THE GAIN OF DIGITAL MULTIPLEXING A CASE STUDY OF NIGERIAN TELECOMMUNICATION LIMITED (NITEL) MINNA.

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A PROJECT SUBMITTED TO THE DEPARTMENT OF MATHEMATICS/COMPUTER SCIENCE, IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF A POST GRADUATE DIPLOMA IN COMPUTER SCIENCE OF THE FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE

CERTIFICATION

I Certify that this project work was carried out by Mr IRIELE ALIONYE LEONARD Mathematics and Computer science is filly adequate in scope and quality as a project for the award of Post Graduate Diploma in Computer Science of the Federal University of Technology, Minna.

_____ _____

Prof. K.R. Adeboye Date

Supervisor

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Dr S. A. Reju Date

Head of Department

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External Examiner Date

ACKNOWLEDGEMENT

This is again another academic achievement by me. First and foremost, I am grateful to God Almighty, who has always been guiding me in every steps of my life till date.

Special thanks goes to my Supervisor Professor K.R Adeboye who through his co-operation made this work a success.

In fact, working under his supervision has changed my attitude and interest (positively) towards research work.

My thanks also go to all the members of staff of Mathematics/Computer department of the university for their contributions in making me computer literate.

I am very much indebted to my sister Mrs Roseline Iwuh who financed this research work.

DEDICATION

This project work is solely dedicated to God Almighty. The author and finisher of all things

ABSTRACTS

In a telephone communication network, trunk calls are possible only with the availability of a multiplex system. Before 1991,NITEL Minna was making use of FDM, which has problems like; low separation, interference and cross talk associated with it. As a result of these problems associated with FDM, in 1991 NITEL adapted Digital Multiplex Systems, which disassociates with these problems. Even with the introduction of this Digital Multiplex System, the subscribers are still complaining of a recording "All trunks are busy please call later" which adversely affect their trunk call seizure. A research was conducted and the result proved that the recording was misleading and that the aim of digital multiplex is being achieved by the organisation while the subscribers are kept in the dark about the resources of digital multiplex. The management of the organisation was advised to enlighten the subscribers on the resources of the digital multiplex system and also employed qualified personnel to maintain her regenerative repeaters.

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CHAPTER ONE

1.0 INTRODUCTION TO NITEL COMPANY

1.1 A GENERAL OVERVIEW OF NITEL

The Nigerian Telecommunications Limited (NITEL) came into existence in 1985 as a result of the merger of the defunct Nigerian External Telecommunications Limited (NET) and the Telecommunications section of the former Post and Telecommunications Department (P&T) of the Ministry of Communications services provision, the post section of the P&T which eventually became the Nigerian Postal Services is responsible for Postal Services within and outside Nigeria.

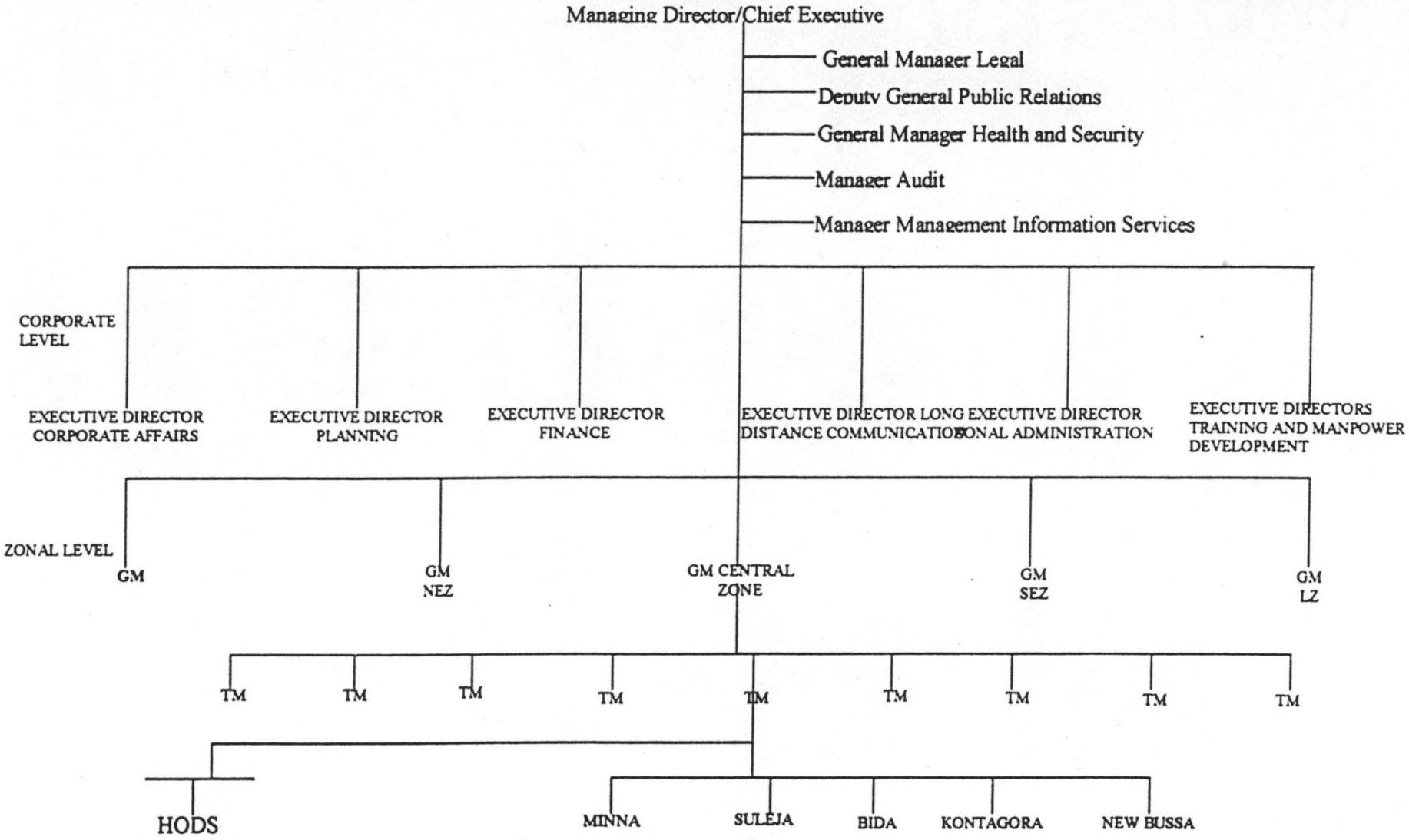
The company, which started in 1985, has staff strength of about seventeen thousand. NITEL has three tiers of management namely the corporate Administration, the Zonal Administration and the Territorial Administration at the state level. The corporate Headquarters is at Abuja. The Company has six zones scattered all over Nigeria. The zones are North West Zone with headquarters at Kaduna, North west zone with headquarters at Bauchi, South west zone with headquarter at Ibadan, South East zone with head headquarters at Enugu, Lagos zone with headquarters at Lagos and lastly central zone with headquarter at Abuja.

At the state level, each state has a territorial Administration with the Territorial Manager overseeing the activities in the territory. Presently, we have thirty-eight(38) Territorial Administrations in NITEL according to the number of states including the Federal Capital Territory (F.C.T) with Lagos having two.

On the broad base, NITEL is divided into six functional areas of operation namely corporate affairs division, planning division, finance/budget division, Long distance communication division, zonal administration division and personnel training and manpower development division. It is worthy of note that all these functional areas work

harmoniously together for effective communication services within and outside Nigeria. In order to have a hitch-free operation, the Managing director/chief Executive (MD/CE) sits at the corporate headquarters and oversees the activities in each division with the aid of the different Executive Directors (EDS).

A pictorial view of NITEL organizational set up will be able to show the different divisions and departments at a glance in order to have a total view of NITEL management. It is necessary to note also that each division which are subdivided into many departments cannot be represented in this pictorial view.


Managing Director/Chief Executive
General Manager Legal
Deputy General Public Relations
General Manager Health and Security
Manager Audit
Manager Management Information Services
CORPORATE LEVEL
EXECUTIVE DIRECTOR CORPORATE AFFAIRS
EXECUTIVE DIRECTOR PLANNING
EXECUTIVE DIRECTOR FINANCE
EXECUTIVE DIRECTOR LONG DISTANCE COMMUNICATIO
EXECUTIVE DIRECTOR ONAL ADMINISTRATION
EXECUTIVE DIRECTORS TRAINING AND MANPOWER DEVELOPMENT
ZONAL LEVEL
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HODS
MINNA
SULEJA
BIDA
KONTAGORA
NEW BUSSA

1.2 SERVICES PROVIDED BY NITEL

The word Telecommunication simply means, distant communication. This implies that with telecommunication facilities, people at distance places can communicate with one another. This distant communication may be for business or otherwise. The possibility of this distant communication has turned the world into a global village where distance is no longer considered NITEL is a leading Telecommunications services provider in Nigeria and her services cover both National and International horizon.

The service provided by the company includes the following.

1 Telephone Services- under these services, NITEL provides public telephone whereby an individual in any part of Nigeria can get in touch with another. Also using the International Direct Dialing (IDD) facilities a subscriber in Nigeria can call any body in a foreign country. The company also provided public pay phones or card phones where people who cannot won their own telephone lines or people who are far from their own telephone lines can with the aid of their phone cards enjoy telephone services.

2 Another group of services provided by NITEL is the Telex services. Under this group of services, printed documents can be sent from one end to another using the telex machine, which transmit the text in signal form over the transmission Network. Furthermore we have domestic telex, international Telex and Telex Delivery services (TDS) in this class of service provision.

3 Telegraph services:-This is slightly different from services provided under telex. While telex signal is being received instantly as it is being sent, the telegraphic message may not necessarily be received at the instant of transmission. Also telegraphic messages are charged according to the number of words contained in the messages whiles telex charge depends upon the time taken to transmit the whole information along the transmission medium. The services included in this

class are domestic telegraphy, international telegraph and registered telegraphic address (RTA).

4 Specialised services:- This include leased circuits whereby a non-telecommunication company leases some circuits or trunks from NITEL for her private communication usage. NITEL provides also transmission and reception of real time messages. The company also provides television signal for network programmes.

5 Other services provided by the company are voice cast and press reception, public facsimile (FAX) services; training of telex and telephone operators are extended to other establishment at agreed fee by the company.

6 Newly introduced services by NITEL management are Data Switching System, Electronic Mail, world/Data processing, Teleconferencing, International Card Payphone.

NITEL is a dynamic organization and thus her volume of services will continue to increase as technology improves.

1.3 STATEMENT OF THE PROBLEM

Before 1991, subscribers in Minna Local exchange area refer to trunk calls as "trunk calls with tears". This name was as a result of the problems they encountered with trunk calls, which are low seizure rate, cross talk and high noise. These problems are understandable as they are problems associated with analogue multiplexing system, which was in use then. These problems had adverse effect on the revenue generation of the company.

To overcome this problem, the organization changed to digital multiplexing in 1991. This time again, the subscribers refers to trunk calls as "All trunk are busy please

call later". This is a recorded message they hear most time they try to initiate a trunk call and once this is heard, trunk seizure is not possible.

The technical meaning of this recorded message is that all the time slots are occupied but a practical check on the channels proves this not to be true most time. The low seizure rate, which is as a result of this recorded message, has a negative effect on the revenue generation of the company and contradicts the theoretical gains of digital multiplexing. As a result of negative effect of this recorded message to both the subscriber and the organization, this research becomes necessary so that suggestions and recommendation could be made in the area of solving it.

1.4 PURPOSE OF STUDY

With the problems stated in the statement of the problem (1.3), the purpose of the study is to ascertain whether the theoretical gains of digital multiplexing are being achieved in Minna Local Exchange Area of NITEL.

1.5 SCOPE AND LIMITATION OF STUDY

This study is limited to Minna local telephone exchange area of Nigeria Telecommunication Limited (NITEL). One hundred telephone subscribers are randomly selected. The reaction of this sample is used to represent the reaction of all the subscribers to Minna local telephone exchange area.

Since the study is being focused on the gains of digital multiplexing, subscribers who procured their telephone lines before 1991 are most targeted and also the generation of the organization between 1986 and 1996 are considered since the organization installed digital multiplex in 1991.

1.6 DEFINITION OF TECHNICAL TERMS

Telephone subscriber:-This is a person who subscribe to the usage of telephone services in a given town.

Telephone Exchange Area:- This is an area of coverage of a telephone exchange.

Telephone line:- A pair of wire linking the subscriber to the telephone exchange equipment.

Trunk Call: Communication between subscribers in different cities which relatively far and must involve the dialing of city code.

Radio Transmission: The transmission of radio signals over a long distance using the space as a medium of transmission.

Radio Transmission Room:- A building in which radio transmission equipment is housed for the purpose of communicating with subscribers over long distance. It is often call carrier room by NITEL management.

Multiplexing Equipment: equipment, which translates subscribers signal or intelligence from one level of low strength to another level of higher strength so that the signal can be transmitted over a long distance.

Audio frequency: Signals level which is low enough for the human ears to detect. It is between 0.3 to 3.4KHZ.

Radio Frequency:- Any Frequency whose level in above the human hearing that is above 3.4KHZ.

Analogue signal:- A continuous representation of a continuous event.

Digital signal:- This represent message consisting only of signals from a single repertoire. It is discreet in time and value and consists of series of signal elements.

Echo: This is caused by reflection at the listener's hybrid circuit. It can interfere with conversation over long distance lines, especially when satellite and long marine cable connections are used.

Time slot: The time interval within which a PCM is transmitted is known as time slot.

Pulse Frame: This is a bit train containing one PCM word from every input signal.

Digital time slot: This is a time slot allocated to a signal digit.

Plesiochronous: Two signals are Plesiochronous if their corresponding significant instants of occurrence are the same. In most case they actually vary but within a specified limit.

Significant instant: This is the transition point from one signal to the next in digital signal.

Synchronous: Two information or timing signals are synchronous if their corresponding significant instants coincide or have a desired phase relationship. All clock generators in a synchronous network operate at the same rate.

Channels: A medium for transmitting data in one direction in time-division multiplex systems. In a time-division multiplex signal a channel is formed by cyclically repeated time slots. In the case of digital signals a time slot of channel may carry a code element or a PCM word. A channel is often wrongly called a time slots.

Channel time slot: A time slot starting at a particular phase in a pulse frame and allocated to a channel for transmitting a PCM word and possibly un-slot signaling or other information.

Decision value: A signal amplitude forming the boundary between adjacent quantization intervals.

Code: Specifies how the signals of a signal repertoire are assigned to the signals of another signal repertoire.

Codec: An assembly comprising an encoder and decoder in the same equipment.

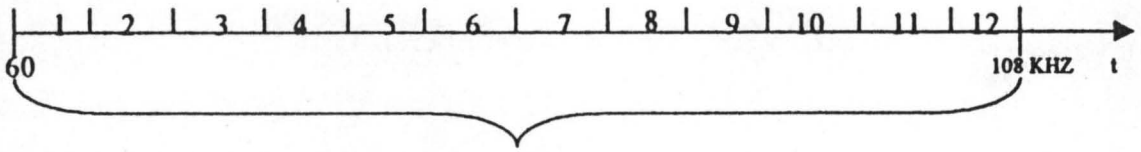
CHAPTER TWO

2.0 THE MULTIPLEX SYSTEM

2.1 INTRODUCTION TO MULTIPLEXING

When telephone communication began individual connecting paths were used i.e a separate pair of wires was used for every telephone connection. This was known as space-division multiplexing (SDM) on account of the fact that multitude of lines was arranged physically next to each other. Since a large proportion of capital is invested in the line plant, efforts were made at an early stage to make multiple uses of at least those lines used for long-range communications. This lead to the introduction of frequency division multiplex (FDM). This involves subdividing a wide frequency band into narrower sub-bands. Fig 2 shows a 48KHZ band subdivided into 12 sub-bands. The sinusoidal signal of a sub-band (carrier) is modulated by a telephone signal. Since a sinusoidal signal acts as the carrier for a telephone signal this process is known as carrier transmission following demodulation on the receive side the telephone signals are again available at their original frequencies FDM is still a commonly used, economically-viable technique.

FDM is not the only way of making multiple use of lines however. Another possibility is offered by time-division multiplex (TDM). Here the transmitted telephone signals are separated in time. Fig. 3 shows a period containing 32 time slots. This subdivision is repeated every 125 μs in consecutive periods. One time slot in each of the consecutive periods is allocated to each telephone signal.



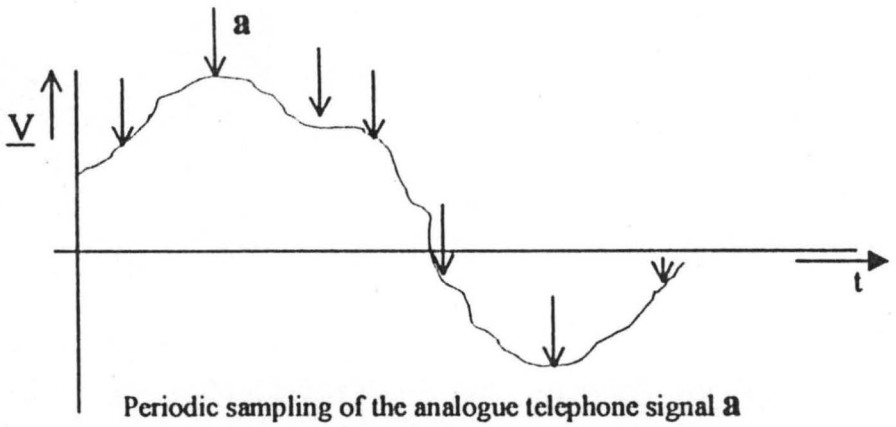
Frequency Band
Sub-divided into 12 sub-bands each of 4KHZ

Fig 2 FDM

Fig 3 TDM

The principle of time division multiplex is based on the theory that a complete waveform is not required in order to transmit signals. Such as those encountered in telephony. It is sufficient to sample the waveform at regular intervals and to only transmit these. When a waveform is sample, a transverse short pulse is produced. The amplitude of each pulse represents the amplitude of the waveform at the specific sampling instants. This conversion is known as pulse amplitude modulation (PAM). The envelope of the PAM signal reflects the original form of the curve (see fig 5).

Relatively large intervals occur between each sample. These intervals can be used for transmitting other PAM signals, i.e. the samples of several different telephone signals can be transmitted one after the other in repeated cycles. When the pulse of several PAM signals are combined they form a PAM time division multiplex signal (see fig 6).



Periodic sampling of the analogue telephone signal **a**

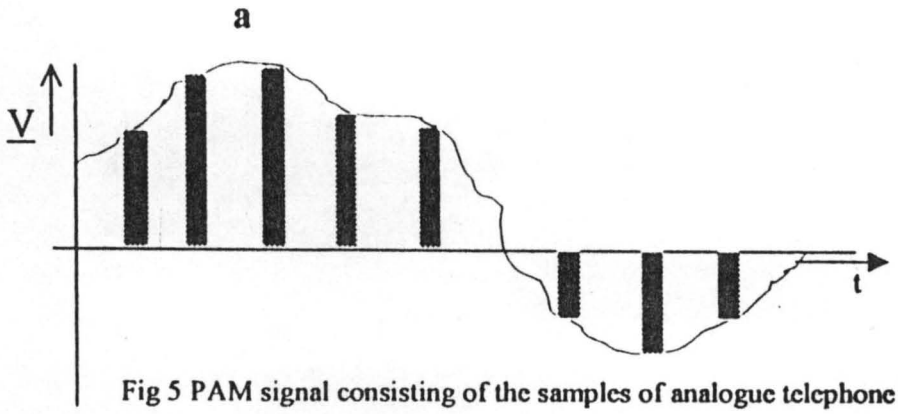


Fig 5 PAM signal consisting of the samples of analogue telephone signal a

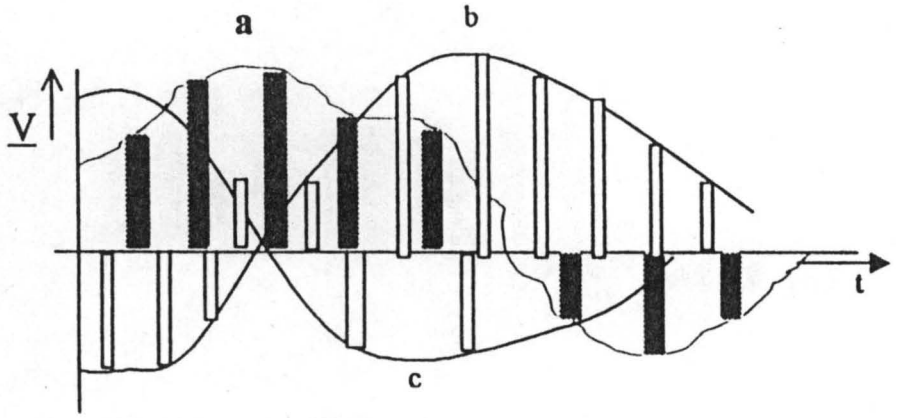


Fig 6 PAM signal consisting of the samples of analogue telephone signal a

If the waveform samples i.e. the pulse with different amplitudes, are converted to binary character signals, the term pulse code modulation (PCM) are used. During this process the pulse like samples are quantized and coded- 8 bits are normally used. When the PCM signal of several telephone signals are inter leaved they produce a PCM time-division multiplex signal.

PCM time division multiplex signals permit the multiple use of lines. Moreover owing to the digital nature of the information, PCM signals are much less sensitive to interference than are analogue signals.

2.2 MULTIPLEX AND TRUNK CALLS

Multiplexing is the interleaving of signals of different sources in order to form a common signal with a strength correspondingly higher than the original signals. On the system receiving side the appropriate signals are re obtained from the sum signal at the original levels.

Communication between subscribers in different cities, which are relatively far and must involve the dialing of city code, is called trunk calls.

In Radio transmission room, there are different multiplex equipment facing different cities. Likewise in the telephone exchange room, there are exchange equipment aligned to these multiplex equipment.

When two or more subscribers dial a common city code (i.e. initiating a trunk call), the telephone exchange equipment recognizes the city code and switches them to the corresponding multiplex equipment in the radio transmission room.

In the case of NITEL Minna, the multiplex equipment is PCM 30. Each PCM 30 has a capacity of 30 channels, which implies that it can accept a maximum of 30 subscribers at a time. In the Radio transmission room, more than one PCM 30 faces each direction.

When the subscriber's signal reaches the multiplex equipment, they are interleavened to produce an output of 2048kbit/s. This outputs of the multiplex equipment is fed to the Radio equipment, which transmits via terrestrial microwaves to the distant city.

At the distant city, the 2048kbit/s signal is received by a radio receiver which send it to the multiplex equipment for demodulation. The 2048kbit/s signal is here separated into their equivalent channels for transmission to the telephone exchange equipment. The telephone exchange equipment now identifies the called subscriber's numbers and connects them via cable network(see fig 7).

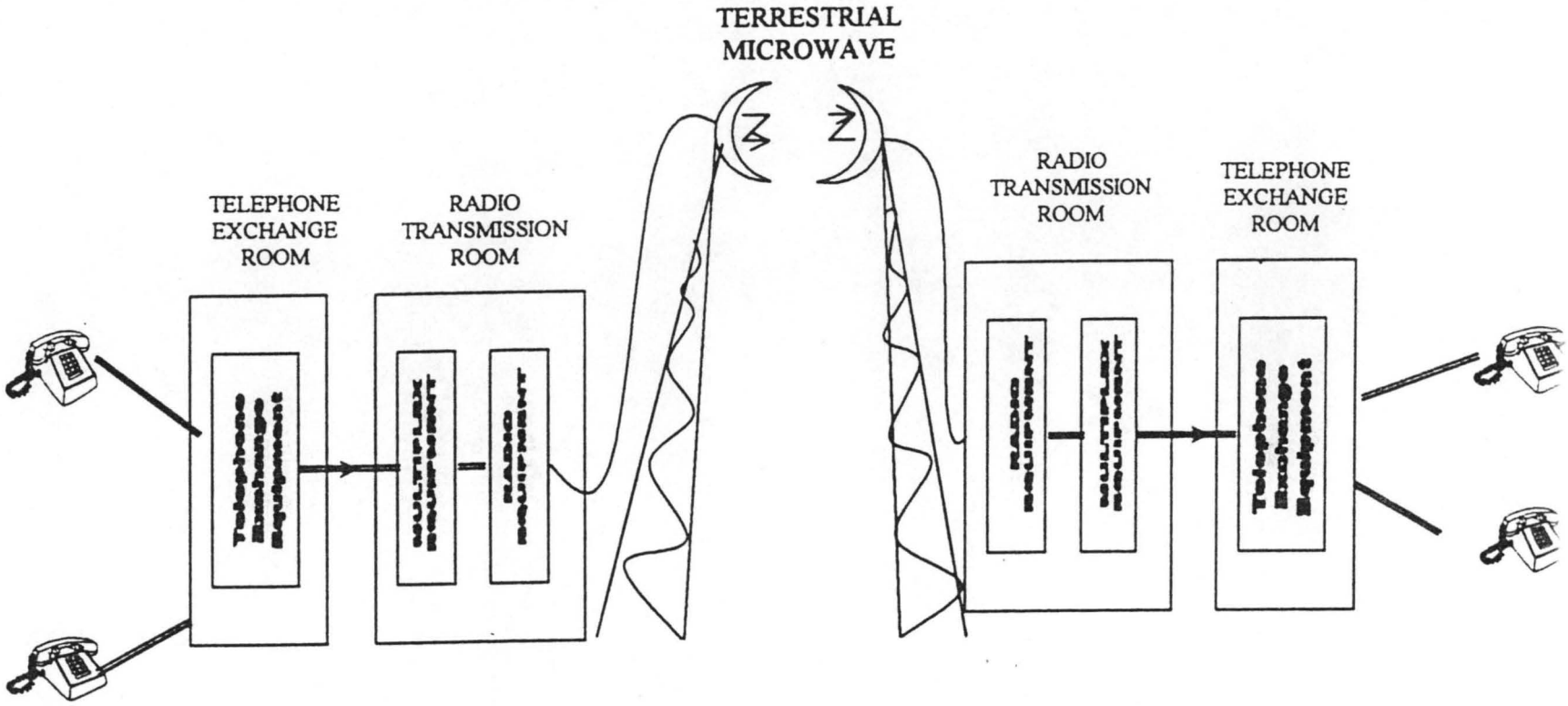


FIG 7 TRUNK CALL SEQUENCE AND THE MULTIPLEX

2.3 GAINS OF DIGITAL MULTIPLEXING

Progress in recent years in semiconductor technology has made digital multiplexing economically attractive telephone switching equipment. It has thus become possible to replace the "analogue" switching equipment used up to now with fully electronic "digital telephone system.

Digital multiplex system offers the following advantages over analogue multiplex systems.

- Digital technology used throughout the system produces high noise immunity.
- Multiple use of lines and exchange equipment
- Separate digital channel for each speech direction right up to the subscriber. This create more favourable conditions for facilities such as those required for hands- free operation and also eliminates cross talks.
- Low space requirements
- Switching network with high traffic capacity, and negligible internal blocking (high seizure rate).
- A signaling channel is always available in both directions between the telephone and the public exchange.

Feature such as calling subscriber number display (CID), letter box functio, conferencing facilities, call waiting facilities, etc will thus be possible in the all digital network of the features.

CHAPTER THREE

3.0 DIGITAL MULTIPLEXING

3.1 FUNDAMENTALS OF PULSE CODE MODULATION (PCM)

3.1.1 SAMPLING THEOREM

The sampling theorem is used to determine the minimum rate at which an analogue signal can be sampled without information being lost when the original signal is recovered. The sampling frequency (FA) must be more than twice the frequency contained in the analogue signal (Fs).

FA > 2FS

3.1.2 ANALOGUE TO DIGITAL CONVERSION

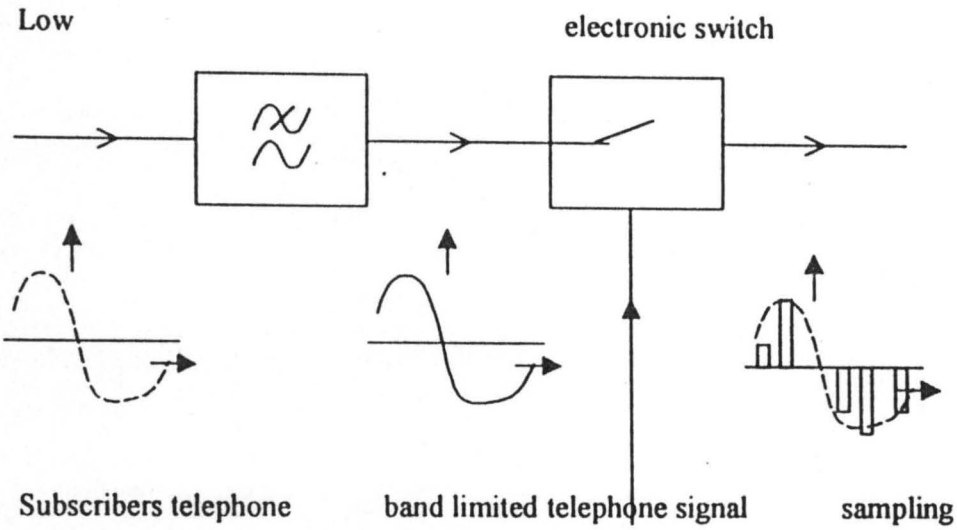
3.1.2.1 SAMPLING

A sampling frequency (FA) of 8000Hz has been specified internationally for the frequency band (300 HZ to 3400HZ) used in telephone systems that is the telephone signal is sampled 8000 times per second. The interval between two consecutives samples from the same telephone signal (sampling interval = TA) is calculated as follows

$$T_A = \frac{1}{F_A} = \frac{1}{8000HZ} = 125\mu s$$

Fig 8 shows how the telephone signal is fed via a low pass filter to an electronic switch. The low pass filter limits the frequency band to be transmitted; it suppresses frequencies higher than half the sampling frequency. The electronic switch is driven at the sampling frequency. The electronic switch is driven at sampling frequency of 8000HZ and takes samples from the telephone signal once every 125μs. A pulse amplitude modulated signal is thus obtained at the output of the electronic switch.

Fig 8 Generation of a PAM signal



$$TA=\frac{1}{TA}=125\mu s$$

3.1.2.2 QUANTIZATION

The pulse amplitude modulated signal (PAM signal) still represents the telephone signal in analogue form. The samples can, however, be transmitted and further processed much more easily in digital form. The first stage in the conversion to a digital signal in this case a pulse code modulated signal (PCM signal) is quantization. The whole range of possible amplitude value is divided into quantizing intervals. The number of bits that is used as a word in the system determines the number of quantizing intervals and it is determined by the telecommunication law in use in the country.

The telecommunication laws are as follows

A-law:- Law for specifying the 13-segment characteristics for non-uniform quantizing in PCM codes. Recommended by the CCITT for PCM 30 transmission system .

μ-law:- law for specifying the 15 segment characteristics for uniform quantizing in PCM codes. Recommended by the CCITT for PCM 24 transmission system.

NITEL uses the A-law which has the following characteristics:-

(a) Sampling frequency = 8KHZ

(b) Number of samples per telephone signal = 8000/s

(c) Pulse frame period = $1/8000 = 125\mu s$

(d) Number of bits in PCM word = 8 bits

(e) Bit rate of telephone channel = 8000/s . 8bit = 64 kbits/s

(f) Number of channel time slots per pulse frame = 32

(g) Number of bit per pulse frame = 8 bit.32 = 256 bits

(h) Period of an 8 bit channel time slots = $\frac{125\mu s \bullet 8}{256} = 3.9\mu s$

(i) Bit rate of time division multiplex system (IDM) = 8000/s.256 = 204kbits/S

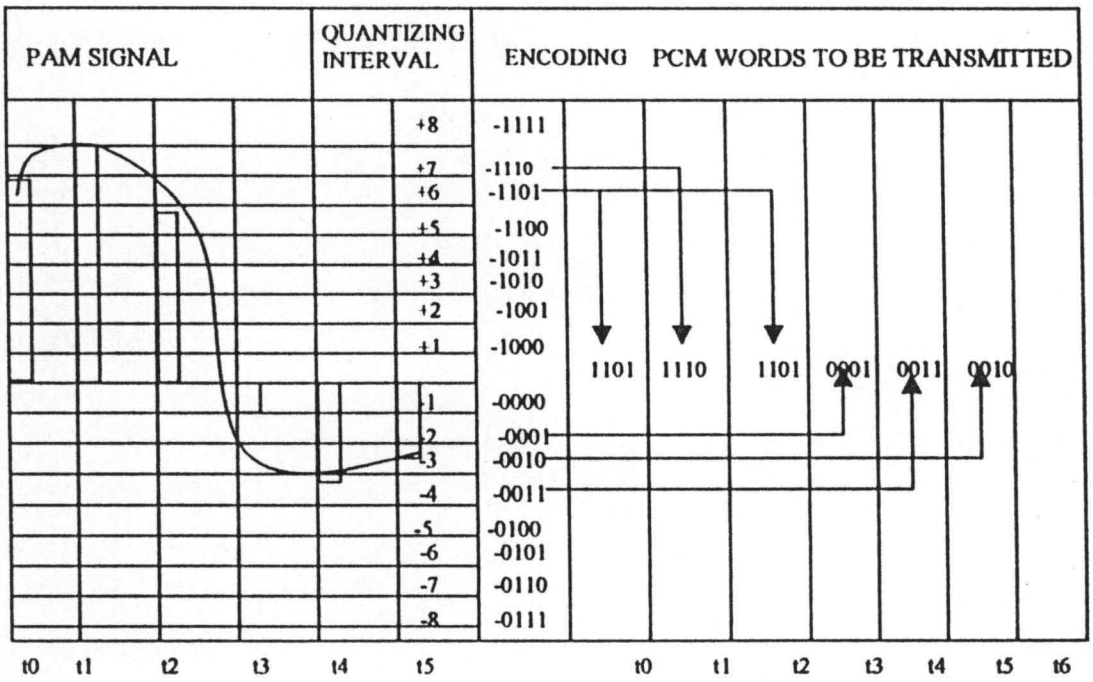
As earlier stated that the number of bits used as word determines the number of quantizing intervals. In this case, 8 bits is being used which implies that the number of quantizing intervals will be 2^8 which is equal to 256. If it is 4 bits per word, the number of quantizing interval will be 2^4 which is equal to 16. Decision values form the boundaries between adjacent quantizing intervals.

On the transmission side, therefore, several different analogue values fall within the same quantizing intervals. On the receive side one signal value, corresponding to the midpoint of the quantizing interval is recovered for each quantizing interval. This causes small discrepancies to occur between the original telephone signal samples on the tranmission side and the recovered values. The discrepancy for each sample can be up to half a qnautizing interval. The qnatizing distortion which may arise on the receive side as a result of this manifests itself as noise superimposed on the useful signal. Quantizing distortion decreases as the number of quantizing intervals are increased. If the quantizing intervals are made sufficiently small the distortion will be minimal and the noise imperceptible. If large quantization intervals are used over whole amplitude range, relatively large discrepancies will occur in the case of small signal amplitudes. These

discrepancies might be of the same order of magnitude as the input signal themselves and the signal-to-quantization noise ratio would not be large enough. For this reason 256 unequal quantizing intervals are therefore used in practice. For convenient, fig 8 below show non uniform quantizing of the samples of an analogue telephone signal using 16 equal quantizing intervals.

3.1.2.3 ENCODING

The PCM signal to be transmitted is obtained by encoding the quantizing intervals. The electronic encoder allocates an 8 bit PCM word to each individual sample, this PCM work being associated with the determined quantizing interval. An 8-bit binary code is used for the 128 positive and 128 negative quantizing intervals ($128+128=256=2^8$); the PCM words therefore have 8-bits. The first bit of all PCM words used for the positive quantizing interval is a "1", the first bit of all PCM words used for the negative quantizing intervals is a "O".



3.1.2.4 MULTIPLEXING

The 8-bit PCM word of a number of telephone signals can be transmitted consecutively in repeated cycles: A PCM word of all other telephone signals arranged in consecutive order. This creates a PCM time-division multiplex signal. The process involved in multiplexing are carried out fully electronically. Fig 10 shows the principles involved using four input signals sampled sequentially by switch A. Switch A moves from one input to the next, synchronous with the incoming PCM word train. The PCM time-division multiplex signal is then available at the output of switch A. The time interval within which a PCM word is transmitted is known as a time slot. A bit train contains one PCM word from every input signal is known as pulse frame.

In the example shown in fig 10 a pulse frame consists of 4 consecutive PCM words, one PCM word being from each of the input signals S1 to S4. In the PCM 30 transmission system which is being used by NITEl, the pulse frame consists of 32 PCM words.

3.1.3 DIGITAL TO ANALOGUE CONVERSION

3.1.3.1 DEMULTIPLEXING

On the receive side the individual PCM signals are recovered from the time-division multiplex signal, i.e. the 8-bit PCM words are distributed to the appropriate outputs as with the multiplexing process on the transmit side, the demultiplexing processes are controlled fully electronically. Fig 10 shows the principle involved using switch B, which, synchronized with switch A, distributes the PCM words to the 4 outputs.

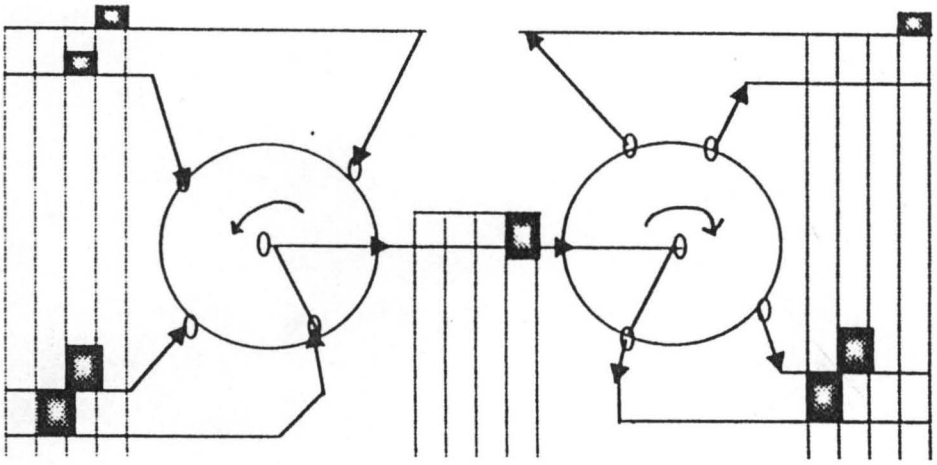


Fig. 10 Multiplexing and Demultiplexing principles

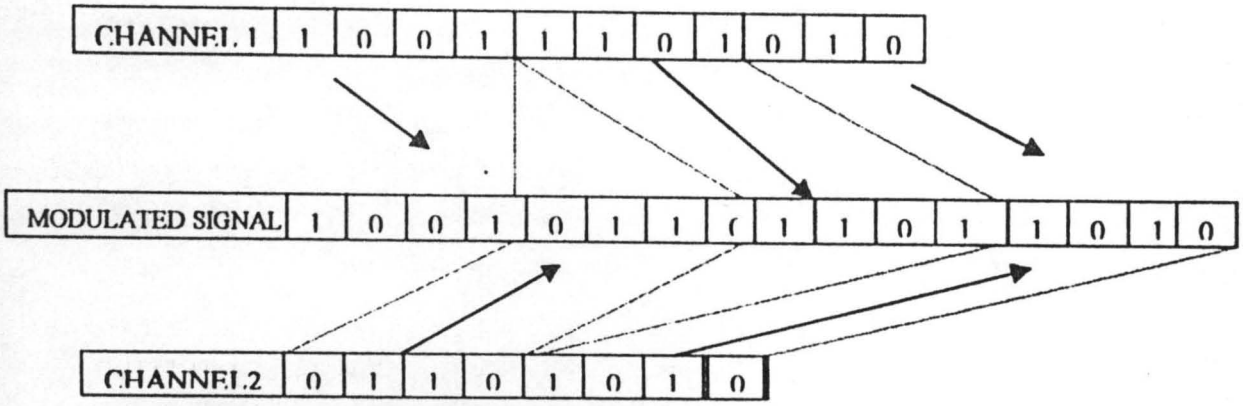
3.1.3.2 DECODING

On the received side, signal amplitude Vout is allocated to every 8-bit PCM word. It corresponds to the mid-point of the particular quantizing interval. The characteristics for decoding is the same as that for non-uniform encoding on the transmit side. The PCM words are decoded in the order in which they are received and converted to a PAM signal. Finally the PAM signal is fed to a low-pass filter, which reproduces the original analogue telephone signal.

3.2 METHODS OF DIGITAL MULTIPLEXING

3.2.1 CODE WORD INTERLEAVING

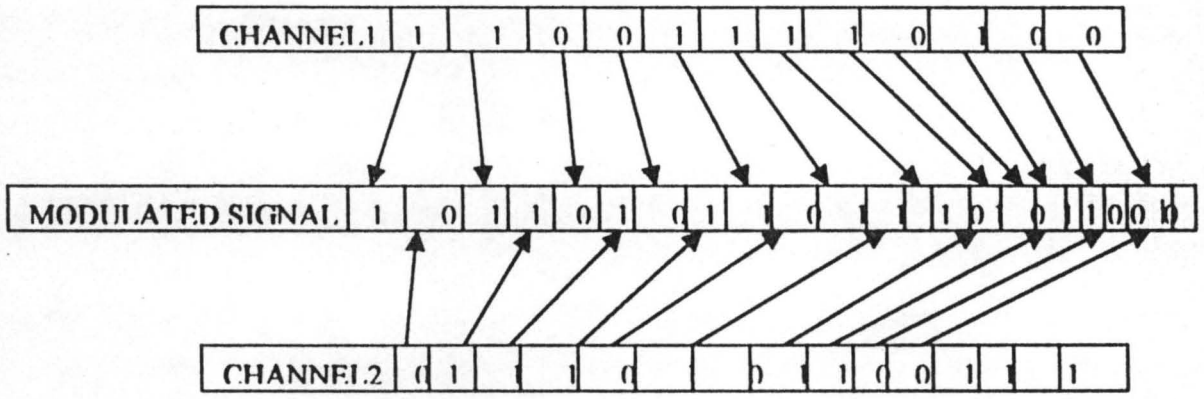
In this method, code word of individual separate signals (i.e. bit combinations having some kind of relation between each other) are arranged one after the other in a time sequence. Such is the case for generation of a 2-Mbits/s signal, when 8-bit binary words of the coded PCM voice channels are transmitted sequentially in 125μs cycles.



This figure shows the code word interleaving of two separate signals with a word length of four bits

3.2.2 BIT-BY-BIT INTERLEAVING

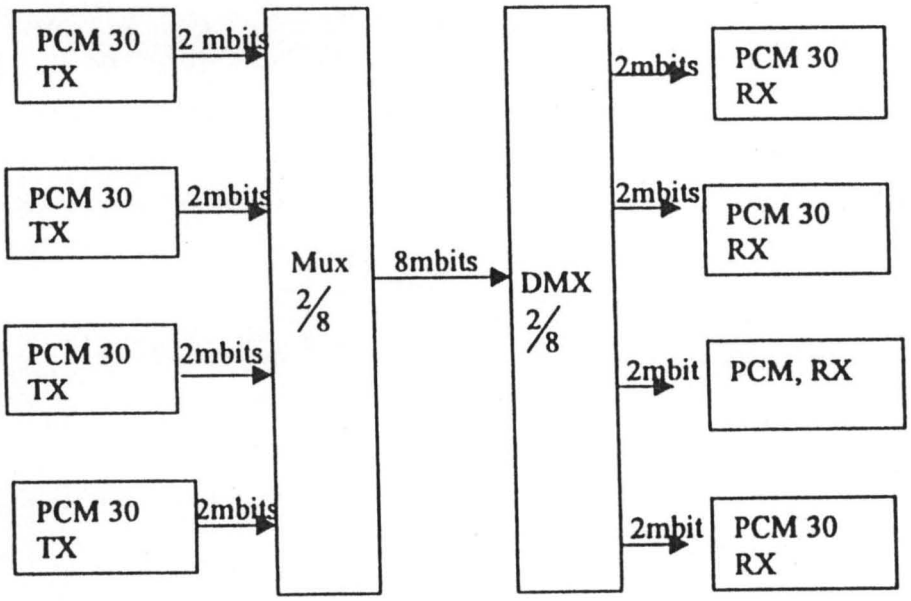
This method is used for all systems beyond the 2-Mbit/s hierarchy. Here a cyclic transmission sequence is applied, where only one bit of each separate signal is transmitted. This means that the signal of a certain multiplexers input appears only in every fourth bit of the sum signal.



3.3 APPLICATION OF DIGITAL MULTIPLEXING

Digital multiplexes are applied wherever a high transmission capacity with effective use of transmission paths has to be realized.

The basic idea of multiplexing is the time-interleaving of digital signals of different sources in order to form a common signal with a bit rate which is correspondingly higher (multiplex process). On the system's receiving side the appropriate separate signals are re obtained from the sum signal (demultiplex process). This means that the original digital signals of the multiplexed signal sources are available again at the outputs of such a system.



The output signals of 4 PCM 30 are combined to a signal of 8-bit/s and transmitted via a common transmission path to the receiving side (multiplex procedure).

On the receiving side the signal is then distributed to the corresponding input of PCM 30 systems (demultiplexing procedure).

3.4 REGENERATIVE REPEATERS

Regenerative repeaters are installed on PCM transmission routes at intervals of about 2 to 5km. They generate the PCM signals in both directions, thus eliminating any distortion, which may be caused by external interference and the transmission parameters of the lines.

3.5 CHANGE OVER

The change over from an old to a new system may be made when:-

- The system has been proved to the satisfaction of the system analyst and other implementing activities have been completed.
- User mangers are satisfied with the result of the system tests, staff training and reference manuals.
- The changeover may be achieved in a number of way. The most common methods are:- Direct, parallel running, pilot running and staged changeover.

A DIRECT CHANGEOVER

This method is the complete replacement of the old system by the new, one move. It is a bold move, which should be under taken only when every one is planned, system tests and training should be comprehensive, and the changeover itself planned in detail. This method is potentially the least expensive but the most risky.

For security reasons, the old system may be held in abeyance, including people and equipment. In the event of a major failure of the new system the organization would revert to the old system.

B PARALLEL RUNNING

This means processing current data by both the old and new systems to cross check the results.

Its main attraction is that the old system is kept alive and co-operational until the new system has been proved for at least one system cycle, using full live data in the real operational environment of place, people, equipment and time. It allows the results of the new system to be compared with the old system before acceptance by the user, thereby promoting user confidence.

It's main disadvantage is the extra cost, the difficulty and (sometimes) the impracticability, of user stuff having to carry out the different clerical operations for two systems (old and new) on the time available for one.

C PILOT RUNNING

This is similar in concept to parallel running data from one or more previous periods for the whole or part of the system in run on the new system after results have been obtained from the old system, and the new results compared with the old. It is not as disruptive as parallel operation, since timing is less critical. This method more like an extended system, test but it may be considered a more practical form changeover for organizational reasons.

D STAGE CHANGEOVER

This involves a series of limited size direct changeover the new system being introduced piece-by piece. A complete part, or logical section, is committed to the new system while the remaining parts or sections are processed by the old system. Only when the selected part is operating satisfactorily is the remainder transferred.

This method reduces the risks inherent in a direct changeover of the whole system and enables the analyst and users to learn from mistakes made as changeover progresses.

Nitel Minna management , after studying all these changeover methods, and their inherent problems opted for direct changeover in 1991. Till date, the system is still working with no major failures.

CHAPTER FOUR

RESEARCH METHOD

4.1 INTRODUCTION

In this chapter, the procedure used in constructing the questionnaire for the study and how the research instrument, were administered are described. In order to achieve this, attention is directed on the following:-

(j) Population and sampling of the subscribers in Nitel Minna Local exchange area.

(k) Searching of Nitel Minna revenue generation records.

(l) The research instruments

(m) Administration of the research instruments

(n) Method of analysis

4.2 POPULATION AND SAMPLING OF THE SUBSCRIBERS IN NITEL MINNA LOCAL EXCHANGE AREA.

This study focused on Nitel Minna local exchange Area and its subscribers.

In order to have a thorough survey of the subscribers, one hundred (100) subscribers are randomly selected in the local exchange area and their reactions are seen as the reaction of the total number of the subscribers in the local exchange area.

4.3 SEARCHING OF NITEL MINNA REVENUE GENERATION RECORDS

The main purpose of searching Nitel Minna revenue generation records is to establish quantitative information (volume, frequencies, trends, rations). It will also help to establish how much reliance can be put on the estimate given by the staff or management of the department. It will also indicate whether the department objective which is increase in revenue generation being achieved..

4.4 RESEARCH INSTRUMENTS

The instruments used for the study are

(i) Record searching for Nitel Minna management

(ii) Questionnaire for subscribers in Nitel Mina local exchange area.

These instrument are designed in such a way that they could attract the relevant and sufficient information for the purpose of the study.

The record searching was targeted on the revenue generation of the organization five years analogue multiplexing and five years of digital multiplexing (1986 to 1996).

The subscribers questionnaires was divided into two sections: section one deals with personal data of the subscribers whole section two was specific on the purpose of the research.

4.5 ADMINISTRATIVE OF RESEARCH INSTRUMENT

The members of staff of the customer's engineering department of Nitel Ltd Minna cooperatively assisted in ensuring that their rewards are searched to ascertain their revenue generation within the required period.

Before conducting the record search, application was written to the Territorial Manager (Niger) by the researcher explaining the purpose of the research. But the permission of the Territorial Manager, the record search was made by the staffers of the section and data given to the researchers.

The distribution of the questionnaire was done personally by the researcher. Some subscribers treated the questionnaire immediately while others did that later before handing them over to the researcher.

After the administration of the scripts, data was collected. The analysis of the data are stated in the next chapter.

4.6 METHOD OF DATA ANALYSIS

Data obtained during the record search was put in two different tables. Table (1) was for the revenue generated during five years (5 years) use of digital multiplexing.

The sum total of the generated revenue in table (1) will be subtracted from that of table (2) and if it yields a positive difference, it means that the organization's purpose of installing digital multiplexing system which is increase in revenue generation is achieved otherwise, it is not achieved.

After collecting the questionnaire from the subscribers, the results are collected. These data are put in tabular form and the obtained frequencies converted to percentages.

These percentages will be used for determining the distribution of responses (accessibility of subscribers to resources of the digital multiplexing system).

If the positive response to any facility is less than forty percent (40%) of the sample, it is assume that the subscribers don't have access to such facility otherwise it is assumed they have.

At the end of the sampling, the total positive and negative responses to the digital multiplex resources are calculated.

If the total positive response is less that forty percent (40%) of the total samples, it is assumed that the subscribers in Nitel Minna local exchange area do not have access to the resources of the digital multiplex system otherwise, they have.

At the end of the sampling, the total positive and negative responses to the digital multiplex resources are calculated. If the total positive response is less than forty percent (40) of the total samples, it is assumed that the subscribers in Nitel Minna local exchange areas do not have access to the resources of the digital multiplex system otherwise they have.

By international Telecommunication Union (ITU) rules, any telephone line seizure that took more than five (5) trials is seen as being difficult. Hence in our analysis, if the total number of samples proved difficult seizure of less than forty percent (40%), it then implies that the subscribers are having easy seizure else they are not. Likewise, if less than forty percent (40%) of the samples proven noise level higher before 1991, it implies that digital multiplexing brought about a reduction in noise level else it did not.

CHAPTER FIVE

ANALYSIS OF DATA

5.1 THE PLACE OF REVENUE AND PROFIT IN BUSINESS

Revenue is an accrued income that comes to a company at the end of it's operation. Profit on the other hand, is a component of revenue or income generated.

PROFIT = INCOME LESS COST OF PRODUCTION

Therefore, the higher the income less cost of production, the higher the profit would be for an organization.

From the above analysis, it implies that the place of revenue and profit cannot be over emphasized in an organization like NITEL. It occupies a prominent position to enable the organization survive. In fact any organization not having profit as a priority can simply be called a charity organization.

NITEL as a telecommunication company has profit maximization as a priority and so she does everything within her reach in the telecommunication world to achieve this and that brought about the installation of digital multiplexing system in 1991

5.2 REVENUE GENERATED BY NITEL UNDER ANALOGUE MULTIPLEX SYSTEM.

Revenue is the main purpose of business thus it is necessary to compare the revenue generated five years (5 years) prior to 1991 when Minna multiplex system was analogue and five years (5 years) after 1991 when digital multiplex system took over. A comparison between the two systems (Analogue and Digital) in terms revenue generation will bring to light whether the company is achieving her purpose of installing digital multiplex which is increase in revenue generation.

The table below shows the revenue generated between 1986 to 1990 due to analogue system.

TABLE 1

Year	1986	1987	1988	1989	1990	Total
Number of lines	1000	1350	1500	1800	2,000	
Revenue per year in Nm	5.0m	7.5m	9.0m	15.5m	20.0m	57.0m

Source: NITEL customers operation Department Minna

5.3 REVENUE GENERATED AS A RESULT OF DIGITAL MULTIPLEX SYSTEM

Digital multiplex system was installed in Minna to enable compatibility with the digital exchange system in 1991. |This brought about easier connectivity. This easier connectivity attracted more subscribers to Nitel services and hence increase in revenue generations was experienced.

The table below shown the revenue generation between 1991 to 1995 which is five years (5 years) of digital multiplexing.

TABLE 2

Year	1986	1987	1988	1989	1990	Total
Number of lines	2300	2800	2850	2900	3,000	
Revenue per year in Nm	26.5m	45.0m	62.0m	70.2m	73.5m	277.2 m

SOURCE: NITEL CUSTOMERS OPERATION DEPARTMENT MINNA

The total generation in table 1 = N57.0

Total generated in table 2 N 277.2

Total generated in table 2 less than total generated in table 1 = N277.2 – N57.0m

N220.2m

This result proves that the installation of digital multiplex system actual brought about increase in revenue generation thus the organization's aim of installing the system is achieved.

5.4 ANALYSIS OF SUBSCRIBERS QUESTIONNAIRE

A = Call waiting facility

B = Call transfer facility

C = Conferencing facility

D = Locking facility (keyword)

E = Calling subscriber identification (CID)

TABLE 3

DIGITAL MULTIPLEX RESOURCES	A	B	C	D	E	TOTAL
Have the following facilities	15	2	0	60	1	78
Do you have the following facilities	85	98	100	40	99	422
TOTAL	100	100	100	100	100	500

ANALYSIS OF TABLE THREE

CALL WAITING FACILITY

From the table only fifteen percent (15%) of the subscribers have access to call waiting facility. This is less than forty percent (40%) of the subscribers of Minna Local exchange. It can then be assumed that the subscribers of Minna Local exchange do not have access to this facility.

CALL TRANSFER FACILITY

The table proved that only two percent (2%) of the subscribers have access to call transfer facility which implies that the remaining ninety eight percent (98%) of the subscribers do not have access to the facility. It can then be assumed that the subscribers of Minna local exchange do not have access to this facility.

CONFERENCING FACILITY

The table proved that no subscriber in Minna local exchange has access to this facility.

LOCKING FACILITY (KEYWORD)

The table proved that sixty percent (60%) of the subscribers have access to this facility while only forty percent (40%) don't. From this, it can be assumed that the subscribers of Minna Local exchange have access to locking facility.

CALLING SUBSCRIBER IDENTIFICATION (CID)

From the table, only one percent (1%) of the subscribers have this facility while the remaining ninety nine percent (99%) don't. It can therefore be assumed that the subscribers of Minna local exchange do not have access to this facility.

The total number of samples was five hundred (500) and of this only seventy eight which is just 15.6% is positive which the remaining four hundred and twenty two (422) or 84.4% in negative response. This implies that the subscribers in Minna local exchange do not have access to the resources available in the digital system.

All the subscribers testified that trunk seizure is better except when they hear "ALL TRUNKS ARE BUSY PLEASE TRY LATER" and that this message means no trunk seizure to them. They also confirmed that noise level was better after 1991. In fact their conversations are almost noise less after 1991.

5.5 SUMMARY ANDS RECOMMENDATIONS

A look at tables one and two that is before and after the installation of digital multiplex system by Nitel Minna, shows an increase in revenue generation as a result of the digital multiplex system. |This satisfies the purpose of installing the equipment which is profit maximization.

While the management is smiling to the bank, the subscriber's questionnaire confirmed reduced noise level and better trunk seizure as a result of this digital multiplex system but are left with two major problems, which are:

(i) In accessibility to the resources available in digital systems

(ii) "ALL TRUNKS ARE BUSY PLEASE CALL LATER" which adversely affect their trunk seizure.

"ALL TRUNKS ARE BUSY PLEASE CALL LATER" as the message reads, indicates trunk congestion but a practical check on the channels proves this to be false as most of them are often met empty.

The message supposes to read "OUR REGENERATING REPEATER IS FAILING PLEASE CALL LATER". It should be so because the message is generated as a result of regenerating repeater failures, which may be caused by either radio transmission, or power generating set failure in the regenerating repeater.

With all these attendant advantages of digital multiplex system, we recommend that all NITEL installations in Nigeria be installed with digital multiplex system to enable compatibility with the digital exchange systems. Also there should be an enlightenment campaign by the management to bring to the knowledge of the subscribers the resources available in the digital telecommunications systems. The management should also develop alternative routes for her telecommunication traffic so that when the regenerating repeater fails, the traffic could be re-routed hence avoiding the problem of "ALL TRUNK ARE BUSY PLEASE CALL LATER".

When these are done both the management of NITEL and her subscribers will have satisfaction being in telecommunication business.

8. Compare the noise level on your telephone conversation before 1991 and now

9. What does "ALL TRUNKS ARE BUSY PLEASE CALL LATER" mean to you?

10. Does this adversely affect the availability of service to you? Yes No

11. If it adversely affects the availability of trunk services to you, please give some suggestions for solving this problem.

BIBLIOGRAPHY

Bahdmus R.O (2000) "Handout on system analysis and design"

CCITT Recommendations

Series G.700, Recommendation G. 811 and series Q.500

Gerk, P and Bocker, P 1979

DTN, an All-Digital Telephony Networks for Voice, Data, Text and fax Communication

telecom report 2 No 3, pp 178 to 185.

Klink D. (1976)

Multiplexgerate der PCM-technik taschenbuch der fernmeldepraxis pp 147 to 207

Nolke, P. (1980)

Introduction of Digital telephone Exchanges in Analogue Networks telecom report 2.

No 1, pp 27 to 31

Scheiger, L (1979)

Voice- frequency Transmission planning in Digital telephone Network and the mixed

Analogue-Digital Network telecom report 2 No 3, pp 185 to 193

Siemens A.G

Echo Suppresors- use, control and operation topic 2, ordering No. N100/3050.101

Siemens A.G.

Signalling systems between exchange topic 3, ordering No N100/3050.101

Siemens A.G.

Loss Assignment in telephone networks topic 4 ordering No. N100/3060.101

Siemens A.G.

Digital Transmission telecom report 2 (1979) special issue

Suckfull, H.

Transmission towards digital public switching networks 3rd world telecommunication forum,

Geneva, Part 2, pp 3.4.1.1 to 3..4.1.4