Paper No. 510

DIGITAL WORLD

By

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SUMMARY

In this paper, salient features of digital technology have been introduced. This technology, it is narrated, received a boost when the speech was digitized with the help of microchip technology. Analogue to digital conversion has been touched along with the principles of switching, signalling and transmission in this technology. Then the digital transmission medias are enumerated. Finally, an outline of ISDN concept both in the present narrow-band and the futuristic broad-band and the services promised by them are indicated.

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The recent shift of the World Telecommunication from analogue to the Digital Technology is quite widely known but its true nature and implications are unknown to many engineers including some of those who are engaged in telecommunication itself. In this article I have tried to cover the basic concepts, the applications and the future outlook of this technology. The mathematical treatment as well as the professional jargons have been avoided.

The digital technology is not altogether new as the telegraph service was introduced more than a century ago. This technology used combination of long & short pulses to signify various letters, to be decoded at the receiving end to extract the original message. Over a period of time, other transmission codes were developed for use by automatic printing machines and ways were found both in frequency division and time division to multiplex various digital messages over one single circuit. The speed of transmission was gradually increased to push more messages in a limited time.

But the revolution in the digital technology became evident when the speech was digitized. Actually, the speech can be represented by a non-recurring curve as can be seen on an oscilloscope. The basic method used to transmit this speech digitally involves sampling of the amplitude of the speech curve at fixed intervals, and to send this information in a digital form to the other end. The arrangement at the other end is to reproduce the various amplitudes and interpolate the curve touching the peaks to receive back the replica of the original speech. This is shown in a simplified manner in fig. No: 1 below:-

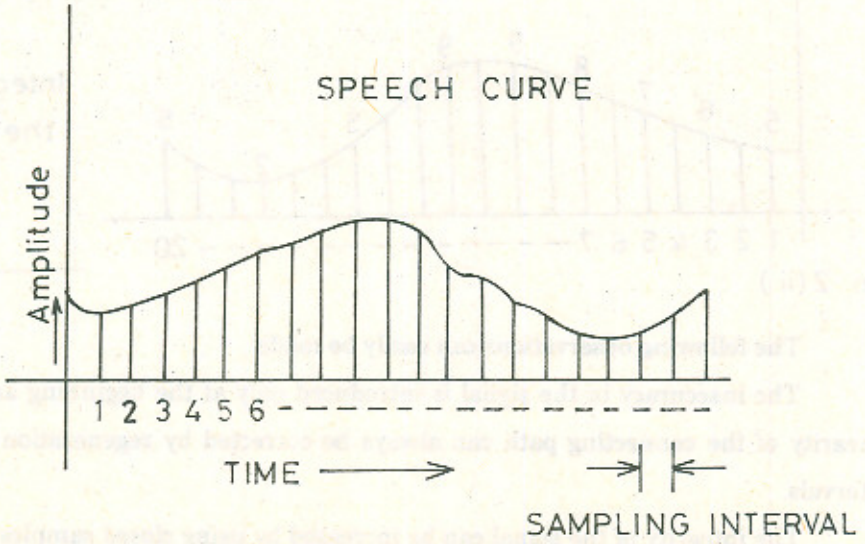


Fig. No: 1(i)

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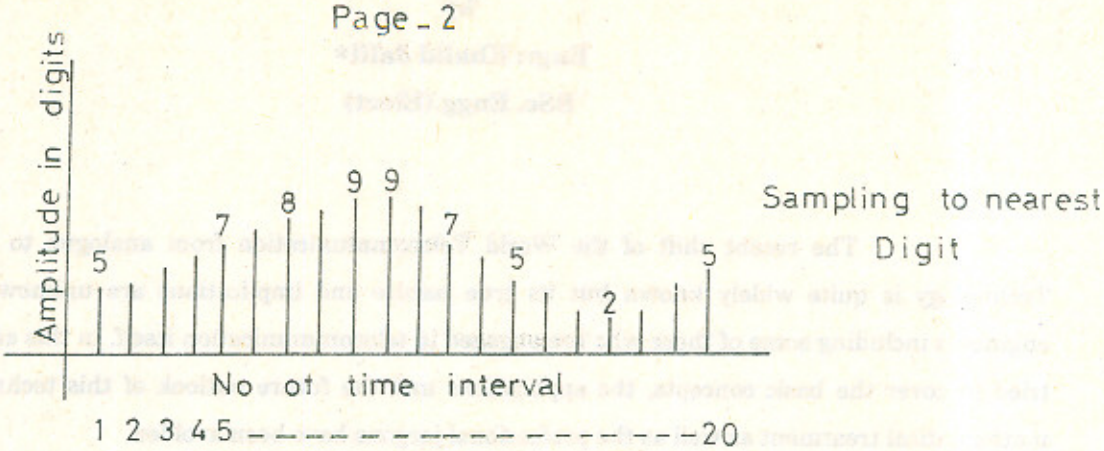


Fig No 1(ii)

The information in fig.No:1 (ii) is transmitted to the other end after converting the various amplitudes to 8 digits binary code. Due to non-linearity and inclusion of noise en-route, the signal is distorted but corrected by regenerating it after suitable intervals. The next process is to join the peaks of the samples of regain the original signal. This is shown in Fig. No: 2 below:-

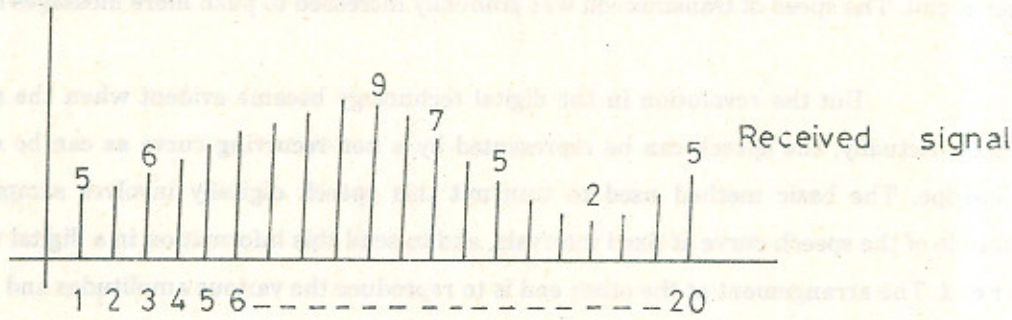


Fig. No. 2(i)

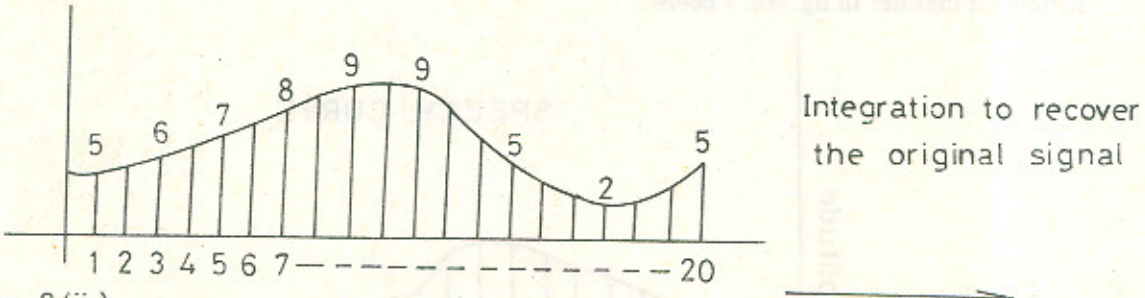


Fig. No. 2(ii)

The following observations can easily be made:

i. The inaccuracy in the signal is introduced only at the beginning and at the end as the non-linearity of the connecting path can always be corrected by regeneration of the signal at suitable intervals.

ii. The integrity of the signal can be increased by using closed samples & by increasing the amplitude steps.

iii. The time in between the two samples can be utilized to sample & transmit other

iii. The time in between the two samples can be utilized to sample & transmit other messages.

In actual practice the sampling time is 125usec yielding a signal of 64 K bits per second. When inter-leaved with 31 other speach signals, the bit rate achieved is 2.048 megabits per second. (In American system 24 signals are combined to form 1.5 megabits per second).

The digital transmission as above has received a boost due to recent advances in microchip technology. Being digital devices the above described functions of sampling, coding and decoding etc. are achieved in a single chip called CODEC and every other day new models with improved features hit the market.

Next to the simplified digital multiplexing & transmission the principles of digital switching are described in Fig. No: 3 below:-

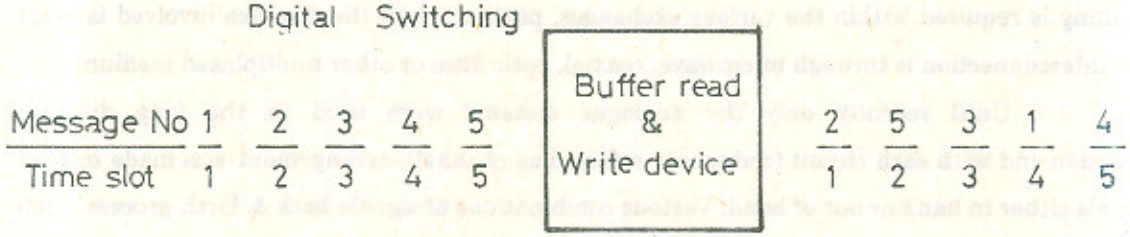


Fig No. 3

Digital switch is a buffer which reads the Incoming signal & stores it momentarily before writing it on to the next time slot in the required succession. In large switches, the switching is achieved in various stages using time switches as described above, combined with switching matrices for physical switching. All the components used are available in IC packages using various levels of miniaturization. All the components are coordinated by central and regional processors which combine to form a telephone exchange.

Due to use of high powered processors, the exchanges are profusely loaded with features, most of which are achieved at a relatively low additional cost. It has become quite standard to have detailed billing and diagnostic facilities in the digital exchanges. A host of other features are also available optionally.

It would be of interest to note that the modern digital exchange (the switch) covers less than 1/10 that of the space needed by a conventional electromechanical switch. However the space required by the power plant & the MDF (Main Distribution Frame) is the same as that of the old exchanges.

SIGNALLING.

The switch needs direction to be able to switch or to carry out its other functions. The simplest form of signalling is the one between a telephone set and the telephone exchange. The conventional dial switch (now achieved in push-buttons) is the commonest mode of signalling as pulses corresponding to the digits dialled are sent on the line, e.g if digit 4 is dialled then 4 times mak-break pulses will be sent on line. Due to international dialing, sometimes 15 or 17 digits have to be dialed which is obviously time consuming. The more modern method is to send combination of tones corresponding to the dialed digit. These tones are noticeable with the new push-button telephones and if required number is connected to a digital exchange, then the connection is immediately established when the last digit has been pushed.

However, since all the calls are not destined within the same exchange, some mode of signalling is required within the various exchanges, particularly if the distance involved is great and the interconnection is through microwave, coaxial, optic fibre or other multiplexed medium.

Until recently only the analogue systems were used in the long distance transmission and with each circuit (commonly referred as channel), arrangement was made to send the signals either in band or out of band. Various combinations of signals back & forth process a call as required. The CCITT which is the international body for standardisation of parameters of international traffic had standardized various methods of signalling e.g C-1, C-2, C-5, C-6, R-1, R-2 signalling etc. Quite recently however, CCITT signalling no. 7 has been introduced mainly for digital transmission which uses quite unconventional concepts.

Firstly it is common-channel signalling signifying that the signalling message contains signals for all the channels together on a certain route. Moreover this signal is separated from the main message channel and can be sent on more than one paths for reliability purposes.

DIGITAL HEIRARCHY

As mentioned before, the basic digital signal contains 32 time slots; each time slot carrying a speech circut. Two of the time slots are used for synchronising & signalling, therefore only 30 time slots are available for 30 speech circuits. The media speed required for these 30 circuits is 2 megabits/sec.

The next higher speed standardized is 8 megabits/sec. This means that four basic PCM systems are combined to from one 8 megabits/sec signal capable of carrying 120 speech channels. Again the third order digital MUX is 34 megabits capable of carrying 480 channels and the fourth order MUX is 140 megabits/sec carrying 1920 speech channels.

The next higher mode is 565 megabits/sec capable of carrying 7680 speech channels but is relatively less popular. Usually optic fiber is used for this last stage of heirarchy with repeater span of about 30-70 KM. This span is being increased gradually with advancement in the optic fiber purification as well as advances in the opto-electrical devices.

The heirarchy is diagrammatically shown in Fig. No: 4 below:-

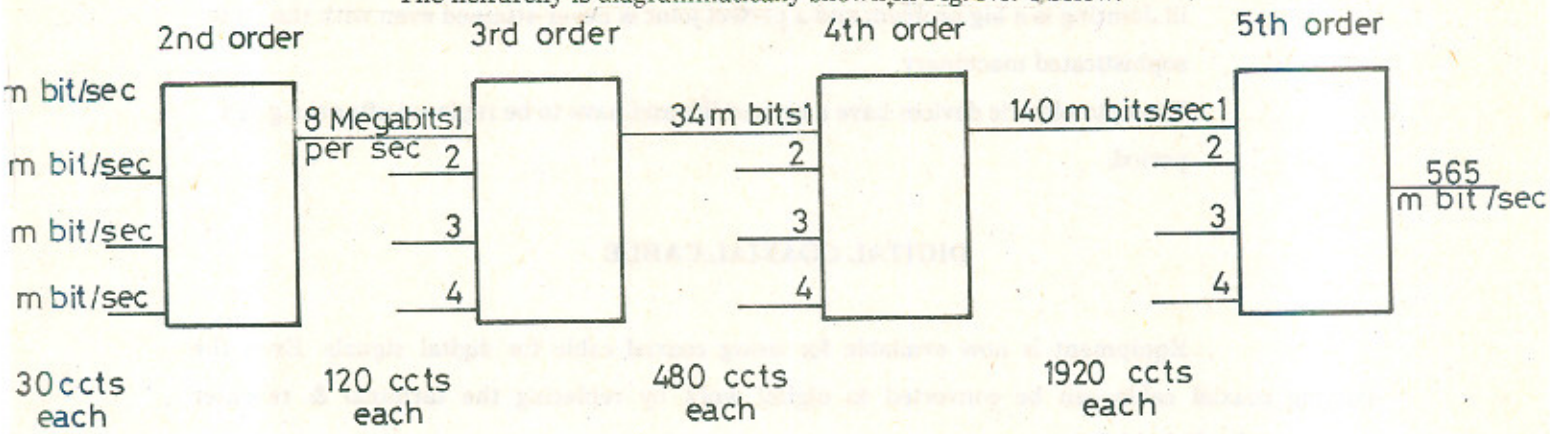


Fig No_4

OPTIC FIBRE

It would be quite natural at this stage to mention about the optic fibre technology, since it is an essential part of the present day digital world. The principle is shown in Fig. No: 5 below:-

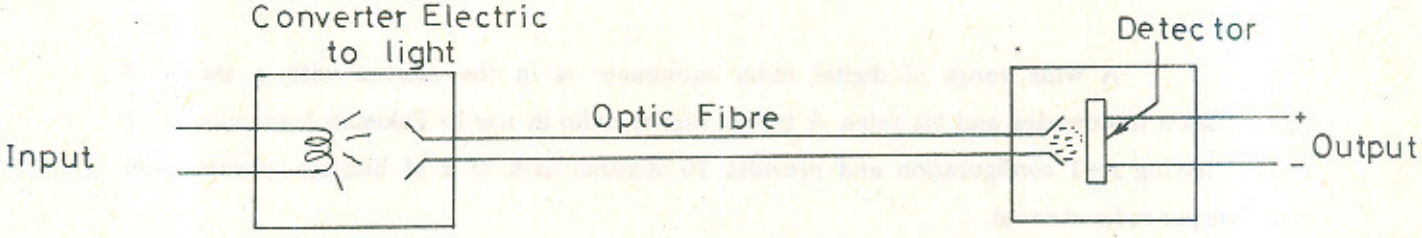


Fig No. 5

The digital electric signal is applied on one end. Then opto-electric device converts it to light which is transmitted through the optic fibre to the other end and is detected by a detector device, converting to electrical signal. The points to note are as follows:-

i. The light is unaffected by other electrical sources, e.g., high tension lines or the lightning and can even be used on high tension poles, without any interference. (in copper systems there is a great problem of induction causing noise or destruction).

ii. The weight of cable is very low due to very small size of the fibre Upto 5 Km of small size cable can be placed on one roll but should be handled with ease.

iii. The repeater span is considerable. A safe span is anywhere near 40 to 45 kilometers and it is ever increasing. So power has not to be fed along with cable for the regenerative repeaters.

iv. Specially suited for digital on-off signals. The disadvantages are:-

i. Highly fragile, needs extra care in handling.

ii. Sharp bends deteriorate performance.

iii. Jointing is a big problem and a perfect joint is never attained even with the most sophisticated machinery.

iv. The opto-electric devices have a limited life and have to be replaced after the given period.

DIGITAL COAXIAL CABLE

Equipment is now available for using coaxial cable for digital signals. Even the existing coaxial cable can be converted to digital work by replacing the terminal & repeater equipment by digital hardware.

A typical example of such application could be to use standard 2.6 / 9.5 m.m coaxial cable for 34 M bit/sec and this will need repeaters (regenerator) after every 7 Km. With lesser repeater distance it is possible to achieve 140 M bits/sec or even a higher bit rate.

DIGITAL RADIO RELAY

A wide range of digital radio equipment is in the market with a choice of transmission frequencies and bit rates. A typical digital radio in use in Pakistan transmits at 13 G Hz., having n+1 configuration and provides 16 streams each of 2 M bits/sec, yielding 480 channels per radio channel.

Equipment with 140 M bits/sec is now quite common for long haul transmission and it is competing successfully with the old analogue equipment. The radio relay has to be very carefully designed with larger safety margins and diversities to overcome the risk of fading.

PCM CABLE

PCM systems of 2 megabits/sec are used utilizing two pairs of the underground cables for each system, with about 1.75 Km spacing of regenerators. In a normal cable, not more than 10% can be effectively used.

Recently, however, cables specially meant for PCM are becoming available. By isolating go and return pairs, 100% pairs are utilized. Many such cables are now in use in Pakistan.

NEW SERVICES

A number of new services are being offered on the digital technology which supplement the already popular Telex and Fax services. These are data links of various speeds and complexity. In Pakistan already high speed point to point data links have been used by various banks, airlines and newspapers, etc. In developed countries it is possible for the subscribers to access various data banks interactively. Tele-Fax, Tele-Text electronic mail etc., have also been offered. For handling such huge quantities of data streams data exchanges are available. A universal switch handling all types of digital signal is called "Packet Switch" and is being procured for Pakistan in forseeable future.

ISDN

Since the introduction of digital switching, the concept of Integrated Services Digital Network has been brewing and after lots of conflicting views among the developed nations, they have settled to more or less agreed configuration. The idea is to use the same cable pair at the customer premises for various services and the switch handling all the services should also be one and the same for the sake of economy. Till present day, separate network as well as separate switch is used for each service. The basic configuration of ISDN is described in Fig. No: 6 below:-

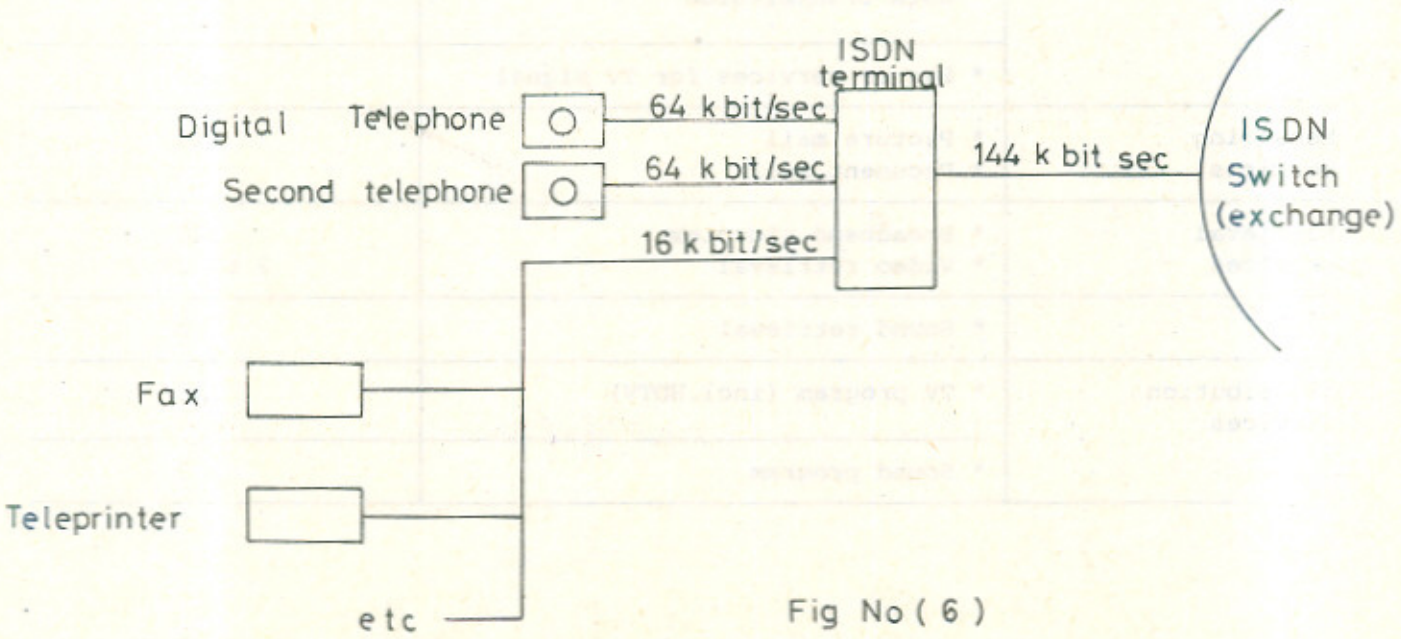


Fig No (6)

BROADBAND ISDN

Till now I have written about the "Narrow band" services using low bit rates i.e. upto 144 K bits/sec to 2 megabit/sec. However, these speeds are not enough for carrying moving TV pictures for which around 140 megabit/sec is required. Since at this speed the signal cannot be transmitted on the conventional cable pairs, the medium will have to be changed to optic fibre. With the provision of optic fibre to ordinar subscriber's premises it will be possible to introduce such services as picture-phone, video conferencing or pay-TV etc. I do not forsee its large scale use in this century in this country or even in the developed countries although experimental equipment is now available. A table depicting various possible services with the required bit rate is given below:-

Service Classes	Broadband services	Bitrates (Mbit/s) requirement
Dialog services (conversational services)	* Video telephony * Video conference	140
	* Fast document transfer * High speed telefax * Bearer services for high speed data transmission	2 34 140
	* Bearer services for TV signal	140
Messaging services	* Picture mail * Document mail	140
Retrieval services	* Broadband videotex * Video retrieval	140 2 to 34
	* Sound retrieval	2
Distribution services	* TV program (incl.HDTV)	140
	* Sound program	2