British Columbia Telephone Company

Technical Reference

Dataroute* Network

Specifications for Digital

Circuit Terminating Equipment

April 30, 1991

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Dataroute Network Data Circuit Terminating Equipment (DCTE) Specifications **APRIL 1991**

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1.0 Purpose of Document

This document describes the Digital Circuit Terminating Equipment (DCTE) used to connect customer Data Terminal Equipment (DTE) to the **Dataroute** network. Three main types of DCTE are used to accommodate the various **Dataroute** network facilities, speeds and service features. These three types of DCTE are described.

This Technical Reference is intended to provide an Original Equipment Manufacturer (OEM) or other skilled persons with information enabling them to design DCTE compatible with the **Dataroute** network. The characteristics of the network access line interface are loop transmission system dependent and are subject to change from time to time as new or improved loop transmission schemes are developed.

1.1 **Dataroute** Service Description

Dataroute is a Telecom Canada service, offering a nation wide, high quality digital data network accommodating a wide range of customer data transmission speeds in point-to-point, multipoint, and multidrop private line configurations.

Both synchronous and asynchronous transmission formats are supported, in both duplex and half duplex mode. In this document, the Standard Speeds are listed (see 2.2 - Speeds and Formats) in units of bits per second (b/s) or thousand bits per second (kb/s). Specific methods are defined for transmission of interface control information to and from the customer provided DTE and for transmission of channel loopback controls to the DCTE.

Dataroute does not provide "secondary channel" transport as is supported by the Dataphone Digital Service (DDS) network in the United States. **Dataroute** does not provide alternate voice or voice co-ordination channels at this time.

Dataroute is a time-division synchronous network. Consequently, with the exception of the asynchronous DTE interfaces offered, all data transfer to and from the customer shall be synchronized with the network clocking system. Neither the **Dataroute** DCTE nor the **Dataroute** network impose restrictions on the format or content of the synchronous data at any of the Standard Speeds. Asynchronous data transfer between the DTE and the DCTE is constrained with respect to bit rate, character length, and over-speed or under-speed tolerance.

Multipoint **Dataroute** provides full duplex communication between a control (or master) station and one or more tributary (or slave or outlying) stations and uses synchronous data bridging devices located in various **Dataroute** network offices.

1.2 **Dataroute** Network Description

The **Dataroute** is functionally discrete from but physically integrated with the overall British Columbia Telephone Company and Telecom Canada transmission network.

Special alarm, testing, monitoring, and maintenance capabilities exist for **Dataroute** that allow rapid isolation and resolution of troubles. The DCTE serves as an element of this system.

All DCTE described in this document are served by non-loaded access loops.

The **Dataroute** time division multiplex structure efficiently packs individual customer data bit streams onto higher rate transmission facilities between the **Dataroute** offices.

Multipoint **Dataroute** service transmits the control station's data to all of the tributaries simultaneously. In the reverse direction, the digital data bridges logically combine the data from the tributaries into a single data bit stream for delivery to the control station. This means that a discipline (to prevent collisions in data from the tributaries travelling towards the control station) must be exercised by the control station and respected by the tributary station such that only one tributary at a time transmits data. Direct data transmission between tributary stations is not possible. All stations on the same multipoint circuit shall operate at the same bit rate, at one of the Standard Rates.

Customers using multipoint service generally use polling techniques to maintain discipline between the control and tributary stations.

Any one of three different types of DCTE may be specified by the **Dataroute** access line provider at his discretion subject to available network equipment and facilities. The first type of DCTE is called a 4 wire Station Terminating Unit or STU. The second type is a 4 wire Data Service Unit or DSU. The third type is a 2 wire Data Terminating Unit or DTU. All three types of DCTE support synchronous or asynchronous data transmission at the Standard Rates.

In this document the expressions STU, DSU or DTU refer to a DCTE for use with a **Dataroute** network access line of the corresponding type. In this document the word "may" is used to describe a negotiable requirement.

1.3 References

All information concerning the STU type DCTE has been drawn from the Bell Canada "**Dataroute** Access (DCTE) Interface Document - **Dataroute** Network Digital Circuit Terminating Equipment Specifications", September,1990 Issue 3.

The DSU type DCTE is partially described in (PUB 62310) the AT&T Technical Reference 62310, "Digital Data System Channel Interface Specification", November 1989 and its Addenda. The asynchronous, 1.2 kb/s and 19.2 kb/s synchronous transmission characteristics of the DSU type DCTE are described in this document. In addition, information on 19.2 kbps DSU criteria are found in the draft ANSI document entitled "Subrate Metallic Customer Installation interfaces", T1E1.4/90-006R1.

The DTU type DCTE is described in relation to information presented in the American National Standards Institute Inc. publication ANSI T1.601-1988, September 1988.

Those references which appear as V.4, V.110, etc. are Recommendations of the CCITT, 1984.

The designation ISO applies to publications of the International Standards Organization.

Those references which appear as RS-232-C, RS-344, or EIA-232-D, etc. are recommended standards of the Electronic Industries Association.

References to CS-03 apply to the most recent issue of Standard for Terminal Equipment, Systems, Network Protection Devices and Connection Arrangements CS-03 and addenda, Government of Canada Department of Communications, as amended from time to time.

All references to "Bell Canada Metallic Specification" or "BCMS" refers to Appendix A of this document.

Some application information is given in (PUB 41458) AT&T Technical Reference 41458 "Special Access Connections to the AT&T Communications Public Switched Network for New Service Applications", October 1988.

1.4 Glossary of Terms and Acronyms

These acronyms appear throughout the document and are listed below for reference.

AML	Actual Measured Loss
ANSI	American National Standards Institute
AT&T	American Telephone and Telegraph Company
AWG	American Wire Gauge
BPV	Biploar Violation
BCMS	Bell Canada Metallic Specification
CCITT	Consultative Committee - International Telegraph and Telephone
CO	Carrier On (EIA RS-232 lead CF)
CSA	Canadian Standards Association
CSU	Channel Service Unit
DCE	Data Circuit Equipment (i.e. dataset,analog or digital)
DCTE	Digital Circuit Terminating Equipment (i.e. digital as opposed to analog dataset)
DDS	Dataphone Digital Service
DSU	Data Service Unit (Dataphone Digital Service type digital dataset)
DS1	Digital Signal Level 1 (1,544,000 bps)
DTE	Data Terminal Equipment (i.e. computer terminal, printer, etc.)
EIA	Electronic Industries Association
EML	Estimated Measured Loss
ISO	International Standards Organization
MJU	Multi Junction Unit
MJS	Multi Junction Shelf
MTBF	Mean Time Between Failure
MTTR	Mean Time To Repair
OCU	Office Channel Unit
OEM	Original Equipment Manufacturer
ORU	Office Repeater Unit
R	Ring (one wire of DCTE transmit pair towards the Network Interface)
R1	Ring 1 (one wire of DCTE receive pair from the Network Interface)
STU	Station Terminating Unit (**Dataroute** type digital dataset)
T	Tip (one wire of DCTE transmit paair towards the Network Interface)
T1	Tip 1 (one wire of DCTE receive pair from the Network Interface)

2.0 General Requirements

This section provides information and requirements common to the STU, DSU and DTU.

2.1 Network Interface Requirements

The following characteristics and functions are required:

A. Balanced 135 ohm loop terminations

B. Timing recovery from received loop signal

C. Proper response to loopback control commands from the network

D. Correct recognition and generation of other control signals

E. Synchronous sampling (see 13.1 - Asynchronous to Synchronous coding)

F. Operable at all of the Standard Speeds and Formats

G. Operates with one or more of the three signal types: as STU, DSU or DTU

2.2 Standard Speeds and Formats

A. In the synchronous format, bit streams are be transmitted at the Standard Speeds of: 1.2, 2.4, 4.8, 9,6, 19.2 and 56 kb/s.

B. In the asynchronous format, characters of 9 or 10 bits as described by V.4 are be transmitted at the Standard Speeds of: 300 b/s and 1200 b/s.

At asynchronous speeds less than 1200 b/s, except 300 b/s, digital access technology is not presently employed. Circuit terminating equipment employed in these cases is outside the scope of this document.

At the asynchronous Standard Speed of 300 b/s, either one of the types of DCTE described in this document or a type of circuit terminating equipment not described in this document may be specified by the Dataroute access line provider, subject to available network equipment and facilities.

At asynchnonous speeds greater than 1200 b/s, the digital access method used for the corresponding synchronous speed in conjunction with the transmission method described in section 13 is applicable.)

2.3 DTE Interface Requirements

As set out in **Dataroute** tariffs, an interface point between the DCTE and the customer provided DTE is clearly demarcated. The following standard Data Circuit-terminating Equipment (DCE) interfaces shall be available for connection by a DTE operating at the Standard Speeds and Formats:

A. All asynchronous speeds - RS-232-C (and also see RS-344).

B. Synchronous speeds between 1.2 and 19.2 kb/s - RS-232-C (and also see RS-344).

C. Synchronous speeds between 19.2 and 56 kb/s - V.35 and also ISO 4593.

In the case of an RS-232-C interface, the control leads CA, CB, CC, CD, CE, and CF shall be implemented by the STU.

Additionally, pin 25 of the STU DCE interface connector may be used as a customer activated Busy Out (BO) control lead.

Additionally, pin 25 of a DSU or DTU may be used as a customer detected Test Mode indication (TM) control lead in accordance with EIA-232-D. Additionally, pin 18 of the DSU or DTU interface may be used as a customer activated Busy Out (BO) control lead.

Leads CA, CD, and BO shall be individually programmable to follow the state of the respective DTE lead or to be forced internally to the equivalent of an EIA ON or OFF state as described in section 9.4.1 of this document.

Lead CB shall follow the condition of lead CA with optioned delays of 0, 40, or 130 milliseconds. In addition, an option shall be provided to force CA internally to the equivalent of an EIA ON state, resulting in lead CB also being in an EIA ON state.

Lead CF shall also be programmable to either follow the receive control code status or be forced to an EIA ON as explained in section 9.4.2.

However, a DSU shall be capable of transmission and operation of RS-232-C control leads as described in PUB 62310.

Other interface features and arrangements may also be included by an OEM at his discretion.

2.4 Multiplexer Terminations

A combination of bit and byte interleaved multiplexers are in common use in the Dataroute network. Bits are transmitted in the order received but no specific guarantee is made concerning which bits are grouped in a given byte.

The Dataroute network terminates DSU loops on OCU (Office Channel Unit) ports or their functional equivalent; STU loops on ORU (Office Regenerator Unit) ports or their functional equivalent; and DTU loops on DNIC (Digital Network Interface Card) ports or their functional equivalent.

3.0 General Performance Objectives

The **Dataroute** provides high quality, reliable data communications on an end to end basis between customer provided equipment. The network is designed and maintained to a set of performance standards selected to satisfy the demands of data customers.

The overall performance of the **Dataroute** end to end connection depends on both the network portion and the access portion. The access portion includes the access line and the DCTE. The excellent performance and availability of **Dataroute** can only be realized by the customer if the quality and performance of the DCTE compliments that of the network by meeting the requirements of this document.

3.1 Channel Quality

The channel quality is a measure of the error performance while the data channel is available. Error Free Seconds (EFS), usually expressed as a percentage of available time, is the measurement used. Errored seconds are transient in nature and are normally separated by long, error free intervals.

The minimum acceptable objective quality level for **Dataroute** connections is 99.50% EFS at 56 kb/s, averaged on a daily basis over available time. Better quality is frequently obtained at the lower bit rates due to the nature of the disturbing events that cause the errored seconds.

The DCTE, being an element within the data channel, shall not contribute measurable errors to the data channel.

3.2 Channel Availability

The channel availability is a measure of channel usability or uptime, usually expressed as a percentage of total time on a per channel basis.

The minimum acceptable objective availability for a **Dataroute** end to end channel is 99.9% averaged on an annual basis. This means that the maximum acceptable annual downtime for a **Dataroute** channel is less than 0.1%. The 0.1% downtime (or unavailability) is allocated to various network, access loop, and DCTE components that comprise the channel. Out of the 0.1% downtime per year, 0.025% is allocated to the access portion. The access portion availability applies to the wire loop facility together with the DCTE. The Mean Time Between Failure (MTBF) for the DCTE shall be such that the 0.025% downtime budget allocated to the access portion is not exceeded. Availability also depends upon the Mean Time To Repair (MTTR). From the following relationship:

$$\text{Availability} = \frac{\text{Uptime}}{\text{Total Time}} = \frac{\text{MTBF}}{\text{MTBF} + \text{MTTR}}$$

From this relationship, given an MTTR in the range of 0.5 to 2.0 hours, an MTBF for the access portion of 2000 to 8000 hours may be calculated. Since some failures are due to problems with the wire loop facility, the MTBF for the DCTE shall be larger than the MTBF for the access portion.

To maximize the availability of the access portion, the DCTE MTBF should be significantly larger than 8000 hours.

4.0 Testing and Maintenance

The testing and maintenance features of **Dataroute** were designed as integral to the network. With this in mind, the DCTE attached to the **Dataroute** network is viewed by the multiplexer as an extension of its circuit interface for purposes of fault location.

Loopback commands are issued to the DCTE from testers located in **Dataroute** test centers, allowing the testers to verify the integrity and measure the performance of the loop facility together with the attached DCTE.

Loopback tests are intrusive. This means that the data channel to the DCTE is interrupted when a loop test is in progress at either end of a point to point circuit. On multipoint circuits, depending on whether the control channel or one of the tributaries is loop tested, interruption can occur at all or only a few stations.

Loopback tests are not normally performed unless a trouble report is received from a customer or a release is obtained.

4.1 **Dataroute** STU Testing

The STU has a "Loop" command sequence permanently assigned to it by the **Dataroute** testing system. This command is intended to remotely control a digital loopback in the STU. There is no equivalent to the "CSU" loopback control as used for DSU testing.

From an appropriate piece of test equipment, the tester issues a Loop command sequence towards the DCTE to be tested. This command is passed through the network to an ORU port in the terminating office that is connected to the 4 wire loop going to the STU.

The ORU then translates the Loop command into a Bipolar Violation (BPV) encoded control sequence and transmits it towards the STU. Upon receipt of the code, the STU, if it is functioning properly, enters into a loopback condition. All the logic in the STU except for the DTE interface drivers and receivers is tested in this loopback condition. This is a latched loopback condition. The test equipment that initiated the loopback periodically verifies that it is is still active.

The loopback is deactivated by a new command instructing the STU to restore normal customer data transmission.

4.2 **Dataroute** DSU Testing

The testing functionality of DSU type DCTE is documented in PUB 62310, section 4.

Additionally, if loop signal rates of 3.2, 6.4, 12.8, 25.6, or 72.0 (see 5.3 - Loop Design for DSU) are used then the DCTE shall provide a permanent transparent synchronous loopback of all S bits. The stream of S bits on the access line may be used by **Dataroute** for non-intrusive performance tests on a continuous or occasional basis.

4.3 **Dataroute** DTU Testing

The testing functionality of the DTU type DCTE is documented in T1.601-1988.

5.0 Access Line Variations and Impairments

Various cable pair configurations may be used to configure Dataroute access lines. Therefore the DCTE shall be required to function without degradation of performance on all variations of the loop design.

Line receivers shall perform self-equalization of the frequency dependent characteristics of the access line throughout every possible access line configuration. Some requirements are:

A. Both the line drivers and receivers present a balanced 135 ohm resistive impedance to the line from 100 Hz to a frequency equal to double the line rate for the STU or DSU, or from 1000 Hz to 200 kHz for the DTU.

B. Loop cable is non-loaded with a nominal 52nF/km shunt capacitance. Cables of 19, 22, 24, and 26 AWG may be encountered and they may be mixed on any given loop. Actual capacitance is subject to considerable variation but exceptionally different characteristics, such as those of open wire, will not be encountered.

To maximize data channel performance, it is desirable to use a DCTE which is minimally disturbed by loop interference and noise. However, information on loop interference and noise is presented so as to indicate impairments which a DCTE could be routinely subjected to.

5.1 Loop Design for STU

5.1.1 Loop Assignment and Loss

A 4 wire non-loaded loop is a candidate for **Dataroute** assignment using STU type DCTE if its one way (2 wire) Estimated Measured Insertion Loss (EML) between ORU and STU, with 135 ohm terminations, is less than or equal to 31 dB at the Nyquist frequency. An exception is made for 1200 b/s, where the maximum EML is 28 dB at 600 Hz.

The Nyquist frequency for an STU is a frequency equal to one-half the loop signal rate (or line rate). The STU loop signal rate is equal to the synchronous Standard Speed of operation.

The maximum Actual Measured Insertion Loss (AML) will be less than or equal to 34 dB at a frequency equal to one-half of the loop signal rate. The 3dB difference between design maximum and measured maximum is reserved by the network as a margin which allows for seasonal variation in loop parameters.

5.1.2 Loop Conditioning

The **Dataroute** STU loops are non-loaded with bridged ("build-out") capacitors removed.

Bridge taps are limited to 1.83 km cumulative total and the longest single bridge tap length are not to exceed 1.83 km on all loops having an EML of 18dB or less at a frequency equal to one-half the loop signal rate.

No bridge taps are be present on loops having an EML greater than 18 dB at a frequency equal to one-half the loop signal rate.

In addition to the bridge tap limitations, all loops have an individual loop resistance less than or equal to 5500 ohm. Loop resistance is measured by connecting Tip to Ring of an individual pair at one end and measuring the resistance with a suitable ohm-meter between the Tip and Ring at the other end.

5.1.3 Loop Interference and Noise

Noise requirements are based on both ends of the loop being terminated in 135 ohm terminations. Requirements are established based on a standard noise measuring set (6F or 6FR or equivalent) that provides readouts in dBrn. (0 dBrn = -90 dBm.) The set shall also have a 50 kb/s flat filter (passband 40 Hz to 34 kHz, type 497F or equivalent).

Assuming a properly balanced 135 ohm termination and a noise measuring set with the characteristics stated in the preceding paragraph, the maximum measured background noise power level is not to exceed 30 dBrn.

Impulse noise measurements are made at two thresholds labeled X and Y. For a loop to be meet the impulse noise objective, there will be no more than 6 counts above the X threshold in a 15 minute test interval, and there will be more than 1 count at the Y level in the same 15 minute interval. The X and Y thresholds are AML dependent as indicated in Table 5.3.3B. Terminations of 135 ohm are assumed and the test set up for background noise measurements is used. The blanking interval between successive counts on the noise test set is 200 milliseconds.

The impulse noise thresholds are specified for AML and loop signal rate in Table 5.3.3B.

5.2 Loop Design for DSU

Loop signal rate is the rate at which signals are transferred to and from the DCTE over the access line. The transmission of a data channel by a DSU involves the use of a loop signal rates ("OCU/loop data rates") equal to or greater than the Standard Speed of operation.

The Nyquist frequencies for a DSU are listed in PUB 62310, section 5.2.

5.2.1 Loop Assignment and Loss

Refer to section 5.2 of PUB 62310.

At a Standard Speed of 19.2 kb/s, the Nyquist frequency for a line rate of 19.2 kb/s is 9.6 kHz and the Nyquist frequency for a line rate of 25.6 kb/s is 12.8 kHz.

5.2.2 Loop Conditioning

Refer to section 5.3 of PUB 62310.

At loop signal rates of 19.2 kb/s or 25.6 kb/s the total bridged tap does not exceed 1.83 km and the single longest bridged tap does not 1.83 km.

5.2.3 Loop Interference and Noise Requirements

Refer to section 5.4 of PUB 62310 and Table 5.3.3B of this document.

To meet the background noise objective at loop signal rates of 19.2 kb/s or 25.6 kb/s, the 40 Hz to 30 kHz (497F) background noise power is not to exceed -53 dBm.

5.3 Loop Design for DTU

5.3.1 Loop Assignment and Loss

A 2 wire non-loaded loop is a candidate for Dataroute assignment using DTU type DCTE if its one way Estimated Measured Insertion Loss (EML) between DNIC and DTU, based on 135 ohm terminations, is less than or equal to 39 dB at 40kHz.

The maximum Actual Measured Insertion Loss (AML) will be less than or equal to 42 dB at 40 kHz. The 3 dB difference between design maximum and measured maximum is reserved by the network as a margin which allows for seasonal variation in loop parameters.

5.3.2 Loop Conditioning

The **Dataroute** DTU loops will be non-loaded with bridged capacitors removed.

Bridged taps will be limited to 1.4 km cumulative total and loop configurations may include any of those shown in Figure 8 of ANSI T1.601-1988. Loops may consist of heavier gauges than those shown in T1.601 Figure 8 or may contain fewer gauge change points.

All loops will have an individual loop resistance less than or equal to 1400 ohms.

5.3.3 Loop Interference and Noise

Noise requirements are based on both ends of the loop being terminated in 135 ohm terminations. Requirements are established based on a special noise measuring set that provides results in dBrn. (0 dBrn = - 90dBm.) The set shall have a Butterworth passband with -3 dB points at 1 kHz and 60 kHz which incorporates 40 dB per decade stopband slopes.

Assuming a properly balanced 135 ohm termination and a noise measuring set with the characteristics stated in the preceding paragraph, the maximum measured noise level objective is 40 dBrn.

The impulse noise level objective specifies no greater than 7 events in a 15 minute period which exceed a threshold of 46 dBrn.

Table 5.3.3B Impulse Noise Threshold Requirements for STU and DSU

X: dBrn	Y: dBrn	AML (in dB) at Line Rate (in kbps): 1.2	2.4-3.6	4.8-7.2	9.6-12.8	19.2-25.6	56.0-72.0
59	65	0-25	0-24	0-20		0-20	0-16
58	64	25.1-26	24.1-25	20.1-21		20.1-21	16.1-18
57	63	26.1-27	25.1-26	21.1-22		21.1-22	18.1-19
56	62	27.1-28	26.1-27	22.1-23		22.1-23	19.1-20
55	61	28.1-29	27.1-28	23.1-24		23.1-24	20.1-21
54	60	29.1-30	28.1-29	24.1-25	0-19	24.1-25	21.1-23
53	59	30.1-31	29.1-30	25.1-26	19.1-20	25.1-26	23.1-24
52	58		30.1-31	26.1-27	20.1-21	26.1-27	24.1-25
51	57		31.1-32	27.1-28	21.1-22	27.1-28	25.1-26
50	56		32.1-33	28.1-29	22.1-24	28.1-29	26.1-27
49	55		33.1-34	29.1-30	24.1-25	29.1-30	27.1-28
48	54			30.1-31	25.1-26	30.1-31	
47	53			31.1-32	26.1-27	31.1-32	28.1-29
46	52			32.1-33	27.1-28	32.1-33	29.1-30
45	51			33.1-34	28.1-29	33.1-34	30.1-31
44	50				29.1-30		31.1-32
43	49				30.1-31		
42	48				31.1-32		32.1-33
41	47				32.1-33		33.1-34
40	46				33.1-34		

6.0 Transmitted Pulse Shape Requirements

Requirements in this section apply to all proposed access loop transmit signal interfaces. It is the purpose of this section to define the requirements for pulse shape and amplitude to provide a signal which can be properly recovered in a **Dataroute** office by an appropriate line port and to ensure that network protection requirements are met, in order to minimize the level of generating interference in the loop plant. Interference limitations and transmission levels are also discussed.

6.1 Signal Limitations for STU

To minimize the level of crosstalk interference in the loop plant, it is necessary to constrain the frequency distribution of energy in the STU loop signal.

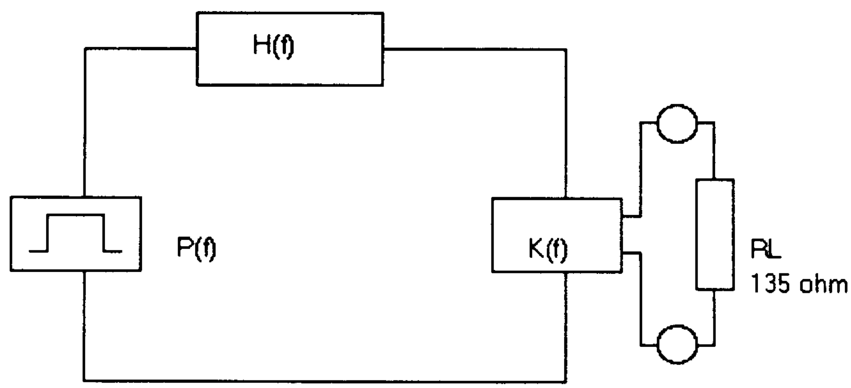
A. The STU pulse sequence uses a 50% duty cycle bipolar return to zero format with a restricted set of permitted bipolar violation sequences used for signalling, all '1' pattern substitution, and all '0' pattern substitution. Scrambling, or pseudo- randomizing, of the transmit signal before bipolar encoding is also used to further spread spectral energy for all customer data sequence patterns.

B. A nominal pulse waveform applicable to all rates is defined, and the data stream consists of a sequence of these pulses occurring at the loop bit rate with the multiplying coefficients satisfying the bipolar sequencing rule. The frequency domain constraints on the individual pulse are intended to control the spectral distribution of the bipolar pulse sequence.

6.1.1 Transmitter Model

The bipolar transmitter of the STU is presented as an idealized model consisting of an ideal pulse generator, an idealized filter, followed by an essentially infinite bandwidth bipolar driver/sequencer. Figure 6.1.1 illustrates this model. P(f) and H(f) are the Fourier transforms for the ideal pulse P(t) and filter transfer function H(t). K(f) is the Fourier transform for the bipolar driver. RL is the load impedance, assumed to be 135 ohm resistive.

Figure 6.1.1 Model of STU Transmitter



6.1.2 Rectangular Driving Pulse

The system excitation prior to any frequency shaping filters is defined as an ideal 50% duty cycle rectangular pulse of amplitude (A). (A) varies with the bit rate (R) so that the amplitude of the shaped bipolar pulse delivered to RL is such that the requirements of the Bell Canada Metallic Specification (Appendix A) are met for speeds from 1200 to 56000 b/s.

The design center values of the amplitude of the rectangular driving pulse delivered to RL for speeds from 1200 to 56000 bps are given below.

Table 6.1.2 Rectangular Driving Pulse Design Center Values for STU

Speed (bps)	Amplitude (volts, base to peak)
1200	1.1 volts
2400	0.8 volts
4800	0.7 volts
9600	0.45 volts
19200	1.4 volts
56000	1.4 volts

For satisfactory performance, the transmitter should maintain these values within +/- 5%.

The 50% duty cycle implies that the pulse maintains a constant value (A) for a duration of 1/2 the pulse unit interval 1/(2R), and is zero at all other times. The bipolar sequence is applied as a synchronous modulation of such pulses with a jitter of no more than +/- 5% of the bit interval around an ideal clock at the required rate (R).

6.1.3 Frequency Domain Constraint

Because deviations from the nominal pulse might have effects in particular frequency bands which would be large relative to the apparent differences from a nominal time domain pulse, the realization requirement for the 50% duty cycle pulse P(t) is stated directly in terms of the frequency domain Fourier transform as shown below.

$$P(f) = \frac{A}{(Pi)f} Sin[\frac{(Pi)f}{2R}]$$

where Pi = 3.14

6.1.4 Low Pass Shaping Filter

For all rates the driving pulse shall be subsequently shaped by a double pole low pass filter whose idealized transfer function H(f) is given below.

$$H(f) = \frac{1}{1 - [\frac{f}{1.3R}]^2 + j[\frac{f}{1.3R}]d}$$

where (d) is a damping factor whose value $0 < d \leq 2$ is selected depending on the filter characteristic desired (eg. flat passband, best delay, fastest roll-off, etc.).

6.1.5 Realization Constraints

The preceding descriptions of the frequency domain limits has been given in terms of an illustrative realization. It is not intended to specify a particular realization.

The composite frequency domain bound may be expressed as

$$L(f) = P(f)H(f)K(f)$$

Whatever the specific realization of L(f), the final constraint is that the Bell Canada Metallic Specification requirements set out in Appendix A shall be met for STU and DSU operation at all Standard Speeds of 1200 bps up to 56 kb/s; and the requirements set out in section 6.4 shall be met for the DTU.

6.1.6 Metallic Network Protection

The Bell Canada Metallic Specification Requirements for Network Protection in Appendix A of this document define the maximum permitted signal levels from directly connected customer provided facilities or equipment to metallic (copper wire) digital **Dataroute** access lines.

Appendix A of this document provides further requirements and limitations for the purpose of network protection. Maximum allowable signal energies are specified within certain frequency bands. Appendix A consists of Issue 3 of "Bell Canada Requirements for Connection of Equipment to Private Line Metallic Circuits".

All requirements set out in Appendix A shall be met except as otherwise provided herein.

6.2 Signal Limitations for the DSU

The design of the DSU, which has been under the control of AT&T, follows a transmitter design philosophy similar to the STU. The 1200 to 56000 b/s implementations of the DSU generally meet specifications similar to the STU.

6.2.1 Transmitter Requirement

Sections 6.0 through 6.3.3 of PUB 62310 comprehensively cover the transmitter signal limitations of the DSU.

6.2.2 Metallic Network Protection

The DSU type DCTE must meet BCMS network protection requirements as detailed in Appendix A for speeds from 1200 to 56000 bps. The average spectral energy output of a DSU to the loop is generally higher than that of the STU due primarily to different transmit filter characteristics and higher pulse amplitudes.

6.3 STU and DSU Limitations at 19.2 and 56 kb/s

The interference limitations for 19200 and 56000 bps STU and DSU type DCTE require special note. Both the 19.2 and 56 kbps STU and DSU type DCTE are implemented on selected pairs when necessary to prevent crosstalk interference with other sensitive services. This interference can arise because of the higher average power levels permitted in the higher frequency bands for the DCTE operating at these speeds. This means that the installation of the 19.2 or 56 kbps access loop is conditional on it not interfering with any susceptible services. If interference does occur, either the cable assignment for the DCTE (or the susceptible service) are changed, or other measures, as required, are taken to eliminate the interference problem.

6.3.1 Rectangular Driving Pulse

The idealized driving pulse maximum peak amplitude delivered to the transmit pair is 1.66 volts. This maximum level is the same for both the STU and DSU at the 19200 bps and 56000 bps rates. The design center amplitude for the maximum peak amplitude delivered to the transmit pair should be 1.4 volts peak to allow for component tolerances. For satisfactory performance, the transmitter is required to maintain its nominal peak amplitude within a +/- 5% range.

6.4 Signal Limitations for DTU

The DTU signal amplitude shall be 2.0 volts peak minimum and 2.5 volts peak maximum in accordance with ANSI T1.601-1988. The signal energy distribution shall meet the metallic out-of-band transmitted power requirement as provided in CS-03, section 3.4.3 Table 3.4(e) except that the maximum signal power in the band 12-70 kHz shall not exceed +12 dBm. Also, the signal shall not exceed limitations specified in ANSI T1.601-1988.

7.0 Receiver Characteristics

The signal received by the DCTE will be modified by individual characteristics of the actual cable pair loops employed.

The receiver shall present a balanced termination of 135 ohm to the line. This impedance shall remain constant from 100 Hz to two times the loop signal rate for the STU or DSU or from 1000 Hz to 200 kHz for the DTU.

8.0 General Requirements for Customer Provided Equipment

This section provides additional detailed requirements for customer provided DCTE connected to the loop facility.

8.1 Isolation from Ground

All loop facility pairs shall be isolated from the local ground reference. Resistance from Tip or Ring of any pair to ground shall exceed 300 kohm. The stray capacitance of Tip or Ring of any pair to ground shall not exceed 500 pF, and the difference between the capacitance to ground of the two conductors of any pair shall not exceed 100 pF.

8.2 Sealing Current Path

The DCTE is required to provide a DC current path on a balanced basis. The balance, which may be established by coupling transformers or terminating resistors, shall be held to a maximum difference of 5% in self inductance or resistance value. This DC path is used to complete a sealing current circuit driven by the line port in the **Dataroute** office.

The absence of sealing current shall not be considered abnormal and shall not affect the data transmission operation of the DCTE. Sealing current may be continuous or intermittent.

8.2.1 STU Requirements

The simplex termination shall be such that DC currents in the range of 4 to 20 mA shall pass between the receive pair and the transmit pair when a simplex voltage of either polarity between 7 and 24 VDC is applied.

8.2.2 DSU Requirements

The requirements for the DSU are described in PUB 62310, section 8.2.

8.2.3 DTU Requirements

The requirements are set out in ANSI T1.601-1988, section 7.5.

8.3 Protection of Customer and Network Safety

The DCTE devices shall comply with all applicable Canadian Standards Association and Canadian Electrical Code requirements and be certified by the CSA.

In addition, the network protection requirements specified in Appendix A shall be met.

9.0 Signal Coding Requirements

Signal coding and scrambling (randomizing) procedures are specified in this section.

9.1 Loop Signal Formats

9.1.1 STU Signal

The STU uses a baseband, bipolar return-to-zero format signal for transmission over the local loop. A bipolar violation (BPV) is deliberately introduced in certain situations. (For information about this format and definition of a BPV see - 9.1.2 DSU Signal.)

The STU uses bipolar violation (BPV) sequences for three purposes:

A. Zero substitution
   Groups of 7 consecutive '0' bits are substituted by a BPV code. This is to ensure sufficient pulse density to allow clock recovery from the line signal.

B. Ones substitution
   Groups of 7 consecutive '1' bits are substituted by a BPV code. This helps to spread spectral energy allowing higher pulse amplitudes.

C. Control Sequence Preamble
   Supervisory signalling is preceded by a 7 bit BPV code. This flags the 20 bits that follow as control information rather than customer data. The 20 bit transmit and receive control code sequences are not scrambled in format. (Only customer data is scrambled; see section 9.2).

9.1.2 DSU Signal

The DSU uses a baseband, bipolar return-to-zero format signal for transmission over the local loop. The following basic coding rules apply:

A. A binary '0' (zero) is transmitted as zero volts across the pair.

B. A binary '1' (one) is transmitted as either a positive or negative pulse across the pair, opposite in polarity to the previous binary '1'.

A deliberate bipolar violation (BPV) can be made to occur by introducing a violation of the alternate polarity rule. For example, the bipolar rule could be violated by transmitting two consecutive negative '1' pulses. The circumstances under which BPV signals are transmitted are described in detail in PUB 62310, sections 9.0 through 9.3.

In this document, the following notation is applied concerning the BPV:

0	Denotes zero volts transmitted (binary zero)
B	Denotes +/- A volts with polarity determined by the bipolar rule (binary one)
V	Denotes +/- A volts with polarity in violation of the bipolar rule (binary one)
X	Denotes 0 or B, depending on required polarity of a violation
N	Denotes the bit value is disregarded, and a binary 0 or 1 may be found

9.1.3 DTU Signal

The DTU employs the 2B1Q format described in detail in ANSI T1.601-1988.

9.2 Scrambling

9.2.1 STU Scrambling

Customer data signals are pseudo randomized or scrambled by the STU prior to pulse shaping and bipolar coding. The scrambler is used to ensure an even spread of spectral energy on the access loop.

The scrambler used in the STU transmitter, and the complementary descrambler used in the STU receiver, belong to a class of scrambler/descrambler known as self synchronizing. This means that the descrambler will automatically align itself with the scrambled signal after about seven bits are received and thereafter will remain in sync with the scrambler as long as a scrambled signal is received.

There is no preferred initialization pattern for the scrambler/descrambler logic. This type of simple scrambler is prone to some lock up[1] modes, depending on scrambler register contents. The 7 ones and 7 zeroes substitution sequences (see 9.1.1) mitigate the affects of an all 1 or all 0 scrambler lock up.

1 A lock up mode is one where the scrambler does not alter the content of the input sequence. For example, if the scrambler registers contained all zeroes and the input sequence was all zero bits, then the output pattern from the scrambler would be all zero also

The primitive generating polynomial for the scrambler and descrambler is described using the following notation:

S	Denotes an arbitrary unscrambled send data sequence
R	Denotes an arbitrary descrambled receive data sequence
Z	Denotes the scrambled data sequence
(t)	Denotes the current data rate clock interval
x(t+n)	Denotes the nth previous data rate clock interval
$\pm$	Denotes modulo 2 addition, where the rules of addition are
	$0 \pm 0 = 0$
	$0 \pm 1 = 1$
	$1 \pm 0 = 1$
	$1 \pm 1 = 0$

The equation for the scrambler is:

$$Z(t) = S(t) \pm Z(t+1) \pm Z(t\text{-}7)$$

or

$$Z(t) = \frac{S(t)}{1 \pm (t+1) \pm (t+7)}$$

The equation for the descrambler is:

$$R(t) = Z(t) \pm Z(t+1) \pm Z(t+7)$$

or

$$R(t) = [Z(t)]\ [\ 1 \pm (t+1) \pm (t+7)\ ]$$

The term $1 \pm (t+1) \pm (t+7)$ represents the generating polynomial. The scrambler is described as dividing the input sequence {S} by the generating polynomial. The descrambler is described as multiplying the the scrambled input sequence {Z} by the generating polynomial.

There shall be a descrambler in the STU receiver since data transmitted to the STU from the **Dataroute** office is scrambled.

Note that the 20 bit transmit and receive control code sequences are not scrambled in format. Only customer data is scrambled.

9.2.2 DSU Scrambling

Customer data bits are transmitted transparently using the methods (BPV format or D bit positions) described in PUB 62310.

9.2.3 DTU Scrambling

After rate adaption, customer data bits are entered into B bit positions and multiplexed with other bits prior to scrambling. The multiplexing and scrambling and descrambling processes are described in detail in ANSI T1.601-1988.

9.3 Encoding and Decoding Procedures

The transmit and receive sections of the DCTE shall code and decode sequences to indicate various control states, substitution patterns, and status indications.

The X bit provides a means for controlling an undesirable DC buildup on the line if unrestricted insertion of violations was allowed. The desired polarity alternation of the V's is achieved by assigning a value 0 or B to X such that the total number of B bits since the last V is odd.

If pulses of the same polarity were adjacent, performance would be degraded. Therefore, the X and V bits are separated by a 0, resulting in an X0V pattern as part of each BPV sequence.

9.3.1 STU Encoding

The following three BPV codes shall be generated by the STU:

A. Zero Substitution
7 consecutive '0' transmit bits are replaced with the sequence 0000X0V with the V bit being the last bit in the sequence. This code applies to all bit rates.

B. Ones Substitution
7 consecutive '1' transmit bits are replaced with the sequence BB00X0V with the V bit being the last bit in the sequence. This code applies to all bit rates.

C. Control Sequence
The control preamble consists of a 7 bit BPV Preamble sequence followed by 10 bits of control code and 10 bits of the complement of the control code bits. The BPV sequence is
B0B0X0V with the V bit being the last bit in the sequence. This code applies to all bit rates.

The assignment of the 10 bit codes for the STU is explained in section 9.4.

9.3.2 STU Decoding

The following actions shall take place upon receipt of any of the BPV sequences described in section 9.3.1:

A. Zero Substitution
Upon receipt of the 7 '0' BPV code sequence, the STU shall decode it as 7 binary 0's. This applies to all bit rates.

B. Ones Substitution

Upon receipt of the 7 '1' BPV code sequence, the STU shall decode it as 7 binary 1's. This applies to all bit rates.

C Control Sequence Preamble

Upon receipt of the 7 bit BPV preamble code, the STU shall examine the next 20 receive bits to determine what action is required. Section 9.4 for STU code assignment details.

9.3.3 DSU Encoding and Decoding

The encoding and decoding procedures for the DSU are described in detail in PUB 62310, section sections 9 through 9.2.3. See section 10 of this document for further information.

9.3.4 DTU Encoding and Decoding

Customer operated control states are coded together with the associated customer data by the method specified in V.110 for all Standard Speeds between 1.2 kb/s and 19.2 kb/s.

At the Standard Speed of 56 kb/s when a Data Transfer State (corresponding with the Request to Send = ON condition in a DSU) exists, customer data is rate adapted in accordance with V.110.

At the Standard Speed of 56 kb/s when an Idle State (corresponding with Request to Send = OFF condition in a DSU) exists, the 1st through 7th bit of each octet are set to '1' and the 8th bit of each octet is set to '0'.

Transitions between Data Transfer State and Idle State may be used for conveyance of signalling information in some applications including **Dataroute** access to circuit switched digital services of the type described in PUB 41458.

At the Standard Speed of 300 b/s asynchronous, customer operated control states are rate adapted by the V.110 method for 2.4 kb/s (see also 10.4 - DTU Requirements).

At a speed of 38.4 kb/s the following method applies:

Octet number:	Bit number: 1	2	3	4	5	6	7	8
1	1	D1	D2	D3	D4	D5	D6	S1
2	1	D7	D8	D9	D10	D11	D12	X
3	0	D13	D14	D15	D16	D17	D18	S3
4	0	D19	D20	D21	D22	D23	D24	S4
5	1	0	1	1	E4	E5	E6	E7

The definition of bits labeled in the above table shall be as provided in V.110 section 2.2.

9.4 STU Code Assignments

Upon receipt of a BPV preamble sequence, the STU shall examine the following 20 bits to determine what action, if any, is required.

In the transmit direction, the change of state of the DTE control leads mentioned in section 2.3 may cause the STU to generate a control code sequence of 20 bits preceded by a BPV preamble sequence. Transmit and receive code sequences are not scrambled.

The general format of the control sequence is:

[7 bit BPV code][10 bits control data][10 bits complement of control data]

The complement of the 10 bit control data sequence is a 10 bit sequence where all the 1's and 0's of the 10 bit control sequence are interchanged. For example, if the 10 bit control sequence was 1110000100 then the 10 bit complement sequence would be 0001111011. The complement sequence is used to verify the integrity of the control sequence.

The total control code sequence, including BPV preamble, is 27 bits long.

9.4.1 Transmit Codes

In the following explanations, the 10 bit code is described in terms of relative bit positions numbered 1 to 10. Bit 1 is the first bit of the sequence transmitted and bit 10 is the last bit of the sequence transmitted. The ON and OFF condition is indicated by a binary 1 or 0. Certain bits are always set to a binary 1 or 0 condition.

Code Bit Position	Use	ON	OFF
1	RS-232 CA (RTS)	0	1
2	RS-232 CD (DTR)	0	1
3	BUSY OUT (BO)	0	1
4	STU FAULT (FLT)	1	0
5	UPDATE REQUEST (UR)	1	0
6	STU LOOP STATUS (LB)	1	0
7	SPARE	0	0
8	BIT DENSITY	1	1
9	SPARE	0	0
10	SPARE	0	0

Note for the EIA terms CA, CD and BO shown in the table above, an EIA RS-232 ON condition is equivalent to a logic level 0, and an EIA RS-232 OFF condition is equivalent to a logic level 1.

For example, if the CA lead was ON at the EIA interface of the STU, bit #1 of the transmit signal code would be set to a 0.

An examination of the 10 bit code sequence shows that a possible combination exists whereby 7 binary 0's may be generated (CA, CD, BO = ON, FLT, UR, LB=OFF). This would cause a BPV sequence for 7 zero substitution to be generated. This condition shall not be allowed. BPV sequences cannot be nested within a control code sequence. To prevent the nested BPV sequence, the 7 ones and 7 zeroes substitution logic should be disabled during the generation of a control code sequence. In other words, 7 zeroes or 7 ones are allowed in a control code.

The 10 bits in the code sequence represent the following conditions:

Bit 1 Follows the state of EIA RS-232 lead CA also known as Request To Send (RTS). This lead shall be programmable, that is, it shall be possible to force bit 1 to an ON condition or have it dynamically follow the condition of lead CA on the RS-232 interface.

Bit 2 Follows the state of EIA RS-232 lead CD also known as Data Terminal Ready (DTR). This lead shall be programmable, that is, it shall be possible to force bit 2 to an ON condition or have it dynamically follow the condition of lead CD on the RS-232 interface.

Bit 3 Follows the state of pin 25, designated Busy Out (BO) on the EIA RS-232 interface. This lead shall be programmable, that is, it shall be possible to force bit 3 to an OFF condition or have it dynamically follow the condition of lead BO on the RS-232 interface.

Bit 4 Is generated by the STU when it detects a fault with itself.

Bit 5 Is generated by the STU when it wants an update of its Receive Control status from the **Dataroute** office ORU.

Bit 6 Is generated by the STU to indicate to the ORU in the **Dataroute** office whether or not it is in a loop back condition.

Bit 7 This bit is spare and shall be set to a binary 0 state at all times.

Bit 8 This bit is used to ensure sufficient binary 1's density and shall be set to a binary 1 state at all times.

Bit 9 This bit is spare and shall be set to a binary 0 state at all times.

Bit 10 This bit is spare and shall be set to a binary 0 state at all times.

9.4.2 Receive Codes

The interpretation of the 10 relative bit positions is similar to the transmit code case, that is, bit 1 is the first bit of the received code sequence and bit 10 is the last bit of the received code sequence. The ON and OFF condition is indicated by a binary 1 or 0. An 'N' indicates that the bit content is to be disregarded. Either a binary 1 or 0 may be found in such bit positions.

Code Bit Position	Use	ON	OFF
1	RS-232 CF (CO)	0	1
2	RS-232 CC (DSR)	0	1
3	RS-232 CE (RI)	1	0
4	SYS ERROR (ERR)	1	0
5	UPDATE REQUEST (UR)	1	0
6	SPARE	N	N
7	STU LOOP COMMAND (DOLP)	1	0
8	SPARE	N	N
9	SPARE	N	N
10	SPARE	N	N

Note for the EIA terms CF and CC shown in the table above, an EIA RS-232 ON condition is equivalent to a logic level 0, and an EIA RS-232 OFF condition is equivalent to a logic level 1. For EIA term CE, the interpretation depends on the bit rate being received.

For example, if bit #1 was detected as a 0, then the lead CF on the STU interface would be set to an EIA RS-232 ON.

The 10 bits in the receive code represent the following conditions:

Bit 1 Follows the status of EIA RS-232 signal CF, also known as Carrier On (CO) or Carrier Detect. This lead shall be programmable, that is, it shall either follow the status of the bit in the receive control code sequence or be forced to an EIA RS-232 'ON' condition towards the customer's DTE.

Bit 2 Follows the status of EIA RS-232 signal CC, also known as Data Set Ready (DSR). It is advisable that this lead be programmable in the same fashion as bit 1 above.

Bit 3 Follows the status of EIA RS-232 signal CE, also known as Ring Indicator (RI). It is advisable that this lead be programmable so that lead CE towards the customer's DTE is OFF, or so that lead CE follows the receive control code sequence.

Bit 4 Follows the SYSTEM ERROR signal from the **Dataroute** office. May indicate a fault somewhere in the network.

Bit 5 **Update** Request bit. When received as ON, commands the STU to send a transmit control code sequence towards the **Dataroute** office.

Bit 6 Spare. May contain either a binary 1 or 0.

Bit 7 STU Loopback command bit. When received as ON, commands the STU to go into a loopback condition towards the **Dataroute** office and to transmit a control code sequence with transmit bit 6 (LP) ON to indicate that the STU has gone into a loopback condition.

Bit 8 Spare. May contain either a binary 1 or 0.

Bit 9 Spare. May contain either a binary 1 or 0.

Bit 10 Spare. May contain either a binary 1 or 0.

During receipt of a control code, the receive data lead (BB) towards the customer should be forced to a binary 1 (MARK hold) condition to prevent control code information from being received by the customer's DTE.

9.4.3 Initiation of Control Sequences

The STU shall initiate a control code sequence towards the **Dataroute** office under the following conditions (Note that unless otherwise stated, the ON and OFF conditions referred to are logic level ON and OFF). Where two or more consecutive code sequences are transmitted, each sequence must be separated from the following sequence by a one bit-time interval. This interval bit must always be set to a 1 state.

A. If the set of three EIA control leads CA, CD, and BO are in any other state than CA = ON, CD = ON, and BO = OFF, then control code sequences shall be transmitted continuously towards the **Dataroute** office until the above states are achieved. Note that since CA, CD, and BO are individually programmable, the actual state of the customer's DTE control leads shall not necessarily cause the generation of a control code sequence.

B. Upon power up of the STU, a control code sequence shall be sent.

C. Whenever the receive line bipolar signal is lost or recovered, a control code sequence shall be sent.

D. If the 10 bit complement field in a receive control code sequence is incorrect, a control code sequence shall be sent with the Update Request bit ON.

E. When a valid receive control code sequence is received with its Update Request bit ON, the STU shall generate a transmit control code sequence.

F. When a valid receive control code sequence is received with the STU Loopback Command (DOLP) bit ON, then the STU shall generate a control code sequence with the STU Loop Status (LP) bit ON.

G. When the STU detects a fault condition with itself, or any other abnormal condition, it shall generate a control code sequence continuously towards the **Dataroute** office with the STU Fault (FLT) bit ON. Only when the fault condition is cleared or normalized shall the STU stop transmission of the control code sequences.

10.0 Other Coding Requirements

This section briefly outlines the additional coding requirements that are required when DCTE units other than the STU are used in the access loop.

10.1 DSU Requirements

The coding requirements for the DSU type DCTE are defined and explained in PUB 62310, sections 9.0 through 12.0. Note that at the present time, **Dataroute** does not make use of secondary channel capabilities when DSU type DCTE are utilized. The DSU requirements described in PUB 62310 do not include 1.2 kb/s synchronous, 19.2 kb/s synchronous, 300 b/s asynchronous or 1200 b/s asynchronous operation which are described here.

The 1.2 kb/s Standard Speed synchronous channel shall be transmitted with all other characteristics, including loop signalling rate and signal level, except the DTE interface clock rate, being the same as those used for the 2.4 kb/s Standard Speed. This involves transmission of each customer data bit twice at a 2.4 kb/s rate. Recovery of the customer data is accomplished by presenting every second bit received at the DTE interface together with appropriate 1.2 kb/s clock signals.

The 19.2 kb/s Standard Speed synchronous channel shall be transmitted using a loop signal rate double the rate used for the 9.6 kb/s Standard Speed. The loop signal amplitude and spectrum shall be as specified in sections 6.2 of this document.

The 1200 b/s Standard Speed asynchronous channel shall be converted into a synchronous bit stream using the process specified in section 13 of this document. After conversion, the 1.2 kb/s stream shall be transmitted by the method specified above for 1.2 kb/s synchronous customer data. Clock signals at a 2.4 kb/s rate may be present at the DTE interface since they are not used by an asynchronous DTE.

10.2 DTU Requirements

Customer data is rate adapted for each of the Standard Speeds, except 300 b/s asynchronous, as specified in section 9.3.4.

For 300 b/s asynchronous data, samples are taken at 2.4 kb/s and the 2.4 kb/s signal is rate adapted as specified in section 9.3.4.

Rate adapted data is transmitted on Channel B1 as defined in ANSI T1.601-1988 unless, at the discretion of the **Dataroute** access line provider, other arrangements are made at the time of subscription.

Dataroute delivers customer data bits in serial bit order but does not guarantee these bits to be delivered in the same byte order or octet order that they were accepted in.

11.0 Multipoint Operation

This section describes the implications of **Dataroute** multipoint channel operation as they apply to the DCTE.

Multipoint operation permits the broadcast of information from a control station to a number of tributary stations. Each tributary in turn transmits information to the control station. Both tributaries and control stations shall operate at the same speed.

In the **Dataroute** network at the present time, most multipoint circuits are routed through bridging devices which do not propagate sudden transitions of the RTS/CD control lead. In the future, new bridging methods which have this capability may also be employed.

Multipoint circuits are possible at all the tariffed **Dataroute** synchronous Standard Speeds.

11.1 **Dataroute** Channel Multipoint Operations

All multipoint circuits in the **Dataroute** network operate in a duplex fashion. Transmission of EIA RS-232 DTE control lead status is not presently provided. Prevention of data transmission collisions between tributaries is the responsibility of the control station, and is usually accomplished by the use of polling techniques and ARQ protocols. Idle tributary stations should present a continuous 1 sequence (sometimes called a MARK hold condition) to the STU on its send data lead (BA).

11.2 STU Application

The STU, when used on an access loop for multipoint operation, must be optioned so that EIA RS-232 leads CA, CD, and BO from the customer's DTE are ignored and these leads are forced to their normal states internally in the STU (ON, ON, and OFF respectively). In addition, EIA RS-232 control leads CF, CC, and CE towards the customer's DTE are forced ON, ON, and OFF respectively. Lead CA to CB (RTS/CTS) delay is set to 0 milliseconds.

Control code sequences due to loss or recovery of the line signal and due to a power up condition of the STU should be transmitted since these are potentially serious service affecting conditions (see 9.4.3).

11.3 DSU Application

As presently used in the **Dataroute** network, the DSU is primarily operated as if it was part of a point-to-point circuit connection. In the event that new bridging methods for multipoint circuits are used, the operating characteristics described in PUB 62310, sections 13.0 through 13.2.2.2 are applicable.

11.4 DTU Application

An option may be provided to fix the Request to Send bit in the ON condition. In the event that new bridging methods are used, operating characteristics similar to those described in PUB 62310, sections 13.0 through 13.2.2.1 are applicable.

12.0 Operation of Channel Loopbacks

In order to meet availability objectives, loopback codes are used to allow rapid sectionalization of trouble to various parts of the network or the access arrangement. Remotely controlled loopbacks are activated by testers in **Dataroute** offices.

12.1 STU Methods

The STU remote loopback command is embedded in a receive control code sequence as described in section 9.4.2. Upon receipt of this code, the STU loops back towards the network all of its logic and circuitry with the exception of the DTE interface drivers and receivers. It also sets its Loop back status bit (LP) and generates a transmit control code sequence towards the **Dataroute** office. Thereafter, the STU is transparent to data from the tester location; however, it is able to receive and decode all BPV code sequences.

Upon receipt of a control code from the network commanding that the loopback be terminated (DOLP=OFF), the STU shall comply and restore all conditions to their pre-loopback state and re-enable its transmit code generator.

During a loopback test, the receive data lead towards the customer's DTE (BB) shall be held in the binary 1 state or looped back to the send data lead from the customer. The control leads CB (CTS), CC (DSR), CE (RI) and CF (CO) toward the customer from the STU should be treated in the following fashion:

CB Follows the state of CA (RTS) with whatever delay has been programmed or, optionally, is set to an EIA ON state (see section 2.3)

CC If optioned to follow bit 2 of the receive control code sequence, lead CC should go to an EIA OFF condition when a loop command is detected. If optioned permanently to an EIA ON state, then CC should remain at an EIA ON state during a loop test. (see section 9.4.2)

CE If optioned to follow bit 3 of the receive control code sequence, lead CE should continue to follow the state of bit 3 during the loop test. If lead CE is programmed permanently to an EIA OFF state, it should remain at an EIA OFF state during a loop test. (see section 9.4.2)

CF If optioned to follow bit 1 of the receive control code sequence, lead CF should continue to follow the state of bit 1 during the loop test. If lead CF is programmed permanently to an EIA ON state, it should remain at an EIA ON state during a loop test. (see section 9.4.2)

The transmit code generator of the STU should be disabled during a loopback test. Changes of state on EIA control leads CA. CD and BO towards the STU will be ignored during a loopback test. Upon termination of the loopback test, the STU must enable its transmit code generator and restore the EIA control leads to the status they had before the loop test was commenced.

The STU loopback is what is termed a "latching loopback" condition.

12.2 DSU Methods

The methods of loopback operation for the DSU type DCTE are described in PUB 62310, sections 14.0 through 14.3.

12.3 DTU Methods

The methods of loopback control are described in ANSI T1.601-1988. As described, loopback control signals are conveyed using the M Channel.

13.0 Asynchronous Transmission Requirements

Asynchronous transmission at Standard Speeds of equal to (or greater than) 1.2 kb/s involve a conversion to a synchronous format. The conversion method is described in section 13.1 below. Following conversion, the synchronous bit stream is rate adapted as specified in sections 9 and 10 of this document. The **Dataroute** network asynchronous character rate tolerance (to other than nominal bit element timing variations) is +1% / -2.5%. In addition, transmission of the "Break" signal condition (as defined in V.14) is also supported.

13.1 Asynchronous/Synchronous Conversion

The asynchronous data shall follow the formats recommended in V.4 with respect to the use of parity bits. Odd, even, or no parity are permissible. Total character length of the asynchronous characters, including start and stop elements, may be either 9 or 10 bits.

The method of conversion specified in V.14 for Extended Range (+2.3% / -2.5% character rate tolerance) is employed. A brief description of this process follows:

To transfer the asynchronous data bits into the synchronous bit stream, contiguous bits, including start and stop bits, from an asynchronous character are re-clocked at the synchronous rate. When no asynchronous characters bits are offered by the DTE (mark idle condition) the synchronous stream shall consist of a series of binary 1's. When over-speed characters are offered, up to one stop bit in four shall be discarded. In the synchronous to asynchronous conversion process, the synchronous stream is examined for any missing stop bits. As per V.14, the missing stop element is re-inserted and the time made up through 25% reduction of stop bit durations (to 75% of a nominal bit interval) within a four character period.

This method enables the transmission of asynchronous customer data over a synchronous bit stream (prior to rate adaption) of equal bit rate. To enable the clean transfer of Break signals which are proceeded by a mark condition, the conversion process may incorporate a one to two character delay.

In addition, an automatic range feature for response to over-speed characters may be incorporated as follows:

The synchronous to asynchronous converter shall, if it fails to receive a stop bit, reduce the duration of the stop interval of the next eight characters which it presents to the receiving DTE by a decrement of 12.5% of the unit interval, to a maximum of 25%. Thereby, for a continuous character stream; if one stop element in four has been deleted, then characters shall be presented with stop intervals equal to 75% of the nominal unit interval; and if one stop element in eight has been deleted, then characters shall be presented with stop intervals equal to 87.5% of the nominal unit interval.

In addition, the DCTE is shall support asynchronous operation at speeds of 2.4, 4.8, and 9.6 kb/s and may support 19.2 kb/s.

In addition, a DTU using the rate adaption method described in section 10.2, may support 38.4 kb/s.

14.0 General Timing and Jitter Requirements

14.1 Timing Accuracy

The term "timing accuracy" is used to describe the difference between the frequency of the received pulses and the nominal data rate. The following specifications apply:

A. Customer to Network:
The transmitted data shall be synchronous with the received data.

15.1 STU and DSU Connecting Arrangement

An eight conductor keyed jack similar to arrangement CA-48S in CS-03, and having the following contact assignments:

Pin 1 Ring Customer Transmit
Pin 2 Tip Customer Transmit
Pin 3 reserved
Pin 4 not connected
Pin 5 not connected
Pin 6 reserved
Pin 7 Tip Customer Receive
Pin 8 Ring Customer Receive

This jack is identical to the RJ48S and SJA 56 used in the United States.

15.2 DTU Connecting Arrangement

An eight conductor non-keyed jack similar to arrangement CA-A11 in CS-03, but having the following contact assignments:

Pin 1 reserved
Pin 2 reserved
Pin 3 reserved
Pin 4 Tip Transmit and Receive
Pin 5 Ring Transmit and Receive
Pin 6 reserved
Pin 7 reserved
Pin 8 reserved

It is cautioned that accidental reversals of the Tip and Ring conductors can sometimes occur. DTU designs shall be contructed to operate without regard to the polarity of the Tip and Ring conductors.

B. Network to Customer:

Under normal conditions, the frequency of the received data agrees with the nominal data rate to within +/- 2 parts in 10_9. Some trouble conditions result in a frequency variance of +/- 0.005% with respect to the nominal data rate.

14.2 Isochronous and Peak Individual Jitter Distortion

Specifications:

A. Customer to network

The Peak Individual distortion of the data transmissions from the customer to the network shall not exceed 5% of a bit interval relative to a reference clock in phase with the mean of the significant transmissions when receiving random data from the network. (The bit interval is the reciprocal of the data rate.) The Isochronous distortion of data transmissions from the customer to the network shall not exceed 10% of a bit interval when receiving random data or periodic patterns from the network.

B. Network to customer

The effects of random noise, inter-symbol interference and data pattern variations may cause data transitions to occur anywhere within the signaling interval. It is expected that inter-symbol interference and pattern variations may be dominant in establishing the average statistics of the received data signal.

15.0 Physical Network Access Line Interface

The interface from both the STU and DSU type DCTE consists of four conductors which are paired to provide a receive pair and a transmit pair. The interface from the DTU type DCTE consists of two conductors which are paired to provide a transceive pair. In the past, various connection arrangements (including hard-wired connectorless arrangements) have been employed. A specific connection arrangement has not yet been designated in CS-03 expressly for the purpose of digital network access line termination.

The following connecting arrangements will be employed by British Columbia Telephone Company during the period prior to implementation of a national standard in Canada. It may be noted that the connecting arrangements employed are similar to arrangements proposed by standards organizations recognized in the U.S.A. and are anticipated to become North American standards.