.

<table>
<thead>
<tr>
<th>PIAOA</th>
<th>$2000</th>
<th>Bit No</th>
<th>Name</th>
<th>Function</th>
</tr>
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<tbody>
<tr>
<td>-7</td>
<td></td>
<td></td>
<td>Not used</td>
<td></td>
</tr>
<tr>
<td>-6</td>
<td></td>
<td></td>
<td>ROW</td>
<td>O/P</td>
</tr>
<tr>
<td>-5</td>
<td></td>
<td></td>
<td>ROW</td>
<td>O/P</td>
</tr>
<tr>
<td>-4</td>
<td></td>
<td></td>
<td>ROW</td>
<td>O/P</td>
</tr>
<tr>
<td>-3</td>
<td></td>
<td></td>
<td>ROW</td>
<td>O/P</td>
</tr>
<tr>
<td>-2</td>
<td></td>
<td></td>
<td>ROW</td>
<td>O/P</td>
</tr>
<tr>
<td>-1</td>
<td></td>
<td></td>
<td>ROW</td>
<td>O/P</td>
</tr>
<tr>
<td>-0</td>
<td></td>
<td></td>
<td>ROW</td>
<td>O/P</td>
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</table>

<table>
<thead>
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<th>Function</th>
</tr>
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<tbody>
<tr>
<td>-7</td>
<td></td>
<td></td>
<td>TIMER: IRQA1</td>
<td>I/P</td>
</tr>
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<td>-6</td>
<td></td>
<td></td>
<td>WATCHDG: CA2</td>
<td>O/P</td>
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</table>

<table>
<thead>
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<th>$2002</th>
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<tr>
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<td></td>
<td>CRDLO</td>
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<td>CRDLO1</td>
</tr>
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<td>-5</td>
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<td>not used</td>
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<tr>
<td>-4</td>
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<td></td>
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<tr>
<td>-2</td>
<td></td>
<td></td>
<td>OPX, BUZZR function</td>
</tr>
<tr>
<td>-1</td>
<td></td>
<td></td>
<td>MUX1, BUZZR function</td>
</tr>
<tr>
<td>-0</td>
<td></td>
<td></td>
<td>MUX0, BUZZR function</td>
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<table>
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<td>-6</td>
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<table>
<thead>
<tr>
<th></th>
<th>CR0B</th>
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<td><em>0</em></td>
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<td></td>
</tr>
<tr>
<td><em>6</em></td>
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<th>Bit No</th>
<th>Name</th>
<th>Function</th>
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<td>COLO</td>
<td>0/P</td>
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<tr>
<td><em>6</em></td>
<td>COLO</td>
<td>0/P</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>5</em></td>
<td>COLO</td>
<td>0/P</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>4</em></td>
<td>COLO</td>
<td>0/P</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>3</em></td>
<td>COLO</td>
<td>0/P</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>2</em></td>
<td>COLO</td>
<td>0/P</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>1</em></td>
<td>COLO</td>
<td>0/P</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>0</em></td>
<td>COLO</td>
<td>0/P</td>
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<table>
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<th>Function</th>
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<td>0/P</td>
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<td></td>
</tr>
<tr>
<td><em>6</em></td>
<td>COL3</td>
<td>0/P</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>5</em></td>
<td>COL3</td>
<td>0/P</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>4</em></td>
<td>COL3</td>
<td>0/P</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>3</em></td>
<td>COL3</td>
<td>0/P</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>2</em></td>
<td>COL3</td>
<td>0/P</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>1</em></td>
<td>COL3</td>
<td>0/P</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>COL3</td>
<td>0/P</td>
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</table>

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<table>
<thead>
<tr>
<th>PIA3A $200C</th>
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<th>Name</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>7</em></td>
<td>KYBRD1: b3,</td>
<td>I/P</td>
<td></td>
</tr>
<tr>
<td><em>6</em></td>
<td>KYBRD1: b2,</td>
<td>I/P</td>
<td></td>
</tr>
<tr>
<td><em>5</em></td>
<td>KYBRD1: b1,</td>
<td>I/P</td>
<td></td>
</tr>
<tr>
<td><em>4</em></td>
<td>KYBRD1: b0,</td>
<td>I/P</td>
<td></td>
</tr>
<tr>
<td><em>3</em></td>
<td>KYBRDO: b3,</td>
<td>I/P</td>
<td></td>
</tr>
<tr>
<td><em>2</em></td>
<td>KYBRDO: b2,</td>
<td>I/P</td>
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- A10 -
An Emergency Fire Telephone System.

**Appendices.**

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**PIA5A $2014**

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**CR5B $2017**

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- A11 -
### A.5 Memory Map.

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<td>$F800</td>
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<td>2764 EPROM</td>
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<td>$C000</td>
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<td>$2014 - $2017</td>
<td>PIA 5</td>
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<td>$2010 - $2013</td>
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<td>$200C - $200F</td>
<td>PIA 3</td>
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</table>

Memory Map of System.
A.6 Operator Command Summary.

R - Rings the Extension telephone number entered on the keyboard and displayed on the operator numeric readout.

- Cannot ring extensions 0, 97, 98, 99.

- Ringing the Extension telephone to which the other operator is connected to disconnects the Extension telephone from that operator and transfers the call to the other operator.

Q - Connects the operator to the Extension telephone at the top of the queue.

- Before making a new call to an Extension telephone the present call must be terminated.

A - Acknowledges a new alarm and silences the audio alarm.

- The flashing fault LED turns on permanently.

C - Clears the operator display and all functions.

L - Executes a lamp test of the Mimic display and operator readout.
### A.7 Board Function Schedule

#### A.7.1 Computer Board

**A Connector (Top)  B Connector (Bottom)**

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<td>N.C.</td>
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<td>PIA3A/7</td>
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</tr>
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<td>CB1/1</td>
<td>CB1/0</td>
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<td>PIA3A/6</td>
<td>PIA2A/6</td>
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### A.7.2 Telephone Controller Board.

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An Emergency Fire Telephone System.

### A.7.3 Multiplexer Monitor Board.

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A.7.4 Multiplexer Monitor Board Interconnections.

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<th>PHON Addr</th>
<th>FAULT Addr</th>
<th>IC No /pin</th>
<th>MUX Addr</th>
<th>Voice: Phone No./ Mux No.</th>
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<td>U19/14</td>
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<td>U19/1</td>
<td>4 5/0 21/2 37/4 53/6 69/8 85/A</td>
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<td>B1a</td>
<td>24/14</td>
<td>5</td>
<td>22/14</td>
<td>U17/4</td>
<td>7 6/0 22/2 38/4 54/6 70/8 86/A</td>
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<td>B1c</td>
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<td>22/17</td>
<td>U17/5</td>
<td>5 7/0 23/2 39/4 55/6 71/8 87/A</td>
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<td>B2a</td>
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<td>7</td>
<td>22/18</td>
<td>U17/2</td>
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A.7.4 Multiplexer Monitor Board Interconnections. (Continued)

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<th>FAULT IC No</th>
<th>MUX Addr</th>
<th>Voice: Phone No./ Mux No.</th>
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<td>25/18 7 23/18</td>
<td>U18/14 U20/14</td>
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<td>4 29/3 45/5 61/7 77/9 93/B</td>
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<td>B19a</td>
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</tr>
</tbody>
</table>

How to use this table:

Take Extension Telephone 72 as an example. This Extension telephone is monitored and multiplexed on Multiplexer Monitor Board M4. The 8 of the 72/8 is the mux no of the multiplexer chip; the total is 12, two per board. U17 and U19 are accessed with an address of 6 for telephone number 72.

The Extension telephone line is connected to pin B2a on the edge connector. Status monitoring is done by U8. Telephone handset status is input to data buffer U24 pin 18, and the fault status input at U22 pin 18.
An Emergency Fire Telephone System.

Appendices.

The handset status of this telephone is bit 6 of the STATUS word and the fault status is b7 of that STATUS word. The voice signals are input to the multiplexer I.C.s on U17 pin 2 and U19 pin 2.
An Emergency Fire Telephone System.

Appendices.

An Emergency Fire Telephone System.

A.8.1 Power Supplies.

<table>
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<td>0V</td>
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<tr>
<td>OV</td>
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<td>26</td>
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<tr>
<td>+5V Outputs</td>
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<td>Ground</td>
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<tr>
<td>+5V</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>+5V Sense</td>
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Appendices.
A.8.2 Operator Telephone and Readout. (LINK)

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<td>Panel</td>
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<table>
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</tr>
<tr>
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<tr>
<td>3</td>
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<td>LSD A</td>
<td>E</td>
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<td>4</td>
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<td>7</td>
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<td>LSD C</td>
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<td>8</td>
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<td>MSD A</td>
<td>O</td>
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<td>P</td>
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<td>E</td>
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<td>R</td>
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VOICE signals are connected to pins 24 and 25.
An Emergency Fire Telephone System.

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<td>23</td>
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<tr>
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<td>24</td>
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<tr>
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<td>25</td>
<td>LSD D</td>
</tr>
<tr>
<td>6</td>
<td>26</td>
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<tr>
<td>7</td>
<td>27</td>
<td>LSD C</td>
</tr>
<tr>
<td>8</td>
<td>28</td>
<td>KYB COL3</td>
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<td>9</td>
<td>29</td>
<td>LSD B</td>
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<tr>
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<td>30</td>
<td>KYB ROWO</td>
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<td>KYB ROW1</td>
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<tr>
<td>13</td>
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VOICE signals are connected to pins 24 and 25.
A.8.3 Operator Telephone to Telephone Controller Boards.

Operator 0:

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Operator 1:

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### A.8.4 Mimic Wiring.

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A.8.4 Mimic Wiring. (Continued)

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An Emergency Fire Telephone System.

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on the Telephone Controller Board 1
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An Emergency Fire Telephone System.

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KYBRD0C B7c  B7c
KYBRD0D B6c  B6c

PSEL CS  A32a  A32a

A.8.5 Backplane Wiring. (Continued)

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<td>LINK1/7 /MSDD</td>
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An Emergency Fire Telephone System.

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<td>CRDL0</td>
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A.8.6 Extension Telephone Wiring.

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</table>

The above table indicates which Extension Telephones are connected to a particular Multiplexer Monitor Board. E.g. Extension Telephone 56 is connected to Pin B2a of the M3 Multiplexer Monitor Board.
REAR PANEL LAYOUT:

COMPUTER BOARD

TELEPHONE CONTROLLER 0

TELEPHONE CONTROLLER 1

MUX MON BOARD 0

M1

M2

M3

M4

MUX MON BOARD 5

NOT USED

NOT USED

POWER SUPPLY

POWER SUPPLY

- A36 -
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i. TOPMILLER, D.A.: Past Approaches, Current trends and Future Requirements
ii. OSTROFSKY, B: A Research Program for the Proper Inclusion of Human Resources in the Design Process
iii. HOLZHAUSEN, K.P: Analysis of Human Movements for Workspace Design
iv. SIMPSON, C.A.: Evaluation of Synthesized Voice Approach Callouts
v. VOSS, M: Narrowing of the Visual Field as an Indicator of Mental workload

I.1.6 Motorola Microprocessors Data Manual 1982. Switzerland

i. MC6809 8/18 bit HMOS Microprocessor
ii. MC6821 Peripheral Interface Adapter


i. Preamplifiers: LM381 Low Noise Dual Preamplifier


«II»
An Emergency Fire Telephone System

Appendices

SOURCE CODE LISTING
The following COMMAND FILES are available:

i. S.CF:1 Assembles and links all the modules for the full system and saves the object code in PREL.LO:1.

ii. SL.CF:1 Assembles and links all the modules for the full system and saves the object code in PREL.LO:1 and the listing in PREL.AL:1.

iii. S.CF:1 Assembles and links all the modules for the full system and outputs the listing on terminal screen and saves the object code in PREL.LO:1.

iv. LP.CF:1 Assembles and links all the modules for the full system. The listing is output to the line printer.

These chain files will call other chain files during execution.

Alister van Tonder 06/02/25
<table>
<thead>
<tr>
<th>OPT</th>
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<tr>
<td>NAM</td>
<td>PREL</td>
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<tr>
<td>TTL</td>
<td>DATA PRELUDE FILE</td>
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</table>

```
DATA PRELUDE FILE

* SYSTEM FLAGS: SYSFLG-
  * B7 - Not used. *
  * B6 - Not used. *
  * B5 - Not used. *
  * B4 - Not used. *
  * B3 - Not used. *
  * B2 - Not used. *
  * B1 - FLASH-ON *
  * B0 - Not used. *

* OPERATOR FUNCTION STATUS: FNCSTx-
  * B7 - ACKM *
  * B6 - LAMP *
  * B5 - RING *
  * B4 - Not used. *
  * B3 - OM *
  * B2 - CLRM *
  * B1 - AUDIOM *
  * B0 - RING *

-------------
```
**DATA PRELUDE FILE**

064 0002  A FLASHB EQU  $02
065 00DF  A NFLASHB EQU  $DF
066 0080  A ACKM EQU  $30
067 007F  A NACKM EQU  $7F
068 0040  A LAMPM EQU  $40
069 00BF  A NLAMPM EQU  $BF
070 0020  A RINGM EQU  $20
071 00DF  A NRINGM EQU  $DF
072 0008  A GM EQU  $08
073 00F7  A NGM EQU  $F7
074 0004  A CLRM EQU  $04
075 00FB  A NCLRM EQU  $FB
076 0000  A CTRLBO EQU  $00
077 00F7  A NSTRBL EQU  $7F
078 0038  A STRBHI EQU  $38
079 0022  A AUDRNG EQU  $22
080 0002  A AUDIOM EQU  $02
081 00FD  A NAUDIO EQU  $FD
082 0001  A RINGNG EQU  $01
083 00FE  A NNRINGNG EQU  $FE
084 00DE  A NRNGNM EQU  $DE
085 1000  A TSTIME EQU  $1000

*** KEYBOARD DECODE DATA ***

086 000C  A LAMPK EQU  $C
087 000D  A ACKK EQU  $D
088 0003  A OK EQU  $3
089 000B  A RINGK EQU  $B
090 000F  A CLRK EQU  $F
091 0007  A NONO EQU  $7
092 000A  A ROW EQU  $2000
093 0001  A CRA0 EQU  $2001
094 0002  A RING EQU  $2002
095 0004  A COL0 EQU  $2004
096 0006  A COL1 EQU  $2006
097 0008  A COL2 EQU  $2008
098 000A  A COL3 EQU  $200A
099 000C  A KYBRD EQU  $200C
100 000E  A CONNCT EQU  $200E
101 000F  A STREPH EQU  $200F
102 2010  A STTSEL EQU  $2010
103 2012  A STATUS EQU  $2012
104 2013  A CRLSCR EQU  $2013
105 2014  A LINKO EQU  $2014
106 2016  A LINK1 EQU  $2016
107 2000  A KYBCR EQU  $2000
108 0180  A FLSHTM EQU  $0180

109 - C3 -
DATA PRELUDE FILE

* DATA SECTION *

DSCT  XDEF  SYSFLG  SYSTEM FLAGS
        XDEF  FNCSTO  OP#0 FUNC STAT FLGS
  0000  0001  A  SYSFLG  RMB  1
  0000  0001  A  FNCSTO  RMB  1
  0001  0001  A  FNCST1  RMB  1
  0003  0001  A  BUFNO  RMB  1
  0004  0002  A  BUFAADD  RMB  2

  MSEC  XDEF  MSEC
  0006  0002  A  MSEC  RMB  2

  IROCNT  XDEF  IROCNT
  0008  0002  A  IROCNT  RMB  2

  KYBUF  XDEF  KYBUF
  000A  0001  A  KYBUF  RMB  1

  KYBUF1  XDEF  KYBUF1
  000B  0001  A  KYBUF1  RMB  1

  NCOLM  XDEF  NCOLM
  000C  0001  A  NCOLM  RMB  1

  NROW  XDEF  NROW
  000D  0001  A  NROW  RMB  1

  BYTNO  XDEF  BYTNO
  000E  0001  A  BYTNO  RMB  1

  BITNO  XDEF  BITNO
  0010  0001  A  BITNO  RMB  1

  OPRNO  XDEF  OPRNO
  0012  0001  A  OPRNO  RMB  1

  KYBINP  XDEF  KYBINP
  0013  0001  A  KYBINP  RMB  1

  RMB  XDEF  RMB
  0014  0001  A  RMB  1

  FRSTNO  XDEF  FRSTNO
  0015  0002  A  FRSTNO  RMB  2

  LASTNO  XDEF  LASTNO
  0017  0002  A  LASTNO  RMB  2

- C4 -
### DATA ARRAYS

- **PEEL DATA PRELUDE FILE**
- **DATA PRELUDE FILE**

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### PROGRAM SECTION: CONSTANTS

- **VOICE MUX DECOD ARRAY**
- **XDEF: VOICE MUX DECOD ARRAY**

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### Notes

- **MSD:** BYTE ADDR AT MUX
- **LSD:** MUX ADDRESS: TOTAL OF 12 MUX'S PER OP
- **VOICE IS MODIFIED TO CORRECT FOR HARDWARE E**
PREL DATA PRELUDE FILE

209P 008C FF A BLIND FCB $FF 1 TO 18 - HANDSETS
210P 008D FF A FCB $FF 19 TO 16 - HANDSETS
211P 008E FF A FCB $FF 17 TO 24 - HANDSETS
212P 008F FF A FCB $FF 25 TO 32 - HANDSETS
213P 008G FF A FCB $FF 33 TO 40 - HANDSETS
214P 0090 FF A FCB $FF 41 TO 48 - HANDSETS
215P 0091 FF A FCB $FF 49 TO 56 - HANDSETS
216P 0092 FF A FCB $FF 57 TO 64 - HANDSETS
217P 0093 FF A FCB $FF 65 TO 72 - HANDSETS
218P 0094 FF A FCB $FF 73 TO 80 - HANDSETS
219P 0095 03 A FCB $03 81 TO 88 - HANDSETS
220P 0096 00 A FCB $00 89 TO 96 - HANDSETS
221P 0097 FF A FCB $FF 1 TO 8 - FAULTS
222P 0098 FF A FCB $FF 9 TO 16 - FAULTS
223P 0099 FF A FCB $FF 17 TO 24 - FAULTS
224P 009A FF A FCB $FF 25 TO 32 - FAULTS
225P 009B FF A FCB $FF 33 TO 40 - FAULTS
226P 009C FF A FCB $FF 41 TO 48 - FAULTS
227P 009D FF A FCB $FF 49 TO 56 - FAULTS
228P 009E FF A FCB $FF 57 TO 64 - FAULTS
229P 009F FF A FCB $FF 65 TO 72 - FAULTS
230P 00A0 03 A FCB $03 73 TO 80 - FAULTS
231P 00A1 00 A FCB $00 81 TO 88 - FAULTS
232P 00A2 00 A FCB $00 89 TO 96 - FAULTS
DATA PRELUDE FILE

INITIALISATION ROUTINE

***********************;

*  

RESET

**************;

O0A4 00A4 1A 10  A  RESET  ORCC  #$10  SET IRQ MASK FOR EMULA

O0A4 00A6 10CE 07FE  A  LDS  #$7FE  INIT S

O0A4 00A8 CE 07FE  A  LDU  #$7FE  INIT U

O265 00B0 86 7F  A  PIA0A  LDA  #$7F

O265 00BA B7 2000  A  STA  #$2000  B6-B0 O/P’S

O265 00BD 86 07  A  LDA  #$07

O265 00BE B7 2001  A  STA  #$2001  CA1 IRQ, ENBL DR’S

O265 00C2 86 FF  A  LDA  #$FF

O265 00C4 B7 00B8  P  STA  PIA0A  DISABLE ALL ROWS

O265 00C7 86 0F  A  PIA0B  LDA  #$0F

O265 00CD C6 04  A  LDB  #$4

O265 00CE F7 2003  A  STB  #$2003

O265 00D1 86 FF  A  COLMS  LDA  #$FF

O265 00D3 8E 2004  A  LDS  #$2004

O265 00D6 A7 81  A  STA  X++  COL0 ALL O/P’S

O265 00DA A7 81  A  STA  X++  COL1 ALL O/P’S

O265 00DB A7 84  A  STA  X  COL3 ALL O/P’S

O265 00DE 30 1B  A  LEAX  -5,X  RESET X #$2005

O265 00E0 E7 81  A  STB  X++  COL0 DR ENBL

O265 00E2 E7 81  A  STB  X++  COL1 DR ENBL

O265 00E4 E7 81  A  STB  X++  COL2 DR ENBL

O265 00E6 E7 84  A  STB  X  COL3 DR ENBL
RESET INITIALIZATION ROUTINE

0279 P 0098 7F 200C A PIA3A CLR $200C ALL I/P'S
0280 P 009B 8E 1F A LDA #$1F CA1 & CA2 POS GOING IR
0281 P 009E B7 200D A STA $200D ENBL DR
0282
0283 P 009F 86 FF A PIA4B LDA #$FF ALL O/P'S
0284 P 009B B7 200E A STA $200E ENBL DR
0285 P 009F 86 34 A LDA #$34 CB2/3 OP, ENBL DR
0286 P 009E B7 200F A STA $200F
0287
0288 P 009F 86 1F A PIA4A LDA #$1F D4-D0 O/P'S
0289 P 009F 86 2010 A STA $2010 ENBL DR
0290 P 009E B7 2011 A STB $2011 ENBL DR
0291
0292 P 009F 86 FF A PIA5B LDA #$FF ALL O/P'S
0293 P 009E B7 2014 A STA $2014 CB1 & CB2 POS GOING IR
0294 P 009F 86 2015 A STB $2015 ENBL DR
0295
0296 P 009E B7 2016 A PIA5B STA $2016 ALL O/P'S
0297 P 0115 F7 2017 A STB $2017 ENBL DR
0298
0299
0300 P 0118 CC 0000 A LDD #0
0301 P 011B 8E 0801 A LDX #$801 RAM TOP
0302 P 011E ED 83 A CLRMEM STD ,--X
0303 P 0120 8C 0000 A CPX #0
0304 P 0123 2E F9 011E BGT CLRMEM
0305
0306 P 0125 86 40 A LNKTS LDA #LAMP SET LAMP TEST FLAG
0307 P 0127 B7 0001 D STA FCSTO
0308
0309
0310 P 012A 8E 0019 D CONST LDX #STBUFF
0311 P 012D BF 0004 D STX BUFADD SET BUFADDR FOR MAKBUF
0312 P 0130 17 0341 0474 LBSR MAKBUF MAKE STATUS BUFFER
0313
0314 P 0133 86 17 A LDA #23
0315 P 0135 B7 000C D STA NCOLM INIT NCOLM
0316 P 0138 86 05 A LDA #5
0317 P 013A B7 000D D STA NROW INIT NROW
0318 P 013D 8E 0180 A LDX #FLSHTM
0319 P 0140 BF 0008 D STX IRCNT
0320
0321 P 0143 86 FF A LDA #$FF
0322 P 0145 B7 200E A STA CONNCT INIT MUX/MON BOARDS
0323 P 0148 17 05E0 072B LBSR STROBE
0324 P 014B 84 7F A ANDA #$7F
0325 P 014D B7 200E A STA CONNCT
0326 P 0150 17 05D8 072B LBSR STROBE
0327
0328 P 0153 16 0214 036A LBRA MAINP START

END OF RESET ROUTINE

- C8 -
**TTL SHORT ROUTINES**

**DELAY ROUTINE**

XDEF DELAYR

XDEF DELAY INITIALISATION ROUTINE

XDEF DELAYR LBSR WTCHDG RESET WTCHDG

LEAX -1, X

BNE DELAYR

Rn:

**FIND MOST SIGNIFICANT BIT**

* -- INPUT PARAM'S: X - DATA POINTER *

* -- OUTPUT PARAM'S: A - SET BIT'S NO *

* --- CHANGED: X *

* --- UNCHANGED: Y,DP,U,S *

XDEF FM:

LDA X DATA

BEO NOSB NO SET BIT

LDX #MASK+8

A BITAGN BITA -X

BEQ BITAGN BIT NOT SET

LDX #MASK

TFR X, D

SUBD #MASK

TFR B, A

RTS

XDEF VALBIT

* TESTS STATUS OF SPECIFIED BIT IN BYTE. *

* -- INPUT PARAM'S: X - DATA POINTER *

* A - BITNO *

* -- OUTPUT PARAM'S: A - BIT STATUS *

* B - MASK(BITNO) *

* Y - #MASK *

* X - #DATA *

* --- UNCHANGED: DP, U, S *

XDEF VALBIT

LDY #MASK

LDB A, Y

MASK(BITNO)

CLRA

BITB X

BEQ BITCLR

INCA

BITCLR RTS
XDEF SETBIT

** SETS/CLEARS THE SPECIFIED BIT WITHIN A SPECIFIED BYTE. **
** -- INPUT PARAM'S: X - DATA POINTER **
** A - BIT STATUS **
** B - BITNO **

** OUTPUT PARAM'S: A - NEW DATA BYTE **
** B - BITNO **
** X - #DATA **
** Y - #MASK **

** --- UNCHANGED: DP, U, S **

XDEF BINDEC

** -- INPUT PARAM'S: A - BIN NO **
** OUTPUT PARAM'S: A - DEC NO **

** --- CHANGED: A, B, DP, S **
** --- UNCHANGED: X, Y, U **

** NOTE: MAX NO: $63 OR 99 **

** **************************************************************
P SETBIT LDY #MASK

TSTA BIT STATUS

BEQ SETOFF

LDA ,X DATA

ORA B,Y MASK(BITNO)

STA ,X NEW DATA

RTS

A SETOFF LDA B,Y MASK(BITNO)

COMA

ANDA ,X NEW DATA

RTS

A BINDEC TFR A,DP

TFR A,B

CLRA

ANDB #$F0 MSD

BRO NOTENS

ADD A ADDA #$16

DAA

SUBB #$10

BNE ADD16

A NOTENS TFR DP,B

ANDB #$0F LSD

CMPB #$10

BLT ONEPLS

ADD #$10

ONEPLS PSHS B

ADDA $S+

DAA

RTS

NAM IRQ
**INTERRUPT DrIVEN ROUTINES**

**INTERRUPT CONTROL ROUTINE**

--- ENTRY PARAM'S: NONE ---

**RETURN TO MAIN PROGRAM**
**INTERRUPT DRIVEN ROUTINES**

*KEYBOARD DECODING ROUTINE.*

*STORES KEYBOARD ENTRY IN KYBINP.*
*THEN BRANCHES TO KYBRDP TO DISPLAY KEYBOARD INPUT.*
*-- INPUT PARAM'S: A - OPERATOR NO*
*GLOBAL: KYBRD*
*-- OUTPUT PARAM'S:  - GLOBAL: KYBINP*

XDEF KYBX

CLRA

BITB #$80

BNE KYBO KYBD 0 IRQ

INCA KYBRD 1 IRQ

LDB KYBRD READ KYBRD/RESET IRQ

LDX #KYBINP

TSTA

LSRB

LSRB

LSRB

LSRB

NEW LSD: KYBRD1

BRA ADDIG

ANDB #$0F KYBRD0

STB A X

NEW KEYBRD INPUT CODE

LBSR KYBRDP DISPLAY KB I/F

RTI RETURN TO MAIN PRGM

-C12-
**INTERRUPT DRIVEN ROUTINES**

**MIMIC CONTROL ROUTINE**

* ENTRY PARAMS: NONE *
* GLOBAL DATA USED FOR PARAMETERS *

IF

ENTRY PARAMS:

GLOBAL DATA USED FOR PARAMETERS:

1. PSCT

2. XDEF MIMIC

3. LDA ##FF

4. STA ROW DISABLE ALL ROWS

5. LDA #LAMP

6. BITA FNCST0 LAMP

7. BNE MIMST

8. LDA FNCST1 LAMP

9. BNE MIMST

10. LDX #COLBUF

11. LDA #FLASH

12. BITA SYSFLG FLASH-ON FLAG

13. BNE MIMFL

14. LDA NCOLM COLUMN COUNTER

15. LDY #FLSH

16. LDA X COLBUF(A)

17. ORB A,Y FLUSH(A)

18. STB COL3

19. DECA

20. STB COL2

21. DECA

22. STB COL1

23. DECA

24. STB COL0

25. DECA

26. FROM24

27. P/RESET NROW

28. STA NCOLM

29. FROM24

30. STA NCOLM COLUM COUNTER

31. LDY #FLSH

32. LDA A,X COLBUF(A)

33. ORB A,Y FLUSH(A)

34. STB COL3

35. DECA

36. STB COL2

37. DECA

38. STB COL1

39. DECA

40. STB COL0

41. DECA

42. XROWS

43. MIMFLS

44. LDA NCOLM

45. ORB A,Y FLUSH(A)

46. STB COL3

47. DECA

48. STB COL2

49. DECA

50. STB COL1

51. DECA

52. STB COL0

53. DECA

54. MIMFLS

55. LDA NCOLM
15 IR0 .SA:1 IR0 INTERRUPT DRIVEN ROUTINES

0281 2E 02 0285 BGT FROM23
0283 B6 17 A LDA #23
0285 B7 000C D FROM23 STA NCOLM
0298 20 0E 0298 BRA XROWS

0 028A B6 FF A MIMTST LDA #FF
P 028C B7 200A A STA COL3
P 028F B7 2008 A STA COL2
P 0292 B7 2006 A STA COL1
P 0295 B7 2004 A STA COL0 ENABLE ALL LEDS

0 0298 B6 000D D XROWS LDA NROW
1P 029B SE 0000 P LDX #MASK
2P 029E A6 86 A LDA A,Y MASK(NROW)
3P 02A0 43 COMA INVERT ROWS

4P 02A1 B7 2000 A STA ROW ENABLE A ROW
5P 02A4 7A 000D D DEC NROW DECREMENT ROW COUNTER
6P 02A7 2C 05 02AE BGE RTNIRO
.27P 02A9 86 05 A LDA #5 SIX ROWS
8P 02AB B7 000D D STA NROW

630P 02AE 39 RTNIRO RTS
631
**Interrupt Driven Routines**

*Keyboard Procedure*

*Function Keys Set Appropriate Flags in*
*Function Status, Numeric Keys Display-*
*ED on Numeric Readout and Stored in*
*KeyBuf.*

**-- Input Param's:** A - Operator No
**-- Global: KYBINP**
**-- Output Param's:** - None

***************************************************************

```assembly
XDEF KYBRDP

; Keyboard Procedure

; Function Keys Set Appropriate Flags in
; Function Status, Numeric Keys Display
; ED on Numeric Readout and Stored in
; KeyBuf.

; -- Input Param's: A - Operator No
; -- Global: KYBINP
; -- Output Param's: - None

;***************************************************************
```
INTERRUPT DRIVEN ROUTINES

0697P 0305 39  RTS  CRDL DWN, DISREGARD
0698P 0306 8E 0013  D  CRDLUP  LDX  KYBINP
0699P 0309 E6 86  A  LDB  A,X  KYBINP(OP#)
0700P 030B C4 0F  A  ANDB  ##0F  LSD: NEW I/P
0701
0702P 030D 8E 0001  D  RINGF  LDX  FNCSCTO
0703P 0310 C1 08  A  CMPB  #RINGK
0704P 0312 26 07 031B  BNE  0
0705P 0314 C6 20  A  LDB  #RINGM
0706P 0316 EA 86  A  ORB  A,X
0707P 0318 E7 86  A  STB  A,X  SET RING MODE FLAG
0708P 031A 39  RTS
0709
0710P 031B C1 03  A  Q  CMPB  #OK
0711P 031D 26 07 0326  BNE  AUDACT
0712P 031F C6 08  A  LDB  #QM
0713P 0321 EA 86  A  ORB  A,X
0714P 0323 E7 86  A  STB  A,X  SET QUEUE MODE FLAG
0715P 0325 39  RTS
0716
0717P 0326 34 04  A  AUDACT  PSHS  B  COPY KYBINP
0718P 0328 8E 0001  D  LDX  #FNCSCTO
0719P 032B C6 02  A  LDB  #AUDIOM
0720P 032D E5 86  A  BITB  A,X  FNCST(OP#)
0721P 032F 27 03 0334  BEO  NOS
0722P 0331 32 61  A  LEAS  I,S  RESTOR S
0723P 0333 39  RTS  DISREGARD NUMERIC I/P
0724
0725P 0334 35 04  A  NOS  PULS  B  KYB I/P
0726P 0336 1F 8B  A  TFR  A,DP  OP#
0727P 0338 8E 0022  P  LDX  #NOSCOD
0728P 033B E1 80  A  NOTNO  CMPB  X+
0729P 033D 26 FC 033B  BNE  NOTNO
0730P 033F 1F 10  A  TFR  X,D  A&B DSTROYD
0731P 0341 83 0023  P  SUBD  #NOSCOD+1
0732P 0344 34 04  A  PSHS  B  COPY NO
0733P 0346 8E 000A  D  LDX  #KYBUF  KYBD DATA BUFFER
0734P 0349 1F B8  A  TFR  DP,A  OP#
0735P 034B E6 86  A  LDB  A,X  KYBUF(OP#)
0736P 034D 58  LSLB
0737P 034E 56  LSLB
0738P 034F 58  LSLB
0739P 0350 58  LSLB  LSD NOW MSD
0740
0741P 0351 EA E0  A  ORB  ;S+  ADD NEW DATA
0742P 0353 E7 86  A  STB  A,X  KYBUF(OP#)
0743
0744

- C16 -
DATA STORED IN KEYBUF() IS DISPLAYED ON *
OPERATOR NUMERIC READOUT.
* -- INPUT PARAM'S: A - OPERATOR NO *
* - OUTPUT PARAM'S:  - NONE *

INPUT PARAM'S: A - OPERATOR NO

XDEF LINKP
LDX #KYBUF
LDB A,X KYBUF(A)
TSTA
BEQ DSPX LINKO
INCA LINK1: A=2
DSPX BITB #$F0 MSD=0?
BITB #$F0
DISPL
ORB #$F0 MASK LEADING ZERO
DISPL
STB A,X KYBUF(A) TO LINK(A)
RTS
NAM MO

TTL MAIN PROGRAM ROUTINES

*************************************************

* MAIN PROGRAM

*************************************************

* ROUTINE ACTIVE WHEN CPU IS NOT

* INTERRUPTED.

* -- INPUT PARAM'S: NONE

* -- ROUTINES CALLED: WTCHDG, OP, RINGP, *

* ACKP, CLRPF, LAMPP, *

* TSTCHNG, CDLUP *

*************************************************
**MO MAIN PROGRAM ROUTINES**

<table>
<thead>
<tr>
<th>Address</th>
<th>Instruction</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>00832</td>
<td>LDB RING</td>
<td>CRDL0, CRDL1 STATUS ON</td>
</tr>
<tr>
<td>00833</td>
<td>ANDB #$C0</td>
<td></td>
</tr>
<tr>
<td>00834</td>
<td>CMPB #$C0</td>
<td></td>
</tr>
<tr>
<td>00835</td>
<td>BEQ GOMNP</td>
<td>A HANDSET LIFTED</td>
</tr>
<tr>
<td>00836</td>
<td>LBSR CRLUP</td>
<td>TURN BUZZR OFF</td>
</tr>
<tr>
<td>00837</td>
<td></td>
<td></td>
</tr>
<tr>
<td>00838</td>
<td>036A GOMNP</td>
<td>BRA MAINP</td>
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<td>00842</td>
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</tr>
<tr>
<td>00843</td>
<td>LDA #$F7</td>
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</tr>
<tr>
<td>00844</td>
<td>ANDA CRA0</td>
<td></td>
</tr>
<tr>
<td>00845</td>
<td>STA CRA0</td>
<td></td>
</tr>
<tr>
<td>00846</td>
<td>LDA #$38</td>
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</tr>
<tr>
<td>00847</td>
<td>ORA CRA0</td>
<td></td>
</tr>
<tr>
<td>00848</td>
<td>STA CRA0</td>
<td></td>
</tr>
<tr>
<td>00849</td>
<td>RTS</td>
<td></td>
</tr>
</tbody>
</table>

XDEF WTCHDG

**- C19 -**
**MAIN PROGRAM Routines**

* TEST CHANGE

* TESTS FOR CHANGES IN ZONE TELEPHONE
* STATUSES: HANDSETS & FAULTS.
* DATA BUFFERS USED ARE: COLBUF & FLASH.

* -- INPUT PARAM'S: NONE.
* -- OTHER PARAM'S: BUFNO.
* BUFADD.
* STBUF0 & STBUF1.
* -- ROUTINES CALLED: MAKBUF, FMSB, VALBIT, SETBIT, BUZZR.

```
0867 XDEF TSTCHG
0868P 03EC B6 0003 D TSTCHG LDA BUFNO O OR 1
0869P 03EF 88 01 A EORA #$01 INVERT BO
0870P 03F1 8E 0019 D LDX #STTBUF
0871P 03F4 B7 0003 D STA BUFNO CHANGE BUF NO
0872P 03F7 27 03 03FC BEC BUFR STATUS BUF 0
0873P 03F9 8E 0031 D LDX #STBUF1 STATUS BUF 1
0874P 03FC BF 0004 D BUF1 STX BUFAADD
0875P 03FF 8D 73 0474 BSR MAKBUF MAK NEW BUFFER
0876 LDA BUFNO 0: STTBUF
0877 LDA BUFNO 1: STBUF1
0878
0879P 0401 86 17 A LDA #23
0880P 0403 8E 0019 D LDX #STTBUF
0881P 0406 108E 0031 D LDY #STBUF1 STBUF1 ADDR
0882
0883P 040A E6 S6 A CHK LDB A,Y A- PORT NO, BYNO
0884P 040C E8 A6 A EOR B A,Y
0885P 040E 26 04 0414 BNE ACHNG CHANGE IN FAULTS
0886P 0410 4A CHK1 DECA
0887P 0411 2C F7 040A BGE CHK DO ALL FAULTS
0888P 0413 39 RTS RTN TO MAIN PRGM
0889
0890P 0414 34 06 A ACHNG PSHS A,B O-PRT, 1-CHNGBUF
0891P 0416 30 61 A MORCHG LEAX 1,S CHNGBUF PTR
0892P 0418 17 FD43 015E LBSR FMSB A- MSB THAT IS SET
0893P 041B 34 02 A PSHS A 0- BITNO, 1-PRT, 2- C
0894
0895P 041D E6 61 A LDB 1,S PRT
0896P 041F BE 0004 D LDX BUFAADD
0897P 0422 30 85 A LEAX B,X BUFAADD(PRT)
0898
0899P 0424 A6 E4 A LDA ,S BITNO
0900P 0426 17 FD4B 0174 LBSR VALBIT A- BINO, X- PTR
0901P 0429 88 01 A EORA #$01 STATUS INVERSION
0902P 042B 1F 38 A TFR A,DP STATUS OF CHANGED BIT
0903P 042D 27 0B 043A BEQ NOTNEW NOT CHANGE TO ACTICE S
0904P 042F C6 01 A LDB #1 ON
0905P 0431 86 02 A LDA #2 OPX BUZZR
0906P 0433 34 06 A PSHS A,B
0907P 0435 17 0310 0748 LBSR BUZZR ENABLE OPX BUZZR
0908P 0438 32 62 A LEAS 2,S RESTOR S
```

-C20-
MAKE BUFFER

MAKES DATA BUFFER OF TELEPHONE

CHANGES IN STATUS IS DEBOUNCED.

MAKBUF DOES NOT SEE STATUS LINES THAT

IS MASKED BY BLIND().

A HARDWARE FAULT IS CORRECTED BY

SHIFTING OF BITS.

-- INPUT PARAM'S: NONE

- GLOBAL PARAM'S: STTBUF & STBUF1

- STATUS

- TSTCNT

- BUFADD

- OUTPUT PARAM'S: NONE

- ROUTINES CALLED: WTCHDG

- ---

XDEF MAKBUF

** REQURED WHEN SYST

**

LBSR WTCHDG

LDX BUFADD

LDY #STDCOD

LDU #STBUF1

LDU #BUFNO

BEQ ABXO

LDU #STTBUF

LEAS -2,S

STU ,S

LDA #23

DECOD MUXNO

LDB A,Y

LDB ,S

OTHER BUFFER

OTHER BUFFER

ADDR. CARD & MUX

PSHS A,B,X,Y

PULS A,B,X,Y

DELAY: SETLING TIME

READ STATUS
This routine corrects wiring errors on the backplane.

Corrections of the status data input from the Multiplexer Monitor boards are done interchanging bits.

It is simpler to correct the error using software than to rewire the entire wire wrapped back plane.
MAIN PROGRAM ROUTINES

1033P 04CC 3E 008C  P  LDX  #BLIND  *** ZONE TELEPHONE MAS
1034P 04CF 4E 86    A  ANDB  A,X  *** ZONE TELEPHONE MAS
1035P 04D1 BE 0004  D  LDX  BUFADD  *** RESTORE X ***
1036  *** ONLY LOOKS AT TELEPHONE EXTENSIONS 1 T
1037
1038P 04D4 E1 06  A  CMPB  A,U  STBUF1 & STTBUFF
1039P 04D5 F7 2010 A  STB  STTSEL  ADDR. CARD & MUX
1040P 04E1 36 34  A  PSHS  A,B,X,Y
1041P 04E2 3F 34  A  PULS  A,B,X,Y  DELAY: SETLING TIME
1042P 04E3 3D 52  A  LDB  STATUS  READ STATUS
1043P 04E4 00 08  P  LDX  #BLIND  *** ZONE TELEPHONE_MAS
1044P 04E5 E4 86  A  ANDB  A,X  *** ZONE TELEPHONE MAS
1045P 04E6 BE 0004 D  LDX  BUFADD  *** RESTORE X ***
1046  *** ONLY LOOKS AT TELEPHONE EXTENSIONS 1 T
1047P 04E7 EE 05  A  LDB  A,Y  DECOD MUXNO
1048P 04E8 EE 05  A  LDB  A,Y  DECOD MUXNO
1049P 04E9 EE 05  A  LDB  A,Y  DECOD MUXNO
1050P 04EA EE 05  A  LDB  A,Y  DECOD MUXNO
1051P 04EB EE 05  A  LDB  A,Y  DECOD MUXNO
1052P 04EC EE 05  A  LDB  A,Y  DECOD MUXNO
1053P 04ED EE 05  A  LDB  A,Y  DECOD MUXNO
1054P 04EE EE 05  A  LDB  A,Y  DECOD MUXNO
1055P 04EF EE 05  A  LDB  A,Y  DECOD MUXNO
1056P 04F0 EE 05  A  LDB  A,Y  DECOD MUXNO
1057P 04F1 EE 05  A  LDB  A,Y  DECOD MUXNO
1058P 04F2 EE 05  A  LDB  A,Y  DECOD MUXNO
1059P 04F3 EE 05  A  LDB  A,Y  DECOD MUXNO
1060P 04F4 EE 05  A  LDB  A,Y  DECOD MUXNO
1061P 04F5 EE 05  A  LDB  A,Y  DECOD MUXNO
1062P 04F6 EE 05  A  LDB  A,Y  DECOD MUXNO
1063P 04F7 EE 05  A  LDB  A,Y  DECOD MUXNO
1064P 04F8 EE 05  A  LDB  A,Y  DECOD MUXNO
1065P 04F9 EE 05  A  LDB  A,Y  DECOD MUXNO
1066P 04FA EE 05  A  LDB  A,Y  DECOD MUXNO
1067P 04FB EE 05  A  LDB  A,Y  DECOD MUXNO
1068P 04FC EE 05  A  LDB  A,Y  DECOD MUXNO
1069P 04FD EE 05  A  LDB  A,Y  DECOD MUXNO
1070P 04FE EE 05  A  LDB  A,Y  DECOD MUXNO
1071P 04FF EE 05  A  LDB  A,Y  DECOD MUXNO
1072P 0500 EE 05  A  LDB  A,Y  DECOD MUXNO
1073P 0501 EE 05  A  LDB  A,Y  DECOD MUXNO
1074P 0502 EE 05  A  LDB  A,Y  DECOD MUXNO
1075P 0503 EE 05  A  LDB  A,Y  DECOD MUXNO
1076P 0504 EE 05  A  LDB  A,Y  DECOD MUXNO
1077P 0505 EE 05  A  LDB  A,Y  DECOD MUXNO
1078P 0506 EE 05  A  LDB  A,Y  DECOD MUXNO
1079P 0507 EE 05  A  LDB  A,Y  DECOD MUXNO
1080P 0508 EE 05  A  LDB  A,Y  DECOD MUXNO
1081P 0509 EE 05  A  LDB  A,Y  DECOD MUXNO
1082P 050A EE 05  A  LDB  A,Y  DECOD MUXNO
1083P 050B EE 05  A  LDB  A,Y  DECOD MUXNO
1084P 050C EE 05  A  LDB  A,Y  DECOD MUXNO
1085P 050D EE 05  A  LDB  A,Y  DECOD MUXNO
1086P 050E EE 05  A  LDB  A,Y  DECOD MUXNO
1087P 050F EE 05  A  LDB  A,Y  DECOD MUXNO
1088P 0510 EE 05  A  LDB  A,Y  DECOD MUXNO
1089P 0511 EE 05  A  LDB  A,Y  DECOD MUXNO
1090P 0512 EE 05  A  LDB  A,Y  DECOD MUXNO
1091P 0513 EE 05  A  LDB  A,Y  DECOD MUXNO
1092P 0514 EE 05  A  LDB  A,Y  DECOD MUXNO
1093P 0515 EE 05  A  LDB  A,Y  DECOD MUXNO
1094P 0516 EE 05  A  LDB  A,Y  DECOD MUXNO
1095P 0517 EE 05  A  LDB  A,Y  DECOD MUXNO
MO MAIN PROGRAM ROUTINES

* QUEUE PHONE *

* CHECKS WHETHER ZONE TELEPHONE HANDSET *
* IS LIFTED OR NOT. *
* IF HANDSET IS LIFTED: ADDS TEL TO *
* QUEUE IF NOT IN QUEUE. *
* IF HANDSET IS DOWN: DELETES TEL FROM *
* QUEUE IF IN QUEUE. *
* *
* -- INPUT PARAM'S: DP- CHANGED BIT STAT *
* -- GLOBAL PARAM'S: FRSTNO *
* -- ROUTINES CALLED :
* PHECOD, BINDEC, CHKQ, *
* DELFQ, ADDQ *

xdef qphon

0534 34 08 a qphon
0536 e6 62 a
0538 a6 61 a
053a 17 0203 0740
053d 17 fc57 0197
0540 88 01 a
0542 19 daa
0543 34 02 a
0545 1f 89 a
0547 17 02ab 07f5
054a e6 61 a
054c 27 0c 055a
054e 81 ff a
0550 26 03 0555
0552 17 025d 07b2
0555 32 62 a
0557 16 ff05 045f

lea 2.s leas

endqf leas

addq

lea 2.s leas

- c25 -
0107
0108
0109
0110
0111
0112
0113
0114
0115P 0534 34 08 A 0PHON PSHS DP CHANGE BIT STATUS
0116P 0536 E6 62 A LDB 2.S PRT: BYNO
0117P 0538 A6 61 A LDA 1.S BINO
0118P 053A 17 0203 0740 LBSR PHECOD
0119P 053D 17 FC57 C197 LBSR BINDEC
0120P 0540 88 01 A ADDA #1 1ST COUNT=1
0121P 0542 19 DAA
0122P 0543 34 02 A PSHS A BCD PHON0
0123P 0545 1F 89 A TFR A,B
0124P 0547 17 02AB 07F5 LBSR CHKQ
0125
0126P 054A E6 61 A LDB 1,S CHANGED BIT STATUS
0127P 054C 27 0C 055A BEQ DELFO
0128P 054E S1 FF A CMPA **FF
0129P 0550 26 03 0555 BNE ENDP ALREADY IN Q
0130P 0552 17 025D 07B2 LBSR ADDQ
0131
0132P 0555 32 62 A ENDP LEAS 2.S RESTOR S
0133P 0557 16 FF05 045F LBRA TSTACH TST FOT MOR CHGES
0134

- C25 -
**MAIN PROGRAM ROUTINES**

`* DELETE FROM QUEUE *`
`* DELETES TELEPHONE NUMBER FROM QUEUE *`
`* IF IN QUEUE & CORRECTS ALL POINTERS. *`
`* -- INPUT PARAM'S: A - PASSED FROM CHKMOD *`
`* -- GLOBAL PARAM'S: FRSTNO *`
`* - ROUTINES CALLED: DELQ, CDLUF, *`

```assembly
0027 MO .SA:1 MO

DELET FROM QUEUE
DELETE TELEPHONE NUMBER FROM QUEUE
IF IN QUEUE & CORRECTS ALL POINTERS
-- INPUT PARAM'S: A - PASSED FROM CHKMOD
-- GLOBAL PARAM'S: FRSTNO
- ROUTINES CALLED: DELQ, CDLUF,

XDEF DELO
CMPA #$FF
BEQ ENDOF Q INACTIVE
LDA ,S BCD PHONO
LBSR DELO
BNE ENDOF Q STILL ACTIVE
BSR CDLUF Q INACTIVE, STOP RINGNG

XDEF CHGLED
LDA 5,S OP#
LDX #BITNO
LDB A,X BITN(OP#)
TFR B,DP
LDX #BYTN0
LDB A,X BYTN(OP#)
LDX 3,S BASE ADDR
LEAX B,X BASE ADDR + BYTN0(OP#)
TFR DP,B BITNO
LDA 2,S ON/OFF
LBSR SETBIT
```

- C26 -
MO MAIN PROGRAM ROUTINES

*************** CRADLE PROCEDURE ***************
* CRADLE UP: LO :: CRADL DWN HI *
*************** FNCST(OF')# ***********************

XDEF CRDLP

OP# 0-OP#
FNCST(OF')#

REG
COPY

XDEF CRDLW

LDB CRDLCP-1
CLR CRDL IRQ

XDEF CRLUP

LDB CRDLCP-1
CLR CRDL IRQ

XDEF CRDLW

LDB CRDLCP-1
RESET CRDL IRQ'S

1210P 05A0  F6  2012  A CRDLDP
LDX #FNCSTO

1211P 05A3  8E  0001  D
LDX #FNCSTO

1212P 05A6  34  02  A
PSHS A

1213P 05A8  E6  86  A
LDB A,X

1214P 05AA  C5  22  A
BITB #AUDRNG

1215P 05AC  27  1E  05CC
BEQ CLRDSP

1216P 05AE  5F

1217P 05AF  8E  0061  D
LDX #FLSH

1218P 05B2  34  14  A
PSHS B,X

1219P 05B4  80  B6  056C
BSR CHGLED

1220P 05B6  8E  0049  D
LDX #COLBUF

1221P 05B9  AF  61  A
STX 1,S

1222P 05BB  8D  AF  056C
BSR CHGLED

1223P 05BD  32  63  A
LEAS 2,S

1224P 05BF  A6  E4  A
LDA ,S

1225P 05C1  5F

1226P 05C2  34  06  A
PSHS A,B

1227P 05C4  17  012F 06F6
LBSR AUDIO

1228P 05C7  17  017E 0748
LBSR BUZZR

1230P 05CA  32  62  A
LEAS 2,S

1231P 05CC  A6  E4  A
LDA ,S

1232P 05CE  8E  000A  D
LDX #KYBUF

1233P 05D1  6F  86  A
CLR A,X

1234P 05D3  17  FD7F 0355
LBSR LINKP

1235P

1236P

1237P 05D6  A6  E4  A
LDA ,S

1238P 05DE  8E  0001  D
LDX #FNCSTO

1239P 05DB  6F  86  A
CLR A,X

1240P 05DD  32  61  A
LEAS 1,S

1241P

1242P 05DF  39
RTS

- C27 -
**ACKNOWLEDGE ALARM ROUTINE**

* ACKNOWLEDGE ALARM ROUTINE.

* SILENCES AUDIO ALARM & STOPS FLASHING

* FAULT LED & TURNS IT ON PERMANENTLY.

* -- INPUT PARAM'S: A - OPRNO

* -- GLOBAL PARAM'S: FLUSH, COLBUF

* FNCSTO & FNCST1

* ROUTINES CALLED: BUZZR

* *

******************************************************************************

XDEF ACKP  
LDB #FNCSTO
LDB #NACKM
ANDB A,X CLEAR ACKM FLAG
STB A,X

LDX #FLUSH+12
LDY #COLBUF+12
LDA #11

A,X XCHNG LDB A,X FLUSH(A)
ORB A,Y FLUSH(A) OR COLBUF(A)
STB A,Y NEW COLBUF(A)
CLR A,X CLEAR FLUSH(A)
DECA

BGE XCHNG

LDA #2

CLRB

PSH A,B 0- MIM BUZZR, 1- OFF

LBSR BUZZR STOP OPERATOR BUZZER

LEA$ 2,$ RESTOR$ 

RTS
**MAIN PROGRAM ROUTINES**

```
01285 01286 01287 01288 01289 01290 01291 01292 01293 01294 01295 01296 01297
01298P 0608 34 02  A LAMPP PSHS  A  OP#
01299P 060A C6 88  A  LDB  #SS#
01300P 060C 8E 2014  A  LDX  #LINK0
01301P 060F 4D  TSTA
01302P 0610 27 01  0613  BEO  DX  A=0
01303P 0612 4C  INCA  A=2
01304P 0613 E7 86  A DX  STB  A,X  ENABLE ALL SEGMENTS
01305
01306P 0615 8E 1000  A  LDX  #TSTIME
01307P 0618 8D 1F  0639  BSR  DELAYP
01308
01309P 061A A6 E4  A  LDA  ,S  OP#
01310P 061C 17 FD36 0355  LBSR  LAMPP  RESTOR LINK(OP#)
01311
01312P 061F C6 BF  A  LDB  #NLAMPM
01313P 0621 8E 0001  D  LDX  #FNCSTO
01314P 0624 A6 E0  A  LDA  ,S+
01315P 0626 E4 86  A  ANDB  A,X
01316P 0628 E7 86  A  STB  A,X
01317P 062A 39  RTS
01318
01319
01320
01321
01322
01323
01324
01325
01326
01327
01328P 062B C6 FB  A  CLRP  LDB  #NCLRM
01330P 062D 8E 0001  D  LDX  #FNCSTO
01331P 0630 E4 86  A  ANDB  A,X
01332P 0632 E7 86  A  STB  A,X  CLEAR CLRPM FLG
01333P 0634 1F 88  A  TFR  A,DP
01334P 0636 16 FF67 05A0  LBRA  CRDLDW

- C29 -
**MAIN PROGRAM ROUTINES**

**DELAY PROCEDURE USING REAL TIME IRQ**

* -- INPUT PARAM'S: NONE

* -- GLOBAL PARAM'S: MSEC

* -- ROUTINES CALLED: WTCHDG

**PRESET COUNTER RESET WATCHDOG**

**NEW TIME WAIT MORE**

**---**

**RING ROUTINE**

* -- INPUT PARAM'S: A - OPRNO

* -- GLOBAL PARAM'S: KYBUF, BYTN, BITNO, BUFADD, FNCST, FNCST1

* -- ROUTINES CALLED: DECBIN, PHDCOD, CHGLED, AUDIO, BUZZR, VALBIT

**XDEF DELAY**

**STX**

**MSEC**

**PRESET COUNTER**

**WAIT**

**WATCHDOG**

**READ NEW TIME**

**RTS**

**XDEF RING**

**RINGP**

**LDX**

**KYBUF**

**LDB**

**A**

**X**

**A**

**KYBUF**

**PHONO**

**#1**

**CHANGE OP#**

**CMPB**

**A**

**X**

**OTHER PHONO**

**LBEQ**

**CRDLDW**

**CANNOT RING SAME NO**

**LDX**

**#FNCST**

**A**

**X**

**FNCST(OP#)**

**LDX**

**#RINGNO**

**A**

**X**

**RINGNO, HAS IT BEEN ANSWERED**

**XDEF RINGP**

**LDX**

**#KYBUF**

**LDB**

**A**

**X**

**KYBUF(OP#)**

**LBEQ**

**RTNRNG**

**INVALID PHONO**

**CMPB**

**#96**

**INVALID PHONO**

**LBSR**

**DECBIN**

**LBSR**

**PHDCOD**

**A**

**BITN, B**

**BYTN**

**B**

**TFR**

**A**

**DP**

**COPY BITN**

**LDA**

**S**

**OP#**

**LDX**

**#BYTN**

**STB**

**A**

**X**

**SET UP BYTN(OP#)**
0140P 0686 8E 0010 D  LD X  #BITNO
0141P 0689 1F  B9  A  TFR  DP,B  BITN
0142P 068B E7  86  A  STB  A,X  SET UP BITN(OP#)
0143
0144P 068D 8E  01  A  LDA  #1  ON
0145P 068E 8E  0061  D  LDX  #FLSH
0146P 0692 34  12  A  PSHS  A,X  0- ON, 1- PTR: FLUSH, 3
0147P 0694 17  FED5 056C  LBSR  CHGLED  FLASH LED
0148P 0697 32  63  A  LEA  3,S  RESTOR S
0149P 0699 A6  E4  A  LDA  ,S  OP#
014AP 069B C6  01  A  LDB  #1  CONNECT
014BP 069D 34  06  A  PSHS  A,B  0- OP#, 2- CONNCT, 3-
014CP 069F 8D  55 06F6  BSR  AUDIO
014DP 06A1 32  62  A  LEA  2,S  RESTOR S; 0- OP#
0144
0145P 06A3 A6  E4  A  LDA  ,S  OP#
0146P 06A5 C6  01  A  LDB  #1  ON
0147P 06A7 34  06  A  PSHS  A,B  0- OP#, 1- ON, 3- OP#
0148P 06A9 17  009C 0748  LBSR  BUZZR  RING MUX1 OR MUX2
0149P 06AC 32  62  A  LEA  2,S  RESTOR S
014AP 06AE A6  E4  A  LDA  ,S  OP#
0145
0146P 06B0 8E  000E  D  OP HUP  LDX  #BYTNO
0147P 06B3 E6  86  A  LDB  A,X  BYTN(OP#)
0148P 06B5 BE  0004  D  LDX  BUFADD
0149P 06B8 30  85  A  LEAX B,X  BYTNO(OP#) + BUFADD
0144
0145P 06BA 108E 0010 D  LD Y  #BITNO
0146P 06BE A6  E4  A  LDA  ,S  OP#
0147P 06C0 A6  A6  A  LDA  A,Y  BITN(OP)
0144
0145P 06C2 17  FFAF 0174  LBSR  VALBIT  X- PTR, A- BITN
0146P 06C5 4D  2B 06F3  TSTA  RTNRNG
0144
0145P 06C8 A6  E4  A  LDA  ,S  OP#
0146P 06CA 5F  CLRB  STOP RING NG
0147P 06CB 34  06  A  PSHS  A,B  0- OP#, 1- STOP
0148P 06CD 8D  79 0748  BSR  BUZZR
0149P 06CF 32  62  A  LEA  2,S  RESTOR S
0144
0145P 06D1 E6  E4  A  LDB  ,S  OP#
0146P 06D3 8E  0001  D  LDX  #FNCSTO
0147P 06D6 A6  85  A  LDA  B,X  FNCST(OP#)
0148P 06D8 84  DE  A  ANDA  #NRI3NI3M  NOT RINGING & NOT RING
0149P 06DA A7  85  A  STA  B,X  CLR RINGNG FLG
0144
0145P 06DC 4F  CLRA
0146P 06DD 8E  0061  D  LDX  #FLSH
0147P 06E0 34  12  A  PSHS  A,X  0- OFF, 1- PTR: FLUSH, 3
0148P 06E2 17  FE87 056C  LBSR  CHGLED
0144
0145P 06E5 8E  0049  D  LDX  #COLBUF
0146P 06E8 AF  61  A  STX  1,S
0147P 06EA 86  01  A  LDA  #1
0148P 06EC A7  E4  A  STA  ,S
0149P 06EE 17  FE7B 056C  LBSR  CHGLED  0- ON, 1- PTR: COLBUF,
0144P 06F1 32  63  A  LEA  3,S  RESTOR S
0145
0146P 06F3 32  61  A  RTNRNG LEA S  1,S  RESTOR S
0144
- C31 -
PAGE 033  M1 .SA:1 M1 MAIN PROGRAM ROUTINES

XDEF AUDIO

******************************************************************************
* AUDIO SWITCHING ROUTINE *
******************************************************************************
* -- Input params on Stack: *
* 1 - S + 0 = RTS ADDR. *
* 2 - MUXNO, OP# *
* 3 - DIS/CONNECT *
* * --- CHANGED: A,B,X,U *
* * --- UNCHANGED: DP,Y,U *
* * -- Routines called: PHECOD *
******************************************************************************

01478 06F6 8E 0001  D AUDIO  LDX  #FCSTO
01480 06F9 ED 63  A  TST  3:S  DIS/CONNECT
01481 06FB 26 0C 0709  BNE  CNNCT
01482 01483 06FD C6  FD  A DIS  LDB  #NAUDIO
01484 06FF A6  62  A  LDA  2:S  OP#
01485 0701 E4  86  A  ANDB  A,X
01486 0703 E7  86  A  STB  A,X  CLR AUDIO FLG
01487 01488 0705 86  7F  A  LDA  #$7F  IMAGINARY NO
01489 0707 20 19 0722  BRA  QMUXNO
01490 01491 0709 A6  62  A  CNNCT  LDA  2:S  OP#
01492 070B C6  02  A  LDB  #AUDIOM
01493 070D EA  86  A  ORB  A,X
01494 070F E7  86  A  STB  A,X  SET AUDIO FLG
01495 01496 0711 8E 000E  D  LDX  #$BYTN
01496 0711 8E 000E  D  LDX  #$BYTN
01497 0714 E6  86  A  LDB  A,X  BYTN(OP#)
01498 0716 8E 0010  D  LDX  #$BITNO
01499 0719 A6  86  A  LDA  A,X  BITN(OP#)
01500 01501 071B BD  23 0740  BSR  PHECOD
01502 01503 071D 8E 002C  P  LDX  #$VOICE
01504 0720 A6  86  A  LDA  A,X  VOICE(PHONNO)
01505 0722 E6  62  A  QMUXNO  LDB  2:S  OP#
01506 0724 26 02 0728  BNE  OP1
01507 0726 8A  80  A  OP0  ORA  #$80  B7= 1 FOR OP#0
01508 0728 B7 200E  A  OP1  STA  CNNCT  B7= 0 FOR OP#1
01509
XDEF STROBE
LDA #NSTRL NOT STROBE LO
ANDA STREPH
STA STREPH STROBE LO

* ENABLE B7 OF CONNCT TO BE DECODED
BY 74LS139.

* DISABLE DECODING BY 74LS139. ALL O/P'S
GO HI, IF NOT HI ALREADY.

RTS

XDEF PHECOD

PHECOD LSLB
LSLB

PHECOD LSLB
LSLB

PSHS B

ORA ,S+}

RTS
XDEF BUZZR
*************
* -- Input params on stack: *
* s + 0  - RTN ADDR *
* 2  - FUNCTION *
* 0: MUXO *
* 1: MUXI *
* 2: OP# *
* 3: ON/OFF *
* --- CHANGED: A,B,X,Y,S *
* --- UNCHANGED: DF,U *
* CRDL UP: LO :: CRDL DWN: HI *
* *************

```
1574P 0748 108E 2002 A BUZZR LDY #RING PIAOB
1575P 074C SE 0645 P LDX #RINGR
1576
1577P 074F 86 02 A LDA #2 FUNCTION
1578P 0751 A1 62 A CMPA 2:S
1579P 0753 26 24 0779 BNE NMIMIC
1580
1581P 0755 6D 63 A TST 3:S ON/OFF
1582P 0757 27 14 076D BEO OFFMIM TURN MIM BUZZR OFF
1583
1584P 0759 F6 2002 A LDB RING FIAOB
1585P 075C 4D 00 A ANDB ##CO CRDLO, CRDL1 STAT ONLY
1586P 075E C1 00 A CMPB ##CO
1587P 0760 26 0A 076C BNE NORG BOTH HANDSETS NOT DOWN
1588
1589P 0762 A6 62 A LDA 2:S FUNCTION: OPX
1590P 0764 E6 86 A LDB A:X RINGER(A)
1591P 0766 FA 2002 A ORB RING
1592P 0769 F7 2002 A STB RING ENABLE OPX BUZZR
1593P 076C 39 NORNG RTS
1594
1595P 076D A6 62 A OFFMIM LDA 2:S FUNCTION: OPX
1596P 076F E6 86 A LDB A:X COMB
1597P 0771 53
1598P 0772 F4 2002 A ANDB RING
1599P 0775 F7 2002 A STB RING TURN MIM BUZZR OFF
1600P 0778 39 RTS
1601
1602P 0779 A6 62 A NMIMIC LDA 2:S FUNCTION
1603P 077B A6 86 A LDA A:X DECOD FUNCTION
1604P 077D 6D 63 A TST 3:S ON/OFF
1605P 077F 27 05 0786 BEO STPRNG STOP RINGNG
1606P 0781 AA A4 A ORA Y
1607P 0783 A7 A4 A STA Y SET BITS
1608P 0785 39 RTS
1609
1610P 0786 43 STPRNG COMA NOT RINGR
1611P 0787 A4 A4 A ANDA Y
1612P 0789 A7 A4 A STA Y STOP RINGNG
1613P 078B 39
1614
1615
- C34 -
```
MAIN PROGRAM ROUTINES

**DECBIN CONVERTS A DECIMAL NO. TO A BINARY NO.**

--- CHANGED: A, B, S, DP |

--- UNCHANGED: X, Y

--- INPUT PARAM'S: |

A - DECIMAL NO. UPON ENTRY. |

A - BINARY NO. UPON EXIT. |

NOTE: 16 = $0F |

1 = $00

*****:t:*:+:*:+:*:t:*:+::t::t::t::+:*:+::t::t::+::+::+::+::t:***:t::+::+:** |

-- DECBIN CONVERTS A DECIMAL NO. TO A BINARY NO. --

DECBIN TFR A, DP |

COPY PHONNO |

COPY PHONNO M:3D |

M~3D = 0 |

B- M<::D |

PHONNO |

LSD |

MSD NOW |

SUM |

TEN |

DECBIN A, B |

#$07 |

#$7:=: |

DP, B |

#$OF |

B |

O:oS+ |

PHDCOD |

*****:t:*:+:*:+:*:t:*:+::t::t::t::+:*:+::t::t::+::+::+::+::t:***:t::+::+:** |

DECODES PHONE NO. TO CARD NO. (B) AND MUX NO. (A). |

-- CHANGED: A, B |

-- UNCHANGED: X, Y

-- INPUT PARAM'S: A - BIN PHON NO. |

-- OUTPUT PARAM'S: A - MUX ADDR |

B - CARD ADDR

PHONO 16 = $0F |

PHONO 1 = $00

XDEF DECBIN 078C 1F 8E A DECBIN TFR A, DP |

COPY PHONNO |

A ANDA #$0F |

MSD |

BEQ ONEDIG |

MSD = 0 |

TFR A, B |

B- MSD |

LSRB |

LSRB |

LSRB |

LSRB |

CLRA |

SUM |

BNE TEN |

DECB |

XDEF PHDCOD 078E 34 F0 A |

ANDA #$0F |

LSD |

PSHS B |

ADD A |

O.S+ |

DECA |

PHONO 16 = $0F |

PHONO 1 = $00 |

XDEF PHDCOD 0790 27 OC 079E |

ONEDIG TFR DP, B |

PHONNO |

ANDB #$0F |

LSD |

PUSH A |

ADD |

0.S+ |

DECA |

PHONNO 16 = $0F |

PHONO 1 = $00 |

XDEF PHDCOD 0792 1F 89 A |

ONE DIG TFR A, B |

COPY OF A |

ANDA #$07 |

MUX ADDR |

ANDB #$78 |

CRD ADDR |

LSRB |

LSRB |

LSRB |

RTS |

-C35-
XDEF ADDQ

* -- INPUT PARAM'S: S - BCD PHONO, 1BYTE *
* -- OUTPUT PARAM'S: X - #QUE *
* --- CHANGED: A, B, X, U *
* --- UNCHANGED: X, D, P, S *

* NOTE: UNUSED ELEMENTS = O *
* LAST ELMNT: NXT = O *
* FIRST ELMNT: PREV = O *

******************************************************************************

LDA 2,S BCD PHONO
BSR DECBIN CONVERT TO BIN
INCA CORRECTION

LDX #QUE
LDD LASTNO
TFR D,Y Y- LASTNO

LDD D,X LAST ELEMENT
LDB 2,S PHONO
LSLB PTR TO NEW PHONO
TFR D,U OLD LASTNO: PREV# NEW
TFR Y,D LASTNO
STU D,X OLD LAST ELEMENT UPDAT

TFR Y,D LASTNO
TFR B,A LASTNO#LASTNO
CLR N NXT
COPY

LDB 2,S NEW PHONO IN D
LSLB PHONO NOW PTR
STU D,X NEW LAST ELEMENT

CLRA
LDB 2,S PHONO
LSLB LASTNO PTR
STD LASTNO

CLRA
CLRA
CMPD FRSTNO QUE NOT IN USE
BNE NTNEW NOT 1ST NO IN NEW O
LDU #$0
STU X CLR UNUSED BYTES
LDB 2,S NEW PHONO
LSLB NOW PTR
CLRA

STD FRSTNO NEW FIRSTNO: 1ST ELMNT

NTNEW RTS

- C36 -
XDEF CHKQ

******************************************************************************
* -- INPUT PARAM'S: B - BCD PHONO
* * -- OUTPUT PARAM'S: A - ENTRY NO
* * -- X - #QUE
* * --- CHANGED: A,B,X,Y,U
* * --- UNCHANGED: S,DP
* * * NOTE: UNUSED ELEMENTS = 0
* * LAST ELMNT:NXT = 0
* * FIRST ELMNT:PREV = 0
******************************************************************************

01747 P 07F5 1F 98 A CHKQ TFR B,A BCD PHONO
01748 P 07F7 8D 93 078C BSR DECBIN CONVERT TO BIN
01749 P 07F9 4C 89 A INCA CORRECTION
01750 P 07FA 1F 89 A TFR A,B

01751

01752 P 07FC 4F CLRA
01753 P 07FD 8E 0079 D LDX #QUE
01754 P 0800 6D 8B A TST D,X
01755 P 0802 27 04 0808 BEQ NFOUND
01756 P 0804 1F 98 A TFR B,A
01757 P 0806 58 LSLB PTR TO PHON
01758 P 0807 39 RTS
01759 P 0808 34 06 A NFOUND PSHS D
01760 P 080A FC 0015 D LDD FRSTNO
01761 P 080D 10A3 E4 A CMPD ,S IS IT FRSTNO
01762 P 0810 26 06 0818 BNE NOQ NOT FRSTNO
01763 P 0812 35 06 A PULS D
01764 P 0814 54 LSRB PTR TO PHON
01765 P 0815 1F 98 A TFR B,A
01766 P 0817 39 RTS
01767

01768 P 0818 32 62 A NOQ LEAS 2,S RESTOR S
01769 P 081A 86 FF A LDA #$FF NO NOT IN Q
01770 P 081C 39 RTS

01771
*** MAIN PROGRAM ROUTINES ***

** QUEUING PROCEDURE **

**********

01638
01639
01640
01641
01642
01643 P 0872 10SE 0001 D Dp XDEF LDP
01644 P 0876 34 02 A PSHS A O-OP#
01645 P 0878 C6 F7 A LDB #NOM
01646 P 087A E4 A6 A ANDB A,Y CLEAR 0 FLAG
01647 P 087C E7 A6 A STB A,Y
01648
01649 P 087E FC 0015 D LDD FRESTNO PTR TO TOO: TOP OF Q
01650 P 0881 26 0D 0870 BNE CONTNO VALID 0
01651 P 0883 C6 00 A LDB #0
01652 P 0885 8E 000A D LDX #KYBUF
01653 P 0888 35 02 A PULS A OP#
01654 P 088A E7 86 A STB A.X SET ZERO
01655 P 088C 17 FAE6 0355 LSRB LINKP DISPLAY ZERO
01656 P 088F 39 RTS
01657
01658 P 0890 A6 E4 A CONTNO LDA ,S OP#
01659 P 0892 C6 20 A LDB #RINGM
01660 P 0894 EA A6 A ORB A,Y
01661 P 0896 E7 A6 A STB A,Y SET RING MODE
01662
01663 P 0898 FC 0015 D LDD FRESTNO TOO PHONO: PTR
01664 P 089B 54 LSRB NOW PHONO
01665 P 089C 1F 98 A TFR B,A
01666
01667 P 089E 17 F6F6 0197 LSRB BINDEC BCD PHONO
01668 P 08A1 34 02 A PSHS A O-PHONO, 1-OP#
01669 P 08A3 1F 89 A TFR A,B PHONO
01670 P 08A5 A6 61 A LDA 1,S OP#
01671 P 08A7 8E 000A D LDX #KYBUF
01672 P 08AA E7 86 A STB A,X PUT TOO PHONO IN KEYBU
01673 P 08AC 17 FAA6 0355 LSRB LINKP DSPY T.O.Q
01674
01675 P 08AF 35 02 A PULS A BCD PHONO
01676 P 08B1 17 FF69 081D LSRB DELQ DEL PHONO FROM TOO
01677
01678 P 08B3 35 02 A PULS A OP#
01679 P 08B5 17 F68F 0648 LSRB RINGP RETURN TO MAINP
01680
01681
01682
01683
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TOTAL WARNINGS 00000---00000

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00505 ABX3 01067+01082
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0052B ABX7 01087 01089*
00518 ABX8 01079*
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**Notes:**
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2010 STTSEL 00108+00982 01048
D 0000 SYSFLG 00122 00123+00489 00490 00566
P 0799 TEN 01642+01644
P 0100 TIMER# 00430*
P 049F TSTACH 00934+01133
P 03EC TSTCHG 00830 00867 00868*
D 0139 TSTCNT 00189 00170+01040 01063 01074
1000 TSTIME 00085+01306
P 0174 VALBIT 00377 00389+00900 01431
P 002C VOICE 00190 00191+01503
P 063C WAIT 01547+01349
P 03DB WTCHDG 00347 00784 00829 00841 00843+00967 01347
P 04C4 X21 01019 01022*
P 05F2 XCHNG 01269+01274
P 029E XROWS 00587 00612 00620*
P 04A6 XX2 00999 01002*
P 04AC XX3 01003 01006*
P 04B2 XX4 01007 01010*
P 04BA XX5 01011 01014*
P 04BE XX7 01015 01018*
Program Logic

Pseudo Code

Note: This pseudo code is not a programming language. It was used to complement the flow charts. The pseudo code is virtually equivalent to MPL coding.
Interrupt Procedures

IRQP: IF real time interrupt THEN
DECREMENT (MSEC) timing counter
DECREMENT (IRQCNT) interrupt counter
IF IRQCNT zero THEN
Equate IRQCNT to LED flash time (FLSHTM)
Invert LED flash status by inverting FLASH-ON in SYSFLG

MIMIC: IF Lamp test flag is set in SYSTAT THEN
Enable all LEDs. Turn on all COLUMNS.
ELSE
IF FLASH-ON flag is set THEN
Enable four LED columns and flashing
COL=COLBUF(NCOLM) OR FLSH(NCOLM) \nNCOLM=NCOLM-1 \n} x4
ELSE
IF NCOLM = 0 THEN NCOLM = 23
ELSE
Enable four LED columns
COL=COLBUF(NCOLM) \nNCOLM=NCOLM-1 \n} x4
IF NCOLM=0 THEN NCOLM=23

XROWS: Enable next Row
ROW=NOT(MASK(NROW))
NROW=NROW-1
IF NROW=0 THEN NROW=5

IF any Operator CRADL flag SET THEN
IF CRADLO THEN Pass parameter 0
IF CRADLI THEN Pass parameter 1
CALL Cradle Procedure (CRDLP)

IF any Keyboard flag is set THEN
IF KEYBRDO THEN
Get KYBRD data
Mask data
Store data in KYBINP(0)
ELSE
Get KYBRD data
Mask data
Store data in KYBINP(0)
CALL Keyboard Procedure (KYBRDP)

RETURN FROM INTERRUPT
Main Procedures.

MAINP: DO FOREVER
   RESET Watchdog
   DO CASE FNCST(OPRNO).
   Execute routines as per set flags in Function Status.
      RINGP, ACKP, QP, CLRIP, LAMPP
   RESET Watchdog
   INVERT Operator No (OPRNO)
   Test for Changes in Extension Telephone Statuses, CALL TSTCHG.
END DO

Operator Cradle Procedure.

CRADLP: IF Cradle is up THEN RETURN
   Reset Cradle IRQs
   IF AUDIO OR RINGMN flags are set THEN
      Disable connection between operator and extension
      Disable Operator Audio Alarm
      Disable LED indicating connection
   CLRDSP: Clear Operator Keyboard buffer
      Clear Operator display
      Clear FNCST(OPRNO), Operator function status
      RETURN
         NOTE: If Operator Handset is up: Status high
            If Operator Handset is down: Status is low.

KYBRDP: Read Keyboard Input
   DO CASE
      UNNAMED KEY, LAMP TEST, ACKN, CLEAR, RING, Numerals
   Display keyboard entry on readout
   Set Mode flag in FNCST, Function Status
RETURN
Test Extension Telephone Status Changes.

TSTCHG: Invert Status Buffer No
IF BUFNO=0 THEN
    BUFADD=STTBUF. Set Database address
ELSE
    BUFADD=STBUFl. Set Database address
CALL MAKBUF. Read all Telephone statuses
DO PORT=24 TO 1
    IF STTBUF(PORT) <> STBUFl(PORT) THEN
        Find Phone No of changed status
        IF Status change active THEN
            Flash appropriate green LED flashing
            ELSE
                Disable flashing or steady LED
                Disable Operator Audio alarm
                IF PORT < 11 THEN, i.e. Phone Status, not Fault
                    IF Active change THEN
                        IF PHONO not in Queue THEN
                            Add PHONO to Queue
                        ELSE
                            IF PHONO in Queue THEN
                                Delete PHONO from Queue
        END DO
RETURN

Lamp Test.

LAMPP: Output $88 to Operator readout
CALL DELAY(TSTIME)
Restore Operator readout
Clear Lamp Test flag in FNCST(OPRNO)
RETURN

Clear Procedure.

CLRP: Clear all flags in FNCST(OPRNO), Function status
Clear Operator readout
RETURN
Ring Procedure.

RINGP: IF sane PHONO as other Operator THEN RETURN
      IF RINGM not set THEN
          Set RINGM flag (Ring Mode flag in FNCST(OPRNO))
          IF PHONO invalid THEN RETURN
          Flash PHONOs LED
          Connect Operator to Extension
          Ring Extension
          IF Extension telephone handset is lifted THEN
            Disable Ringing
            Clear RINGM flag
            Flashing LED turned on
      RETURN

Acknowledge Procedure.

ACKP: Turn flashing LEDs on permanently
      Disable Operator Audio Alarm
      RETURN

Queue Procedure

QP: Clear QM (Queue Mode) flag in FNCST(OPRNO)
    Display Phone number at top of QUE on Operator readout
    GOTO RINGP with PHONO as parameter

Add Extension Telephone number to Queue.

ADDQ: IF QUE > one entry THEN
        Add BCD Phone No to end of QUE
        Correct all linked list pointers
    ELSE
        FIRSTNO=PHONO
RETURN
**Keyboard Procedure.**

KYBRDP: BUF=KYBINP(OPRNO). Get appropriate keyboard data
   IF BUF=Unmarked key THEN RETURN
   IF BUF=Lamp Test code THEN set LAMPM flag in FNCST(OPRNO)
   IF BUF=Ackn code THEN set ACKM flag in FNCST(OPRNO)

   IF Cradle is down THEN RETURN
   IF BUF=Ring code THEN set RINGM in FNCST(OPRNO)
   IF BUF=Queue code then set QM in FNCST(OPRNO)

   DO NO=1 TO 0
      IF BUF=NOS(NO) THEN GOTO X
   ENDDO

X: Shift KEYBUF(OPRNO) LSD to MSD
   LSD=BUF, New data no the LSD
   GOTO LINKP

**Operator Readout routine.**

LINKP: Output KEYBUF(OPRNO) to Operator readout
       RETURN
CHAIN FILES.

These command files were written to save the user much repetitively keyboard entry during assembly and linking.

The assembly and linking of source code modules is controlled by A.CF and L.CF respectively. Parameters used during execution of the chain files are passed on by the calling chain file to both A.CF and L.CF. Four calling chain files are available and are described on page C1.

Page C51 is a screen dump showing the user prompt when an error occurs during assembly. Execution of the chain file is terminated by pressing the 'Break' key.

A screen dump of the complete assembly and linking process is shown on pages C52 to C54. The single line S.CF invokes A.CF. Parameters are passed from S.CF to A.CF and are displayed on the screen by the latter. Run time errors or assembler errors will terminate execution of the chain file and prompt the user.

If no assembler errors are detected, A.CF calls the linker chain file L.CF and pass parameters to the it. L.CF links up to four relocatable object modules and stores the object code in a specified loadable object file.

A full listing of the command files are given on pages C56 to C61.
Assembles and links the EMERGENCY TELEPHONE SYSTEM and then outputs the listing to the file: PREL.AL:1

CHAIN SL.CF:1

Assembler and links the EMERGENCY TELEPHONE SYSTEM and then outputs the listing to the file: PREL.AL:1

HAIN A.CF:1:F%PREL%:F1%RESET%:F2%IRQ%:F3%M0%:F4%M1%:L1%L%  

Assembler Chain file.

F - PREL
F1 - RESET
F2 - IRQ
F3 - M0
F4 - M1
LI - L: Listing saved in file: PREL.AL:1
LP - : Listing output to line printer.
LG - : Listing to terminal screen.
OR - : ORG'D. Used for absolute file creation.
SET F0FF 0800

* SL PREL.AL:1,PREL.R0:1,PREL.LX:1
REL .AL:1 DOES NOT EXIST
REL .RO:1 DELETED
REL .LX:1 DOES NOT EXIST
ASMO9 PREL:1,RESET:1,IRQ:1,M0:1,M1:1:N=120,L=PREL:1,O=PREL:1,XS
8099 MACROASSEMBLER 3.02
COPYRIGHT BY MOTOROLA 1978

* PROGRAM I/O ERROR-STATUS=33 AT 08F6 ON DRIVE 1-PSN 0428
JMP 86FB
TST,FO00 0000 0027
JMP 8706

*

************************************************************************
* --- Assembler error! Press BREAK to exit.
************************************************************************

LBL 8712

* OS CHAIN ABORTED BY BREAK KEY

- C51 -
HAIN S.CF:1
Assembles and links the EMERGENCY TELEPHONE SYSTEM. No Listing is given.

---------------------

HAIN A.CF:1;F%PREL%,F1%RESET%,F2%IR0%,F3%MO%,F4%M1%
Assembler Chain file.

F = PREL
F1 = RESET
F2 = IR0
F3 = MO
F4 = M1
LI = : Listing saved in file: PREL,AL:1
LP = : Listing output to line printer.
SS = : Listing to terminal screen.
OR = : ORG'D. Used for absolute file creation.
SET F0FF 0800
* EL PREL,AL:1,PREL,RO:1,PREL,LX:1
REL . AL:1 DELETED
REL . RO:1 DOES NOT EXIST
REL . LX:1 DOES NOT EXIST
ASM09 PREL:1,RESET:1,IR0:1,MO:1,M1:1;0=PREL:1
6809 MACROASSEMBLER 3.02
COPYRIGHT BY MOTOROLA 1979

JMP 86FB
TST,FOOO 0000 0027
JMP 8712
*

*----------------------------------------------------------------------*
* --- BREAK if you do not want to link: PREL, VECTOR.               *
*----------------------------------------------------------------------*

HAIN L.CF:1;F%PREL%,F1%VECTOR%,X%XR%,S%SP%$FO00%
Linking chain file.

- Do not specify File Type or Drive No
- Links relocatable object files and load them into user memory.

-- The loader file has name of the first linked .RO file.

F = PREL
F1 = VECTOR
F2 =
F3 =
SB = : Start Base addr.
EB = : End Base addr.
SD = : Start Data addr.
ED = : End Data addr.
SP = $FO00 : Start Program addr.
EP = : End Program addr.
XR = X : Cross Reference Table.
LB = : MPL Cross Reference Library File.
@SET F0FF 0800
DEL TEMP IF:0
TEMP IF:0 DELETED
DEL PREL LO:1
PREL LO:1 DELETED
LOAD
MOOS LINKING LOADER REV 03.00
COPYRIGHT BY MOTOROLA 1977
?IF=TEMP
?BASE=0
?STRB=0
?STRC=0
?STRD=0
?ENDD=$7FF
?STRP=$FO00
?LOAD=PREL:1
?LOAD=VECTOR:1
?+-- MAPF follows.
MAPF
NO UNDEFINED SYMBOLS

MEMORY MAP

S SIZE STR END COMN
A 0010 FFOF FFFF
B 0000 0000 0000 0000
C 0000 0000 0000 0000
D 01F9 0000 07FF 0000
P 08BA F000 F8B9 0000

MODULE NAME BSCT DSCT PSCT
PREL 0000 0000 F000
VECTOR 0000 01F9 F8BA

DEFINED SYMBOLS

MODULE NAME: PREL
ACKP P F5E0 ADDO P F7B2 AUDIO P F6F6 BINDEC P F197
BITNO D 0010 BUZZR P F748 BYTNO D 000E CHGLED P F56C
CHKO P F7F5 CLR P F62B COLBUF D 0049 CRDLWD P F5A0
CRDLFL P F008 CRDLRP P F584 CRLUP P F532 DECBIN P F76C
DELAYP P F639 DELAYR P F156 DELFO P F55A DEL0 P F81D
FLSH D 0061 FSMB P F15E FNCSTO D 0001 FRSTNO D 0015
IRONCT D 0008 IR0P P F1B9 KIBRDF P F2AF KIBUF D 000A
KYBUF1 D 000E KYBX P F1FA LAMPP P F608 LINKP P F355
MAINP P F36A MAKBUF P F474 MASK P F000 MIMIC P F217
MSEC D 0006 MSECOD P F022 OPFNO D 0012 PHDCOD P F7A8
PHECOD P F740 OIP P F872 OFH0N P F534 OUE D 0079
RESET P F0A4 RINGP P F648 RINGR P F645 SVGCD P F49D
SETBIT P F181 STB0F1 D 0031 STDCOD P F00A STROBE P F72B
STTBUF D 0019 SYSFLG D 0000 TSTCHG P F3EC TSTCNT D 0139
VALBIT P F174 VOICE P F02C WTCHEG P F3DB

MODULE NAME: VECTOR
FIROV A FFF6 IROV A FFF8 NMIV A FFFC RSRVD A FFF0
RSTV A FFFE SW12V A FFF4 SW13V A FFF2 SWIV A FFFA

?MO=#LP
?OBJA=PREL.10:1

-C53-
NO UNDEFINED SYMBOLS

MEMORY MAP

S SIZE STR END COMN
A 0010 FFFF FFFF
B 0000 0000 0000 0000
C 0000 0000 0000 0000
D 0800 0000 07FF 0000
F 083A F000 F8BA 0000

MODULE NAME BSCT DSCT FSCT
PREL 0000 0000 F000
VECTOR 0000 01F9 F8BA

DEFINED SYMBOLS

MODULE NAME: PREL
ACKP P F5E0 ADDQ P F7B2 AUDIO P F6F6 BINDEC P F197
BITNO D 0010 BUZZR P F748 BYTNO D 000E CHGLED P F56C
CHCO P F7F5 CLRQ P F42B COLBUF D 0049 CRDDLW P F5A0
CRDLP P F008 CRDLPL P F586 CRLUP P F592 DECBIN P F78C
DELAYP P F639 DELAYR P F156 DELFO P F55A DELP P F81D
FLASH D 0061 FMSB P F15E FNCSTO D 0001 FRSTNO D 0015
IRQCN T D 0008 IRQP P F1B9 KYBRDP P F2AF KYPFW D 000A
KYBUF1 D 000B KYBX P F1FA LAMFP P F608 LINKP P F355
MAINP P F36A MAKBUF P F474 MASK P F000 MIMIC P F217
MSEC D 0006 NOSCOD P F022 OPRNO D 0012 PHDCOD P F7A8
PHDECOD P F740 0P P F872 OPHON P F534 QUE D 0079
RESET P F0A4 RINGP P F648 RINGR P F645 SAVCOD P F49D
SETBIT P F181 STBUFF1 D 0031 STDCOD P F00A STROBE P F72B
STTBUF D 0019 SYSFLG D 0000 TSTCHG P F3EC TSTCNT D 0139
VALBIT P F174 VOICE P F02C WTCBD6 P F3DB

MODULE NAME: VECTOR
FIROV A FFFF IROV A FFF8 NMIV A FFFC RSVRD A FFF0
RSTV A FFFE SWI2V A FFF4 SWI4V A FFF2 SWIV A FFFA

?EXIT

2* - Load Object file into user memory.
2* - Press BREAK if you do not want to load .LO file into user memory.

LOAD PREL.LO:11U

** 08 CHAIN ABORTED BY BREAK KEY - C54 -
Listing of Chain Files.
Assembles and links the EMERGENCY TELEPHONE SYSTEM. No Listing is given.

CHAIN A.CF:1;F\PREL\%;F1\RESET\%;F2\IRQ\%;F3\M0\%;F4\M1\%

Assembles and links the EMERGENCY TELEPHONE SYSTEM and then outputs the listing to the file: PREL. AL:1

CHAIN A.CF:1;F\PREL\%;F1\RESET\%;F2\IRQ\%;F3\M0\%;F4\M1\%;LI\%L\%

Assembles and links EMERGENCY TELEPHONE SYSTEM source code. Outputs the listing to the line printer. Page length = 64 lines.

CHAIN A.CF:1;F\PREL\%;F1\RESET\%;F2\IRQ\%;F3\M0\%;F4\M1\%;LP\%LP\%

- C57 -
Assembler Chain file.

Listing saved in file: %F%.AL:1
Listing output to line printer.
Listing to terminal screen.

ORG'D. Used for absolute file creation.

DEL %F%.AL:1,%F%:RO:1,%F%.LX:1
/IFS F4
/IFS LI
RASM09 %F%:1,%F1%:1,%F2%:1,%F3%:1,%F4%:1:N=120,L=%F%:1,O=%F%:1,XS
/ELSE
/IFS SS
RASM09 %F%:1,%F1%:1,%F2%:1,%F3%:1,%F4%:1:O=%F%:1,L=#CN,-P
/ELSE
/IFS LP
RASM09 %F%:1,%F1%:1,%F2%:1,%F3%:1,%F4%:1:P=64,LXS
/ELSE
RASM09 %F%:1,%F1%:1,%F2%:1,%F3%:1,%F4%:1:O=%F%:1
/XIF
/XIF
/XIF
@JMP FIN
/XIF
/IFS F3
/IFS LI
RASM09 %F%:1,%F1%:1,%F2%:1,%F3%:1:N=120,L=%F%:1,O=%F%:1,XS
/ELSE
/IFS SS
RASM09 %F%:1,%F1%:1,%F2%:1,%F3%:1:O=%F%:1,L=#CN,-P
/ELSE
/IFS LP
RASM09 %F%:1,%F1%:1,%F2%:1,%F3%:1:1:P=64,LXS
/ELSE
RASM09 %F%:1,%F1%:1,%F2%:1,%F3%:1:1:O=%F%:1
/XIF
/XIF
/XIF
@JMP FIN
/XIF
/IFS F2
/IFS LI
RASM09 %F%:1,%F1%:1,%F2%:1:N=120,L=%F%:1,O=%F%:1,XS
/ELSE
/IFS SS
RASM09 %F%:1,%F1%:1,%F2%:1:O=%F%:1,L=#CN,-P
/ELSE
/IFS LP
RASM09 %F%:1,%F1%:1,%F2%:1:P=64,LXS
/ELSE
RASM09 %F%:1,%F1%:1,%F2%:1:O=%F%:1
/XIF
/XIF
/XIF
@JMP FIN
/XIF
RASMOV : PROFILE

@LBL FIN
@TST,$ E0
@JMP ERROR
@IFS CR
EXBIN %F%:1
DEL %F%:LX:1
@XIF
@JMP THEEND
@LBL ERROR
@*
@*
--- Assembler error! Press BREAK to exit.
@*
@*
--- BREAK if you do not want to link: %F%, VECTOR.
@*
@*
CHAIN L.CF:1;F\%F\%,F1\%VECTOR\%,XR\%X\%,SP\%F000%
@SET,M 8

****************************

* Linking chain file. *
****************************

- Do not specify File Type or Drive No
- Links relocatable object files and load them into user memory.
-- The loader file has name of the first linked .RD file.

F = %F%
F1 = %F1%
F2 = %F2%
F3 = %F3%
SB = %SB% : Start Base addr.
EB = %EB% : End Base addr.
SD = %SD% : Start Data addr.
ED = %ED% : End Data addr.
SP = %SP% : Start Program addr.
XR = %XR% : Cross Reference Table.
LB = %LB% : MPL Cross Reference Library File.

DEL TEMP,IF:0
DEL %F%.LO:1
RLOAD
IF=TEMP
BASE=O
/IFS SB
STRB=%SB%
/ELSE
STRB=O
/XIF
/IFS EB
ENDB=%EB%
/XIF
/IFS SC
STRC=%SC%
/ELSE
STRC=O
/XIF
/IFC SD
STRD=O
/ELSE
STRD=%SD%
/XIF
/IFS ED
ENDD=%ED%
/ELSE
ENDD=$7FF
/XIF
/IFC SP
STRP=#F000
/ELSE
STRP=%SP%
/XIF
/IFS EP
ENDP=%EP%
/XIF
/LOAD=%F%:1

- C60 -
/IFS F1
LOAD=%F1%:1
/XIF
/IFS F2
LOAD=%F2%:1
/XIF
/IFS F3
LOAD=%F3%:1
/XIF
/IFS LB
LIB=FLSLIB
/XIF
@* -- MAPF following.
MAPF
/IFS XR
MO=#LP
/XIF
OBJECT=%F%.LO:1
EXIT
@*
@*  ******************************************************
@* - Load Object file into user memory.
@*  ******************************************************
@*
@ - Press BREAK if you do not want to load .LO file into user memory.
LOAD %F%.LO:1:U
Switching Power Supplies.

VERO Monovolt GK60
Primär getaktete Netzteilnetze (Schaltnetzteile)

Hier wird die gleichgerichtete und gesteuerte Netzspannung durch einen mit hoher Frequenz arbeitenden Transistorstromschalter an das Primärnetz eines Übergangspuffers gespeist. Diese Technologie erlaubt den Einsatz von kleinen Ferrit-Transformatoren für die Netztransformierung, die Neben der Erhöhung des Wirkungsgrades und einer wesentlichen Verkleinerung des Leistungsumsatzes auch eine deutliche Gewichtsreduzierung der Netzanschlussnetzteile ermöglicht. Die wesentlichen Vorteile von Schaltnetzteilen erstrecken sich auf:

- Hoher Wirkungsgrad > 75%
- Volumenleistung ca. 100 W/dm³
- Kompakt durch Gewichts- und Volumenreduzierung um den Faktor 5 gegenüber Linearumrechnern


Primär getaktete Schaltnetzteile (SNT) von BICC-VERO ELECTRONICS sind kompakte, zukunftsgerechte Stromversorgungen mit hohen Anforderungen an die Qualität der Funktionsbereitschaft. Für einen reibungslosen Betrieb empfehlen wir die Beachtung folgender Hinweise:


Unterbrauschutz (OCP)


Stromversorgungen für die 19. Technik

Seit Jahren entwickelt BICC-VERO ELECTRONICS Stromversorgungen für die 19. Technik, die sich in vielen fachlichen Industrieanwendungen bewähren haben. Ausgeprägte Entwicklungen, hochwertige Bauelemente, kontinuierliche Fertigung und auf gesteuerte Testvorfahren sichern eine optimale Qualität und Zuverlässigkeit unseres Gerätes.

Linear geregelter Netzteil

Diese Stromversorgungen werden durch einen 50 Hz (60 Hz)-Trapezgenerator desgleichen als einer der beiden Teil der Leistung in Wärme umgewandelt, dementsprechend liegt der Wirkungsgrad nur zwischen 50 und 50%. Die diegesetzten Bauteile (Transformator, Kühlkörper u.a.) bewirken, dass linear geregelter Netzteil größer und schwerer ausfallen als 2. Schaltnetzteil.

Schatzschutz in MOS-Technologie für den Einsatz in 19"-Baunippelträger nach DIN 41494 Teil 5

Prinzipschaltbild

Derating-Kurve

Eingangsgrößen

<table>
<thead>
<tr>
<th>Eingangsgrößen</th>
<th>Wirkungsgrad (bei Vollast)</th>
<th>Ausgangsgrößen</th>
<th>Regelgrößen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eingangsspannung</td>
<td>24 V DC (10 - 30 V) bzw. 48 V DC (24 - 72 V)</td>
<td>&gt; 75 %</td>
<td>Ausgangsspannung, einstellbar: 15 V ± 1 V</td>
</tr>
<tr>
<td>Ausgangsstrom</td>
<td>4 A</td>
<td></td>
<td>24 V ± 2 V</td>
</tr>
<tr>
<td>Laststrom</td>
<td>&lt; 0,1 mA</td>
<td></td>
<td>Ausgangsspannung einstellbar: 15 V ± 1 V</td>
</tr>
<tr>
<td>Spannungsabnahme</td>
<td>0,2 mA</td>
<td></td>
<td>Netzregelung (Un): ± 0,1 %</td>
</tr>
<tr>
<td>Schutz- und Kontrollanschlägen</td>
<td></td>
<td></td>
<td>0,5 V</td>
</tr>
<tr>
<td>Begrenzung Ausgangsstrom</td>
<td></td>
<td></td>
<td>Prüffach: 2,5 kW</td>
</tr>
<tr>
<td>Begrenzung Ausgangsspannung (OVP): 15 V ± 2 V</td>
<td></td>
<td></td>
<td>Sekundär: 1,5 kW</td>
</tr>
<tr>
<td>Begrenzung Einseitigstrom</td>
<td></td>
<td></td>
<td>Erde: 0,5 kW</td>
</tr>
</tbody>
</table>
| Netzanschluss: Prüffach: 4,3 A | | | | Sicherheit
| | | | | Leistungseingang nach VDE 0871, Kurve B (150 kVA - 30 MVA) |
| | | | Betriebegrößen | Funkentstörung |
| | | | Max. Umgebungstemperatur | Funkentstörung nach VDE 0871, Kurve B (150 kVA - 30 MVA) |
| | | | Leistungseingang nach Diagramm | Leistungseingang nach Diagramm |
| | | | Lagertemperatur | Leistungseingang nach Diagramm |
| | | | Stabile, schwarze zweiseitige Kassetten mit rückwärtiger Kühlkörper und profiliertem Gufdachanschlag | Leistungseingang nach Diagramm |
| | | | Kompatibel zu 19" Einschubtechnik nach DIN 41494, Teil 5 | Leistungseingang nach Diagramm |
| | | | Gewicht ca. 350 g | Leistungseingang nach Diagramm |

Lieferung

<table>
<thead>
<tr>
<th>Bezeichnung</th>
<th>Beschreibung</th>
<th>Bestellcode</th>
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</thead>
<tbody>
<tr>
<td>MONOVOLT GK 60/24 V DC mit Steckverbindern Bauform H15</td>
<td></td>
<td>116-33393L</td>
</tr>
<tr>
<td>MONOVOLT GK 60/48 V DC mit Steckverbindern Bauform H15</td>
<td></td>
<td>116-33394L</td>
</tr>
<tr>
<td>DIN 41612 Bauform H15</td>
<td></td>
<td>017-144001</td>
</tr>
</tbody>
</table>

*Lieferung mit Steckverbindern Bauform H15 auf Anfrage
Single Board Computer Component Layout
EMERGENCY TELEPHONE SYSTEM
TELEPHONE CONTROLLER (LOGIC CCTS.)

LINK: CS2 TO CS
AND CS1 TO PSEL CS
OR
CS TO PSEL CS FOR OTHER BOARD

FOR FULLY POPULATED BOARD
Telephone Controller Board Component Layout
EMERGENCY TELEPHONE SYSTEM
TELEPHONE CONTROLLER (ANALOGUE)
EMERGENCY TELEPHONE SYSTEM
CABINET TAG BLOCK INFORMATION

TAG BLOCK A TO CONSOLE: CARRIES MIMIC, OPERATOR TELEPHONE CONNECTIONS AND +5V & 48V FOR MIMIC

TAG BLOCK B TO DISTRIBUTION BOARD: FOR ALL TELEPHONES TO ALL FLOORS OF MAIN & PODIUM TOWER BLOCKS.

TAG BLOCK C SPARE

NOTE 1: POWER CABLE TO PAIX; GOV FUSE ON MC RACK 2 IN PAIX
NOTE: LEDS IN ROW 0 - ROW 2 ARE GREEN.
LEDS IN ROW 3 - ROW 5 ARE RED.
TRANSISTORS:
PnP - TI 2.7
NPN - 2N2180

MIMIC
Multiplexer Monitor Board Component Layout