nt northern telecom

Datapath
Service Interface
Specification

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1986.

Datapath Technology
Licensing
Program

Datapath
Interface
Specification

NORTHERN TELECOM

DATAPATH SERVICE
INTERFACE SPECIFICATION

DATAPATH SERVICE
INTERFACE SPECIFICATION

Switched Network Compatibility and
Performance Specification
For Two Wire Connection to
The Public Switched Digital Network

Issue 2

October/1986

This document is designated general specification No. S204-2, it constitutes the Northern Telecom Datapath Service Interface Specification.

This document contains the description of the interface requirements for terminal equipment to be compatible with the network interface to Datapath service as provided from a Northern Telecom DMS 100 Family switch or one of its associated remotes.

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- "Appendix A. T-Link Rate Adaption Protocol"

- "Appendix B. Datapath Call Set-Up Sequences"

- "Appendix C. Clocking Considerations For
  The End To End Connection"

1.0 INTRODUCTION

1.1 General

This document is intended as a disclosure document that defines the performance and compatibility requirements for terminal equipment (TE) that will be directly connected to the interface for Datapath service. Datapath service will be provided from a Northern Telecom DMS-100 Family Switch. This service is planned to provide the user with a circuit switched data transmission service. This can be either via an access line connected directly to the CO or via a remote such as the remote line concentrating module (RLCM), outside plant module (OPM), remote switching centre (RSC),etc.. When the user is outside the range of the CO and no remote module is available, basic Datapath service may be provided by Datapath extension (DPX) cards that plug into channel bank units.

Due to the current digital transmission network restriction, it is planned that the maximum data rate that will be provided is 56 kbit/s synchronous/asynchronous data end to end for interoffice calls. Datapath does have the capability to transfer 64 kbit/s data end to end on intraoffice calls. This capability will be extended to interoffice calls in the future when common channel signaling is widely used.

The loop facility will provide a full duplex 72 kbit/s channel with 8 kbit/s used for a signaling channel for messages between the terminal equipment and the data line card (DLC). The remaining 64 kbit/s will be the data channel. The data channel is used during call set-up for PCM encoded call progress tones for the originating end and ringing at the answering end. The data channel is then used for data transfer once the end-to-end connection has been established.

In addition to meeting the performance and compatibility requirements given in this document, any terminal equipment that is to be connected to this interface must be registered under the provisions of Part 68 and Part 15 of the FCC Rules and Regulations.

1.2 Terminology

The following terms and abbreviations are used within this specification:

AMI	–	Alternate Mark Inversion
byte	–	a group of eight bits
Checksum or ChSum	–	The nibble that is transmitted when the RACK state is indicated. The value of the Checksum is determined by summing the four data nibbles and using the four LSB of the sum as the Checksum.
CH0	–	This is the transmitter state indicated when data is contained within the byte.
DLC	–	Data Line Card
DMS Machine	–	DMS-100 Family Northern Telecom Digital Multiplex System
DN	–	Directory Number
DTE	–	Data Terminal Equipment
DTR	–	Data Terminal Ready
FDHP	–	Full Duplex Handshaking Protocol
Idle	–	This is the transmitter state indicated when there is no data transmitted in the byte.
inband protocol	–	the protocol used on the 64 kbit/s data channel
LSB	–	Least Significant Bit
Message	–	Any of the messages as defined in the TE/DLC Message Protocol Specification (contained within a 16 bit envelope)
MSB	–	Most Significant Bit
NACK	–	Negative ACKnowledgement is the receiver state transmitted when the received Checksum does not agree with the. receiver's calculated Checksum or

		when the received state is not the expected received state.
NI	-	Network Interface
nibble	-	a group of four bits (half a byte)
No-op	-	No-operation
PACK	-	Positive Acknowledgement is the receiver state transmitted when the received Checksum agrees with the receiver's calculated Checksum.
PSDS	-	Public Switched Digital Service
RACK	-	Request Acknowledgement is the transmitter state that is transmitted when the receiver is requested to acknowledge receiving the data nibbles either correctly or incorrectly. The Checksum transmitted with the RACK is what the receiver uses to perform the validity test on the received data.
RI	-	Ring Indication
RTS	-	Request To Send
TCM	-	Time Compression Multiplexing
TE	-	Terminal Equipment
T-Link	-	an inband rate adaption protocol (see Appendix A)

1.3 Applicable Documents

TR-880-22135-84-01 -Bell Communications Research,Inc.
Technical Reference, July 1984
Issue 1, Circuit Switched Digital
Capability Network Interface Specification
(Appendix A, Cable Characteristics 1 Hz to
5 MHz)

2.0 INTERFACE OVERVIEW

Access to the Datapath service is through a jack on the customer premises. This jack is provided with a two wire tip and ring interface. Datapath service enables the switching of a data connection through the public switched network. Synchronous and asynchronous DTE data rates of 56 kbit/s and lower can be provided over this interface.

The functions and capabilities of the network are accessed through the proper physical and electrical interfacing and interface protocol.

Table 2-1 summarizes many, but not all, of the physical layer interface characteristics.

```
- TCM transmission over 2-wire loop
- Line transmission rate: 160 kbit/s
- Modulation scheme: 50% BIPOLAR, Alternate Mark Inversion
- Transmit power: 10 dBm average
- Maximum loop range: 5.4 km (Nominal)
- Maximum insertion loss: 45 dB
- Maximum one way delay 37.5 microseconds
- Clock recovery from received burst
- Overvoltage Protection
- DC Termination of 2 kohms
  for 6 mA ±1 mA Sealing Current
- AC Termination of 135 ohms (5 kHz to 160 kHz)
```

SUMMARY OF INTERFACE CHARACTERISTICS
Table 2-1

3.0 INTERFACE PHYSICAL AND ELECTRICAL CONNECTION REQUIREMENTS

The requirements detailed here give the physical layer requirements necessary to provide Datapath service. Datapath provides a DMS machine with a switched digital data capability.

At the two wire interface that is defined here Time Compression Multiplexing (TCM) is used to transfer bidirectional digital signals at an effective line rate of 72 kbit/s full duplex. The 72 kbit/s is configured as an 8 kbit/s signal channel plus a 64 kbit/s data channel. The TCM is used to transfer the signaling plus data information across this interface by alternately time interleaving bursts of data in the transmit and receive directions (sometimes called Ping-Pong).

The instantaneous line rate for TCM transmission is 160 kbit/s. The TCM is based on a 1 millisecond time frame with each frame containing two bursts of data. The first burst of data is sent from the (master) DLC (Data Line Card) in the DMS machine to the TE (slave) i.e. DLC is in the transmit mode, the TE is in the receive mode.

During the latter half of the frame, the second burst will be transmitted. For this burst the transmit and receive directions will be interchanged and the TE (slave) will transmit to the DLC (master).

The format of each of these bursts is identical. Each burst contains 72 bits of signaling plus data in addition to a start and stop bit.

The TCM burst that is transmitted from the DLC (master) will be timed according to a master clock on the DLC side of the interface. The master clock controls the transmission of bursts at 1 millisecond intervals. The TCM burst that is transmitted from the TE (slave) will be timed with timing information derived from the received DLC TCM burst.

The mechanical, electrical and logical connection requirements are given here to enable correct interworking between the equipment on either side of the interface.

3.1 Physical Connection Requirements

The interface consists of a single pair of conductors (Tip and Ring) connected to the Terminal Equipment on one side and to the Data Line Card (DLC) in the DMS machine via the access line on the other side as shown in Figure 3-1. The DLC may also reside in an associated remote module connected to the DMS machine.
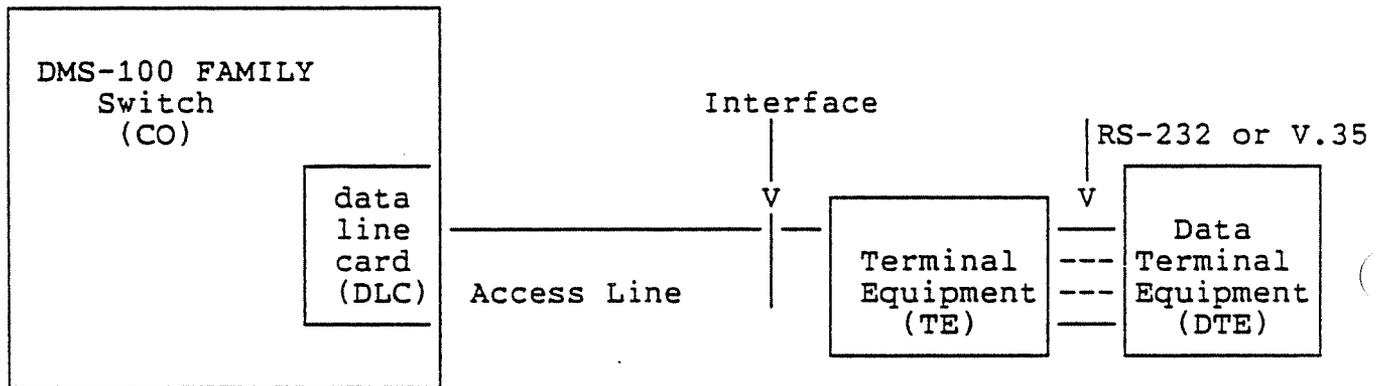
Figure 3-1   Datapath System Physical Configuration

3.1.1 Telco Provided Interface

The physical connection of the TE to the network is made using a miniature 6-position series jack. The jack used is as shown in FCC Rules and Regulations, Part 68, Subpart F, Figures 68.500(b)(1) and 68.500(b)(2). This connection configuration is shown in Figure 3-2 below.

```
                          _____
                         |                |
                         | --<1           |
          To             | --<2           |           To
       Central     ----------<3  <----- Terminal
       Office      ----------<4  <----- Equipment
                         | --<5           |
                         | --<6           |
                         |_____|
```
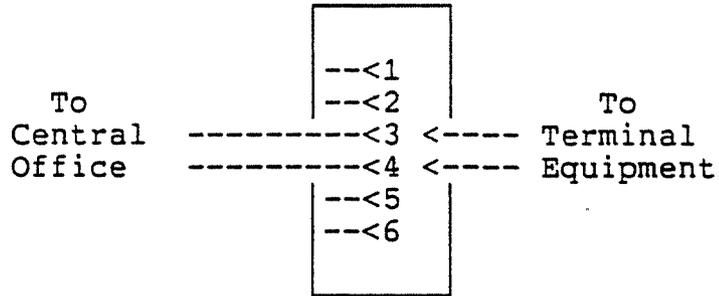
Figure 3-2
Interface To Datapath Service

3.2 Power Requirements

The power requirements for the terminal equipment shall be provided locally by the customer.

3.3 Sealing Current

The DLC provides a sealing current of 6 mA ±1 mA over the access line.   The sealing current is to ensure that continuity of the two-wire metallic loop is maintained. The TE must provide a DC path for the sealing current.

3.4 Electrical Connection Requirements

3.4.1 AC and DC Termination Requirements

3.4.1.1 DC Characteristics

The Terminal Equipment shall present a nominal DC resistance of 2 kohms across the network interface.

3.4.1.2 AC Characteristics

At the network interface the Terminal Equipment shall present a balanced termination with an impedance of 135 ohms ± 10 percent over a frequency range of 5 kHz to 160 kHz.

3.4.2 Transmitter Characteristics

The line driver in the TE shall be enabled only during the transmit period of the TCM frame. The line signal shall be Alternate Mark Inversion (bipolar), Return to Zero, 50 % duty cycle. To reduce crosstalk on the loop facility the Bipolar signal should be shaped by a first order Low Pass filter. Corner frequency of the filter shall be approximately 260 kHz.

3.4.2.1 Transmit Pulse Characteristics

The transmit pulse characteristics given in Table 3-1 below represent the Bipolar signal prior to being passed through the first order filter defined above.

Pulse Type	Bipolar Return-to-Zero
Duty Cycle	50 %
Pulse Repetition Period	T=6.25 microseconds
Pulse Height (A+,A-)	2.4 V ± 0.15 V
(at the NI into 135 ohms)	
Pulse Width (W+,W-)	3.125 microseconds
	± 100 nanoseconds
Pulse Overshoot	h+ less than or = to 0.01A
	h- less than or = to 0.01A
Maximum Dynamic	
Pulse Jitter	± 100 nanoseconds

Table 3-1
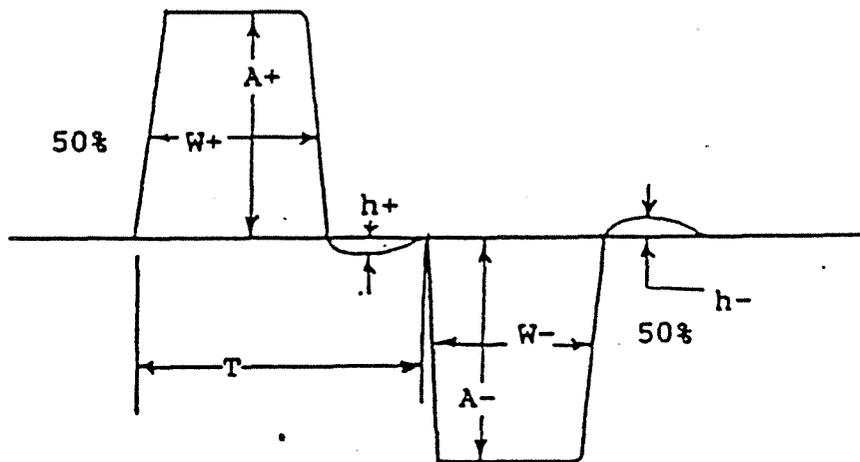
Transmit Pulse Parameters
Figure 3-3

3.4.2.2 Transmitted Signal Power

The average power in a TCM burst transmitted by the TE into a 135 ohms termination at the network interface shall be a maximum of 10 dBm.

The peak power in a TCM burst transmitted into 135 ohms shall be a maximum of 16 dBm.

3.4.2.3 Data Channel Bit Polarity Inversion

The terminal equipment (TE) connecting to this Network Interface shall invert all bits received and transmitted over the 64 kbit/s data channel. This requirement must be met regardless of the application of the data channel. Hence, it is true for both the PCM u-law encoded call progress signals and ringing as well as the data bits.

This inversion of the bits only applies to the data channel and not to the signaling channel.

All interfaces between a DMS machine and other parts of the network, such as a DS-1 trunk interface, provide polarity inversion of the data channel. Therefore, any call progress tones or data transmitted or received will conform to the industry standard at the DS-1 trunk interface to another CO providing PSDS service.

3.4.3 Scrambler Characteristics

A scrambler and descrambler shall be provided to randomize the data to ensure there are no spectral peaks in the transmitted bursts. This randomization will also provide sufficient density of "1" bits in the bursts to facilitate timing recovery.

The scrambler and descrambler shall be frame synchronized. This means that with the exception of the start and stop bits, framing the TCM bursts, the 72 bits are exclusive ORed with a pseudo-random bit pattern. This applies to both the transmitted data and the received data. Prior to the data being coded into bipolar form and being transmitted, it is fed into one of the inputs of a two input exclusive OR gate with the bit pattern fed into the second input coming from the pseudo-random generator. The bit pattern created by the generator is given in Table 3-2. The start and stop bits are not passed through the scrambler or descrambler.

Table 3-2 Pseudo Random Generator Output

Bit Count	Value		Bit Count	Value
0	1		36	1
1	0		37	0
2	1		38	0
3	1		39	1
4	0		40	1
5	1		41	0
6	1		42	1
7	0		43	1
8	0		44	1
9	0		45	0
10	1		46	1
11	0		47	0
12	1		48	0
13	0		49	0
14	0		50	1
15	0		51	0
16	0		52	0
17	0		53	0
18	1		54	1
19	1		55	1
20	1		56	0
21	0		57	1
22	1		58	0
23	1		59	1
24	0		60	1
25	1		61	0
26	0		62	0
27	0		63	1
28	1		64	1
29	1		65	1
30	1		66	0
31	1		67	0
32	0		68	1
33	0		69	1
34	0		70	0
35	0		71	0

3.4.4 Synchronization

3.4.4.1 Transmit Bursts (DLC to TE)

The DLC shall control the burst sequence based on a 1 ms frame period. The DLC transmits a burst of 74 bits at 160 kbit/s as indicated in Figure 3-4.

Figure 3-4 Loop Burst Format

```
                                                              Stop
   Start                                                       Bit
    Bit   ┌── 8 Signalling Channel Bits                         |
     |    |                                                     |
     V    V                                                     V
    ┌─┬────┬────┬────┬────┬────┬────┬────┬────┬────┬─┐
    │ │    │    │    │    │    │    │    │    │    │ │
    └─┴────┴────┴────┴────┴────┴────┴────┴────┴────┴─┘
    |<------------- 64 Data Bits--------------------->|
```
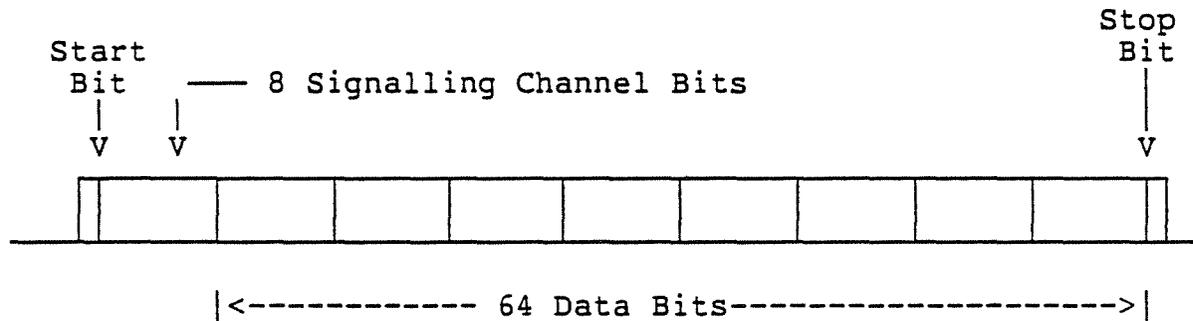
       Line Rate   160 kbit/s (T=6.25 micro seconds)

       TCM Frame   1 ms

       Burst Length 74 bits

3.4.4.2 TE Synchronization

The transmit clock of the TE shall be frequency locked to a clock derived from the received TCM bursts.

The timing of the transmission and reception of data between the TE and the user device (DTE) can be accomplished in a number of ways. One solution is described in Appendix C.

3.4.4.3 Sync Loss and Recovery

The status of the interface in terms of synchronization is defined by the four possible states indicated in Fig. 3-5. The states are: in sync, hold on to sync, off sync and test for sync. Sync is determined by detecting the start and stop bits framing the data.

A four step filter with a maximum count of four and a minimum count of zero is used for determining sync. For each good frame received the count is increased by one and for each bad frame received the count is decreased by one as indicated in Figure 3-5, Test For Sync. When the count reaches its maximum count of four the TCM system is considered in sync. The count will remain at four as long as good frames are received. The Hold On To Sync state is entered whenever a bad frame is received. As was the case for the Test For Sync state, the count is decreased by one for each bad frame and is increased by one for each good frame. Therefore should the count drop to zero the OFF Sync state is entered and the TCM system is considered out of sync

The definition of a good received frame is if the period between the stop bit and the next received bit is 0.5357 ms (86 bit count). This indicates the full 1 ms frame can be accounted for (74 x 6.25 microsec + 0.5375 ms = 1 ms).

On the TE side of the interface if sync is lost, the TE shall stop transmitting any data. The receive window is then opened so that any data on the loop can be received. The TE shall then start to hunt for the Start and Stop framing bits to reestablish sync.

On the DLC side of the interface if sync is lost the receive enable window will move to the end of the receive window to ensure that the stop bit is received. The DLC will then begin to hunt for the Start and Stop bits received to reposition the receive enable window. When sync is lost the DLC continues to transmit the framing bits as well as random data to the TE.

Figure 3-5 Sync State Diagram

Good Frame

In Sync

Fault-Frame

TRANSMIT ENABLER

TRANSMIT DISABLE

Back In Sync Mode

Good Return To Sync

Test For Sync

GOOD FRAME

4th Frame

FAULT FRAME

3rd Frame

2nd Frame

1st Frame

GOOD FRAME

1st Frame

FAULT FRAME

2nd Frame

3rd Frame

4th Frame

HOLD ON SYNC

Bad Frame

Confirmed Frame

OFF SYNC

Bad Frame
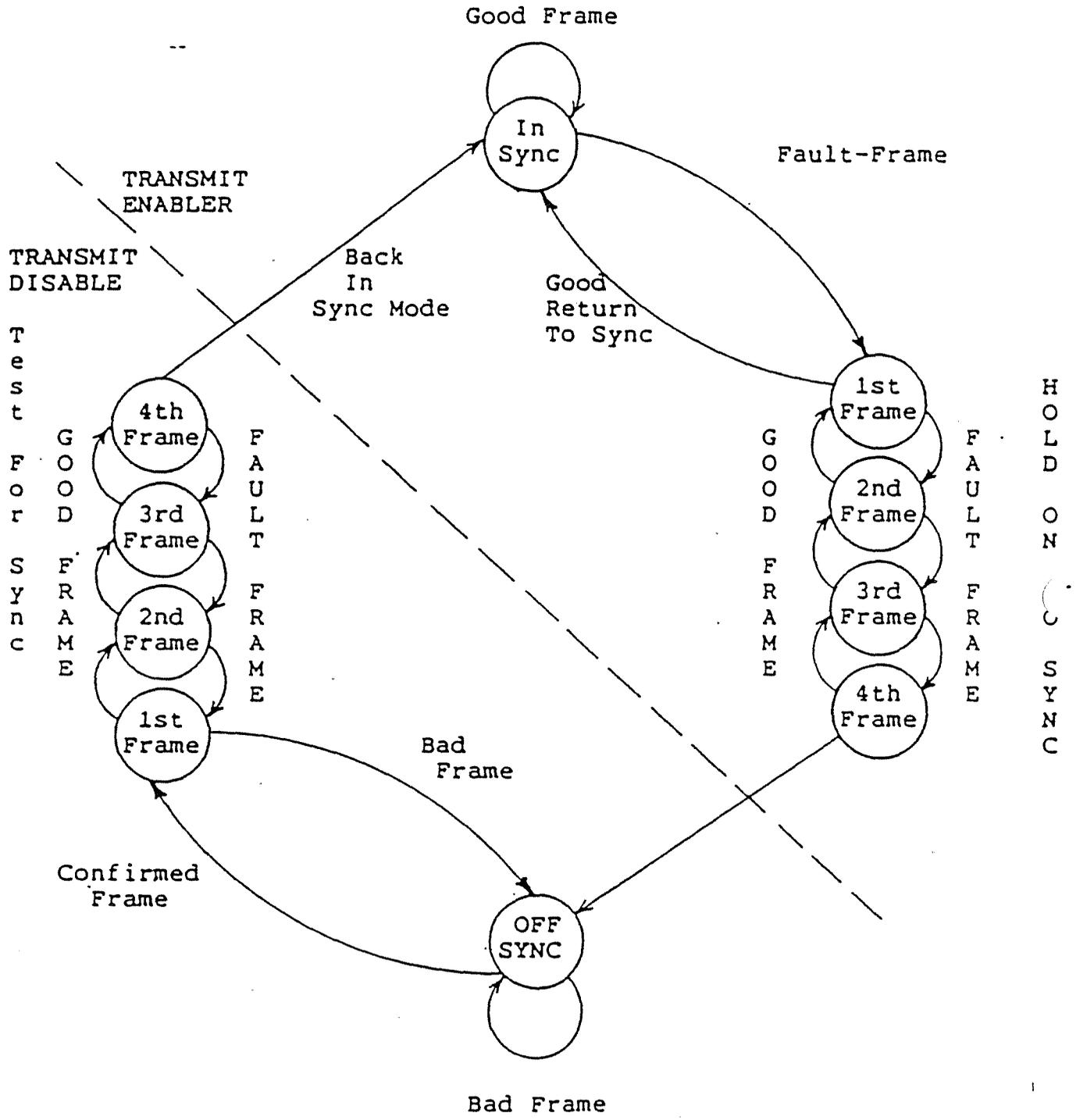
3.4.5 Logical Characteristics

3.4.5.1 Frame Structure

The DLC, which acts as the master, operates on a frame rate of 1 ms. During each frame the DLC transmits 64 bits of data, 8 bits of supervision or control signaling and 2 framing bits as shown in Figure 3-4. The same sequence of bits is received in the receive half of the 1 ms frame as shown in Figure 3-6 .

For the received and transmitted bursts, the time required for each is 462.5 microsec. or a total time of 0.925 ms. Therefore the sum of the time delay introduced by the TE from the end of the received burst to the start of its transmit burst plus the round trip delay introduced by the subscriber's loop shall not exceed 75 microsec.. Hence, the rationale for the maximum one way delay introduced by the subscriber loop that can be tolerated is 37.5 microsec. assuming no delay is introduced by the TE. The maximum one way delay is reduced by a time interval equal to one bit time (6.25 microsec.) to provide a guard time at both the TE and the DLC. The guard time is provided to allow for the TE and the DLC circuitry to switch from the receive mode to the transmit mode.

Figure 3-6   TCM FRAME TRANSMISSION & RECEPTION

TCM Frame As Seen From The Data Line Card

```
T=0 ->|                                                            T=1ms->|
      |---------------------------------------------------------------------|
      |                  |1 Way |1 Way |                      |      |
      | Transmitted      |Delay |Delay | Received             |      |
      |                  |Out-  |In-   |                      |      |
      | Burst            |going |coming| Burst                |      |
      |---------------------------------------------------------------------|
              \                    Guard               /        Guard
               \                   Time               /         Time
                \                                    /
                 \                                  /
                  \                                /
                   \                              /
                    \                            /
                     \                          /
      |---------------------------------------------------------------------|
      |1 Way   |              |  |              |1 Way   |
      |Delay   | Received     |  | Transmitted  |Delay   |
      |        |              |  |              |        |
      |Incoming| Burst        |  | Burst        |Outgoing|
      |---------------------------------------------------------------------|
                          Guard
                          Time
```
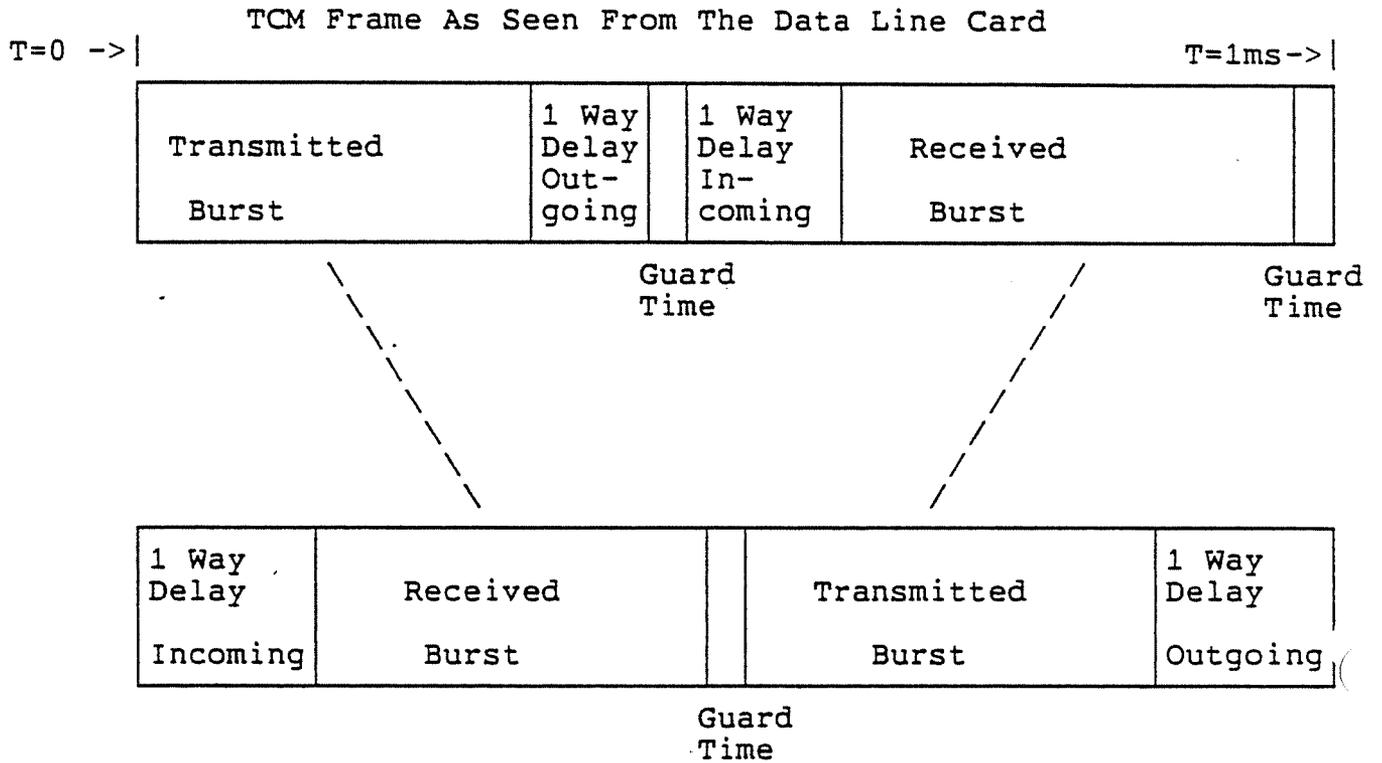
TCM Frame As Seen From The Network Interface

3.4.6 Receiver Characteristics

The function of the line receiver is to recover data from the
received signal. The line receiver shall be enabled only during
the receive period of the TCM frame and its function is to
recover data from the bipolar signal received. The signal
received at the interface will be generated by a driver on the
DLC meeting the requirements given in section 3.4.2 and modified
by cable facilities with characteristics as outlined in the
Appendix A of TR-880-222135-84-01, Bellcore Technical Reference
(see Sec. 1.3).

3.4.7 Transmission Limitations

3.4.7.1 General

The line code in both directions is bipolar Alternate Mark Inversion (AMI). The pulses have a nominal 50 percent duty cycle. The line transmission rate is 160 kbit/s (DLC to TE) with a line receive rate of 160 kbit/s ± 2 percent jitter (TE to DLC). The maximum allowable access line attenuation at the Nyquist frequency, 80 kHz, is 45 dB.
The maximum available one way access line delay is 37.5 microsec..
The maximum line attenuation at the Nyquist frequency will be 42 dB when a 3 dB margin for loss variation is provided. Also the maximum one way line delay is reduced to 31.25 microsec. when a guard time of 6.25 microsec. is provided. The following table gives the access line range limitations.

Cable Gauge (AWG)	Max. Length for 42 dB Loss at 21 Degrees C, 80 kHz		Max. Length for 31.25 Micro Sec. Delay		Limiting Factor (*)
	km	kft	km	kft	
26	4.0 *	13.1 *			Atten.
24			5.4*	17.5 *	Delay
22			5.7*	18.5 *	Delay

Table 3-3 Loop Length Limits
(excluding other loop impairments)

3.4.7.2 Bridge Tap Limitations

The transmission limitations specified in section 3.4.7.1 are based on access lines with no bridge tap. Those access lines that do have bridge taps, in addition to meeting the maximum loss requirements, including the losses caused by bridge taps, are required to meet the following requirements.

(a) If all the bridge taps are less than 1 kft then only the loss constraint applies.

(b) If one or more bridged tap exceeds 1 kft then the sum of all bridged taps shall be less than or equal to 2.5 kft.

4. PROTOCOL OVERVIEW

The two wire Datapath network interface provides a 72 kbit/s full duplex transmission capability that is comprised of an 8 kbit/s signaling channel and a 64 kbit/s data channel. The 8 kbit/s signaling channel allows communication between the DMS machine and the terminal equipment (TE).

The two related protocols that must be used over the signaling channel form the link level protocol that shall be used for network access, call set-up and special features activation.

The first of the two related protocols is used to transfer the link level messages over the signaling channel and it is defined in section 5.1.

The second of the two related protocols specifies the actual link level messages that are transferred over the signal channel and it is defined in section 5.2.

The 64 kbit/s data channel provides a network transparent end-to-end 56 kbit/s full duplex transmission path (8kbit/s of the 64 kbit/s is reserved to fulfill the network requirement of the 8th bit equal to 1). Within the 56 kbit/s data channel any protocol may be used for end-to-end transmission provided the terminal equipment at both ends of the connection use compatible protocols.

Since this network access and interface specification cannot make a specific protocol mandatory, Section 7 of this specification only defines the minimum requirements for the data format on the 64 kbit/s data channel.

The inband protocol required to be used for end-to-end compatibility with Northern Telecom Datapath Data Units is specified in Appendix A. This protocol, entitled T-Link rate adaption protocol, must be used by any terminal equipment (Data Unit) designed to interwork with a Northern Telecom Datapath Data Unit or designed to access the Datapath modem pooling feature.

Terminal equipment that has implemented T-Link rate adaption protocol is also able to provide compatibility with the minimum Public Switched Digital Service capability as defined in Section 7 as a default operating mode. This is possible through the use of the link level protocol messages and the timers within the DMS machine provided for each Datapath call. Appendix B describes how this feature is implemented on the DMS machine.

5.0 LINK LEVEL PROTOCOL

The link level protocol described herein is a requirement for
network access. This is the protocol structure used in the
signaling channel for communication between the network and the
terminal equipment. This protocol is comprised of two related
protocols; the transfer protocol that is called Full Duplex
Handshaking Protocol (FDHP) and the link level message protocol
that is called TE/DLC message protocol.

5.1 Transfer Protocol

5.1.1 General

The messages passed over the 8 kbit/s signaling channel are 16
bits long. The messages are defined by the TE/DLC message
protocol specified in section 5.2. The transfer protocol that is
used to send and receive the messages is called Full Duplex
Handshaking Protocol (FDHP). FDHP is a byte oriented envelope
protocol that provides error detection via checksum, error
correction via re-transmission, and flow control. To transmit a
single message (2 bytes) plus the checksum twice, will require
six signaling bytes. Both the data and handshaking control
information are designed to communicate in a full duplex mode.
Every byte transmitted contains 3 types of information:
    1. Transmit State (2 bits)
    2. Receive State (2 bits)
    3. Data nibble   (4 bits)

The checksum is determined by serial addition of each of the four
data nibbles that form a message. Each data nibble is added to
the sum as it is received or transmitted with the four least
significant bits used as the checksum. In Section 5.2.3.2 ,under
the description of Checksum, an example of the modulo sixteen
addition is shown.

5.1.2 Basic Structure

Full Duplex Handshaking Protocol is a byte oriented envelope
protocol. The byte format is shown in Figure 5-1 below.

MSB   LSB

TxS1	TxS0	RxS1	RxS0	D3	D2	D1	D0
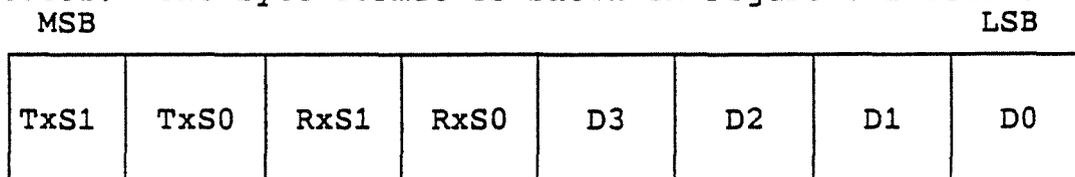
BYTE FORMAT
Figure 5-1

5.1.3 Transmit and Receive States

The transmit and receive states are indicated using the four MSB of the byte. The possible states are defined in Figure 5-2, Byte Contents, shown below.

Transmit States	TxS1	TxS0	RxS1	RxS0	D3 D2 D1 D0
IDLE (no data)	0	0	X	X	X
CH0 (data on channel 0)	0	1	X	X	data nibble
RACK (request acknowledge)	1	0	X	X	checksum nibble
Receive States					
CTS (clear to send)	X	X	1	1	X
PACK (positive ACK)	X	X	1	0	X
NACK (negative ACK)	X	X	0	0	X

Note: X = Don't Care

BYTE CONTENTS
Figure 5-2

5.1.4 State Diagrams

The transmitter and receiver processes are represented by states and the transitions between them. An input causes the process to leave a state and the flow of the state diagram varies depending on the input received. Whenever the state number reached is one that has occurred previously in the state diagram the flow of the state diagram reverts to the earliest occurrence of the state defined.

A number of definitions are given below to clarify the symbols used in the state diagrams that follow.
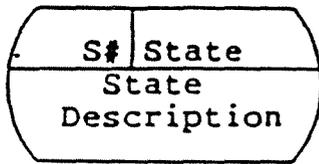
This symbol indicates a state. The number (S#) in the upper left corner indicates the state number and the state that is transmitted is indicated to the right of the S#.
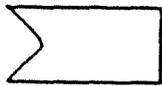
Symbol for received Inputs
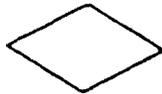
Decision Symbol

Connector Symbol

Internal Task Symbol

5.1.4.1 Transmitter State Diagram

```
                    ┌─────────────┐
                    │  S1 | Idle  │
                    │  Wait for   │
                    │    Data     │
                    └──────┬──────┘
        ┌──────────────────┼──────────────────┬──────────────────┐
   ┌────┴────┐       ┌─────┴────┐       ┌─────┴────┐       ┌──────┴──────┐
   │  NACK   │       │   PACK   │       │   CTS    │       │   Message   │
   └─────────┘       └─────┬────┘       └──────────┘       └──────┬──────┘
                           │                                      │
                    ┌──────┴──────┐                               │
                    │  S1 | Idle  │                               │
                    │  Wait for   │                               │
                    │    Data     │                        ┌──────┴──────┐
                    └─────────────┘                        │  S2 | Idle  │
                                                           │  Wait for   │
                                                           │     CTS     │
                                                           └──────┬──────┘
                 ┌─────────────┬──────────────────────────────────┤
           ┌─────┴────┐  ┌─────┴────┐                        ┌─────┴────┐
           │   NACK   │  │   PACK   │                        │   CTS    │
           └──────────┘  └─────┬────┘                        └─────┬────┘
                               │                                   │
                        ┌──────┴──────┐                     ┌──────┴──────┐
                        │  S2 | Idle  │                     │  S3 | CH0   │
                        │  Wait for   │                     │     Tx      │
                        │     CTS     │                     │  Nibble 0   │
                        └─────────────┘                     └──────┬──────┘
                 ┌─────────────┬──────────────────────────────────┤
           ┌─────┴────┐  ┌─────┴────┐                        ┌─────┴────┐
           │   NACK   │  │   PACK   │                        │   CTS    │
           └──────────┘  └─────┬────┘                        └─────┬────┘
                               │                                   │
                        ┌──────┴──────┐                     ┌──────┴──────┐
                        │  S2 | Idle  │                     │  S4 | CH0   │
                        │  Wait for   │                     │     Tx      │
                        │     CTS     │                     │  Nibble 1   │
                        └─────────────┘                     └──────┬──────┘
                 ┌─────────────┬──────────────────────────────────┤
           ┌─────┴────┐  ┌─────┴────┐                        ┌─────┴────┐
           │   NACK   │  │   PACK   │                        │   CTS    │
           └──────────┘  └─────┬────┘                        └─────┬────┘
                               │                                   │
                        ┌──────┴──────┐                     ┌──────┴──────┐
                        │  S2 | Idle  │                     │  S5 | CH0   │
                        │  Wait for   │                     │     Tx      │
                        │     CTS     │                     │  Nibble 2   │
                        └─────────────┘                     └──────┬──────┘
                                                                  ( 1 )
```
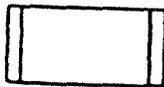
Transmit State Diagram (continued)

①

> NACK   > PACK   > CTS

S2|Idle
Wait for
CTS

S6|CH0
Tx
Nibble 3

> NACK   > PACK   > CTS

S2|Idle
Wait for
CTS

S7|RACK
Tx ChSum
1st Time

> NACK   > PACK   > CTS

Wait for|
2nd NACK|--
        _|

S9|RACK
Tx ChSum
2nd Time

Wait for|
2nd PACK|--
        _|

S8|RACK
Tx ChSum
2nd Time

S7|RACK
Tx ChSum
1st Time

> CTS   > PACK

S7|RACK
Tx ChSum
1st Time

> NACK   > CTS

S7|RACK
Tx ChSum
1st Time

> NACK

S2|Idle
Wait for
CTS

> PACK

Clear
Message

S1|Idle
Wait for
Data
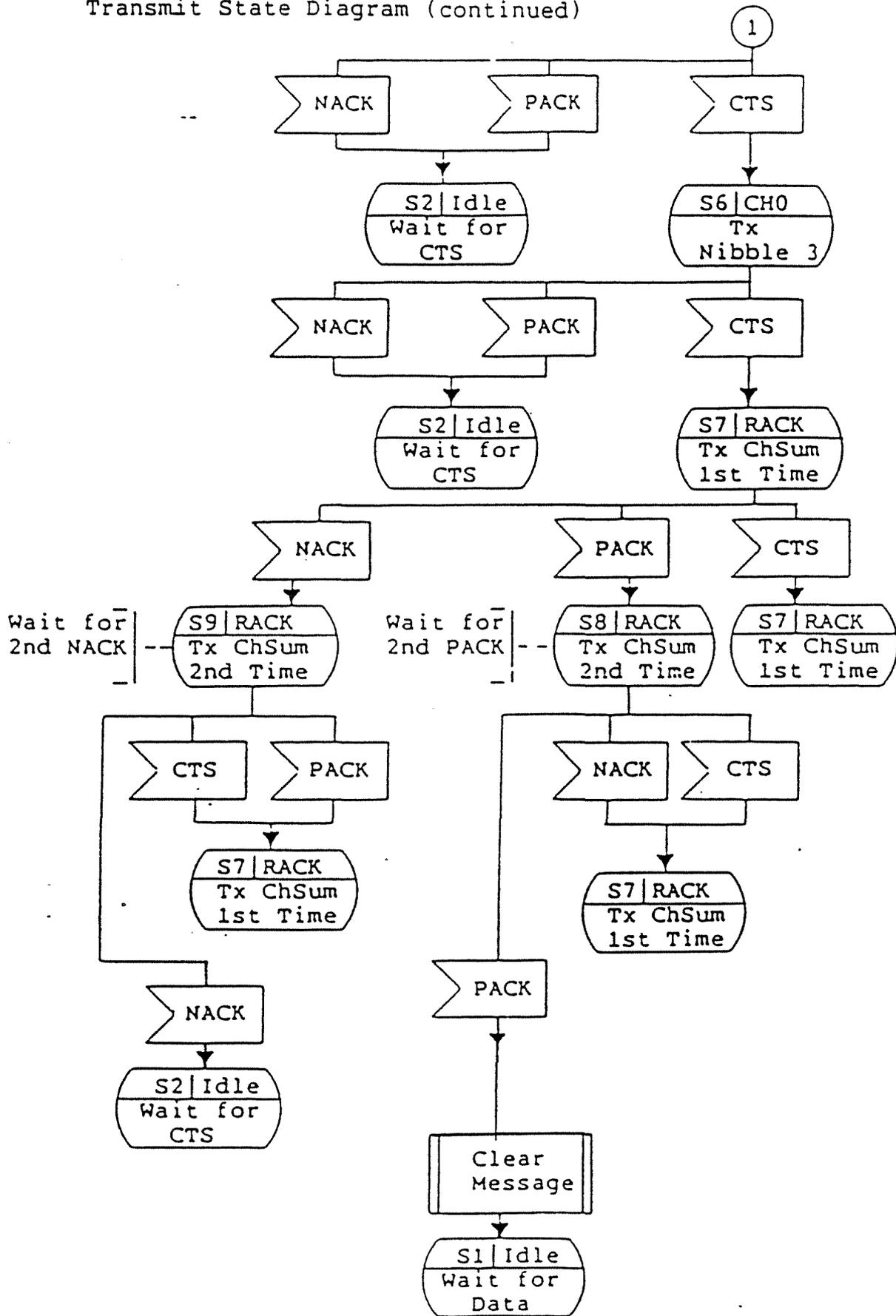
5.1.4.2 Receiver State Diagram

Receiver State Diagram
      (continued)

①

```
   RACK        IDLE        CH0
②
```

Rx
ChSum
Agrees with   NO
calculated
ChSum?

S3│NACK
Wait for
Idle

Yes

S7│PACK
Wait for
Idle

```
   IDLE           CH0           RACK
```

S1│CTS   S3│NACK   ②
Wait for   Wait for
CH0 Data   Idle
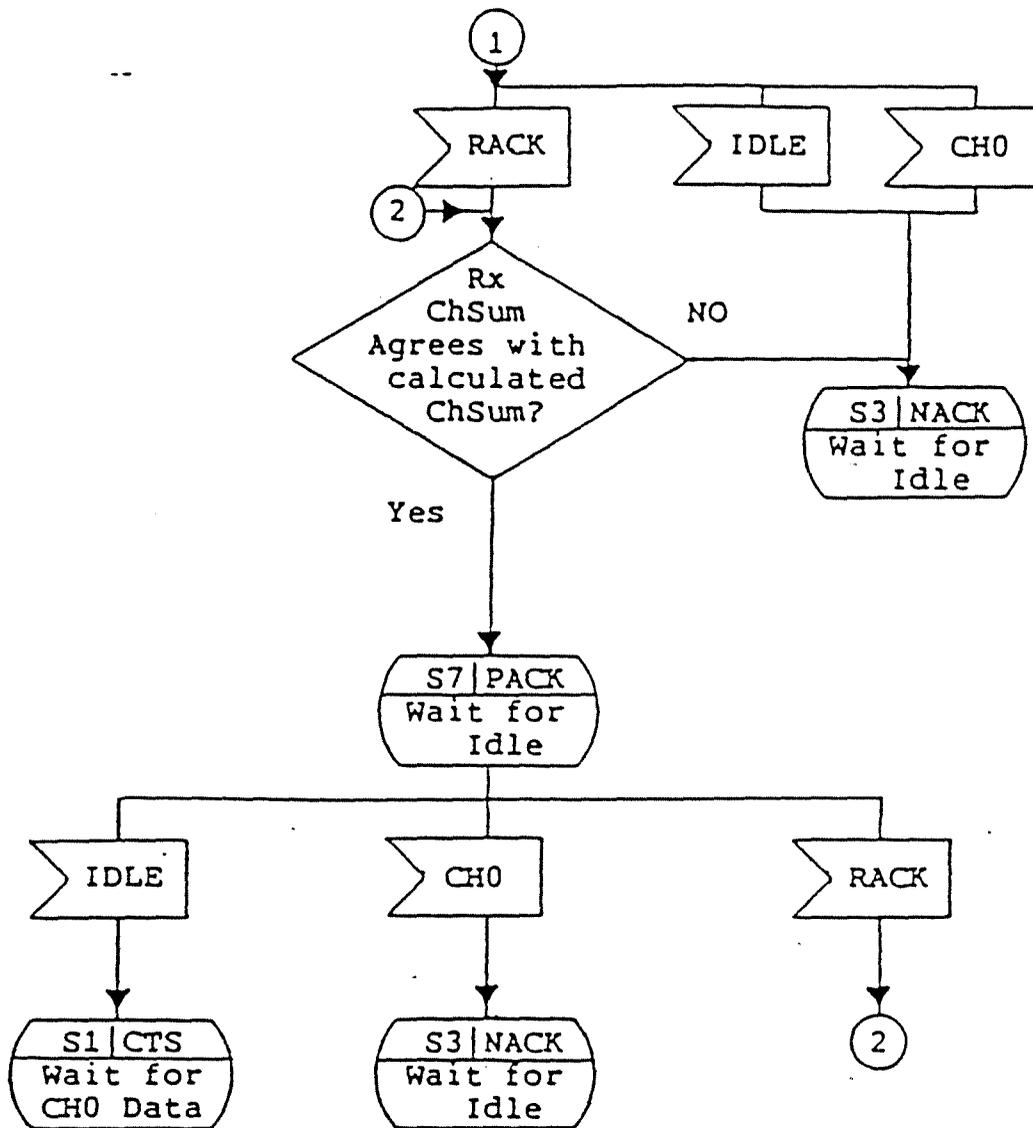
5.1.5 Typical Message Transfer

The following description is typical of a message transfer when the received checksum is correct and when there is no interruption in the message transmission introduced by a request from the receiver. The receiver can stop the transmission of the message at any time by entering the NACK state. If this does occur during the transmission of a message, the transmitter is required to re-transmit the complete message after the receiver re-enters the CTS state.

| TRANSMITTER | | | | RECEIVER | | |
Tx-state	Rx-state	Data		Tx-state	Rx-state	Data
			<---	X	PACK/NACK	X
IDLE	X	X	--->			
			<---	X	CTS	X
CH0	X	nibble0	--->			
			<---	X	CTS	X
CH0	X	nibble1	--->			
			<---	X	CTS	X
CH0	X	nibble2	--->			
			<---	X	CTS	X
CH0	X	nibble3	--->			
			<---	X	CTS	X
RACK	X	checksum	--->			
			<---	X	PACK	X
RACK	X	checksum	--->			
			<---	X	PACK	
IDLE	X	X	--->			
			<---	X	CTS	X

Figure 5-3
Typical Message Transfer

5.2 Link Level Message Protocol

5.2.1 Basic Structure

Datapath service provides a 64 kbit/s full duplex data channel that has an associated 8 kbit/s full duplex signal channel. The signal channel is used for call set-up as well as several other control functions outlined in the signal channel message protocol as defined below. The eight bit control commands contained within a sixteen bit envelope have been developed to handle call processing. The message protocol for Datapath service has several additional commands that are defined to provide the necessary communication between the Terminal Equipment and the CO. Both incoming and outgoing messages on the signal channel consist of 16 bits contained within a two byte structure as shown in Figure 5-4.

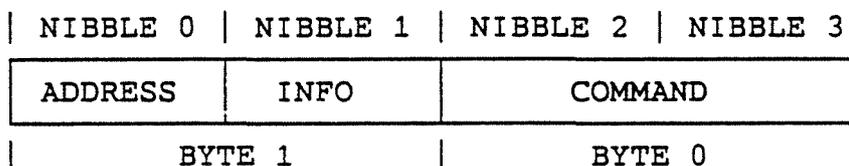| NIBBLE 0	NIBBLE 1	NIBBLE 2	NIBBLE 3
ADDRESS	INFO	COMMAND	

| BYTE 1 | BYTE 0 |

FIGURE 5-4

BASIC MESSAGE STRUCTURE

This structure only represents the format of the message and does not represent how the message will be transported over the signal channel. The protocol used to transport the messages is the Full Duplex Handshaking Protocol (FDHP) as defined in Section 5.1.

Byte 1   The first byte of the message to be passed over the interface. This is the high order byte.

Byte 0   The second byte of the message to be passed over the interface. This is the low order byte.

Address   The four MSB of byte 1 are reserved for the address. For Datapath service, the address is used to enable the DMS Machine to direct a message to either the DLC or to the TE. The DLC is assigned address 8 Hex (1000). The TE is assigned address 0 Hex (0000). Hence, the received messages from the CO relevant to the TE will always have address 0 Hex. Also any messages transmitted by the TE will normally have address 0 Hex, thereby indicating to the CO that the message originated from the TE rather than the DLC.

Info   The Information nibble of byte 1 when not used should be set to logic level 0. The one exception to this is when the bulk data transfer option is used.

Command   These eight bits form the actual commands that are to be acted on by the TE or the CO.

5.2.2 Loopbacks, Status Requests and Bulk Data Transfer

The TE is not required on a mandatory basis to provide the loopback features or the capability of receiving bulk data transfers. The capability of responding to status requests is also an optional feature.

The support of these optional capabilities enhances both the customer's and the operating company's ability to perform diagnostics.

The loopbacks, in particular, provide an effective means to sectionalize the location of a fault during either routine maintenance or as a result of a trouble report. This is also true for the bulk data transfer that is used to momentarily disconnect the termination presented by the TE to the network interface to enable tip to ring diagnostics on the access line.

TE that supports these features can thereby help the customer to avoid the expense of a service call by the operating company.

The customer will be required to specify if the TE does or does not support loopbacks when the service is installed. In addition the messages that are used to establish the TE status (e.g. TE Status Request - Near End) and the capability to support bulk data transfer are included as part of this option.

The alternatives are designated as follows:

        TE supports All Optional Features = Option A

        TE Supports No Optional Features = Option B

The above information will then form part of the customers profile in the CO software that is intended for use in look up tables used during maintenance diagnostics initiated by the CO.

Throughout the description of the link level commands and the required responses the use of the word "shall" for loopback related commands, bulk data transfer commands or status request commands is on the basis that option A is implemented.

5.2.3 Bulk Data Transfer

The bulk data transfer messaging scheme is used on the signal channel for routine maintenance diagnostics.

It is used specifically as a means of providing a timed disconnect of the termination presented to the network interface by the TE. This enables the CO to perform tip to ring tests on the access line with the TE, AC and DC terminations removed by the operation of a cut-off relay in the TE.

5.2.3.1 Message Format

For bulk data transfer, the Info nibble is used unlike all other messages passed over the signal channel.

The following illustration of a message sequence for bulk data transfer shows all of the components of the transfer. When the data being transferred consists of several nibbles the message shown as number three in the sequence is repeated the required number of times to transfer all of the data.

In the case of the data transfer by the CO requesting TE cut-off relay operation, only one nibble of data is required. Therefore the message sequence as shown in Figure 5-5 applies.

```
Message
Seq. No.
             |<——————— 16 Bit Message ————————>|

   1      | ADDRESS | Context  | Start Data      |

   2      | ADDRESS | Msg. Type| Data Carrier    |

   3      | ADDRESS | Data     | Data Carrier    |

   4      | ADDRESS | Count    | Data Carrier    |

   5      | ADDRESS | Chksum   | Stop Data       |
```
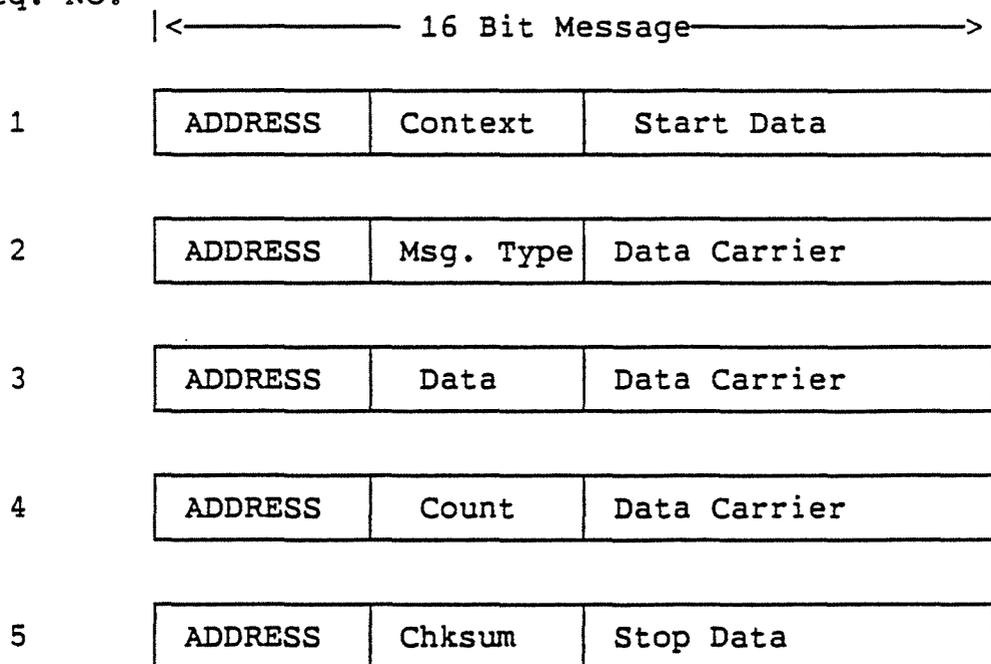
Figure 5-5
General Message Format & Sequence For
Bulk Data Transfer

5.2.3.2 Message Description

Each part of the five basic message formats used for bulk data transfer is defined in the same order that the parts of the messages would be received by the TE.

Address
This indicates where the message is addressed to and is always 0000 for the TE.

Context
This indicates the type of bulk data that is being transferred and in the case of maintenance related data is defined as 0011 in binary form.

Start Data
This indicates the beginning of the bulk data transfer and is specified as 7C hexadecimal for the CO to TE link level commands.

Message Type
This indicates the type of message and is relevant to the Context defined above. When the Context is maintenance, the CO indicates to the TE that the message is related to the cut-off relay by the message type code 0000 in binary form.

Data Carrier
This indicates the message is carrying information relevant to the bulk data transfer in the Info nibble.

Data
This is the actual information that is being transferred. In the case of the maintenance application for operation of the cut-off relay the value transmitted to the TE corresponds to the length of time the TE is to remain disconnected as shown in the table below.

Binary Value	Time (minutes)
0000	1
0001	2
0010	3
0011	4
0100	5
0101	6
0110	7
0111	8
1000	9
1001	10
1010	11
1011	12
1100	13
1101	14
1110	15
1111	16

Count

This value shall correspond to the modulo sixteen count for the number of messages that contain the Data Carrier command in the bulk data transfer sequence including the one that contains the COUNT nibble. Therefore in the case where the count is sixteen, the count value is 0000 in binary form. For the case of the cut-off relay operation message sequence, the count is 0011 in binary form.

Checksum

This value is calculated by summation of the Info nibbles starting with the one associated with the Start Data command and continuing to the last message with an associated Data Carrier command. Each nibble is added to the sum with the modulo sixteen result as the checksum. In the minimum message sequence shown in Figure 5-5 the checksum is equal to Context + Msg. type + Data + Count as illustrated below.

Binary Value	Info Nibble
0011	Context
0000	Message Type
0001	Data
0011	Count
0111	Checksum

5.2.3.3 Acknowledgement By The TE to The CO

The TE is required to give either a positive acknowledgement (PACK) or a negative acknowledgement (NACK) based on the Count being correct and the checksum agreeing when the message type and context are supported by the TE.

For the Nack and Pack commands the Info nibble is transmitted as all zeroes and is ignored when received as is the case for all other commands with the exception of those specified for bulk data transfer.

For TE that does not support the type of bulk data transfer that is indicated by the Context and Message Type nibbles received, the TE shall treat the received messages as no-op codes with no acknowledgement provided.

In the case where bulk data transfer is supported to initiate operation of the cut-off relay in the TE, the PACK command shall be transmitted to the CO prior to operating the cut-off relay.

5.2.4 Central Office (CO) To Terminal Equipment (TE)

(See Table 5-1 for the actual command codes.)

5.2.4.1 Command Descriptions

Alert ON
This command alerts the terminal equipment of an incoming call and that the CO is transmitting a PCM u-law encoded ringing signal over the data channel.

Alert OFF
This alerts the TE that the ringing signal is no longer on the Data Channel.

Progress Tone Alert-On
This command alerts the TE to monitor the data channel for PCM u-law encoded voiceband signals.

This is used when the TE is originating a call to request the TE to monitor the data channel for call progress tones. When the TE is answering a call, it is used to request the TE to monitor the data channel for voiceband signals from the network.

The transition of the TE from the Progress Tone Alert (ON) state to the

OFF state shall occur if any one of the following four events occur:

1) The detection by the TE of valid data, if the Progress Tone Alert (ON) command is followed by a Data Alert ON command.

2) Any one of the three resets is received (call processing reset, hard reset, soft reset).

3) The Progress Tone Alert (OFF) command is received.

4) The Far End Answered command is received (see the description of this command for further details).

Progress Tone Alert-Off

This command is used to turn off the line monitor. Its present use is only at the answering end of a connection and it is sent once the TE answers the incoming call.

Count

This value shall correspond to the number of messages that contain the Data Transfer sequence including the one that contains the Count nibble.

Checksum

This value is calculated by summation of the Info nibbles starting with the Start Data command and continuing to the last message with an associated Data Carrier command. Each nibble is added to the checksum with the carry information discarded. In the minimum message sequence shown in Figure 5-5 the checksum is equal to Context + Msg. Type + Data + Count.

Feature Alert ON/OFF

These commands are for special feature signaling depending upon which feature was subscribed to. (Example: ring again recall)

Secondary Feature Alert On/Off

These commands alert the TE of a special feature which was subscribed to.

Data Alert ON

This command alerts the TE to monitor the data channel for valid data.

"Data", as defined here, includes any inband handshaking protocol.

Data Alert OFF

This command is not used at the present time but is reserved for future use.

TE Status Request
(Data Rate)

This command requests the TE to report the present operating data rate of the TE. This request command will only be used if the modem pooling feature is subscribed to.

TE Status Request
(Loopbacks)

This command requests the TE to report the loopback status of the TE should the TE have loopback capability. This command can occur at any time.

TE Status Request
(Near End)

This command requests the TE to give the status of the near end TE/DTE interface and can occur at any time.

TE Status Request
(Far End)

This command requests the TE to give the status of the far end TE/DTE interface as indicated by the inband protocol should the TE employ the T-Link protocol described in Appendix A.

Loopbacks Off

This command requests a reset of any loopback established by the CO.

Data Channel Loopback

This command requests the TE to place the 64 kbit/s data channel within the TE in a loopback state.

TE/DTE Loopback

This command requests a loopback of the Data Channel at the local TE/DTE interface.

Far End DTE/TE Loopback

This command requests the local TE to initiate an inband request to the far end TE to establish a loopback at the DTE/TE interface. This command assumes that both TEs use the inband protocol described in Appendix A.

Message Echo Start/Stop

This command requests the TE to loopback all subsequent commands in the signal channel to the DLC. While in the Echo mode no incoming commands will be acted

	upon by the TE until the echo message stop command is received. TE keyboard inputs though are acted upon.
Under Test Alert(On/Off) --	This command alerts the TE that the CO is seizing the TE or access line for testing and may not be used for calls.
Call Processing Reset	This command is used when a TE to TE connection is taken down. It is a single command that combines the functions of the Alert Off, the Call Progress Alert Off, and the Feature Alert Off commands. It is also sent after the Local DTR-On command is received.
Soft Reset	This command is used when the TE is placed in service and also during maintenance procedures. This command shall perform all the reset functions defined for the Call Processing Reset command in addition to signaling the TE that all previously requested special features are cancelled.
Hard Reset	This command is sent by the CO after loop maintenance procedures are completed to ensure that the TE is left in a known state. This command shall perform all the reset functions defined by the soft reset in addition to resetting any loopback state and the FDHP transmitter/receiver.
Feature Indicator (ON,OFF, Primary Indicators ,Secondary Indicators)	These commands send feature status messages to the TE. The status messages can be one of four states: ON, OFF, Primary Indicator or Secondary Indicator. An example of a primary versus a secondary indicator is a lamp flashing at 120 vs. 60 interruptions per minute. The last three bits of these command bytes are left open so that they can be mapped to the different features available (See Table 5-2 on feature command codes and section 5.2.5.1).
RI Cycle On	This command indicates to the TE that an incoming call exists. It can be used as an alternate means of signaling should

—	the TE not wish to use the PCM encoded ringing signal.
RI Cycle Off	This command turns off the ringing indicator described in the RI cycle On.
Proceed to Select	This command indicates to the TE that the CO is ready to receive dial pad digit messages. It can be used as an alternative to the use of PCM endoded dial tone the TE receives.
Connection in progress	This command is sent by the CO after all the dial pad messages that are required to place a call have been received. This indicates to the TE that the set up of the end-to-end connection is in progress.
Busy	This command is sent by the CO only on intra-office calls if the called Directory Number is busy. On intra-office calls it can be used as an alternative to the PCM encoded busy tone from the CO.
Reorder	This command will be sent to the originating TE if either an all circuits busy condition is encountered or if any equipment irregularities exist in relation to the originating switch. An example of an irregularity is if the TE attempts to utilize a feature that is not part of the customer's feature profile in CO software. This command is only sent and is therefore only useable as an alternative to the inband PCM reorder tone when the reorder tone originates from the serving DMS machine.
Report Vintage & Version	This is command sent by the CO to establish the firmware version and vintage of the TE. This will be used as a part of the subscriber maintenance diagnostics that can be initiated from the CO as a result of a reported trouble. This is reserved for future use.
Inband Sync Timeout	This command shall be a no-op code unless the TE is arranged for a data rate of either 56 kbit/s or 64 kbit/s synchronous and the TE supports T-Link rate adaption protocol. When the above

two conditions exist, the TE shall use this command as an indication to abort the attempt to rate adapt using T-Link protocol and go directly into the data transfer mode (see Appendix B).

Start Data | This command is used by the CO to initiate bulk data transfer between the CO and the TE. The use of this command is described in section 5.2.3.

Data Carrier | This command is used by the CO to indicate that there is data in the Info nibble of the associated message that is relevant to bulk data transfer. The use of this command is described in section 5.2.3.

Stop Data | This command is used by the CO to indicate the end of a bulk data transfer between the CO and the TE. The use of this command is described in section 5.2.3.

Far End Answered | This command is used by the CO to indicate to the originating TE that the called party has answered (e.g. answer supervision has been returned to the originating CO). This command alerts the TE to turn off the line monitor. It is provided as an alternative means of turning off the line monitor so that the TE does not have to rely on the detection of valid data to initiate turning off the line monitor (see the description of Progress Tone Alert-On).

No-op Codes | Commands that do not match any of the commands defined in this specification or are optional commands that are not supported by the TE shall be treated as no-op codes, i.e. they are acknowledged but no action is taken.

Table 5-1
CO to TE Command List

FUNCTION	M7	M6	M5	M4	M3	M2	M1	M0	HEX
					COMMAND CODE				
Alert On	0	1	1	0	1	1	1	1	6F
Alert Off	0	0	0	0	1	1	1	1	0F
Progress Tone Alert On	0	1	1	0	1	1	0	0	6C
Progress Tone Alert Off	0	0	0	0	1	1	0	0	0C
Feature Alert On	0	1	1	0	1	1	1	0	6E
Feature Alert Off	0	0	0	0	1	1	1	0	0E
Secondary Feature Alert On	0	1	1	0	1	0	1	0	6A
Secondary Feature Alert Off	0	0	0	0	1	0	1	0	0A
Data Alert On	0	1	1	1	0	0	0	0	70
Data Alert Off	0	0	0	1	0	0	0	0	10
TE Status Request (Data Rate)	0	0	0	1	0	0	0	1	11
TE Status Request (Loopback)	0	0	1	1	0	0	0	1	31
TE Status Request (Far End)	0	1	1	1	0	0	0	1	71
TE Status Request (Near End)	0	1	0	1	0	0	0	0	51
Loopbacks Off	0	0	0	1	0	1	0	0	14
Data Channel Loopback	0	0	1	1	0	1	0	0	34
TE/DTE Loopback	0	1	1	1	0	1	0	0	74
Far End DTE/TE Loopback	0	1	0	1	0	1	0	0	54
Message Echo Stop	0	0	0	0	1	0	0	1	09
Message Echo Start	0	1	1	0	1	0	0	1	69
Under Test Alert (On)	0	1	1	1	0	1	1	1	77
Under Test Alert (Off)	0	0	0	1	0	1	1	1	17
Call Processing Reset	0	1	0	0	1	0	0	0	48
Soft Reset	0	0	0	0	1	0	0	0	08
Hard Reset	0	1	1	0	1	0	0	0	68
RI Cycle On	0	1	1	1	0	1	0	1	75
RI Cycle Off	0	0	0	1	0	1	0	1	15
Feature Indicator On	0	1	1	0	0	D	D	D	6X
Feature Indicator Off	0	0	0	0	0	D	D	D	0X
Primary Indicator	0	0	1	0	0	D	D	D	2X
Secondary Indicator	0	1	0	0	0	D	D	D	4X
Start Data	0	1	1	1	1	1	0	0	7C
Stop Data	0	0	0	1	1	1	0	0	1C
Data Carrier	0	0	1	1	1	1	0	0	3C
Inband Sync Timeout	0	1	1	1	1	1	0	1	7D
Far End Answered	0	1	1	1	1	1	1	0	7E
Report Version and Vintage	0	0	0	1	1	0	0	1	19
Proceed To Select	0	0	0	1	0	0	1	0	12
Connection In Progress	0	0	1	1	0	0	1	0	32
Busy	0	1	0	1	0	0	1	0	52
Re-order	0	1	1	1	0	0	1	0	72

NOTE: "DDD" indicates the binary code associated with a feature. For example, the indicator message for Auto Dial Feature would be "01100010" or 62 in hexadecimal (See Section 5.2.5).

5.2.5 Terminal Equipment (TE) to Central Office (CO)

(See Table 5-2 for TE to CO command Codes)

5.2.5.1 Command Descriptions

DN Command	This command is sent to the CO to indicate a request for service has been made i.e. the equivalent of taking a telephone set off-hook.
Release Command	This command is sent to the CO to indicate that a call is terminated, i.e. the equivalent of placing a set on-hook.
Dial Pad Commands	These commands are sent to the CO and serve the same purpose as the keys on a standard dial pad of a phone, i.e. for network addressing.
Resource	This command requests the modem pooling resources, if available, from the CO. In addition, this command can be used, in the future, to make additional features and resources available for the TE. See section 5.3 for alternative applications.
Auto Dial	This command initiates the CO to place a call to a preset directory number. See Section 5.3 for alternative applications.
Speed Call	This command is an indication to the CO that the following dial pad entries are for access to a programmed directory number in a list of frequently called numbers. See Section 5.3 for alternative applications.
Ring Again	This command may be used when the originating party reaches a busy directory number to instruct the CO to monitor the called Directory Number. When the called DN is no longer busy, the CO alerts the originator using the Feature Alert-ON and the Feature Alert-OFF sequence. See Section 5.3 for alternative applications.

Feature Key 8 —	This command is reserved for future use to provide additional features.
Local DTR ON/OFF --	These commands indicate the status of the DTR lead of the TE/DTE interface. A call cannot be originated or answered unless the DTR ON message has been sent. The only two exceptions to this are when the originate and answer commands are used. If during an established call a DTR OFF message is sent, the CO will break down the call.
Inband Sync-Found	This command is sent when the TE to TE connection has been made and the TE has detected that one valid handshake sequence has occurred as per the inband rate adaption protocol (e.g. parameter 4 has been transmitted and received as per T-Link protocol). This is used where the modem pooling feature is provided by the local BOC. It is also used where the TE supports T-Link rate adaption and 56 kbit/s or 64 kbit/s synchronous data rates are supported. In this case it is used to inhibit the CO from transmitting the Inband Sync Timeout command (see Appendix B for an example of this application).
Inband Sync-Lost	At the present time this command is only used where the modem pooling feature is provided by the Telco. It may be used in the future for other purposes.
Originate	This command provides the same function as the DN command for originating calls. Using the originate command also automatically indicates to the CO that the local DTR is on.
Answer	This command accomplishes the same function as the DN command for answering. It is primarily used for an auto answer capability. Before this command is sent, the TE must receive the RI Cycle ON command. Sending the Answer command automatically indicates to the CO that the DTR is on.
Data Rate status	This command shall be sent when the TE receives the TE Status Request-Data Rate command from the CO. This command may be used by the CO to perform

diagnostics, using its own TE resident in the CO, which can be configured to be compatible with the customer's data rate adaption, if a common protocol is used. The four LSB of this command indicate the Data Rate Status as follows:

RATE (kbit/s)	SYNC/ASYNC	FOUR LSB	HEX
0.3	ASYNC	0000	0
0.6	ASYNC	0001	1
1.2	ASYNC	0010	2
2.4	ASYNC	0011	3
4.8	ASYNC	0100	4
9.6	ASYNC	0101	5
19.2	ASYNC	0110	6
1.2	SYNC	0111	7
2.4	SYNC	1000	8
4.8	SYNC	1001	9
9.6	SYNC	1010	A
19.2	SYNC	1011	B
48.0	SYNC	1100	C
56.0	SYNC	1101	D
64.0	SYNC	1110	E
illegal speed setting		1111	F

NOTE: Not all TE's may support all rates defined above.

Loopback Status

This command shall be sent in response to receiving a TE Status Request Loopbacks command from the CO.

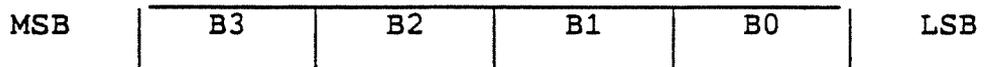|				
MSB	B3	B2	B1	B0	LSB

FIGURE 5-6
LOOPBACK NIBBLE

The four LSB of this command, as shown in Figure 5-6 indicate the loopback status of both the near and far end TE as follows:

Bit "B3" shall be set to 1 if the local TE is requesting that the far end TE/DTE interface be looped back. This can occur either as a result of a switch setting on the local TE or due to a

previous command sent by the CO, otherwise this bit shall be 0.

Bit "B2" shall be set to 1 if the local TE/DTE interface is looped back either as a result of a switch setting on the local TE or due to a previous command sent by the CO, otherwise this bit shall be 0.

Bit "B1" shall be set to 1 if the far end TE has placed the the local interface in a loopback state using the inband protocol. This bit shall be 0 when this condition does not exist.

Bit "B0" shall be set to 1 if the local 64 kbit/s data channel is looped back within the TE, otherwise it shall be 0.

Near End Status

This command shall be sent in response to receiving a TE status Request-Near End command from the CO.

MSB	RI	CTS	RTS	DTR	LSB

FIGURE 5-7
STATUS NIBBLE

The four LSB of this command indicate the near end status of the TE/DTE interface as follows:

The "RI" bit shall indicate the status of the RI lead of the TE/DTE interface.

The "CTS" bit shall indicate the status of the CTS lead of the TE/DTE interface.

The "RTS" bit shall indicate the status of the RTS lead of the TE/DTE interface.

The "DTR" bit shall indicate the DTR lead status of the TE/DTE interface.

Sgvi Found

This command is used for two specific rates. They are 56 kbit/s and 64 kbit/s synchronous data rates. If the TE supports T-Link rate adaption protocol and it is arranged to originate or answer a call at one of these two data

rates this command shall be transmitted by the TE when the last sixteen contiguous data channel bytes received are Sgvi signaling messages (see Appendix A&B).

Version-Count 1
(high order nibble)

This is the first half of the two byte command that shall be sent in response to receiving the Report-Version and Vintage command from the CO. The four LSB of Count 1 and Count 2 shall be stored in non-volatile memory. The four LSB of Count 1 shall indicate the type of TE. The type code will allow the CO to distinguish between different production models. Such differences as data rate capabilities and firmware versions will be defined by this code. This is reserved for future use.

Vintage-Count 2
(low order nibble)

This is the second half of the two byte command that shall be sent in response to receiving the Report-Version and Vintage Command from the CO. The four LSB of Count 2 shall indicate if the firmware has been updated relative to the original product version and if so to what vintage. This is reserved for future use.

Nack

This command shall be transmitted by the TE in reply to a bulk data transfer where either the received Count or Checksum does not agree with values determined by the TE. See Section 5.2.3 for further details.

Pack

This command shall be transmitted by the TE in reply to a bulk data transfer where both the Count and Checksum received agree with the values determined by the TE. See Section 5.2.3 for further details.

Far End Status

This command shall be sent in response to receiving a TE Status Request-Far End command from the CO.

```
   _    MSB  | 0   |  0   |  RTS |  DTR |  LSB
             |_____|_____|_____|_____|
```

FIGURE 5-8
STATUS NIBBLE

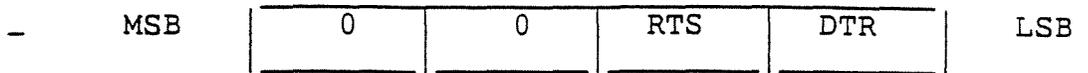The four LSB of this command are used in the manner indicated in Figure 5.8. The command determines the far end TE/DTE interface status.

The two MSB of the nibble as shown in Figure 5.8 are not in use at the present time and therefore shall be 0.

The two LSB of this command are used in the same manner as were the two LSB of the previous command except their status reflects the far end TE/DTE status.

Table 5-2
TE to CO Command List

FUNCTION	COMMAND CODE								
	M7	M6	M5	M4	M3	M2	M1	M0	HEX
* DN Command	0	0	0	0	0	0	0	0	00
Release	0	0	0	0	1	1	1	1	0F
Local DTR On	0	0	1	0	0	0	1	1	23
Local DTR Off	0	0	1	0	0	0	1	0	22
* Resource	0	0	0	0	0	0	0	1	01
* Auto Dial	0	0	0	0	0	0	1	0	02
* Speed Call	0	0	0	0	0	0	1	1	03
* Ring Again	0	0	0	0	0	1	1	0	06
Feature Key 8	0	0	0	0	0	1	1	1	07
Originate	0	0	1	0	0	1	1	0	26
Answer	0	0	1	0	0	1	1	1	27
Inband Sync - Lost	0	0	1	0	0	1	0	0	24
Inband Sync - Found	0	0	1	0	0	1	0	1	25
Data Rate Status	0	1	0	0	X	X	X	X	4X
Loopback Status	0	1	0	1	X	X	X	X	5X
Near End Status	0	1	1	0	X	X	X	X	6X
Far End Status	0	1	1	1	X	X	X	X	7X
Dial Pad Commands '1'	0	0	0	0	1	0	0	0	08
'2'	0	0	0	0	1	0	0	1	09
'3'	0	0	0	0	1	0	1	0	0A
'4'	0	0	0	0	1	1	0	0	0C
'5'	0	0	0	0	1	1	0	1	0D
'6'	0	0	0	0	1	1	1	0	0E
'7'	0	0	0	1	0	0	0	0	10
'8'	0	0	0	1	0	0	0	1	11
'9'	0	0	0	1	0	0	1	0	12
'0'	0	0	0	1	0	1	0	1	15
'*'	0	0	0	1	0	1	0	0	14
'#'	0	0	0	1	0	1	1	0	16
Version-Count 1 (high order nibble)	1	0	0	1	X	X	X	X	9X
Vintage-Count 2 (low order nibble)	1	0	1	0	X	X	X	X	AX
Sgvi Found	0	0	1	0	0	0	0	1	21
Nack	0	0	1	0	1	1	1	1	2F
Pack	0	0	1	0	1	1	1	0	2E

NOTE: The "*" indicates those features that have an associated indicator. The three LSB of the feature command codes given above are the same as the three LSB of the received command codes for the related feature indicators described in Table 5-1.

5.3 Translation Table

The translation table, Table 5-3, enables the Telco to specify which features are going to be assigned for a specific customer installation. Key numbers 1, 2, 3, 4 and 7, are the assigning codes used by the Telco. Although key number 8 is defined in the translation table, it is not a valid feature key at the present time. It is reserved for future use. Key 1 is always enabled in the customer's feature profile contained in the CO software since it forms part or the basic service offering. It is shown here to indicate the relationship between this key command and its related indicator. The other four keys (2,3,4,7) are classified as optional, since they may or may not be subscribed to by a customer that is provided with the service. This means that the customer profile in CO software can be set to select any combination of the four optional features.

Table 5-3
Translation Codes

Key No.	Command Code TE to CO (see Table 5-2)	Indicator Code-DDD (see Table 5-1)	Ind. No.
1	00 - DN	000	1
2	01 - Resource	001	2
3	02 - Auto Dial	010	3
4	03 - Speed Call	011	4
7	06 - Ring Again	110	7
8	07 - unassigned	(No Indicator)	

As an example, if the key number 7 feature were enabled for a particular profile, then the TE sending the "Ring Again" command would activate this feature under the proper circumstances. Also the change of the "Ring Again" feature would be indicated to the TE using the indicator commands as follows:

```
                    (key 7 - DDD = 110)
         Feature Alert - ON   = 0110   0110
         Feature Alert - OFF  = 0000   0000
         Primary Indicator    = 0010   0110
         Secondary Indicator  = 0100   0110
```

The translation Table 5-3 indicates what the primary applications
are for the four feature keys 2, 3, 4 and 7. If any one of these
four features is desired by the customer the associated key code
must be used (e.g. Ring Again if desired must be assigned to key
number 7).

If the customer does not desire one or more of these four
features, the unused key numbers can be assigned to alternative
features that are offered by the Telco. For more information on
the alternative features available, contact the local operating
company.

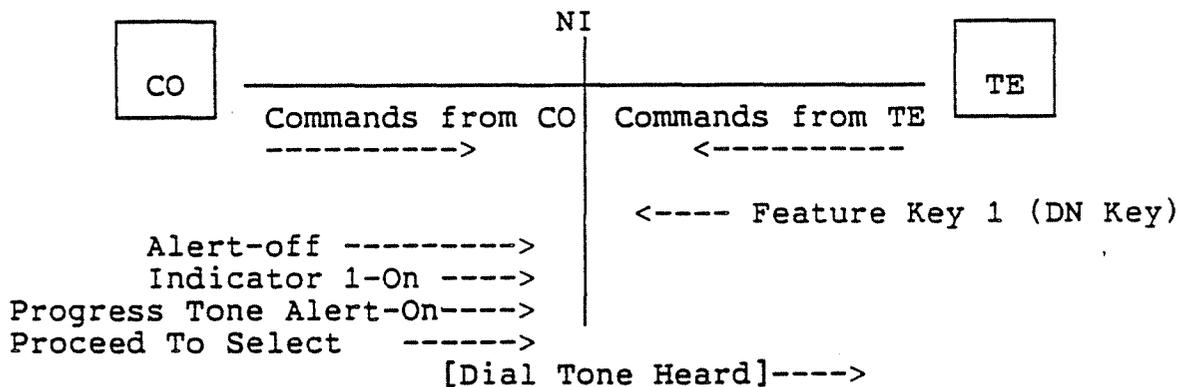5.4 CO and TE Command Inter-Action

The CO functions on the basis of stimulus signaling received from
the TE in the form of commands passed over the 8 kbit/s signal
channel.   The CO in turn expects the TE to react to the commands
sent to the TE as per the command protocol.   The following
sequences are provided as an illustration of the CO and TE
interaction across the Network Interface (NI).

                       Command Sequence 1

        Situation: DN Key is pressed

        Assumptions:
                     1. TE is Idle.
                     2. Square brackets,[], indicates u-law encoded
                        voiceband signal on the 64 kbit/s TE receive
                        channel.
                     3. DTR is On.

                                     NI
        ┌──────┐   │   ┌──────┐
        │ CO │ ─────────────────────┼───────────────────── │ TE │
        └──────┘   Commands from CO   │ Commands from TE   └──────┘
                   ----------->   │   <----------
                                      │
                                      │ <---- Feature Key 1 (DN Key)
                                      │
             Alert-off ---------->   │
             Indicator 1-On ---->   │
        Progress Tone Alert-On---->   │
        Proceed To Select   ------> │
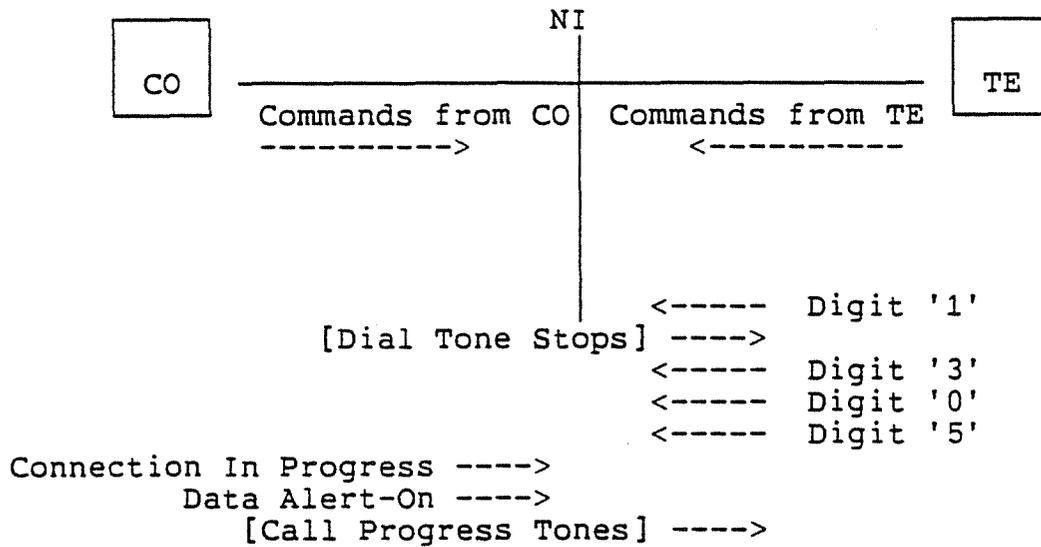   [Dial Tone Heard]---->

Command Sequence 2

Situation: To Dial Ext. '1305'

Assumptions:

         1. Dial Tone is present.
         2. Indicator 1 is on.
         3. Square brackets,[], indicates u-law encoded
            voiceband signal on the 64 kbit/s TE receive
            channel.
         4. DTR is On.

```
                          NI
 ┌──────┐                  │                         ┌──────┐
 │      │                  │                         │      │
 │  CO  │ ─────────────────┼─────────────────────────│  TE  │
 │      │  Commands from CO│ Commands from TE         │      │
 └──────┘  ---------->     │       <----------        └──────┘
                           │
                           │
                           │
                           │
                           │       <-----  Digit '1'
           [Dial Tone Stops] ---->
                                   <-----  Digit '3'
                                   <-----  Digit '0'
                                   <-----  Digit '5'
Connection In Progress ---->
       Data Alert-On ---->
           [Call Progress Tones] ---->
```

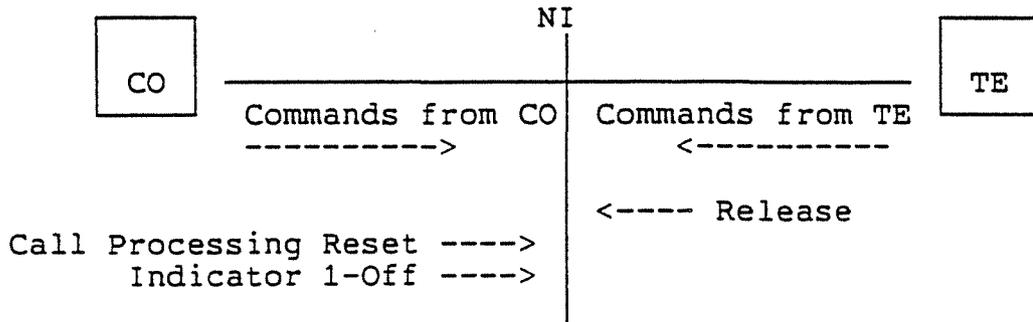# Command Sequence 3

Situation: Aborting Call

Assumptions:
            1. Call may be at any stage
            2. Indicator 1 is On
            3. DTR is On.

```
                              NI
 +------+                     |                         +------+
 |      |                     |                         |      |
 |  CO  |---------------------|-------------------------|  TE  |
 |      |  Commands from CO   | Commands from TE        |      |
 +------+                     |                         +------+
          ---------->         |      <----------
                              |
                              |      <---- Release
                              |
 Call Processing Reset ---->  |
       Indicator 1-Off ---->  |
                              |
```
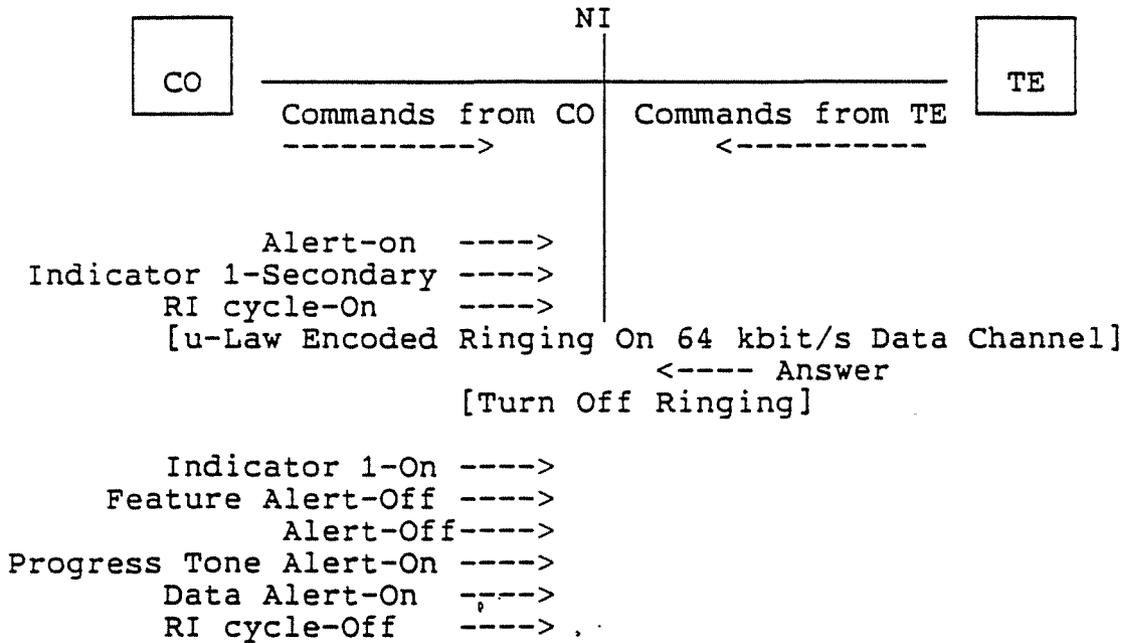
5-31

Command Sequence 4

Situation: Auto Answer

Assumptions:
              1. TE is Idle.
              2. Square brackets,[], indicates u-law encoded
                 voiceband signal on the 64 kbit/s TE receive
                 channel.
              3. DTR is On.
              4. Indicator 1 is Off
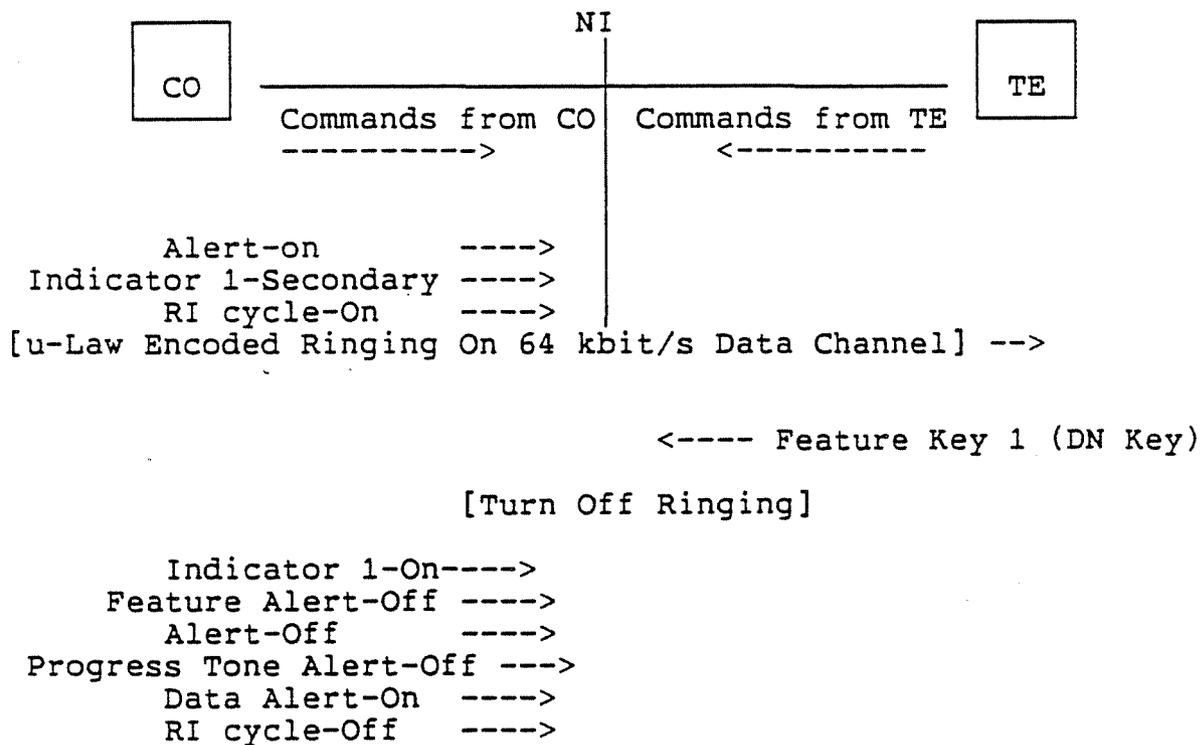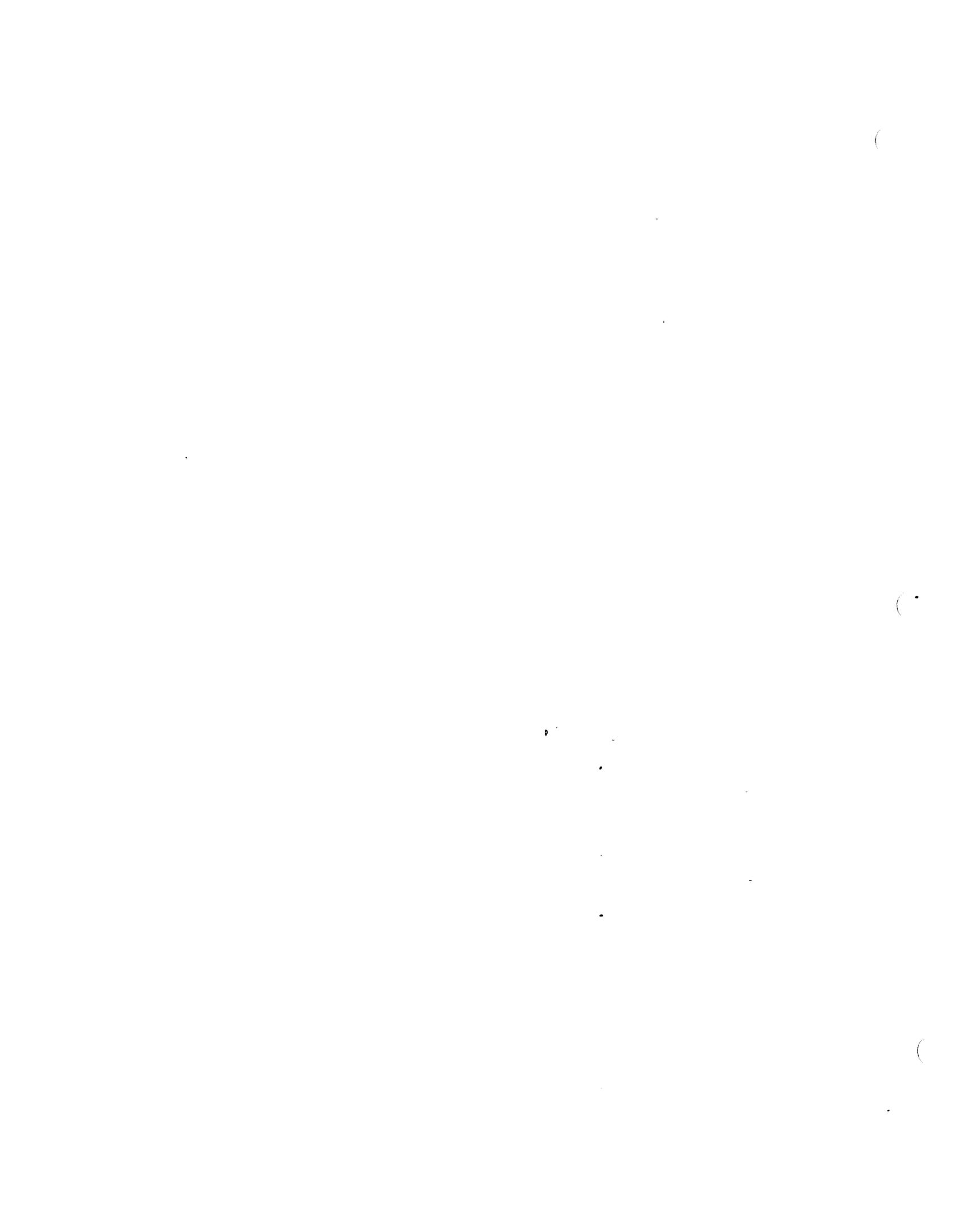   5. TE is set to auto answer incoming calls.

```
                                    NI
       ┌──────┐                     │                        ┌──────┐
       │  CO  │─────────────────────┼────────────────────────│  TE  │
       └──────┘  Commands from CO   │  Commands from TE      └──────┘
                 ---------->        │      <----------
                                    │

               Alert-on   ---->     │
     Indicator 1-Secondary ---->    │
           RI cycle-On    ---->     │
           [u-Law Encoded Ringing On 64 kbit/s Data Channel]
                               <---- Answer
                     [Turn Off Ringing]

           Indicator 1-On ---->
      Feature Alert-Off ---->
               Alert-Off---->
  Progress Tone Alert-On ---->
           Data Alert-On  ---->
           RI cycle-Off    ---->
```

5-32

Command Sequence 5

Situation: Manual Answer

Assumptions:

      1. TE is Idle.
      2. Square brackets,[], indicates u-law encoded
         voiceband signal on the 64 kbit/s TE receive
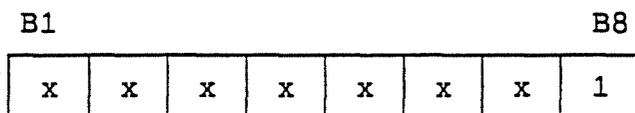   channel.
      3. DTR is On.
      4. Indicator 1 is Off

```
                              NI
 ____                          |                          ____
|    |                         |                         |    |
| CO |_____|_____| TE |
|____|   Commands from CO      |   Commands from TE      |____|
         ---------->           |   <----------

         Alert-on         ---->|
 Indicator 1-Secondary    ---->|
        RI cycle-On       ---->|
[u-Law Encoded Ringing On 64 kbit/s Data Channel] -->


                              <---- Feature Key 1 (DN Key)

                    [Turn Off Ringing]

        Indicator 1-On---->
    Feature Alert-Off ---->
         Alert-Off        ---->
 Progress Tone Alert-Off --->
         Data Alert-On    ---->
         RI cycle-Off     ---->
```

6.0 DATA FORMATS ON THE 64 KBIT/S CHANNEL

6.1 Basic 56 kbit/s End-To-End Data Channel

The 64 kbit/s full duplex data channel between the TE and the CO is reduced to a maximum end-to-end capacity of 56 kbit/s. This is due to the constraint that each byte shall be transmitted with B8 set to one to assure at least one "1" per byte. This is to meet the ones density constraint on DS-1 facilities. Therefore, the general format for all bytes, once an end-to-end connection has been established is:

```
B1                                      B8
+---+---+---+---+---+---+---+---+
| x | x | x | x | x | x | x | 1 |
+---+---+---+---+---+---+---+---+
```

Where "x" indicates the data bits

The format as shown represents the bytes as seen transmitted and received prior to the required inversion that the TE must provide.

6.2 Data Channel Protocol

No particular data channel protocol is required for compatibility with the network. However, to be compatible with Northern Telecom's TE or the modem pooling feature, it is a requirement that the end-to-end protocol as defined in Appendix A (T-Link Rate Adaption Protocol), be used for data transfer over the 56 kbit/s data channel.

TE that is capable of supporting T-Link protocol and that is connected to a DMS machine can also provide compatibility with other PSDS terminal equipment that offers 56 kbit/s synchronous data transfer. This capability is provided as a default mode for TE that implements T-Link protocol and the related link level protocol commands. The implementation of this feature is described in Appendix B.
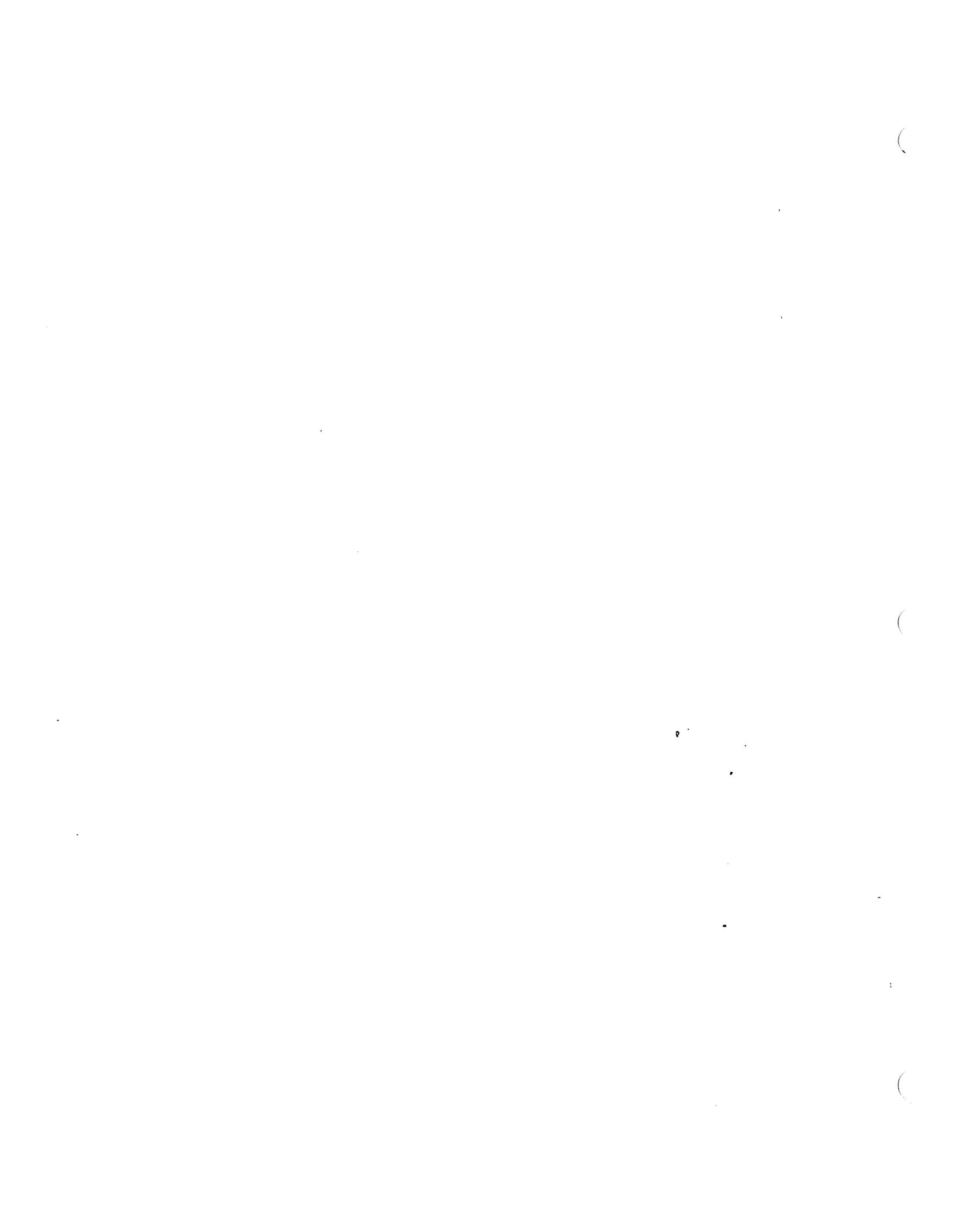
7.0 NETWORK MAINTENANCE

7.1 General

Datapath has the capability for both automatic routine testing as well as diagnostics that may be initiated when a fault is suspected. To conduct some of these tests it is necessary that the TE be equipped with certain loopback capabilities and the bulk data transfer capability. Although these "features" cannot be defined as mandatory interface requirements, including them in TE may eliminate the cost, to the customer, of an unnecessary field visit by the local operating company.

7.2 User Initiated Tests

7.2.1 Local Loopback

When activated this feature is required to place the local TE/DTE interface in a loopback state in both directions, i.e. towards the DTE and towards the DLC. This allows the customer to verify the operation of his DTE. The status of this feature shall be indicated by the Loopback Status command (See the TE to CO commands).

7.2.2 Far End Loopback

When activated this feature tells the local TE to request the far end TE to loopback at its TE/DTE interface. The user can then check the integrity of the end-to-end data channel and verify the operation of the data encoding/decoding in the TE by examining the looped back data at the local TE/DTE interface. The status of this feature shall be indicated by the Loopback Status command (see TE to CO commands).

7.3 CO Initiated Loopbacks

In order to implement CO - initiated loopbacks the TE should be capable of responding to the various loopback commands that can be initiated by the CO using the messages specified in Section 5.2. These loopbacks include loopback of the 64 kbit/s data channel, the signal channel and either the local or far end TE/DTE interfaces.

7.4 CO Initiated Access Line Tests

In order for the CO to perform routine maintenance tests on the access line on a tip to ring basis, it must be possible to remove the termination presented by the TE to the network interface.

For Datapath service this requirement has been provided for through the use of bulk data transfer to initiate the operation of a cut-off relay in the TE.

The description of how this feature is implemented is described in Section 5.2.

APPENDIXES

This part contains the following appendixes:

- "Appendix A. T-Link Rate Adaption Protocol"

- "Appendix B. Datapath Call Set-Up Sequences"

- "Appendix C. Clocking Considerations For
       The End To End Connection"

APPENDIX A

T-LINK PROTOCOL
FOR RATE ADAPTION
OVER A 64 KBPS CHANNEL

TABLE OF CONTENTS
--

LIST OF ILLUSTRATIONS

1.0 <u>GENERAL</u>

1.1 <u>SCOPE</u>

This document specifies the requirements for a data rate adaption protocol. This protocol is designed to provide the required procedures for rate adapting both asynchronous and synchronous user data to a 64 kbit/s full duplex digital channel. This specification does not define the method of connection or disconnection that is used.

1.2 INTRODUCTION

This specification defines an end to end rate adaption protocol that can transfer either synchronous or asynchronous data at rates up to 64 kbit/s. T-Link protocol is a full duplex byte oriented protocol.

The protocol provides a common set of messages that are used to establish compatible end to end data transfer characteristics on a 64 kbit/s digital channel. Also the protocol is designed to be applicable to both 64 kbit/s unrestricted and 64 kbit/s restricted digital channels.

Appendix A

1.3 SPECIFICATION CONTENTS

Section 2 specifies the minimum requirements to ensure conformance with this protocol.

Section 3 illustrates a hypothetical system overview and indicates the relationship between the user and the service provider. The lower layer dependencies of the protocol are also given.

Section 4 defines the service provided by this rate adaption protocol and the sequence of events for a successful call.

Section 5 defines the protocol in terms of the eight bit messages that are used. Also specified are the message sequences that occur during the rate adaption process.

1.4 REFERENCES

1.   EIA Standard RS-232 C, "Interface Between Data Terminal Equipment and Data Communications Equipment Employing Serial Binary Data Interchange".

2. EIA Standard RS-449, "General Purpose 37-Position and 9-Position Interface For Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange", November, 1977.

3.   CCITT Recommendation V.24, "List of Definitions For Interchange Circuits Between Data-Terminating Equipment and Data Circuit-Terminating Equipment", 1980.

4.   Computer-PBX Interface Specification (T1/DS-1 Version), Issue 1.1 20 February, 1984.

Appendix A

1.5 TERMINOLOGY

byte - an eight bit octet
CTS - Clear To Send
DCE - Data Circuit-terminating Equipment
DH - high nibble data format
     for asynchronous data transfer
DHp0 - high order nibble of parameter 0
DHp1 - high order nibble of parameter 1
DHp2 - high order nibble of parameter 2
DHp3 - high order nibble of parameter 3
DHp4 - high order nibble of parameter 4
DHvi - high order nibble of
       the protocol version identifier
Didle - data channel idle signaling byte
DL - low nibble data format
     for asynchronous data transfer
DLp0 - low order nibble of parameter 0
DLp1 - low order nibble of parameter 1
DLp2 - low order nibble of parameter 2
DLp3 - low order nibble of parameter 3
DLp4 - low order nibble of parameter 4
DLvi - low order nibble of
       the protocol version identifier
Ds6 - data format for 48 kbit/s
      or less synchronous data transfer
Ds7 - data format for 56 kbit/s
      synchronous data transfer
Ds8 - data format for 64 kbit/s
      synchronous data
DTE - Data Terminal Equipment
inband - within the 64 kbit/s channel
kbps - kbit/s
nibble - four bits, half of a byte
Sd - EIA/CCITT signaling message
Sgdis - channel disabled signaling message
Sgidle - channel idle signaling message
Sgp0 - parameter 0 signaling message
Sgp1 - parameter 1 signaling message
Sgp2 - parameter 2 signaling message
Sgp3 - parameter 3 signaling message
Sgp4 - parameter 4 signaling message
Sgr - call restart request
      signaling message
Sgss - secondary signaling message
Sgvi - protocol version identifier

Appendix A

signaling message
TE - Terminal Equipment
T1 - 1.544 M bit/s (DS-1) facility
T-Link - Rate adaption protocol

Appendix A

2.0 CONFORMANCE

2.1 MINIMUM REQUIREMENTS

The minimum requirements that must be met to conform to this protocol are as follows:

• Use of the synchronization sequence to establish both ends in a known state.

• Exchange of the protocol versions

• Exchange of the five mandatory parameters in sequence (0 to 4)

• Conformance to one or more of the specified data formats used to transport synchronous or asynchronous data

• messages not defined by this specification shall be discarded.

• optional messages that are received and not understood shall be discarded

2.2 OPTIONAL REQUIREMENTS

The protocol implementation may provide on an optional basis the following features:

• Call restart request signaling message support

• Parameter adaption by the TE

• Transfer of parameters other than the five mandatory ones

3.0 <u>ARCHITECTURE</u>

3.1 <u>SYSTEM OVERVIEW</u>
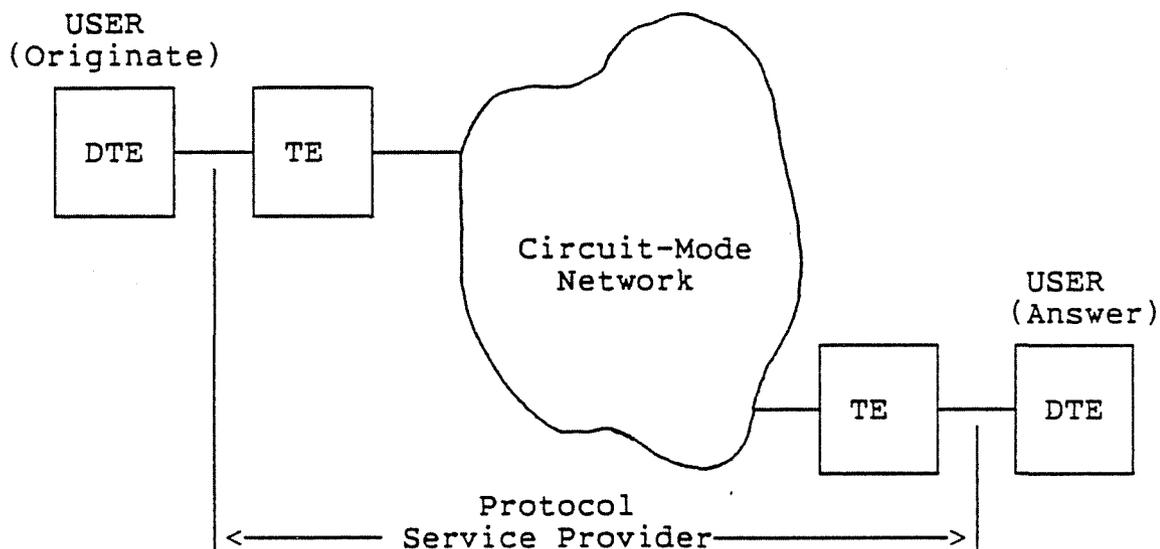
Figure 1. Physical Configuration For The System

The above diagram illustrates one possible system configuration where T-Link protocol is implemented to provide the two end users with a transparent end to end service.

The terminology associated with this hypothetical configuration is used to define the T-Link rate adaption protocol within this specification.

3.2 PROTOCOL ARCHITECTURE

```
                    +---------------------+
                    |                     |
                    |                     |
                    |        USER         |
                    |                     |          ┌─ T-Link Interface
                    |                     |          │
                    +---------------------+          V
  ──────────────────────────────────────────────────────────────


                    +---------------------+
                    |                     |
                    |  T-Link Protocol    |
                    |      Service        |
                    |     Provider        |          ┌─ Physical Interface
                    |                     |          │
                    +---------------------+          V
  ──────────────────────────────────────────────────────────────
```
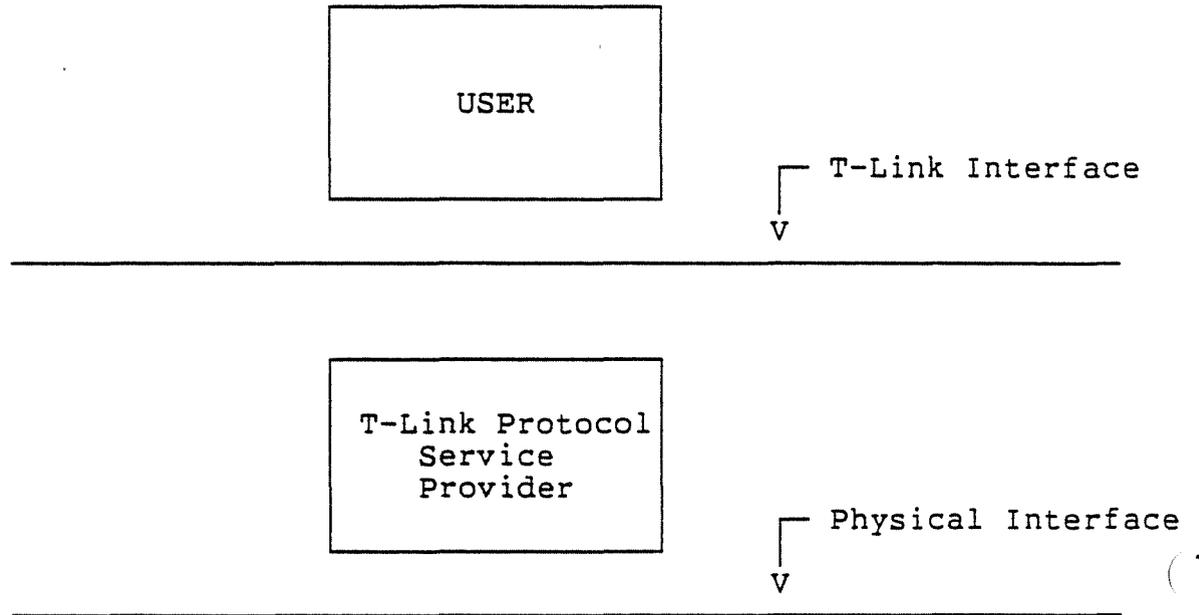
Physical Layer Connection

Figure 2. Layer Service Model

The Figure 2 illustrates the users view of the service provided by T-Link rate adaption protocol.

3.3 RELATIONSHIP TO PROTOCOL ARCHITECTURE

This protocol is designed to provide the services for the transfer of either synchronous or asynchronous digital data over a 64 kbit/s digital channel.

3.4 PROTOCOL DEPENDENCIES

This protocol requires, at the physical layer, a 64 kbit/s full duplex channel. The channel may be either a 64 kbit/s clear channel (unrestricted), where common channel signaling is provided and there is no 1's density requirement or a 64 kbit/s restricted channel that permits the use of the full capacity but with a 1's density requirement.

This protocol may also be used on a 64 kbit/s channel that is restricted to a 56 kbit/s capacity due to the use of inband signaling (A and B bits) and/or a 1's density requirement that limits the capacity as in the case of a 64 kbit/s channel on many North American DS-1 facilities.

The type of channel the protocol is used on is an application dependent requirement.

The protocol also depends upon the signaling protocol specific to the local interface to provide the means of connection and disconnection.

T-Link protocol does not define the medium over which it is used.

—

4.0 PROTOCOL SERVICE DEFINITION

4.1 SERVICES PROVIDED

This rate adaption protocol provides the user with the following capabilities:

1. Operation over a clear 64 kbit/s transmission facilities (e.g. DS-1 with B8ZS).

2. Operation over non-clear digital transmission facilities, (e.g. DS-1 without B8ZS and/or with inband A and B bit signaling), without violation of the DS-1, 1's density, requirement.

3. Support of terminals with synchronous data rates from 1200 bit/s to 64 kbit/s.

4. Support of terminals with asynchronous data rates from 50 bit/s to 19.2 kbit/s.

5. The passing of terminal interface signals (e.g. EIA RS-232C Signals).

6. The optional capability of requesting the restart of the rate adaption procedure under some circumstances (e.g. error conditions).

7. The optional capability of adapting to the originating TE requested parameters.

8. Error correction for user data rates of 9600 bit/s or less.

4.2 SERVICE FUNCTIONS

The service functions provided by this protocol are shown in Figure 3. This illustrates the steps involved in a typical call sequence.

The first step involves establishing an end to end connection ..and this, as shown, is outside the boundary of T-Link protocol.

Following this is the handshake which consists of three phases; synchronization phase, protocol version exchange phase, and the parameter exchange phase.

The first phase is the synchronization phase that establishes that the TE at both ends are in a known state.

The synchronization phase is followed by the protocol version exchange phase that is initiated by the answering TE. This exchange ensures both ends know what version of T-Link is supported by the other end.

If the T-Link versions at both ends are compatible the call proceeds to the parameter exchange phase and if they are not compatible the call may either be aborted by external means or call restart may be used to re-initiate the synchronization phase.

During the parameter exchange phase the TE at either end sends a series of five (or more) parameter messages which indicate the mode in which they would like to operate. The parameters define such things as whether the data being sent will be synchronous or asynchronous and the desired data rate.

If the parameters are compatible or if the answering TE can adapt its parameters to match the originating TE parameters the call proceeds to the data transfer phase. If, however, the answering TE cannot adapt, it is left with two possible alternatives.

The first alternative applies to TE that supports the call restart request option. When this is the case the TE can request the complete handshake be repeated with the originator assuming the role of the party required to adapt and the answering party dictating the parameters to be adapted to.

The second alternative is that the answering TE can initiate disconnect by external means.

Once the call reaches the data transfer phase, data transfer will continue end to end until the connection is broken by external means with one possible exception. The exception

applies under certain circumstances if the call restart message is supported by the TE at both ends of a connection. When this is the case the call restart message may be used during the data transfer phase to re-initiate the handshake (see Section 5.5.3 for further details).

CONNECTION
ESTABLISHED BY
EXTERNAL MEANS

T-LINK
PROTOCOL
BOUNDARY

HAND-
SHAKE

SYNCHRONIZATION
PHASE

CALL RESTART
TO
BEGIN AGAIN

YES

PROTOCOL
VERSION
EXCHANGE
PHASE

NOT
COMPATIBLE

RESTART
SUPPORTED
BY TE?

NO

DISCONNECT
BY EXTERNAL
MEANS

COMPATIBLE

A

CALL RESTART
TO
BEGIN AGAIN

YES

PARAMETER EXCH.
PHASE
(MINIMUM PARAM. 0
TO PARAM. 4)

ANSWERING
TE
CANNOT
CONFORM

RESTART
SUPPORTED
BY TE?

NO

DISCONNECT
BY EXTERNAL
MEANS

ANSWERING
TE CAN
CONFORM

DATA
TRANSFFER
PHASE

DISCONNECT BY
EXTERNAL MEANS

Figure 3. Service Functions

4.3 TIME SEQUENCE DIAGRAM

Figure 4 is used to illustrate the normal sequence of events for a typical call where the service provider uses T-Link protocol for rate adaption. The diagram is partitioned by two vertical lines into three fields. The central field represents the protocol service provider and the two side fields represent the two service users. The vertical lines represent the service access points between the service users and the protocol service provider.

The service access points represent an abstract interface that is used here for the purpose of describing the protocol usage.

This description of the sequence of events is provided as an example of the protocol usage and as such may or may not represent the implementation of the protocol for a specific application.

The sequence of events at each service access point are based on the rate adaption process being successful followed by entry into the data transfer phase.

USER
(ORIGINATE)

PROTOCOL
SERVICE
PROVIDER

USER
(ANSWER)

TRANSMITS
SGR'S
(OR NON-SGVI'S)

1 ———————————→ 1

SYNC
PHASE

2 TRANSMITS
SGVI'S

RECEIVES
SGVI'S

3 ←—————————

TRANSMITS
SGVI'S

4 —————————→ 5 RECEIVES
SGVI'S

6 VERSION
(DL/DH) X3

PROTOCOL
VERSION
EXCHANGE
PHASE

RECEIVES
(DL/DH) X3

7 ←—————————

VERSION
(DL/DH) X3

8 —————————→ 9 RECEIVES
(DL/DH) X3

PARAMETERS   10
0 TO 4

11 PARAMETERS
0 TO 4

PARAMETER
EXCHANGE
PHASE

RECEIVES
PARAMETERS   12
0 TO 4

13 RECEIVES
PARAMETERS
0 TO 4

ENTERS DATA   14
TRANSFER
PHASE

14 ENTERS DATA
TRANSFER
PHASE

DATA
TRANSFER
PHASE

DISCONNECT   15 →
OCCURS

← 15 DISCONNECT
OCCURS

Figure 4. Time Sequence Diagram For A Typical Call

The following is a detailed description of the sequence of events shown in the sequence diagram.

The number at the left indicates the relative time between events.

Event No.   **Description of The Event**

1.   Prior to the answering TE initiating the synchronization sequence, the originating TE shall transmit a byte pattern other than the Sgvi signaling message.

                  If the originating TE supports the call restart option, the Sgr signaling message is recommended.

2.   Once the answering TE has established a connection to the 64 kbit/s channel by means outside the scope of this protocol, the answering TE shall initiate the synchronization sequence by the continuous transmission of the Sgvi signaling message.

3.   The originating TE shall accept sixteen contiguous Sgvi messages received as a valid request for synchronization.

4.   The originating TE, after receiving the valid synchronization request, shall acknowledge the request by the continuous transmission of the Sgvi signaling message to the answering TE.

5.   The reception of sixteen contiguous Sgvi signaling messages by the answering TE shall indicate that end to end synchronization is established.

6.   Once the answering TE receives the synchronization indication, it shall change from transmitting continuous Sgvi messages to the transmission of the T-Link protocol version message.

                  The T-Link protocol version message shall consist of the protocol version of the answering TE encoded into a DL/DH pair that is repeated three times in succession and is transmitted immediately after the continuous transmission of Sgvi messages is stopped.

It is recommended that the answering TE follow the
above message sequence by transmitting the
signaling message Sgp0 as time fill. Although the
Sgvi message may be used for this purpose, it is
not recommended.

7.   The originating TE shall accept the three copies
        of the protocol version identifier DL/DH pair and
        determine the answering TE's T-Link protocol
        version identifier using a majority voting scheme.

8.   After the originating TE has compared its own
        T-Link protocol version to that received from the
        answering TE, it makes a decision. If the versions
        are compatible the originating TE shall respond by
        transmitting its own T-Link protocol version (see
        Section 5.4.3). This shall be the DL/DH pair
        repeated three times and is transmitted
        immediately after the continuous transmission of
        Sgvi messages is stopped.

9.   The answering TE shall accept the three copies of
        the DL/DH pair and determine the originating TE
        T-Link protocol version identifier using a
        majority voting scheme.

10.&11. After the originating TE has transmitted its
        T-Link protocol version, the parameter data may be
        sent.

        This also applies to the answering TE once it
        receives the T-Link protocol version of the
        originating TE.

        Which end begins the transmission of its parameter
        data first and which end is finished first may
        vary depending on the specific implementation of
        the protocol.

        This is due to the fact that such variables as the
        number of signaling messages that precede each
        parameter can vary. It is recommended that the TE
        transmit all of the parameter signaling messages
        and the related parameter data as a continuous
        sequence. It is also recommended that each end
        start this sequence as soon as the TE has
        confirmed that the received TE protocol version is
        compatible with its own.

—

Therefore, it is assumed that the originating TE transmits its five parameters in sequence right after the T-Link protocol version identifier data and that the answering TE likewise transmits its five parameters right after it receives the originating TE protocol version identifier data.

For both ends, the parameter data shall consist of a minimum of five mandatory parameters sent in sequential order with parameter 0 first and followed by parameter 1, 2, 3 and 4.

Each parameter shall be preceded by a recommended minimum of thirty two signaling bytes to indicate which parameter the data is relevant to.

The parameter data shall consist of the DL/DH pair repeated three times for each parameter.

12.&13.   It is recommended that the TE receiving the first parameter shall require a minimum of four contiguous parameter 0 signaling messages. Following this the TE shall look for parameter 0 data received three times. This shall be repeated for parameter 1, parameter 2, parameter 3 and parameter 4. The receiving TE shall determine the correct parameter data for each parameter using a majority voting scheme on the three copies of the received parameter data.

NOTE: It is recommended that the TE that has transmitted all of its parameters (0 to 4) but is still awaiting to receive the last of the opposite end TE parameters shall transmit the Sdidle signaling message as time fill.

14.   When the last parameter, which must always be parameter 4, has been transmitted and received, the originating and answering TE shall enter the data transfer phase.

The specific method of entry into the data transfer phase is dependent on the data rate that was agreed upon during the parameter exchange. The methods used are described in the protocol specification Section 5.9 .

15.   As was the case for the connection establishment, an external mechanism must be provided to break the switched connection. T-Link protocol does not define the means of disconnect.

5.0 PROTOCOL SPECIFICATION

5.1 PROTOCOL FUNCTIONS

The protocol provides the following functions:
- End to end synchronization.
- Exchange of protocol version identifiers.
- Exchange of five mandatory parameters.
- Exchange of EIA or CCITT DTE/DCE lead status.
- Optional adaption to the received parameters by the answering TE.
- Optional use of the call restart request message.
- Optional transfer of parameters other than the five mandatory ones.
- User data (asynchronous or synchronous) transfer
- Error Correction at Lower User Data Rates (9600 bit/s or less)

5.2 BIT AND BYTE NOMENCLATURE

This specification defines the encoding of T-Link messages in terms of bytes or octets. Since this is a byte oriented protocol all procedures are defined in these terms.

In order to differentiate between the bits and their order of transmission and reception at the interface to the 64 kbit/s channel versus the data bits as they are transmitted and received at the DTE/DCE interface, different designations are used. This is illustrated in Figure 5.

```
                              DTE/DCE        Channel
                              Interface      Interface
         USER                     |              |
              d7.....d0 -->       V         V  B8......B1 -->
   +-----+        Sent 1st   +--------+          Sent 1st
   |     |_____|      |_____
   | DTE |                     |      |
   | or  |                     |  TE  |
   | DCE |                     |      |
   |     |    <-- d0.....d7    |      |     <-- B1......B8
   |     |    Rec. 1st         |      |     Rec.1st
   +-----+_____+------+_____
```
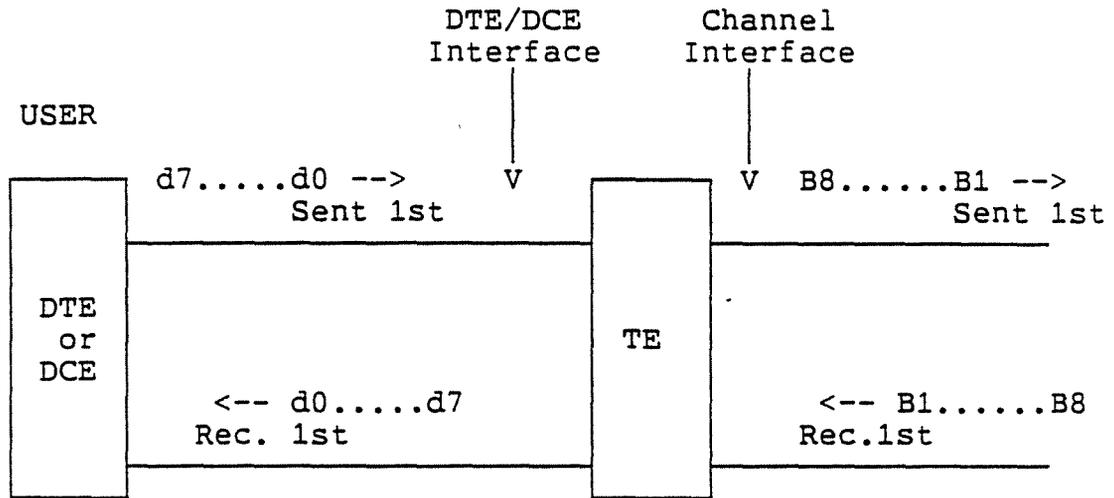
Figure 5.   Bit Sequence At DTE/DCE & Channel Interface

At the DTE/DCE to TE interface the bits are designated as d0
to d7, with d0 always transmitted and received first. The
bits in each byte of the 64 kbit/s channel are   numbered B1
to B8 for each byte on the 64 kbit/s channel. Bit B1 is
always transmitted first and received first as indicated in
Figure 5 at the TE to channel interface.

The mapping of the data bits, d0 to d7, into the 64 kbit/s
channel byte format of B1 to B8 is dependent on the data
rate that is adapted to and the protocol version that is in
use.

The data bits to and from the DTE/DCE are defined as d0,
least significant bit and d7, most significant bit.

5.3 BYTE FORMAT SUMMARY

5.3.1 Overall Characteristics

All signaling information and data are expressed as bytes on the 64 kbit/s channel using the format shown in Figure 6.

| B1 | B2 | B3 | B4 | B5 | B6 | B7 | B8 |
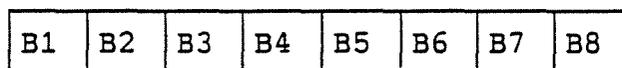
Figure 6. Byte Format

Where the bits are numbered in the order they are transmitted and received. The first bit B1 is transmitted and received first and B8 is transmitted and received last.

Within T-Link, data and signaling bytes are distinguished by the value of bit, B7. It is zero for bytes containing user or parameter data and one for bytes used to signal between the two ends of the circuit.   B8 is reserved for inband signaling. It is set to one on transmission and ignored on receipt.

```
          |<---- information ---->|   r- 0=Data
          |         (data or      |   |  1=Signal Byte
          |      type of signal)  |   |
          | B1 | B2 | B3 | B4 | B5 | B6 | B7 | B8 |
                                              |
                                              |
                                              L-Reserved for
                                                Signaling
```
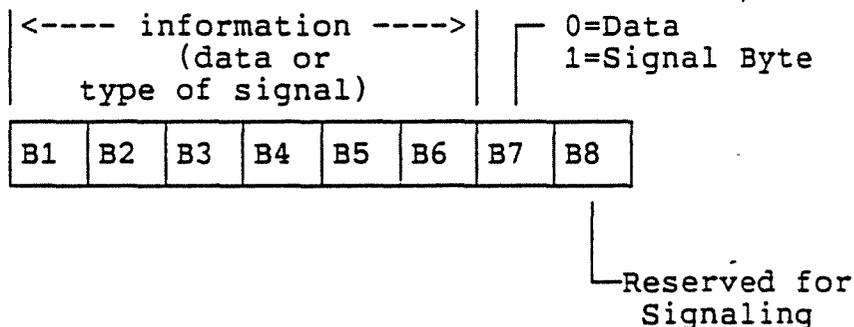
Figure 7. Identification of the Bytes

The only two exceptions to the format as shown in Figure 7 occur for the data transfer phase for 56 kbit/s and 64

kbit/s data transmission. In the case of 56 kbit/s data transmission bit B7 is required for data since seven out of the eight bits are required in each of the 8000 bytes per second. Therefore once the handshake is complete and the true data transfer phase is entered the above format does not apply.

In the case of 64 kbit/s data transmission both bits B7 and B8 are required for data and therefore once the true data transfer phase is entered all eight bits are required for data.

5.3.2 Unassigned Messages

Messages not defined by this specification shall be discarded and no other action taken.

5.3.3 Optional Messages Not Supported

Optional messages that are not supported by a specific implementation of this protocol shall be treated the same as unassigned messages.

5.3.4 Summary of Specified Byte Formats

The Figure 8 summarizes all the defined byte formats used for T-Link protocol.

When T-Link protocol is in use, bit B8 shall be transmitted with a logic level of 1 and its status for received bytes shall be ignored with the exception of the 64 kbit/s data transfer mode where all eight bits are required for data transfer.

Signaling Messages									
Abbr.	Meaning	B1	B2	B3	B4	B5	B6	B7	B8
Sgvi	Protocol Version Follows	0	1	0	1	0	1	1	1
Sgp0	Parameter 0 Data Follows	0	0	0	0	0	1	1	1
Sgp1	Parameter 1 Data Follows	0	0	0	1	0	1	1	1
Sgp2	Parameter 2 Data Follows	0	0	1	0	0	1	1	1
Sgp3	Parameter 3 Data Follows	0	0	1	1	0	1	1	1
Sgp4	Parameter 4 Data Follows	0	1	0	0	0	1	1	1
Sgr	Call Restart Request	0	1	1	0	0	1	1	1
Sd	EIA/CCITT Signaling	s3	s2	s1	s0	BK	0	1	1
Sgss	Secondary Signaling	0	1	1	1	0	1	1	1

Data Formats -Version 1									
Abbr.	Meaning	B1	B2	B3	B4	B5	B6	B7	B8
DL	Low Nibble of Asyn. Data	d3	d2	d1	d0	0	1	0	1
DH	High Nibble of Asyn. Data	d7	d6	d5	d4	1	1	0	1
Ds6	48 kbps & Lower Syn. Data	d5	d4	d3	d2	d1	d0	0	1
•Ds7	56 kbps Syn. Data	d6	d5	d4	d3	d2	d1	d0	1

Data Formats -Version 2									
Abbr.	Meaning	B1	B2	B3	B4	B5	B6	B7	B8
DL	Low Nibble of Asyn. Data	d3	d2	d1	d0	0	1	0	1,
DH	High Nibble of Asyn. Data	d7	d6	d5	d4	1	1	0	1
Ds6	48 kbps & Lower Syn. Data	d5	d4	d3	d2	d1	d0	0	1
•Ds7	56 kbps Syn. Data	d0	d1	d2	d3	d4	d5	d6	1
•Ds8	64 kbps Syn. Data	d0	d1	d2	d3	d4	d5	d6	d7

Network Signals									
Abbr.	Meaning	B1	B2	B3	B4	B5	B6	B7	B8
Sgidle	Channel Idle	0	1	1	1	1	1	1	1
Sgdis	Channel Disabled	1	1	1	1	1	1	1	1
Didle	Data Channel Idle	0	0	0	0	0	0	1	0

• Indicates the difference between Versions 1&2

Figure 8. Summary of The Defined T-Link Byte Formats

Protocol Specification   A5-5

As shown in Figure 8, the messages can be divided into three types.

The first type of message is used for signaling. The first seven of the messages in this group, Sgvi, Sgp0 to Sgp4 and Sgss, are used to identify the meaning of the data that follows.

The signaling message, Sd, is unique in that it contains the related signaling information within the message rather than indicating what is to follow.

The signaling message, Sgr, is used to signal the far end that the near end TE requests that the rate adaption process be restarted.

The second type of messages is used to transport data. There are two sets of data formats, one for Version 1 and one for Version 2 as shown. The DL and DH formats are used by the protocol for the exchange of protocol version data as well as parameter data for p0 to p4 and also secondary signaling data if provided. The DL and DH formats are also used for all the defined asynchronous data rates during the data transport phase. Ds6, Ds7 and Ds8 formats are the data formats used for synchronous data transfer. As indicated in Figure 8, the difference between Version 1 and Version 2 is the format for Ds7 and the fact that Version 2 has a Ds8 format where as Version 1 does not.

The third type of messages, Sgidle, Sgdis and Didle are are relevant to network level indications. As network level signals, they are specified to indicate byte patterns that may exist prior to or after a T-Link call.

5.4 GENERAL SIGNALING BYTE FORMATS

Of the ten defined general signaling byte formats, six (Sgvi, Sgp0, Sgp1, Sgp2, Sgp3, Sgp4) are mandatory and must be transmitted and received during the rate adaption handshake. Two (Sgss, Sgr) of the other general signaling byte formats are optional and the remaining two (Sgidle, Sgdis) are only used by the network to indicate the channel status.

5.4.1 Protocol Version Identifier Signaling Message

	B1							B8
Sgvi	0	1	0	1	0	1	1	1
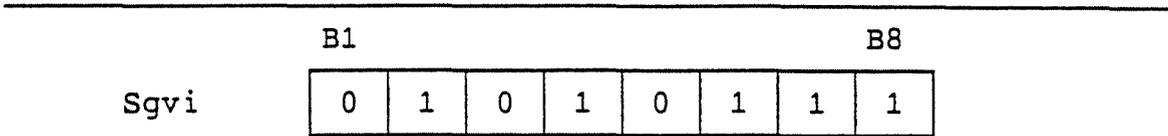
Figure 9.   Sgvi Signaling Message Format

The Protocol Version Identifier Signaling message (Sgvi) is
used to indicate that the Protocol Version Identifier
message is coming next.   The originating TE shall not
transmit the Sgvi byte pattern until it has been received
from the answering TE. It is recommended that where the
originating TE supports the use of the Sgr message, this
message be transmitted continuously to guarantee that the
answering TE is initialized to start a new call. There shall
be a minimum of sixteen contiguous Sgvi messages before the
arrival of the Protocol Version Identifier.

By requiring the answering TE to initiate the exchange of
Sgvi bytes and also requiring the originating TE to only
transmit Sgvi bytes, once it has received them, an end to
end synchronization is established prior to protocol version
and parameter exchange.

5.4.2 Exchange of Version Identifier Signaling Messages

When the 64 kbit/s channel has been established by external
means, the TE answering the call shall send repeated copies
of the Sgvi byte to the TE originating the call. The TE
originating the call, upon receipt of a minimum of sixteen
contiguous Sgvi bytes, shall start sending Sgvi bytes. When
the TE answering the call then receives a minimum of sixteen
contiguous Sgvi bytes, it shall send the DL-DH pair three
times with the encoded protocol version identifier for the
answering TE. Using the format shown in Figure 10.

The TE originating the call, upon receipt of the DL-DH pair from the answering TE, shall send its DL-DH pair constituting its Protocol Version Identifier Message.

5.4.3 Protocol Version Identifier Message

```
        B1                                      B8
DLvi    | d3 | d2 | d1 | d0 | 0 | 1 | 0 | 1 |

        B1                                      B8
DHvi    | d7 | d6 | d5 | d4 | 1 | 1 | 0 | 1 |
```
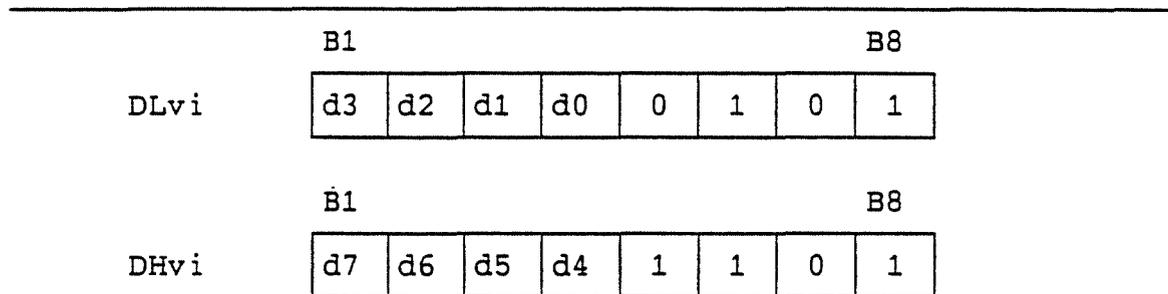
Figure 10. Protocol Version Data Format

Data bits d0 to d7 as shown in Figure 10 contain a protocol version identifier that indicates which version or versions of T-Link protocol applies to the data bytes, signaling bytes, and methods of operation used by the TE sending this message.

d7	d6	d5	d4	d3	d2	d1	d0	
0	0	0	0	0	0	0	1	Version 1
0	0	0	0	0	0	1	0	Version 2
0	0	0	0	0	0	1	1	Version 1&2
1	0	0	0	0	0	0	0	Version 8

If the TE is compatible with more than one version of T-Link protocol, this is shown by the appearance of additional 1-bits in the Protocol Version Identifier Message. An example of this is illustrated above where compatibility with version 1 and 2 is shown.

When the TE at both ends indicate they are compatible with more than one protocol version, the one selected shall be the highest numerically common one. Therefore, for example,

if the TE is compatible with versions 1 and 2 at both ends
of a connection, version 2 would be used.

The DL-DH pair containing the Protocol Version Identifier
Message information, designated as "DLvi" and "DHvi" in
Figure 10, are repeated three times. The receiving
equipment shall vote upon the repeated data using methods
described in section 5.8.6 .

When the originating TE receives a Protocol Version
Identifier Message from the called TE, it shall check for
compatibility. If compatibility is found, the originating
interface sends its Protocol Version Identifier Message. If
compatibility cannot be found, the originating TE shall send
the Protocol Version Incompatibility Identifier Message as
shown in Figure 11.

d7	d6	d5	d4	d3	d2	d1	d0
0	0	0	0	0	0	0	0
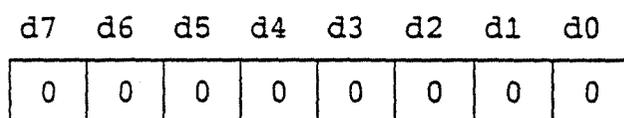
Figure 11. Protocol Version Incompatibility Identifier

The originating TE may then initiate disconnect by external
means or alternatively when the call restart request option
is supported , the TE may reinitiate the synchronization
sequence by the continuous transmission of the call restart
request (Sgr) messages.

5.4.4 Transmit Sequence For Each Identifier And Message

The same format is recommended for each of the parameters
(p0,p1, p2,p3,p4 and secondary signaling). This format
consists of thirty two signaling identifier messages
followed by three copies of the parameter data in the form
of a DL/DH pair. The additional signaling identifier
messages (minimum requirement is sixteen) are recommended to
ensure compatibility with existing implementations of the
protocol.

5.4.5 Receive Sequence For Each Identifier And Message

It is recommended that the TE require the reception of a minimum of four contiguous signaling identifier messages prior to the reception of the related parameter data. This shall apply to parameters 0,1,2,3,4 and secondary signaling data.

The three copies of the DL/DH pair for any of the parameters may be followed by some number (including zero) of the same signaling identifier message as the ones that preceded the data. This also applies to the Sgvi identifier messages that may be received after the protocol version data. This is illustrated below.

    Sgp3...Sgp3/DLp3/DHp3/DLp3/DHp3/DLp3/DHp3/Sgp3....Sgp4

5.4.6 Parameter 0 Identifier and Message

The parameter 0 identifier signaling message, Sgp0, shall conform to the format shown in Figure 12.

	B1							B8
Sgp0	0	0	0	0	0	1	1	1

Figure 12. Parameter 0 Identifier Message

This signaling message, Sgp0, indicates that the parameter 0 message is to follow. This message shall be transmitted a minimum of sixteen times (recommended thirty two) prior to the parameter 0 message.

The parameter 0 message shall be encoded into two bytes as shown in Figure 13.

B1   B8

DLp0 | d3 | d2 | d1 | d0 | 0 | 1 | 0 | 1 |

B1   B8

DHp0 | d7 | d6 | d5 | d4 | 1 | 1 | 0 | 1 |
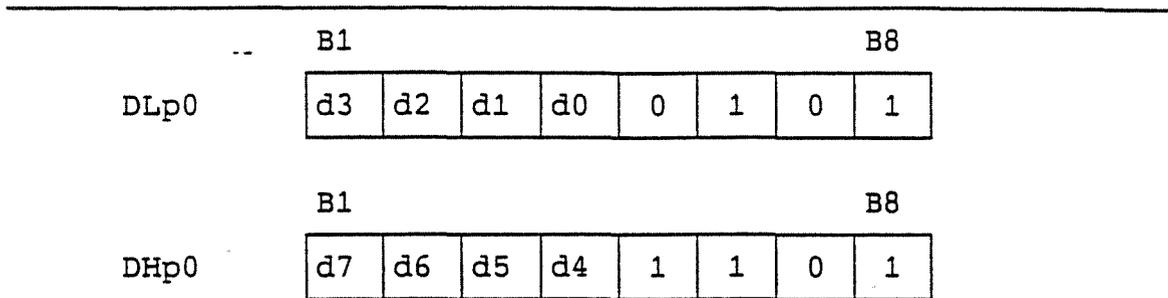
Figure 13.   Parameter 0 Data Format

The two bytes shall be alternately transmitted three times to allow for error correction at the receiving TE. The byte sequence is DLp0, DHp0, DLp0,DHp0, DLp0 and DHp0.

The receiving terminal equipment shall vote upon the repeated data using methods as described in section 5.8.6.

The parameter 0 message data bits shall have the following meanings:

<u>Data Bit</u>   <u>Description of Use</u>

d0 to d4   Reserved: Transmitted as zeros and ignored when received.

d5   Indicates how the TE is configured to interface to the user device.

            0: The sending TE is connected to a DTE (e.g. the user device is a terminal) with the TE acting as a DCE.

            1: The sending TE is connected to a DCE (e.g. the user device is a modem) with the TE acting as a DTE.

d6   Reserved: Transmitted as a zero and ignored when received.

d7   Indicates whether the user device at the sending end is synchronous or asynchronous.

0: Indicates asynchronous transmission.

1: Indicates synchronous transmission.

5.4.7 Parameter 1 Identifier and Message

The parameter 1 identifier signaling message, Sgp1, shall conform to the format shown in Figure 14.

	B1							B8
Sgp1	0	0	0	1	0	1	1	1

Figure 14. Parameter 1 Identifier Message

The Sgp1 signaling message is transmitted preceding the parameter 1 message. It shall be transmitted a minimum of sixteen times (recommended thirty two) prior to the parameter 1 message.

The parameter 1 message shall be encoded into two bytes as shown in Figure 15.

	B1							B8
DLp1	d3	d2	d1	d0	0	1	0	1

	B1							B8
DHp1	d7	d6	d5	d4	1	1	0	1

Figure 15. Parameter 1 Data Format

The two bytes shall be alternately transmitted three times. The required byte sequence is DLp1, DHp1, DLp1, DHp1, DLp1 and DHp1.

The receiving terminal equipment shall vote upon the repeated data using methods as described in section 5.8.6.

The data bits, d0 to d7, shall be interpreted differently depending on whether the sender is asynchronous or synchronous (i.e. d7 of parameter 0 is "0" or "1" respectively). If the sender is asynchronous, the bits in parameter 1 shall have the following meaning:

Data Bit   **Description of Use**

d0 to d3   Reserved: Transmitted as zeros and ignored when received.

d4   Indicates the TE generates a parity bit based on the received user data from the 64 kbit/s channel interface and adds the parity bit to the data word prior to sending it to the DTE/DCE interface. In addition, the TE removes the parity bit from the DTE/DCE interface prior to sending the data to the 64 kbit/s channel interface.

If parity is enabled, the parity is not transmitted from one TE to the other TE, and the type of parity used may vary at either end of the connection.

It is the goal of T-Link protocol to transfer data and parity transparently from the DTE/DCE through the TE and the network to the far end TE whenever such transferal is possible. See Appendix A for further information on the use of parity.

0: Indicates the TE shall not generate a parity bit, parity is disabled.

1: Indicates the TE shall generate a parity bit, parity is enabled.

d5   Indicates the type of parity if parity is enabled. If parity is disabled (d4=0) this bit shall be ignored on receipt.

0: Indicates even parity

1: Indicates odd parity

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d6   Indicates the mode of transmission (from the DTE).

0: Indicates half duplex

1: Indicates full duplex

Note that the actual connection between the TE remains full duplex in either case.

d7   Indicates the length of a data word. This choice may be subsequently overridden by bits d6 and d7 of parameter 3 if operation with 5 or 6 bit data words is desired. If parity is enabled (e.g. d4=1), the word length defined by this parameter shall not include the parity bit, since the parity bit is not transported over the 64 kbit/s channel.

O: Indicates a 7 bit word length.

1: Indicates a 8 bit word length.

If the sender is synchronous, the bits in parameter 1 shall have the following meaning:

Data Bit   Description of Use

d0 to d5   Reserved: Transmitted as zeros and ignored when received.

d6   Indicates the mode of transmission.

0: Half duplex

1: Full duplex

d7   Indicates the transmit data clocking source for the data from the user (DTE) to the TE(DCE) or from the TE (DTE) to the user (DCE) depending on the configuration used. The receiver data clock is always derived from the DCE.

0: The transmit clock is provided by the DTE.

1: The transit clock is provided by the DCE.

5.4.8 Parameter 2 Identifier and Message

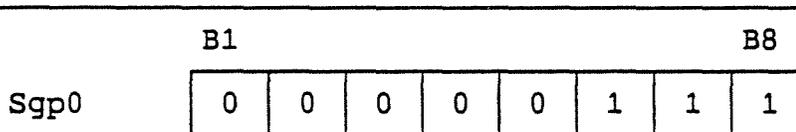The parameter 2 identifier signaling message, Sgp2, shall conform to the format shown in Figure 16.

B1   B8

Sgp2 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 |

Figure 16. Parameter 2 Identifier Message

The Sgp2 signaling message is transmitted preceding the parameter 2 message. It shall be transmitted a minimum of sixteen times (recommended thirty two) prior to the parameter 2 message.

The parameter 2 message shall be encoded into two bytes as shown in Figure 17.

B1   B8

DLp2 | d3 | d2 | d1 | d0 | 0 | 1 | 0 | 1 |

B1   B8

DHp2 | d7 | d6 | d5 | d4 | 1 | 1 | 0 | 1 |
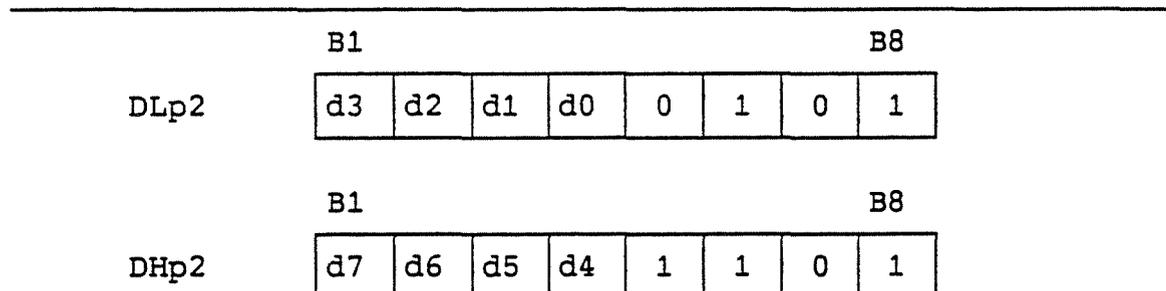
Figure 17. Parameter 2 Data Format

The two bytes shall be alternately transmitted three times. The required byte sequence is DLp2, DHp2, DLp2, DHp2, DLp2 and DHp2.

The receiving terminal equipment shall vote upon the repeated data using methods as described in section 5.8.6.

The data bits, d0 to d7, of parameter 2 with the exception of d4 shall have the same meaning for synchronous and

asynchronous transmission. The data bits in parameter 2 shall have the following meaning:

Data Bit   Description of Use

d0 to d3   Reserved: Transmitted as zeros and ignored when received.

d4   For Asynchronous operation (d7 of parameter 0 is "0") this indicates the number of stop bits. This choice can be overridden by bit d4 of parameter 3 to obtain 1.5 stop bits.

            0: 1 bit stop time

            1: 2 bit stop time

            For Synchronous operation (d7 of parameter 0 is "1") this bit shall be set to zero on transmission and shall be ignored when received.

d5   Echo Indication

            This bit shall indicate if the data transmitted over the 64 kbit/s channel from the DTE/DCE will be echoed back by an intermediate device (generally the TE) as well as being transmitted to the far end TE.

            O=Data will be echoed back by an intermediate device at the end sending this parameter.

            1=Data will NOT be echoed by an intermediate device at the end sending this parameter. If echoing is desired it must be done by other means.

d6   Auto Answer. This bit shall indicate if the sender is set up to auto-answer a modem when the TE is connected to an associated modem. This information is not used by T-Link protocol but may be passed to the user device (DCE) in a case where it is required for a specific application. If the TE is not connected to a modem (DCE) this bit should be set to zero.

            O=Manual assistance will be required to answer a call to a modem at the sender's end.

1=The modem at the sender's end is arranged for auto-answer.

d7   This bit shall be used to start and stop a loopback at the receiving end. The TE receiving this message shall continue the normal rate adaption procedures, but upon successful entry into the data mode, shall return the received data and Sd bytes without acting upon them.

Once the TE has been placed in the loopback state, it shall be required to set up a new call with this bit set to turn loopback Off during the parameter exchange with the following exception.

When the call restart request message is supported and the data rate selected allows for its use during the data mode, the TE may initiate call restart as the means of turning loopback Off.

If both TE at either end of a connection request for a far end loopback simultaneously during the parameter exchange it is recommended that the originating TE take precedence with it ignoring the received request and the answering TE being required to enter the loopback state.

0=turn loopback OFF

1=turn loopback ON

5.4.9 Parameter 3 Identifier and Message

The parameter 3 identifier signaling message, Sgp3, shall conform to the format shown in Figure 18.

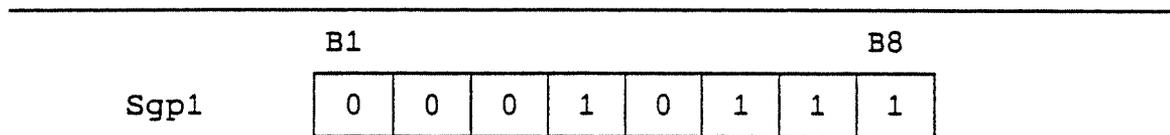|	B1							B8
Sgp3	0	0	1	1	0	1	1	1

Figure 18. Parameter 3 Identifier Message

The Sgp3 signaling message is transmitted preceding the parameter 3 message. It shall be transmitted a minimum of sixteen times (recommended thirty two) parameter 3 message.

The parameter 3 message shall be encoded into two bytes as shown in Figure 19.

DLp3
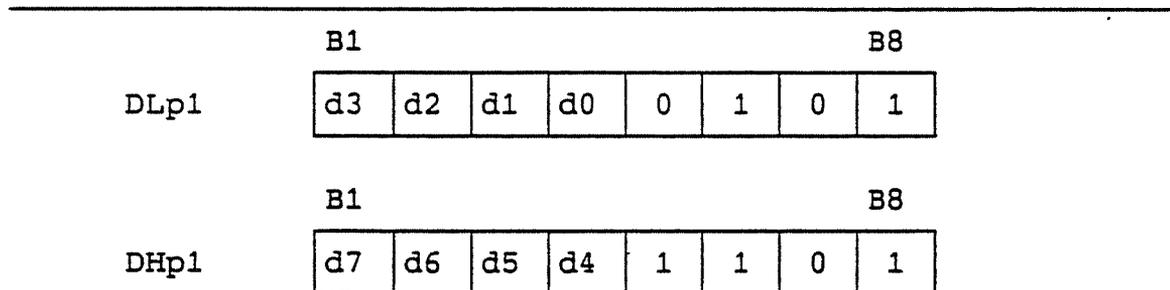| B1							B8
d3	d2	d1	d0	0	1	0	1

DHp3
B1							B8
d7	d6	d5	d4	1	1	0	1
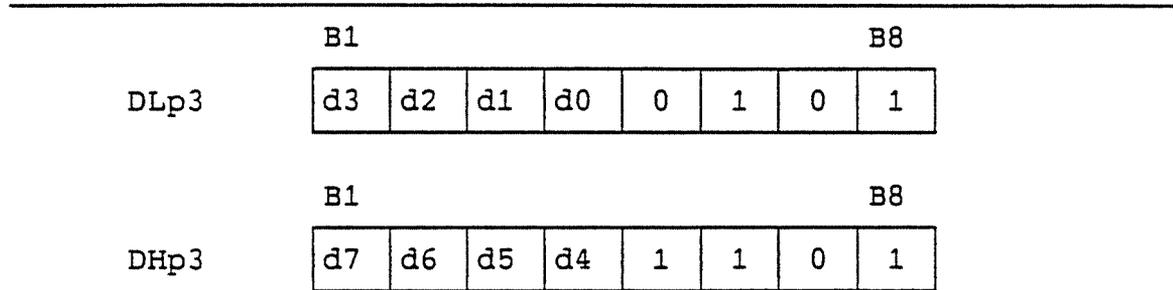
Figure 19. Parameter 3 Data Format

The two bytes shall be alternately transmitted three times. The required byte sequence is DLp3, DHp3, DLp3, DHp3, DLp3 and DHp3.

The receiving terminal equipment shall vote upon the repeated data using methods as described in section 5.8.6.

When the sending terminal equipment operates synchronously (bit d7 of parameter 0 is "1") the data bits d0 to d7 shall be set to zero on transmission and be ignored when received.

When the sending terminal equipment operates synchronously (bit d7 of parameter 1 is "0") the data bits d0 to d7 shall have the following meaning:

Data Bit.   Description of Use

d0 to d3   Reserved: Set to zero on transmission and shall be ignored on receipt.

d4   This indicates if 1.5 stops bits will be used for asynchronous data to and from the TE to the associated DTE/DCE at the sending end.

0=The number of stop bits specified by bit d4 of parameter 2 shall be used.

1=1.5 stop bits shall be used (overriding the selection as per d4 of parameter 2).

d5   Reserved: Transmit as zero and ignore when received.

d6 &d7   These two bits shall be used to define shorter data word lengths than was defined by bit d7 of parameter 1. As before, if parity generation is enabled (d4=1 in parameter 1) the length specified excludes parity bits. The following table indicates the possible settings.

d7	d6	Word Length
0	0	As per parameter 1
0	1	6 bit data word
1	0	5 bit data word
1	1	not a valid setting

If the two bits are received set to one this should be treated as a bad parameter exchange.

5.4.10 Parameter 4 Identifier and Message

The parameter 4 identifier signaling message, Sgp4, shall conform to the format shown in Figure 20.

B1   B8
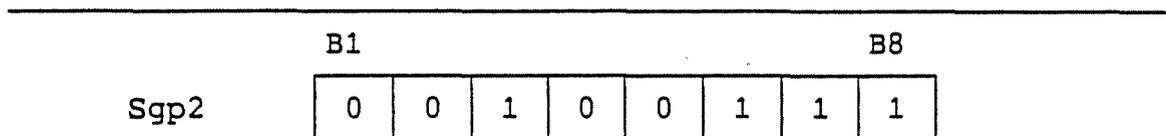
Sgp4 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 |
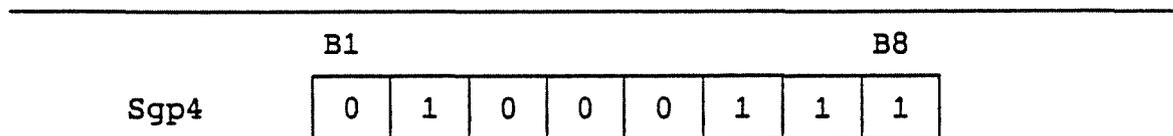
Figure 20. Parameter 4 Identifier Message

The Sgp4 signaling message is transmitted preceding the parameter 4 message. It shall be transmitted a minimum of sixteen times (recommended thirty two) prior to the parameter 4 message.

The parameter 4 message shall be encoded into two bytes as
shown in Figure 21.

	B1							B8
DLp4	d3	d2	d1	d0	0	1	0	1

	B1							B8
DHp4	d7	d6	d5	d4	1	1	0	1
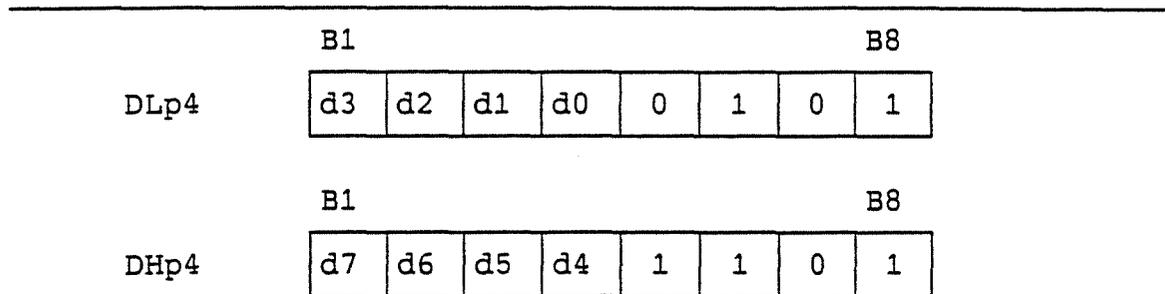
Figure 21.   Parameter 4 Data Format

The two bytes shall be alternately transmitted three times.
The required byte sequence is DLp4, DHp4, DLp4, DHp4, DLp4,
and DHp4.

The receiving terminal equipment shall vote upon the
repeated data using methods as described in section 5.8.6.

Parameter 4 message is used to define the data rate that is
requested by the sender for use between the TE and the
associated DTE/DCE.   The   interpretation   of   this message
shall depend on whether the sender requested asynchronous
(d7 of parameter 0 was a "0") or synchronous (d7 of
parameter 0 was a "1") operation.

The data bits d0 to d7 of parameter 4 shall have the
following meaning:

Data Bit   Description of Use

d0 to d3   Reserved: Transmitted as zeros and ignored when
           received.

d4 to d7   The setting of these bits shall define the data
           rate option that is selected as per Figure 22 .

d7	d6	d5	d4	Async. Data Rate (bit/s) Par.0 bit d7=0	Sync. Data Rate (bit/s) Par.0 bit d7=1
0	0	0	0	19200#	64000+
0	0	0	1	50	16000 •
0	0	1	0	75	32000 •
0	0	1	1	110	50000 ••
0	1	0	0	134.5	1200*
0	1	0	1	150	2400*
0	1	1	0	300#	3600
0	1	1	1	600	4800*
1	0	0	0	1200#	7200
1	0	0	1	1800	9600*
1	0	1	0	2000	14400
1	0	1	1	2400#	19200*
1	1	0	0	3600	38400
1	1	0	1	4800#	40800
1	1	1	0	7200	48000
1	1	1	1	9600#	56000*

• These codes are currently reserved for these rates if needed but may be subsequently changed if no implementation requires them.

•• Use of 50000 bit/s rate is for further study.
 * Recommended minimum set supported for general purpose use for synchronous data transfer.
 # Recommended minimum set supported for general purpose use for asynchronous data transfer.
 + Recommended when a clear channel is available.

Figure 22. Options For The User Data Rate

5.4.11 Secondary Signaling Identifier and Message

The use of the secondary signaling identifier and the associated message is defined as optional. It is

recommended that the use of this message be reserved for further study.

The secondary signaling identifier message, Sgss, shall conform to the format shown in Figure 23.

Sgss	B1							B8
	0	1	1	1	0	1	1	1

Figure 23. Secondary Signaling Identifier Message

The Sgss signaling message is transmitted preceding the secondary signaling message. It shall be transmitted a minimum of sixteen times (recommended thirty two) prior to the secondary signaling message.

The secondary signaling message shall be encoded into two bytes as shown in Figure 24.

DLss	B1							B8
	d3	d2	d1	d0	0	1	0	1

DHss	B1							B8
	d7	d6	d5	d4	1	1	0	1

Figure 24. Secondary Signaling Data Format

The two bytes shall be alternately transmitted three times. The required byte sequence is DLss, DHss, DLss, DHss, DLss and DHss. The receiving terminal equipment shall vote upon the repeated data using methods as described in section 5.8.6 .

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The secondary signaling message is provided as a means of supporting additional TE to DTE/DCE interface leads. If used it may be transmitted before parameter 0 or between parameter 0 and 1, 1 and 2, 2 and 3, 3 and 4, but not after parameter 4 during the parameter exchange.

The length of the required byte sequence to transmit this message means that it can only be sent during the data transfer mode when the data rate option selected by parameter 4 is 1200 bit/s or slower.

The functions of the secondary signaling message for bits d0 to d6 are as defined in Figure 25. Also shown in the figure is the direction of the signals. When the TE is connected to a DTE, the signals labelled "in " will be sent by the TE to the DTE based on the received parameter values from the far end TE. While the transmitted bit values (TE to TE) will reflect the levels of the signals received on the DTE leads labeled "out".

The reverse is true for a DCE. As a result, some of the bits may have no meaning on transmission since no corresponding input exists and others can be ignored on receipt since there is no output for that signal. If a secondary signaling line is not used the corresponding bit should be set in a neutral state.

Neutral is a state that will not interfere with the other signals and data and may be off for some leads (e.g. test mode) and on for others (e.g. secondary clear to send).

T-Link simply provides a means to transport the signals shown in Figure 25 end-to-end and any actions taken on receipt of these signals is implementation dependent. Specifically, the reaction to loopback and test signals may be to simply pass the signals to the user device or the TE may act on them in some way.

Signaling Bit	Name Of The Signal	RS232C Lead(1)	RS449 Lead(2)	CCITT Lead(3)
d0	Secondary Request to Send (Out)	SCA	SRS	120
d1	Secondary Clear to Send (In)	SCB	SCS	121
d2	Local Loopback(Out)	-	LL	141
d3	Remote Loopback (Out)	-	RL	140
d4	Test Mode (In)	-	TM	142
d5	Terminal In Service (Out)	-	IS	-
d6	Secondary Receive Ready (In)	SCF	SRR	122

Notes: 1. Dashes in the columns for RS232C and CCITT (V.24) leads indicates that the function is not defined for that interface.

2. A one value for a signaling lead shall represent the ON condition (active) and a zero shall represent the OFF condition (inactive).

3. Unused signals shall be set in the OFF condition (0).

4. The direction in brackets after the names of the signals indicates which way the signal flows relative to a DTE. The directions will be reversed for a DCE.

Figure 25. Secondary Signaling Bit Functions

d7-This bit is unused and shall be transmitted as zero and ignored on receipt.

5.5 CALL RESTART REQUEST MESSAGE

The capability of transmitting and responding to the reception of this message is defined as optional for T-Link protocol.

The call restart request shall be transmitted by the TE when it finds itself in a condition where it is impossible to continue with the call. Therefore many of the circumstances that would cause disconnect by external means for TE not providing this capability will initiate the transmission of this message when it is provided.

Some examples of such circumstances includes the failure of the received byte sequence to comply with the required rate parameter exchange procedures. Also the inability of the TE required to adapt to conform to the requested parameters can utilize this message.

Hence, this can be used to reverse the roles played by the TE (i.e. the TE that acts as originating=non-adaptive and the TE that acts as answering=adaptive) in an effort to resolve any incompatibilities. The number of attempts at parameter exchange with the roles being interchanged using the Sgr message is implementation dependent.

When the TE at both ends of a connection support this option the TE that restarted the call using the Sgr message is required to act as the non-adaptive TE (same as the originator during the first rate adaption sequence). The TE that responds to receiving Sgr messages with the protocol version signaling message acts as the adaptive TE (same as the answering TE during the first rate adaption sequence).

5.5.1 Message Format

The call restart request message shall conform to the format shown in Figure 26.

	B1							B8
Sgr	0	1	1	0	0	1	1	1
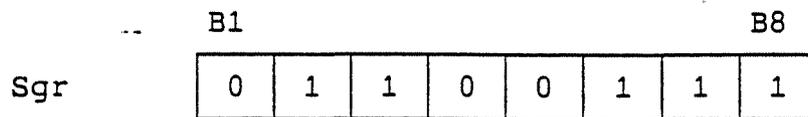
Figure 26.   Call Restart Request Message

The TE requesting call restart shall transmit the Sgr message continuously until the far end TE responds.

The required response, that indicates that the far end also supports call restarts, is the reception of a minimum of sixteen contiguous protocol version identifier signaling messages (Sgvi's).

Failure to receive the required response to the continuous transmission of the Sgr messages will require the user to initiate disconnect by external means.

5.5.2   Use During Parameter Exchange

It is recommended that the detection of four contiguous Sgr messages by the TE during the parameter exchange be accepted as a valid indication to restart the synchronization sequence. The TE receiving the Sgr messages shall then assume the role of the answering TE for the rate adaption handshake.

5.5.3   Use During The Data Transfer Phase

The use of this message once the data transfer phase has been entered is dependent on the data rate that was selected. For those data rates that require the use of the Sd bytes for time fill, the detection of the Sgr message is straightforward since the receiving TE can recognize the presence of Sgr messages as compared to the normal Sd bytes.

For the three synchronous data rates that do not allow any
time for the transmission of Sd bytes, it is recommended
that the Sgr message not be used during the data transfer
phase. This is because of the possibility of the received
data being falsely detected as a call restart request.

The one exception to this is where this protocol is used on
a dedicated connection and some means of altering the data
transfer parameters is required. Under these circumstances
a sufficiently robust test over an extended time interval is
required to ensure a valid call restart request is being
made.

5.5.4 Collisions

If a collision occurs, that is, the Sgr message is received
while it is being transmitted, the TE at either end shall
assume their initial roles (originating=non-adaptive,
answering=adaptive) as they were when the connection was
originally established. In this case the answering TE shall
stop transmitting Sgr messages and the originating TE shall
ignore received Sgr messages.

The answering TE shall then begin transmitting Sgvi messages
continuously to initiate the synchronization phase.

5.6 EIA/CCITT CONTROL LEAD SIGNALING MESSAGE

5.6.1 Sd Signaling Message

The EIA/CCITT control lead signaling message shall have the format as shown in Figure 27.

	B1							B8
Sd	s3	s2	s1	s0	BK	0	1	1
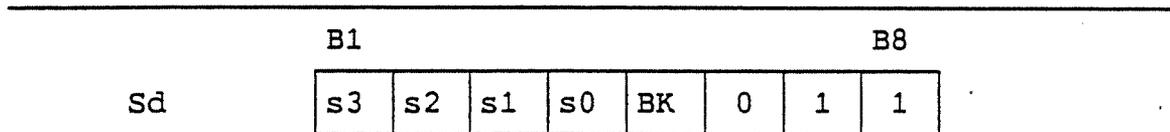
Figure 27.   Sd Signaling Message Format

The control lead signaling byte is used to convey EIA/CCITT control signals from the DTE/DCE to TE interface at one end of a connection to the DCE/DTE to TE interface at the opposite end of the 64 kbit/s channel connection.

This message is also used for time fill for some data rates that do not require the full 64 kbit/s channel capacity.

The Sd message is used by the TE at both ends to signal when the TE has completed the rate adaption parameter exchange procedure and is therefore ready to enter the data transfer stage.

Sd type signaling bytes contain the actual information that is being transported as opposed to signaling the meaning of the data that is to follow.

The Sd signaling message supports the major control leads required by RS-232C (EIA) or V.24 (CCITT).

The interpretation of the option bits in the Sd message (s0, s1, s2, s3 and BK) depends on whether the TE is connected to a DCE or a DTE. The function of these option bits is to take the levels on the EIA/CCITT control leads that are inputs to the TE from the DTE/DCE and transport these levels

to the other end of the 64 kbit/s channel where they are provided on corresponding EIA/CCITT outputs at the TE to DTE/DCE interface.

The implications of this are:

1) If one end of the connection terminates in a DCE and one end terminates in a DTE, the signaling bits will map inputs at one end to outputs on interface pins with the same name at the far end, for example connecting data set ready to data set ready and data terminal ready to data terminal ready (EIA pins CC and CD, CCITT pins 107 and 108/2).

2) If both ends terminate in a DCE or DTE the EIA/CCITT control leads monitored will be either an input or an output at both ends of the connection. In this case an output pin at one end is mapped to a different pin that is an output at the other end. For example, the data terminal ready input will control the data set ready output or vice versa with similar devices at both ends.

The specific applications of the option bits s0, s1, s2 and s3 are indicated in Figure 32 .

(a) DTE Sending (bits sent) or DCE Receiving (bits received)

Signaling Bit	Name Of The Signal	EIA Lead	CCITT Lead
s0	Request to Send (RTS)	CA(4)	105
s1	Speed Select (CH) to Send (In)	CH(23)	111
s2	Secondary Transmit Data (STD)	SBA(14)	118
s3	Data Terminal Ready (DTR)	CD(20)	108/2

(b) DCE Sending (bits sent) or DTE Receiving (bits received)

Signaling Bit	Name Of The Signal	EIA Lead	CCITT Lead
s0	Carrier Detect (CD)	CF(8)	109
s1	Clear To Send (CTS)	CB(5)	106
s2	Secondary Receive Data (SRD)	SBB(16)	119
s3	Data Set Ready (DSR)	CC(6)	107

Figure 28. The Use of The Bits In The Sd Byte

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Notes	Sd Bits Interpretation

1.   EIA leads correspond to the terminology of EIA standard RS-232C. The number in brackets is the pin number on a DB25 connector.

2.   CCITT leads correspond to the terminology of CCITT recommendation V.24.

3.   In cases where the bits are sent, the corresponding leads are inputs. In cases where bits are received, treat the leads as outputs.

4.   Carrier Detect is also referred to as Receive Line Signal Detect (RLSD).

5.   The speed select signal (CH) is used to signal the data rate between a DTE and a DCE and does not affect the rate at which the TE operates.

6.   A 1 value for a signaling bit represents the ON condition (active) and a 0 represents an OFF (inactive).

Among the leads transported by the Sd byte the carrier detect (CD), request to send (RTS), clear to send (CTS), data terminal ready (DTR) and data set ready (DSR) signals will be used by most DCE/DTE's and must be supported if RS-232C or V.24 type interfaces are used. The other signals, speed select, secondary transmit data and secondary receive data, may not be provided by all DCE/DTE's.

The setting of bit B5 in the Sd signaling message, designated as "BK", shall be used to indicate when the TE detects a break condition (a long continuous space condition) from an asynchronous DTE/DCE. The bit has no meaning for synchronous transmission and shall be set to the off state, zero, during a synchronous connection.

When the TE receives a break from the DTE/DCE, the TE shall set the BK bit in the Sd messages to one. The TE shall continue to transmit the Sd message with the BK bit set until the break condition is no longer received from the DTE/DCE. The BK bit shall then be reset to zero. The TE may optionally transmit one or more Null (all zero) characters during the period that the Sd messages with the BK bit set to one are being transmitted.

The TE receiving Sd bytes with the BK bit set to one shall transmit Break (Continuous space) to the associated DTE/DCE until the Sd byte is received with the BK bit reset to zero.

The TE receiving Sd bytes with the BK bit set shall ignore any associated received data.

The change in the status of any of the Sd message bits shall not be accepted as valid until a minimum of two consecutive Sd messages give the same indication. This is to reduce the risk of a bit error in an Sd byte causing an incorrect transition of the control leads.

5.6.2 Sdidle Message

The Sdidle message is transmitted to indicate that all the associated indicators are in their idle state and is as shown in Figure 29.

B1   B8

Sdidle | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
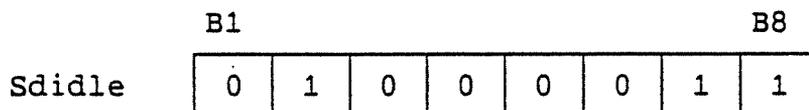
Figure 29. Sdidle Message

It is recommended that the Sdidle message be used for two purposes. The first use is as the time fill message for the TE that has transmitted all of its parameters and is waiting to receive the last parameter in the sequence to complete the parameter exchange. The second use is by the TE that assumes the role of the adaptive party (i.e. during the initial parameter exchange this is the answering TE). The Sdidle message in this case indicates the TE is still in the process of determining if it can conform to the received parameters. If the TE determines that it can adapt, then the Sd messages should reflect the actual status of the EIA/CCITT leads as they correspond to the Sd bits s0 to s3. The Sdidle messages as used in this case are Sd messages to

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indicate the TE is in a transition state between the parameter exchange phase and the the data transfer phase.

5.6.3 S2 Setting To Avoid Alarms

When the s2 bit of the Sd messages is not used to transmit secondary data it shall be set to one. This requirement is relevant to the use of T-Link protocol on T-1 (DS-1) facilities where B2 of each received byte being equal to zero for an extended period of time may result in a false yellow alarm.

5.6.4 Example of the Mapping of the Sd Bits

Examples of End-to-End Signaling Using
the Bits in Sd

a) Connection of Control Leads for DTE-DCE Signaling

DTE Control Leads	TE (values in Sd)	DCE Control Leads
RTS ---------------------->	s0	----------------------> RTS
CH ---------------------->	s1	--------------------> CH
TD ---------------------->	s2	--------------------> STD
DTR ---------------------->	s3	--------------------> DTR
(as Transmitted)		(as Received)
CD <----------------------	s0	<-------------------- CD
CTS <----------------------	s1	<-------------------- CTS
SRD <----------------------	s2	<-------------------- SRD
DSR <----------------------	s3	<-------------------- DSR
(as Received)		(as Transmitted)

b) Connection of Control Leads for DTE-DTE Signaling
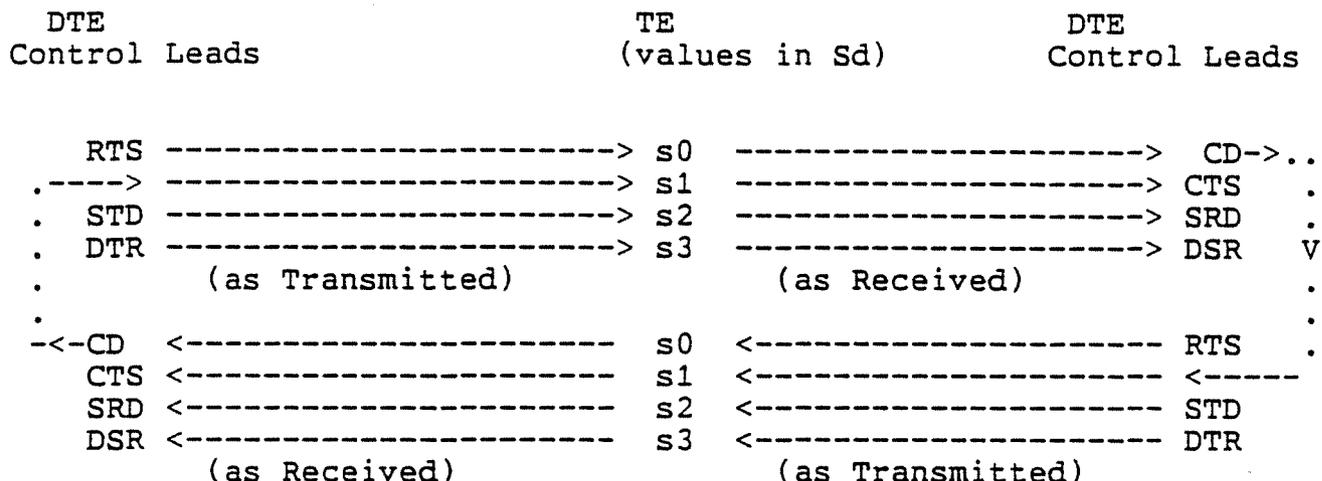
```
    DTE                             TE                    DTE
Control Leads                  (values in Sd)       Control Leads


    RTS ----------------------> s0 ----------------------> CD->..
 .----> ----------------------> s1 ----------------------> CTS   .
 . STD ----------------------> s2 ----------------------> SRD   .
 . DTR ----------------------> s3 ----------------------> DSR   V
 .           (as Transmitted)            (as Received)          .
 .                                                              .
-<-CD  <---------------------- s0 <--------------------- RTS   .
   CTS <---------------------- s1 <--------------------- <-----
   SRD <---------------------- s2 <--------------------- STD
   DSR <---------------------- s3 <--------------------- DTR
         (as Received)                 (as Transmitted)
```
The dotted line shows the looping of a received signal to
create a transmitted signal. This should be done within the
TE. In half duplex applications a delay may be inserted
between transitions on the received s0 and the transmitted
s1 to provide an RTS-CTS delay if needed by the DTE or DCE.

5.7 DATA TRANSFER BYTE FORMATS

The following section defines the various byte formats that
are used to transmit and receive the actual data that is
transported over a 64 kbit/s channel using T-Link rate
adaption protocol.

The set of data transfer byte formats that are defined in
this section includes both Version 1 and Version 2 of T-Link
protocol. The TE must indicate if it supports one or more
of the byte formats defined for data transfer by the
transmission of its protocol version identifier with bit d0
set to 1 if the formats are for version 1 and with bit d1
set to 1 if the formats are for version 2 of T-Link protocol
(see Section 5.4.3 for further details).

When the complete set of byte formats for version 2 are
implemented , it is recommended that version 1 byte formats
also be supported. This will only require the support of
one additional byte format and that is the Ds7 byte format
for version 1. This will ensure that the T-Link

implementation will interwork with other existing
implementations that use version 1 of the protocol.

The byte formats defined below determine the mapping of the
data bits (d0 to d7) to and from the DTE/DCE into the 64
kbit/s channel bytes (B1 to B8). These are the formats used
by T-Link protocol during the data transfer phase of a
connection.

As indicated in the diagram in section 2, Architecture, the
user is provided with a transparent service using this
protocol. This allows the transfer of any higher level
protocol at the user data rate established during the
parameter exchange procedure.

5.7.1 64 kbit/s Synchronous Data

```
         B1                               B8
Ds8      ┌────┬────┬────┬────┬────┬────┬────┬────┐
         │ d0 │ d1 │ d2 │ d3 │ d4 │ d5 │ d6 │ d7 │ Version 2
         └────┴────┴────┴────┴────┴────┴────┴────┘
```
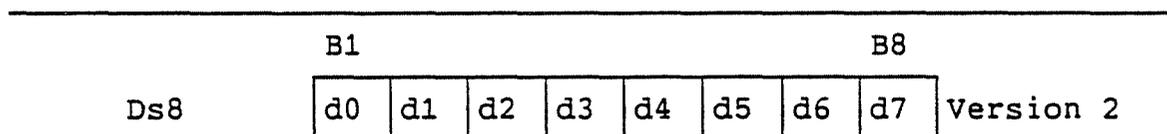
Figure 30. Ds8 Synchronous Data Format

When the rate adaption parameter exchange indicates that 64
kbit/s synchronous data rate is required, the format
specified in Figure 30 shall be used. This byte format
applies to version 2 of T-Link protocol.

5.7.2 56 kbit/s Synchronous Data

```
          B1                              B8
Ds7     | d0 | d1 | d2 | d3 | d4 | d5 | d6 | 1 |      Version 2


          B1                              B8
Ds7     | d6 | d5 | d4 | d3 | d2 | d1 | d0 | 1 |      Version 1
```
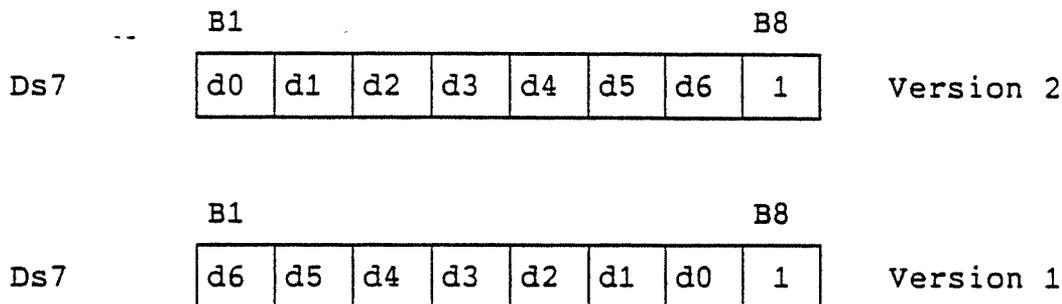
Figure 31. Ds7 Synchronous Data Format

When the rate adaption parameter exchange indicates that 56
kbit/s synchronous data rate is required, the formats
specified in Figure 31 shall be used during the data
transfer phase. B8 shall be transmitted as "1" and be
ignored when received.The byte format selected is dependent
on the protocol version agreed to during the protocol
version exchange (see section 5.4.3.)

5.7.3 48 kbit/s or Lower Synchronous Data

```
          B1                              B8
Ds6     | d5 | d4 | d3 | d2 | d1 | d0 | 0 | 1 |      Versions 1 & 2
```
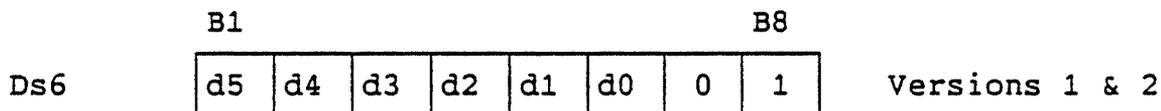
Figure 32. Ds6 Synchronous Data Format

When the rate adaption parameter exchange indicates that 48
kbit/s or lower synchronous data rate is required, the
format specified above shall be used during the data
transfer phase.This format applies to both versions 1 and 2
of T-Link protocol.

5.7.4 Asynchronous Data Format

The asynchronous data words for version 1 or version 2 of T-Link protocol shall be transmitted and received as a two byte pair over the 64 kbit/s channel. The DL byte shall have the four least significant bits of the data word encoded and shall be transmitted first. The format for this byte is shown in Figure 33.

	B1							B8	
DL	d3	d2	d1	d0	0	1	0	1	Version 1 & 2
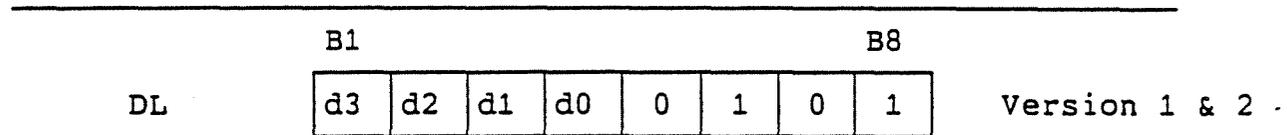
Figure 33. Low Order Nibble-Data Format

The DH byte shall be transmitted following the DL byte and shall conform to the format shown in Figure 34.

	B1							B8	
DH	d7	d6	d5	d4	1	1	0	1	Version 1 & 2
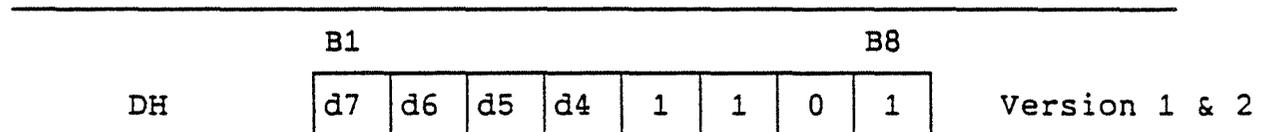
Figure 34. High Order Nibble-Data Format

When the asynchronous word length is less than eight bits, the unused bit positions should be set to zero for transmission and ignored when received. B7 for these two bytes is set to zero to indicate they are data bytes rather than signaling bytes. B5 and B6 are set to zero and one respectively to indicate the "DL" byte contains the lower order nibble. B5 and B6 are set to one to indicate the "DH" byte contains the high order nibble.

5.8 DATA MODE BYTE SEQUENCES

5.8.1 General

The data mode byte sequences assume that the parameter exchange between the TE at either end of a connection is successful and therefore compatible data transfer parameters have been agreed upon.

The specific byte sequences on the 64 kbit/s channel during the data mode will be determined by the selected synchronous or asynchronous data rate adapted to by the answering TE.

In general terms the data rates and the associated required byte sequences can be divided into three categories.

The data rates that require the exclusive use of the channel for data transfer is the first category. This includes synchronous data rates of 64 kbit/s, 56 kbit/s and 48 kbit/s.

The data rates that do not require the full capacity of the channel but are too fast to allow data byte repetition for error detection and correction is the second category. This includes asynchronous data rates from 14400 to 40800 bit/s.

The data rates that are slow enough to allow multiple transmissions of the same data byte is the third category. This applies to all synchronous and asynchronous data rates of 9600 bit/s or lower.

5.8.2 Synchronous Data-64 kbit/s, 56 kbit/s, 48 kbit/s

For these three synchronous data rates there is no spare time to transmit signaling bytes. Also in the case of 64 kbit/s and 56 kbit/s data rates, the use of the bit position, B7, for user data does not permit the recognition of Sd or Sg type signaling bytes. Therefore once the data mode is entered for those two data rates signaling bytes cannot be transmitted. For the data rate of 64 kbit/s the byte sequence transmitted and received is as shown below.

0 Time

|------>

../Ds8/Ds8/Ds8/Ds8/Ds8/Ds8/Ds8/Ds8/Ds8/.....

For 56 kbit/s it is as follows:

..Ds7/Ds7/Ds7/Ds7/Ds7/Ds7/Ds7/Ds7/Ds7/.....

For 48 kbit/s it is as follows:

.../Ds6/Ds6/Ds6/Ds6/Ds6/Ds6/Ds6/Ds6/Ds6/Ds6/.....

5.8.3 Synchronous Data (14400 to 40800 bit/s)

For a synchronous data rate that is higher than 9600 bit/s but less than 48000 bit/s the Ds6 byte format shall be used with the Sd signaling bytes used for timing pads and as conveyors of EIA/CCITT interface signaling information. The data shall NOT be repeated.

The synchronous data rates in this category are 40800 bit/s, 38400 bit/s, 19200 bit/s and 14400 bit/s.

The synchronous bit stream from the DTE/DCE to the TE is arbitrarily split into six bit blocks that are encoded into the Ds6 byte format and the process is reversed in the receive direction.

The number of times the Sd signaling bytes are repeated depends upon the transmission rate. The specific number of Sd signaling bytes between the data bytes in Ds6 format is not fixed for any of these data rates. As the synchronous data rate used increases the number of Sd bytes decreases.

The following is an example of the byte sequence for a synchronous data rate of 19200 bit/s as sent on the 64 kbit/s channel.

0 Time

|------>

../Ds6/Sd/Ds6/Sd/Sd/Ds6/Sd/Ds6/Sd/Sd/.....

5.8.4 Synchronous Data (9600 bit/s or less)

For a synchronous data rate that is 9600 bit/s or lower the Ds6 byte format shall be used with each Ds6 byte of encoded data repeated four times. The Sd signaling byte shall be used for timing pads on the 64 kbit/s channel until the next encoded Ds6 byte is ready for transmission.

The synchronous data rates in this category are 9600 bit/s, 7200 bit/s, 4800 bit/s, 3600 bit/s, 2400 bit/s and 1200 bit/s.

The number of Sd signaling bytes between the blocks of four Ds6 data format bytes is NOT fixed for any of the data rates. This makes the protocol suitable for both synchronous and "nearly-synchronous" data.

Some examples of the possible byte sequences on the 64 kbit/s channel are shown below.

For a synchronous data rate of 2400 bit/s.

0 Time

|------>

../Ds6/Ds6/Ds6/Ds6/Sdx16..../Ds6/Ds6/Ds6/Ds6/Sdx16/...

For a synchronous data rate of 4800 bit/s

0 Time

|------>

../Ds6/Ds6/Ds6/Ds6/Sdx6.../Ds6/Ds6/Ds6/Ds6/Sdx6/...

For a synchronous data rate of 9600 bit/s

0 Time

|------>

.../Ds6/Ds6/Ds6/Ds6/Sd/Ds6/Ds6/Ds6/Ds6/Sd/...

The TE receiving shall compare each of the four received Ds6 bytes in a group to one another and determine the correct data bits by a voting process. If no two Ds6 bytes agree

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an arbitrary choice shall be used such as accepting the last Ds6 byte as the valid data.

5.8.5 Asynchronous Data Over 9600 bit/s

For asynchronous data rates over 9600 bit/s the data shall be transmitted in the two byte format of DL followed by DH and only transmitted once. The required time pads shall be provided using Sd type signaling bytes.

For the one asynchronous data rate that falls into this category 19200 bit/s, the DL and DH bytes shall be followed by at least two Sd signaling bytes as shown below.

0 Time

|------->

../DL/DH/Sd/Sd/

5.8.6 Asynchronous Data-9600 bit/s or Less

For an asynchronous data rate of 9600 bit/s or less the data shall be transmitted in the two byte format of a DL and DH pair repeated three times. The Sd byte format shall be used for the required time pads and as a conveyor of EIA/CCITT interface lead status over the 64 kbit/s channel. Each group of three DL/DH pairs shall be framed by a minimum of two Sd signaling bytes preceding the group as illustrated below.

0 Time

|----->

.../Sd/Sd/DL/DH/DL/DH/DL/DH/Sd/Sd/DL/DH/DL/DH/DL/DH/...

The TE receiving the byte sequence shall compare the three copies of the received DL byte and the three copies of the DH byte and determine the correct data by a majority voting scheme (eg. bit by bit or byte by byte). Where there is no majority agreement the last DL or DH byte or some other

arbitrary choice shall be used to recreate the data word
that is passed on to the DTE/DCE interface.

5.9 TRANSITION TO THE DATA TRANSFER MODE

5.9.1 High Speed Synchronous Data Rates

The transition to the data transfer mode for the three high
speed synchronous data rates of 48 kbit/s, 56 kbit/s, and 64
kbit/s is unique because during the actual transfer of data
Sd messages cannot be used.

Hence the following procedures are only applicable when the
parameter exchange by the TE acting as the originator
requests one of the above three synchronous data rates.

```
                           ┌─────────────────┐
                           │ TRANSMIT    │1│ │
                           │ PARAMETERS      │
                           │ 0   TO   4      │
                           └─────────────────┘
                                    │
         ┌──────────────────────────┤
         │                          ▼
  ┌──────────────┐    NO      ╱  HAS   ╲
  │ TRANSMIT │2│ │◄──────────╱ PARAMETER 4╲
  │ "SDIDLE"     │           ╲ BEEN  RX? ╱
  └──────────────┘            ╲         ╱
                                  │ YES
                                  ▼
                              ╱  IS  TE ╲
  AS ORIGINATING             ╱ ACTING AS ╲   AS ANSWERING
     PARTY                   ╲ ORIG. OR ANS╱     PARTY
  (NON-ADAPTIVE ROLE)         ╲ PARTY? ╱   (ADAPTIVE ROLE) ┌──────────────┐
                                  │                        │ CONTINUE │3│ │
                                  │                        │ TO  TRANSMIT │
                                  │                        │ "SDIDLE"     │
                                  │                        └──────────────┘
                                  │                               │
                                  │                               ▼
                                  │                        ┌──────────────┐
                                  │                        │ CHECK RX │4│ │
                                  │                        │ PARAMETERS   │
                                  │                        │ FOR   MATCH  │
                                  │                        └──────────────┘
                                  │                               │
                                  │              YES              ▼
                                  │◄──────────────────────╱  CAN      ╲
                                  │                       ╱ CONFORM TO RX╲
                                  ▼                       ╲ PARMETERS? ╱
  ┌──────────────┐                                         ╲         ╱
  │ SEND   BYTE│5││                                            │ NO
  │ FORMAT       │                                            ▼
  │ OTHER  THAN  │                          ╱ IS IT ╲
  │ SDIDLE  OR SGR│     NO                  ╲  SGR? ╱
  └──────────────┘                           YES
       ╱ ARE  ╲    YES
      ╱ RX BYTES╲──────►
      ╲ SDIDLE OR╱
       ╲ SGR? ╱
         │ NO
         ▼
```



```
  ┌──────────────┐   ┌──────────────┐   ┌──────────────┐   ┌──────────────┐
  │ ENTER    │6│ │   │ TX   SGVI'S│7│   │ TX   SGR'S│9│ │   │ INITIATE │8│ │
  │ DATA TRANSFER│   │ & RESTART    │   │ &  WAIT  TO  │   │ DISCONNECT BY│
  │ PHASE        │   │ SYNC. AS ANS.│   │ RX   SGVI'S  │   │ EXTERNAL MEANS│
  │ (DISABLE SGR │   │ PARTY        │   └──────────────┘   └──────────────┘
  │  DETECTION)  │   └──────────────┘
  └──────────────┘
```

Figure 35. Transition to Data Transfer for High Speed
Synchronous Rates

It is recommended, as illustrated in Figure 35, that the end that completes transmitting all of the parameters 0 to 4 first shall transmit the Sdidle message as time fill until it has received the last parameter data.

As shown in the flow chart, if the TE is acting as the originating party, it is recommended that it enter a pseudo data mode and transmit some byte format other than Sdidle or Sgr. The originating TE while in this state is still not connected through to the DTE/DCE.

While in the pseudo data mode the originating TE monitors the received bytes to establish the status of the answering TE. As long as the received bytes are Sdidle, the originating TE shall remain in the psuedo data mode.

If the received messages are Sgr messages and these are supported by the originating TE, this shall initiate the TE acting as the originator to assume the role of the answering TE and to start transmitting Sgvi messages to re-initiate the synchronization phase of the handshake.

If the originating TE does not support the call restart capability, the Sgr messages will be ignored and data mode will be entered.

If the TE is acting as the answering party, the recommended sequence of events after parameter 4 has been received and transmitted is as shown in Figure 35.

It is recommended that the answering TE continue to transmit Sdidle messages while it determines if it is capable of operating as per the received parameters from the originating TE.

If the answering TE can conform to the received parameters then it shall transmit a byte format other than Sgidle or Sgr to indicate it is transferring to the data transfer state.

Transition to the actual transfer of data by the DTE/DCE beyond this stage will require the use of a higher level protocol (eg. transmission of an all ones byte pattern until the DTE/DCE is prepared to begin true data transfer).

If the answering TE cannot conform to the received parameters the TE shall either initiate disconnect by

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external means if restarts are not supported or if restarts are supported the TE may transmit Sgr messages as a signal to the far end to restart the handshake with the TE at either end assuming reverse roles relative to the originating and answering TE functions.

Once the data transfer state is entered it is recommended that the call restart capability if supported, be disabled. This is to prevent false restarts.
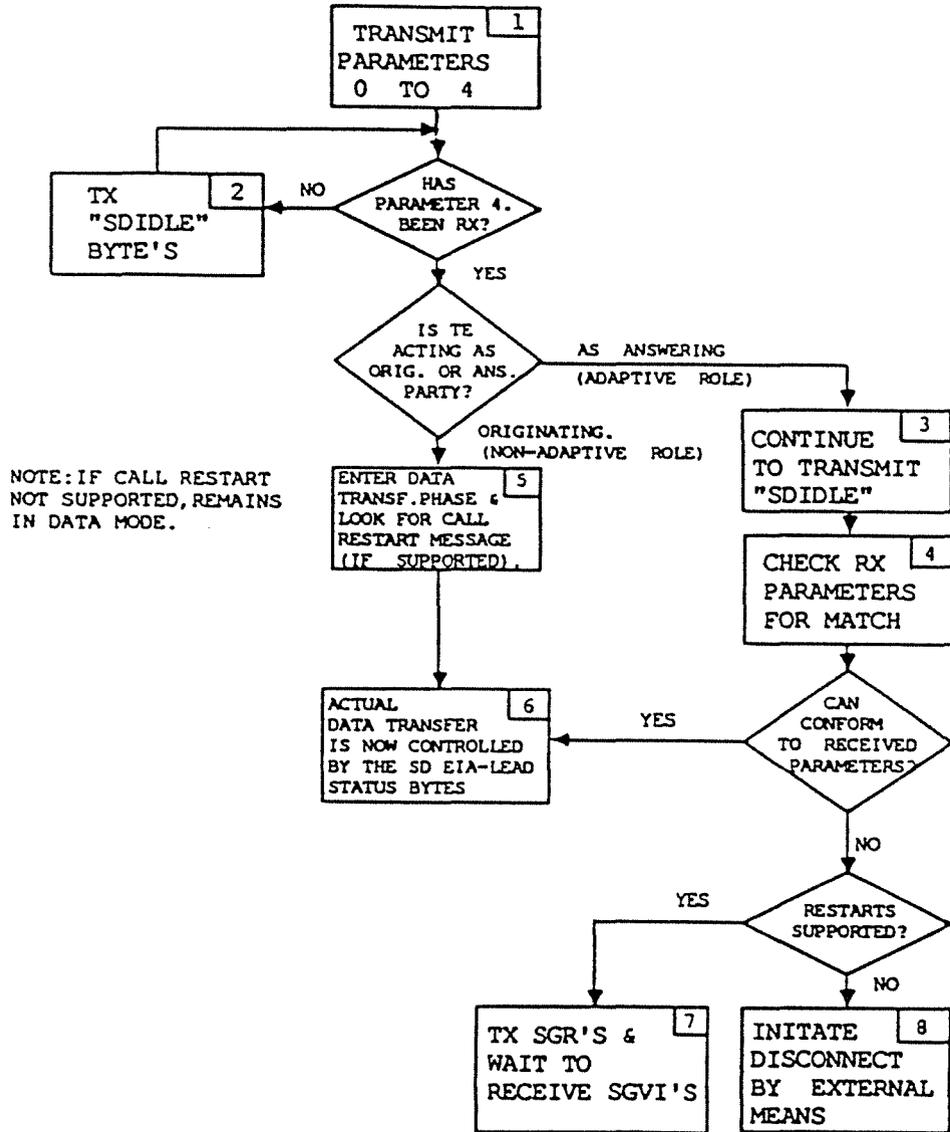
Figure 36. Data Rates That Use Sd Bytes For Time Fill

5.9.2 All Other Data Rates

It is recommended that for the data rates that require the use of the EIA/CCITT lead signaling messages (Sd) for time fill in the data transfer mode, the entry into the data transfer mode be implemented as illustrated in Figure 36.

As was the case for the high speed synchronous data rates, it is recommended that the end that completes transmission of all the parameters first use the Sdidle message as time fill as indicated in Figure 36.

The next step in the sequence of events is dependent upon the role being assumed by the TE. If the TE is acting as the originating party (non-adaptive), it is recommended that it enter the data mode and monitor the received bytes for call restart requests (Sgr) if they are supported by the TE.

If the TE is assuming the role of the answering party (adaptive role), it is recommended the TE continue to transmit the Sdidle message while it compares the received parameters to see if they match its parameters or can be adapted to.

If the answering TE can conform to the requested parameters, then the actual transition to the transfer of data will be controlled by the status of the various EIA/CCITT leads (the SD bytes) received at either end.

When the answering TE cannot conform to the received parameters, there are one or two alternatives that may be selected. The first applies if the T-Link protocol implementation does not support call restart requests. In this case the TE shall initiate disconnect by means external to T-Link protocol. The second alternative applies if the answering TE supports call restart (Sgr) messages. In this case the TE transmits the Sgr message continuously and awaits to receive Sgvi messages as an indication the handshake is going to be repeated with the roles of the TE as adaptive and non-adaptive at either end being reversed.Failure to receive the required response to the transmission of the Sgr message will require the user to initiate disconnect by external means.

5.10 NETWORK SIGNALING FORMATS

	B1							B8
Sgidle	0	1	1	1	1	1	1	1
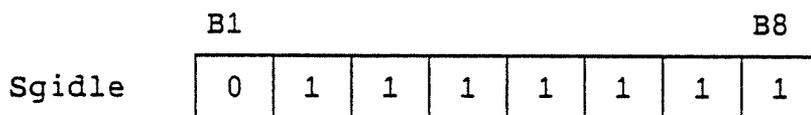
Figure 37. Idle Signaling Message

	B1							B8
Sgdis	1	1	1	1	1	1	1	1
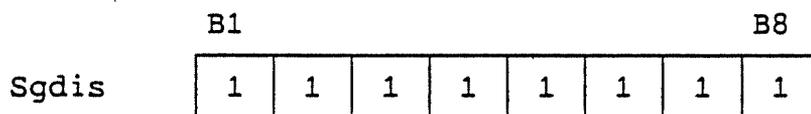
Figure 38. Channel Disabled Signaling Message

These two bytes may be used in the network to signal the status of a channel when it is not in use by T-Link. As such, these bytes will not be sent by T-Link but may be received during the periods before the connection is established and after it is cleared. The Sgidle byte may be sent by the TE when it is connected to the 64 kbit/s channel but, for some reason, is not ready to start T-Link synchronization. Because they are used during call setup on a restricted 64 kbit/s channel, B8 may be overwritten with a 0 or 1 in the channel for signaling purposes external to T-Link (e.g. dialing information and call supervision).

Another network signaling byte that may be encountered between T-Link calls is the data channel idle byte:

	B1						B8	
Didle	0	0	0	0	0	0	1	0
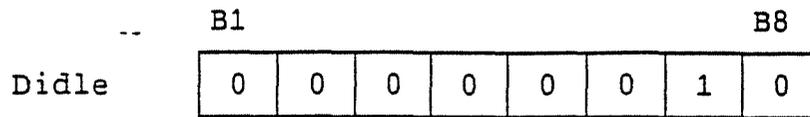
Figure 39. Data Channel Idle Message

This is an all zero (null) byte acted on by zero code suppression. Null bytes are briefly sent by some equipment between connection establishment and the start of T-Link synchronization. As was the case for the other bytes, bit B8 may be overwritten in the channel making it a 1 on a restricted 64 kbit/s channel.

APPENDIX A.

A.1 TRANSMISSION OF PARITY

The DTE/DCE may be arranged to transfer characters in the form of eight data bits plus parity, eight data bits with no parity, seven data bits with parity, or other arrangements that are listed in the first column of the table below.

The terminal equipment (TE) may or may not include switches which determine a relationship between the number of bits received from the DTE/DCE and the number of bits transferred towards the network. It is a goal of T-Link protocol to transfer data and parity transparently from the DTE/DCE through the TE and the network to the far end TE whenever such transferal is possible. For TE equipped with character length selection switches, the settings necessary to achieve transparent transfer of data and parity are shown in the second column of the table below.

The data and parity transferred over the 64 kbit channel is shown in the third column of the table below. The bits marked "X" are either 0 or 1 depending upon the data being sent. The bits marked "P" are parity bits calculated by the DTE/DCE. The bits marked "•" are "don't care" bits, i.e. they are ignored by the receiving TE.

A.2 AN EXAMPLE OF PARITY TRANSFER

To illustrate one specific application of the transfer of parity , the situation where one end of a connection is to a DTE and the other is to a host computer is assumed.

In such a case the typical asynchronous or synchronous multiplexers for connecting RS-232 lines to a host computer present data right aligned, filling unused bit positions with zeros. Parity bits are not usually presented to the host computer software in the data field, but rather are checked for correctness and the correct/incorrect indication is given in a Parity Error Flag located in a program-addressable register. Presuming that a host computer interface using T-Link protocol would be designed

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to emulate a standard multiplexer, the "received data" registers of the TE multiplex interface at the host computer would be identical to the right-most column of the table below.

DTE Data Format	TE Set.	Character Transferred By T-Link d7 ... d0								Character Presented To Host d7 ... d0								
8+P	8 no P	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
										See Note 1								
8 no P	8 no P	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
7+P	8 no P	P	X	X	X	X	X	X	X	0	X	X	X	X	X	X	X	PEF
										See Note 2								
7 no P	8 no P	•	X	X	X	X	X	X	X	0	X	X	X	X	X	X	X	
6+P	7 no P	•	P	X	X	X	X	X	X	0	0	X	X	X	X	X	X	PEF
6 no P	6 no P	•	•	X	X	X	X	X	X	0	0	X	X	X	X	X	X	
5+P	6 no P	•	•	P	X	X	X	X	X	0	0	0	X	X	X	X	X	PEF
5 no P	5 no P	•	•	•	X	X	X	X	X	0	0	0	X	X	X	X	X	

Figure 40.   Parity As Tansferred By T-Link

Note 1: Parity operation with eight data bits is not supported for T-Link protocol. The eight data bits are passed, but no parity information is passed.

Note 2: The abbreviation PEF refers to the Parity Error Flag. Parity is calculated on the character received over the 64 kbit/s channel via T-Link protocol (third column in the , table) according to the odd/even selection loaded into the host TE interface by the host software. If the character received has improper parity, the PEF is set.

The host computer interface should base its character length and parity operation on the commands of the host software, as these will match the DTE/DCE data format, in a fashion identical to conventional multiplexers. However, the information passed during the exchange of parameter messages should correspond to the appropriate entries in the "TE Set." column so that the call will not be abandoned due to a mismatch of parameter messages.

The T-Link protocol can map software requested settings (first column) into TE settings (second column) via this table.

Appendix B

Datapath
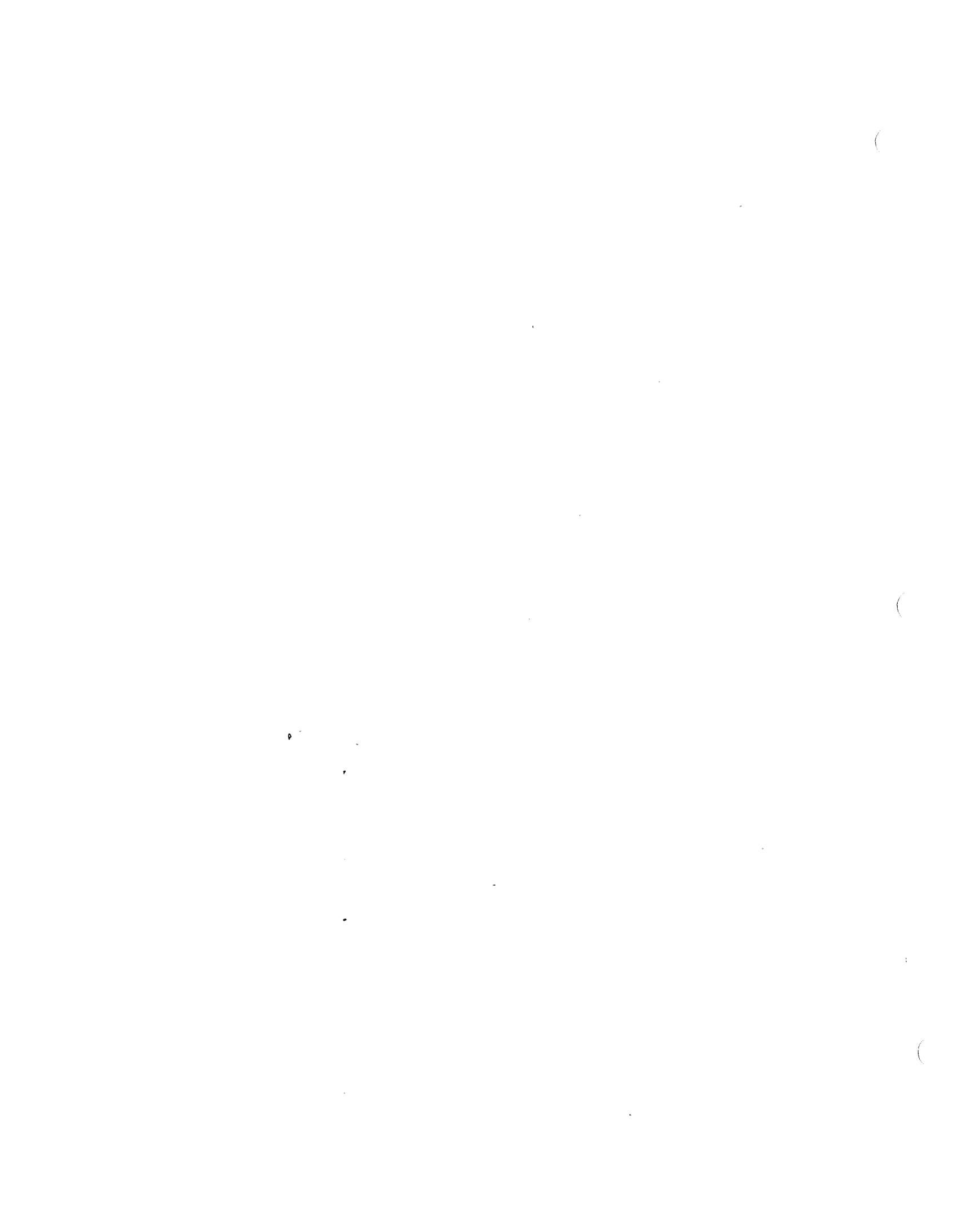
Call Set-Up

Sequences

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Appendix B

1.0 INTRODUCTION

Datapath service, when the TE implements T-Link protocol, is capable of providing compatibility with DTE operating at various asynchronous and synchronous data rates.

Northern Telecom's high speed version of the Data Unit will also function with other implementations of the generic service offering Public Switched Digital Service (PSDS) that provides 56 kbit/s full duplex synchronous data service.

Section 2 of this appendix describes the programmable timers that the DMS machine uses for each Datapath call originated or answered.

Section 3 describes the interaction between the DMS machine and the TE on both the inband and out of band channels under various hypothetical calling conditions.
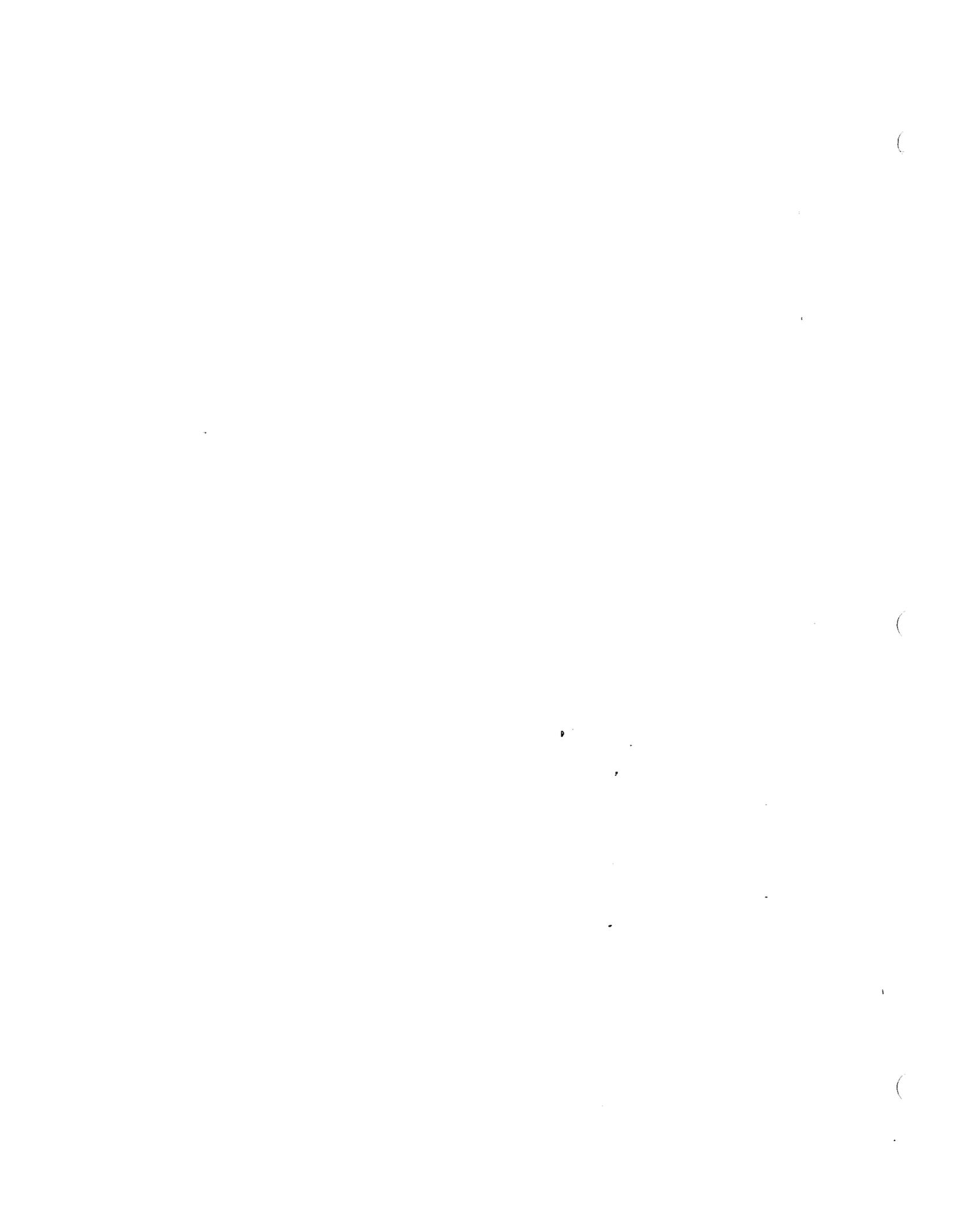
2.0 DMS MACHINE TIMERS

2.1 TIMER TA

TA is a programmable DMS machine timer that is initialized when the Datapath subscriber is receiving an incoming call. It starts running when the off-hook indication is received from the TE over the out of band signal channel. When the timer runs out, the "Data Alert-On" command is sent to the TE, thereby enabling the TE to TE data connection. This is presently programed to conform with the FCC Part 68 requirement for a minimum of 2 seconds between the CO receiving answer supervision and the end to end connection being allowed to be cut through.

2.2 RATE ADAPTION TIMERS

The following timers and the associated link level commands are only relevant to TE that is arranged for 56 kbit/s synchronous data rate operation. The use of these timers provides TE that has implemented T-Link rate adaption protocol with a means of defaulting to Public Switched Digital Service (PSDS) if the TE on the other end of the connection does not support T-Link rate adaption protocol.

Timers TB, TC and TD are CO parameters that can be set for values of 0 to 10 seconds in 1 second increments.

2.2.1 Timer TB

Timer TB is associated with an incoming call on a DMS machine to a Datapath subscriber.

The timer is initialized when the timer TA has timed out. The value it is set for determines how long the DMS machine will wait to receive the out of band signal, Sgvi Found, as an indication that T-Link rate adaption has begun. If the CO receives the Sgvi Found command prior to TB timing out the timer will be reset and the timer TC will be initialized.

If however, the TB timer times out, the command Inband Sync Timeout is sent to the TE.

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2.2.2 Timer TC

Timer TC is only initiated if timers TB or TD do not time out. Timer TC is used to control the length of time the DMS machine permits the end-to-end rate adaption process to be completed in.

If timer TC is still running when the DMS machine receives the out of band command, Inband Sync Found, then the timer is reset. However, if the timer runs out before the Inband Sync Found command is received the CO assumes the originating or answering TE does not support T-Link rate adaption and the out of band command, Inband Sync Timeout, is sent to the TE.

2.2.3 Timer TD

Timer TD is associated with a Datapath subscriber that is originating a call. This timer is initialized when the CO that the answering TE is connected to indicates that the called party has answered (i.e. answer supervision is returned to the originating CO). This timer determines the length of time the originating TE is allowed to detect the beginning of the T-Link handshake. If the out of band Sgvi Found command is received prior to this timer timing out then the timer is reset and timer TC is initialized.

If timer TD times out, then the DMS machine sends the out of band command, Inband Sync Timeout, to the originating TE. The value of the timer TD will be equal to the sum of TA plus TB.

2.2.4 Hypothetical Timer Values

The following values of the various timers are shown here to illustrate the possible settings a particular BOC could use. The specific values used by any operating company are beyond the scope of this description.

TA = 2 seconds

TB = 2 seconds

TC = 7 seconds

TD = 4 seconds

3.0 DATAPATH CALL SEQUENCE CHARTS

3.1 INTRODUCTION

The sequence charts are designed to indicate the status of the 64 kbit/s inband channel and the 8 kbit/s out of band channel in both the receive (Rx) and transmit (Tx) directions at the Network Interface (NI). Arrows are used to indicate if the signals are transmitted or received on both channels. The numbers in square brackets " [ ] " , associated with the events are used to indicate the relative order of events. The signals that are passed on an end to end basis are shown as such by the event number in brackets appearing as a transmitted signal at one end and as the same event number received at the other end. Also during call set-up when for example the called party has ringing applied and ring back tone is applied towards the originating end the same sequence number is used to indicate the events are occurring simultaneously.

In the sequence charts only a sub-set of the actual signals are shown in order to reduce the charts complexity. For example when the DN key command is transmitted by the TE there are several messages returned by the CO such as the one to turn on the associated DN indicator.

3.2 SEQUENCE CHART 1

Event No. Description of The Event

1   With the inband channel in the idle state the Sgidle byte format is transmitted.

2   The Sgidle byte format is also received on the inband channel.

3   Transmission of the out of band command for the DN key indicates the request for service by the originator.

4   The TE receives the out of band commands Progress Tone Alert-On and the Proceed to Select as indications that the CO-A is ready to receive digits.

5   Dial Tone is transmitted over the 64 kbit/s channel in the u-law encoded format.

DATAPATH CALL SEQUENCE CHARTS   B3-1

Appendix B

6   The originator begins dialing the digits of the desired DN. The dial tone from the CO-A is cut off after the first digit is received.

7   Following the last digit of the DN that is transmitted by the originating TE, the DMS machine transmits the commands Connection In Progress and Data Alert-On.

8   When the originating TE receives the Data Alert-On command, this initiates a change in the inband transmitted byte pattern from Sgidle to Sgr.

9   The inband receive channel of the originating TE is now monitored for u-law encoded call progress tones and at the same time it is required to look for the Sgvi byte format that indicates the T-Link rate adaption process has been started by the answering TE.

10   Once the connection has been established to the called DN, the answering CO-B transmits the Alert-On command over the out of band channel to the answering TE.

11   The u-law encoded ringing signal is transmitted over the inband channel and the ring back signal is transmitted to the originating TE.

12   The called TE answers the incoming call by sending the DN key command to the CO-B.

13   The CO-B receiving the DN key command starts the timer, TA and answer supervision is returned to CO-A. This initiates CO-A to transmit the Far End Answered command.

14   The CO-B sends the Alert-Off command and the Progress Tone Alert-On command to the answering TE.

15   After the TA has timed out, the CO-B sends the Data Alert-On command to the answering TE.

16   Receiving the Data Alert-On command is the signal to the answering TE to begin T-Link rate adaption.

17   T-Link rate adaption parameter exchange proceeds and following the transmission and reception of parameter 4, the TE at each end transmits the out of band message Sync-Found.

18   Data transfer over the 64 kbit/s channel proceeds.

ORIGINATING

```
        Access  ┌─────────┐
 ┌────┐  Line   │DMS-100  │
 │ TE ├─────────┤Family   │   Trunk
 │    │    │    │         ├──────────
 │[A] │    │    │  CO-A   │
 └────┘    │    └─────────┘
          V
        ──────>Tx           ┌Time
       Rx<──────            │
┌──────────────┬──────────┐ │
│   Inband     │Out of Band│ V
│ [64 kbit/s]  │[8 kbit/s] │
├──────────────┼──────────┤
│   Sgidle     │          │
│  ──────>[1]  │          │
│   Sgidle     │  DN Key  │
│ [2]<──────   │          │
│              │ ──────>[3]│
│              │          │
│              │ Progress │
│              │Tone Alert│
│              │ [4]<──── │
│              │Proceed To│
│              │Select    │
│Dial Tone[5]  │  <────   │
│              │Dial Pad  │
│              │Digits    │
│              │ ──────>[6]│
│  Dial Tone   │    .     │
│    Stops     │    .     │
│              │    .     │
│      .       │    .     │
│      .       │Last Digit│
│      .       │  ──────> │
│      .       │          │
│      .       │ Conn. In │
│      .       │ Progress │
│      .       │ [7]<──── │
│   Sgidle     │          │
│  ──────>     │          │
└──────────────┴──────────┘
```

ORIGINATING   ANSWERING

```
+--------+  Access  +----------+        +----------+  Access  +--------+
|  TE    |  Line    | DMS-100  |  Trunk | DMS-100  |  Line    |  TE    |
|        |----------| Family   |--------| Family   |----------|        |
|  [A]   |          |          |        |          |          |  [B]   |
|        |          |  CO-A    |        |  CO-B    |          |        |
+--------+          +----------+        +----------+          +--------+
              |                                          |
              V                                          V
         ------->Tx          T-Time              ------->Rx
      Rx<------                |               Tx<------
                               V
```

Inband [64 kbit/s]	Out of Band [8 kbit/s]		Inband [64 kbit/s]	Out of Band [8 kbit/s]
	Data Alert On [8]<———			
Sgr ———>				
Call Prog. [9]<——— or T-Link Bytes?				
				Alert On ———>[10]
Ringback [11]<——— Sgr ———>		TA	Ringing[11] ———>	DN Key [12]<———
	Far End Answered <———	| V [13]	Ringing Off	Alert Off ———>[14]
				Progress Tone Alert ———> On
		| V [15]		Data Alert On ———>[15]

DATAPATH CALL SEQUENCE CHARTS   B3-4

Appendix B

ORIGINATING   ANSWERING

```
┌──────┐  Access   ┌──────────┐          ┌──────────┐  Access   ┌──────┐
│  TE  │   Line    │ DMS-100  │  Trunk   │ DMS-100  │   Line    │  TE  │
│      │───────────│ Family   │──────────│ Family   │───────────│      │
│ [A]  │           │          │          │          │           │ [B]  │
└──────┘           │   CO-A   │          │   CO-B   │           └──────┘
                   └──────────┘          └──────────┘
                        │                               │
                        V                               V
                     ──────>Tx          ┬Time        ──────>Rx
                   Rx<──────             │          Tx<──────
                                         │
┌─────────────────┬──────────────┐      V    ┌─────────────────┬──────────────┐
│    Inband       │ Out of Band  │           │    Inband       │ Out of Band  │
│  [64 kbit/s]    │ [8 kbit/s]   │           │  [64 kbit/s]    │ [8 kbit/s]   │
├─────────────────┼──────────────┤           ├─────────────────┼──────────────┤
│         Sgvi's  │              │           │         Sgvi's  │              │
│   [16]<──────   │              │           │   [16]<──────   │              │
│        Sgvi's   │              │           │        Sgvi's   │              │
│   ──────>       │              │           │   ──────>       │              │
│  T-Link Par.    │    Sync.     │           │  T-Link Par.    │    Sync.     │
│  Exchange       │    Found     │           │  Exchange       │    Found     │
│  Par.4 Rx&Tx    │   ──────>[17]│           │  Par.4 Rx&Tx    │ [17]<──────  │
│                 │              │           │                 │              │
│                 │              │           │                 │              │
│   Data          │              │           │   Data          │              │
│   Transfer      │              │           │   Transfer      │              │
│   <──────       │              │           │   <──────       │              │
│     [18]        │              │           │     [18]        │              │
│   ──────>       │              │           │   ──────>       │              │
└─────────────────┴──────────────┘           └─────────────────┴──────────────┘
```

3.3 SEQUENCE CHART 2

Event No.   Description Of Events

1   The originating TE follows the same sequence of events
             numbered 1 to 9 as in the first sequence chart.

2   Once the connection has been established to the
             answering TE, the answering CO transmits the Alert-On
             command over the out of band channel to the answering
             TE.

3   Ringing is transmitted in u-law encoded form to the
             called TE.

4   The called TE indicates it is answering the call by
             transmitting the DN message to the CO-B.

5   The CO-B at the answering end passes answer supervision
             back to the originating CO-A.   Receiving answer
             supervision in the originating CO-A starts timer TD and
             initiates the transmission of the command Far End
             Answered.

6   The reception of the DN message by the answering CO-B
             also starts timer TA.

7   The command Alert-Off is transmitted to the answering
             TE along with the Progress Tone Alert-On command.   The
             latter command enables the answering TE to monitor the
             channel in case it was a wrong no. dialed.

8   When timer TA times out, the CO-B transmits the Data
             Alert-On   command   to   the answering TE.   For TE
             supporting T-Link rate adaption protocol this is the
             signal used to initiate the rate adaption handshake
             [e.g. the answering TE begins to transmit the Sgvi
             signaling message]. Timer TB is also initialized when
             timer TA times out.

             Note: The sequence or events following this stage is
             dependent on the originating and answering TE
             capabilities.

<u>Case A</u>

<u>Originating and Answering TE Support T-Link</u>

<u>Rate Adaption Protocol</u>

<u>Event No.</u>   <u>Description of the Events</u>

9A   Sgr is transmitted by originating TE and is received by
            the answering TE.

10A   Answering TE transmits Sgvi signaling messages over the
            64 kbit/s data channel.

11A   The originating TE receives the Sgvi messages and
            transmits Sgvi Found command over the out of band
            channel to the originating CO. This resets the TD
            timer and starts the TC timer in the originating CO.

12A   The originating CO transmits Sgvi messages over the 64
            kbit/s data channel in reply to the received Sgvi
            messages.

13A   .   The answering TE detects the Sgvi messages and
            transmits the Sgvi Found command to the answering CO
            over the out of band channel. Receiving the Sgvi Found
            message in the answering CO resets the TB timer and
            starts the TC timer.

14A   The rate adaption parameter exchange proceeds between
            the TE.

15A   After each end has received parameter 4, the TE
            transmits the Sync-Found command over the signal
            channel to the respective CO. Receiving this command
            resets the TC timer in each CO.

16A   Data transfer occurs as per T-Link protocol.

Case B

Only The Originating TE Supports T-Link

Rate Adaption Protocol

Event No.   Description of the Events

9B   Sgr is transmitted by the originating TE and is received by the answering TE.

10B   The originating TE does not receive Sgvi signaling messages from the answering TE.

11B   Timer TD in the originating CO times out and the Inband Sync Timeout command is transmitted by the CO to the originating TE over the signal channel.

12B   The originating TE upon receiving the Inband Sync Timeout defaults to 56 kbit/s synchronous data transfer mode. This assumes the originating TE is arranged for 56 kbit/s synchronous data transfer. If the TE is arranged for 64 kbit/s synchronous data transfer it will default to 64 kbit/s data transfer. When the TE is arranged for any other data rates, the Inband Sync Timeout command shall be treated as a no-op code. Therefore the TE will continue to attempt to complete the T-Link handshake.

13B   Data transfer can now occur assuming the called TE is a PSDS subscriber not using T-Link protocol and the TE is arranged for 56 kbit/s data transfer [the capability of defaulting to 64 kbit/s data transfer is relevant to future 64 kbit/s clear channel networks when common channel signaling becomes widely deployed].

Case C

Only The Answering TE Supports T-Link

Rate Adaption Protocol

Event No.   Description of the Events

9C   The answering TE transmits the inband signaling message
            Sgvi.

10C   The TB timer in the answering CO times out since no
            Sgvi Found command is received.

11C   The answering CO transmits the out of band signaling
            command Inband Sync Timeout to the TE.

12C   If the answering TE is arranged for 56 kbit/s
            synchronous data transfer, the reception of the Inband
            Sync Timeout shall stop the attempt to rate adapt as
            per T-Link rate adaption protocol and the data transfer
            mode shall be entered. If the TE is arranged for 64
            kbit/s synchronous data transfer it will default to 64
            kbit/s data transfer. When the TE is arranged for any
            other data rates, the Inband Sync Timeout command shall
            be treated as a no-op code. Therefore the TE will
            continue to attempt to complete the T-Link handshake.

13C   Data transfer can now occur assuming the called TE is a
            PSDS subscriber not using T-Link protocol and the TE is
            arranged for 56 kbit/s data transfer [the capability of
            defaulting to 64 kbit/s data transfer is relevant to
            future 64 kbit/s clear channel networks when common
            channel signaling becomes widely deployed].

Case D

TE At Originating or Answering End of The Connection Does Not Rate Adapt Within Time Limit Set By Timer-TC

Event No.   Description of the Events

9D   If either the originating or answering TE erroneously
          detects the   inband Sgvi signaling message, the out of
          band command Sgvi Found will be transmitted to the CO
          by the TE.

10D   If it is the originating CO, timer TD will be reset and
          timer TC will be initialized. If it is the answering
          CO, timer TB will be reset and timer TC will be
          initialized.

11D   When the timer TC times out the CO will transmit the
          Inband Sync Timeout command over the signal channel.

12D   If the answering or originating TE is arranged for 56
          kbit/s synchronous data transfer, the reception of the
          Inband Sync Timeout shall stop the attempt to rate
          adapt as per T-Link rate adaption protocol and the data
          transfer mode shall be entered. If the TE is arranged
          for 64 kbit/s synchronous data transfer it will default
          to 64 kbit/s data transfer.   When the TE is arranged
          for any other data rates, the Inband Sync Timeout
          command shall be treated as a no-op code. Therefore the
          TE will continue to attempt to complete the T-Link
          handshake.

13D   Data transfer can now occur assuming the called TE is a
          PSDS subscriber not using T-Link protocol and the TE is
          arranged for 56 kbit/s data transfer [the capability of
          defaulting to 64 kbit/s data transfer is relevant to
          future 64 kbit/s clear channel networks when common
          channel signaling becomes widely deployed].

CALL SEQUENCE CHART 2

ORIGINATING   ANSWERING

```
            Access  ┌─────────┐          ┌─────────┐  Access
┌──────┐    Line    │ DMS-100 │  Trunk   │ DMS-100 │  Line    ┌──────┐
│  TE  │────────────│ Family  │──────────│ Family  │──────────│  TE  │
│ [A]  │            │         │          │         │          │ [B]  │
│      │            │  CO-A   │          │  CO-B   │          │      │
└──────┘            └─────────┘          └─────────┘          └──────┘
              │                                         │
              V                                         V
          ──────>Tx              ┬Time             ──────>Rx
        Rx<──────                │                Tx<──────
                                 V
┌──────────────┬──────────────┐ V ┌──────────────┬──────────────┐
│   Inband     │ Out of Band  │   │   Inband     │ Out of Band  │
│ [64 kbit/s]  │ [8 kbit/s]   │   │ [64 kbit/s]  │ [8 kbit/s]   │
├──────────────┼──────────────┤   ├──────────────┼──────────────┤
│              │              │   │              │  Alert On    │
│              │              │   │              │ ──────>[2]   │
│   Ringback   │              │[6]│  Ringing[3]  │              │
│[3]<────────  │              │TA │ ──────────>  │   DN Key     │
│     Sgr      │              │─  │              │ [4]<──────   │
│  ────────>   │              ││ │  Ringing Off │  Alert Off   │
│              │   Far End    ││ V│              │ ──────>[7]   │
│              │   Answered   │V  │              │              │
│              │    <──────   │TD │              │  Progress    │
│              │              │[5]│              │ Tone Alert   │
│              │              ││  │              │ ──────> On   │
│              │              │V  │              │              │
│              │              │[8]│              │  Data Alert  │
│              │              ││  │              │     On       │
│              │              │V  │              │ ──────>[8]   │
│              │              │TB │              │              │
│   Sgvi's     │              │   │   Sgvi's     │              │
│[8]<────────  │              │   │[8]<────────  │              │
└──────────────┴──────────────┘   └──────────────┴──────────────┘
```

DATAPATH CALL SEQUENCE CHARTS   B3-11

Appendix B

[For Case A]

ORIGINATING   ANSWERING

```
┌──────┐  Access  ┌──────────┐           ┌──────────┐  Access  ┌──────┐
│ TE   │  Line    │ DMS-100  │   Trunk   │ DMS-100  │  Line    │ TE   │
│      │──────────│ Family   │───────────│ Family   │──────────│      │
│ [A]  │          │          │           │          │          │ [B]  │
│      │          │  CO-A    │           │  CO-B    │          │      │
└──────┘          └──────────┘           └──────────┘          └──────┘
```

```
                  V                   ┬Time              V
           ──────>Tx                  │            ──────>Rx
        Rx<──────                     │         Tx<──────
                                      V
```

Inband [64 kbit/s]	Out of Band [8 kbit/s]		Inband [64 kbit/s]	Out of Band [8 kbit/s]

Sgr
──────>[9A]
    Sgvi
[10A]<──────
Sgvi
──────>[12A]
	Sgvi
	Found
	──────>[11A]
		─
		│TC
		V
			Sgr
			──────>[9A]
			    Sgvi
			[10A]<──────
			
			Sgvi
			──────>[12A]	

		─ TC│ V		Sgvi Found [13A]<──────
[14A] T-Link Par. Exchange Par.4 Rx&Tx	Sync. Found ──────>[15A]	│ V │ ─ V ─	[14A] T-Link Par. Exchange Par.4 Rx&Tx	Sync. Found [15A]<──────
Data Transfer <────── [16A] ──────>			Data Transfer <────── [16A] ──────>	

[For Case B]

ORIGINATING   ANSWERING

```
          Access  ┌─────────┐                    ┌─────────┐  Access
┌──────┐  Line    │ DMS-100 │                    │         │  Line    ┌──────┐
│  TE  │──────────│ Family  │──── Trunk ─────────│  CO-B   │──────────│  TE  │
│      │          │         │                    │         │          │      │
│ [A]  │          │  CO-A   │                    │         │          │ [B]  │
└──────┘          └─────────┘                    └─────────┘          └──────┘
```

```
          V
        ─────>Tx                            ─Time
      Rx<─────                              │
                                            V
┌─────────────────┬────────────────┐
│    Inband       │  Out of Band   │
│  [64 kbit/s]    │  [8 kbit/s]    │
├─────────────────┼────────────────┤
│     Sgr         │                │
│   ──────>[9B]   │                │
│                 │                │
│                 │                │
│   Non-Sgvi      │                │
│   Bytes Rx      │                │              │
│   [10B]<─────── │                │              V
│                 │ Inband Sync    │   ── Timer TD in
│                 │   Timeout      │      CO A times
│                 │ [11B]<──────── │      out.
│                 │                │
│                 │                │
│                 │                │
│                 │                │
│    Data         │                │
│  Transfer       │                │
│   <───────      │                │
│    [12B]        │                │
│   ──────>       │                │
└─────────────────┴────────────────┘
```

[For Case C]

ORIGINATING   ANSWERING

```
        Access          ┌──────────┐          ┌──────────┐  Access       ┌──────┐
┌──────┐ Line           │          │  Trunk   │ DMS-100  │  Line         │  TE  │
│  TE  │────────────────│   CO-A   │──────────│ Family   │───────────────│      │
│ [A]  │                │          │          │          │               │ [B]  │
└──────┘                │          │          │  CO-B    │               └──────┘
                        └──────────┘          └──────────┘
```

```
                                                         V
                                                ─────>Rx
                                          Tx<─────
                       ┌Time
                       │        ┌────────────────┬────────────────┐
                       │        │   Inband       │  Out of Band   │
                       V        │  [64 kbit/s]   │  [8 kbit/s]    │
                                ├────────────────┼────────────────┤
                                │        Sgvi    │                │
                                │  [9C]<──────── │                │
 Timer TB in           │        │                │                │
 CO B times            │        │                │                │
 out.                  V        │                │  Inband Sync   │
                       ──       │  [10C]         │   Timeout      │
                                │                │   ────>[11C]   │
                                │                │                │
                                │                │                │
                                │                │                │
                                │   Data         │                │
                                │  Transfer      │                │
                                │  <──────────   │                │
                                │    [13C]       │                │
                                │  ──────────>   │                │
                                │                │                │
                                └────────────────┴────────────────┘
```

Appendix B

[For Case D]
Where The Originating TE Erroneously Detects Sgvi's

ORIGINATING   ANSWERING
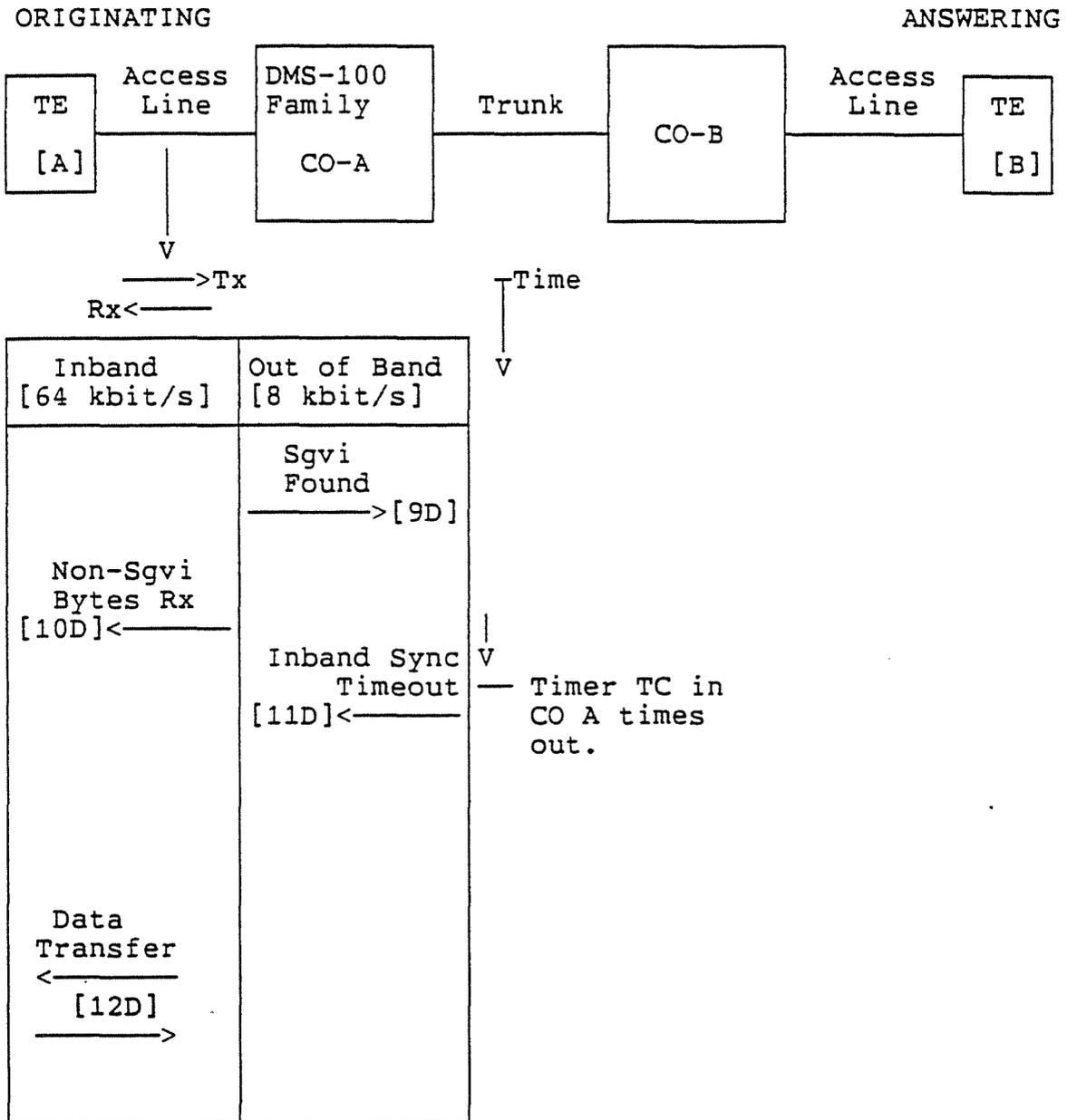
```
 ┌──────┐  Access  ┌──────────┐         ┌──────────┐  Access  ┌──────┐
 │  TE  │  Line    │ DMS-100  │  Trunk  │          │  Line    │  TE  │
 │      │──────────│ Family   │─────────│   CO-B   │──────────│      │
 │ [A]  │          │          │         │          │          │ [B]  │
 └──────┘          │   CO-A   │         └──────────┘          └──────┘
                   └──────────┘
                        │
                        V
                 ────>Tx                    ┬Time
              Rx<────                        │
                                             V
 ┌────────────────┬────────────────┐
 │    Inband      │  Out of Band   │
 │  [64 kbit/s]   │  [8 kbit/s]    │
 ├────────────────┼────────────────┤
 │                │      Sgvi      │
 │                │     Found      │
 │                │ ────────>[9D]  │
 │                │                │
 │   Non-Sgvi     │                │
 │   Bytes Rx     │                │
 │ [10D]<─────    │                │  │
 │                │ Inband Sync │V │
 │                │     Timeout │── Timer TC in
 │                │ [11D]<───── │   CO A times
 │                │                │   out.
 │                │                │
 │                │                │
 │    Data        │                │
 │  Transfer      │                │
 │ <────          │                │
 │   [12D]        │                │
 │ ────────>      │                │
 │                │                │
 └────────────────┴────────────────┘
```

[For Case D]
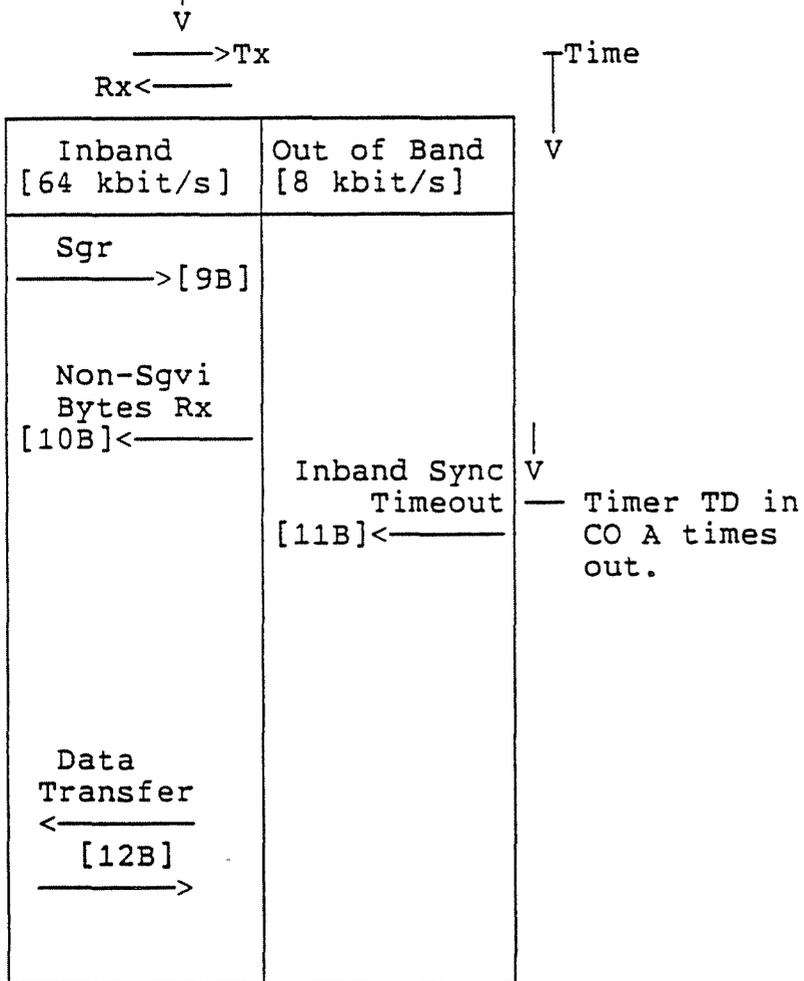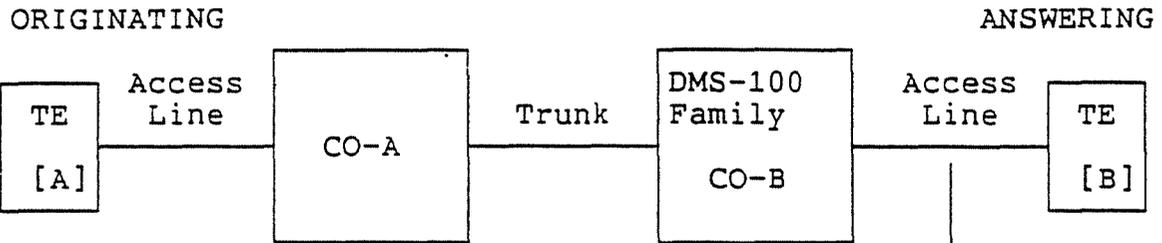. Where The Answering TE Erroneously Detects Sqvi's

ORIGINATING   ANSWERING

```
  ┌──────┐   Access   ┌──────────┐  Trunk  ┌──────────┐  Access   ┌──────┐
  │  TE  │    Line    │          │─────────│ DMS-100  │   Line    │  TE  │
  │      │────────────│   CO-A   │         │ Family   │───────────│      │
  │ [A]  │            │          │         │          │           │ [B]  │
  └──────┘            └──────────┘         │   CO-B   │           └──────┘
                                           └──────────┘
                                                              V
                          ┬Time                        ────>Rx
                          │                          Tx<────
                          V        ┌─────────────┬─────────────┐
                                   │   Inband    │ Out of Band │
                                   │ [64 kbit/s] │ [8 kbit/s]  │
                                   ├─────────────┼─────────────┤
                                   │             │     Sgvi    │
                                   │             │    Found    │
  Timer TC in             │        │             │  [9D]<───── │
  CO B times              │        │             │             │
  out.                    V        │             │ Inband Sync │
                          ──       │  [11D]      │  Timeout    │
                                   │             │    ──>[12D] │
                                   │             │             │
                                   │             │             │
                                   │             │             │
                                   │    Data     │             │
                                   │  Transfer   │             │
                                   │   <──────   │             │
                                   │    [13D]    │             │
                                   │   ──────>   │             │
                                   └─────────────┴─────────────┘
```

Appendix C

Clocking

Considerations

For The End To End Connection

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Appendix C

CLOCKING CONSIDERATIONS

1.1 Clocking Between the End to End Connection

For synchronous and asynchronous data transmission, the TE must either
generate or obtain a data clock to time the transmission and reception
of data to and from the user device (DTE/DCE).

1.2 Clocking at the User Terminal

In the case of asynchronous transmission the TE and the user device car
both tolerate short term variation in the data rate since each data wo:
has a start bit which provides a reference point from which the
following data bits can be located. However, if the data being sent
consists of strings of consecutive bytes (i.e., the stop bit of one wo:
is followed immediately by the start bit of the next) the average bit
rates must be reasonably close at both ends or data will be lost.

There are two common methods of generating a synchronous clock.
The first assumes a completely synchronous system. In a synchronous
system all the data clocks used in the system are derived from the sam·
source as the clock for the 64 kbits/s channel. Synchronous
transmission does not require a synchronous system but it is desirable
The timing signal from the 64 kbits/s channel is used to derive
independent but synchronized clocks at both ends. This method will
require that the TE provides both the transmit and receive clocks to t:
user device and will be prone to slips if the timing signals from the
kbits/s channel are not synchronized at both ends.

The second method is network independent and works even if the
connection is not synchronized. One end of the connection is designat
as the master and derives the data rate from a local oscillator or an
external network independent clock source provided by the user. The
other end is the slave and synchronizes its data rate clock to the
received byte stream.

1.3 "Nearly Synchronous" Data

"Nearly synchronous" data events occur when the clock used to generate
the events is not synchronized to the clock used to sample the events.
This situation occurs frequently when a synchronized data network
interchanges data with computers which have their own internal clocks.

If the units external to the network (public or private) control the rate at which data arrives, it will be close but cannot be precisely equal to the 64 kbits/s; therefore, the data is "nearly synchronous".

When a "nearly synchronous" data source is connected to a data sink, the data source can overrun or underrun the data sink, which results in periodic errors. The number of error free seconds depends upon the relative clock rates and the amount of buffering between the two systems. The buffering in T-Link protocol is provided by the Sd bytes being inserted between the Ds bytes.

The number of signaling bytes separating the repeated synchronous data bytes is not a constant. The difference between the synchronous and "nearly synchronous" flow of bytes is illustrated below:

(a)   Synchronous Byte Repetition

bit rate	# of signaling bytes separating the data bytes
2400	16
4800	6
9600	1

(b)   Nearly-synchronous Byte Repetition

bit rate	# of signaling bytes separating the data bytes
2400+	15 or 16
2400-	16 or 17
4800+	5 or 6
4800-	6 or 7
9600+	0 or 1
9600-	1 or 2

Note: a + sign indicates a rate slightly higher than indicated.
   a - sign indicates a rate slightly lower than indicated.