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Transaction Network, Telephones, and Terminals:

Dial Access Interface

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The basic purpose of the Transaction Network is to switch messages between remote stations and Customer Service Centers and between CSCs. The access method may be either polled or dial-in. Dial-In Service is included in TN to provide economical access to the message switch for low volume users. This paper describes the Dial-In Access Network which involves three protocols between dial telephones and the message switch.

I. INTRODUCTION

The three Dial-In protocols in Transaction Network (TN) range from a simple protocol with no transmission error recovery capabilities to a more complex protocol which includes error recovery and rigorous checks for transmission irregularities between the telephone and the TN message switch (MS). The simplest, the Voice Response protocol, uses audio-prompting messages for input error correction and only audio responses from the message switch. The Voice/Keyed Answer Tone (KAT) protocol employs no error-correcting facility, but can be used with automatic telephones that transmit control sequences, some of which help detect transmission errors. The types of responses from the Customer Service Center (CSC) that are allowed in the Voice/KAT protocol are either a Keyed Answer Tone by itself or in combination with a voice message. Last is the Data Response protocol which has a facility for transmission error correction and whose responses from the message switch use frequency-shift keying (FSK).

Once access to the MS has been established,[1] the user may enter single or multiple inquiries before a response message is received. This, in fact, may be necessary if the CSC requires a message whose length exceeds the TN maximum of 128 characters. Although multiple inquiries with a single

response are permitted, multiple responses are not. The user may continue to enter sets of inquiry-response messages until the CSC requests a disconnect or until all transactions are completed.

II. DIAL-IN SERVICE

2.1 Dial-in access

Any user wishing to transmit data to the MS using a dial-in telephone must establish a line connection by dialing a number in a Line Hunting Group (LHG) which terminates on the MS. The LHG will be designed for a service objective of 1 percent blocking in a time consistent with the busy hour of the average busy season.

An LHG is designated as being for Data Response calls or for Voice Response and Voice/KAT calls. Any dial-in port, which consists of a 407A Data Set and a Dial Line Adapter (DLA), can transmit FSK. However, only those ports connected to the Audio Response Unit (ARU) associated with the message switch can transmit voice. The system is configured for a maximum of 256 dial-in ports, of which there is a maximum of 152 audio ports (76 on each of two ARUs). The separation of LHGs, therefore, yields more efficient usage of the system resources. To enhance service availability, the ports in a voice designated LHG are distributed across the two ARUs.

2.2 Transmission characteristics

2.2.1 Input

Data sent to the message switch from a dial telephone must be transmitted as *TOUCH-TONE** frequencies at a rate not exceeding 10 characters per second. The 407A Data Set, as part of a dial-in port, translates these frequencies into a double 1-out-of-4 hexadecimal encoding.[2†] This encoding is then translated by the dial call processing software[3] into the ASCII‡ representation of the input that will be sent across the MS. See Table I for the translation of the *TOUCH-TONE* signal input to ASCII characters.

2.2.2 Output

Data display responses are transmitted to telephones from the DLA[4] as frequency shift keying at a rate of 150 bits per second. Each transmission is preceded by at least 20 ms of line-charging carrier at the mark frequency. A mark or space bit is represented by 2225 or 2025 Hz, re-

* Registered service mark of AT&T Co.
† A double 1-out-of-4 encoding means that only 1 bit out of 4 bits can be a one. This encoding is also called 2-out-of-8 code, although this is not strictly a truism. Example: 0100 0001 is a double 1-out-of-4 code and a 2-out-of-8 code. However, 1001 0000 is a 2-out-of-8 code that is not a double 1-out-of-4 code.
‡ American Standard Code for Information Interchange. This code is the mapping of binary digits to real-world symbols.

Table I — *TOUCH-TONE*-to-ASCII translation table—text field

TOUCH-TONE Signal		2 of 8	Hexa-	ASCII
Freq. (Hz)	Char.	Code	decimal	Char.
697/1209	1	11	31	1
770/1209	4	12	34	4
852/1209	7	14	37	7
941/1209	*	18	3C	<
697/1336	2	21	32	2
770/1336	5	22	35	5
852/1336	8	24	38	8
941/1336	0	28	30	0
697/1447	3	41	33	3
770/1447	6	42	36	6
852/1447	9	44	39	9
941/1447	#	48		
697/1633	a	81	3B	;
770/1633	b	82	3D	=
852/1633	c	84	3E	>
941/1633	d	88	3F	?
	#0†	48, 28	3D	=
	#1	48, 11	3A	:
	#2†	48, 21	7f	DEL

† Used only by the Voice Response protocol.

spectively. Each asynchronous FSK character is comprised of 10 bits: a start bit, one seven-bit ASCII character with the least-significant bit transmitted first, an even parity bit, and a stop bit.

Two types of Keyed Answer Tone responses can be transmitted to a telephone from a 407A Data Set. Although both are of 2025-Hz modulation, their duration times differ. One KAT signal has a duration of 1.5 seconds. This is used to activate a device that signals "approval." The other KAT signal is for a duration of 3 seconds. This response is used in conjunction with a voice message and would be the signal for the user to listen to the telephone. Although the tone frequency is generated by the hardware, the duration time is controlled by the dial call processing software. See Section 3.4 for more information.

Unlike FSK and KAT transmission, voice responses are generated by the ARU. Each audio dial-in port must be connected to an ARU port. Every 1/6 second, the ARU sends a "speech segment" over each of its ports. The speech segment is transmitted over a 600-ohm balanced wire pair in the DLA to a hybrid in the 407A Data Set which drives the telephone line. The ARU "knows" which speech segment to speak because the dial call processing software sends the ARU an address for each speech segment to be spoken on each port every 1/6 second.

2.3 Status messages

In general, a status message is an indication of an irregularity that occurred in the reception, routing, or forwarding of a message. The Dial-In Service has two types of status messages. One type can be considered disconnect error messages. The other is made up of prompting messages.

A disconnect error message can be either a voice or an FSK message; that is, all three protocols employ them. They are always followed by an immediate equipment disconnect. This type of status message can be caused by a reception error, a routing error, a no forward path error, or a forwarding irregularity error. The error types are divided into priority classes. The higher the number of the class, the higher the priority is. As only one disconnect error message can be sent to a telephone, the priority system helps determine which of two errors is more important. If more than one error occurs, the first one within a class and the one with highest class priority will take precedence. For example, suppose a user inputs a second inquiry with more than the allowable number of text characters (Class I error). Furthermore, suppose the first inquiry is returned because the called number is an invalid CSC (Class II error). Then the disconnect error message would be a status message of "no such number" as this error has highest priority. See Table II for possible errors with their codes.

A voice disconnect error message will be spoken only once, with no repeats. However an FSK message, if a transmission error occurs, can be retransmitted a predetermined number of times. All disconnect error messages for the Voice/KAT protocol are voiced; KAT is not used for disconnect errors.

Table II — Message status codes

Contents of Message Status Subfield XY	Irregularity Defined†
	Class I Reception Irregularities
10	Heading format error
11	Maximum text length exceeded
12	Improper use of characters
13	Inquiry message timing error
14	Protocol error
15	Invalid calling station
17	Excessive inquiry retransmission
20	Maximum response wait exceeded
	Class II Routing Irregularities
30	No such number
31	Number changed
32	Improper class of service
33	Invalid called number
	Class III Irregularities Preventing Forwarding
50	Called station unavailable
51	Called station queue overflow
53	Transaction network trouble
	Class IV Irregularities Encountered During Attempted Forwarding
73	CSC requested disconnect
74	Excessive response retransmission

† Voiced disconnect error messages input the same information using standardized phrases from the ARU vocabulary.

Prompting messages are implemented for the Voice Response protocol only. It is assumed that the input is manual and that more errors are likely to occur than if input were automatic (i.e., through use of a magnetic card reader). Prompting messages will be given only for either heading field format errors or for use of illegal character sequences in the text field. (See Section 3.2, Message Formats, for definition of the heading and text fields.) These messages are spoken as soon as the error is detected. These status messages may be repeated once. Two attempts at repeating will cause a disconnect error message. A user is allowed at most three errors (i.e., three prompting messages, not including repeats) in any one field before a disconnect error message will be voiced.

All system messages, disconnect or prompting, that are voiced are preceded by an alerting one-second burst of tones: ⅓ second of 950 Hz, ⅓ second of 1400 Hz, and ⅓ second of 1800 Hz. The same burst of tones also follows each message to indicate that the message has completed.

2.4 Type of service

Basically, the Dial-In Service is an unrestricted service. The dial call processing software will send any format error-free message across the MS. However, the synchronous call processing software of TN will screen the message to ensure that the called CSC accepts messages from dial-in telephones. If it does not, then the inquiry message will be returned to the dial message task to be processed as a status message.

2.5 Addressing

The calling number subfield, contained in the heading field of the first inquiry message transmitted to the CSC, identified the MS port accessed by the user. Dial-in ports are addressable by the CSC in the range of NXX-8000 to NXX-8255, where the NXX is the TN number assigned to the MS in the range 200 through 999. This address defines a port to which a user has established a connection. (See Ref. 5 for a description of the TN numbering plan.) The CSC and the TN, however, do not know, nor can they determine, the user's telephone number. In sending a response, a problem would exist if the port address was the only indication of who was to receive the message. Consider the sequence of user A hanging up, user B connecting to the same port, and then the message for user A being received from the CSC for delivery to the telephone. User B would then get user A's message. To ensure against this, a class of service character is inserted into the inquiry message which is returned by the CSC in the response message. Each port's CSC is incremented with each connection. It ranges in value from a hexadecimal 50 through hexadecimal 5F, successively. In the previous example, although the port address is the same, the class of service character for user A and user B would be different. Thus, the message would be returned to its sender

with a message status of "Invalid Class of Service Character," and user B would not get an erroneous response.

Customer Service Centers are addressed by NXX-0010 through NXX-0499, where NXX is again the TN number assigned to the message switch (note that this is not the telephone number). For Dial-In Service, the user may enter the called number subfield in the inquiry message as 2, 3, or 7 digits. For example, CSC 888-0025 may be keyed in as 25, 025, or 8880025. Any other combination, even 0025, will be flagged as an error. This error would result in a prompting message in the Voice Response protocol or in a disconnect error message in the other two protocols.

III. DIAL-IN CONNECTION

3.1 Connection procedures

The dial-in telephone addressed the TN in the same manner as any ordinary home or business telephone addresses another telephone via the Switched Telecommunications Network (STN). Ordinary telephone loops are used to connect the dial-in telephone to the Central Office. The user will be provided with the seven-digit telephone number of the LHG assigned by the telephone company.

Dialing the number will establish a connection to an idle port on the LHG required by the user's telephone. When the 407A Data Set detects the ringing signal, it informs the message switch which in turn commands the data set to go off-hook, tripping ringing. The 407A Data Set then initiates transmission of a 1.5-second, 2025-Hz tone. This tone, called an answer tone, alerts the user that the connection has been established and inputs may begin.

The answer tone informs the user that transmission of the first inquiry message must start within 15 seconds. From this point on, intercharacter spacing may not exceed 13 seconds, and the entire message must be completed within 2 minutes. Subsequent inquiry messages must start within 15 seconds after the end of a previous inquiry or response message. Failure to meet any of the above timing constraints will result in the appropriate disconnect message followed immediately by an equipment disconnect.

The response message must be received by the MS within 20 seconds after the inquiry is forwarded to the CSC. Failure to meet this timing constraint will result in a disconnect error message and an equipment disconnect. If the CSC subsequently transmits the response, it will get the message returned with a message status indicating why the response could not be forwarded.

The called number subfield contained in the heading field of the first inquiry message specifies the desired CSC. This heading is stored by the TN and attached to subsequent inquiries that consist of text only. The user, therefore, can communicate with only a single CSC per connection.

To communicate with another CSC, the user must disconnect, dial the same telephone number again, and input a different CSC's called number.

There is no limit to the number of inquiries which may be transmitted per connection, provided no disconnectable errors are committed. The CSC, however, may request a disconnect at any time.

3.2 Message formats

3.2.1 Inquiry messages

The first inquiry message (Fig. 1) always consists of a heading and a text field. In the Data Response and Voice/KAT protocols, the heading field contains a Start of Header (SOH) delimiter—a *TOUCH-TONE b* character (Table III), a station identifier subfield specifying the type of response required and a called number subfield defining the desired CSC. The TN also uses the station identifier subfield to verify that the

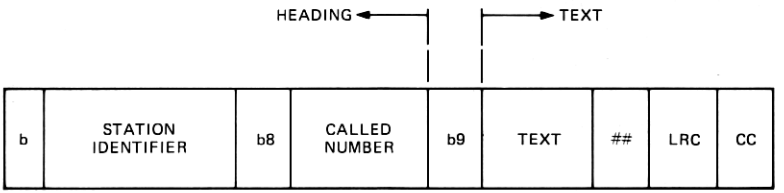


Fig. 1—First inquiry message.

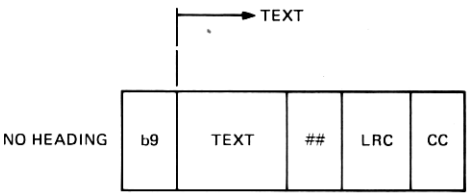


Fig. 2—Subsequent inquiry message.

Table III — Control characters used for message formatting

TOUCH-TONE Character Sequences Transmitted by the Data Response Telephone (inquiry message)	Function	ASCII Characters Transmitted by the Transaction Network (response and error messages)
b	Start of header	SOH
b8 (heading only)	Subfield delimiter	Not used
#0 (text only)†	Subfield delimiter	Not used
b9	Start of text	STX
#0†	Start of text	Not used
##	End of text	ETX
Not used	Subfield delimiter	GS

† Used only by the Voice Response protocol.

telephone has accessed the correct type of port. Both heading subfields contain only digits and are separated by the *TOUCH-TONE* b8 character sequence. However, in the Voice Response protocol, the heading field of an inquiry message contains only the called number; the TN will fill in the Station Identifier subfield with an ASCII 99 character sequence. The MS recognizes this type of call by the lack of the leading SOH character.

The heading and text fields are separated by the Start of Text (STX) delimiter. This is represented by a *TOUCH-TONE* #0 character sequence in the Voice Response protocol or by a *TOUCH-TONE* b9 character sequence in the other two protocols. The text field may contain any of the 16 possible *TOUCH-TONE* characters and cannot exceed 128 characters after translation to ASCII.

Because the *TOUCH-TONE* # character is used to alert the dial software that a control sequence is beginning, it requires special treatment. To have a # (ASCII :) character inserted in the text field, a #1 character sequence must be entered at the telephone. In the Voice Response protocol, the *TOUCH-TONE* #0 delimiter sequence serves not only as the STX character, but also as a text subfield delimiter. This delimiter is used by TN to number text subfields in prompting error messages. The Voice Response protocol also allows for the heading field or a text subfield to be deleted one at a time. The user enters a *TOUCH-TONE* #2 character sequence to do this. TN will insert the ASCII delete (DEL) character into a text subfield only upon receipt of a *TOUCH-TONE* #2 control character sequence. All other *TOUCH-TONE* text character sequences in which # is the first character are illegal except for #* (disconnect alert) which can appear at any time and ##. The character sequence ## serves as the End Of Text (ETX) delimiter and, in the cases of the Data Response and Voice/KAT protocols, is followed by two characters that are used to detect transmission errors. These characters are the Longitudinal Redundancy Check (LRC) character and the Character Count (CC) character. The LRC is a bit wise exclusive OR of all input characters from the SOH to the ETX, inclusive; the CC character is the number of characters, modulo 10, that comprised the message (SOH to LRC, inclusive).

Subsequent inquiry messages (Fig. 2) consist of a text field, bracketed by the STX and the ETX delimiters, and, if appropriate, the LRC and CC.

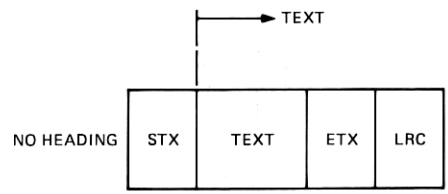


Fig. 3—Response message.

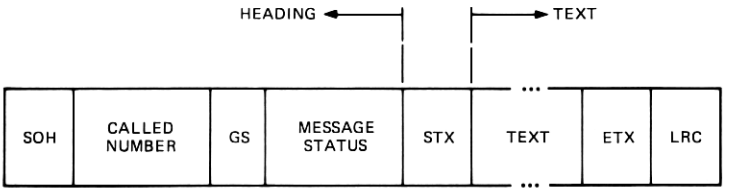


Fig. 4—Returned inquiry message/disconnect error message.

However, when the Voice Response protocol is used, the STX delimiter is omitted. Before a subsequent inquiry message is sent across the switch, the heading field, obtained from the first inquiry, is attached to preface the message.

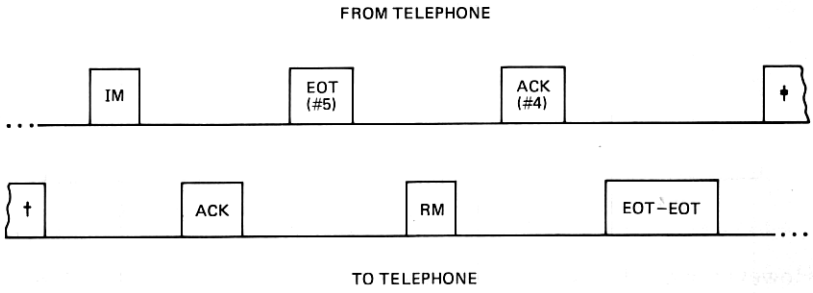
3.2.2 Response message

The station identifier subfield contained in the heading field of a response message from the CSC specifies the type of response to be transmitted to the telephone. When a voice response is requested, the contents of the text field consists of triplets of ASCII characters specifying the phrases which comprise the message. When an FSK message is requested (Fig. 3), only the text field delimited by STX and ETX and followed by the LRC character is transmitted to the telephone.

The text field may contain any character from the ASCII character set except SOH, STX, EOT, ENQ, ACK, NAK, and DLE. A maximum of 128 characters is permitted, exclusive of STX and ETX. In the Data Response protocol, an inquiry which is returned (Fig. 4) to the telephone is considered a disconnect error message. It will include a two-digit message status subfield as part of the heading, defining the irregularity (Table II) which prevented forwarding the inquiry to the CSC. Whenever possible, the first two characters of the text will be included, bracketed by STX and ETX, and followed by the LRC character. Inquiry message irregularities detected by the other two protocols result in the appropriate voiced disconnect error message.

Table IV — Control sequences used to implement the data response protocol

TOUCH-TONE Character Sequence Transmitted by the Data Response Telephone	Function	ASCII Characters Transmitted by the Transaction Network
#3	Negative acknowledgment	NAK
#4	Positive acknowledgment	ACK
#5	End of transmission	EOT
#6	Request	Not used
#*	Disconnect	DLE EOT
Not used	P-ACK	DLE ACK
Not used	P-NAK	DLE NAK
Not used	Enquiry	ENQ



† ANSWER TONE OR EOT–EOT

‡ INQUIRY MESSAGE (IM) OR DISCONNECT

Fig. 5—Single inquiry—single response transaction.

3.3 Control sequences in data response protocol transmission

Transfer of messages across an FSK port is in accordance with a protocol which is implemented by the control sequences shown in Table IV. A normal single inquiry—single response message transfer is shown in Fig. 5. Upon receiving a positive acknowledgment (ASCII-ACK character) that the inquiry message was received without transmission errors, the telephone turns the line around by transmitting the *TOUCH-TONE* #5 character sequence indicating the end of transmission.

When a response is received from the CSC, it is forwarded to the telephone. When the telephone sends a *TOUCH-TONE* #4 character sequence to indicate that the message was received without transmission errors, the TN turns the line around with an ASCII EOT character and the telephone is then free to disconnect or launch another inquiry.

If either an inquiry or a response message contains a transmission error, the TN or the telephone, respectively, will transmit a negative acknowledgment. This control sequence is represented by either the ASCII character NAK if transmitted by the TN, or by the *TOUCH-TONE* #3 character sequence if transmitted by the telephone. The protocol requires an immediate retransmission of the message upon receipt of the negative acknowledgment. This error correction procedure will be

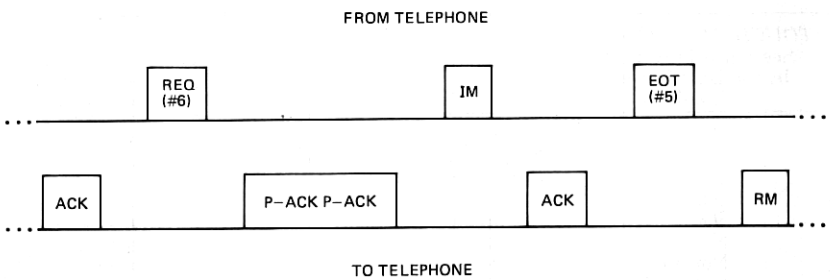
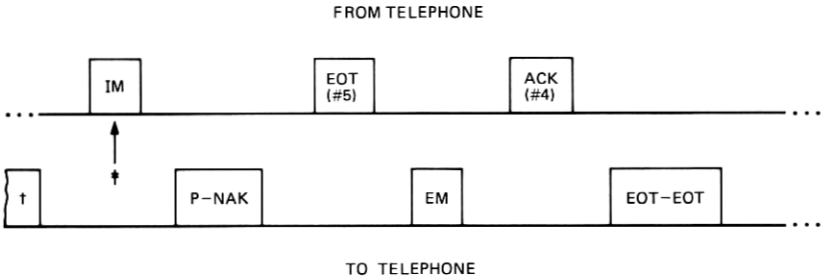


Fig. 6—Multiple inquiry—single response transaction.



† ANSWERTONE, P–ACK OR EOT–EOT

ǂ ERROR MESSAGE READY FOR FORWARDING

Fig. 7—Error message ready for forwarding to the telephone.

repeated for a total of three times, and if a positive acknowledgment is not received, a disconnect occurs.

To transmit multiple inquiry messages, the telephone transmits a request (REQ) instead of a line turnaround as shown in Fig. 6. The TN will acknowledge the request by transmitting a P-ACK P-ACK character sequence (request granted). The TN will transmit a P-NAK character sequence (request withheld), however, if a disconnect error message or a response message is ready for delivery to the telephone (Fig. 7). The telephone must then turn the line around.

Figure 8 outlines the error recovery procedure for lost or garbled terminations. If the telephone fails to turn the line around, the TN will retransmit the ASCII ACK character up to three times, at which point, if still unsuccessful, a disconnect takes place without any attempt to return the inquiry (error message). Figure 9 indicates that, if the telephone fails to acknowledge a response message, the TN will transmit an ASCII ENQ character up to three times. If an acknowledgment has still not been received at this point, a disconnect takes place and the response message is returned to the CSC marked undeliverable.

3.4 Control sequences in Voice/KAT protocol transmission

The Voice/KAT protocol includes a means for conveying short responses to the user, such as "Transaction Approved," without resorting to the ARU. This is accomplished by keyed answer tones which are generated by turning the 407A Data Set tone generator on and then off after a specified interval of time has elapsed.

3.4.1 "Green" tone

A "green" tone consists of a 1.5-second, 2025-Hz burst transmitted by the TN to the telephone. The CSC requests the TN to transmit this tone by inserting an ASCII 02 character sequence in the station identifier subfield of a response message heading; the text field will be null. This

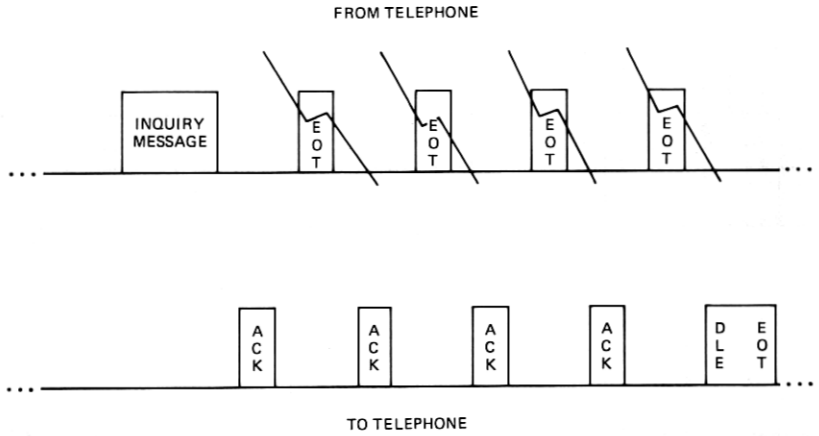


Fig. 8—Lost or garbled termination from telephone.

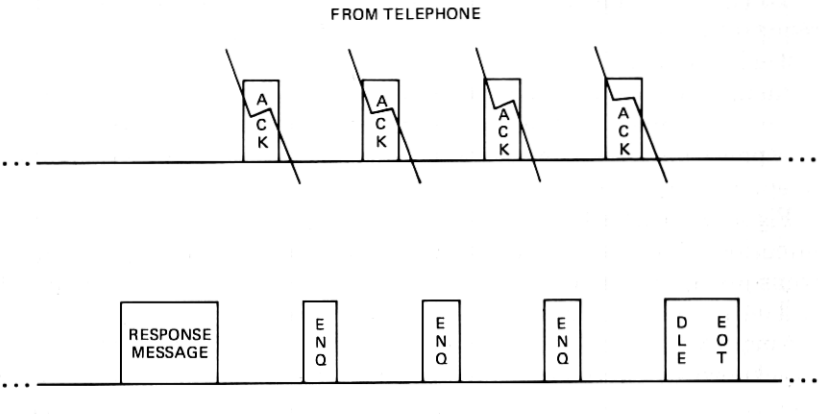


Fig. 9—Lost or garbled replies from telephone.

tone may be used to operate any one of a number of possible devices—for example, the green response lamp on the Transaction I telephone. The TN message switch expects the telephone to echo the "green" tone by transmitting a single *TOUCH-TONE a* character. If the TN does not receive this echo within two seconds after the end of the tone, a disconnect error message is transmitted to the telephone followed by an equipment disconnect.

3.4.2 "Yellow" Tone

A "yellow" tone consists of a three-second, 2025-Hz burst transmitted by the TN to the telephone as specified by the appearance of an ASCII 03 character sequence in the station identifier subfield. This tone alerts the user to pick up the handset and listen to the voice message which will

follow. The text field of the response message, like other voice messages, will contain the triplets of ASCII characters specifying the phrases which will be voiced by the ARU. The TN expects the telephone to echo the "yellow" tone by transmitting a single *TOUCH-TONE b* character within two seconds after the end of the tone. The telephone then must also transmit an "off hook" indication consisting of a *TOUCH-TONE* # # character sequence within 10 seconds after the echo. This control sequence indicates that the user has picked up the handset. Failure to meet either of these two time constraints will result in the transmission of a disconnect error message followed by an equipment disconnect. Again, this tone may be used to operate any one of a number of devices for getting the user's attention—for example, the yellow lamp on the Transaction I telephone.

IV. SUMMARY

This paper has described the dial-in interface which provides access to the Transaction Network over the existing Switched Telecommunications Network. One of the three Dial-In protocols permits communications via *TOUCH-TONE* telephones; the other protocols interface with more sophisticated telephones.

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