NORTHERN TELECOM

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

NIS D302-1

LIST OF ILLUSTRATIONS

TABLE OF CONTENTS

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This document is designated general specification No. D302-1, it constitutes the Northern Telecom T-Link Protocol Speicfication.

This document contains the description of the T-Link rate adaption protocol supported by Northern Telecom. The rate adaption scheme is suitable for interworking with an ISDN B channel and provides the following benefits:

* *Rate Adapts a wide range of user data rates, synchronous and asynchronous.*

  * *50 to 19.2 kbit/s asynchronous*

  * *1200 to 64 kbit/s synchronous*

* *Provides full support of EIA control leads.*

* *Provides Forward Error Correction for data rates of 9600 bit/s or less (useful for operation over "voice-grade" T1 facilities).*

* *Operates over standard T1 DS0 facilities - no problem with A/B bit signaling or ones density requirements.*

* *Interworks with CSDC (at 56 kbit/s).*

* *Provides an inband exchange of parameters (baud rate, data format, loopbacks, etc.).*

To assist CPE developers in the implementation of T-Link, Northern Telecom has instituted a T-Link Building Block (TBB) program. This program provides vendors with the technology to implement T-Link in hardware. Details may be obtained from Northern Telecom.

1.0 GENERAL

1.1 SCOPE

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.

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.

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

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

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 ARCHITECTURE

3.1 SYSTEM OVERVIEW

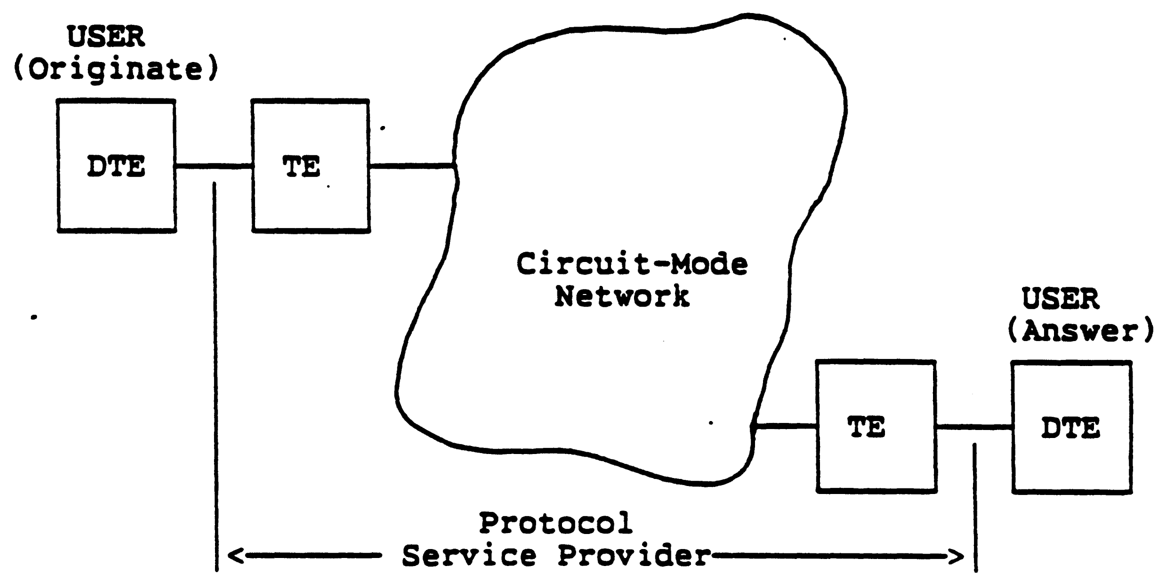

Figure 1. Physical Configuration For The System

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

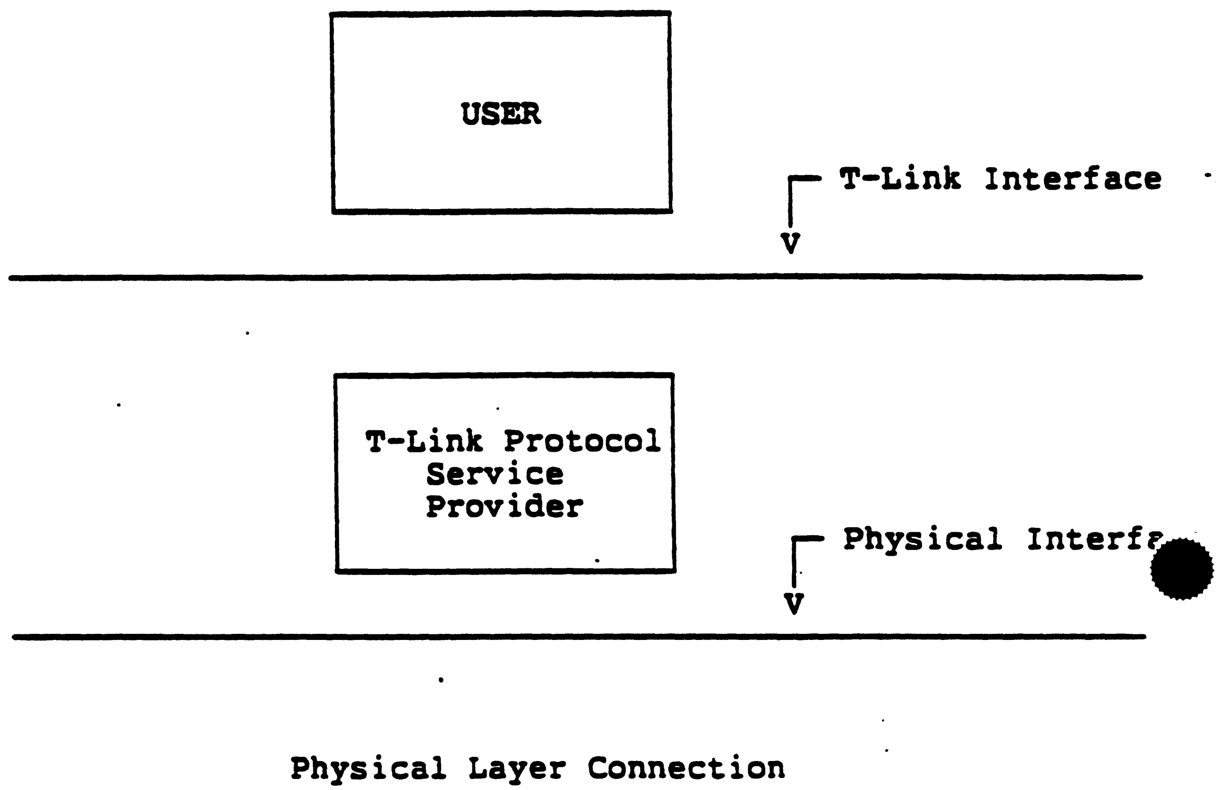

Figure 2. Layer Service Model

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).

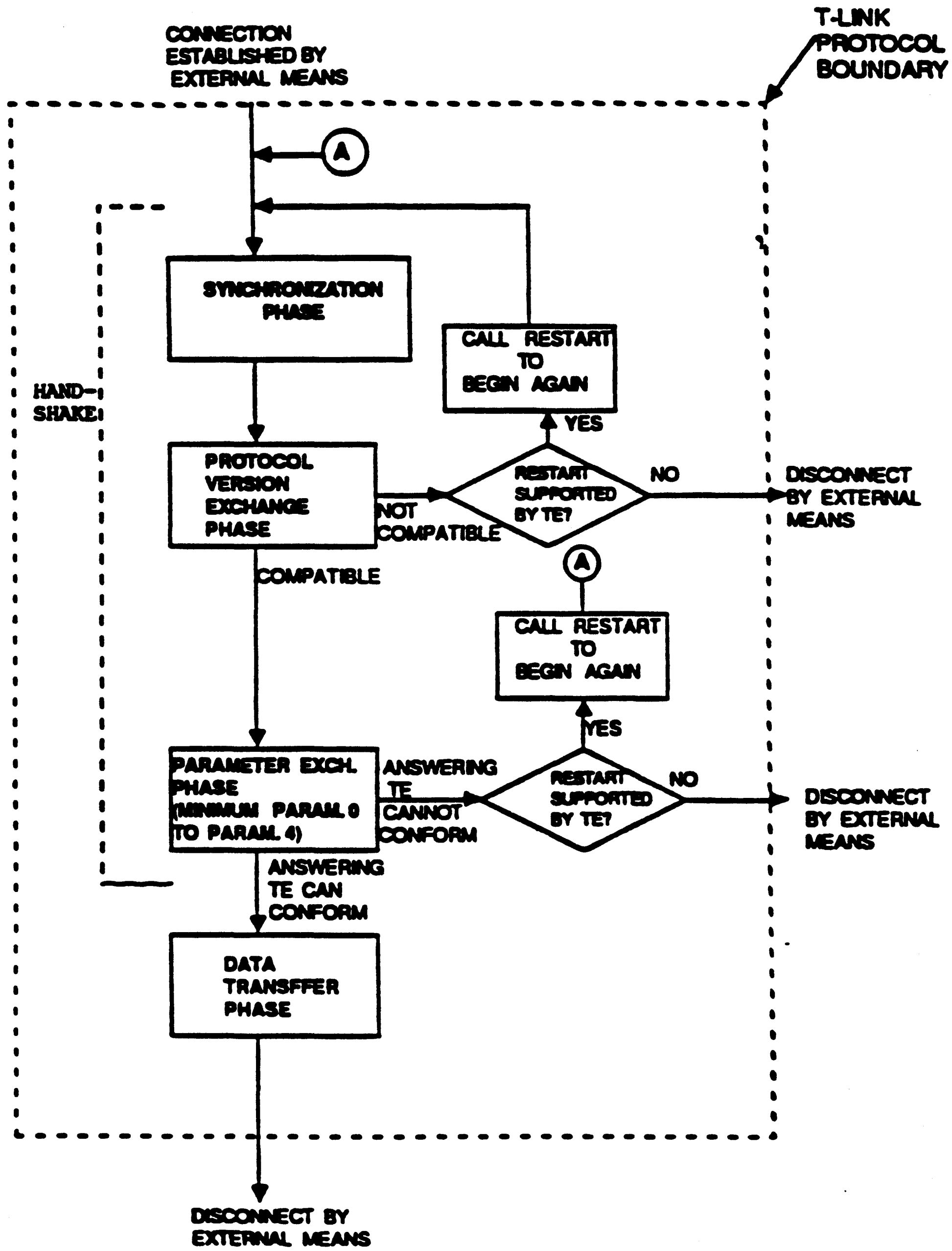

Figure 3. Service Functions

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.

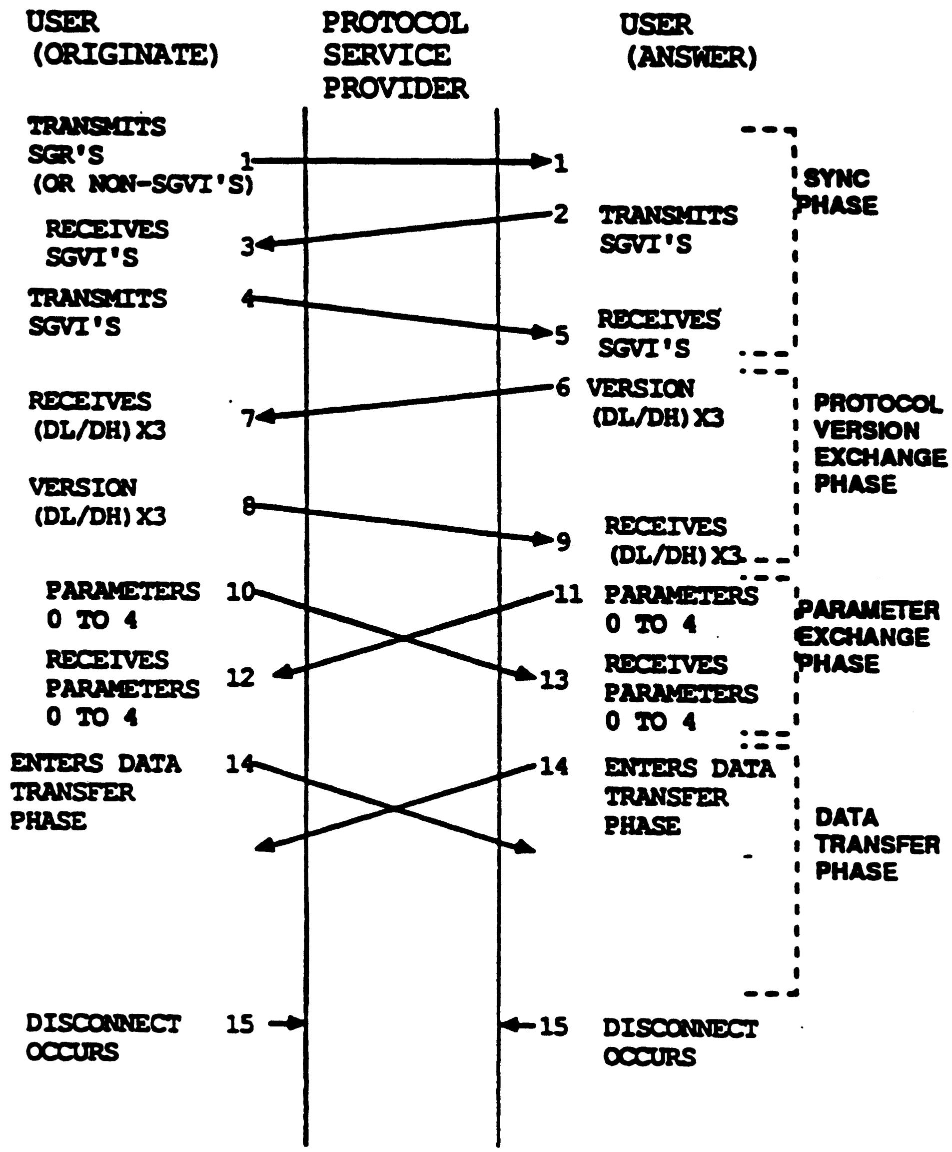

Figure 4. Time Sequence Diagram For A Typical Call

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.

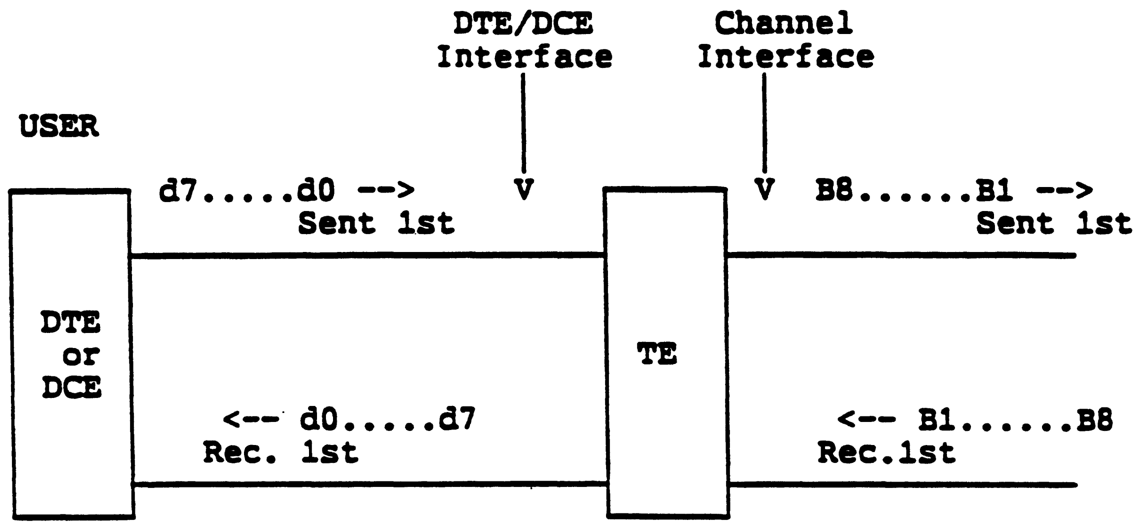

Figure 5. Bit Sequence At DTE/DCE & Channel Interface

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.

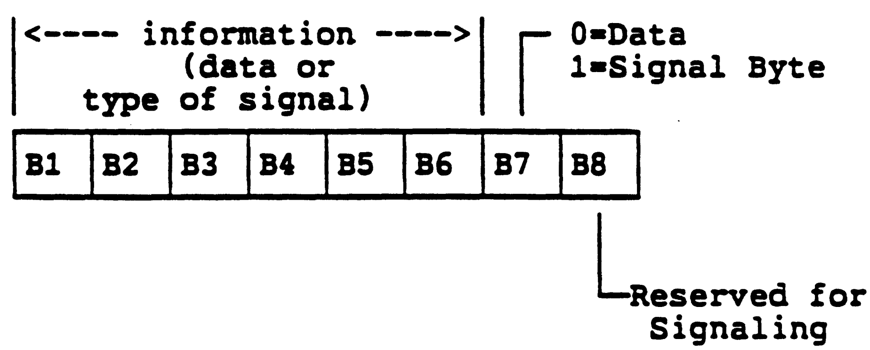

Figure 7. Identification of the Bytes

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

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:

Data Bit	Description of Use
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

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.

0: 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. 0=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. 0=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.

	B1							B8
DLp3	d3	d2	d1	d0	0	1	0	1

	B1							B8
DHp3	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:

<u>Data Bit.</u>	<u>Description of Use</u>
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 <u>Secondary Signaling Identifier and Message</u>

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.

	B1							B8
Sgss	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.

	B1							B8
DLss	d3	d2	d1	d0	0	1	0	1

	B1							B8
DHss	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 .

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

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

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                                   TE                     DCE
Control Leads                       (values in Sd)          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/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 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.

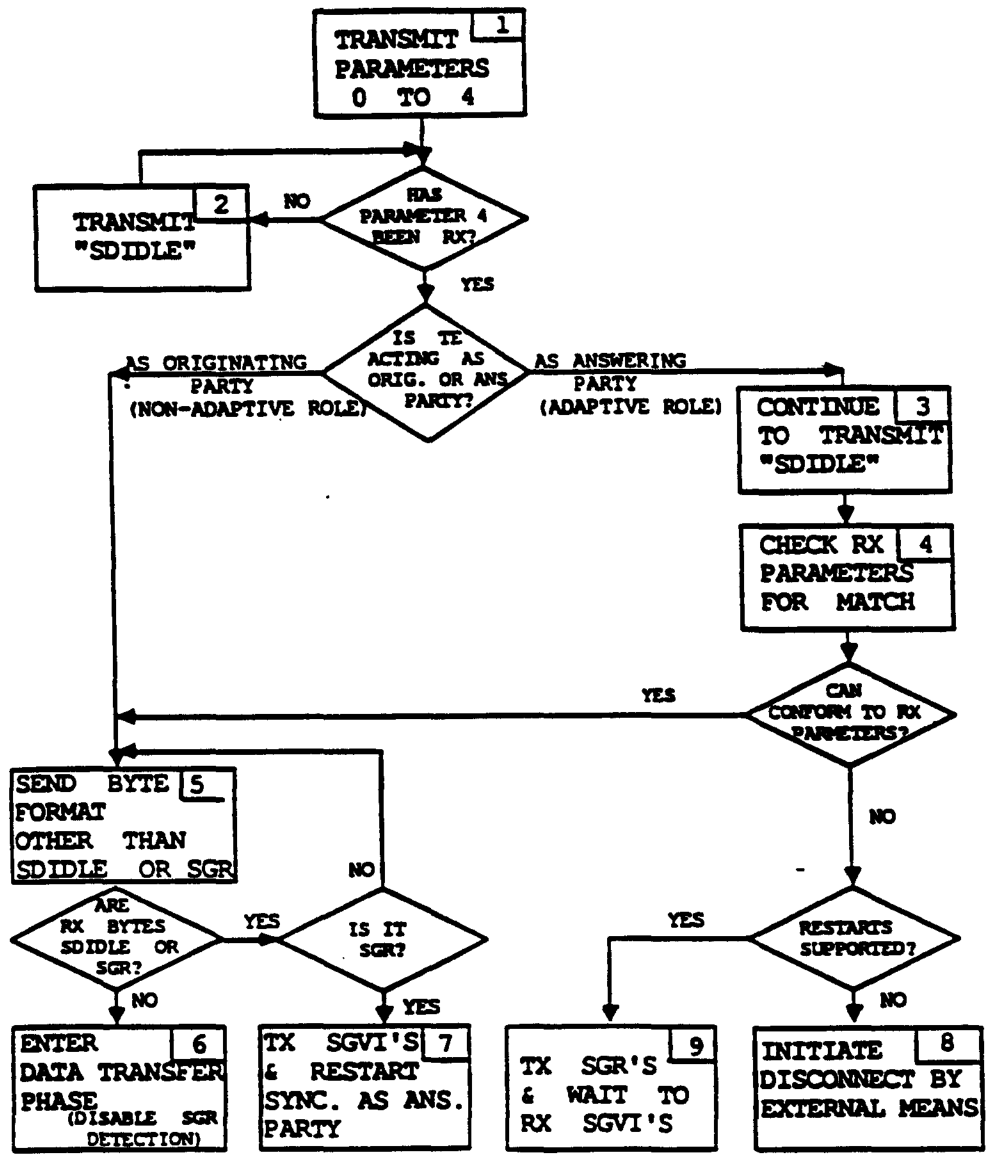

Figure 35. Transition to Data Transfer for High Speed Synchronous Rates

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 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.

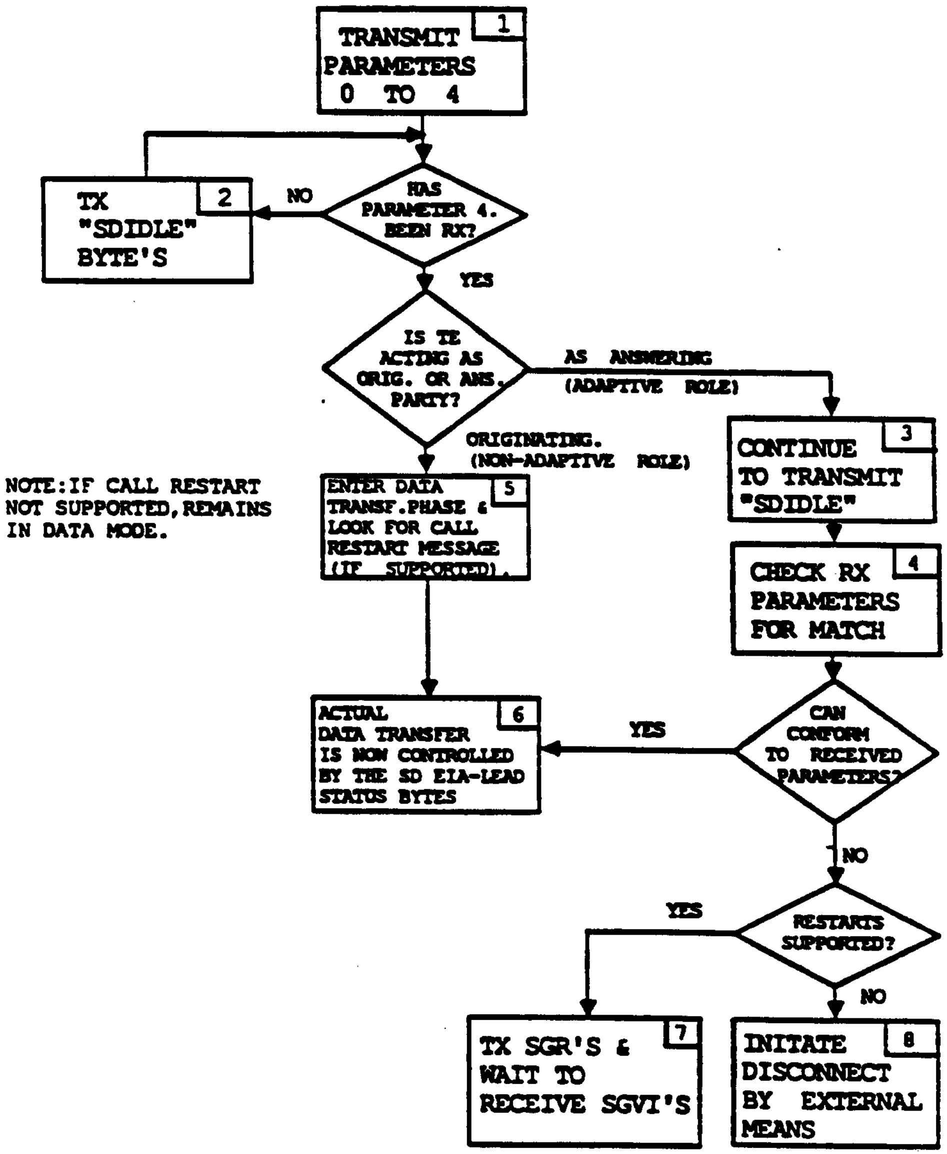

Figure 36. Data Rates That Use Sd Bytes For Time Fill

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 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								Character Presented To Host								
		d7							d0	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.