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SECOND WORKSHOP ON TELEMATICS

6 - 24 November 1989

Telematics and Developing Countries

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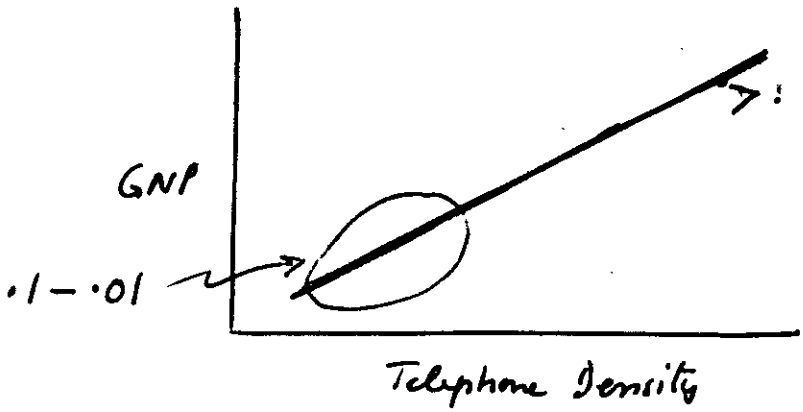
These notes are intended for internal distribution only.

TELEMATICS AND DEVELOPING COUNTRIES

- Telematics : Telecommunication + Informatiques
  science and technology of Information
  - Transmission . Processing . Distribution
- Communication - backbone of the development process



Well known curve
Telephone density vs. GNP.
Shows a direct link between telephone density and income / inhabitant.

- Telecom benefits : economic and other are too well known
- Provides an opportunity to the developing countries to catch up with the industrialized countries
- IT IS A TECHNOLOGY FOR FREEDOM!

FEATURES:

A common technology for :

- COMMUNICATION • COMPUTERS • PRINTING • BROADCASTING
- Hardware is getting cheaper
- Software cost is going up
  - Digital Signal Processing
  - Software • VLSI

} Key technologies of this decade

PROBLEM AREAS

- TECHNOLOGY getting more and more complex

  Too many options, Decision making becomes difficult

- Tech. changing too fast

  From > 50yrs now new generation takes place in 2-3 years. How to manage this change?

- How to get the best technology for a given investment?
- We are being driven increasingly by the technology and not by the real needs
- Running after "fashion".
- How to manage this technology ourselves? and be atleast to a limited extent self reliant
- Serious problem in the markets of the industrialized countries. Everyone has a phone, etc. Markets saturated Looking for markets in the developing countries.
- Right choice is very important. Wrong choice will have a very long time impact
- Rural Communication . Multiple scripts / languages

Basic Telephony: **POTS** plain old telephone service

Well established as a worldwide network

Voice communication: 300 - 3300 Hz bandwidth end to end

- Highly modular and standardized
- Very high investment "Recovery" over 40 yr period.
- Digital facilities thru modems - 300 - 9600 bps
- computers • data terminals • Facsimile etc.

Roughly US $ 2000 per telephone on average

- Phones with rotary dials - Tone type being introduced
- Wide range of technologies

Transmission: Open wires, twisted pairs, coaxs

VHF / UHF / μw radio

fibre optics, satellite ck.

Analog, digital, FDM, TDM

Switching: Strowger step by step

Cross bar

Stored Program Control (SPC) "Electronic"

- Analog switch (electromechanical) - Digital Switch (latest)

- TELEX NETWORK: shared telephone channels

- 50 - 75 bps. Worldwide network. Backbone of business

Reliable, secure, sender identification and verification

T[illegible] TAX [illegible] ?

New Technologies and Services

ISDN Integrated Services Digital Network

- DIGITAL CHANNELS
  - New protocols
  - Signalling complexities
  - 64 Kbps voice
  - 64 Kbps data
  - T1 (1.5/2 Mbps) service
  - Wider bandwidth services for images, graphics, video
  - Video conferencing
  - Telematic services : Videotex, Teletext, etc.
  - New equipment / investment
    (older network cannot support this)
  - New Transmission links
  - New Signalling Protocols
  - New Switches
  - Difficult to integrate on worldwide basis
    - full enhancement needed
  - Sophisticated services – need sophisticated user
  - Ideal for corporate / business networks
  - Overkill for home use -
    Not quite user friendly yet
  - Still in evolution

Problem areas:

Not technology but <u>SERVICE</u> is important

Switching systems: not more than ½ hr down time in 20 yrs!

- Discipline
- Cultural aspects
- Maintenance
- Quality control
- Accept that the customer is always right

Unlike TV or Hifi equipment, the real work starts after sales, after installation

cheaper hardware, expensive service

- Decision making driven by technology, not needs
- Development of confidence in handling most sophisticated technology - learning thru mistakes (preferably others) - No short cuts and remember NO RISK, NO GAIN
- We are chasing a moving target that is moving faster and faster (developed countries are developing faster than the developing countries)
- Act fast
- This is the best time (still)

How to go about it :

- We have to achieve mastery and command over new technology. understand its intricacies and put it to our best use
- What is available is not necessarily best suited in fact in some cases it might be expensive and ill suited
- Need systems / products / etc that are
  - cost effective • simple to operate and maintain
  - work with less, irregular power . Need no A/C
  - work in high temp. humidity . dust , etc.
  - Less skills to operate • fully adapted to local environment
  - "Appropriate" technology needs more sophisticated and complex solutions.
  - Be wary of false claims.

    e.g. Adaptability of Software. OK. in theory almost impossible in practice
  - Technology Transfer is not easy

    Real absorption of technology needed for
    - adaptation • modification • maintenance • Upgrading
  - Idea to Product – very tough problems

- Do not get too much conditioned by the past
  - The real expansion is ahead of us,
  - What has been invested is quite negligible
- Faster decision making :

  Technology used to change very slow (decades)

  now it changes within 2/3 years

  How to manage this change ? How not to get saddled with obsolete technology / equipment ?
- Learn from other examples :
  - Brazil
  - Korea
  - India

  launched switching projects successfully
- National discussion on various issues

  educate public, decision makers, of the real issues

  demyshify technology
- Understand and appreciate that this needs heavy investment in funds and manpower (expensive even for rich countries)
- Pooling resources : nation wide / world wide
  - cooperative effort taking advantage of commonality of problems and needs
- Setting up appropriate standards / voice at international bodies

- new egalitarian culture
- Age and seniority are of no importance
- Peer evaluation of ideas
- Because of rapid changes in technology, the best and latest is likely to be with the younger generation
- New ideas blossom when there are no hierarchies and bureaucratic hurdles
- Minimum red tape
- Thinking has to rational rather than emotional
- New centres of excellence might be required to be created

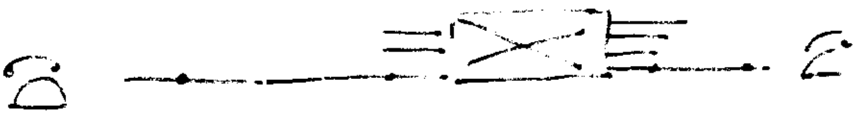
TELEMATICS encompasses:

- computers · communications · VLSI · Advanced electronics
- Acquiring command over this will help in many other areas
- Unique combination: Challenge and relevance — attractive to the young scientist and engineer
- Best time to make significant contributions
- Let us not waste this opportunity

Models, Definitions, Terminology, Diagrams, etc.

All networks have:

- Terminals – · Telephone set
  - · FAX
  - · CRT
- Links – Transmission lines
  - openwires, coax, fibre optics
  - satellite, etc.
  - Radio links
- Nodes – Exchanges, switches



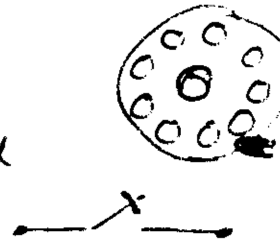
Two basic functions

- Information (Data), Speech
- Signalling (Address)

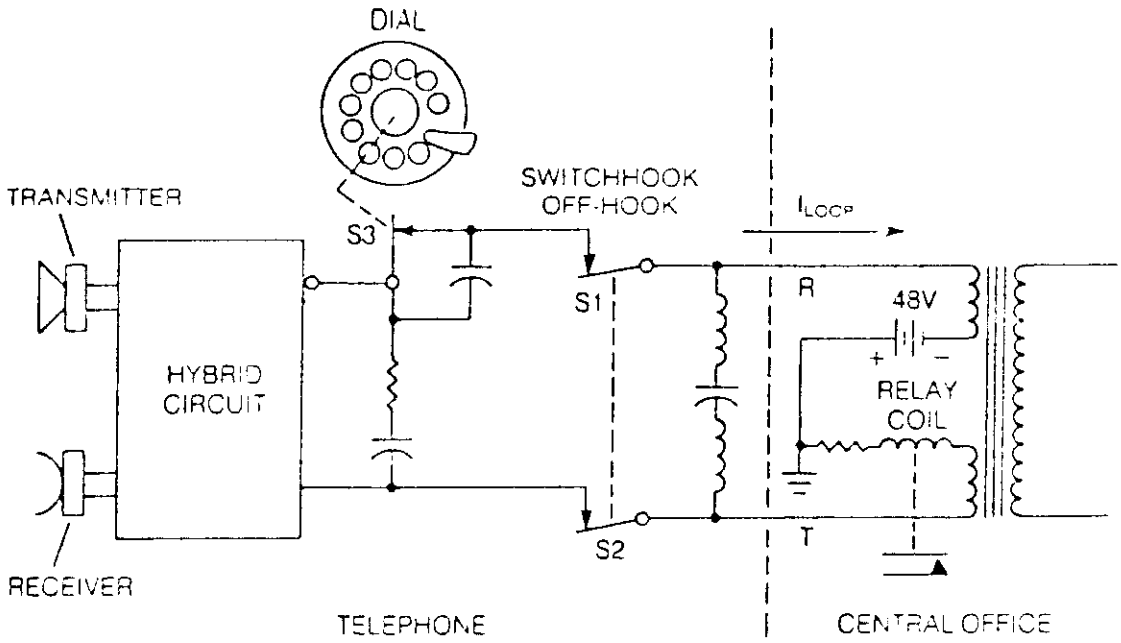
The signalling function could be quite complex

Simplest case:

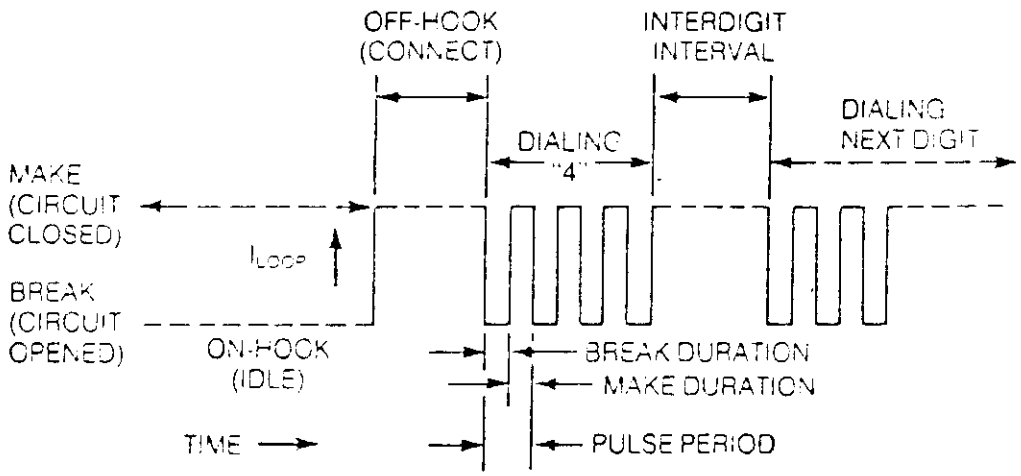
- Rotary Dial
  10 pulses per second



- Bell, Buzzer
  Ringer 80V, 25 Hz
- off hook / on hook for
  service demand



a. Dial Circuit with Switchhook Closed (Off-Hook)



b. Dial Pulse Timing (for "4")

Pulse Period = Break Duration + Make Duration (100 Milliseconds Nominal)
Pulse Rate = Pulses Per Second = 1000 ÷ Pulse Period (MS)
Percent Break = 100 × Break Ratio
= 100 × Break Duration ÷ Pulse Period
Interdigit Interval = 700 Milliseconds Nominal (may range from 600 to 900 depending on system)

Figure 2-2. Dial Pulses

FACILITIES

- Basic voice POTS
- Telex
- Telegraph
- Data
- FAX
- Mobile Radio
- Cellular
- Paging
- Payphones
- Credit card calling
- Key telephones
- Smart cards
- Cordless
- TDMA / FDMA
- Conferencing
- Satellite Networks — Direct broadcast (Receive only) DBS, TVRO; Data DRO, Two way
- Special Networks — VSATS
  - Business
  - Finance
  - Security
  - Railways
  - Military
  - Airlines
  - Education and Research
- BITNET, Electronic Mail, Messaging
- Teletext
- Videotex
- VOICEMAIL
- Videoconferencing

To watch:
- Photonics
- Mm wave.
- Parallel processing
- Superconductors

- TWO WAY COMMUNICATION "ON-LINE"
- ONE WAY Broadcast
- Information Retrieval, Data base access, etc.
- Bandwidth compressors (speech) and video
- Voice Recognition and Synthesis } DSP
- Pattern Recognition
- Text to speech and Speech to Text conversion
- TASI - Speech interpolators, etc.
- ISDN PRI services
- Wide band service .....

Links / Lines

- Pair of wires (open pair or twisted pair)
  Balanced transmission • Earth not used (common in US)
- Reasonable length / Reasonable attenuation over a few kilometres.
- ~ 1000 Ω loop resistance.
- Loading coil added to reduce attenuation (handle very long lines)
- [illegible] V DC Trans
  ~ [illegible] V 20Hz AC for ringing

Nodes / Switches

- Electromechanical • Relays & switches
  Uniselectors
- Hugely distributed, but no intelligence
  ↙ ie failure resilient.

Distributed control; highly desirable. Requires constant maintenance

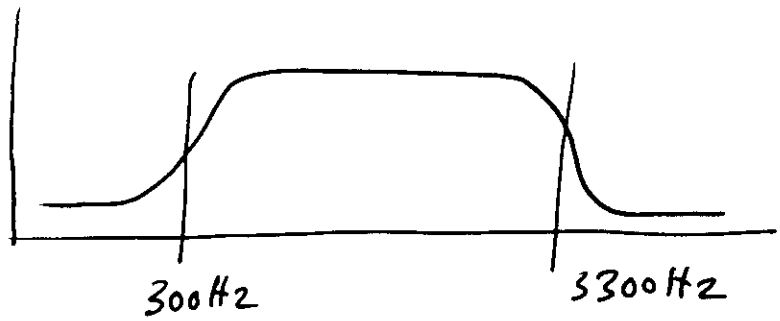
- All this without any amplifying elements!
- Long distance automatic switching almost impossible
- Most phones → Crossbar (still [illegible] [illegible])

Network :

World wide, fully automatic, end to end connection

Two stds : • FCC (USA)
• CCITT (Europe, ek)

Basic human speech comm^{n}



Dynamic Range : 70 db

Noise level : -100db (idle channel noise)

Every item connected to the telephone line must conform to this and many, many other restrictions

Many Most P+T administrations do not permit user owned / selected equipment

- Very high availability
- Very long life - 30 - 40 yrs
- failure rate 1 hr in 20 - 25 yrs.

- Every step is taken to ensure highest reliability

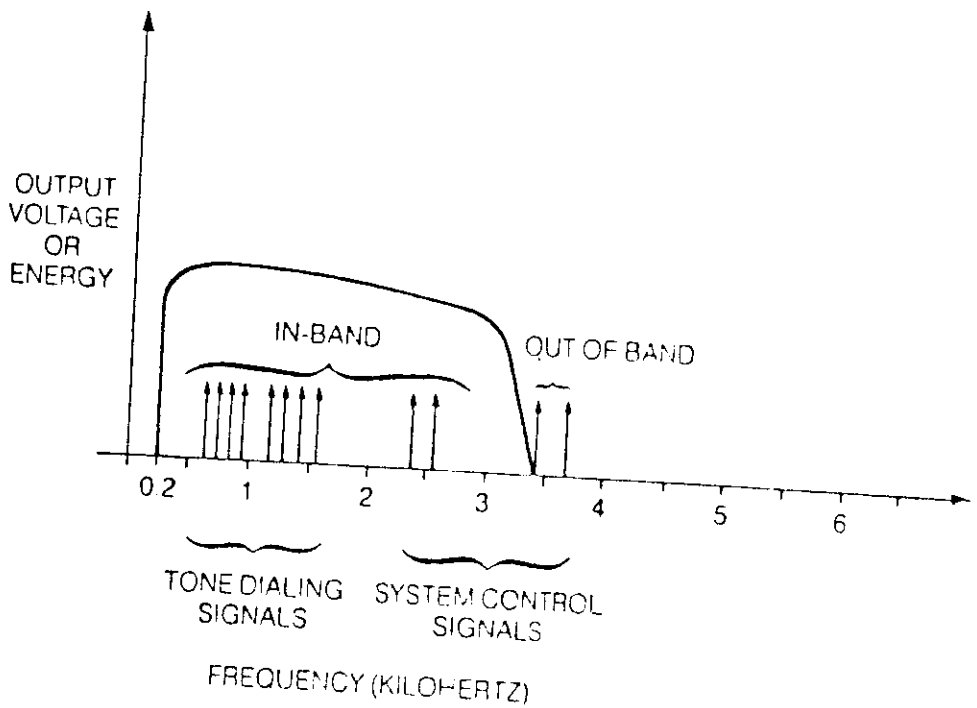


Figure 1-9. *In-Band and Out-of Band Signaling*

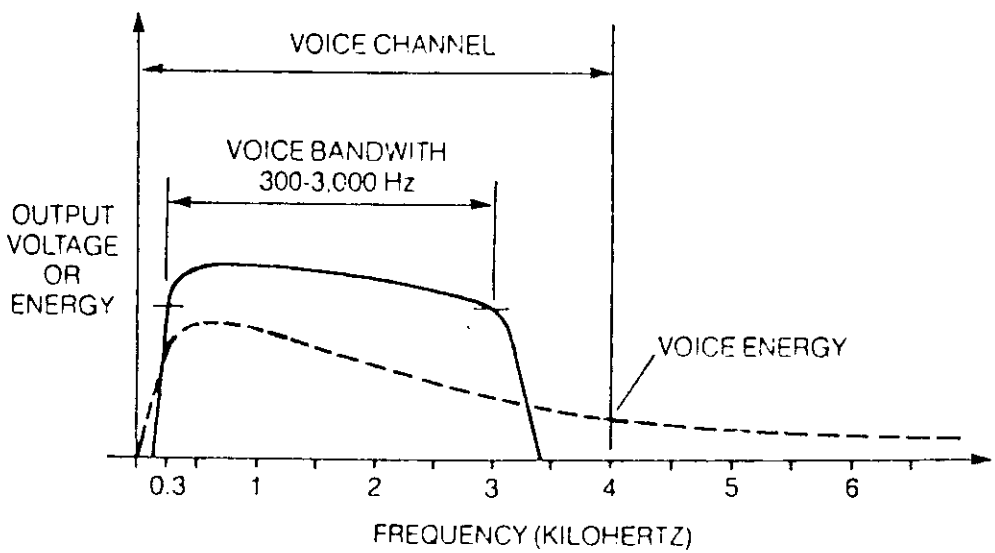


Figure 1-8. Voice Energy Versus Frequency

Problem areas for the Designer

- Digitization
- VLSI implementation

Two wire and Four wire communication

└ eg. RS232

- Bidirectional path
  Same path for transmission as well as reception

- path separation done at the end as well as at one or several intermediate stages
  - A "hybrid" is used. This is not perfect allows ~ 20 db leakage
  - Sidetone in the telephone

- Dektion of low d.c. current in the presence of a high AC voltage (Ringing)

- Transmission of data on the lines. (delays, etc)

- Protection against high voltages (MDF - Main distribution frame) } complex cktry designed with 'switch'.

- Signalling : 10 pps "is out of band"

- Conferencing

- Signalling "cutoff" after establishment of connection.

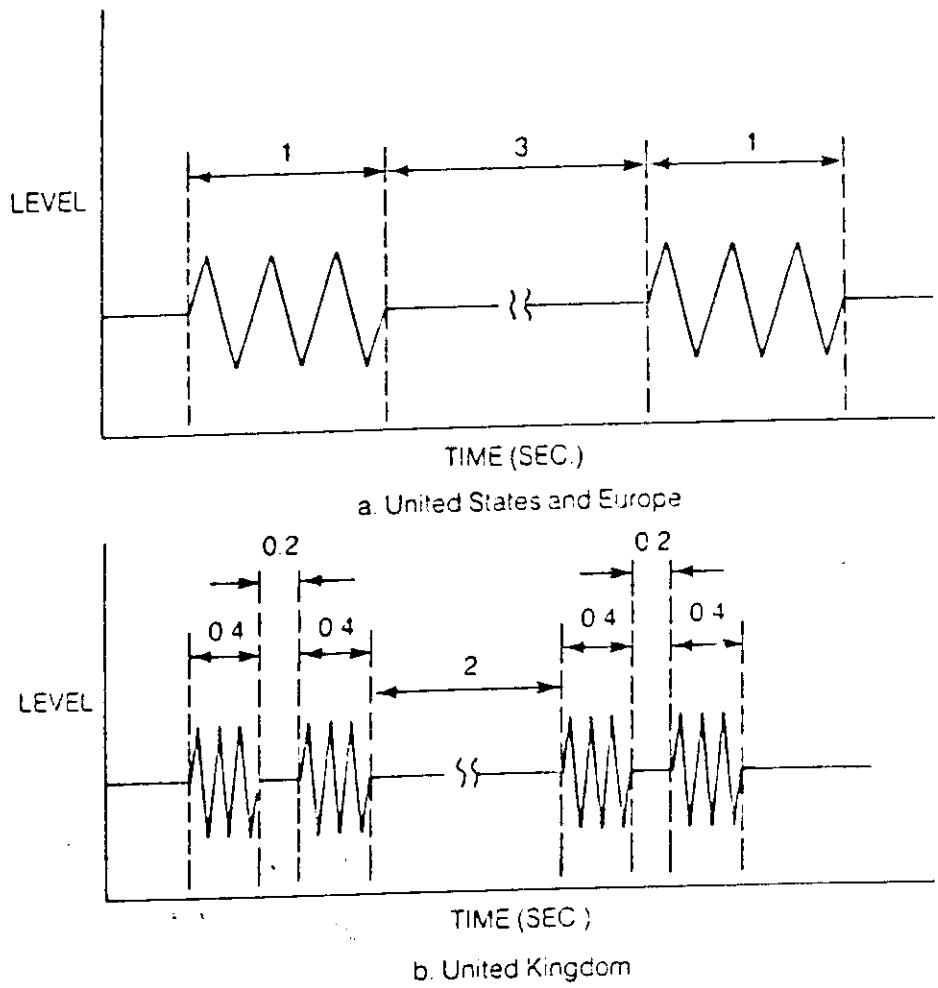


Figure 2-12. Ringing Cadence

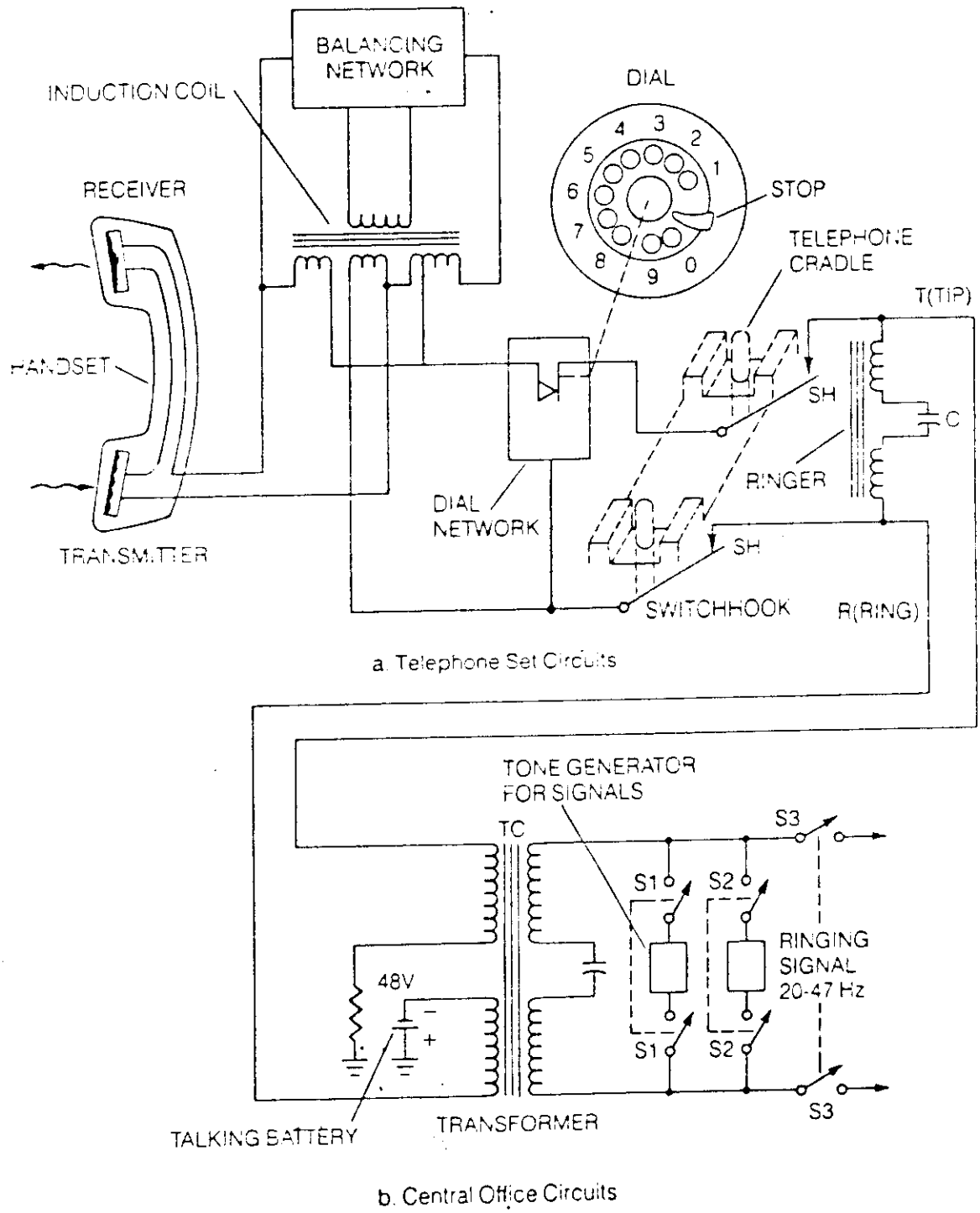


Figure 1-2. *Telephone Set and Central Office Exchange Simplified Circuits (Source: D.L. Cannon and G. Luecke,* Understanding Communications Systems, *Texas Instruments Incorporated, 1980)*

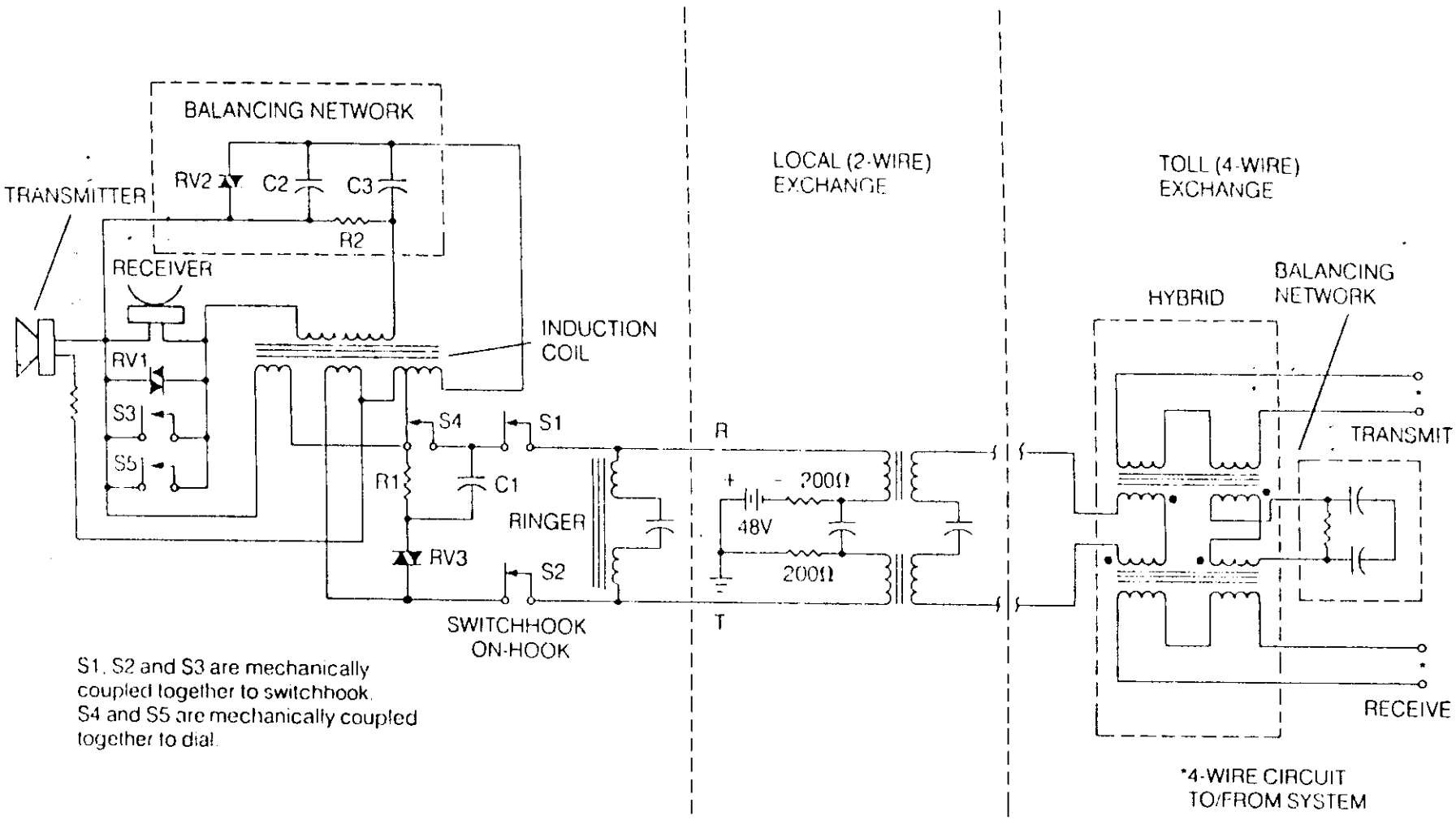


Figure 2-13. The Hybrid Function in the Telephone and Exchange

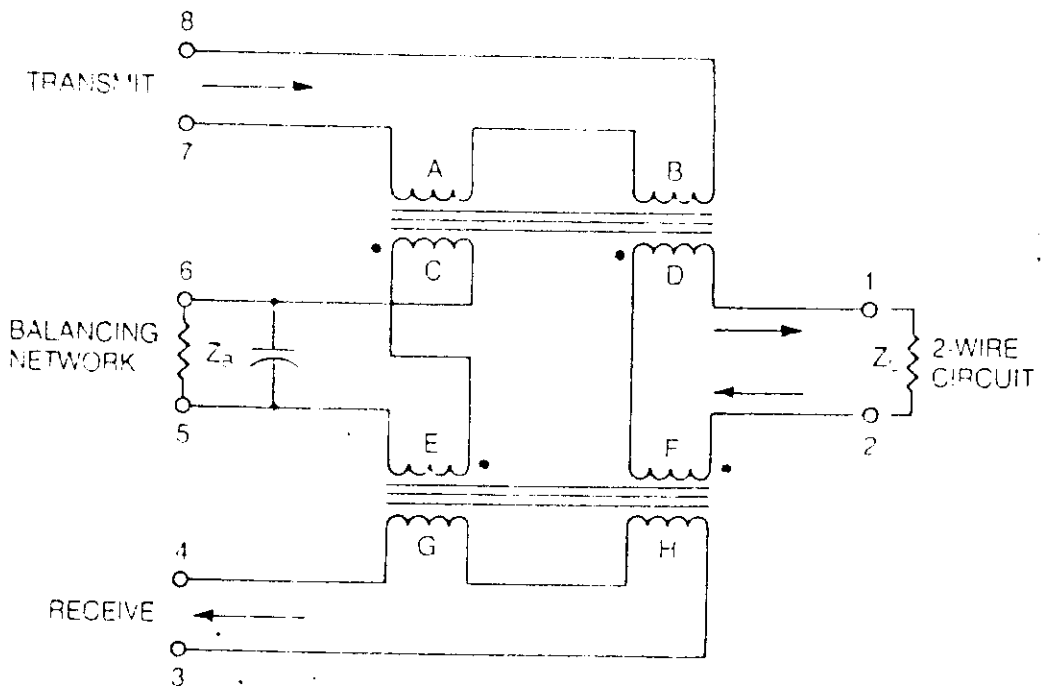


Figure 2-14. Hybrid

Signalling

- In band signalling DTMF
- Out of band signalling (voice line)
  (simple to implement)

Inband signalling :

DTMF Dual Tone Multi frequency

very fast

A pair of tones represents a digit

Expensive receiver - shared by a number of lines

Signalling possible even after the connection has been made i.e. speech/conversation is in progress.

Advantages: • Providing special facilities
  Customer defined
- Transparent to the network
  Set up split networks with special facilities
- Remote control and monitoring
- Coming with computer / data base access

:

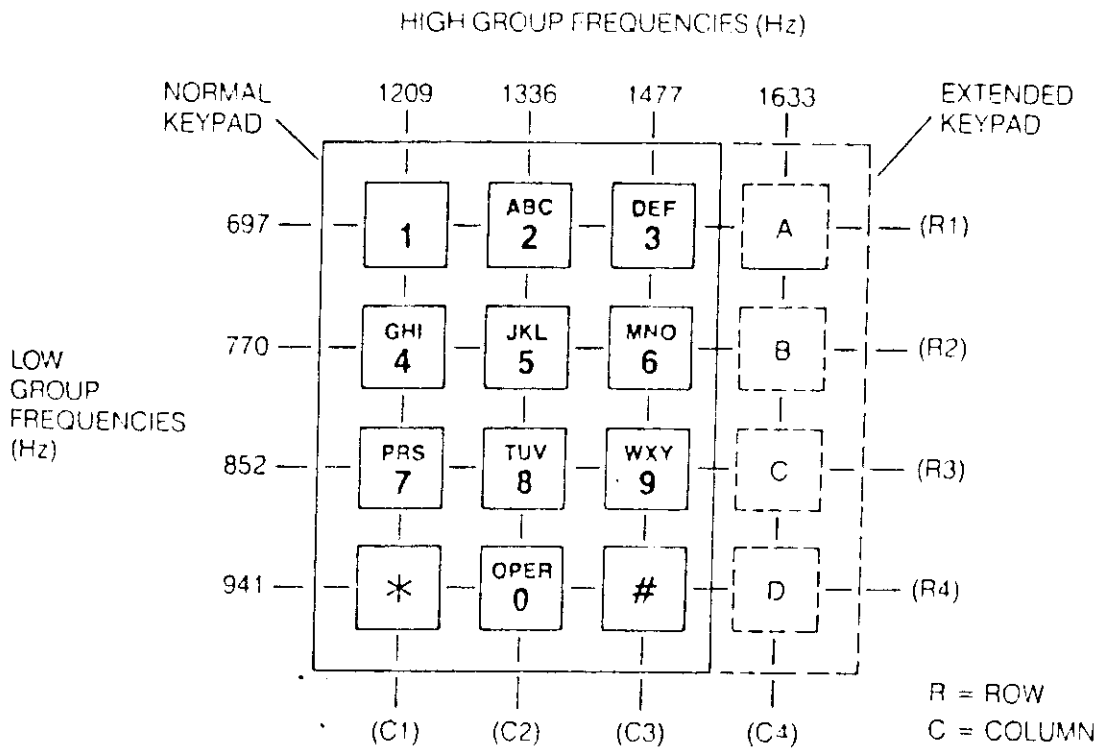


Figure 2-4. DTMF Keypad and Frequencies

WHY DIGITAL ?

Advantages:

- Cheaper hardware (VLSI oriented)
- Higher Reliability
- Easy to Multiplex and Demultiplex
  "Time sharing"
  - A wide range of services & dimensions can be easily integrated into one bit stream
- Better noise tolerance (only two levels)
- Natural integration with computer
  Easy to process, transform, store, retrieve, etc.
- Sharing common circuitry (TDM)
- Easy to monitor, detect errors, etc. and introduce redundancy for reliability
- Signals are easy to regenerate.
- Ability to have good error control
- Easy to assemble and manufacture.

Disadvantages:

- AD/DA conversions
- Integration with older networks
- Synchronization
- Higher bandwidth – 64 kbps/voice channel
  (problem with radio)
- Mandatorily less amenable to intervention
- Quantization noise.

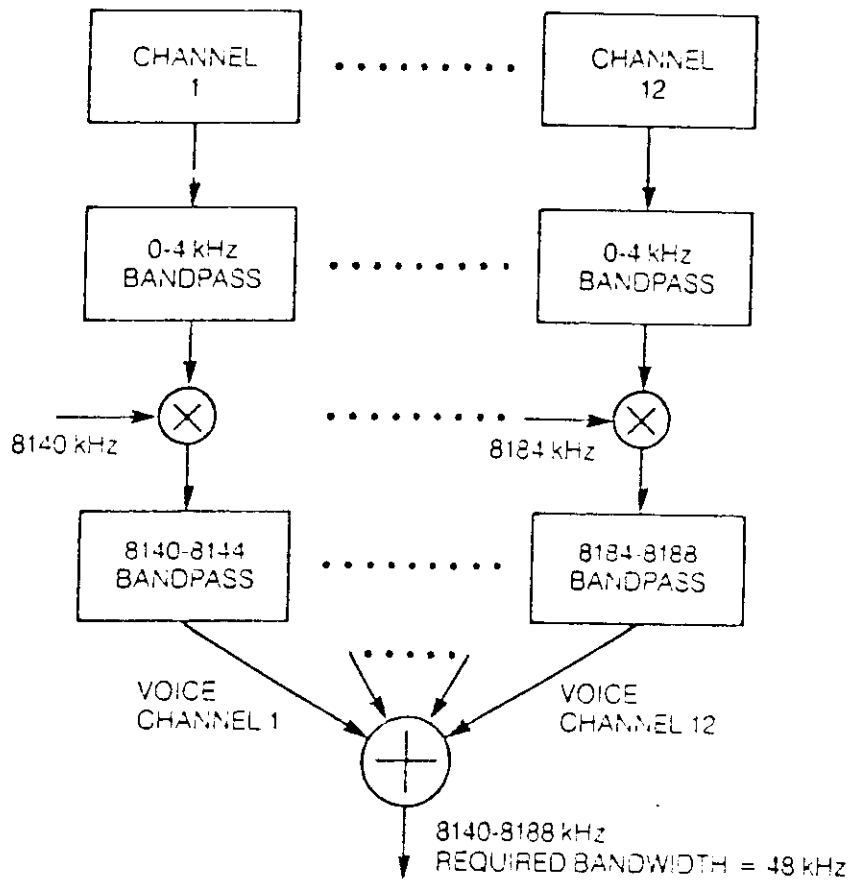
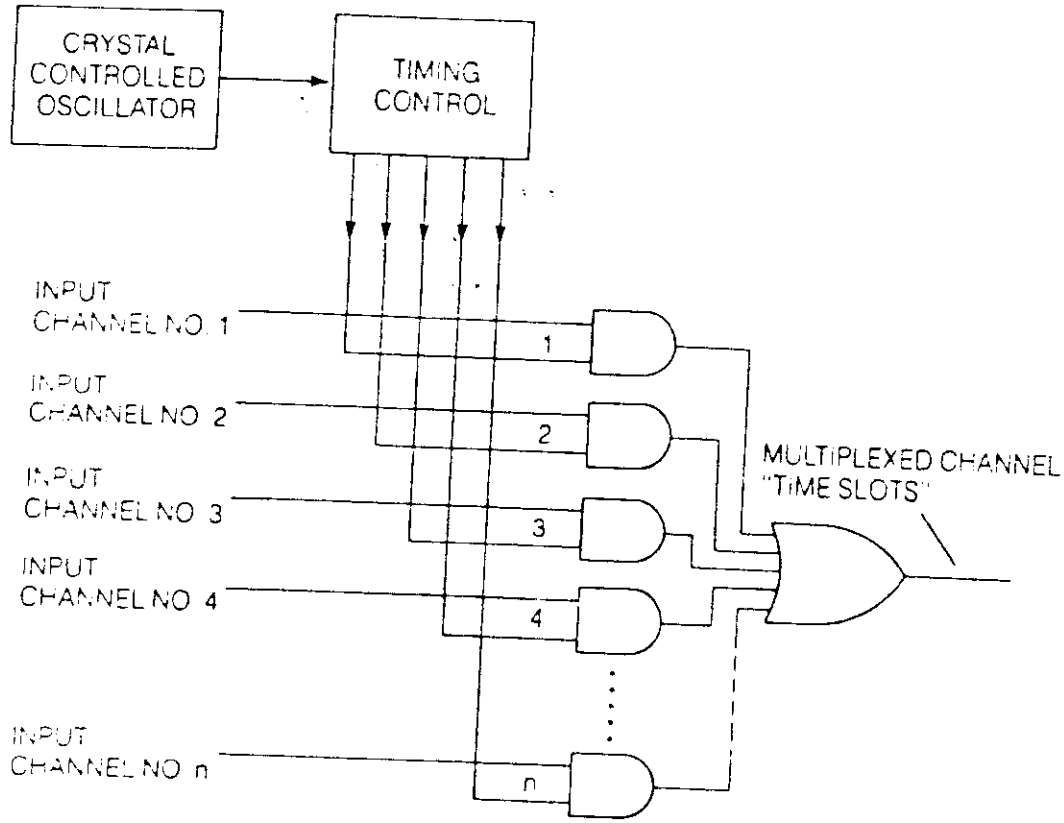


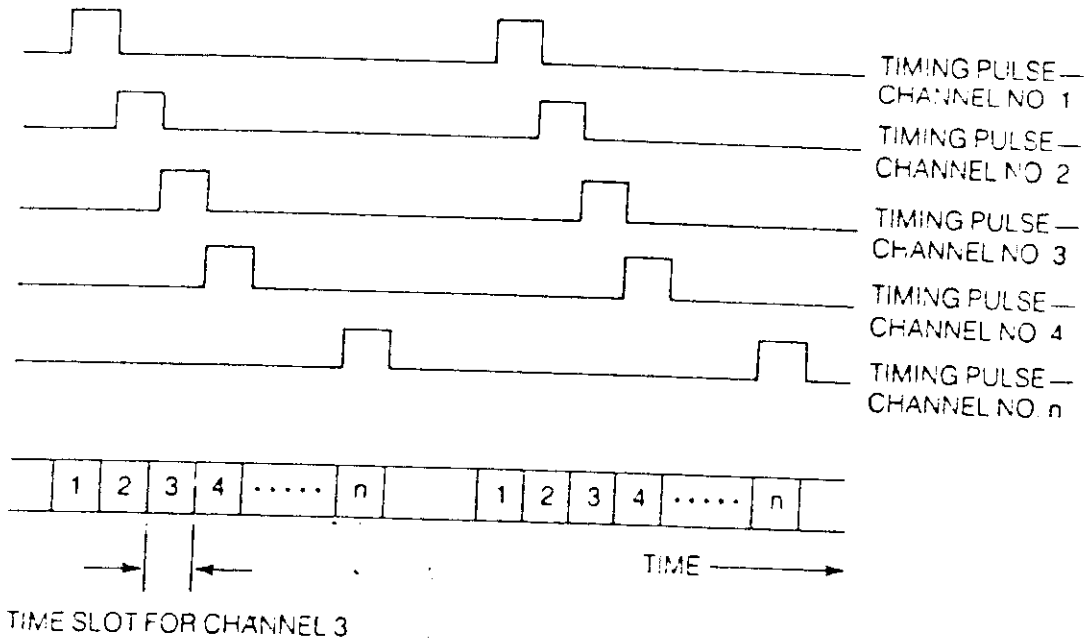
Figure 1-12. *Multiplexed Frequency Signals*
(Source: D.L. Cannon and G. Luecke, Understanding Communications Systems, *Texas Instruments Incorporated, 1980)*

Table 1-1. Analog Carrier and Multiplex Systems

Medium	Carrier Type	Number of VF Channels	Number of Pairs or Radio Channels	Bandwidth
Open-Wire	O	4-12	2	200 kHz
	On-2	24	2	200 kHz
Twisted Pairs In Cables	K	12	2	300 kHz
	N-1	12	2	300 kHz
	N-2	12	2	300 kHz
	N-3	24	2	300 kHz
	N-4	24	2	300 kHz
Coaxial Cable Pairs	L1	1,800	3	3 MHz
	L3	9,300	5	10 MHz
	L4	32,400	9	20 MHz
	L5	108,000	10	68 MHz
Microwave Radio	TD-2	19,800	11	500 MHz
	TD-3	12,000	10	500 MHz
	TH-1	10,800	6	500 MHz
	TH-3	14,400	6	500 MHz
	TM-1	3,600	4	500 MHz
	TJ	1,800	3	1000 MHz
	TL-1	720	3	1000 MHz
	TL-2	2,700	3	1000 MHz
	AR6-A	42,000	7	500 MHz



a Circuit



b. Timing Diagram

Figure 6-25. Basic Principles of Time Division Multiplexing

THE DIGITIZATION

- Terminal: – Telephone.
- Links – Transmission
- Node: – Exchange.

Transmission came first
Pulse Code Modulation PCM

- 30s idea level (implement with vacuum tubes!)
- 60s transistors – commercialization
- 70s widespread use.

speech signal : Bandwidth and dynamic range
~ 12 bit coding required
4 KHz max freq. 8 KHz Sampling frequency
12 bit AD conversion accuracy
96 Kbps . Reduction by Compression
(used in analog ckts)
Use nonlinear coding, higher levels, lesser accuracy

It has to be "full" replacement of analog channel
transparent

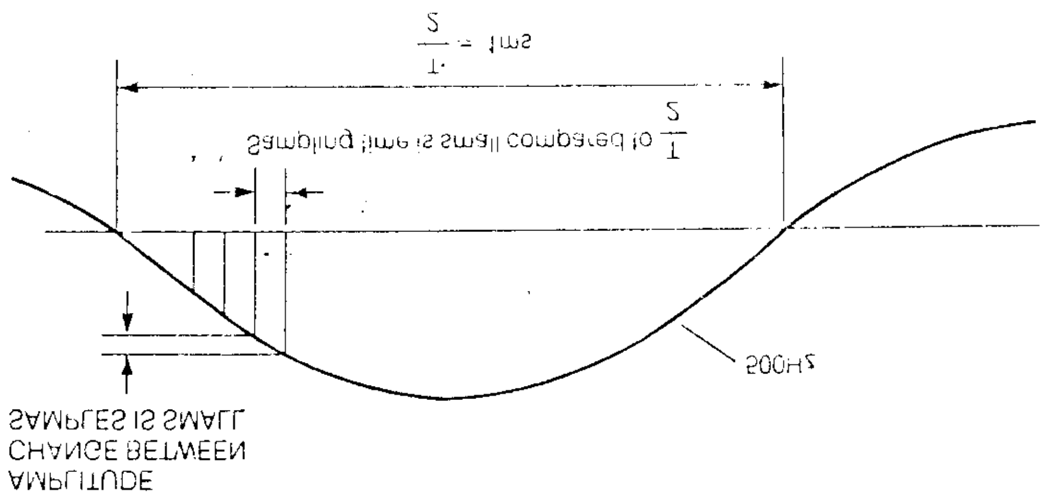
8 bits per sample 8000 samples per second
64 Kbp.

What about Signalling?
Synchronization?
Extra channel, added bit.

~ 1/8 bit stealing

32 ch. CEPT European format 2.048 Mbps
24 ch. US format 1.544 Mb.

Figure 6-15. Sampling of an Analog Waveform



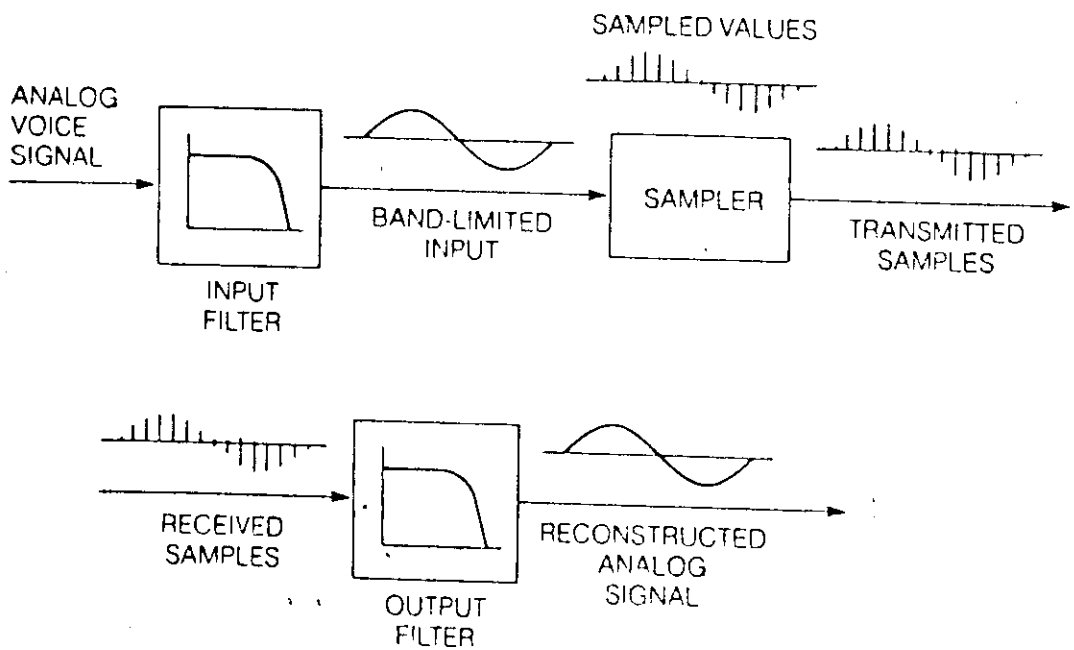


Figure 6-16. *Pulse Amplitude Modulated Transmission*

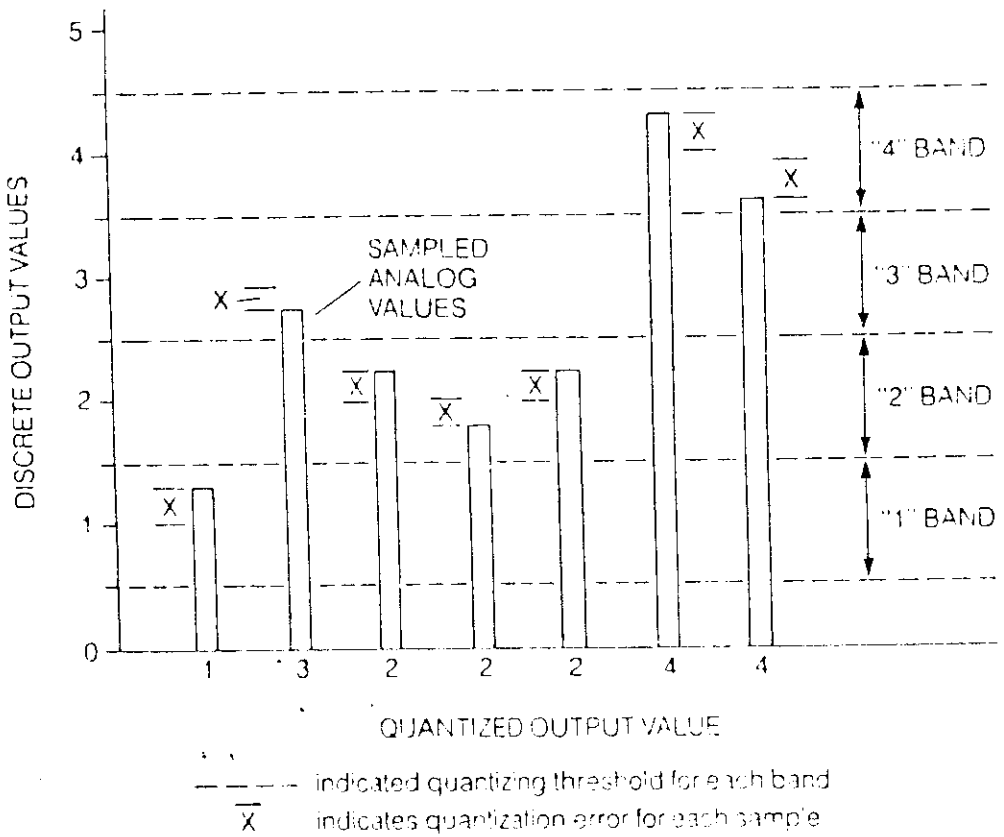


Figure 6-17. Quantization

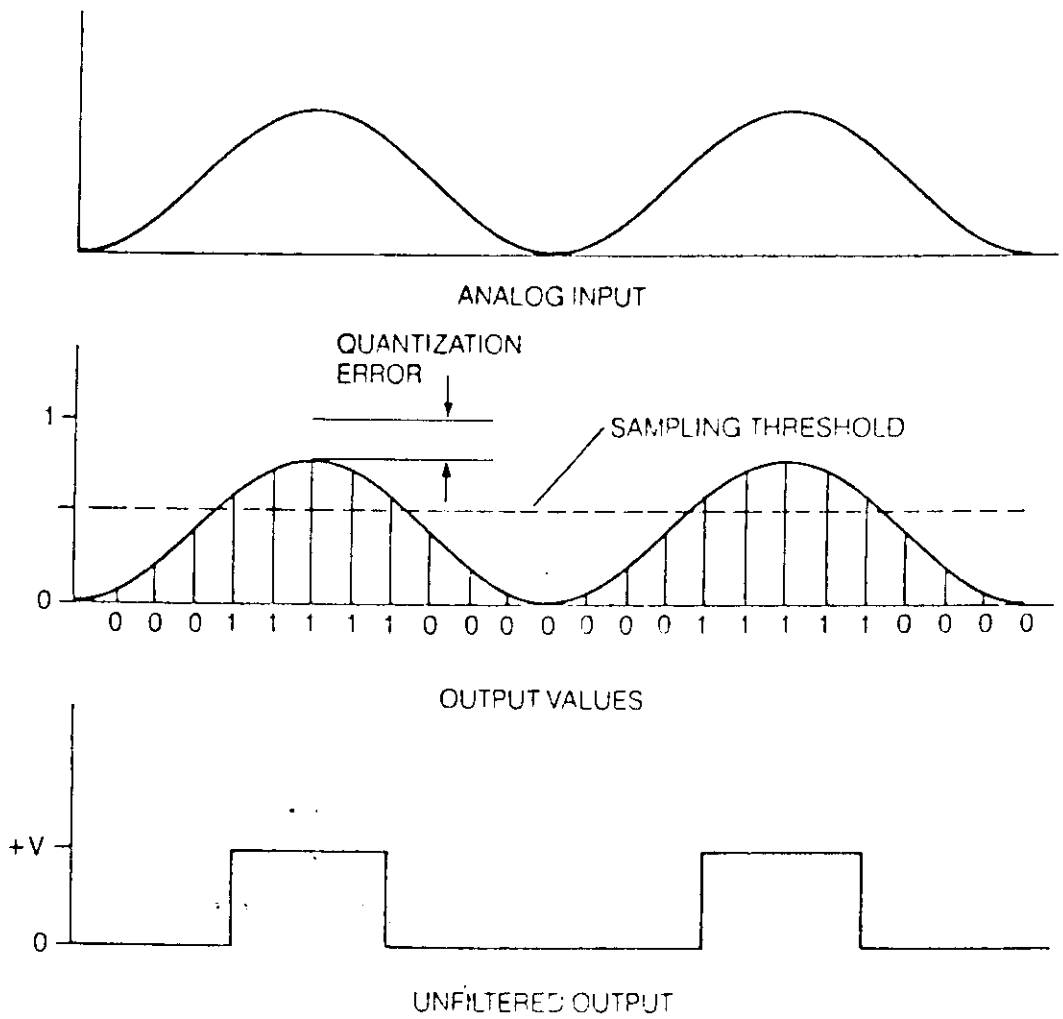


Figure 6-18. *Idle Channel Noise Produced by Quantization*

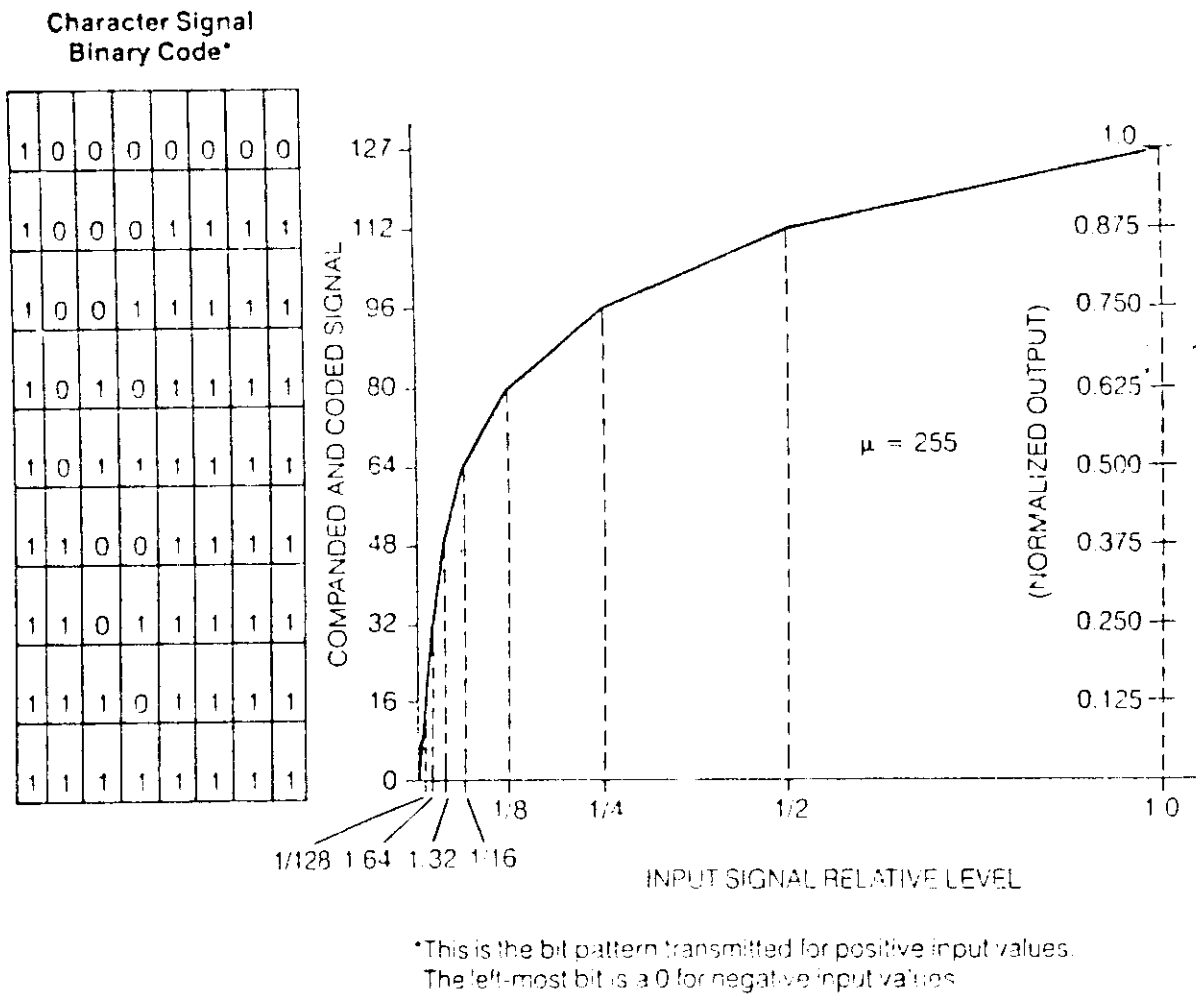
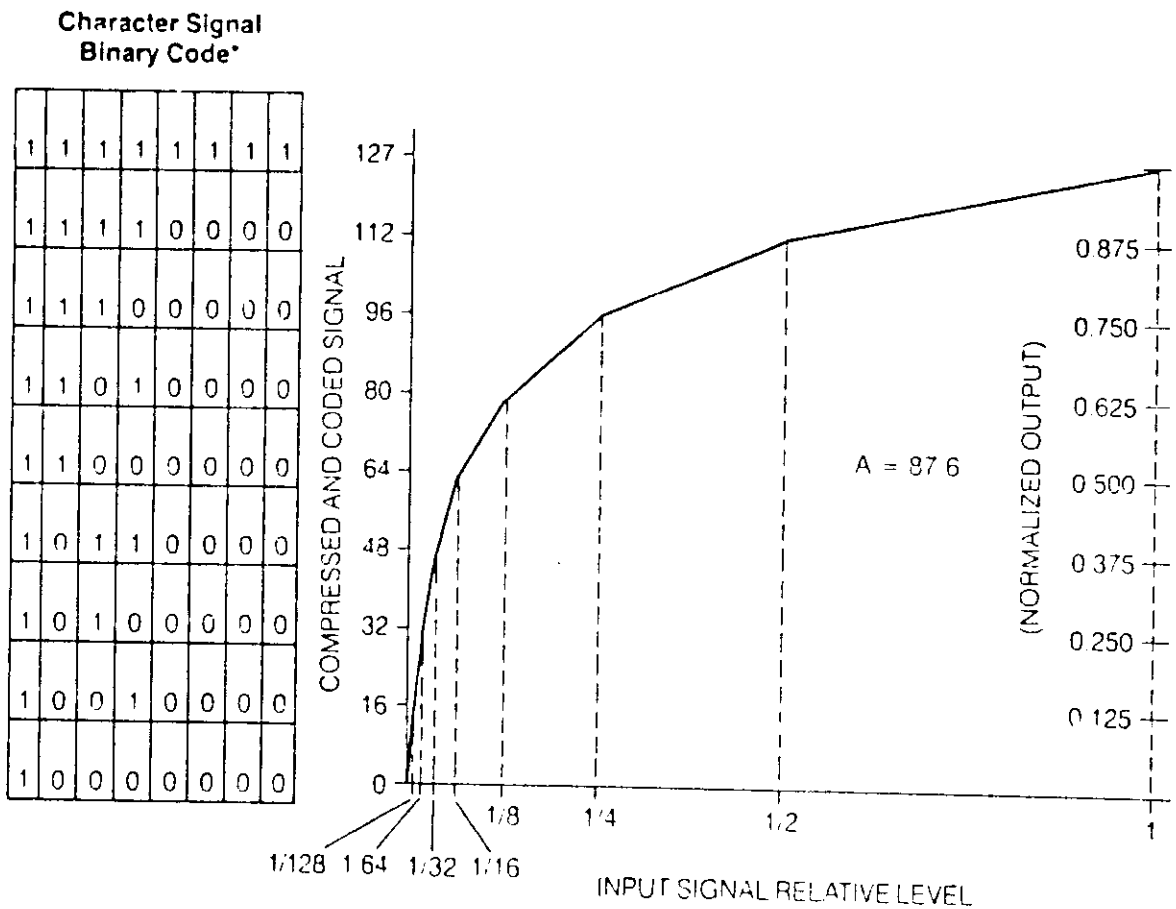


Figure 6-21. Companding Curve of the μ-Law Compander



*For positive input values. The left-most bit is a 0 for negative input values. Even bits (beginning with 1 at the left) are inverted before transmission.

Figure 6-22. Companding Curve of the A-Law Compander

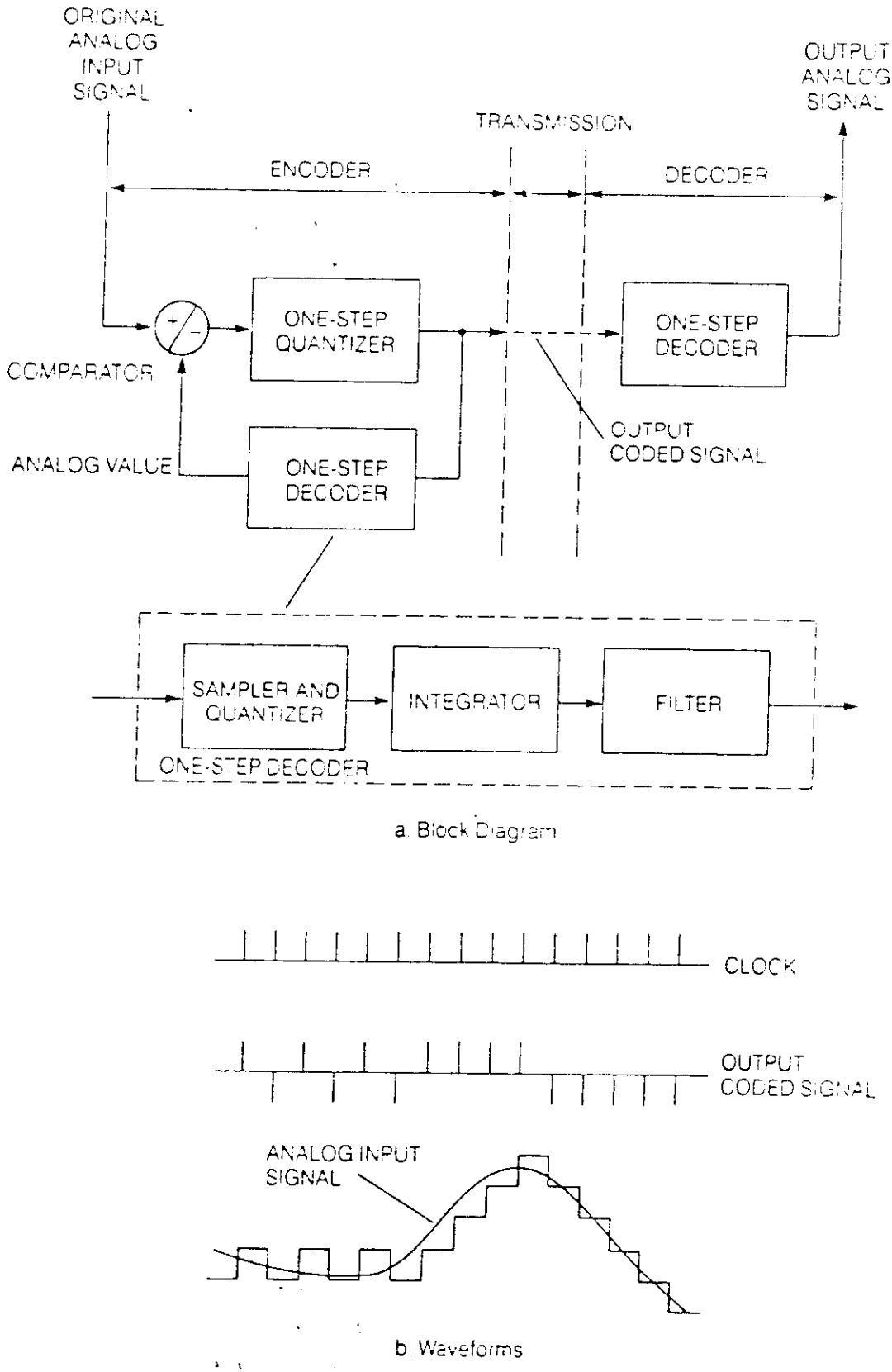


Figure 6-23. *Simple Delta Modulation*

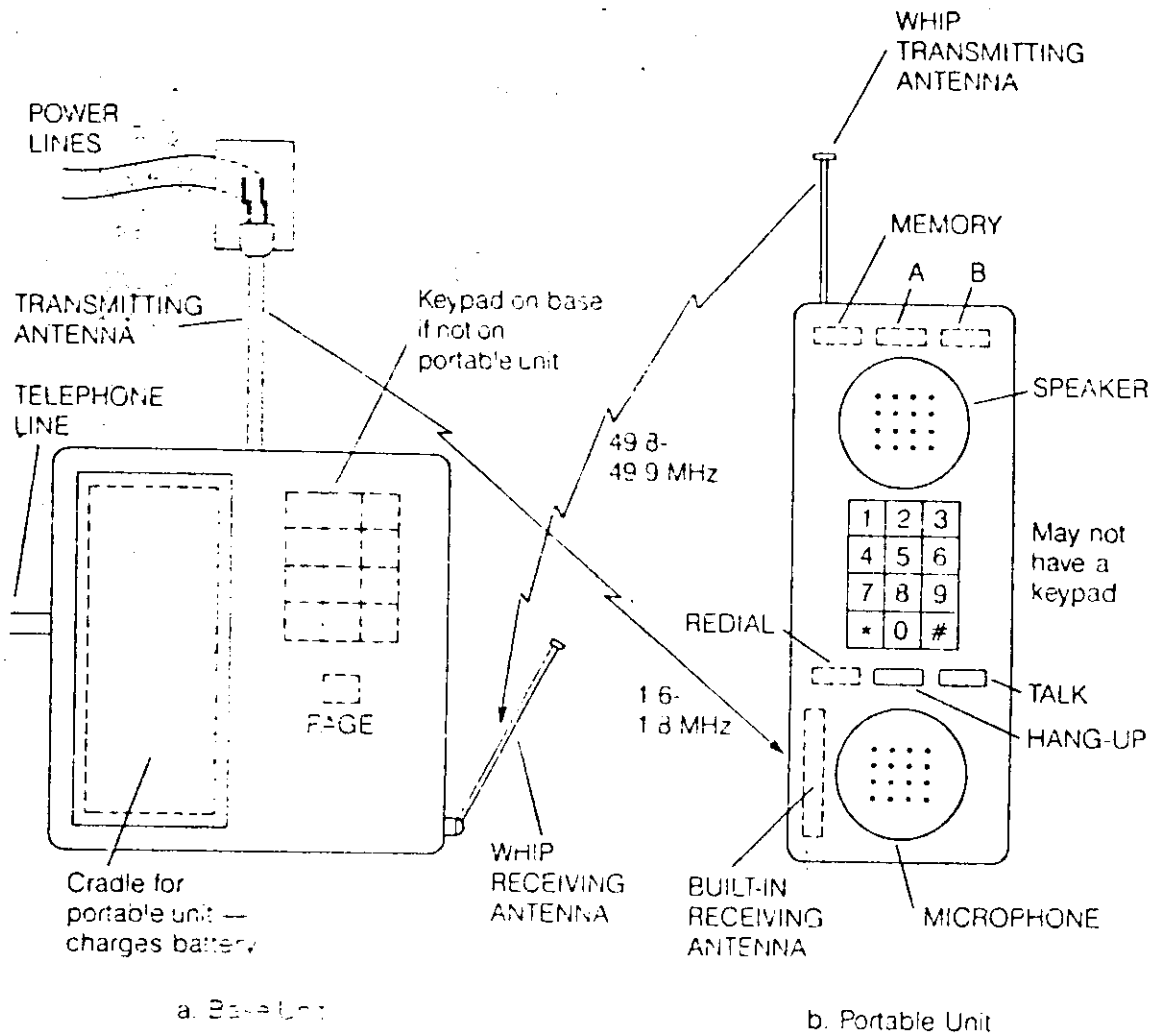


Figure 10-1. Cordless Telephone

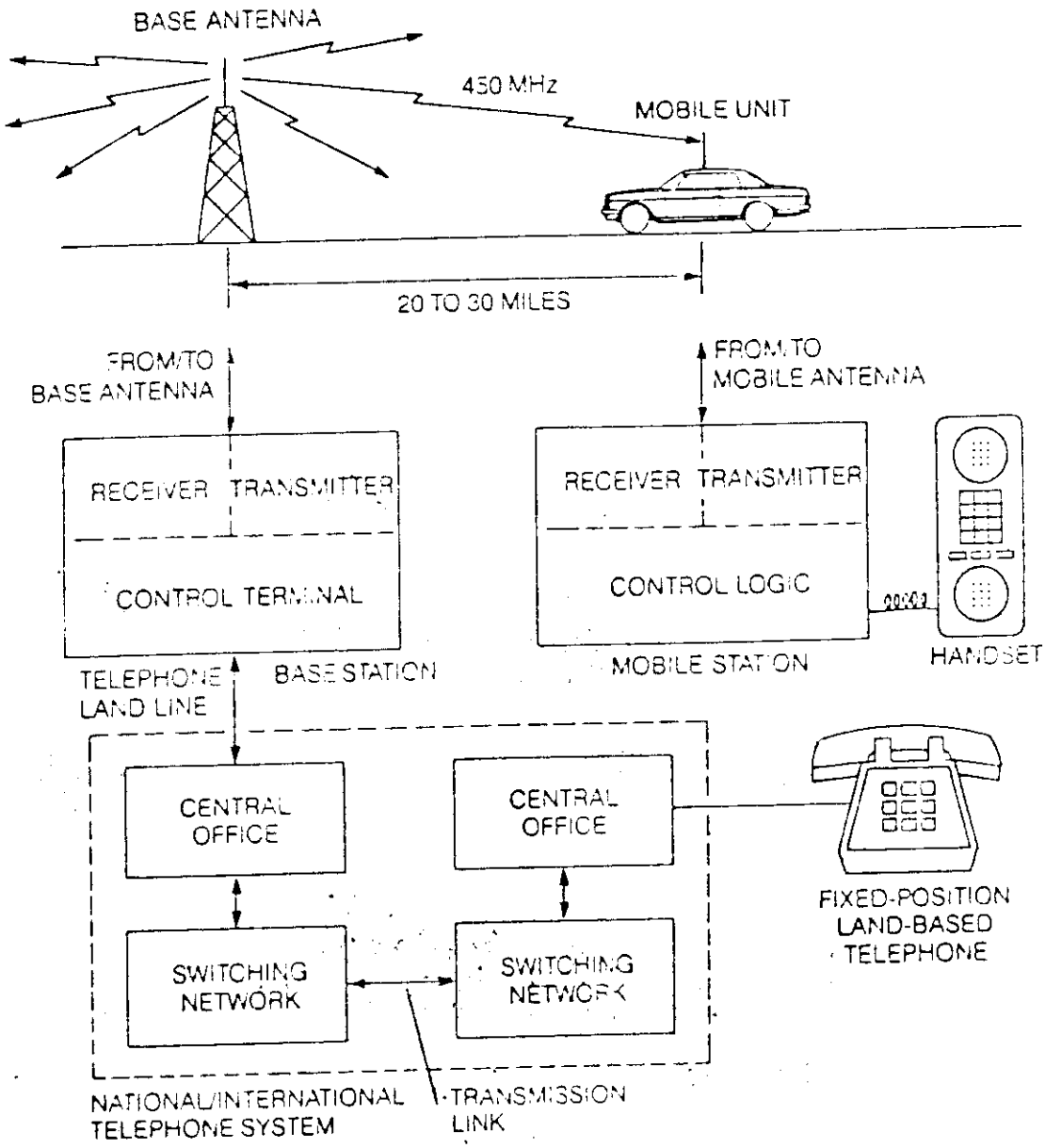


Figure 10-2. Mobile Telephone System

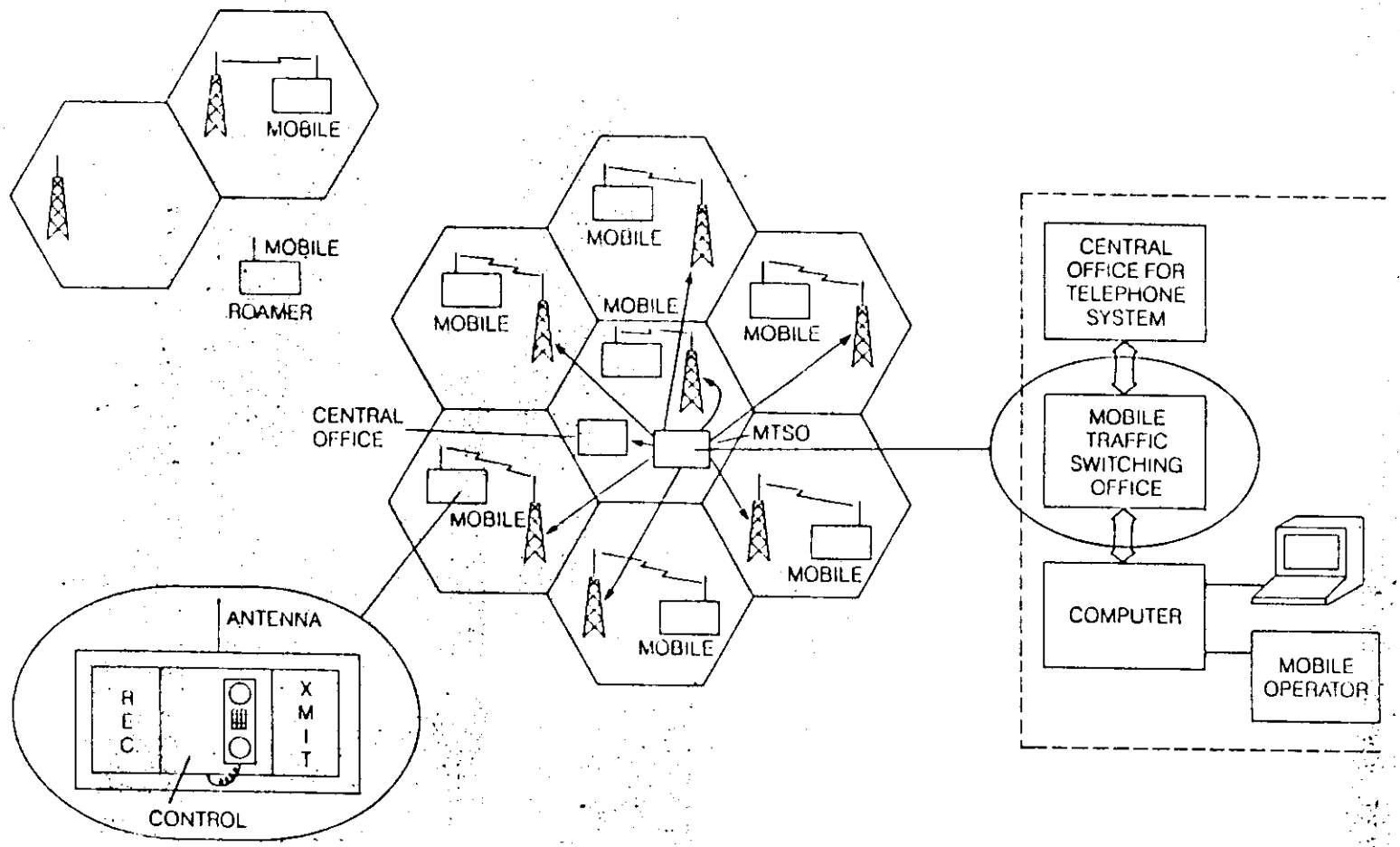


Figure 10-6. Cellular Network

We keep still very high for communication on existing links. Attempts to reduce this by making use of special properties of speech signal

- Delta Modulation
- Adaptive delta Modulation
- Adaptive PCM Modulation
- LPC
- Vocoding techniques
- Many others depending on digital signal processing

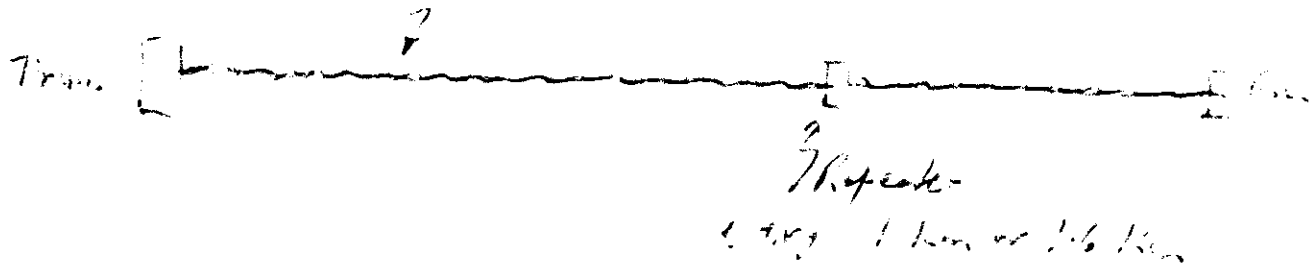
To REMEMBER: These transmit speech and only speech satisfactorily. Cannot replace the voice channel.

- Music
- Signaling
- Modem signals

all have problems.

Take advantage of:

- Existing subscriber loops can carry digital signals
- Twisted pair is ideal for PCM



Expand handling capacity of existing wiring

Steps: Put in transmission

Put in switching

Put in terminal digital channel.

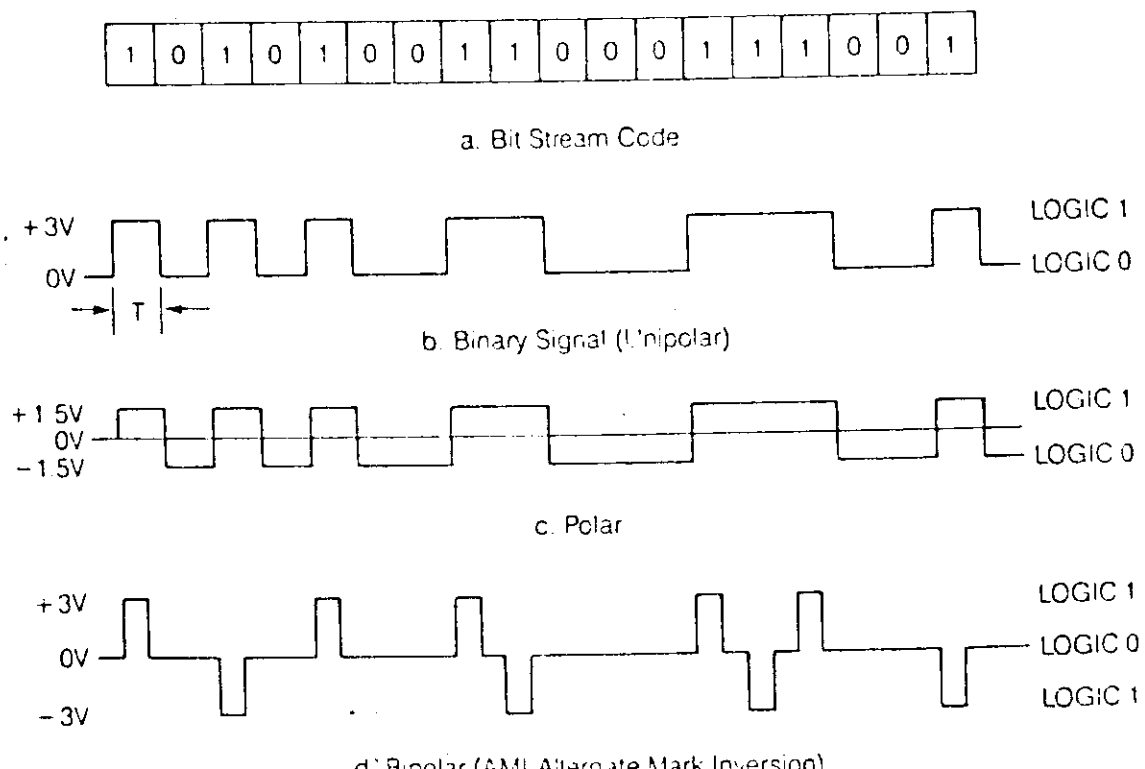


Figure 8-9. Types of Line Coding

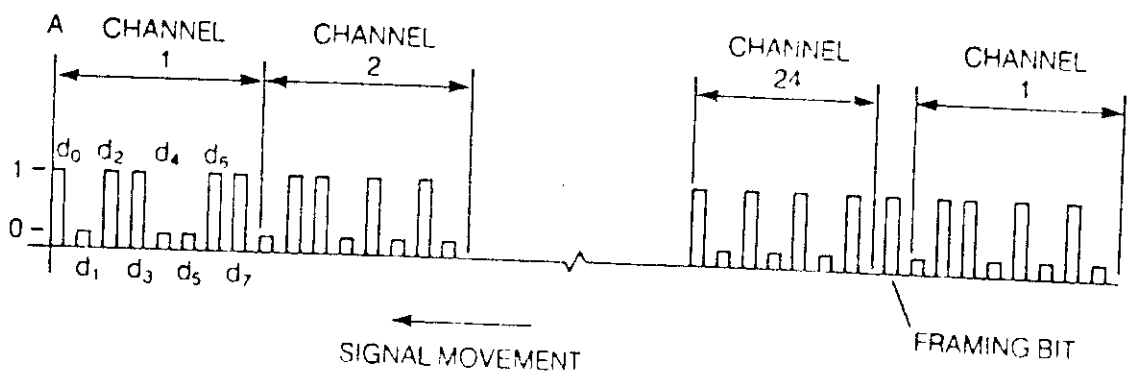


Figure 1-15. *Multiplexed PCM Signals*
(Source: D.L. Cannon and G. Luecke, Understanding Communications Systems, *Texas Instruments Incorporated, 1980)*

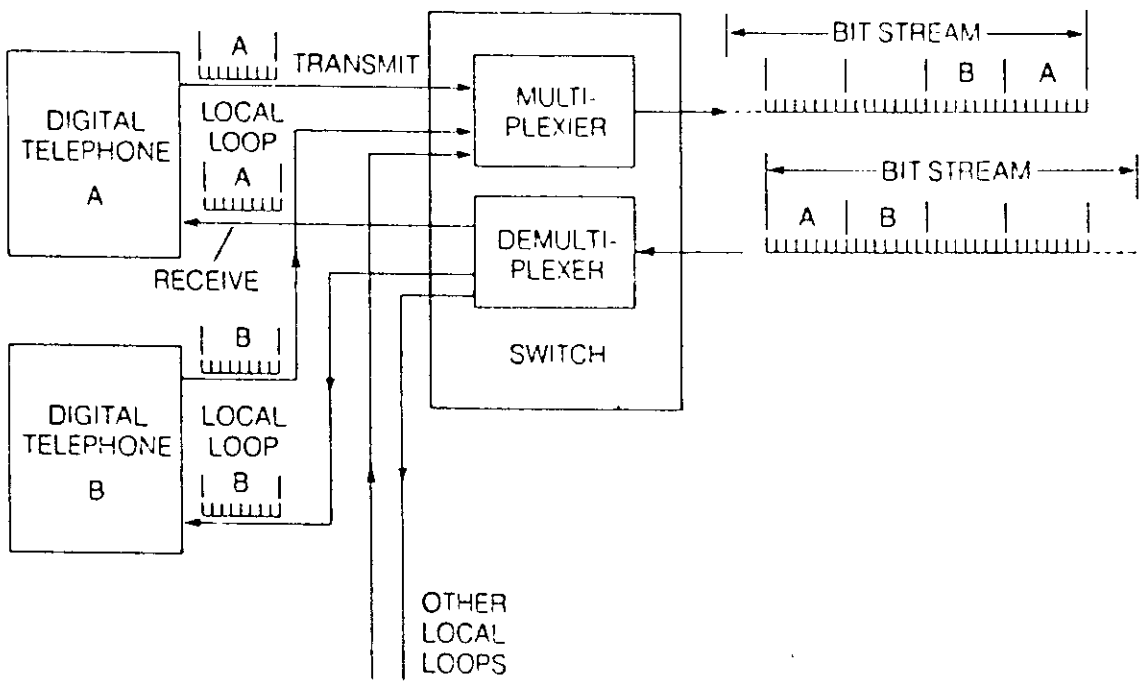


Figure 6-6. *Digital Transmission Using Multiplexing Technique*

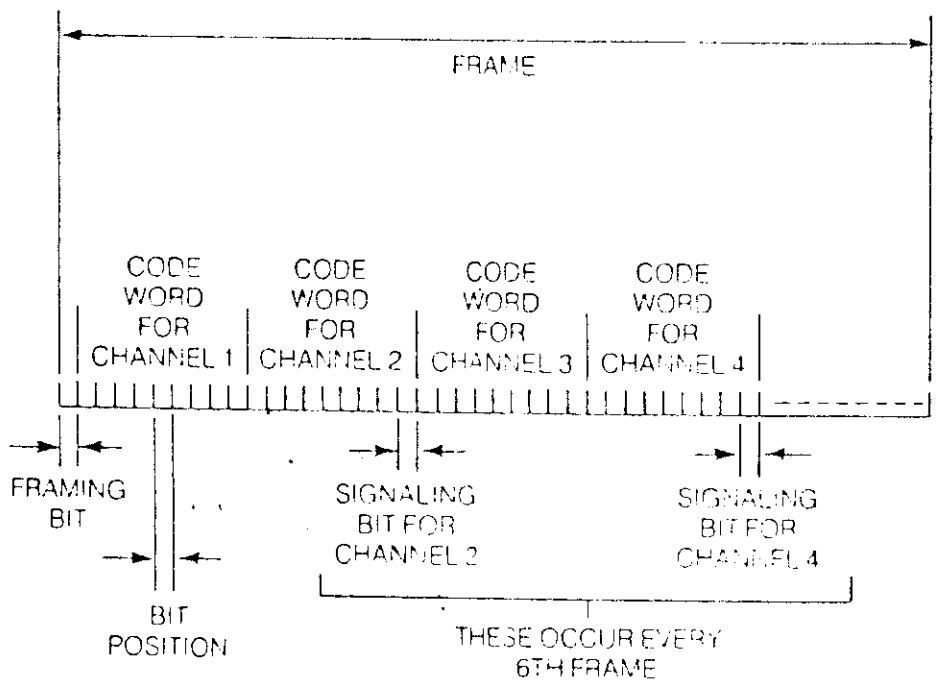


Figure 6-7. Signaling in the Digital Bit Stream

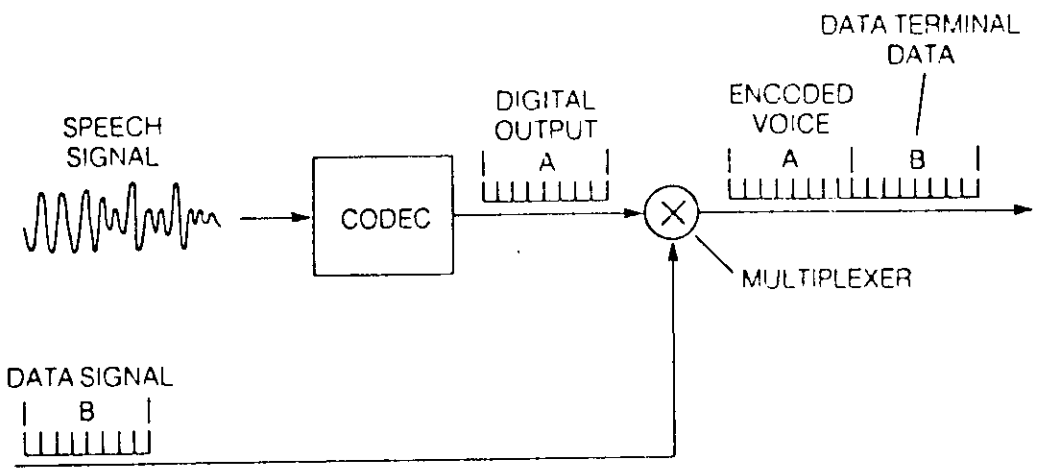


Figure 6-10. *Mixing Speech and Non-speech Signals in a Digital Network*

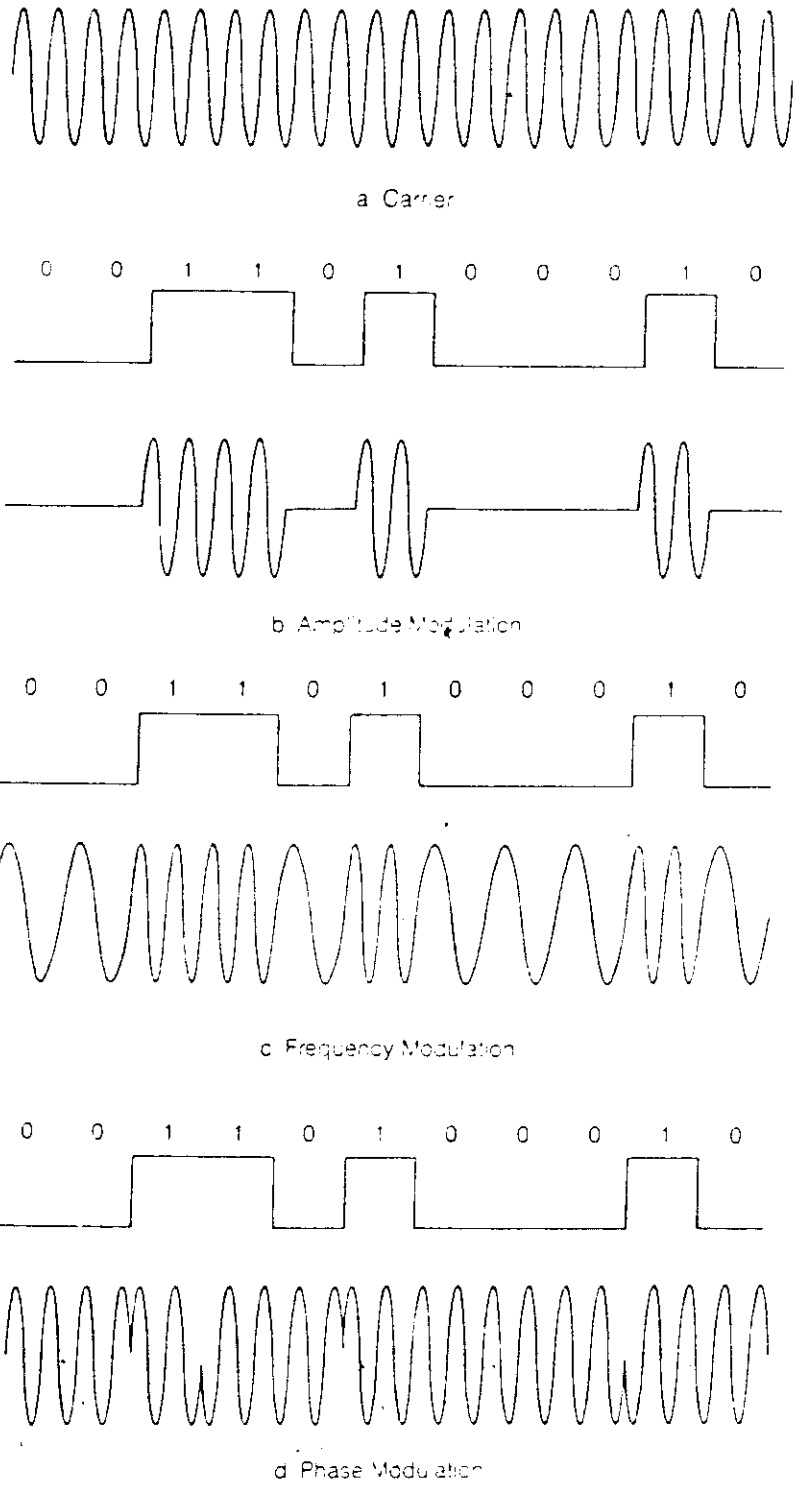


Figure 9-7. *Types of Modulation*
(From D. Doll, Data Communications: Facilities, Networks and System Design, *John Wiley & Sons, 1978. Copyright© 1978 by John Wiley & Sons, Inc., Reprinted by permission of John Wiley & Sons, Inc.)*

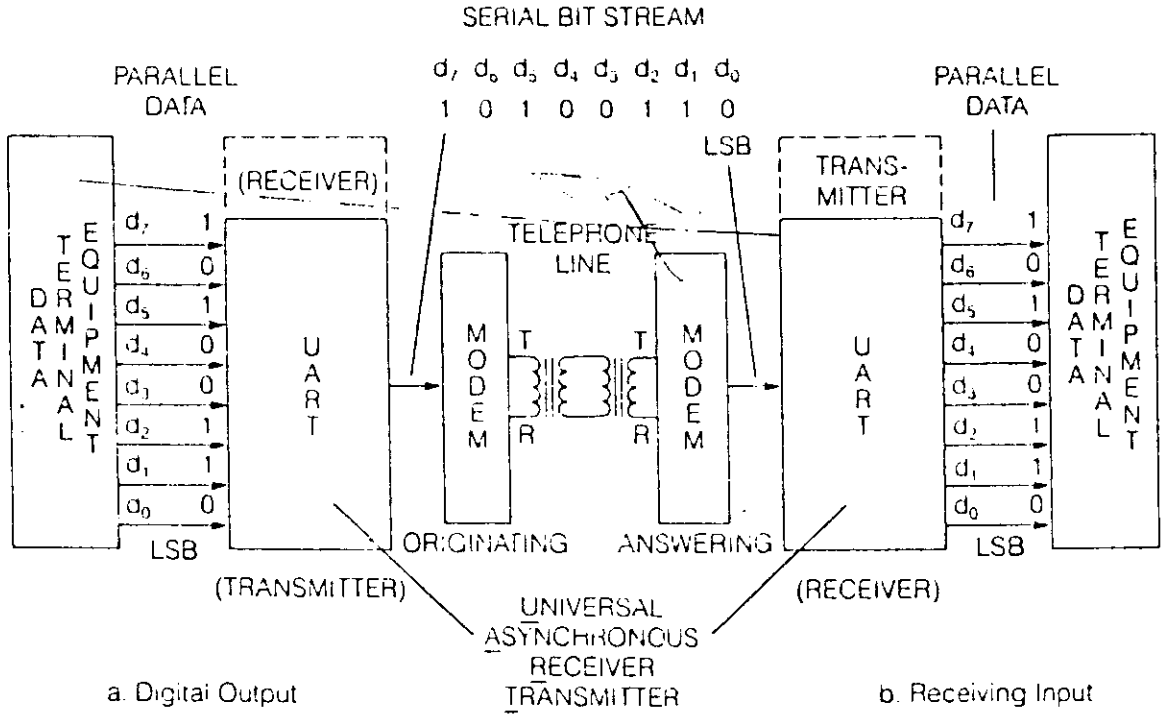
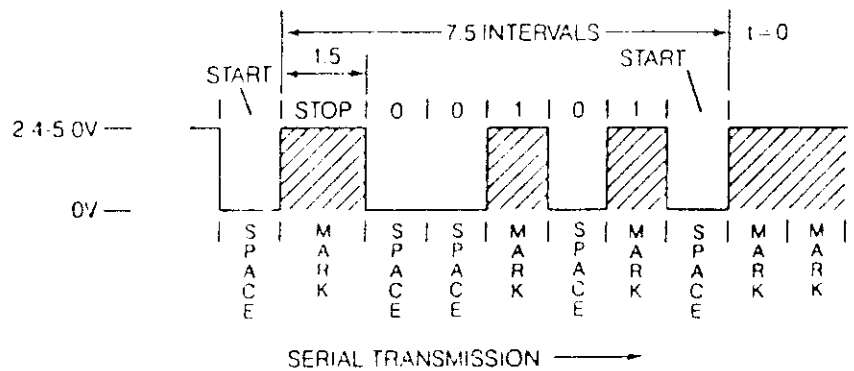
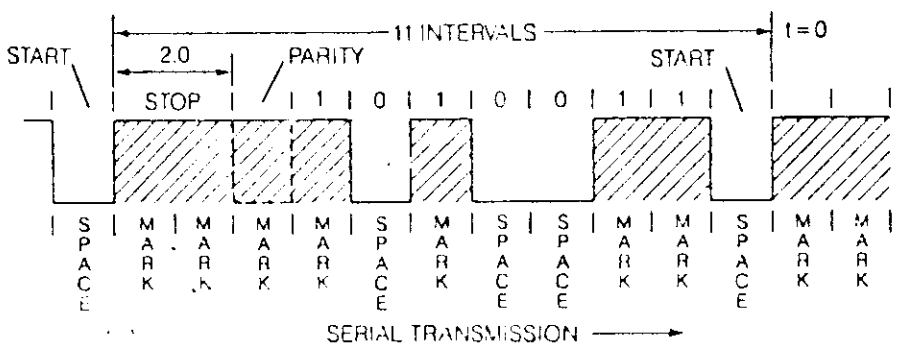


Figure 9-1. *Communicating Digital Data*



a. Letter S in 5-Bit CCITT Alphabet No. 2 Code



b. Letter S in 7-Bit ASCII

Figure 9-3. 5- and 7-Bit Characters in Asynchronous Format

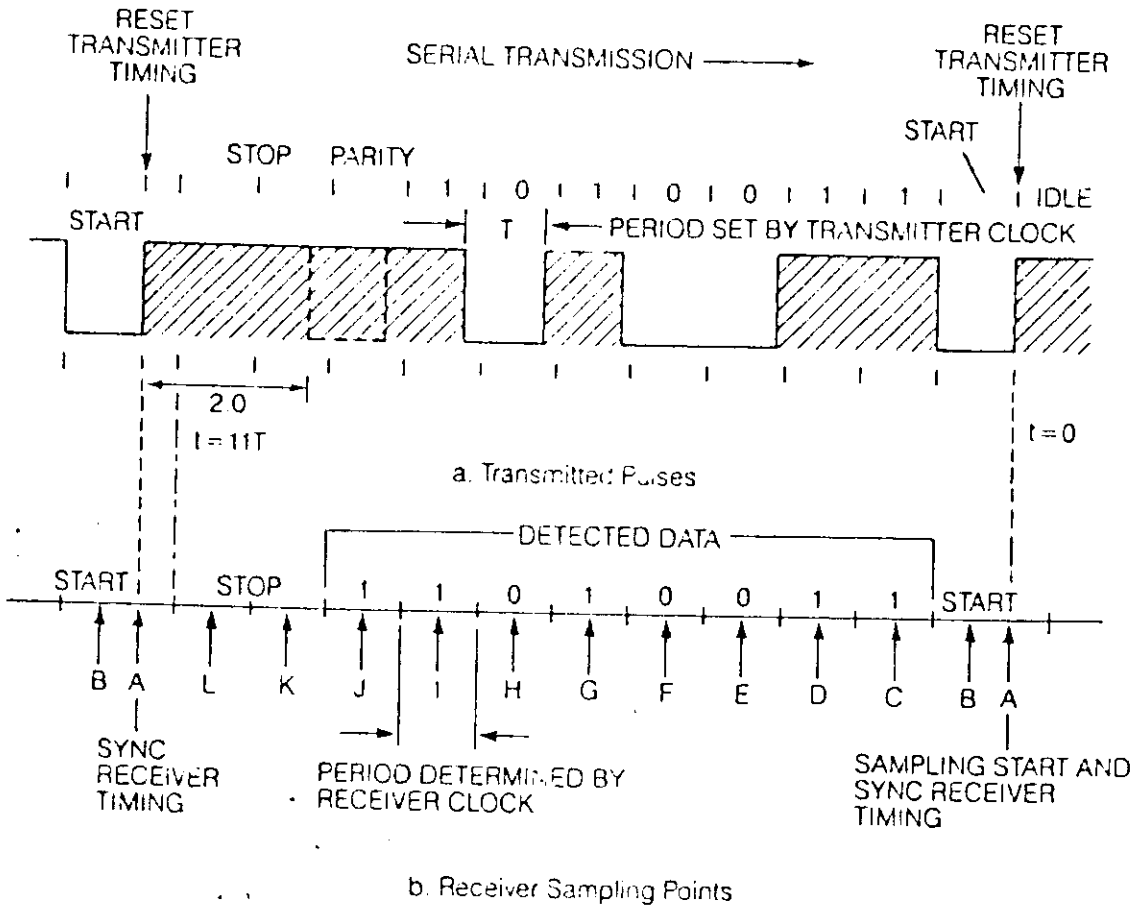


Figure 9-4. Asynchronous Operation of Transmitter and Receiver

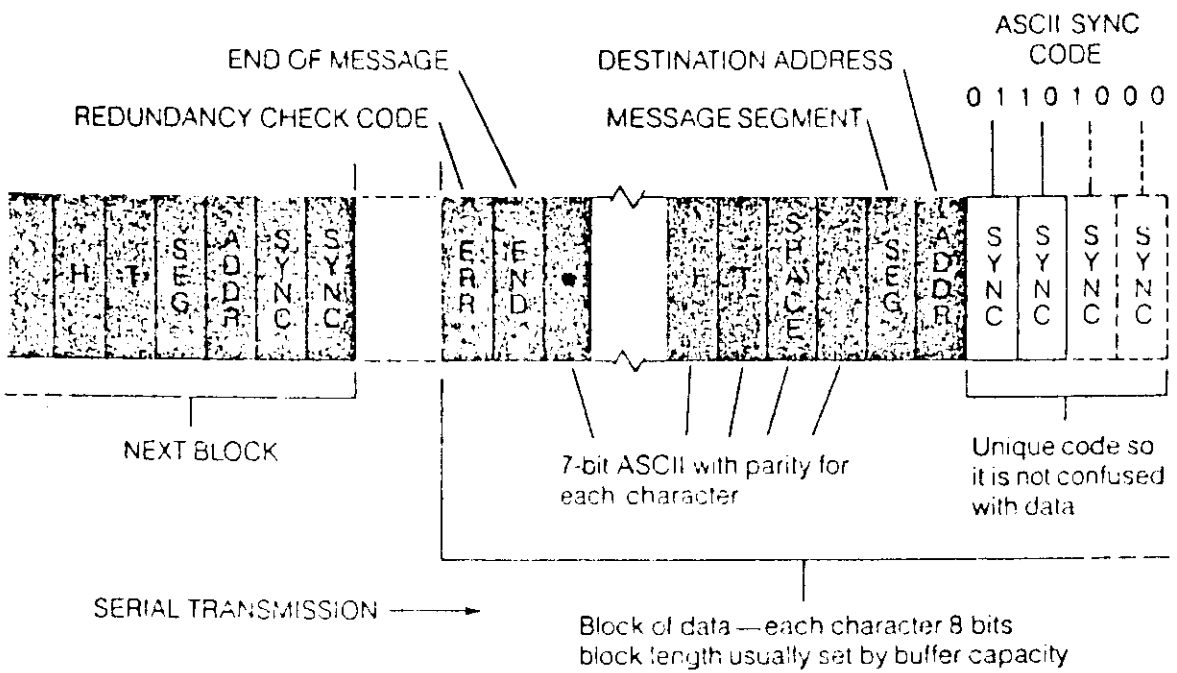


Figure 9-5. Synchronous Message Format