COMMUNICATIONS BULLETIN NO. 1

XDS STANDARD COMMUNICATIONS PRODUCTS CONFIGURATION

INTRODUCTION

XDS has a comprehensive line of data communication equipment to complement its Sigma computers. This line permits a salesman to offer his potential customer a competitively priced array of "off-shelf" equipment, thus saving him from expensive and time consuming development items. A quantitative analysis of the customer's operational requirements will quickly determine whether or not his system needs can be met with our standard products. If the results of the analysis show that some special equipment is needed, then the salesman must consult with the appropriate XDS Systems and Applications organization. This bulletin will attempt to enlighten the salesmen in such a manner that they can increase the probability of a sale by being able to show their customers how XDS can supply standard equipment and software at competitive prices and delivery times.

We recognize the fact that the field sales forces are not communications engineers. Furthermore, it is not a requirement to be a successful salesman in the computer/communications market. However, as with the computer salesman, the successful one knows what he is talking about.

OPERATIONAL REQUIREMENTS

Any system that has a remote device inputting or outputting data with a computer involves communications facilities. The specific facilities and equipment are determined by the operational requirements. The salesman should first determine the answers to the following questions.

- Where are the communication points in the total system?
- How much data must be exchanged between each point?
- How fast must the data be transmitted?
- What are the response times for each point?
- In what form must the data be presented at the receiving terminal?
- In what form must the data be generated at the transmitting terminal?

- When must data be transmitted?
- What terminal equipment will be used?
- What are the communication facility interface signals?

A block diagram of the system should be sketched to facilitate proper selection of equipment at each point and communications facilities among them. In order to properly understand and apply the terminology of data communications, the following tutorial on communications and its relationship to our equipment is presented.

TYPES OF COMMUNICATION FACILITIES

There are two major categories of communication facilities; public and private, with the former being the most commonly encountered in our systems. Private communication facilities exist primarily within those organizations which can economically justify ownership because they already possess right-of-way for their operations. Such organizations include railroads, power transmission agencies, and pipeline companies. The communications facilities for these operations may be open-wire on poles with cross-arms, buried cable, the high voltage conductors themselves (through power line carrier devices), and microwave radio with periodic repeaters for long distances. The nature of the communications carried on in such facilities are, by present law, restricted to the operations of the organization, and cannot contain messages of non-company business. Such networks are therefore prohibited from offering communications services to the public. The public communication organizations are referred to as common carriers and their operations are restricted by the regulations of State and Federal regulatory bodies. Generally, no competition between telephone common carriers is permitted. For the specifically permitted services which may be offered to the public under predetermined charges (tariffs) each carrier is assigned the sole authority and responsibility in an exactly defined geographical area. That assignment, called the filed territory, is subject to periodical renewal, and proof of acceptable public service performance must be supplied by the carrier.

The economics of privately owned communications facilities has been briefly presented. Occasionally, you may have a customer who will desire to interface our equipment with such a facility. Since there is no assurance of private communication channel performance specifications such as those that exist under filed tariffs of common carriers, the salesman is strongly advised to consult with the home office.

Why, beside economic reasons, do we use the facilities of common carriers? In the early days of telephone companies, and prior to filed areas and regulation, competition among phone service companies existed, and subscribers of one company's service could talk only with that company's subscribers; i.e., no interconnection between companies. It soon became obvious that the nation needed a voice communication network which, through proper (even if laborious) switching, would permit any telephone instrument to connect with another anywhere in the U.S. This led to the present interconnected voice network through "exchange offices", predominantly with dial capability, which is called the Exchange Network, Switched Network, or DDD (for Direct Distance Dial) Network. In order to connect an input, output, or combination device to a computer which is located at a place remote from the device, a communication facility is needed. Since devices may be located at one or many geographic positions, the logical facility to utilize is the ubiquitous

telephone company network. However, one fundamental difference in intelligence transmission must be realized and their incompatibility overcome. The telephone network is a voice, or audible frequency intelligence system, while the computer and its I/O device utilize digital intelligence. The latter intelligence usually takes the form of dc pulses, each of which can exist in one of two states, or binary. The dc pulses cannot be transmitted over the telephone network because of two primary considerations; non-dc coupled circuits and rapid attenuation, or signal loss due to impedance of wire conductors. The digital data must therefore be converted to the form of intelligence which can be transmitted over the telephone network. The converter which performs such a function is called a modem or data set.

MODEMS AND INTERFACE STANDARDS

Before proceeding further, terms such as Modem should be defined. Within this text, explanatory definitions will be presented. At the conclusion of this bulletin there is a glossary of terms using the precise, internationally accepted definitions.

MODEM

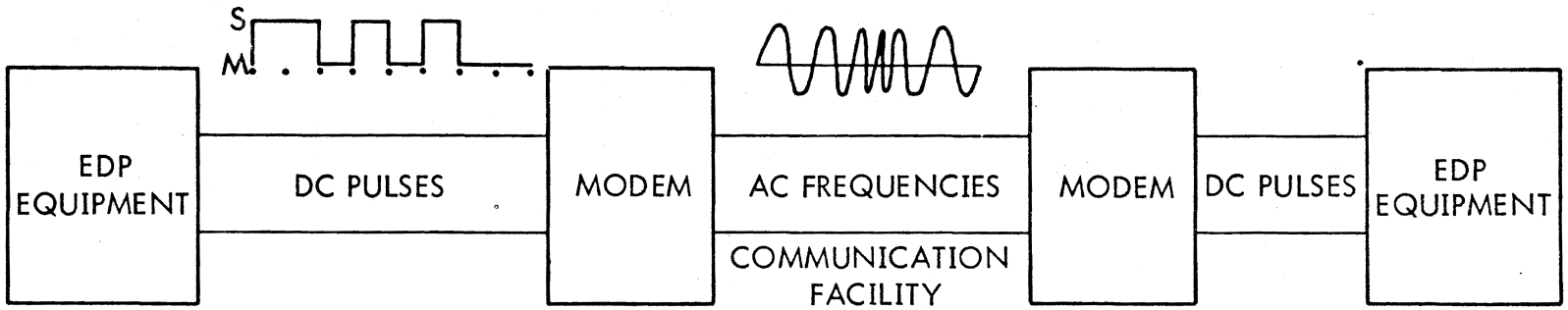
Modem is a contraction of two words, MODulator and DEModulator. Modulation is a process whereby the message is translated into information-bearing signals for purposes of transmission over the intervening medium. Demodulation is, of course, the reverse operation. A modem is, by definition, both a transmitter and receiver. A data set can be a modem, but it can also be a transmitter or receiver alone. Referring to Figure 1, a modem converts the pulses it receives from EDP equipment in the form of "mark" or "space" (1 or 0) variations, to ac frequencies which can be transmitted on the communication facility. The receiving modem converts the varying ac frequencies back into the originally transmitted dc pulse variations for acceptance by the receiving EDP equipment. The particular form of modulation shown in the example is that called FSK, or Frequency Shift Keying. The dc pulses are converted, or modulated, into signals of either f_1 or f_2 depending on the pulse state of 1 or 0. The mark and space frequencies are usually equidistant from f_c which is called the carrier frequency. On the dc pulse side of a modem, the electrical magnitude and polarity are well defined by, and often different among, different "standards". The three most commonly encountered "standard interface" functions are available in off-shelf XDS hardware. Excerpts from these standards are given next, which will also define mark and space more explicitly.

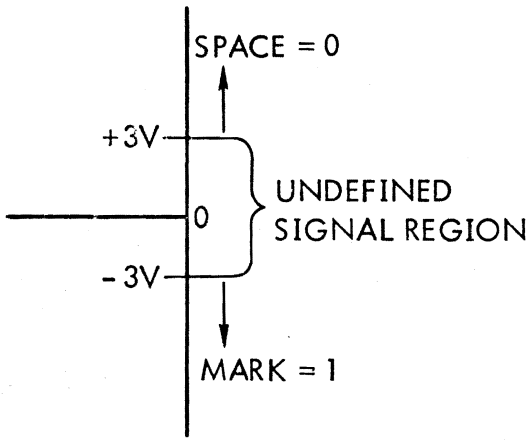
E.I.A. RS-232B –

The Electronic Industries Association Recommended Standard 232, with subsequent lettered revisions, defines the Interface Between Data Processing Terminal Equipment and Data Communication Equipment. It delineates the electrical signal characteristics which have been accepted by equipment designers in the computer as well as communication fields, and is the interface between XDS equipment and practically all of the data sets supplied by the common carriers. This specification states that the data signal shall be considered in the "marking" and binary state "one" condition when the voltage of the dc pulse is more negative than -3V with respect to the signal ground, and the signal shall be considered in the "spacing" and binary state "zero" when the voltage is more than +3V with respect to signal ground. The maximum voltage between any data circuit and ground shall not exceed 25V.

MODEM (MODULATOR - DEMODULATOR) = DATASET

HARDWIRE CONNECTED MODEM





E.I.A. RS-232B

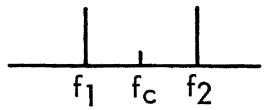


Figure 1

Summary of Data Circuit Interface Terms

Binary State	ONE	ZERO
Signal Condition	Marking	Spacing
Voltage	-3V min	+3V min
Paper Tape	Hole	No Hole

MIL-STD-188 –

Military Standard 188, Military Communication System Technical Standards, is a Department of Defense document specifying what the name implies. XDS supplies interface units to match the Sigma equipment to a data set used on a military communication facility. This specification states that the data signal shall be such that a positive six (plus or minus one) volts, with respect to signal ground, shall indicate a marking state, and a negative six (plus or minus one) volts, with respect to signal ground, shall indicate a spacing state.

Summary of Data Circuit Interface Terms

Binary State	ONE	ZERO
Signal Condition	Marking	Spacing
Voltage	+6 ±1V	-6 ±1V
Paper Tape	Hole	No hole

DC INTERFACE TELETYPE –

The output from the Teletype keyboard is a simple contact closure which makes or breaks a 2-wire loop. The input to the printer section offers a choice of two input current options. The current in the loop is adjusted at the power supply for either the "high level" standard of 60 milliamperes or the "low level" standard of 20 milliamperes. The high value is found in long distance dc teletypewriter networks. The XDS interface modules are designed to drive both levels of operation. Remote operation beyond five miles always requires the use of the EIA interface and data sets working over a common carrier communication facility.

MODES OF OPERATION

The communication facilities over which data sets transmit the intelligence are categorized by their capabilities of handling information by direction and permissive time, and are often called Simplex (SPLX), Half Duplex (HDX), or Full Duplex (FDX). They are defined as follows:

SIMPLEX –

A method of operation of a communication circuit where signals can be transmitted in only one direction at a time and is synonomous with "half-duplex". This definition is the standard of the electronics industry, but not that of the telephone companies. To the latter, a simplex circuit is one that is used for dc telegraphy or teletypewriters over a standard ac voice circuit by

means of a "phantom circuit". The dc phantom circuit connects the telegraphy devices between a center tap of the line side of a repeater coil and a common ground. The usually used meaning of simplex operation in the data processing industry is an irreversible transmission of information, or only one direction. The only terms which should be used in ordering the facility from the common carrier are "half-duplex" or "full duplex". The mode of operation called Simplex in XDS manuals is really the non-alternate directional use of half-duplex.

HALF-DUPLEX –

Transmission in one direction at a time.

DUPLEX –

Synonomous with FULL-DUPLEX. The operation of associated transmitting and receiving apparatus in which the process of transmission and reception are concurrent.

ECHOPLEX –

Synonomous with ECHO CHECK which is a method of checking the accuracy of transmission of data in which the received data are returned to the sending end for comparison with the original data. In the XDS time-sharing echoplex operation a character transmitted as a result of the operator depressing a key on the teletypewriter is decoded by the Sigma and retransmitted back to the terminal's printer. Thus, the operator has a visual verification ability to determine if that, indeed, was the key depressed.

CONFIGURATION OF THE XDS 7611 SYSTEM

To illustrate the application of these terms defined so far, we will consider how the XDS 7611 Character Oriented and 7601 Message Oriented communications equipment configures in these modes.

CHARACTER ORIENTED EQUIPMENT –

Reference should be made to XDS Document 90-09-81. The communication facility connects to the XDS equipment via the 7620, 7621, or 7622 Line Interface Units (LIU). An interface module contains the line interface circuits and control logic for connecting one send module and one receive module to their data sets, communication lines, or relays. Three standard interface modules are available: Model 7620 (relay) for a 2-wire or 4-wire telegraphic transmission facility; Model 7621 EIA-RS232 for a standard data set or a direct cable between the COC controller and a remote device; and Model 7622 MIL-STD-188 for a military data set.

From one to eight interface modules are used per LIU and may be used in any combination of the available options. Since each interface module connects to one send and one receive line, the send and receive lines are paired. Each member of a pair must use the same interface module as the other member of that pair.

Model 7623 DC Power Supply (optional) provides power for up to 16 half-duplex or full duplex circuits over distances up to five miles. If line current is supplied by a Sigma computer, one Model 7623 Power Supply is necessary for unipolar operation; two power supplies are required for bipolar operation.

CONFIGURING THE SEND/RECEIVE MODULES

Note that one interface module per circuit is required, but now the mode of operation (half duplex or full duplex) determines the ordering of the Formatted Send and/or Formatted Receive modules. The three possible modes and the necessary Send and Receive modules will be:

- One Way Transmission Only – One 7615 Send or one 7616 Receive module
- One Way Transmission Alternately (Half-Duplex) – One each 7615 and 7616
- Concurrent Transmission Both Ways (Full Duplex) – Same module configuration as Half-Duplex

A specially priced package offered for installations requiring eight or multiples of eight communication circuits is available in the Model 7630/7631. This consists of the 7611, eight 7615 Formatted Send, eight 7616 Formatted Receive, and eight 7621 Line Interface modules

It becomes obvious that the operating mode difference between half-duplex and full duplex lies in the software and not the XDS hardware. There are, however, considerable differences in the data set hardware and communication facility which must be considered as a result of the required data rate transmission and intelligence format. These will be discussed later. At this point, some additional terms should be defined in order to complete the configuration.

CHARACTER STRUCTURE AND DEFINITIONS

Character Structure (Format)	–	A set of signal elements corresponding to a character. Character structures vary from one code to another. Of the myriad existing codes, XDS has standard hardware to handle the codes falling in the generic categories of Baudot type and "eight-level". The different types will be shown after some necessary additional definitions.
Bit	–	The unit of selective information; i.e., the amount of information derived from the knowledge of the occurrence of one of two equi-probable exclusive and exhaustive events. The term is not to be used in two-condition data transmission instead of the "unit-element".
Unit Element	–	Character signal element having a duration equal to the unit interval.

Unit Interval (Signal Element-USA) – The interval of time is such that the theoretical durations of the significant intervals of a telegraph modulation (or restitution) are whole multiples of this interval.

Baud – The unit of modulation rate. It corresponds to a rate of one unit interval per second.

Note carefully that, contrary to many brochures, baud does not mean either bit or rate of bits. The signalling speed of intelligence of any digital code, regardless of the number of different time duration signal elements, can be expressed in bauds. A signalling rate expressed in bits per second can refer only to a code whose complete character structure is comprised of equal signal elements of the same time duration and contain only binary information (which can exist in one of two states only).

Start/Stop Transmission – Asynchronous transmission in which each group of code elements corresponding to a character signal is preceded by a start signal which serves to prepare the receiving mechanism for the reception and registration of a character, and is followed by a stop signal which serves to bring the receiving mechanism to rest in preparation for the reception of the next character.

In the asynchronous mode, characters may be transmitted with any time between characters. The receiver is only conditioned by the receipt of the start element and will wait any amount of time for it. An explanation follows, of the terms unit interval, unit element, signal element, start/stop elements, and how they relate to the data transmission rate in bauds. Figure 2 shows the character structure for the letter "W" in three different codes: Baudot, International Morse, and USA Standard Code for Information Interchange (USASCII). The Baudot character contains a "start" element equal to one unit interval, which is always "spacing" condition, followed by five information signal elements, each equal in duration to one unit interval, followed by a "stop" element which is always "marking" condition equal in duration to 1.5 unit intervals. The entire character of this start/stop code is 7.5 unit intervals in time duration. The information contained in the character is 5 unit intervals in duration. This "format" is referred to as 5/7.5 or "five out of seven and one half". Telegraph and teletypewriter transmission rates are more often expressed in "words per minute". Consequently, one more definition is needed.

Word (Telegraph or Teletype) - A group of six consecutive characters including a space between printable characters. For example

12345 67890 24680 13759 = a group of four words

XDS SIGMA COMPUTER SYSTEMS = a group of characters containing four words and two characters and three spaces

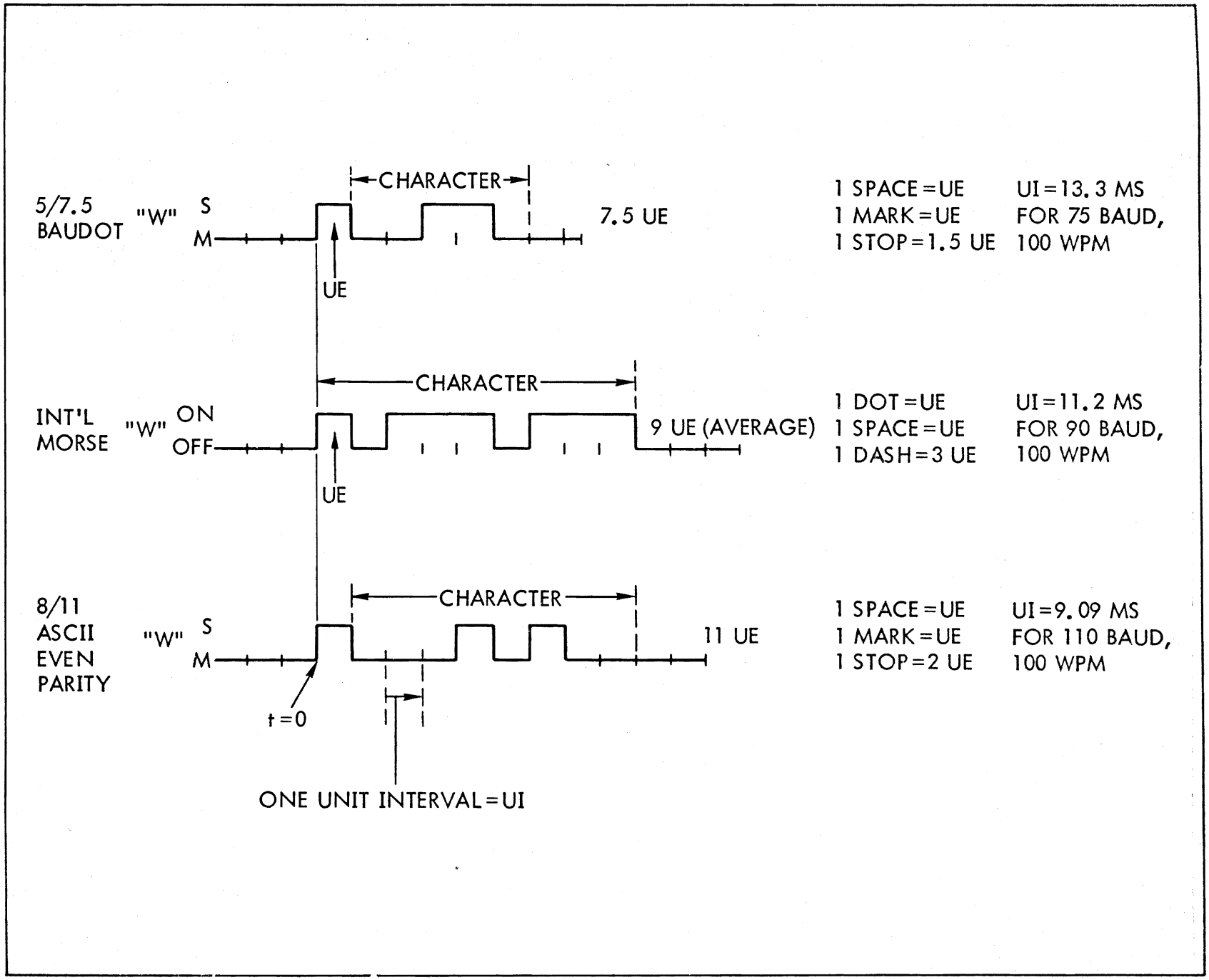

CHARACTER
5/7.5 BAUDOT
"W"
S
M
7.5 UE
UE
1 SPACE = UE
1 MARK = UE
1 STOP = 1.5 UE
UI = 13.3 MS
FOR 75 BAUD,
100 WPM
CHARACTER
INT'L MORSE
"W"
ON
OFF
9 UE (AVERAGE)
UE
1 DOT = UE
1 SPACE = UE
1 DASH = 3 UE
UI = 11.2 MS
FOR 90 BAUD,
100 WPM
CHARACTER
8/11 ASCII EVEN PARITY
"W"
S
M
11 UE
t = 0
ONE UNIT INTERVAL = UI
1 SPACE = UE
1 MARK = UE
1 STOP = 2 UE
UI = 9.09 MS
FOR 110 BAUD,
100 WPM

Figure 2

Simple arithmetic will show that since a word is 6 characters, the information rate can also be expressed in terms of characters per second by dividing the words per minute by 10.

(100 wd/min = 10 ch/sec)

Teleprinter codes always utilize the same quantity of information signal elements for each and every character. Telegraph codes use different quantities of information signal elements. The reason for this is that telegraph codes were originally designed for maximizing the information transmission rate based upon the probability of distribution of letters in the alphabet. The letter "E" being the most often used in the English language, resulted in the character structure for "E" being the shortest signal element, and the space separating the signal elements was chosen to be equal to the duration of the shortest signal element. Analysis of the total possible character structures in the International Morse Code resulted in an average of nine signal elements. To determine the average data rate of this code, the baud rate is computed on the basis of 9 unit elements. Figure 2 shows the Morse character structure for "W" as one unit interval of mark (on), one unit interval of space (off), three unit intervals of mark (on), one unit interval of space (off), three unit intervals of mark (on). The character has now been transmitted. Be fore sending the next character, there must be a separating interval equal to a minimum of three unit intervals in order to discretely identify the preceding character as having been completed.

The Baudot five-level unit (five information signal elements, each containing intelligence in binary form - either mark or space) yields a possible total combination of 2^5, or 32 characters and functions. Since this is inadequate to transmit 26 letters and 10 digits plus certain control functions, the Baudot characters are duplicated, yielding a possible combination of 64 with the determination of whether the character is letter of numeral/function being the prior receipt of either a "LTR" or "FIGS" character. Physically, these two control characters merely shifted the teleprinter carriage to lower or upper case. Recognizing the limitations of a five-element code and the need for additional special characters and control functions, the International Telegraph and Telephone Consultative Committee (I.T.T.C.C.) recommended a standard seven-unit code, each element of which is equal in duration and contains only binary intelligence. This was adopted by the USA Standards Association as the 7-bit "ASCII".

This code is used in data transmission systems with an additional bit for parity checking, making an 8-bit character code, but ASCII is only a 7-bit code. Figure 2 shows the ASCII character structure for the letter "W" as transmitted by a Teletype Model 33 or 35 terminal which generates the following: One start element, always "spacing" (equal to one unit interval); seven information signal elements (each equal to one unit interval), seven information signal elements (each equal to one unit interval); one parity signal element (equal to one unit interval); followed by a stop element, always "marking" (equal to two unit intervals). The entire character is equal to eleven unit intervals in duration and the information is contained in eight elements and is therefore called the "8/11" or "eight out of eleven" format. Note that in this unique case, the signal elements are exact integral numbers of the unit interval and can be considered to contain binary information only; therefore the data rate can be expressed in bits per second as well as baud. Only in such a case can baud equal bps. Figure 3 illustrates the data rate computation for two formats, both 100 wpm.

CONFIGURING THE 7612 TIMING MODULES

With these terms understood, the process of configuring the rest of the XDS modules can proceed. Since the received signal element states (mark or space) must be decoded in proper sequence for conversion to binary data for the computer (and conversely for transmitting) the state of the signal elements must be determined, or sampled, at the right time. For each format of code transmission used in the system, the appropriate 7612 Timing Module and Send/Receive modules must be selected. Only one timing module for a given format is required, regardless of the quantity of communication channels using that format. A single 7611 controller can accommodate four different timing modules without restriction. Five different modules can be used in special, restricted application. Table 1 lists the available timing modules required for each type of code format.

SIGNIFICANCE OF TIMING

At this point, the aspect of timing and signal element sampling will be considered. Obviously, if a "one" is transmitted, a "one" is desired at the receiver, or the information is in error. Many factors contribute to the causes of error, and the first one we will consider is timing. The term "start/stop asynchronous" has already been formally defined, as it applies to data transmission. The word synchronous means coincident in time and will be defined formally later. When the transmitting device, such as a Teletype, and the receiving device, such as the XDS 7611, are not in step with each other (or synchronized) one can see why it is necessary for the transmitting terminal to notify the receiver prior to the beginning of sending information (start element) and at the conclusion (stop element). Figure 4 illustrates the transmission of three characters in asynchronous Baudot format. In order to more fully understand the operation, a brief description of the accepted convention relating to "mark" and "space" will be presented. Since the days of dc teleprinter operation the condition of the current in the wire loop connecting terminals has determined the state of mark or space. In order to provide a check on the physical integrity of the wire, the "idle" or

(Continued)

WORD

5 CHARACTERS PLUS 1 SPACE CHARACTER

EXAMPLE : |BAKER_|CHARLIE_|DELTA|

BITS PER SECOND VS. BAUD

BITS FOR BINARY, 2-STATE, CONDITIONS ONLY

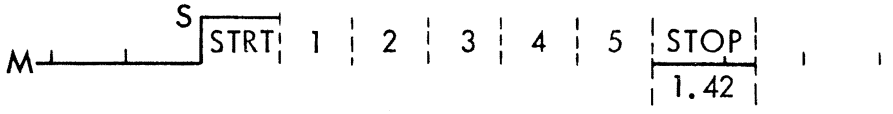
0 = SPACE

1 = MARK

BAUD APPLIES TO ANY DIGITAL CODE. DEFINES RATE OF ONE UNIT INTERVAL PER SECOND, OR RECIPROCAL OF PERIOD OF ONE UNIT CODE ELEMENT

CHARACTER STRUCTURE :

TELETYPE 5-LEVEL (5 UNITS OF INFORMATION DEFINE CHARACTER)
7.42 UNITS



EXAMPLE : 100 WPM, 5 LEVEL

$$100\ \frac{\text{WORDS}}{\text{MIN}} \times 6\ \frac{\text{CHAR.}}{\text{WORD}} \times \frac{7.42\ \text{UNITS}}{\text{CHAR.}} \times \frac{1}{60\ \frac{\text{SEC}}{\text{MIN}}} = 74.2\ \frac{\text{UNITS}}{\text{SEC}} = 74.2\ \text{BAUD}$$

EXAMPLE : 100 WPM, 8 LEVEL

$$100\ \frac{\text{WORDS}}{\text{MIN}} \times 6\ \frac{\text{CHAR.}}{\text{WORD}} \times \frac{11\ \text{UNITS}}{\text{CHAR.}} \times \frac{1}{60\ \frac{\text{SEC.}}{\text{MIN}}} = 110\ \frac{\text{UNITS}}{\text{SEC}} = 110\ \text{BAUD} = 110\ \text{BPS}$$

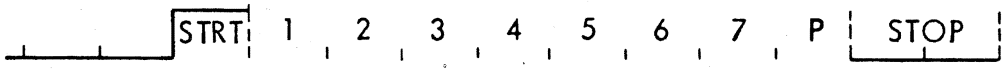


Figure 3

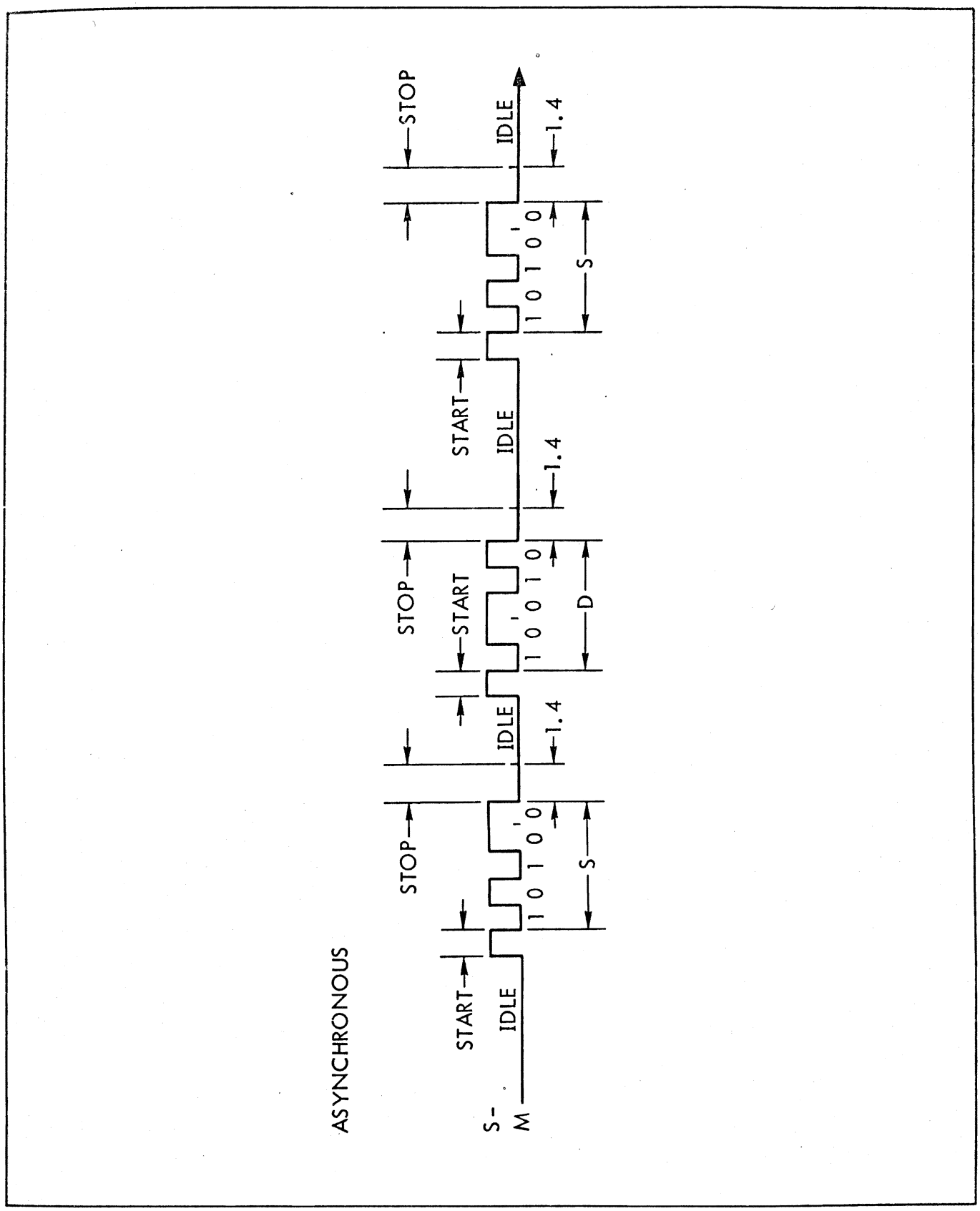

ASYNCHRONOUS
S-M
IDLE
START
1 0 1 0 0
S
STOP
IDLE
1.4
START
1 0 0 1 0
D
STOP
IDLE
1.4
START
1 0 1 0 0
S
STOP
IDLE
1.4

Figure 4

Table 1.

Timing Module	Format Group	Data Format	Speed (Char/Sec)	Typical Terminal Devices
7612-IA	I	5-level/7.5-unit	6.0	Teletype Models 28 and 32
7612-IB	I	5-level/7.5-unit	6.6	Teletype Models 28 and 32
7612-IC	I	5-level/7.5-unit	7.5	Teletype Models 28 and 32
7612-ID	I	5-level/7.5-unit	10.0	Teletype Models 28 and 32
7612-IIA	II	7-level/ 9-unit	14.8	IBM 1050
7612-IIIA	III	8-level/10-unit	15.0	XDS Model 7550 Keyboard Display, Teletype Model 37
7612-IVA	IV	8-level/11-unit	10.0	Teletype Models 33 and 35
7614-VA	V	8-level/10-unit	120.0	XDS Model 7555 Keyboard Display
7614-VB	V	8-level/10-unit	180.0	XDS Model 7555 Keyboard Display

Table 2 lists the available Send and Receive modules for each code format.

Table 2.

Send	Receive	Format and Timing Group
7615-I	7616-I	I (5/7.5)
7615-II	7616-II	II (7/9)
7615-III	7616-III	III or V (8/10)
7615-IV	7616-IV	IV (8/11)

non-use of the circuit was set to the condition of current flowing in it. Thus, if the line broke, the current dropped to zero and an alarm was activated. The circuit condition of current flowing was also (and is today) the "mark" state. Consequently, even today in accordance with the EIA-RS232 standard, the idle line condition must be mark (sometimes referred to as "mark hold"). Since the idle condition was mark, in order to notify the receiving terminal that information was about to be transmitted to it the sending terminal had to change the state of the line. The only way that could be accomplished was to send an opposite state signal (or open the line) which is the "space" condition. All asynchronous devices therefore utilize a spacing start element. At the conclusion of sending the information the receiving device must be conditioned to be in the marking state to be ready for the next start space signal. Consequently, the stop elements are always in the marking state. The various start/stop teleprinter codes have a common one-unit interval spacing start element, but different length marking stop elements. Standard stop elements are 1.0, 1.42, 1.5, and 2.0 Unit Intervals. Examples of these are:

Teletype Model 37	–	1.0 Unit Intervals
Teletype Model 28	–	1.42 Unit Intervals
Teletype Model 32	–	1.5 Unit Intervals
Teletype Model 35	–	2.0 Unit Intervals

The structure of the three characters illustrated in Figure 4 are for the code having a stop element equal to 1.42 unit intervals. Note that the idle time, in mark state, can be any duration from zero to infinity.

Next, we will consider the aspects of timing required for transmission of data to a receiver where both devices must be synchronized, or in precise time-step, with each other. In synchronous transmission, each character is transmitted immediately following the preceding (with no identifying start or stop elements) and all signal elements are equally spaced in time. To completely understand such operation it is necessary to analyze sampling or the point in time at which the information pulse will be examined to determine its state, mark or space.

Referring to Figure 5, notice that in synchronous data transmission there are no start or stop elements. The first character illustrated is the ASCII "Start of Heading" (SOH) structure. It is obvious that the receiver must have the capability of determining the fact that the first signal element of the character is a "1" or mark even though the line has been in the mark (idle) condition prior. The first signal element, which is necessary information, did not change the state of the communication line. In addition, the succeeding six signal elements are all zeros or space. The receiver must be able to determine this fact. The foregoing requirements exemplify the need for sampling the signal elements periodically and precisely. The precision, or allowable deviation in time, for sampling is related to a function known as "distortion". The details of that will not be covered in this Bulletin, but for the interested reader, the allowable variations are detailed in the specification titled E.I.A.-RS334, Signal Quality at Interface Between Data Processing Terminal Equipment and Synchronous Data Communication Equipment. Upon initiation of the connection via a communication facility between a terminal and computer, such as a synchronous keyboard/display terminal and the 7601, the two ends must be synchronized. The characteristics of the XDS Message Oriented Equipment will be discussed later, but is introduced here to explain the difference between asynchronous and synchronous transmission.

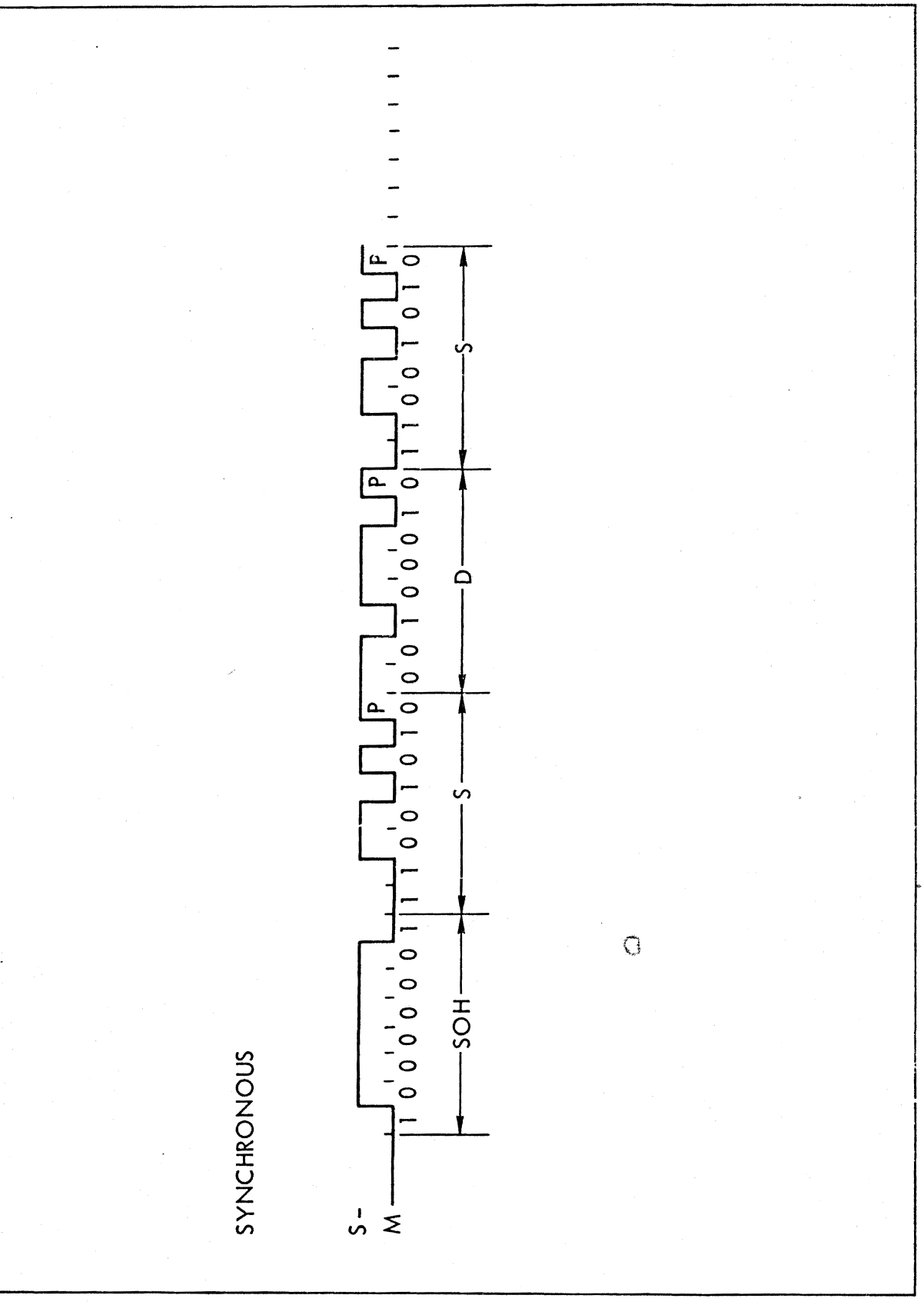

SYNCHRONOUS
S-
M
1 0 0 0 0 0 0 0 1
SOH
1 1 0 1 0 1 0 1 0
S
0 0 1 0 0 0 1 0 1
P
0 0 1 0 0 0 1 0 1
D
1 1 0 1 0 1 0 1 0
P
1 1 0 0 1 0 1 0 1
S
1 1 0 1 0 1 0 1 0
F

Figure 5

Obviously, there must be a best point in time to sample the information signal element to determine its state. A quick analysis will show that the worst point would be the leading or trailing edge of the pulse (i.e., the beginning or end of the signal element) because this is a possible transition point from mark to space, or vice-versa. The result of sampling could be ambiguous. The best point in time is that point at which the signal element is in its most stable state, or exactly midway between the beginning and end. The interval of time between sampling must be a fixed duration since the signal elements are being transmitted at a fixed rate. This periodicity is the true data rate on the communication facility, regardless of the content of the information. It should be clear now, that that synchronous data transmission requires a fixed data rate for each form of transmission, unlike the asynchronous operation. Since the sampling rate must be coincident in time with the transmitted data, the sending terminal must transmit a series of synchronizing signal elements, which are often called "clock pulses". In synchronous systems, encountered in those that utilize the common carrier furnished data sets (as well as customer owned data sets), the transmitting modem sends the necessary signal element transitions to the receiving modem and thus locks them together in time. The derived pulses at the receiving modem are utilized by the computer system, such as the XDS 7601 equipment, to properly "clock" the data into the storage device. Errors in received data will occur if the devices get out of step with each other, or "lose synch". This fault can occur due to variations in the communication facility, thus necessitating an occasional automatic synch-check by the computer equipment.

All of the terms used so far have now been defined and clarifications presented. We can now return to the configuration of the asynchronous Character Oriented Communications (COC) equipment, 7611.

OPERATING THE 7611 ON EXCHANGE NETWORK

The 7611 COC will operate on two basic types of communication facilities - the Exchange Network or Private Line. The latter can be supplied by either a common carrier or the customer. Remember the warning, however, that if the private facility belongs to the customer the salesman should consult the home office. The Exchange Network is that national communication facility explained earlier that utilizes DDD through "exchange" or "central" offices. The term exchange is derived from the fact that the communication channels are switched, interconnected, or exchanged at central locations. Each switching office is assigned a unique 3-digit number. For public convenience in remembering telephone dial numbers, two letters had been substituted for the first two digits. They were known by names such as the PEnnsylvania 6 or MAin 5 exchange, and serve a specific geographic area. With the advent of higher level switching centers, interconnected by multiple channels called "trunk lines", the DDD network became possible but required a change in the numbering plans to all-digit dialing as well as an additional three digits to specify area code.

A series of private or dedicated communications facilities can be furnished by the common carriers. The one of most interest to this discussion is the private data circuit called Full Period Data. This service is a non-switched communication facility between fixed locations that can be used at any time or 24 hours a day at the same cost. The charges for using the exchange network, on the other hand, are presently a function of time as well as distance.

If the customer is going to use the 7611 on a Full Period Data (FPD) service, the interface modules discussed so far will suffice for connection. If the system is to be operated on the Exchange

Network, (DDD), the equipment must have the ability to dial the addressee(s). The predominant method of dialing switching centers today is that of dc pulsing, although ac tone (Touch-Tone*) dialing is slowly replacing it. Before continuing with the 7611 dial options, a brief discussion of the dialing operations will be given.

DIALING CONSIDERATIONS

Dial pulsing was developed by the telephone companies to operate automatic switching offices utilizing "Strowger Switches", but is in use today in almost all automatic systems. The mechanism required at the customer's telephone is a simple and very reliable rotating mechanism. It is manually rotated for a specific length of arc corresponding to each digit and, upon release, a contact opens the the dc circuit to the exchange office, thus breaking the current. In the U.S. the number of breaks is equal to the digit sent, 0 representing 10 pulses. The pulses are repeated by relays at the exchange and the total digits are stored by relays for decoding to operate the switching equipment to connect the subscriber terminal dialed.

Voice frequency pulsing, or Touch-Tone*, is a method developed to speed up the process of dialing. A dial takes, on the average, 1/2 second to transmit a digit. The interdigit time averages about 1 second; therefore, the total time may take 15 seconds. With the use of quick acting pushbutton switches instead of the rotary dial, the time required to transmit each and any digit is the same. The total time to transmit the same quantity of digits is reduced to about 5 seconds.

There are other devices available for use with either rotary or pushbutton systems for customers who call specific subscribers frequently. These repertory dialers store a group of numbers each of which, when selected, is automatically sent to the exchange office.

Understandably, the telephone companies do not want customers using non-telephone company leased or approved equipment actuating their switching centers in order to maintain network integrity. Dial pulse timing, for example, is critical to proper operation of the switching equipment. In order to permit data operation over the exchange network, equipment to control dialing was developed and offered under tariff. The devices that perform the dialing function are the Bell System 800 series Data Auxiliary Sets. Although there are many models in the series, there are two basic types with the following characteristics:

ALTERNATE VOICE DATA USE –

The Model 804A set is equipped with a rotary dial and a standard telephone. To initiate data communication, the originator depresses a "Talk" key, removes the handset and, upon receipt of dial tone, manually dials the number of the addressee. The addressee, upon receipt of ringing signal, removes the handset, depresses the "Talk" button and commences voice communication. This is often referred to as "handshaking" operation. Upon mutual agreement that the data handling equipment is ready to communicate, both parties depress the "Data" key, disconnecting the telephones and connecting the data handling equipment.

The Model 804G set is equipped with a Touch-Tone* dial and a standard telephone. It is used in an identical manner as the Model 804A.

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DATA USE ONLY –

The Model 801A set is a dc dial-pulse Automatic Calling Unit (ACU). It permits a business machine, such as the 7611 system, to call any number in the switched telephone network and transfer the circuit to the associated data set for the automatic transmission of data. The telephone number, which is stored in the computer, is passed to the ACU in the form of parallel 4-bit characters, one character for each digit to be dialed. In response to an order from the computer equipment, the ACU presents an "off-hook" condition to the exchange office. After receiving the dial "go-ahead" signal (analogous to dial tone) the ACU passes the telephone number digit-by-digit to the exchange office. Upon completion of the dialing, the ACU waits for the call to be answered. When the called station answers, the ACU detects the answer signal and transfers the telephone line to the data set.

The Model 801C set is a Touch-Tone* ACU whose operation is essentially the same as that of the Model 801A.

In addition to the improvement in speed of the ac tone dialing over rotary dc dialing, the voice frequency tones used are completely compatible with the voice exchange network. This fact permits the tones to be transmitted to any part of the national network. The method offers an additional use for remote computer entry for those systems that have the necessary decoding equipment – that of transmitting digital data from a Touch-Tone* after establishing the connection on the exchange network.

Returning once more to configuring the 7611 for the exchange network, XDS has standard products to permit its operation with the Bell 801 Automatic Call Units - the XDS 7618 Automatic Dial Equipment Controller (ADEC), and 7619 ACU Interface Module. The detailed operation of these units is described in XDS Technical Manual 90-11-80. The general operation is described as follows.

The primary function of the ADEC is to transmit a sequence of four-bit dialing digits to the ACU. The automatic dial equipment controller (ADEC) and automatic call unit (ACU) interface module control communication between an input/output processor (IOP) and an automatic call unit (ACU). Communication between the IOP and the ADEC is through the IOP eight-bit data path interface in the ADEC. Communication between the ADEC and the ACU is through a special cable connected to the ACU interface module. From 1 to 16 ACU interface modules (and associated cable assemblies) may be included in the ADEC to interface with from 1 to 16 associated ACU's.

The CPU program sets up a table of dialing digits in the memory, then addresses one of the automatic call units through an ACU interface module in the ADEC. If the addressed ACU interface module is available and the associated ACU is ready, the sequence begins.

CONFIGURING THE 7613 LINE INTERFACE UNITS

The remaining component of the 7611 COC system necessary for completing the configuration is the 7613 Line Interface Unit. The LIU's permit the connection of multiple Send (7615), Receive (7616),

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or combinations thereof, formatted S/R modules to the 7611 controller. Each 7613 LIU has the capability of connecting up to eight half-duplex or full duplex circuits. The basic 7611 controller is equipped with one 7613 LIU permitting its use with eight circuits. Up to seven additional 7613 LIU's can be added, bringing the total number of communication circuit handling capability to 64 per controller. From one to 16 controllers can be connected to a Sigma computer, thus permitting the use of 1024 circuits.

DATA SET SELECTION

All of the components obtainable from XDS to form a 7611 COC system have now been covered. We will now examine the selection of data sets. This bulletin will not attempt to discuss the various models of military nomenclature modems. Suffice to state that if they are designed to operate in accordance with MIL-STD-188 or EIA-RS232 there is no problem. The other possible data sets are those that may be leased from the common carrier or purchased by the customer. In either case, we will consider only those sets that conform to EIA-RS232. The reader should also study Communications Bulletin No. 2 pertaining to Data Transmission Systems versus Data Transmission Assemblies and responsibilities which the telephone companies will and will not assume. In the process of selecting the appropriate data set to be furnished by the common carrier, the salesman is again strongly advised to use the free services of the local telephone company Data Services Advisor. To give our people a conversational knowledge of the different data sets and a brief understanding of their operation, this Bulletin will cover those modems that could be used with our equipment.

Bell System data sets are used by both Bell operating companies and independent telephone companies. The latter often use other data sets as well. For example, General Telephone also uses data sets manufactured by Automatic Electric Co.; United Utilities operating companies also use data sets built by their wholly-owned subsidiary Rixon; Western Union also uses data sets made by Milgo. Each manufacturer may build their modem to interface to EIA-RS232, but that is only the dc (data processing equipment) side of the set. The modulation methods and consequent signal on the communication facility vary considerably; thus, modems of different manufacturers may be incompatible, resulting in an unworkable system. We should be careful to point out these potential problems to our customers if they intend to use their own data sets. The decision to purchase modems rather than lease from a common carrier is usually based upon cost comparison of payoff period versus accumulated lease cost and often does not consider the additional cost of necessary maintenance and test equipment concomitant with owned equipment.

In a system that uses data sets furnished by the common carriers it is often possible for different terminals to be located in the territories of different telephone companies - Bell and General for example. Since the Data Transmission System is furnished by the carrier, the onus is upon those companies to assure compatibility between their own sets. In such configurations, the usual practice is for the independent company to utilize the Bell data sets.

The salesman is strongly advised to consult with the Data Service Advisor regarding the facility which will be required, as early as possible before delivery of the XDS equipment. This is because of very long delivery schedules of data sets and provisioning of data circuits - often many months. The ordering of data sets from the telephone company should also be the subject of a meeting with the Advisor in order to obtain the proper configuration of the data set. Each specific data set has

"strapping options" which, if not specifically stated in the service order, can result in an unworkable system. The strapping options required for XDS equipment will be the subject of future Communications Bulletins.

The Bell System data sets that may be required by our Sigma systems are the following:

- 103A and 103F for asynchronous character data service for speeds up to 300 baud
- 202 series for asynchronous character data service at speeds up to 1800 baud
- 201A and 201B for synchronous data service at speeds of 2000 bps and 2400 bps, respectively
- 203A for synchronous data service at speeds of 1800, 3600, or 5400 bps
- 205B for synchronous data service at speeds of 600, 1200, or 2400 bps
- 301B for synchronous data service at a speed of 40,800 bps
- 303 series for synchronous data service at speeds of 19,200, 50,000, 200,000, and 230,400 bps
- 303J for special synchronous data service, limited to 50 miles, over T1 carrier system at a speed of 460,800 bps

Detailed descriptions of these and all of the other data sets are contained in documents titled Bell System Data Communications Technical Reference Manual. Every XDS field office should have a set of these informative manuals. They can be obtained by writing to:

Mr. V. N. Vaughan, Engineering Director
Data Communications
American Telephone and Telegraph Company
195 Broadway
New York, New York 10007

EXCHANGE NETWORK VERSUS FULL PERIOD DATA (FPD) CIRCUITS

The modems to be used with our systems will most frequently be selected for use on either the exchange network or private line (FPD), both of which are communication facilities referred to as "voice grade circuits". Remembering that the telephone network was designed for voice communication, the only "specification" for such service was that the parties talking to each other should be able to hear each other. If the voice connection is a bad one, the telephone company will try reconnecting the parties. Such a loose specification is quite inadequate for data transmission. The Bell System presently offers more controlled data communications facilities such as Data-Phone* on the exchange network and various grades of special "conditioning" of FPD circuits. It is important to understand these differences as they have a definite effect on our total computer/communication system. Without going into engineering and mathematics, a brief description will be presented before describing how the specific data sets are selected.

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On any communication circuit, the information being sent is subject to degradation resulting from interference. This "noise" is the result of many causes and takes many forms. Voice communication suffers from interference which may not affect digital data communication and vice versa. In digital data systems, the longer time the transmitted mark or space has to stabilize after the transition from the previous state, the more accurate will be the reproduction of that intelligence at the receiver because there is less ambiguity in the sampling determination. Obviously, the longer the pulse, the slower the data rate. The sampling process at the receiver must also discriminate between the intelligence and the omnipresent noise. The longer the receiver is permitted to do it the less will be the ambiguity of mark or space determination. Most noise occurs in the form of sudden variations of signal energy level or amplitude. The most commonly encountered analogy is the static crash due to lightning which is heard on standard AM (Amplitude Modulated) radio receivers. Since both the transmitted signal and lightning are amplitude-varying forms of signal, the receiver detects both equally well. To overcome this deficiency, a different form of broadcast transmission was invented in 1933 by E. H. Armstrong. The method utilized a modulation different from amplitude variations and, thus, not subject to lightning and spark or ignition type interference. That method is called Frequency Modulation (FM). This method of modulation is the most commonly used in data transmission since the receiving modem responds only to frequency variations of the signals it receives.

If data signals are transmitted using relatively long pulses in addition to being frequency modulated, the chances of receiving error-free data are better. Thus, FM signals at speeds of 300 baud or less can practically always be successfully sent over the exchange network. These data rates correspond to teletypewriter rates. The modems used for this purpose are, most often, devices that will convert (modulate) the dc pulses into corresponding mark or space frequencies (f_1 and f_2 of Figure 1). This form of FM is also called Frequency Shift Keying (FSK) and is the form of modulation used in the Bell Data sets 103 and 202. As the data transmission speed is increased, the pulse duration gets shorter, thus making it more difficult for the receiver to sample and determine the pulse state. At speeds higher than 300 baud, characteristics of the communication facility must be controlled more closely. The most important of these are passband (bandwidth), envelope delay distortion, and noise-signal power. These terms are obviously going to require explanation. They are important because they are the primary characteristics that apply to the "grade-of-conditioning" and cost of the circuits available from the common carriers for computer communications.

A "voice grade" channel is designed to pass the band of frequencies generated by both male and female humans but not the wider band of frequencies that both are capable of hearing. The speech generation band ranges from around 100 Hertz for a male bass to around 1100 Hertz for a female soprano. The human ear detects overtones, harmonics, and higher frequencies resulting from the products of the composite speech, of which up to the third multiple is important for "intelligence" detection of the voice and recognition of the speaking party. Thus, the telephone network was designed to pass a band of frequencies roughly from 300 to 3000 Hertz. The characteristics of the channels are such that not all frequencies in this band are transmitted from one end to the other with the same amplitude. Additionally, as the transmitted frequency becomes lower than 300 or higher than 3000 Hertz, the signal is attenuated exponentially. A standard method of defining the passband ("bandwidth" or "frequency response") of a channel is to state the lower and upper limits in terms of the two frequencies at which the signal energy or power has been attenuated to one-half its original value. The unit of measurement most often used is the decibel (db). The half-power level corresponds to an attenuation of 3db. A "voice grade" circuit therefore has a nominal passband of 300 to 3000 Hertz, but could be narrower and, in a rare instance, wider. It is important,

therefore, that a data set transmit frequencies within the passband subject to the least attenuation.

The communication channel characteristic that is most critical for data transmission, and thus most controlled and defined, is "envelope delay distortion" (EDD). Its full explanation would require the use of differential calculus, but a good understanding of what it is and how it affects digital data can be obtained from the following. Consider the method of transmitting a mark (by sending a 1200 Hz frequency) or a space (by sending 2200 Hz frequency) used by the 202 data set. It takes a finite amount of time for data to reach the receiving end. Data signals are subject to pejorative modifications as a function of the channel's Phase Delay and Envelope Delay characteristics. These cause a delay of one frequency with respect to another. Since the receiver is required to make an unambiguous determination of the signal state at a specified point in time, at a given instant it should be presented with either f_1 or f_2, and in the proper sequence. If, at the moment of sampling, the receiver is presented with both frequencies due to a delay of one with respect to the other, then the intelligence is lost. The method of controlling signal distortion due to envelope delay is called "equalization". Circuit constants are inserted in the channel, at installation, to equalize the delay within specified time limits. This equalization, or conditioning, is available in grades under tariff in terms of C1, C2, or C4. Additionally, control of the channel frequency response is a function of the conditioning grade. This conditioning is available only in private line FPD service. These controlled channel characteristics of frequency response and delay are not found in the exchange network.

The third characteristic of a communication channel, important to voice but more so to digital data transmission, is that of noise and signal power. Ideally, the receiving modem should be presented with only the signal from the transmitting modem without any accompanying noise or signals from other data transmitters. This latter form of interference is due to "crosstalk", or signals being picked up from adjacent channels that result in the signals "talking across" among channels. Another serious form of interference to digital data transmission is pulse noise or "hits". These are caused by some known factors such as arcing relay contacts, and unknown factors under study. A circuit routed through many switching exchanges will be subject to this form of crosstalk more than a non-switched FPD circuit. The maximum quantity of hits per unit time is a part of the specification for C conditioning. To control the amount of crosstalk resulting from signal power emanating from the transmitting modem, all customers are limited to a maximum power level at which the modem is permitted to send. A maximum level is established for all channels, whether on the exchange network or FPD.

Before proceeding to the next step of selecting modems, a brief discussion on the methods of connecting modems to communication circuits is necessary.

DATA SET CONNECTIONS

If a customer has a FPD circuit, he is permitted to connect any device provided it stays within the limits of the maximum signal power allowed under the tariff. For digital data transmission, the data set may be telephone company-supplied or customer-owned. Connecting to the exchange network, however, is an entirely different matter. Prior to August 1967, connection of any "foreign attachment" to the exchange network was illegal. In that month, as a result of a court decision in the "Carterphone Case", the Federal Communications Commission ordered the telephone company to permit such connection. The telephone industry, understandably desirous of maintaining the integrity of its switching equipment and preventing service pejoration by "foreign attachments" over

which they had no control, filed a new tariff before the F.C.C. The tariff (T-263) acknowledged the order to permit connection of foreign attachments (such as customer-owned data sets) but requested amendment of the ruling to permit a telephone company-installed protected device between the attachment and the exchange network. The resultant protective device is known as the Automatic Data Coupling Unit (ADCU) and the service is known as the Data Access Arrangement. Customers now have the option of connecting their own data sets or having the telephone company supply data sets. Both of these connections are in the category of "hard wire" or "direct" connection. The ADCU isolates the customer equipment from the dc operation of supervisory control functions such as dialing and permits the transfer of ac signals. In addition, the ADCU has other protective functions such as limiting the amount of power that can be applied to the circuit and the band of frequencies that can be passed.

There is still another method of quasi-coupling data equipment to the exchange network that is used by many customers and that is "acoustic coupling". It is a convenient method since it merely uses the ubiquitous telephone. The modem is a converter which, in turn, couples as the human mouth and ear to the telephone microphone and earphone. Digital pulse data from the terminal (such as a portable teletypewriter, is modulated to audible frequency tones, one for mark and one for space, much as the type 103 data set. The modem has its own microphone and earphone mounted in a sound-inhibiting container. The telephone handset is placed in the container so that the tones generated at the modem earphone output are acoustically picked up by the handset microphone. Returned data from the communication facility is picked up by the modem microphone from the handset earphone. This method has been fairly satisfactory since the data is usually transmitted at rates of 110 baud and less. However, there are deficiencies in this method because the device (being acoustically coupled) is subject to ambient audio noise, efficiency of individual handsets, and the fact that the transmission facility is only "voice grade" and therefore subject to all attenuation variations and noise of the exchange network.

SPECIFIC DATA SET SELECTION

Coverage of the data set operation now permits selection of specific data sets to meet the operational requirements. The 7611 character oriented equipment operates with asynchronous data up to a maximum of 1800 baud (with the Type V, 7612 Timing module). Starting at the low speed end, each data set that can be used will be examined. The lowest speed data is that accommodated by the timing modules of the Type I category and varies from 45 to 75 baud. The data rates for the remaining "low speed" modules are:

Type II	133 baud
Type III	150 baud
Type IV	110 baud

The fastest data rate in these categories can be handled by the Bell System 103 Data Set. The 103 is a generic term and considerable variations exist. A description of each one, with their major characteristics, follows.

- Model 103A

  Provides for the transmission and reception of binary serial data at rates of up to 300 baud in either or both directions, half-duplex or full duplex. The 103A1 is used in TWX-CE service and the 103A2 is used for exchange network Data-Phone operation.

- Model 103F

  Provides for the transmission and reception of binary serial data at rates of up to 300 baud in either or both directions, half-duplex or full duplex, on private line facilities (FPD).

- Models 103E, 103G, 103H

  Provides for the transmission and reception of binary serial data at rates of up to 300 baud in both directions, duplex, on the exchange network. They are constructed in different manners for different installations, but are electrically compatible with the 103A sets. The 103E is a non-housed modem which can be configured singly as a 103G or 103H, or multiply in a Data station.

- Model 202C

  Provides for the transmission and reception of binary serial data at rates of up to 1200 bps half-duplex Data-Phone service on the exchange network (duplex if two circuits are used), or at rates of up to 1800 bps half-duplex or full duplex on conditioned FPD, two-wire or four-wire circuits, respectively. The set has an optional "reverse channel", with a maximum signalling rate capability of 5 baud for use on two-wire systems, for applications requiring a line-break or error detection alarm. It also provides a means of holding "echo-suppressors", disabled in the facility when no data is being transmitted. The set is configured with a dial telephone for alternate voice/data.

- Model 202D

  Electrically identical to the 202C, except that no telephone or dial is supplied. It is intended for FPD circuit operation but can be used for alternate FPD/Data-Phone in conjunction with the Data Auxiliary Set, Model 804A. This latter device supplies a telephone and dial to permit operation on the exchange network.

CHARACTER ORIENTED COMMUNICATION LINE MULTIPLEXOR, MODEL 7640

The definition of multiplex is the transmission of two or more signals on one channel. In the previous text the words "channel" and "circuit" have been used without prior definition. At this point it is necessary to be explicit –

Channel - A means of one-way transmission

Circuit - A means of two-way communication between two points, comprising the associated "go" and "return" channels.

The reason for this demarcation may be best understood by the fact that signals (voice, data, etc.) are attenuated with distance of the communication facility, and therefore require restoration by

amplifiers or "repeaters". For example, you can use an amplifier to accept the low-level signals from a record player and increase them to high-level output for speaker systems, but it will not work in the opposite direction. Amplifiers are one-way devices. On a long distance message circuit, amplifiers are required for signals originating at either end. There is a series of amplifiers in channel #1 going from A to B, and in the reverse channel #2 from B to A as shown in Figure 6.

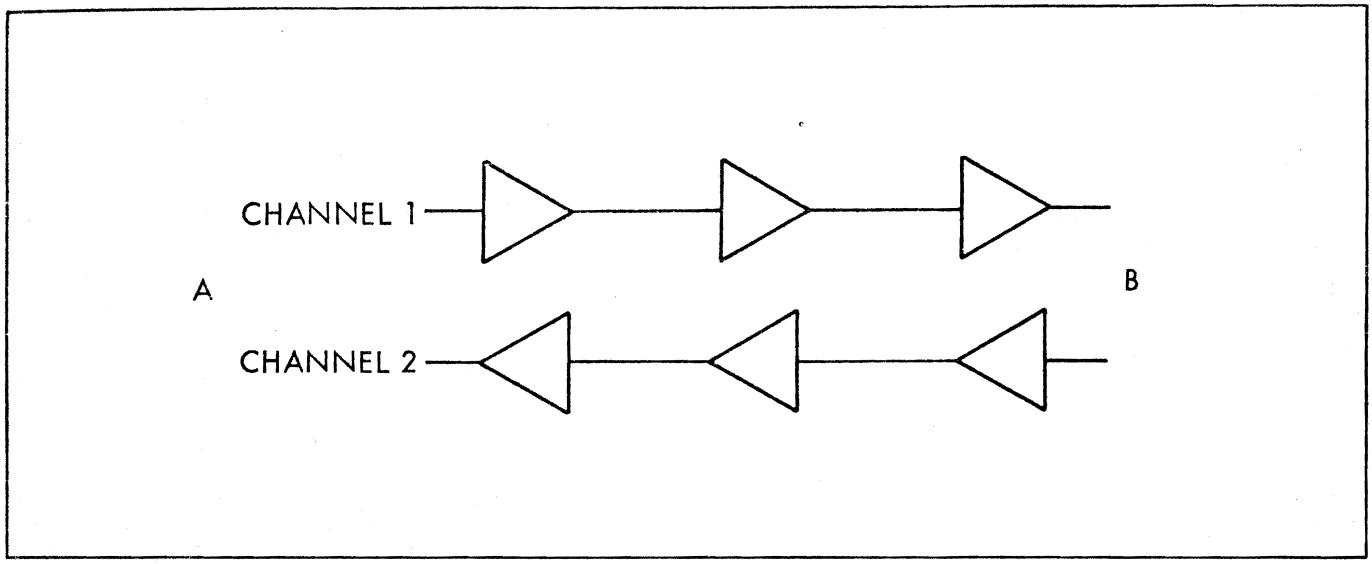


Figure 6.

MULTIPLEX

There are many forms of multiplexing, but we will consider only some of the more simple methods used on telephone facilities. The three basic forms of multiplex are accomplished by methods of "frequency division", "time division", and "phase division". Equipment with which XDS systems work are frequency and time. The XDS 7640/7643 CLM is a device that multiplexes by division of the multi-signal input into time frames. The remote 7643 can also be called a "data concentrator" because it concentrates the low speed teletypewriter data from up to 16 terminal keyboards, each on a separate channel, and retransmits them in assigned time positions over a single high-speed "Go" channel to the receiving 7640 CLM. This latter device de-multiplexes the data from each discrete time slot and transmits it to the 7611 COC. Thus, the COC operates as if it were directly connected to the 16 terminals over 16 channels. The reverse process, from the COC and 7640 CLM is the same, except that the data is now sent from Formatted Send modules, multiplexed, and re-transmitted over the "return" channel of the high-speed circuit. Then it is de-multiplexed by the remote CLM, and transmitted to each terminal over the reverse channel of each teletype circuit. A typical process is shown in Figure 7.

Figure 7 also illustrates Frequency Division Multiplex. Note that the 103 modem has the ability to transmit mark/space data as well as receive mark/space data on the same two wires simultaneously. Those two wires are called the subscriber circuit because it accommodates intelligence transmission

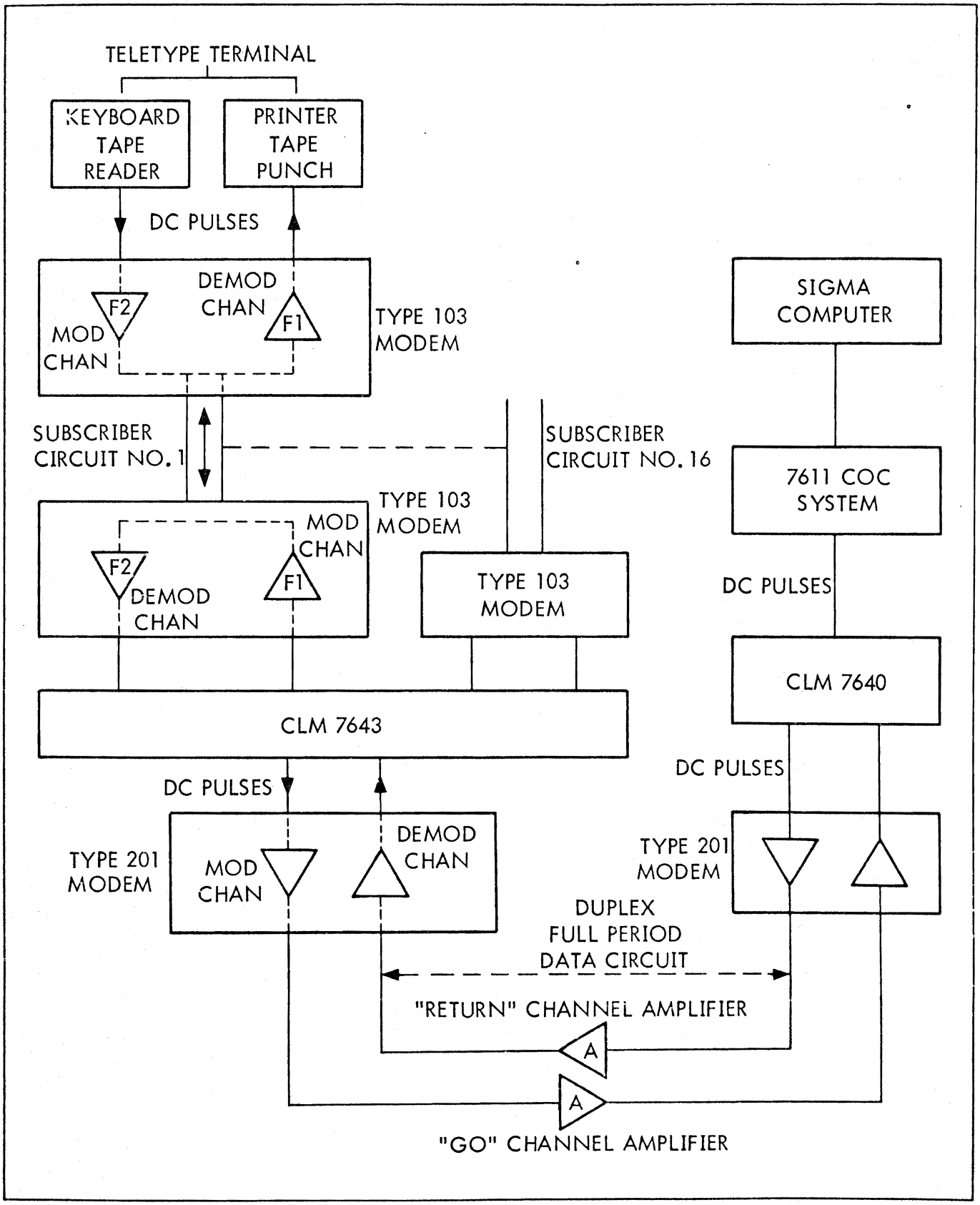

TELETYPE TERMINAL
KEYBOARD TAPE READER
PRINTER TAPE PUNCH
DC PULSES
DEMOD CHAN
F2
MOD CHAN
F1
TYPE 103 MODEM
SUBSCRIBER CIRCUIT NO. 1
SUBSCRIBER CIRCUIT NO. 16
TYPE 103 MODEM
MOD CHAN
F2
DEMOD CHAN
F1
TYPE 103 MODEM
CLM 7643
DC PULSES
TYPE 201 MODEM
MOD CHAN
DEMOD CHAN
SIGMA COMPUTER
7611 COC SYSTEM
DC PULSES
CLM 7640
DC PULSES
TYPE 201 MODEM
DUPLEX FULL PERIOD DATA CIRCUIT
"RETURN" CHANNEL AMPLIFIER
A
A
"GO" CHANNEL AMPLIFIER

Figure 7.

in both directions, over short distances from the telephone exchange office (without amplifiers). The Type 103 modem has a transmitter that sends information by modulating the frequency 1170 Hertz (f_1) and receives information by demodulating the frequency 2125 Hertz (f_2). The modem on the other end of the circuit does the reverse. The modulated frequencies f_1 and f_2 do not interfere with each other. Obviously then a device can be used to send multiple information on one channel if the information is separated in non-interfering frequencies. Such division is therefore called frequency division multiplexing. A commonly used FDM device permits the use of 16 telegraph grade channels on one voice grade channel. Each telegraph channel occupies 150 Hertz, thus using a total of 2400 Hertz of the voice grade channel. The multiplexer shifts the frequencies of each channel modem to a different band of frequencies within the voice frequency spectrum and the de-multiplexer shifts them back again to the original modem frequencies.

MESSAGE ORIENTED EQUIPMENT, MODEL 7601

In message oriented systems such as the XDS 7601, transmission is synchronous for 2 to 8 level characters with no start/stop elements, and asynchronous for 5/7.5 to 8/11 codes. Message oriented systems can handle the exchange of intelligence much faster than character oriented ones. This is because an entire message comprising a string of characters can be transmitted sequentially without any intervening time between characters. Reference should be made to XDS Document No. 90-15-68. The 7601 system consists of a Data Set Controller and a Format Unit. The controller connects to one data set which, in turn, connects to one circuit. Since the speed of the data can be anywhere from 45 to 230,400 bps, the appropriate Format Unit, modem, and communication circuit must be determined from the system's operational requirements. Table 3 lists the possible formats and required type of data set.

Table 3.

Data Format	Speed	AT&T Data Set	Typical Terminal Devices
5-level/ 7.5-unit	45 baud	103A, 103F	Teletype Models 28 and 32
5-level/ 7.5-unit	50 baud	103A, 103F	Teletype Models 28 and 32
5-level/ 7.5-unit	56 baud	103A, 103F	Teletype Models 28 and 32
5-level/ 7.5-unit	75 baud	103A, 103F	Teletype Models 28 and 32
7-level/ 9.0-unit	133 baud	103A, 103F	IBM 1050
8-level/10.0-unit	150 baud	103A, 103F	XDS Multi-purpose Keyboard Display and Teletype Model 37
8-level/10.0-unit	1200 bps	202C, 202D	XDS Multi-purpose Keyboard display
8-level/10.0-unit	1800 bps	202C, 202D	XDS Multi-purpose Keyboard Display
8-level/11.0-unit	110 baud	103A, 103F	Teletype Models 33 and 35

(Continued)

Table 3. (Cont.)

Data Format	Speed	AT&T Data Set	Typical Terminal Devices
2- to 8-level	2000 bps	201A	General Purpose, medium-speed
2- to 8-level	2400 bps	201B	General Purpose, medium-speed
2- to 8-level	40,800 bps	301B	General Purpose, high-speed
2- to 8-level	19.2 kbps	303	General Purpose, high-speed
2- to 8-level	50 kbps	303	General Purpose, high-speed
2- to 8-level	230.4 kbps	303	General Purpose, high-speed

The 7601 handles information in a half-duplex manner. For operation requiring full duplex transmission, the 7602 Full-Duplex Option must also be obtained. Like the character oriented equipment, if the system is to operate on the exchange network a dialing capability must be added. The 7603 Automatic Dialing Option permits the use of either the Bell 801A dc pulse or 801C Touch-Tone* automatic dialers. Of course, operation on the exchange network is possible with the use of the manual dialers such as the 804 without the 7603.

COMMUNICATION FACILITY SELECTION

If the customer plans on using a "company owned and maintained" communications facility or COAM data sets, the specific characteristic of either must be examined for compatibility with the XDS equipment. If the system is to use the facilities of a common carrier, the salesman should work closely and as far in advance of installation as possible, with the local Data Services Advisor of the telephone company in the customer's area. In order to give salesmen an understanding of the types of data services available from common carriers, a brief description of typical services will be given. The reader is cautioned to remember that tariffs vary among states, telephone companies, and even with company area. Additionally, new services are occasionally offered and some discontinued.

LOW SPEED DATA SERVICES

There are tariffed facilities for data transmission between the range of 0 to 150 baud. The tariff is often called a schedule. Table 4 lists typical Bell System offerings and their characteristics.

Table 4.

Tariff	Speed	Characteristics
Schedule 0	0-30 baud	DC mark/space signalling
Schedule 1	0-45 baud	AC signalling; teletypewriter 60 wpm

(Continued)

Table 4. (Cont.)

Tariff	Speed	Characteristics
Schedule 2	0-55 baud	AC signalling; teletypewriter 75 wpm
Schedule 3	0-75 baud	AC signalling; teletypewriter 100 wpm
Schedule 3A	0-150 baud	AC signalling; keyboard/CRT, Teletype Model 37

HIGH SPEED DATA SERVICES

The lowest grade of service in this category is the "voice grade" circuit. Its characteristics are variable as a function of telephone equipment condition, length of circuit, and quantity of users.

Table 5 lists the schedule of private line facilities available for Full Period Data usage.

Table 5.

Tariff	Speed	Characteristics
Schedule 3002	Not specified	300-3000 Hz, -3 +12db EDD: 1750 μsec max, 800-2600 Hz
C1 conditioning	1600 bps	300-2700 Hz, -2 +6db EDD: 1000 μsec max, 1000-2400 Hz
C2 conditioning	2400 bps	300-3000 Hz, -2 +6db EDD: 500 μsec max, 1000-2600 Hz
C4 Conditioning	3000 bps	300-3200 Hz, -2 +6db EDD: 300 μsec max, 1000-2600 Hz
Schedule 8001		
A2 Terminal	40.8k bps	Equivalent to 12 voice-grade circuits in bandwidth. Conditioned over 48 kHz.
A3 Terminal	50k bps	Equivalent to 12 voice-grade circuits in bandwidth. Conditioned over 48 kHz.
TELPAK C	230.4k bps	Equivalent to 60 voice-grade circuits
TELPAK D	960k bps	Equivalent to 240 voice grade circuits

The broadband facilities offered under TELPAK may be used by the customer in a combination of ways. The channels can be used for alternate voice/data or in combinations of data, teletypewriter,

and facsimile. Channels of equal or lesser bandwidth may be derived from one voice-grade channel equivalent as follows:

12 Teletypewriter channels

12 Data Schedule 1, 2, or 3 channels

4 Data Schedule 3A channels

1 Data, C conditioned channel

1 Telephotograph channel

There is an additional tariffed offering of broadband data service which can be supplied in conjunction with Data-Phone and switched network facilities. This is called Data-Phone 50, and is a combination dial-up 50k bps data circuit and voice circuit available between two points located at major cities.

CONCLUSION

This Bulletin has examined the XDS equipment which permits remote devices to operate with Sigma computer systems over communications facilities. It has explained the various methods of operation in a tutorial manner with reference to accepted standards of the telephone industry. Knowledge of the material contained herein will permit a salesman to understand communications sufficiently to enable him to configure the standard XDS communication interface products.

GLOSSARY OF DATA COMMUNICATION TERMS

Asynchronous Transmission	A transmission process such that between any two significant instants in the same group*, there is always an integral number of intervals. Between two significant instants located in different groups, there is not always an integral number of unit intervals (CCITT).
Bandwidth	The range of frequencies within which performance, with respect to some characteristic, falls within specified limits (IEEE)
Baud	The unit of modulation rate. It corresponds to a rate of one unit interval per second
Carrier	A wave suitable for being modulated. Examples of carriers are sine wave, recurring series of pulses, or a direct current (IEEE)
Channel	A means of one-way transmission. Several channels may share a common path as in carrier systems; in this case, each channel is allocated a particular frequency band which is reserved to it (CCITT)
Circuit, Telecommunication	A means of two-way communication between two points, comprising the "go" and "return" channels (CCITT)
Circuit, Four-Wire	There are two forms of four-wire operation. (1) Physical – A circuit comprising two oppositely directed channels which, by two physically separated pairs of wires, are kept separate and distinct from one end of the circuit to the other. (Bell System, Transmission Systems) (2) Equivalent – A circuit comprising two oppositely directed channels which, by different frequency bands, are used to form a high group and a low group for the directions of transmission, thereby permitting operation over a single pair of wires. (Bell System, Transmission Systems)
Circuit, Two-Wire	A circuit comprising a combination of hybrid transformer arrangements permitting the insertion of an amplifier for the "go" channel and an amplifier for the "return" channel in two wires. (Bell System, Transmission Systems)

*In data transmission this group is a block or character; in telegraphy this group is a character.

Data Set	Signal conversion equipment which is that part of the terminal installation belonging to the data channel, comprising at least one modulator or one demodulator and providing (1) Modulation according to the signals to be transmitted and/or (2) Demodulation of the signals received (CCITT)
Duplex	Synonomous with full-duplex. The operation of associated transmitting and receiving apparatus in which the process of transmission and reception are concurrent (IEEE)
Echoplex	Synonomous with Echo Check which is a method of checking the accuracy of data in which the received data are returned to the sending end for comparison with the original data (CCITT)
Half-Duplex	Transmission in one direction at a time (IEEE)
Modem	A contraction of "modulator-demodulator". The term may be used when the modulator and demodulator are associated in the same signal conversion equipment (CCITT)
Modulation	The process or result of the process whereby some characteristic of one wave is varied in accordance with another wave (IEEE)
Simplex	That type of operation which permits the transmission of signals in either direction alternately (MIL-STD-188). Synonomous with half-duplex. It is also a method of operation used by telephone companies to obtain a telegraph or teletypewriter channel from a voice channel by means of a dc phantom circuit (AT&T Long Lines). The term is often incorrectly used to mean one-way irreversible transmission
Start/Stop Transmission	Asynchronous transmission in which each group of code elements corresponding to a character signal is preceded by a start signal which serves to prepare the receiving mechanism for the reception and registration of a character and is followed by a stop signal which serves to bring the receiving mechanism to rest in preparation for the reception of the next character (CCITT)
Synchronous Transmission	A transmission process such that between any two significant instants there is always an integral number of unit intervals (CCITT)
Unit Interval	The interval of time such that the theoretical durations of the significant intervals of a telegraph modulation (or restitution) are whole multiples of this interval (CCITT)