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SERIES V: DATA COMMUNICATION OVER THE TELEPHONE NETWORK

Transmission quality and maintenance

Test procedure for evaluation of 2-wire 4-kHz voiceband duplex modems

ITU-T Recommendation V.56 *ter*

(Previously "CCITT Recommendation")

ITU-T V-SERIES RECOMMENDATIONS

DATA COMMUNICATION OVER THE TELEPHONE NETWORK

1 – General
2 – Interfaces and voiceband modems
3 – Wideband modems
4 – Error control
5 – **Transmission quality and maintenance**
6 – Interworking with other networks

For further details, please refer to ITU-T List of Recommendations.

FOREWORD

The ITU-T (Telecommunication Standardization Sector) is a permanent organ of the International Telecommunication Union (ITU). The ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Conference (WTSC), which meets every four years, establishes the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1 (Helsinki, March 1-12, 1993).

ITU-T Recommendation V.56 *ter* was prepared by ITU-T Study Group 14 (1993-1996) and was approved under the WTSC Resolution No. 1 procedure on the 16th of August 1996.

NOTES

1. In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

2. The status of annexes and appendices attached to the Series V Recommendations should be interpreted as follows:

- an *annex* to a Recommendation forms an integral part of the Recommendation;
- an *appendix* to a Recommendation does not form part of the Recommendation and only provides some complementary explanation or information specific to that Recommendation.

CONTENTS

Foreword

This Recommendation is intended to provide a common basis for comparison of modem performance. Different test procedures described in this Recommendation emphasize different modem applications. The Throughput versus network model coverage test procedure, for example, is important for evaluating modem performance when used in asynchronous file transfer applications; the Error Rate versus Network Model Coverage test procedure is important for evaluating modem performance in synchronous or asynchronous network applications.

No single test is comprehensive enough to determine which modem will perform best in all applications, but this series of tests permits the gathering of sufficient data on a modem to determine its strengths and weaknesses.

Individual users shall decide which factors are important for their particular application or applications.

There are two annexes and eight appendices in this Recommendation. Annexes A and B are normative and are considered part of this Recommendation; Appendices I through VIII are informative and are not considered part of this Recommendation.

Introduction

Because of the lack of consistent test procedures and criteria for interpretation of results, modem performance evaluations historically have resulted in widely varying modem comparisons. This Recommendation was adopted from the ANSI TIA TSB-38 "Test Procedure for Evaluation of 2-wire 4-kilohertz voiceband duplex modems", which was created by TIA TR-30.3 to resolve this problem.

This Recommendation provides a consistent set of repeatable test procedures designed to characterize the performance of modems. This is achieved by stating the precise configuration of all the required test equipment, then giving step-by-step instructions for performing each test. This Recommendation also suggests some formats for analysing, interpreting, and presenting the results.

TEST PROCEDURE FOR EVALUATION OF 2-WIRE 4- kHz VOICEBAND DUPLEX MODEMS

(Geneva, 1996)

1 Scope

This Recommendation specifies the procedures for testing 2-Wire 4-kHz Voiceband Duplex Modems that operate over the Public Switched Telephone Network (PSTN). These procedures apply regardless of the manufacturer, type, or implementation of the modem.

Due to ongoing developments within ITU Study Group (SG) 14 in the fields of modems, future enhancements of this Recommendation with regard to:

- compression of synchronous data;
- simultaneous voice and data modems;
- DTE-DCE interface matters; and
- startup times,

are likely to take place.

2 Normative references

The following Recommendations and other references contain provisions that, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; all users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent editions of the Recommendations and other references listed below. A list of currently valid ITU-T Recommendations is regularly published.

- CCITT Recommendation O.151 (1992), *Error performance measuring equipment operating at the primary rate and above*.
- CCITT Recommendation V.1 (1972), *Equivalence between binary notation symbols and the significant conditions of a two-condition code*.
- ITU-T Recommendation V.14 (1993), *Transmission of start-stop characters over synchronous bearer channels*.
- ITU-T Recommendation V.24 (1993), *List of definitions for interchange circuits between Data Terminal Equipment (DTE) and Data Circuit-Terminating Equipment (DCE)*.
- CCITT Recommendation V.25 *bis* (1988), *Automatic calling and/or answering equipment on the General Switched Telephone Network (GSTN) using the 100-series interchange circuits*.
- ITU-T Recommendation V.25 *ter* (1995), *Serial asynchronous automatic dialling and control*.
- ITU-T Recommendation V.42 (1993), *Error-correcting procedures for DCEs using asynchronous-to-synchronous conversion*.
- CCITT Recommendation V.42 *bis* (1990), *Data compression procedures for Data Circuit-Terminating Equipment (DCE) using error correction procedures*.
- ITU-T Recommendation V. 56 *bis* (1995), *Network transmission model for evaluating modem performance over 2-wire voice grade connections*.
- ANSI X3.4-1986, *Coded character set – 7-Bit American National Standard Code for Information Interchange (referred to herein as "ASCII")*.
- ANSI X3.15-1976 (R1983), *Bit Sequencing of the American National Standard Code for Information Interchange in serial-by-bit data transmission*.
- ANSI X3.16-1976 (R1983), *Character structure and character parity sense for serial-by-bit data communication in the American National Standard Code for Information Interchange*.

– ANSI/EIA/TIA-232-E-1991, *Interface between data terminal equipment and data circuit-terminating equipment employing serial binary data interchange*.

– ANSI/EIA-404-A-1986, *Standard for start-stop signal quality for non-synchronous data terminal equipment*.

– ANSI/EIA-449-1984, *General purpose 37-position and 9-position interface for data terminal equipment and data circuit-terminating equipment employing serial binary data interchange*.

– ANSI/EIA/TIA-530-A-1992, *High speed 25-position interface for data terminal equipment and data circuit-terminating equipment, including alternative 26-position connector*.

– ANSI/EIA/TIA-561-1990, *Simple 8-position non-synchronous interface between data terminal equipment and data circuit-terminating equipment employing serial binary data interchange*.

– ANSI/EIA/TIA-574-1990, *9-position non-synchronous interface between data terminal equipment and data circuit-terminating equipment employing serial binary data interchange*.

3 Definitions

For the purposes of this Recommendation, the following definitions shall apply.

3.1 **asynchronous**: The transmission of characters (over a DTE-to-modem port interface) or other signal elements (over a line interface) at irregular times without a bit clock signal being sent at the same time.

3.2 **bit**: Acronym for "binary digit", which can have one of two values (0 or 1). When describing parts of an asynchronous character, "bit" is used to refer to a signalling element.

3.3 **bit-error ratio; BER**: Ratio of erroneous bits to total bits received at a DTE-to-modem interface.

3.4 **block**: Group of contiguous bits.

3.5 **block-error ratio; BLER**: Ratio of erroneous blocks to total blocks received at a DTE-to-modem interface.

3.6 **British Telecom Ziv-Lempel; BTLZ**: Compression algorithm used in Recommendation V.42 *bis*.

NOTE – The order of the letters "LZ" and the name "Ziv-Lempel" is not a typographical error.

3.7 **buffered mode; normal mode**: Mode of data transmission whereby the V.24 circuits 103 (transmit data) and 104 (receive data) transfer data at a port rate independent of the line rate. The difference in transfer rates is compensated for by buffering data as required in the modem. Neither error correction protocols nor data compression algorithms are used. For modem modulation methods which transfer data synchronously, V.14 synchronous/asynchronous conversion is used within the modem.

3.8 **byte**: Group of 8 contiguous bits; octet.

3.9 **character**: For bit-serial interfaces, a group of five to eight contiguous data bits that is preceded by one start (condition Z, space) bit and followed by at least one complete stop (condition A, mark) bit; a parity bit appearing between the final data bit and the first (or only) stop bit is optional.

For bit-parallel interfaces, a character is equivalent to a byte.

3.10 **compression mode**: Mode of data transmission whereby the ITU-T circuits 103 (transmit data) and 104 (receive data) transfer characters of data at a DTE port rate independent of the modem-to-modem line rate, and the transferred information is then transformed inside the modem by a compression algorithm. Information is transferred reliably between modems using V.42 error control, and is compressed by using V.42 *bis* compression.

3.11 **compression ratio**: Ratio of the size of the original data to the size of the compressed data.

3.12 **data terminal equipment; DTE**: Equipment comprising a data source and a data sink. A single computer may have two DTE ports and, therefore, constitute two DTEs.

3.13 **dictionary size**: V.42 *bis* negotiated parameter P_1 that specifies the maximum number of elements in the BTLZ coding dictionary.

3.14 direct mode: Mode of data transmission whereby the V.24 circuits 103 (transmit data) and 104 (receive data) transfer data at a port rate equal to the line rate. The modem does not buffer data in either direction, nor does the modem implement flow control. For modem modulation methods that transfer data synchronously, this mode implies the use of V.14 synchronous/asynchronous protocol within the modem.

3.15 duplex modem; full duplex modem: Modem classification denoting the modem's ability to send and receive data simultaneously over the modem-to-modem channel.

3.16 end office-to-end office impairment combinations; EO-EO combinations; IC: Combinations of impairments that build together with the Test Loop Combinations (TLC) a test channel for the modem under test. The EO-EO combinations are specified in Recommendation V.56 *bis*. They are given there for the intracontinental and intercontinental network.

3.17 error control mode: Mode of data transmission whereby the ITU-T circuits 103 (transmit data) and 104 (receive data) transfer asynchronous character data at a port rate independent of the line rate. Information is transferred reliably between the modems using the V.42 error control protocol. No compression algorithms are used in this mode.

3.18 FOX message: The 50-character message:

THE_QUICK_BROWN_FOX_JUMPED_OVER_THE_LAZY_DOGS_BACK

with each character being in the ASCII character set. The underline character represents the ASCII SPACE character in the message. The message does not include any line-ending characters.

NOTE – All characters in the message are either capital letters or space; no lower-case letters are used. The value of the eighth or parity bit is not specified.

3.19 half duplex modem: Modem classification denoting the modem's ability to send or receive data, but not both at the same time, over the modem-to-modem channel.

3.20 line rate; data signalling rate: Speed in bits per second of information transfer in one direction between the signal converter functions in a pair of modems over a telephone channel. This speed may differ in each direction, such as in a connection between two V.23 modems.

3.21 maximum string length: V.42 *bis* negotiated parameter P_2 that specifies the longest string of characters represented by a single BTLZ code word.

3.22 message-error ratio; MER: Ratio of erroneous messages to total messages received at a DTE-to-modem interface.

3.23 one way transfer: Transfer of a data file or test pattern in one direction with no information transfer in the opposite direction during a throughput test.

3.24 parity bit: Optional check bit in a character whose value is calculated such that the number of bits in the character (exclusive of the start and stop bits) which are set to a value of one (1) is always even (or odd).

3.25 port rate: Speed in bits per second of information transfer in one direction at the interface between a DTE and a modem.

3.26 RTS/CTS flow control; hardware flow control: Method used over a DTE-to-modem interface in which the V.24 circuits 133 (Ready for Receiving) and 106 (Clear to Send) are used by the DTE and modem, respectively, to indicate readiness to accept additional data. See Appendix VI for a detailed description of how this method works.

3.27 signal converter: Element of a modem that translates between a digital bitstream and an analogue signal carried over the telephone network.

3.28 synchronous: Transmission of bits or other signal elements with separately-transmitted signal element timing information.

3.29 synchronous mode: Mode of data transmission whereby the V.24 circuits 103 (transmit data) and 104 (receive data) transfer data at the line rate, using V.24 circuits 113 (DCE sourced) or 114 (DTE sourced) for transmitter bit timing and circuit 115 for receiver bit timing. The modem does not buffer data in either direction, nor does it implement flow control. No compression algorithms are used in this mode.

NOTE – The testing procedure for modems that perform compression of synchronous data is under study.

3.30 **throughput**: Effective rate of data transfer from one DTE to another through a pair of DCEs and a transmission channel. Throughput is expressed in characters per second, and is the number of characters transmitted at the DTE-to-modem interface divided by the elapsed time in seconds. The elapsed time is the interval from the time the start bit of the first character is transmitted from the DTE source to the time the first (or only) stop bit of the last character is received by the DTE sink.

3.31 **two-way transfer**: Transfer of independent data files or test patterns in both directions at the same time during a throughput test.

3.32 **XON/XOFF flow control; software flow control**: Method used over a DTE-to-modem interface in which the V.24 circuits 103 (transmit data) and 104 (receive data) are used by the DTE and modem, respectively, to indicate readiness to accept additional data.

4 Requirements

The test procedures described in this Recommendation are designed with the assumption that the two modems being tested are the same model and revision from the same manufacturer. This assumption is based on the fact that different implementations of modems due to some available but not mandatory options in some modem Recommendations can lead to different results for the tests given.

At the discretion of the tester, the tests described in this Recommendation may be performed on modems of different model or manufacturer to support specific applications and or interoperability testing. The results obtained in this manner may not be indicative of the performance of either modem.

Figure 1 shows the components and interconnections in the test setup. The detailed setup depends on the actual equipment used.

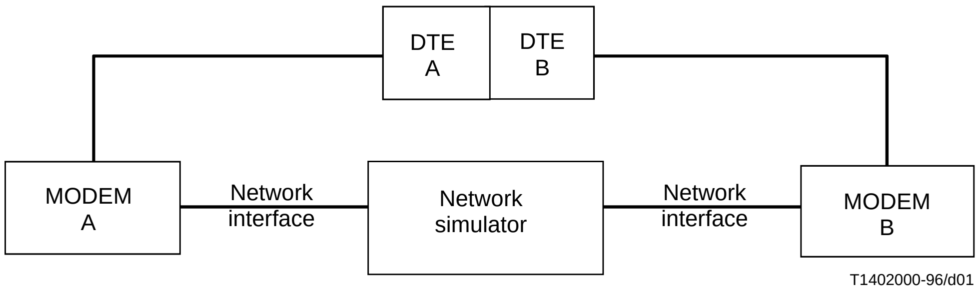

FIGURE 1/V.56 *ter*

Diagram of test setup

4.1 Network simulator

These test procedures require a network simulator for accurate, controllable representation of telephone network conditions. Recommendation V.56 *bis* contains functional requirements for the network simulation equipment used in this test procedure. V.56 *bis* compliant simulators shall be used for all testing described in this Recommendation.

4.2 DTEs

These test procedures require a pair of DTEs that comply with the requirements described below. The DTEs generate data transmitted to the modems being tested and check data received from the modems being tested.

In this Recommendation, all DTE interface circuits are referenced using the V.24 circuit designations. See Appendix VIII for a summary of these circuits and their corresponding designation in EIA/TIA-232-E.

4.2.1 Functions

Each DTE shall be able: to transmit the files and patterns associated with particular tests; to receive and verify the same files and patterns; and to measure time intervals and throughput rates as specified for each test.

4.2.2 Interface requirements

Each of the DTEs shall have an interface that is compatible with the modems to be tested.

For testing modems operating in direct, buffered, error control, or compression modes, each DTE shall support the following V.24 interchange circuits or their equivalent: 102, 103, 104, 106, 107, 108/2, 109, and 133. Circuit 133 shall be asserted by the DTE at all times. For DTEs that perform automatic dial and answer functions, V.24 interchange circuit 125 shall be supported.

For testing modems operating in synchronous mode, each DTE shall support the following V.24 interchange circuits or their equivalent: 102, 103, 104, 105, 106, 107, 108/1 or 108/2, 114, and 115. For DTEs that perform automatic dial and answer functions, V.24 interchange circuit 125 shall be supported. For DTEs that provide DTE transmitter signal element timing, V.24 interchange circuit 113 shall be supported.

NOTES

1 Many modems incorporate control and status information on V.24 interchange circuits 103 and 104 that can be used by either or both DTEs in lieu of separate signals for V.24 interchange circuits 107, 108/2, and 125.

2 For modems using interfaces other than the commonly-used communications interfaces (ANSI/EIA/TIA-232-E-91, EIA-449, ANSI/EIA/TIA-530-A-92, ANSI/EIA/TIA-561-90, ANSI/EIA/TIA-574-90, CCITT V.35-1984, and others) the DTE should use the facilities provided in the interface to access the V.24 functions described above.

4.2.3 Port rate requirements

Each DTE shall support testing at the highest DTE port rate supported by each modem to be tested.

4.2.4 DTE transmission performance

For testing modems operating in direct, buffered, error control, or compression modes, the DTE shall be capable of transmitting data without extending the period of the stop bit in any transmitted asynchronous character, except: after transmitting the final character in a stream, block, or single-character transmission; or after the character in a stream or block following the modem's indication to the DTE to stop transmitting.

For testing modems in synchronous mode, the DTE shall transmit the specified test pattern exactly, bit-for-bit, without inserting extraneous, unspecified bits in the data stream.

For all tests, the DTE shall not inhibit the flow of data from the modem to the DTE, but shall process the data rapidly enough to avoid the need for such stoppage.

4.2.5 Flow control

When flow control is specified to be recognized, the DTE shall recognize CTS flow control. XON/XOFF flow control shall not be recognized nor generated.

4.3 Modems

4.3.1 Compression mode

When modems are running in compression mode, the modems shall be configured to enable compression with the same parameters in both directions.

NOTE – V.42 *bis* negotiated parameter P_0 shall be set to a value of three when enabling compression.

4.3.2 Flow control

For those modems that have separate controls for RTS and CTS flow control, the modem shall be set up with RTS flow control disabled for all tests, and CTS flow control shall be as specified in the test procedure. For those modems which control RTS and CTS flow control with a single modem setup command or strap, both RTS and CTS flow control shall be set up when CTS flow control is specified in the test procedure. XON/XOFF flow control between DTE and modem shall not be recognized nor generated by either the modem or the DTE.

4.3.3 Forced modes of operation

In most of the test procedures, references are made to a specified mode being "forced". The modem shall be set such that if the modem cannot negotiate or does not incorporate support for the particular mode of operation on a given connection, the modem shall terminate the connection instead of using a mode not specified.

4.4 Indication of establishment of connection

A connection is considered to have been successfully established at the time when both modems become ready to begin data transmission or reception. The indication of this state can differ among modem implementations. The tester is encouraged to become familiar with the operation of the modem being tested to determine precisely the conditions that indicate readiness for that modem.

For V.25 *ter* compliant modems, a connection is considered established when both a CONNECT message has been sent by the modem to the DTE, and V.24 circuits 106, 107, and 109 (if implemented and available in the interface) are active. These indications may occur in any order.

For V.25 *bis* compliant modems, a connection is considered to be established when the conditions described in clause 4/V.25 *bis* are obtained.

5 Network model coverage considerations

In the Throughput versus network model coverage and the Error ratio versus network model coverage tests, the tester may trade testing time for coverage. The rationale for the truncation of Network Model Coverage (NMC) testing is that the results obtained over some of the simulated connections reflect performance over very small portions of the PSTN model. This clause describes how to use the network model truncation option provided for in Recommendation V.56 *bis* and described in 4.7/V.56 *bis*.

Table 3/V.56 *bis* shows the cross-product scores for the 168 EO-EO combinations. Table 3/V.56 *bis* has the impairment combinations ordered top to bottom from most likely to least likely; the test loop combinations are already ordered left to right by most likely to least likely. In the middle of Table 3/V.56 *bis*, the cross products for each test are less than one-half of 1% – this means that for each of those tests the result represents performance on less than 0.5% of the network model. At the extreme lower right-hand corner of Table 3/V.56 *bis*, the cross product is 0.0007%, or seven parts per million.

Tables 4, 5, and 6 of V.56 *bis* show how the number of tests can be reduced from 168 to a smaller number by sacrificing the least-likely tests. 100 tests cover 99.1% of the model, reducing test time by almost one-half while sacrificing less than 1% of testing coverage (see Table 4/V.56 *bis*). Table 5/V.56 *bis* shows how 55 tests cover 95.3% of the model, while Table 6/V.56 *bis* shows how 36 tests cover 90.6% of the network model.

Annex B/V.56 *bis* describes another option for reducing testing time: conditional testing. This option applies to network model coverage tests when testing modems that implement a range of line rates.

Table 1/V.56 *bis* contains two network models. The intracontinental network model is contained in Table 1a/V.56 *bis*, and the intercontinental network model is contained in Table 1b/V.56 *bis*. For both Tables 1a and 1b of V.56 *bis* the same likelihood of occurrence of the EO-EO combinations are valid and are given in Table 3/V.56 *bis*.

6 Test procedures

The test procedures in this clause describe how to perform each test once. To increase the confidence in test results, the test procedures can be repeated at the tester's discretion.

Suggested formats for reporting the results of these tests are in Appendix IV.

The test procedures described below apply to each of the network models (intercontinental and intracontinental) of Recommendation V.56 *bis* separately.

NOTE – At the discretion of the tester, the tests described in this Recommendation may be performed on either one or both types of network models.

In the following test procedures, the modem initiating the connection is modem A. When performing tests for a particular application, the tester should refer to Appendix V for guidance in modifying or augmenting these test procedures to fulfil specific testing goals.

The following summarizes the tests described in this clause:

- **Throughput versus network model coverage** measures the modem's asynchronous throughput performance over a number of simulated telephone connections. The compression mode variant defined in this clause exercises the complete end-to-end modem system over the network model, and closely resembles how the modem is used in typical asynchronous applications. The error control mode variants examine the function of the modem signal converter and V.42 function, separately from the effects of the V.42 *bis* data compression function.

- **Throughput versus file type** measures the modem's throughput performance for each of five different file types over a benign simulated telephone connection. This compression-mode test concentrates primarily on V.42 *bis* compression algorithm implementation.

- **Error ratio versus network model coverage** directly measures the modem signal converter's error ratio for each of a number of simulated telephone connections. This synchronous-mode test (bit- and block-error ratio) or direct-mode test (message-error ratio) concentrates exclusively on the signal converter and its reactions to the different test connections.

- **Connect reliability versus local loop combinations** measures how well the modem connects across seven combinations of local-loop conditions, and measures connection set-up time. This compression mode test concentrates on start-up procedures in the signal converter and V.42 error control.

- **Character echo delay** and **Block acknowledge delay** measure a modem's response time to single-character transfer and to block-oriented asynchronous file transfer, respectively, over the four asynchronous modes of the modem: direct, buffered, error control, and compression mode. These tests concentrate on the real-time delay introduced in these various modes.

6.1 Throughput versus network model coverage

Three alternative test procedures for measuring asynchronous throughput versus network conditions are provided:

- File-based transfer with compression.

- File-based transfer without compression.

- Pattern-based transfer without compression.

The file-based transfer with compression test shows how well the modem will perform in typical asynchronous applications.

NOTE – When performing comparative tests using file-based transfer with compression, differences in compression performance can obscure differences in signal converter and V.42 performance.

The file-based or the pattern-based transfer without compression test, measures the performance of the modem signal converter function and V.42 function. It measures the effects of transmission errors, caused by EO-EO combination impairments, on asynchronous performance.

See clause 5 and Table 3/V.56 *bis* through Table 6/V.56 *bis* to select the set of EO-EO combinations to use in testing.

6.1.1 File-based with compression

6.1.1.1 Overview

This procedure determines a modem's throughput under a variety of telephone network conditions. The results indicate how well the modem performs in typical asynchronous applications.

This test uses file 2X10.TST, a moderately compressible file.

See clause 5 and Table 3/V.56 *bis* through Table 6/V.56 *bis* to select the set of EO-EO combinations to use in testing.

6.1.1.2 DTE configuration

Configure the DTEs per the requirements described in 4.2. Furthermore, both DTEs shall be configured as follows:

- asynchronous character format: 8 data bits, no parity bit, and 1 stop bit;
- DTE port rate: fixed at the maximum port rate supported by the modem;
- CTS flow control: recognized by the DTE.

6.1.1.3 Modem configuration

Configure the modems as follows:

- asynchronous character format: 8 data bits, no parity bit, and 1 stop bit;
- line rate: adaptive with all line rates enabled;
- data compression mode forced;
- adaptive line rate changes and retrain: enabled;
- CTS flow control: enabled.

6.1.1.4 Network simulator configuration

Set the network simulator to the first EO-EO combination defined in the selected V.56 *bis* table.

During the course of testing, the network simulator parameters will be changed.

6.1.1.5 Test procedure

a) Establish a connection with modem A originating the call.

b) Transfer the test file 2X10.TST from DTE A to DTE B with no delay between establishment of the connection as defined in 4.4 and the beginning of data transfer.

c) Record the throughput at DTE B in characters per second.

d) Break the connection (modems to on-hook state).

e) Repeat steps a) through d) for each of the EO-EO combinations defined in the selected V.56 *bis* table.

6.1.1.6 Results

If either DTE detects an error during a throughput test, this fact shall be recorded and the results of that test shall be considered invalid. An invalid test result may need to be investigated to determine the cause and the test rerun for that particular EO-EO combination.

Results for each test are to be presented in terms of throughput in characters per second for each EO-EO combination. An invalid test result (if not resolved by retesting) is considered to be a result of zero characters per second.

This test yields one measurement for each EO-EO combination specified in the selected V.56 *bis* table.

6.1.2 File-based without compression

6.1.2.1 Overview

This procedure determines a modem's asynchronous throughput performance under a variety of telephone network conditions without the obscuring effect of data compression. This test is useful for evaluating the effects of transmission errors on those modems that are incapable of synchronous-DTE operation.

This test uses file 1X04.TST. The 1X04.TST file is a highly compressible file; if the modem is incorrectly configured with data compression enabled, the tester will be able to determine this fact by inspecting the throughput result.

See clause 5 and Table 3/V.56 *bis* through Table 6/V.56 *bis* to select the set of EO-EO combinations to use in testing.

6.1.2.2 DTE configuration

Configure the DTEs per the requirements described in 4.2. Furthermore, both DTEs shall be configured as follows:

- asynchronous character format: 8 data bits, no parity bit, and 1 stop bit;
- DTE port rate: fixed at the maximum port rate supported by the modem;
- CTS flow control: recognized by the DTE.

6.1.2.3 Modem configuration

Configure the modems as follows:

- asynchronous character format: 8 data bits, no parity bit, and 1 stop bit;
- line rate: adaptive with all line rates enabled;
- error control mode forced;
- adaptive line rate changes and retrain: enabled;
- CTS flow control: enabled.

6.1.2.4 Network simulator configuration

Set the network simulator to the first EO-EO combination defined in the selected V.56 *bis* table.

During the course of testing, the network simulator parameters will be changed.

6.1.2.5 Test procedure

a) Establish a connection with modem A originating the call.

b) Transfer the test file 1X04.TST from DTE A to DTE B with no delay between establishment of the connection as defined in 4.4 and the beginning of data transfer.

c) Record the throughput at DTE B in characters per second.

d) Break the connection (modems to on-hook state).

e) Repeat steps a) through d) for each of the EO-EO combinations defined in the selected V.56 *bis* table.

6.1.2.6 Results

If either DTE detects an error during a throughput test, this fact shall be recorded and the results of that test shall be considered invalid. An invalid test result may need to be investigated to determine the cause and the test rerun for that particular EO-EO combination.

Results for each test are to be presented in terms of throughput in characters per second for each EO-EO combination. An invalid test result (if not resolved by retesting) is considered to be a result of zero characters per second.

This test yields one measurement for each EO-EO combination specified in the selected V.56 *bis* table.

6.1.3 Pattern-based without compression

6.1.3.1 Overview

This procedure determines a modem's asynchronous throughput performance under a variety of telephone network conditions without the obscuring effect of data compression. This test is useful for evaluating the effects of transmission errors on those modems that are incapable of synchronous-DTE operation. This test is defined as an alternative to the File-based without compression test, for compatibility with test equipment incapable of performing the File-based without compression test.

The DTEs shall transfer one million bits of repeated 511-bit pseudo-random pattern; see Recommendation O.151 for a description of the pattern and its generator. The data pattern is sent with start and stop bits framing each 8 bits of data.

See clause 5 and Table 3/V.56 *bis* through Table 6/V.56 *bis* to select the set of EO-EO combinations to use in testing.

6.1.3.2 DTE configuration

Configure the DTEs per the requirements described in 4.2. Furthermore, both DTEs shall be configured as follows:

- asynchronous character format: 8 data bits, no parity bit, and 1 stop bit;
- DTE port rate: fixed at the maximum port rate supported by the modem;
- CTS flow control: recognized by the DTE.

6.1.3.3 Modem configuration

Configure the modems as follows:

- asynchronous character format: 8 data bits, no parity bit, and 1 stop bit;
- line rate: adaptive with all rates enabled;
- error control mode forced;
- adaptive line rate changes and retrain: enabled;
- CTS flow control: enabled.

6.1.3.4 Network simulator configuration

Set the network simulator to the first EO-EO combination defined in the selected V.56 *bis* table.

During the course of testing, the network simulator parameters will be changed.

6.1.3.5 Test procedure

a) Establish a connection with modem A originating the call.

b) Transfer the 511 pattern, framed as characters, from DTE A to DTE B, with no delay between the establishment of the connection as defined in 4.4 and the beginning of data transfer.

c) After 1250 blocks of 100 characters each have been analysed at DTE B, record the throughput at DTE B in characters per second.

d) Break the connection (modems to on-hook state).

e) Repeat steps a) through d) for each of the EO-EO combinations defined in the selected V.56 *bis* table.

6.1.3.6 Results

If either DTE detects an error during a throughput test, this fact shall be recorded and the results of that test shall be considered invalid. An invalid test result may need to be investigated to determine the cause and the test rerun for that particular EO-EO combination.

Results for each test are to be presented in terms of throughput in characters per second for each EO-EO combination. An invalid test result (if not resolved by retesting) is considered to be a result of zero characters per second.

This test yields one measurement for each EO-EO combination specified in the selected V.56 *bis* table.

6.2 Throughput versus file type

6.2.1 Overview

This procedure determines a modem's asynchronous throughput performance for a variety of data types. The procedure transmits a number of files selected for their varying degree of compressibility and to represent a broad range of user data.

Many applications, such as file transfer, involve the transmission of data in a single direction. These applications are represented by the one-way throughput tests. Other applications, such as LAN bridging and applications sharing, require significant amounts of data be transferred in both directions at the same time. These applications are represented by the two-way tests. The relevance of specific test results to a given application or set of applications thus depends on the characteristics of the application data stream or streams.

The EO-EO combination 2c2/10c2 has been selected to minimize the number of symbol errors due to channel impairments. Symbol errors cause the V.42 error control function to request frame retransmissions, thereby disrupting the flow of data and distorting the results of the test.

Compliance with these test procedures requires that both one-way and two-way transfers be made. It is recommended that the results be interpreted in a manner consistent with the application, if known. In those cases where the specific application area is not known, a weighted average score can be used. See IV.2, for an example.

Testers are cautioned that major modem functional blocks that have a great influence on the performance of the modem in actual use – such as the signal converter – are not evaluated in this procedure.

6.2.2 DTE configuration

Configure the DTEs per the requirements described in 4.2. Furthermore, both DTEs shall be configured as follows:

- asynchronous character format: 8 data bits, no parity bit, and 1 stop bit;
- DTE port rate: fixed at the maximum port rate supported by the modem;
- CTS flow control: recognized by the DTE.

6.2.3 Modem configuration

Configure the modems as follows:

- asynchronous character format: 8 data bits, no parity bit, and 1 stop bit;
- line rate: adaptive with all line rates enabled;
- compression mode forced;
- adaptive line rate changes and retrain: enabled;
- CTS flow control: enabled.

6.2.4 Network simulator configuration

Set the network simulator to EO-EO combination 2c2/10c2, per Recommendation V.56 *bis*.

The network simulator parameters are not varied during the course of this test.

6.2.5 Test procedure – One-way transfer

a) Establish a connection with modem A originating the call.

b) Transfer the test file 1X30.TST from DTE A to DTE B, with no delay between the establishment of the call as defined in 4.4 and the beginning of data transfer.

c) Record the throughput at DTE B in characters per second.

d) Break the connection (modems to on-hook state).

e) Repeat steps a) through d) for each of the following files:

   2X10.TST
   3X06.TST
   4X04.TST
   5X16.TST

6.2.6 Test procedure – Two-way transfer

a) Establish a connection with modem A originating the call.

b) Start a simultaneous transfer of independent copies of the test file 1X30.TST from DTE A to DTE B and from DTE B to DTE A. The two-file transmissions shall begin within a five millisecond period of each other, and with no delay between the establishment of the connection as defined in 4.4 and the beginning of data transfer.

c) Calculate the arithmetic mean of the throughput values measured at both DTE A and DTE B and record the resulting mean.

d) Break the connection (modems to on-hook state).

e) Repeat steps a) through d) for each of the following files:

2X10.TST (A to B) and 2X10.TST (B to A)
3X06.TST (A to B) and 3X06.TST (B to A)
4X04.TST (A to B) and 4X04.TST (B to A)
5X16.TST (A to B) and 5X16.TST (B to A)

6.2.7 Results

If either DTE detects an error during a throughput test, this fact shall be recorded and the results of that test shall be considered invalid. An invalid test result may need to be investigated to determine the cause and the test rerun for that particular EO-EO combination.

Results for each test are to be presented in terms of throughput in characters per second for each file type. An invalid test result (if not resolved by retesting) is considered to be a result of zero characters per second.

This test yields ten measurements.

6.3 Error ratio versus network model coverage

Two alternative test procedures for measuring error ratio versus network model coverage are provided:

- bit- and block-error ratio versus network model coverage;
- message-error ratio versus network model coverage.

The bit- and block-error ratio tests are used with DTEs and modems that support synchronous data transfer as described in 4.2.2. The message-error ratio test is used in place of the block-error ratio test for those modems or DTEs that do not support synchronous transfer.

Depending on the application, a modem's performance may be evaluated over different ranges of error ratio. Therefore, Table 1 specifies four different test durations.

For these durations, the minimum block-error ratio that can be reliably measured ranges from 1×10^{-2} down to 2×10^{-4}. The minimum number of block or message errors that can be reported is ten. For bit-error ratio testing, there shall be a minimum of ten block errors before the bit-error ratio can be reported.

At this minimum reportable error ratio, there is approximately a 95% confidence level that the true error rate is within a factor of two of the measured error ratio. See Appendix III for a more complete discussion of measurement confidence limits.

TABLE 1/V.56 *ter*

Error ratio test durations

Minimum block-error ratio to measure	Number of 1000-bit blocks to transmit
10^{-2}	1000
2×10^{-3}	5 000
10^{-3}	10 000
2×10^{-4}	50 000

6.3.1 Bit- and block-error ratio versus network model coverage

6.3.1.1 Overview

This procedure determines the modem's synchronous signal converter performance over a variety of telephone network conditions. Unlike the Throughput versus network model coverage test procedures described in 6.1, this procedure measures error ratio directly. The results of this test are a set of error ratios over the network model.

This test is useful for the evaluation of modems for synchronous applications. Block-error ratio is an appropriate measure of modem performance in applications where the DTE implements its own error-control protocol. Other applications exist, such as real-time video transmission, for which bit-error ratio may be a better indicator of modem performance.

See clause 5 and Table 3/V.56 *bis* through Table 6/V.56 *bis* to select the set of EO-EO combinations to use in testing. Based on the application requirements, choose the number of blocks to be transmitted for the duration of the testing with the selected test set. The recommended values are shown in Table 1.

It is recommended that Table 4/V.56 *bis* (100 EO-EO combinations covering 99% of the network model) be used for most testing, and that ten thousand (10 000) blocks of 1000 bits each be transmitted for each test.

6.3.1.2 DTE configuration

Configure the DTEs as follows:

- synchronous data format;
- DTE port rate: equal to line rate (changed during the test but follows line rate);
- transmit clock supplied by modem.

6.3.1.3 Modem configuration

Configure the modems as follows:

- synchronous data mode;
- line rate: as desired to a fixed line rate (changed during the test);
- compression: disabled;
- modem clock: internal;
- adaptive line rate changes and retrain: disabled.

6.3.1.4 Network simulator configuration

Set the network simulator to the first EO-EO combination defined in the selected V.56 *bis* table.

During the course of testing, the network simulator parameters will be changed.

6.3.1.5 Test procedure

a) Establish a connection with modem A originating the call.

b) Begin continuous transmission of the 511 test pattern at DTE A with no delay from the establishment of the connection as defined in 4.4 and the beginning of data transfer.

c) Wait for indications of data pattern synchronization at DTE B. When DTE B is in synchronization with the received test pattern, begin analysis of the test pattern for errors.

d) After the chosen number of blocks of 1000 bits each have been analysed at DTE B, record the BER or BLER (depending on the test being performed) at DTE B.

e) Break the connection (modems to on-hook state).

f) Repeat steps a) through e) for each of the EO-EO combinations defined in the selected V.56 *bis* table.

g) Set the simulator to the first EO-EO combination defined in the selected V.56 *bis* table

h) Repeat steps a) through g) for each modem line rate for which results are desired.

6.3.1.6 Results

Results of each test are to be presented in terms of an error ratio for each EO-EO combination and line rate tested.

This test yields one measurement for each line rate and EO-EO combination specified in the selected V.56 *bis* table.

6.3.2 Message-error ratio versus network model coverage

6.3.2.1 Overview

This procedure determines the modem's synchronous signal converter and V.14 async-to-sync converter performance over a variety of telephone network conditions. The result of these tests is a set of message-error ratios over the network model.

Message-error ratio testing is an appropriate measure of modem performance for applications where the DTE processes asynchronous data in blocks or in transactions, and error control is not used. Bit-error and character-error ratio tests will not result in meaningful measurements due to the error multiplication effect caused by an error between the two signal converters disrupting the synchronization of the V.14 converter, and therefore disrupting the start-stop framing of the data presented to the DTE.

Message-error ratio testing is also appropriate for evaluating the performance of modems that do not support V.24 circuits 113, 114, or 115. This is particularly true of modems that use alternative interfaces to the DTE: PCMCIA modems, cellular digital transport systems, and modems designed to be built into laptop computers.

See clause 5 and Table 3/V.56 *bis* through Table 6/V.56 *bis* to select the set of EO-EO combinations to use in testing. Based on the application requirements, choose the number of blocks to be transmitted for the duration of the testing with the selected test suite. The recommended values are shown in Table 1.

It is recommended that Table 4/V.56 *bis* (100 EO-EO combinations covering 99% of the network model) be used for most testing.

6.3.2.2 DTE configuration

Configure the DTEs per the requirements described in 4.2. Furthermore, both DTEs shall be configured as follows:

- asynchronous character format: 8 data bits, no parity bit, and 1 stop bit;
- DTE port rate: set to the line rate of the modem (see Note in 6.3.2.3);
- CTS flow control: disabled.

6.3.2.3 Modem configuration

Configure the modems as follows:

- asynchronous character format: 8 data bits, no parity bit, and 1 stop bit;
- line rate: as desired to fixed line rate (changed during the test);
- direct mode forced;

  NOTE – Some modems support DCE rates that cannot be supported by DCE-DTE interfaces; examples include the V.32 *bis* 12-kbit/s rate and the V.34 26.4-kbit/s rate (among others) which cannot be selected on many DTEs. In this case, force buffered mode and use any DTE port rate higher than the desired line rate.

- adaptive line rate changes and retrain: disabled;
- CTS flow control: disabled.

6.3.2.4 Network simulator configuration

Set the network simulator to the first EO-EO combination defined in the selected V.56 *bis* table.

During the course of testing, the network simulator parameters will be changed.

6.3.2.5 Test procedure

a) Establish a connection with modem A originating the call.

b) Begin transmission of the 50-character FOX message at DTE A with 30 milliseconds of mark-idle (no transmission) between messages.

NOTE – The 30-millisecond delay is to allow time for V.14 converter to recover synchronization after an error event.

c) Count the number of times the FOX message is received correctly at DTE B.

d) After the chosen number of FOX messages have been transmitted from DTE A and given time to be received at DTE B, record the message error rate at DTE B.

e) Break the connection (modems to on-hook state).

f) Repeat steps a) through e) for each of the EO-EO combinations defined in the selected V.56 *bis* table.

g) Set the simulator to the first EO-EO combination defined in the selected V.56 *bis* table.

h) Repeat steps a) through g) for each of the modem's transmission rates for which results are desired.

6.3.2.6 Results

Results of each test are to be presented in terms of an error ratio for each EO-EO combination and line rate tested.

This test yields one measurement for each line rate and EO-EO combination specified in the selected V.56 *bis* table.

6.4 Connect reliability versus test loop combinations

6.4.1 Overview

This procedure determines the modem's ability to consistently make connections. It does so by attempting 119 connections over the range of test loop combinations as defined in Table 2/V.56 *bis*. The total time required to make each connection and transfer a short message is also measured and reported.

The EO-EO combinations 1c1/9c1 through 1c7/9c7 are used in this test because EO-EO impairment combination 1c/9c represents more than 55% of the connections in the PSTN model described in Recommendation V.56 *bis*.

6.4.2 DTE configuration

Configure the DTEs per the requirements described in 4.2. Furthermore, both DTEs shall be configured as follows:

- asynchronous character format: 8 data bits, no parity bit, and 1 stop bit;
- DTE port rate: fixed at the maximum port rate supported by the modem;
- CTS flow control: recognized by the DTE.

6.4.3 Modem configuration

Configure the modems as follows:

- asynchronous character format: 8 data bits, no parity bit, and 1 stop bit;
- line rate: adaptive with all line rates enabled;
- data compression mode forced;
- adaptive line rate changes and retrain: enabled;
- CTS flow control: enabled.

6.4.4 Network simulator configuration

Set the network simulator to EO-EO impairment combination 1c1/9c1, per Recommendation V.56 *bis*.

During the course of the test, the network simulator parameters will be changed.

6.4.5 Test procedure

a) Establish a connection with modem A originating the call.

b) When modem B goes off-hook, start TIMER1.

c) Transfer the FOX message from DTE A to DTE B with no delay between establishment of the connection as defined in 4.4 and the beginning of data transfer.

d) When the last character of the FOX message is received by DTE B, stop TIMER1.

e) Break the connection (modems to on-hook state).

f) Record whether the connection was successful and, if successful, the value of TIMER1. A failure shall be recorded if the FOX message is not transferred error-free from DTE A to DTE B. A failure shall also be recorded if the last character of the FOX message is not received within 60 seconds of the time modem B goes off-hook.

g) Repeat steps a) through f) until 46 calls have been attempted on EO-EO impairment combination 1c1/9c1.

h) Repeat steps a) through f) for each EO-EO impairment combination (from Recommendation V.56 *bis*) for the number of attempts as shown:

EO-EO	1c2/	1c3/	1c4/	1c5/	1c6/	1c7/
Combination:	9c2	9c3	9c4	9c5	9c6	9c7
Attempts:	23	10	10	10	10	10

i) Calculate the call completion ratio for all calls and the call completion ratios for each EO-EO combination.

j) Calculate the overall average of all TIMER1 measurements associated with successful test attempts, and the average of all TIMER1 measurements taken for each EO-EO combination associated with successful test attempts.

NOTE – The overall call completion ratio calculated using the results from 119 connection attempts is accurate to better than ±9% at a confidence level of 95%. For the same confidence level, the call completion ratio taken individually by TLC is:

TLC 1 ±15%
TLC 2 ±20%
TLC 3 ±30%
TLC 4 ±30%
TLC 5 ±30%
TLC 6 ±30%
TLC 7 ±30%

Particularly in the case of TLCs 3 through 7, the results are so statistically coarse that a measurement difference of 20% in call completion ratio is not significant. When individual call completion ratio by TLC measurements are going to be used to differentiate the performance of two or more modems, the number of trials per TLC should be increased. It is recommended that a minimum of 100 trials per TLC (700 total) be used in such a situation.

6.4.6 Results

Results for this test are to be presented in terms of call completion ratio and average call cycle time.

Call completion ratio is defined as the ratio of the number of successful calls to the number of total call attempts. The overall call completion ratio is the ratio of the number of all successful completed calls [as determined in 6.4.5 f)] to the number of attempts. Call completion ratios for each test loop combination are the ratios of the number of successful completed calls for each test loop combination to the number of attempts for the same test loop combination.

Average call cycle time is the arithmetic mean of TIMER1 measurements, the time in seconds from initial answer to message transfer complete, for all successful calls. The call cycle time for a test loop combination is undefined if there are no successful attempts. The overall call cycle time is the arithmetic mean of all TIMER1 values associated with successful attempts. Call cycle times for each test loop combination are the arithmetic mean of all TIMER1 values associated with successful attempts for each test loop combination.

This test yields 16 measurements.

6.5 Character echo delay

6.5.1 Overview

This procedure determines the amount of time it takes a character to be sent from a transmitting DTE to a receiving DTE, passing through all components of both modems and over a telephone channel. Latency (also known as propagation delay) is an important factor in the user's perception of modem performance when modems are used in environments where each keystroke is processed and echoed (remote character echo) or acted on immediately (menu, and word search or completion) by a remote DTE.

Rate renegotiation and retraining are disabled because the data-transfer delay caused by these features can significantly distort the measurements more than the presence of symbol errors in the modem's signal converter. EO-EO combination 2c2/10c2 is used to minimize the number of symbol errors due to channel impairments.

Times measured by this test include propagation (round trip) delays introduced by the network simulator.

6.5.2 DTE configuration

Configure the DTEs per the requirements described in 4.2. Furthermore, both DTEs shall be configured as follows:

- asynchronous character format: 8 data bits, no parity bit, and 1 stop bit;
- DTE port rate: set to the line rate of the modem (changed during the test);
- CTS flow control: disabled (changed during the test).

The DTE configuration will be changed during the course of the test.

6.5.3 Modem configuration

Configure the modems as follows:

- asynchronous character format: 8 data bits, no parity bit, and 1 stop bit;
- line rate: as desired to a fixed line rate;
- direct mode forced (changed during the test);
- adaptive line rate changes and retrain: disabled;
- CTS flow control: disabled (changed during the test).

The modem configuration will be changed during the course of this test.

6.5.4 Network simulator configuration

Set the network simulator to EO-EO combination 2c2/10c2, per Recommendation V.56 *bis*.

The network simulator parameters are not changed during the course of this test.

6.5.5 Test procedure

a) Establish a connection with modem A originating the call.

b) From DTE A, transmit a single, randomly selected character with a decimal value between 0 and 255 inclusive and with a uniform distribution. Start TIMER1 and TIMER2 concurrently with the transmission of the start bit of the character.

c) Stop TIMER1 when the first stop bit of the character is received by DTE B. Then transmit the same character back from DTE B to DTE A with no delay.

d) Stop TIMER2 when the first stop bit of the echoed character is received by DTE A.

e) If the character received at DTE A and the character received at DTE B are correct, record TIMER1 and TIMER2. TIMER1 provides the one-way character latency, and TIMER2 provides the round trip character-echo delay.

f) Delay a random amount of time, for an interval between 0.05 and 0.50 seconds, with a uniform distribution. This delay reflects the normal variations in the typing speed of human operators and performance of DTE software.

g) Repeat steps b) through f) at least 100 times. Average the two sets of timer results.

h) Break the connection (modems to on-hook state).

i) Adjust the DTE configuration and modem configuration to enable CTS flow control, and adjust the DTE port rate to operate at the highest port rate supported by the modem.

j) Repeat steps a) through h) for the following modes of operation:

- buffered mode;
- error control mode;
- compression mode.

6.5.6 Results

Character echo delay results shall be reported in milliseconds for each of the two timers per mode. For each of the four modes, there are two timer values: one-way character delay, and round trip delay.

If data is received incorrectly, the timer values associated with that exchange are not included in the averages. There is no report of the number of correct versus incorrect data transfers. If no data is received correctly for a particular mode, then the averages for that mode are undefined.

This test yields eight measurements.

6.6 Block acknowledge delay

6.6.1 Overview

This procedure determines the amount of time it takes a block of characters to be sent from a transmitting DTE to a receiving DTE – passing through all components of both modems – and for a single-character response to be sent back to the transmitting DTE. Latency (also known as propagation delay) is an important factor in the performance of DTE-to-DTE protocols that alternately transmit and receive (e.g. XMODEM and Kermit, in which each block of data is acknowledged before the next can be sent).

This test uses random data without framing instead of using a defined protocol. This avoids skewed measurements due to protocol recognition and optimization by the modem under test. Rate renegotiation and retraining are disabled because the data-transfer delay caused by these features can significantly distort the measurements more than the presence of symbol errors in the modem's signal converter. EO-EO combination 2c2/10c2 is used to minimize the number of symbol errors due to channel impairments.

Times measured by this test include propagation (round trip) delays introduced by the network simulator.

6.6.2 DTE configuration

Configure the DTEs per the requirements described in 4.2. Furthermore, both DTEs shall be configured as follows:

- asynchronous character format: 8 data bits, no parity bit, and 1 stop bit;
- DTE port rate: set to the line rate of the modem (changed during the test);
- CTS flow control: disabled (changed during the test).

The DTE configuration is changed during the course of this test.

6.6.3 Modem configuration

Configure the modems as follows:

- asynchronous character format: 8 data bits, no parity bit, and 1 stop bit;
- line rate: as desired at a fixed line rate (changed during the test);

- direct mode forced (changed during the test);
- adaptive line rate changes and retrain: disabled;
- CTS flow control: disabled (changed during the test).

The modem configuration will be changed during the course of this test.

6.6.4 Network simulator configuration

Set the network simulator to EO-EO combination 2c2/10c2, per Recommendation V.56 *bis*.

The network simulator parameters are not changed during the course of this test.

6.6.5 Test procedure

a) Establish a connection with modem A originating the call.

b) From DTE A, transmit 133 randomly selected characters with a decimal value between 0 and 255 inclusive and with a uniform distribution. The contents of this block should vary in repeated iterations of this step. Start TIMER1, TIMER2, and TIMER3 concurrently with the transmission of the start bit of the first character of the block.

c) Stop TIMER1 when the first stop bit of the first character is received by DTE B.

d) Stop TIMER2 when the first stop bit of the 133rd character is received by DTE B.

e) From DTE B, transmit an ASCII acknowledge character with no delay. The ASCII acknowledge character has a decimal value of 6.

f) Stop TIMER3 when the first stop bit of the ASCII acknowledge character is received by DTE A.

g) If the character received at DTE A and the data received at DTE B are correct, record TIMER1, TIMER2, and TIMER3. TIMER1 provides the one-way character latency, TIMER2 provides the one-way block latency, and TIMER3 provides the round trip delay.

h) Repeat steps b) through g) a minimum of 100 times. Average the three sets of timer results.

i) Break the connection (modems to on-hook state).

j) Adjust the DTE configuration and modem configuration to enable CTS flow control, and adjust the DTE port rate to operate at the highest port rate supported by the modem.

k) Repeat steps a) through i) for the following modes of operation:
   - buffered mode;
   - error control mode;
   - compression mode.

6.6.6 Results

Block acknowledge delay test results shall be reported in milliseconds for each of the three timers per mode. For each of the four modes, the three timer values are: first-character delay, last-character delay, and round trip delay.

If information is received incorrectly at either modem, the timer values associated with that exchange are not included in the averages. There is no report of the number of correct versus incorrect data transfers. If no information is received correctly for a particular mode, then the averages for that mode are undefined.

This test yields 12 measurements.

Annex A

DTE verification procedures

The DTE shall be tested to determine if it meets the requirements specified in 4.2 by performing the following procedure:

a) Connect an asynchronous test cable between the DTE ports. The schematic for the asynchronous test cable is shown in Figure A.1.

b) Perform a two-way transfer using file 4X04.TST in both directions.

The DTE may be used to test modems if the throughput is within 0.05% (500 parts per million) of the nominal asynchronous rate. Table A.1 gives the allowable limits for each DTE port rate.

TABLE A.1/V.56 *ter*

DTE performance limits

DTE Port Rate	Minimum throughput (character/s)	Maximum throughput (character/s)
115 200 bit/s	11 514	11 526
57 600 bit/s	5 757	5 763
38 400 bit/s	3 838	3 842
19 200 bit/s	1 919	1 921
14 400 bit/s	1 439	1 441
9 600 bit/s	959	961

The asynchronous test cable defined in Figure A.1 shall be used to verify the accuracy of the DTE port rates.

The 105/133 circuit connections are optional because, as specified in 4.2.2, the DTE is not permitted to lower circuit 133 at any time during a data transfer to prevent the continuous flow of data from the attached device. Similarly, the 107 and 108/2 signals are optionally crossed over as a matter of convenience, not necessity. The optional connections allow the testing of hardware flow control and DTR call control.

An asynchronous test cable that includes the mandatory connections is acceptable; however, it is recommended that the optional connections be provided as well.

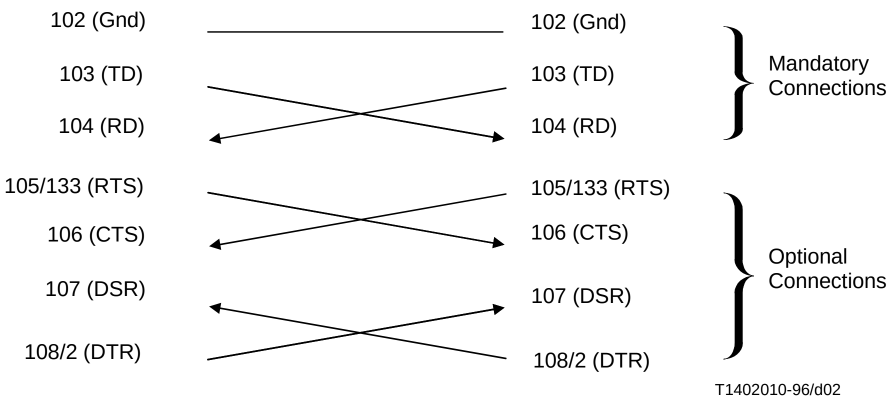

FIGURE A.1/V.56 *ter*

Asynchronous test cable

Annex B

Description of data files

The floppy disks that accompany this Recommendation contain the data files that shall be used for the throughput tests. These files represent different types of data that might be transferred between modems in typical user applications.

The data files are provided in two forms. The segment form is a 32 768-byte file, which the DTE shall send a specific number of times one after another. The extended form is a full-length file that the DTE shall send once. The extended-form files each consist of a specific number of repetitions of the segment-form files.

The naming convention for a segment-form file is *n*.TST, where *n* is the file number. The naming convention for an extended-form file is *n*X*mm*.TST, where *n* is the file number and *mm* is the number of times the 32-kilobyte segment is repeated. For example, 1X30.TST is file 1.TST repeated 30 times.

Table B.1 below indicates the name of each file along with its file size.

TABLE B.1/V.56 *ter*

Throughput test files

Segment file name	1.TST	2.TST	3.TST	4.TST	5.TST	1.TST
Repetitions	30	10	6	4	16	4
Extended file name	1X30.TST	2X10.TST	3X06.TST	4X04.TST	5X16.TST	1X04.TST
Size (bytes)	983 040	327 680	196 608	131 072	524 288	131 072

The length of each extended-form file is different so that the length, after having been compressed by the V.42 *bis* algorithm, is roughly equal. The only exception to this rule is the 1X04.TST file, which is intended for use in the Throughput versus network model coverage test procedure described in 6.1.2. Four repetitions of this file were chosen so that the amount of data transferred through the modem-to-modem link will be about equal to the amount of data transferred through the modem-to-modem link in 6.1.1.

Appendix I

Characteristics of data files

The files accompanying this Recommendation consist of data with widely differing compressibility by V.42 *bis* algorithms, and therefore produce various throughput rates. The wide range of compressibility allows exploration of its effect on overall throughput, particularly when comparative evaluations of modems are being performed.

The files represent a wide range of different data types. The 1.TST file is representative of number-only files, and is taken from a vector-graphic drawing description. The 2.TST file is taken from a WordPerfect word-processing file. The 3.TST file is a portion of an executable (.EXE) program for the Intel 8086 family of computers. The 4.TST file is taken from a 64-bit random-number generator, and its characteristics are typical for files compressed with Ziv-Lempel algorithms. The 5.TST file is a mixture of different types of files combined into one; it is derived from the file used to examine proposed V.42 *bis* algorithms.

There are various implementations of V.42 *bis* data compression in existence, and it cannot be guaranteed that all implementations will yield the same compression ratios on the five data files. For information purposes only, the compressed file sizes have been provided as measured by a V.42 *bis* implementation when there are no time limitations on the compression process. This implementation was used to measure the file size after compression for each of the five data files using dictionary sizes of 512, 1024, 2048, 4096, 8192, and 16 384 elements and maximum string lengths of 6, 16, 32, 64, 128 and 250 bytes.

The results provided in Tables I.1 through I.5 can be used as a baseline to determine the relationship between the measured and reference throughput results.

TABLE I.1/V.56 *ter*

Compressed file size for file 1X30.TST (bytes)

String length	Dictionary size					
	512	1 024	2 048	4 096	8 192	16 384
6	302 386	252 399	245 509	250 899	264 958	264 958
8	283 180	226 703	200 959	193 943	203 621	208 732
16	275 607	205 223	165 877	141 556	123 188	122 804
32	276 417	195 870	156 546	127 525	105 132	92 178
64	276 417	193 170	151 824	126 168	102 516	86 366
128	276 417	191 871	149 276	124 224	102 638	87 055
250	276 417	191 871	149 276	124 224	102 677	86 784

TABLE I.2/V.56 *ter*

Compressed file size for file 2X10.TST (bytes)

String length	Dictionary size					
	512	1 024	2 048	4 096	8 192	16 384
6	146 836	144 258	147 938	147 133	131 877	118 115
8	143 911	140 425	142 932	141 217	123 062	107 328
16	141 086	138 830	137 082	133 353	116 021	96 418
32	140 999	138 096	135 950	131 161	114 244	93 406
64	140 999	138 144	135 901	130 662	114 103	92 583
128	140 999	138 144	135 901	130 662	114 103	92 583
250	140 999	138 144	135 901	130 662	114 103	92 583

TABLE I.3/V.56 *ter*

Compressed file size for file 3X06.TST (bytes)

String length	Dictionary size					
	512	1 024	2 048	4 096	8 192	16 384
6	128 433	134 873	148 187	151 322	154 492	146 762
8	127 704	134 075	142 184	150 517	152 902	145 015
16	127 562	134 015	142 125	150 011	152 297	143 745
32	127 562	134 015	142 125	149 993	152 089	143 565
64	127 562	134 015	142 125	149 993	152 089	143 565
128	127 562	134 015	142 125	149 993	152 089	143 565
250	127 562	134 015	142 125	149 993	152 089	143 565

TABLE I.4/V.56 *ter*

Compressed file size for file 4X04.TST (bytes)

String length	Dictionary size					
	512	1 024	2 048	4 096	8 192	16 384
6	131 268	131 268	131 268	131 268	131 526	131 526
8	131 268	131 268	131 268	131 268	131 526	131 526
16	131 268	131 268	131 268	131 268	131 526	131 526
32	131 268	131 268	131 268	131 268	131 526	131 526
64	131 268	131 268	131 268	131 268	131 526	131 526
128	131 268	131 268	131 268	131 268	131 526	131 526
250	131 268	131 268	131 268	131 268	131 526	131 526

TABLE I.5/V.56 *ter*

Compressed file size for file 5X16.TST (bytes)

String length	Dictionary size					
	512	1 024	2 048	4 096	8 192	16 384
6	192 429	189 878	192 544	186 097	174 574	171 017
8	179 466	175 289	175 082	166 435	150 837	144 760
16	161 238	154 633	151 009	138 896	120 974	109 536
32	154 002	145 665	140 402	126 803	107 428	95 218
64	152 986	141 419	135 848	121 103	101 260	88 677
128	157 750	140 741	133 992	118 540	99 045	85 175
250	158 519	142 621	134 730	117 812	98 023	84 120

Appendix II

Determination of reference throughput values

The reference throughput will vary depending on the line rate of the connection, the BTLZ dictionary size, and the maximum string length used by the V.42 *bis* algorithm in the modem under test. In Table II.1, the compressed size for each file using a 2048-entry dictionary and 32-character maximum string length was used to determine the reference throughput values shown. Actual results collected from modems that use different dictionary sizes and maximum string lengths can then be normalized for comparative purposes.

Equation (II-1) is used to determine the reference throughput:

$$R_f = L \cdot C_f \cdot \varepsilon \qquad \text{(II-1)}$$

where R_f is the calculated reference throughput for file f, L is the line rate in bits per second, C_f is the file compression ratio that is computed by dividing the uncompressed file size from Annex B by the theoretical compressed file size from Appendix I, and ε is the V.42 error control efficiency factor defined in equation (II-2) below.

The V.42 error control efficiency factor is a constant that is calculated for a V.42 frame size of 128 bytes. The factors in the equation are:

- the start bit and stop bit stripping factor;
- the conversion from asynchronous bit rate to character rate;
- the zero-bit insertion expansion factor (one inserted bit for every 62 data bits in the 132 random bytes of the 134-byte frame); and
- the V.42 framing factor (128 bytes of data in a 134-byte frame).

The resulting value, taking each of these factors in order, is:

$$\varepsilon = (1.2500)\,(0.10000)\,(0.98436)\,(0.95522) = 0.11745 \qquad \text{(II-2)}$$

Table II.1 gives the reference throughput values R_f over a range of line rates for the five standard test files. These values were calculated using a V.42 frame size of 128, V.42 *bis* dictionary size of 2048 entries, and a V.42 *bis* maximum string length of 32.

A modem can use V.42 frame size, V.42 *bis* string length, and V.42 *bis* dictionary size values other than 128, 32, and 2048 respectively. It is therefore possible for a modem's actual throughput results to exceed the reference values, resulting in reported normalized values greater than one. For consistent comparisons, a common reference value table should be used for all modems tested.

TABLE II.1/V.56 *ter*

Reference Throughput Values (characters/s)

Rate \ File	1X30.TST	2X10.TST	3X06.TST	4X04.TST	5X16.TST
28 800 bit/s	21 594	8 288	4 757	3 434	12 841
26 400 bit/s	19 794	7 598	4 361	3 147	11 771
24 000 bit/s	17 995	6 907	3 964	2 861	10 701
21 600 bit/s	16 195	6 216	3 568	2 575	9 631
19 200 bit/s	14 396	5 526	3 171	2 289	8 561
16 800 bit/s	12 596	4 835	2 775	2 003	7 490
14 400 bit/s	10 797	4 144	2 378	1 717	6 420
12 000 bit/s	8 997	3 453	1 982	1 431	5 350
9 600 bit/s	7 198	2 763	1 586	1 145	4 280
7 200 bit/s	5 398	2 072	1 189	858	3 210
4 800 bit/s	3 599	1 381	793	572	2 140
2 400 bit/s	1 799	691	396	286	1 070
1 200 bit/s	900	345	198	143	535

Appendix III

Error rate estimation

This appendix deals with the estimation of error rates based on observed error ratios. There are two main issues that need to be considered when estimating (measuring) error rates.

- The fundamental error mechanism.
- The desired accuracy or confidence level.

The following subclauses discuss the accuracy issues first, then address the estimation of bit-error rates and block-error rates.

III.1 Definitions

Because it is necessary to distinguish between an error rate, which is a probability, and an observed ratio, we define the following notation:

T A trial is the reception of one bit, block, or message, depending on the type of error rate being estimated.

n Represents the number of trials for a test.

m Represents the number of errors counted during a test.

P_{bit} Bit-error ratio.

P_{block} Block-error ratio.

P_{char} Character-error ratio.

III.2 Test duration

Errors are binary events: for each transfer, an error either occurs or it does not. Error rate is the probability that an error will occur during reception of a bit, block, or message. Error ratio can be used to estimate the error rate, which is assumed to be constant for the duration of an estimation.

The issue of how many errors or trials need to be observed to obtain reasonable error rate estimation accuracy is discussed in several papers identified in the bibliography at the end of this appendix. Reference [1] gives general guidelines and a list of references. Reference [2], on which this appendix is based, discusses four error rate estimation procedures. The following two types are most often used:

Type A: Stop the test when the number of trials reaches a limit.

Type B: Stop the test when the number of error events reaches a limit.

Table III.2, which is based on the table in [2], shows the normalized upper and lower 90%, 95%, and 99% confidence limits that apply when the number of trials is large (at least 1000) and the errors are independent.

When a test is conducted, the actual error rate, E, will satisfy the following equation:

$$m L_m/n < E < m U_m/n \tag{III-1}$$

where L_m and U_m are taken from Table III.2 for the test type and confidence limit desired.

Table III.2 does not contain entries for a zero value for m. If a type-A test is run and no errors are counted, then the lower confidence limit L_{zero} is zero. The absolute upper 90% limit U_{zero} is $(3/n)$, the upper 95% limit U_{zero} is $(3.7/n)$, and the upper 99% limit U_{zero} is $(5.3/n)$.

NOTE – The 90% or other confidence limits are not unique. There is an infinite set of lower and upper limits for each error count. The limits shown in Table III.2 are representative.

To illustrate the use of Table III.2 for a type-A test, suppose a test is run for 1000 blocks and ten block errors are counted. The lower and upper 95% limits, from Table III.2, are $L_{10} = 0.48$ and $U_{10} = 1.84$. The block-error ratio m/n is 0.01 and one can say with 95% confidence that P_{block} is between 0.0048 and 0.0184. As mentioned above, other upper and lower limits exist for the same confidence level.

If a type-B test is run until ten errors are counted and the number of trials turns out to be 1000, then the 95% lower limit is 0.0048 (as before) but using the type-B column the upper limit of P_{block} is 0.0171.

III.3 Application to bit-error rate

Bit errors are seldom independent. However, when bit errors are independent, Table III.2 can apply.

When the modem under test uses QAM (with or without trellis coding), bit errors are usually the result of some modem receiver process that causes a group of bit errors to occur each time the underlying error event occurs; e.g. the QAM modulation of V.22 *bis* produces error strings. This problem is worse when the modem uses trellis coding: bit errors occur in larger bursts.

ITU-T Study Group (SG) 14 recommends against the use of BER estimation with QAM modems for two reasons:

1) A higher BER does not imply a poorer modem; the BLER may be lower.

2) One cannot accurately estimate BER from the ratio of bit errors to bits without more information about the way bit errors occur.

The first point is especially applicable to tests intended to show which modem of a group is "better." BER estimates can be misleading.

Table III.1 illustrates the second point. The table shows the number of errors that must be counted in a type-B test when the error bursts contain only errors (no good bits) and the number of errors per burst is uniformly distributed between the indicated minimum and maximum burst size. The entries for minimum burst and maximum burst of one correspond to entries in Table III.2.

TABLE III.1/V.56 *ter*

Counts for 0.5m/n < error-rate < 1.5m/n

Number of bits errors to count for 90% and 95% confidence that the bit error rate will be between 0.5 and 1.5 times the observed error ratio.

Min. burst	Max. burst	90% count	95% count
1	1	11	15
1	2	19	30
1	3	35	57
1	4	25	36
1	10	65	92
1	20	137	198
1	30	210	305
1	40	282	410
10	20	175	258
10	30	241	359
10	40	313	462
20	30	280	413

III.4 Application to block-error rate

When a modem is used to send and receive data in blocks of bits, then block-error rate is the best measure of performance. Fortunately, even when bit errors occur in clusters, block errors can be treated as if they are independent. Thus, to make accurate estimates of block-error rate, a large number of blocks should be transmitted (more than 1000) and at least ten block errors should be recorded.

Block size is important if one wants to use the block-error ratio (BLER) to predict throughput. For example, the default frame size used by V.42 is about 1080 bits. Therefore, tests made with a block size of 1000 bits can be used to estimate the V.42 frame-error rate.

III.5 Procedure

When estimating an error rate of a modem, it is recommended that a new connection be established after selecting a new EO-EO combination. Some modems will continue to function when channel parameters change in the middle of a connection, but will not be able to establish a new connection (i.e. complete the handshake) with the changed channel. Other modems will not achieve the same quality of adaptive equalization or other adaptive behaviour during a call. This type of behaviour, if it exists, might be more important to know than estimates of error rate.

III.6 Cautions

If the DTE loses synchronization during an error ratio test, the error ratio is not likely to provide an accurate estimate of the true error rate. It is recommended that the cause of synchronization loss be identified and corrected.

P_{bit} is very difficult to estimate from the character-error ratio. When a start or stop element is erroneous, the DTE is likely to lose synchronization. It is recommended that BER be measured with the modem operating in synchronous mode.

TABLE III.2/V.56 *ter*

Lower and upper confidence limit factors

	90%			95%			99%		
Errors *m*	L_m	Type A U_m	Type B U_m	L_m	Type A U_m	Type B U_m	L_m	Type A U_m	Type B U_m
1	0.051	4.70	3.00	0.025	5.60	3.70	0.005	7.40	5.30
2	0.18	3.15	2.35	0.12	3.60	2.80	0.05	4.65	3.70
3	0.27	2.60	2.10	0.21	2.93	2.40	0.11	3.67	3.10
4	0.34	2.30	1.95	0.27	2.55	2.20	0.17	3.15	2.75
5	0.39	2.10	1.84	0.32	2.34	2.04	0.22	2.82	2.52
6	0.43	1.97	1.75	0.37	2.18	1.95	0.26	2.62	2.35
7	0.47	1.87	1.69	0.40	2.06	1.87	0.29	2.44	2.24
8	0.50	1.80	1.64	0.44	1.98	1.80	0.32	2.33	2.14
9	0.52	1.74	1.60	0.46	1.90	1.76	0.35	2.22	2.07
10	0.54	1.70	1.57	0.48	1.84	1.71	0.37	2.14	2.00
11	0.56	1.65	1.55	0.50	1.79	1.67	0.39	2.07	1.95
12	0.58	1.62	1.52	0.52	1.75	1.64	0.41	2.01	1.90
13	0.59	1.59	1.49	0.53	1.71	1.62	0.43	1.96	1.85
14	0.61	1.56	1.48	0.55	1.68	1.59	0.44	1.91	1.82
15	0.61	1.54	1.46	0.56	1.65	1.57	0.46	1.88	1.79
16	0.63	1.52	1.44	0.57	1.63	1.54	0.48	1.84	1.76
17	0.64	1.50	1.43	0.58	1.60	1.53	0.49	1.81	1.74
18	0.64	1.48	1.42	0.59	1.58	1.51	0.49	1.78	1.71
19	0.65	1.47	1.41	0.60	1.56	1.49	0.51	1.76	1.69
20	0.67	1.45	1.40	0.61	1.55	1.49	0.52	1.75	1.67
21	0.67	1.44	1.39	0.62	1.52	1.48	0.53	1.71	1.67
22	0.68	1.43	1.37	0.63	1.50	1.45	0.54	1.68	1.64
23	0.68	1.42	1.37	0.63	1.52	1.43	0.54	1.65	1.61
24	0.69	1.41	1.36	0.64	1.50	1.46	0.55	1.67	1.58
25	0.70	1.40	1.35	0.65	1.48	1.44	0.56	1.64	1.60
26	0.70	1.38	1.35	0.65	1.46	1.42	0.57	1.62	1.58
27	0.71	1.37	1.33	0.66	1.44	1.41	0.57	1.59	1.56
28	0.71	1.36	1.32	0.66	1.43	1.39	0.58	1.61	1.54
29	0.71	1.38	1.31	0.67	1.45	1.38	0.59	1.59	1.55
30	0.72	1.37	1.33	0.67	1.43	1.40	0.59	1.57	1.53
35	0.74	1.31	1.17	0.70	1.40	1.23	0.62	1.51	1.34
40	0.76	1.30	1.15	0.72	1.35	1.23	0.64	1.48	1.33
45	0.77	1.29	1.16	0.73	1.33	1.20	0.66	1.44	1.31
50	0.78	1.26	1.16	0.74	1.32	1.20	0.67	1.42	1.30
55	0.78	1.25	1.15	0.75	1.31	1.20	0.69	1.40	1.29
60	0.80	1.23	1.15	0.77	1.28	1.20	0.70	1.38	1.28
65	0.80	1.23	1.14	0.77	1.28	1.18	0.71	1.37	1.28
70	0.81	1.21	1.14	0.79	1.26	1.19	0.71	1.36	1.27
75	0.81	1.21	1.13	0.79	1.25	1.17	0.73	1.33	1.27
80	0.83	1.20	1.14	0.79	1.25	1.17	0.74	1.33	1.25
85	0.82	1.20	1.13	0.80	1.24	1.18	0.74	1.32	1.25
90	0.83	1.19	1.13	0.80	1.23	1.17	0.74	1.30	1.24
95	0.84	1.19	1.13	0.81	1.22	1.17	0.76	1.29	1.23
100	0.84	1.18	1.13	0.81	1.22	1.16	0.76	1.29	1.23

III.7 Bibliography

[1] NEWCOMBE (E. A.), PASUPATHY (S.): Error Rate Monitoring for Digital Communications, *Proc. IEEE*, Vol. 70, No. 8, pp. 805-828, August 1982.

[2] CROW (E. L.), MILES (M. J.): A Minimum Cost, Accurate Statistical Method to Measure Bit Error Rates, *Int. Conf. Computer Communication Record*, pp. 631-635, 1976.

Appendix IV

Data reporting format and interpretation of results

This appendix describes the recommended format for displaying test results generated by the procedures described in clause 6. The use of a common display format permits easy direct comparison of test results by different testers.

The results in this appendix are given for the use of the intracontinental network model of Table 1a/V.56 *bis*.

IV.1 Throughput versus network model coverage

Results of throughput testing as described in 6.1 are presented in a line chart showing throughput versus percentage of network model coverage as shown in Figure IV.1.

Three different variations of the throughput versus network model coverage test are described in 6.1. All three tests report the same set of measurements in the same units, so the identical analysis method is used for all these tests.

Table IV.1 shows how the raw data is presented in a matrix. The results are throughput measurements in characters per second for each EO-EO combination. For the purposes of this analysis, a failure to connect is equal to a throughput of zero characters per second. In the example, it is assumed that the test described in 6.1.1 is being performed on a V.34 modem.

Each throughput result in Table IV.1 is paired with the corresponding entry ("Score") in Table 3/V.56 *bis*. The result for this example is shown in Table IV.2 in the unsorted list.

The Table is then sorted in descending order by the throughput, and the accumulated network coverage calculated. The result of this step is shown in Table IV.3.

The data from the sorted table is then plotted as shown in Figure IV.1.

In this example, the modem pair achieves a throughput of approximately 7700 characters per second on about 30% of the network model, and achieves better than 7000 characters per second on almost 80% of the model.

This analysis may also be broken down by individual test loop combinations, in order to display the performance levels that users on different types of local loops can expect. Data is sorted by ascending TLC number, and then sorted descending by throughput within each TLC subgroup. The score used for each impairment combination is that listed for each such combination in Table 1a/V.56 *bis*. Coverage is then accumulated individually within each subgroup. The result of this sort and calculation is shown in Table IV.4.

The data from the TLC-sorted table is then plotted as shown in Figure IV.2.

Results of throughput testing as described in 6.1 are presented in a dual axis chart showing throughput versus network model line type and network model coverage percentage versus network model line type coverage as shown in Figure IV.3. Three different variations of the throughput versus network model coverage test are described in 6.1. All three tests report the same set of measurements in the same units, so the identical analysis method is used for all these tests. In this example, the modem pair achieves a throughput of approximately 77 000 bits per second on about 30% of the network model. The modem under test also fails to connect on three separate line impairment combinations. This analysis displays throughput performance along with LOO scores in a pair of curves that graphically represent the relation between throughput and probability of encountering a particular line type. Data is sorted by descending LOO. The score used for each impairment combination is that listed for each such combination in Table 1a/V.56 *bis*. Coverage is then accumulated individually and plotted in Figure IV.4.

Figure IV.5 shows the DCE connect rates for the 168 channels tested when performing the network model tests. The data is sorted by connect rate in descending order and displayed at a percentage of the total connections.

TABLE IV.1/V.56 *ter*

Throughput table (Raw data)

IC	TLC 1	TLC 2	TLC 3	TLC 4	TLC 5	TLC 6	TLC 7
1c	7084	7728	7084	7084	7084	6440	6440
2c	7728	7728	7728	7728	7084	6440	6440
3c	7084	6440	6440	7084	5796	6440	6440
4c	6440	6440	5796	0	5796	5796	5796
5c	7728	7728	7728	7728	7084	7084	6440
1b	7015	7084	6440	7015	5980	5796	6325
1a	6302	6440	5129	6440	5152	5796	5796
7c	5796	5796	6440	6440	6440	5796	5152
8c	6440	3864	6440	5152	6440	5152	5152
2b	7084	7084	7015	7084	6440	6440	6440
2a	7015	7084	6440	7084	6440	6440	6394
6c	5773	7728	7084	7084	6049	6440	6440
3b	6440	6440	6394	6440	5796	5796	5152
3a	3864	6440	5152	0	5796	0	5152
5b	7728	7728	7084	7728	7084	5014	6440
5a	7728	7728	7084	7728	6440	4508	5796
4b	5796	5796	5796	0	5152	5152	5152
4a	0	5796	5152	0	5152	0	4508
7b	5152	0	0	0	5152	3956	3864
7a	4508	0	0	0	0	0	3864
8b	5796	0	5796	5152	5796	0	4508
8a	0	0	0	0	3864	0	3864
6b	5750	2063	7084	7084	5796	5014	6440
6a	5727	2047	6440	0	5796	0	5152

TABLE IV.2/V.56 *ter*

Unsorted throughput worksheet

IC	TLC	Score	Throughput	IC	TLC	Score	Throughput	IC	TLC	Score	Throughput
1c	1	22.8620%	7084	8c	3	0.1700%	6440	4b	5	0.0200%	5152
2c	1	7.5440%	7728	2b	3	0.1400%	7015	4a	5	0.0200%	5152
3c	1	4.2780%	7084	2a	3	0.1400%	6440	7b	5	0.0120%	5152
4c	1	2.1620%	6440	6c	3	0.0900%	7084	7a	5	0.0120%	0
5c	1	1.9780%	7728	3b	3	0.0500%	6394	8b	5	0.0120%	5796
1b	1	1.2880%	7015	3a	3	0.0500%	5152	8a	5	0.0120%	3864
1a	1	1.2880%	6302	5b	3	0.0350%	7084	6b	5	0.0040%	5796
7c	1	0.7820%	5796	5a	3	0.0350%	7084	6a	5	0.0040%	5796
8c	1	0.7820%	6440	4b	3	0.0250%	5796	1c	6	0.7952%	6440
2b	1	0.6440%	7084	4a	3	0.0250%	5152	2c	6	0.2624%	6440
2a	1	0.6440%	7015	7b	3	0.0150%	0	3c	6	0.1488%	6440
6c	1	0.4140%	5773	7a	3	0.0150%	0	4c	6	0.0752%	5796
3b	1	0.2300%	6440	8b	3	0.0150%	5796	5c	6	0.0688%	7084
3a	1	0.2300%	3864	8a	3	0.0150%	0	1b	6	0.0448%	5796
5b	1	0.1610%	7728	6b	3	0.0050%	7084	1a	6	0.0448%	5796
5a	1	0.1610%	7728	6a	3	0.0050%	6440	7c	6	0.0272%	5796
4b	1	0.1150%	5796	1c	4	4.9700%	7084	8c	6	0.0272%	5152
4a	1	0.1150%	0	2c	4	1.6400%	7728	2b	6	0.0224%	6440
7b	1	0.0690%	5152	3c	4	0.9300%	7084	2a	6	0.0224%	6440
7a	1	0.0690%	4508	4c	4	0.4700%	0	6c	6	0.0144%	6440
8b	1	0.0690%	5796	5c	4	0.4300%	7728	3b	6	0.0080%	5796
8a	1	0.0690%	0	1b	4	0.2800%	7015	3a	6	0.0080%	0
6b	1	0.0230%	5750	1a	4	0.2800%	6440	5b	6	0.0056%	5014
6a	1	0.0230%	5727	7c	4	0.1700%	6440	5a	6	0.0056%	4508
1c	2	11.4310%	7728	8c	4	0.1700%	5152	4b	6	0.0040%	5152
2c	2	3.7720%	7728	2b	4	0.1400%	7084	4a	6	0.0040%	0
3c	2	2.1390%	6440	2a	4	0.1400%	7084	7b	6	0.0024%	3956
4c	2	1.0810%	6440	6c	4	0.0900%	7084	7a	6	0.0024%	0
5c	2	0.9890%	7728	3b	4	0.0500%	6440	8b	6	0.0024%	0
1b	2	0.6440%	7084	3a	4	0.0500%	0	8a	6	0.0024%	0
1a	2	0.6440%	6440	5b	4	0.0350%	7728	6b	6	0.0008%	5014
7c	2	0.3910%	5796	5a	4	0.0350%	7728	6a	6	0.0008%	0
8c	2	0.3910%	3864	4b	4	0.0250%	0	1c	7	0.6958%	6440
2b	2	0.3220%	7084	4a	4	0.0250%	0	2c	7	0.2296%	6440
2a	2	0.3220%	7084	7b	4	0.0150%	0	3c	7	0.1302%	6440
6c	2	0.2070%	7728	7a	4	0.0150%	0	4c	7	0.0658%	5796
3b	2	0.1150%	6440	8b	4	0.0150%	5152	5c	7	0.0602%	6440
3a	2	0.1150%	6440	8a	4	0.0150%	0	1b	7	0.0392%	6325

TABLE IV.2/V.56 *ter (concluded)*

Unsorted throughput worksheet

IC	TLC	Score	Throughput	IC	TLC	Score	Throughput	IC	TLC	Score	Throughput
5b	2	0.0805%	7728	6b	4	0.0050%	7084	1a	7	0.0392%	5796
5a	2	0.0805%	7728	6a	4	0.0050%	0	7c	7	0.0238%	5152
4b	2	0.0575%	5796	1c	5	3.9760%	7084	8c	7	0.0238%	5152
4a	2	0.0575%	5796	2c	5	1.3120%	7084	2b	7	0.0196%	6440
7b	2	0.0345%	0	3c	5	0.7440%	5796	2a	7	0.0196%	6394
7a	2	0.0345%	0	4c	5	0.3760%	5796	6c	7	0.0126%	6440
8b	2	0.0345%	0	5c	5	0.3440%	7084	3b	7	0.0070%	5152
8a	2	0.0345%	0	1b	5	0.2240%	5980	3a	7	0.0070%	5152
6b	2	0.0115%	2063	1a	5	0.2240%	5152	5b	7	0.0049%	6440
6a	2	0.0115%	2047	7c	5	0.1360%	6440	5a	7	0.0049%	5796
1c	3	4.9700%	7084	8c	5	0.1360%	6440	4b	7	0.0035%	5152
2c	3	1.6400%	7728	2b	5	0.1120%	6440	4a	7	0.0035%	4508
3c	3	0.9300%	6440	2a	5	0.1120%	6440	7b	7	0.0021%	3864
4c	3	0.4700%	5796	6c	5	0.0720%	6049	7a	7	0.0021%	3864
5c	3	0.4300%	7728	3b	5	0.0400%	5796	8b	7	0.0021%	4508
1b	2	0.2800%	6440	3a	5	0.0400%	5796	8a	7	0.0021%	3864
1a	3	0.2800%	5129	5b	5	0.0280%	7084	6b	7	0.0007%	6440
7c	3	0.1700%	6440	5a	5	0.0280%	6440	6a	7	0.0007%	5152

TABLE IV.3/V.56 *ter*

Sorted throughput worksheet

IC	TLC	Score	Coverage	T'put	IC	TLC	Score	Coverage	T'put	IC	TLC	Score	Coverage	T'put
1c	2	11.4310%	11.4310%	7728	7c	3	0.1700%	90.0278%	6440	8c	4	0.1700%	97.6417%	5152
2c	1	7.5440%	18.9750%	7728	7c	4	0.1700%	90.1978%	6440	7b	1	0.0690%	97.7107%	5152
2c	2	3.7720%	22.7470%	7728	3c	6	0.1488%	90.3466%	6440	3a	3	0.0500%	97.7607%	5152
5c	1	1.9780%	24.7250%	7728	2a	3	0.1400%	90.4866%	6440	8c	6	0.0272%	97.7879%	5152
2c	3	1.6400%	26.3650%	7728	7c	5	0.1360%	90.6226%	6440	4a	3	0.0250%	97.8129%	5152
2c	4	1.6400%	28.0050%	7728	8c	5	0.1360%	90.7586%	6440	7c	7	0.0238%	97.8367%	5152
5c	2	0.9890%	28.9940%	7728	3c	7	0.1302%	90.8888%	6440	8c	7	0.0238%	97.8605%	5152
5c	4	0.4300%	29.4240%	7728	3b	2	0.1150%	91.0038%	6440	4b	5	0.0200%	97.8805%	5152
5c	3	0.4300%	29.8540%	7728	3a	2	0.1150%	91.1188%	6440	4a	5	0.0200%	97.9005%	5152
6c	2	0.2070%	30.0610%	7728	2b	5	0.1120%	91.2308%	6440	8b	4	0.0150%	97.9155%	5152
5a	1	0.1610%	30.2220%	7728	2a	5	0.1120%	91.3428%	6440	7b	5	0.0120%	97.9275%	5152
5b	1	0.1610%	30.3830%	7728	5c	7	0.0602%	91.4030%	6440	3b	7	0.0070%	97.9345%	5152
5b	2	0.0805%	30.4635%	7728	3b	4	0.0500%	91.4530%	6440	3a	7	0.0070%	97.9415%	5152
5a	2	0.0805%	30.5440%	7728	5a	5	0.0280%	91.4810%	6440	4b	6	0.0040%	97.9455%	5152
5b	4	0.0350%	30.5790%	7728	2b	6	0.0224%	91.5034%	6440	4b	7	0.0035%	97.9490%	5152
5a	4	0.0350%	30.6140%	7728	2a	6	0.0224%	91.5258%	6440	6a	7	0.0007%	97.9497%	5152
1c	1	22.8620%	53.4760%	7084	2b	7	0.0196%	91.5454%	6440	1a	3	0.2800%	98.2297%	5129
1c	4	4.9700%	58.4460%	7084	6c	6	0.0144%	91.5598%	6440	5b	6	0.0056%	98.2353%	5014
1c	3	4.9700%	63.4160%	7084	6c	7	0.0126%	91.5724%	6440	6b	6	0.0008%	98.2361%	5014
3c	1	4.2780%	67.6940%	7084	6a	3	0.0050%	91.5774%	6440	7a	1	0.0690%	98.3051%	4508
1c	5	3.9760%	71.6700%	7084	5b	7	0.0049%	91.5823%	6440	5a	6	0.0056%	98.3107%	4508
2c	5	1.3120%	72.9820%	7084	6b	7	0.0007%	91.5830%	6440	4a	7	0.0035%	98.3142%	4508
3c	4	0.9300%	73.9120%	7084	3b	3	0.0500%	91.6330%	6394	8b	7	0.0021%	98.3163%	4508
2b	1	0.6440%	74.5560%	7084	2a	7	0.0196%	91.6526%	6394	7b	6	0.0024%	98.3187%	3956
1b	2	0.6440%	75.2000%	7084	1b	7	0.0392%	91.6918%	6325	8c	2	0.3910%	98.7097%	3864
5c	5	0.3440%	75.5440%	7084	1a	1	1.2880%	92.9798%	6302	3a	1	0.2300%	98.9397%	3864
2a	2	0.3220%	75.8660%	7084	6c	5	0.0720%	93.0518%	6049	8a	5	0.0120%	98.9517%	3864
2b	2	0.3220%	76.1880%	7084	1b	5	0.2240%	93.2758%	5980	7b	7	0.0021%	98.9538%	3864
2b	4	0.1400%	76.3280%	7084	7c	1	0.7820%	94.0578%	5796	7a	7	0.0021%	98.9559%	3864
2a	4	0.1400%	76.4680%	7084	3c	5	0.7440%	94.8018%	5796	8a	7	0.0021%	98.9580%	3864
6c	3	0.0900%	76.5580%	7084	4c	3	0.4700%	95.2718%	5796	6b	2	0.0115%	98.9695%	2063
6c	4	0.0900%	76.6480%	7084	7c	2	0.3910%	95.6628%	5796	6a	2	0.0115%	98.9810%	2047
5c	6	0.0688%	76.7168%	7084	4c	5	0.3760%	96.0388%	5796	4c	4	0.4700%	99.4510%	0
5b	3	0.0350%	76.7518%	7084	4b	1	0.1150%	96.1538%	5796	4a	1	0.1150%	99.5660%	0
5a	3	0.0350%	76.7868%	7084	4c	6	0.0752%	96.2290%	5796	8a	1	0.0690%	99.6350%	0
5b	5	0.0280%	76.8148%	7084	8b	1	0.0690%	96.2980%	5796	3a	4	0.0500%	99.6850%	0
6b	3	0.0050%	76.8198%	7084	4c	7	0.0658%	96.3638%	5796	7b	2	0.0345%	99.7195%	0
6b	4	0.0050%	76.8248%	7084	4b	2	0.0575%	96.4213%	5796	7a	2	0.0345%	99.7540%	0

TABLE IV.3/V.56 *ter (concluded)*

Sorted throughput worksheet

IC	TLC	Score	Coverage	T'put	IC	TLC	Score	Coverage	T'put	IC	TLC	Score	Coverage	T'put
1b	1	1.2880%	78.1128%	7015	4a	2	0.0575%	96.4788%	5796	8b	2	0.0345%	99.7885%	0
2a	1	0.6440%	78.7568%	7015	1b	6	0.0448%	96.5236%	5796	8a	2	0.0345%	99.8230%	0
1b	4	0.2800%	79.0368%	7015	1a	6	0.0448%	96.5684%	5796	4b	4	0.0250%	99.8480%	0
2b	3	0.1400%	79.1768%	7015	3b	5	0.0400%	96.6084%	5796	4a	4	0.0250%	99.8730%	0
4c	1	2.1620%	81.3388%	6440	3a	5	0.0400%	96.6484%	5796	8a	4	0.0150%	99.8880%	0
3c	2	2.1390%	83.4778%	6440	1a	7	0.0392%	96.6876%	5796	7b	3	0.0150%	99.9030%	0
4c	2	1.0810%	84.5588%	6440	7c	6	0.0272%	96.7148%	5796	7a	3	0.0150%	99.9180%	0
3c	3	0.9300%	85.4888%	6440	4b	3	0.0250%	96.7398%	5796	8a	3	0.0150%	99.9330%	0
1c	6	0.7952%	86.2840%	6440	8b	3	0.0150%	96.7548%	5796	7b	4	0.0150%	99.9480%	0
8c	1	0.7820%	87.0660%	6440	8b	5	0.0120%	96.7668%	5796	7a	4	0.0150%	99.9630%	0
1c	7	0.6958%	87.7618%	6440	3b	6	0.0080%	96.7748%	5796	7a	5	0.0120%	99.9750%	0
1a	2	0.6440%	88.4058%	6440	5a	7	0.0049%	96.7797%	5796	3a	6	0.0080%	99.9830%	0
1a	4	0.2800%	88.6858%	6440	6b	5	0.0040%	96.7837%	5796	6a	4	0.0050%	99.9880%	0
1b	3	0.2800%	88.9658%	6440	6a	5	0.0040%	96.7877%	5796	4a	6	0.0040%	99.9920%	0
2c	6	0.2624%	89.2282%	6440	6c	1	0.4140%	97.2017%	5773	7a	6	0.0024%	99.9944%	0
3b	1	0.2300%	89.4582%	6440	6b	1	0.0230%	97.2247%	5750	8b	6	0.0024%	99.9968%	0
2c	7	0.2296%	89.6878%	6440	6a	1	0.0230%	97.2477%	5727	8a	6	0.0024%	99.9992%	0
8c	3	0.1700%	89.8578%	6440	1a	5	0.2240%	97.4717%	5152	6a	6	0.0008%	100.00%	0

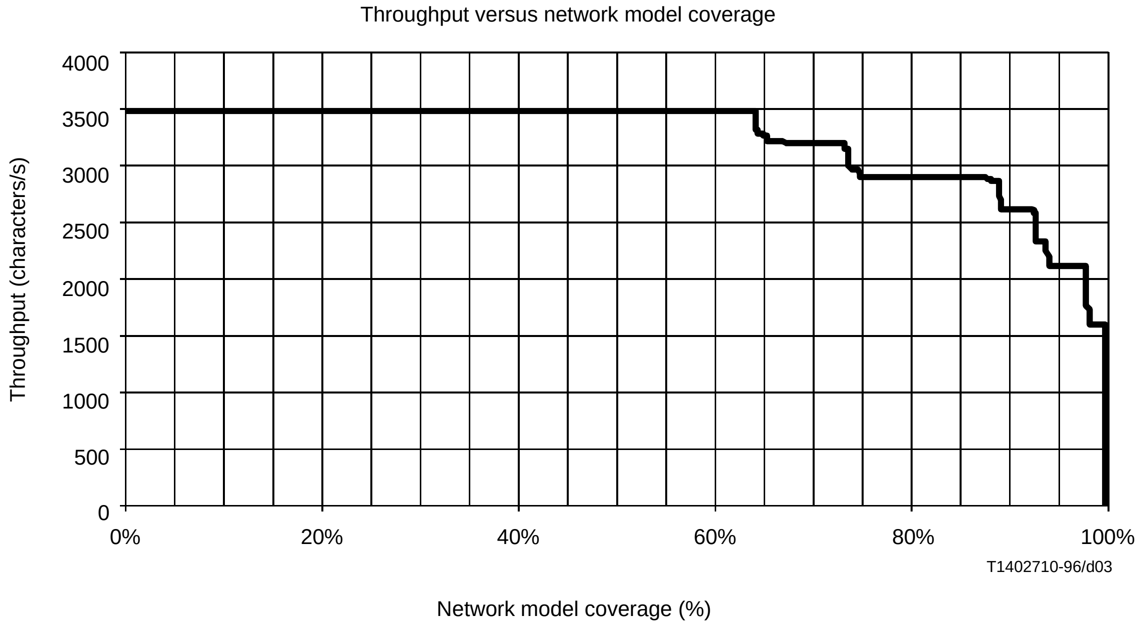

FIGURE IV.1/V.56 *ter*

Throughput coverage chart

TABLE IV.4/V.56 *ter*

TLC Sorted throughput worksheet

TLC 1				TLC 2				TLC 3				TLC 4				TLC 5				TLC 6				TLC 7			
IC	Score	Coverage	T'put	IC	Score	Coverage	T'put	IC	Score	Coverage	T'put	IC	Score	Coverage	T'put	IC	Score	Coverage	T'put	IC	Score	Coverage	T'put	IC	Score	Coverage	T'put
2c	16.400%	16.400%	7728	1c	49.700%	49.700%	7728	2c	16.400%	16.400%	7728	2c	16.400%	16.400%	7728	1c	49.700%	49.700%	7084	5c	4.300%	4.300%	7084	1c	49.700%	49.700%	6440
5c	4.300%	20.700%	7728	2c	16.400%	66.100%	7728	5c	4.300%	20.700%	7728	5c	4.300%	20.700%	7728	2c	16.400%	66.100%	7084	5c	49.700%	54.000%	6440	2c	16.400%	66.100%	6440
5a	0.350%	21.050%	7728	5c	4.300%	70.400%	7728	1c	49.700%	70.400%	7084	5b	0.350%	21.050%	7728	5c	4.300%	70.400%	7084	2c	16.400%	70.400%	6440	3c	9.300%	75.400%	6440
5b	0.350%	21.400%	7728	6c	0.900%	71.300%	7728	6c	0.900%	71.300%	7084	5a	0.350%	21.400%	7728	5b	0.350%	70.750%	7084	3c	9.300%	79.700%	6440	5c	4.300%	79.700%	6440
1c	49.700%	71.100%	7084	5b	0.350%	71.650%	7728	5b	0.350%	71.650%	7084	1c	49.700%	71.100%	7084	7c	1.700%	72.450%	6440	2b	1.400%	81.100%	6440	2b	1.400%	81.100%	6440
3c	9.300%	80.400%	7084	5a	0.350%	72.000%	7728	5a	0.350%	72.000%	7084	3c	9.300%	80.400%	7084	8c	1.700%	74.150%	6440	2a	1.400%	82.500%	6440	6c	0.900%	82.000%	6440
2b	1.400%	81.800%	7084	1b	2.800%	74.800%	7084	6b	0.050%	72.050%	7084	2b	1.400%	81.800%	7084	2b	1.400%	75.550%	6440	6c	0.900%	83.400%	6440	5b	0.350%	82.350%	6440
1b	2.800%	84.600%	7015	2a	1.400%	76.200%	7084	2b	1.400%	73.450%	7015	2a	1.400%	83.200%	7084	2a	1.400%	76.950%	6440	4c	4.700%	88.100%	5796	6b	0.050%	82.400%	6440
2a	1.400%	86.000%	7015	2b	1.400%	77.600%	7084	3c	9.300%	82.750%	6440	6c	0.900%	84.100%	7084	5a	0.350%	77.300%	6440	1b	2.800%	90.900%	5796	2a	1.400%	83.800%	6394
4c	4.700%	90.700%	6440	3c	9.300%	86.900%	6440	1b	2.800%	85.550%	6440	6b	0.050%	84.150%	7084	6c	0.900%	78.200%	6049	1a	2.800%	93.700%	5796	1b	2.800%	86.600%	6325
8c	1.700%	92.400%	6440	4c	4.700%	91.600%	6440	8c	1.700%	87.250%	6440	1b	2.800%	86.950%	7015	1b	2.800%	81.000%	5980	7c	1.700%	95.400%	5796	4c	4.700%	91.300%	5796
3b	0.500%	92.900%	6440	1a	2.800%	94.400%	6440	7c	1.700%	88.950%	6440	1a	2.800%	89.750%	6440	3c	9.300%	90.300%	5796	3b	0.500%	95.900%	5796	1a	2.800%	94.100%	5796
1a	2.800%	95.700%	6302	3b	0.500%	94.900%	6440	2a	1.400%	90.350%	6440	7c	1.700%	91.450%	6440	4c	4.700%	95.000%	5796	8c	1.700%	97.600%	5152	5a	0.350%	94.450%	5796
7c	1.700%	97.400%	5796	3a	0.500%	95.400%	6440	6a	0.050%	90.400%	6440	3b	0.500%	91.950%	6440	3b	0.500%	95.500%	5796	4b	0.250%	97.850%	5152	7c	1.700%	96.150%	5152
4b	0.250%	97.650%	5796	7c	1.700%	97.100%	5796	3b	0.500%	90.900%	6394	8c	1.700%	93.650%	5152	3a	0.500%	96.000%	5796	5b	0.350%	98.200%	5014	8c	1.700%	97.850%	5152
8b	0.150%	97.800%	5796	4b	0.250%	97.350%	5796	4c	4.700%	95.600%	5796	8b	0.150%	93.800%	5152	8b	0.150%	96.150%	5796	6b	0.050%	98.250%	5014	3b	0.500%	98.350%	5152
6c	0.900%	98.700%	5773	4a	0.250%	97.600%	5796	4b	0.250%	95.850%	5796	4c	4.700%	98.500%	0	6b	0.050%	96.200%	5796	5a	0.350%	98.600%	4508	3a	0.500%	98.850%	5152
6b	0.050%	98.750%	5750	8c	1.700%	99.300%	3864	8b	0.150%	96.000%	5796	3a	0.500%	99.000%	0	6a	0.050%	96.250%	5796	7b	0.150%	98.750%	3956	4b	0.250%	99.100%	5152
6a	0.050%	98.800%	5727	6b	0.050%	99.350%	2063.1	3a	0.500%	96.500%	5152	4b	0.250%	99.250%	0	1a	2.800%	99.050%	5152	3a	0.500%	99.250%	0	6a	0.050%	99.150%	5152
7b	0.150%	98.950%	5152	6a	0.050%	99.400%	2047	4a	0.250%	96.750%	5152	4a	0.250%	99.500%	0	4b	0.250%	99.300%	5152	4a	0.250%	99.500%	0	4a	0.250%	99.400%	4508
7a	0.150%	99.100%	4508	7b	0.150%	99.550%	0	1a	2.800%	99.550%	5129	8a	0.150%	99.650%	0	4a	0.250%	99.550%	5152	7a	0.150%	99.650%	0	8b	0.150%	99.550%	4508
3a	0.500%	99.600%	3864	7a	0.150%	99.700%	0	7b	0.150%	99.700%	0	7b	0.150%	99.800%	0	7b	0.150%	99.700%	5152	8b	0.150%	99.800%	0	7b	0.150%	99.700%	3864
4a	0.250%	99.850%	0	8b	0.150%	99.850%	0	7a	0.150%	99.850%	0	7a	0.150%	99.950%	0	8a	0.150%	99.850%	3864	8a	0.150%	99.950%	0	7a	0.150%	99.850%	3864
8a	0.150%	100.000%	0	8a	0.150%	100.000%	0	8a	0.150%	100.000%	0	6a	0.050%	100.000%	0	7a	0.150%	100.000%	0	6a	0.050%	100.000%	0	8a	0.150%	100.000%	3864

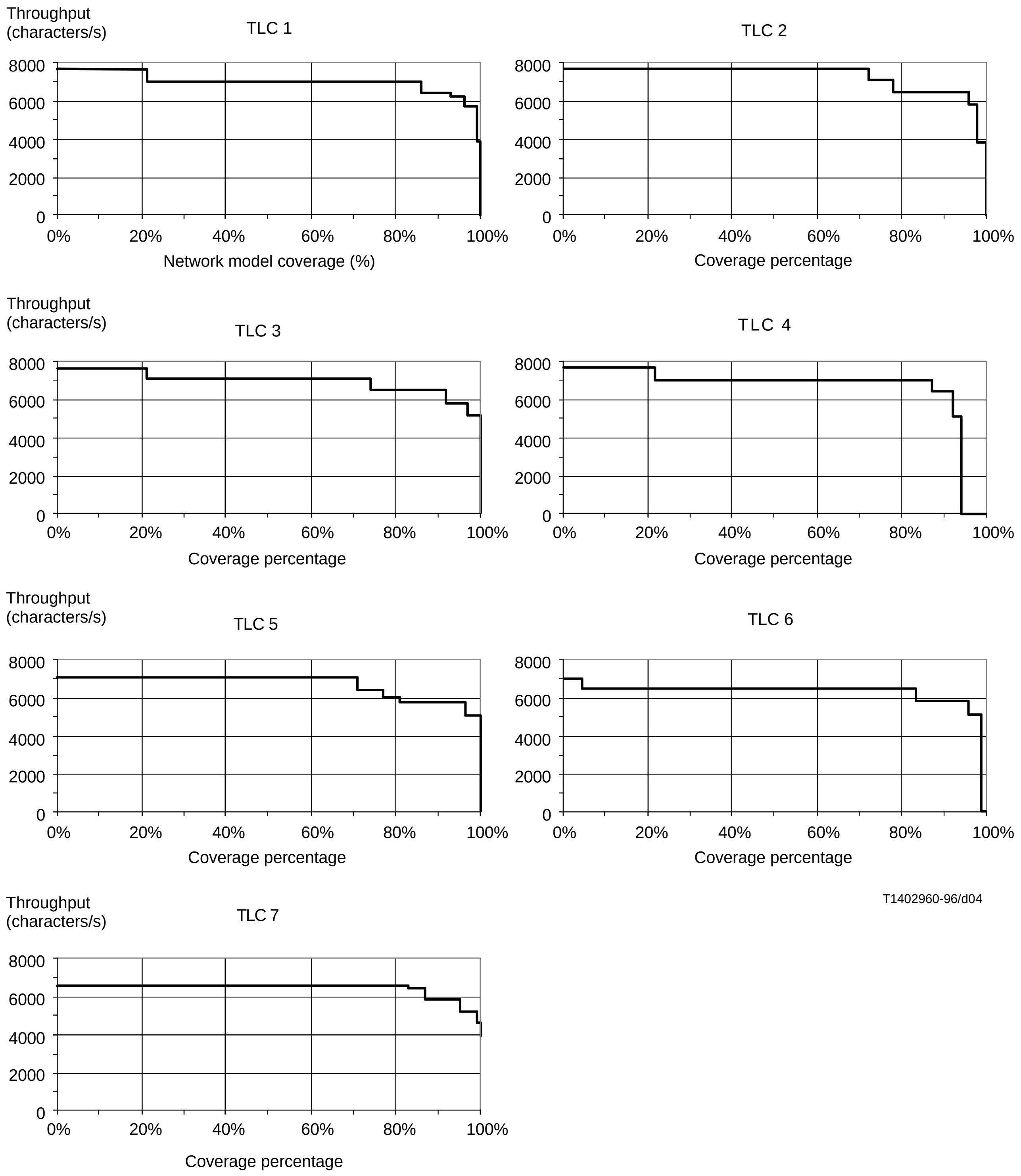

FIGURE IV.2/V.56 *ter*

Throughput by TLC coverage chart

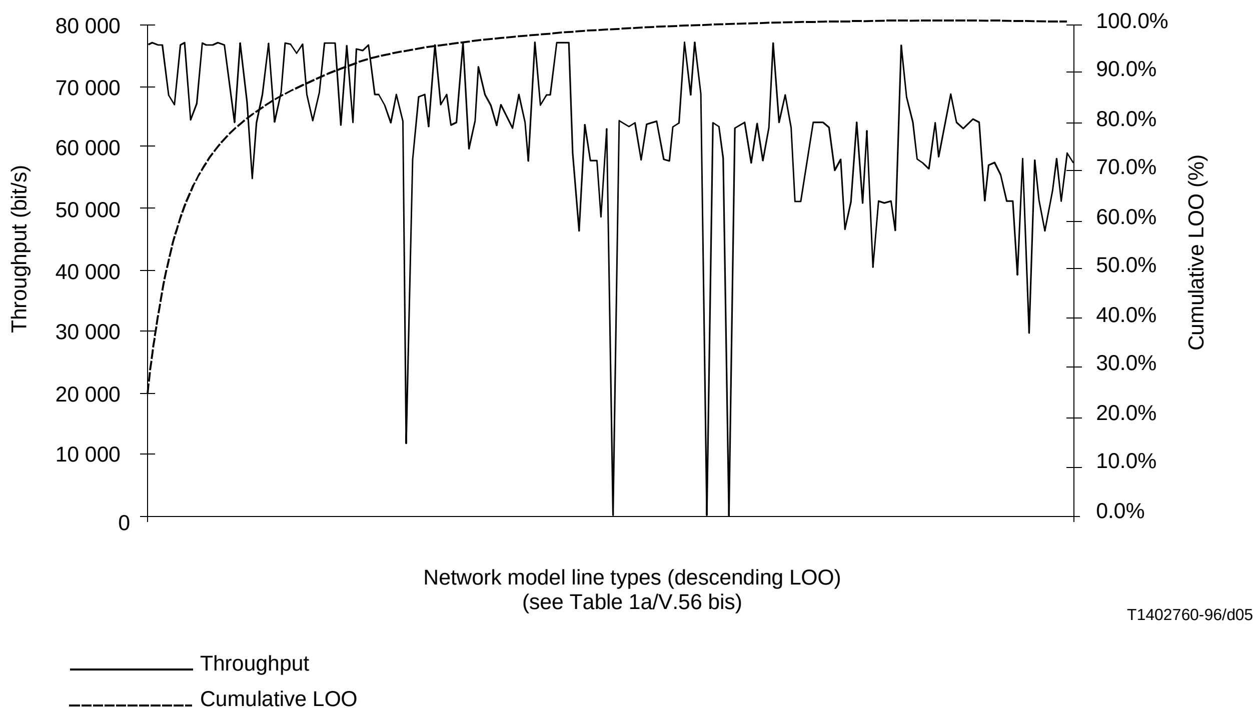

FIGURE IV.3/V.56 *ter*

Throughput and cumulative LOO vs network model line types

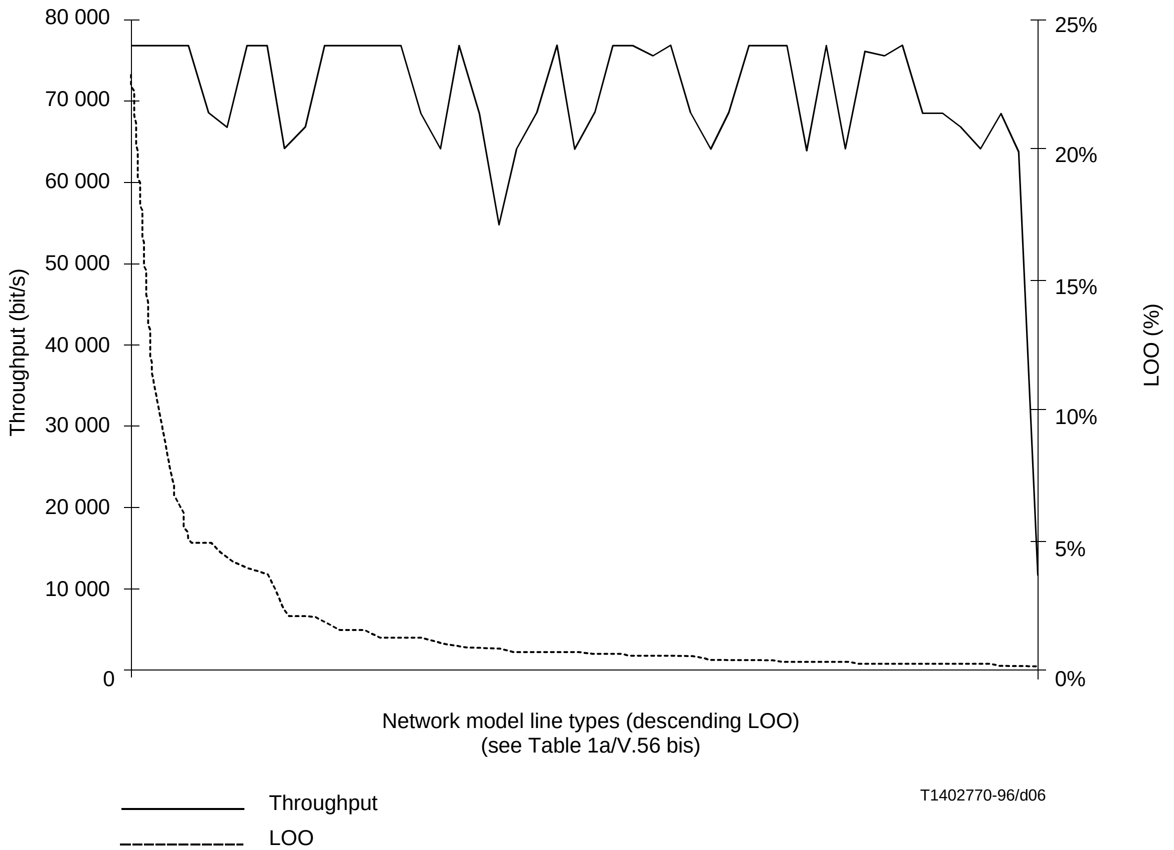

FIGURE IV.4/V.56 *ter*

Throughput and LOO vs network model line types

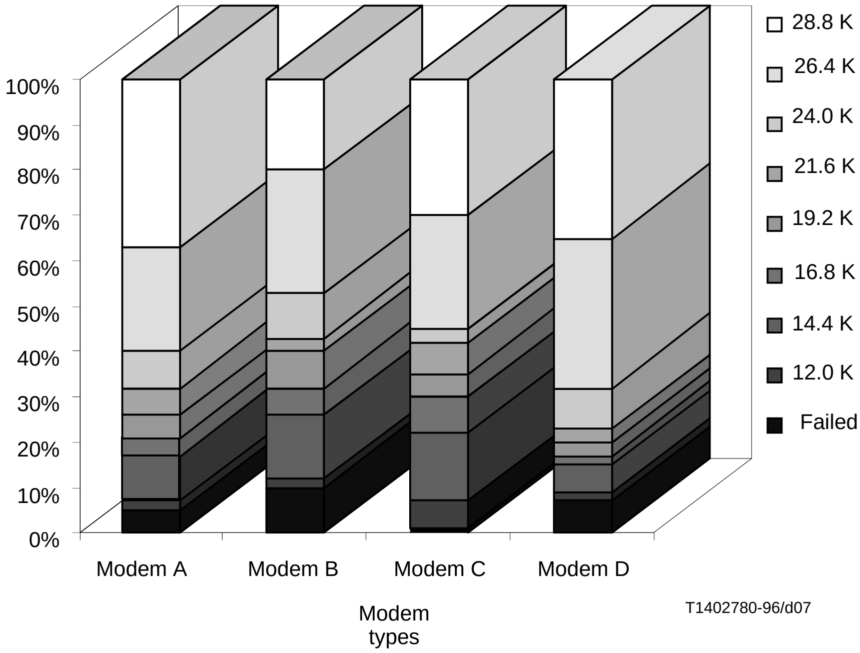

FIGURE IV.5/V.56 *ter*

Connect reliability for V.34 – NMC 168 lines

IV.2 Throughput versus file type

The throughput versus file type test procedure specified in 6.2 produces throughput results in characters per second for one-way and two-way file transfers for each test file.

TABLE IV.5/V.56 *ter*

Sample table, throughput versus file type

Test file	Reference throughput	Raw test results		Weighted test results		
		One-way throughput	Two-way throughput	One-way weighted	Two-way weighted	Average throughput
1X30.TST	21 594	11 474	9 421	8 606	2 355	10 961
2X10.TST	8 288	8 268	5 872	6 201	1 468	7 669
3X06.TST	4 757	4 741	3 731	3 556	933	4 489
4X04.TST	3 434	3 437	2 712	2 578	678	3 256
5X16.TST	12 841	9 405	4 782	7 054	1 196	8 249

(All values are character/s)

Test Conditions			Results Weighting	
Dictionary Size:	2 048	elements	One-Way:	75%
String length:	32	characters	Two-Way:	25%
DTE Data Rate:	115 200	bit/s		
Line Rate:	28 800	bit/s		

Table IV.5 is an example of the tabular presentation of throughput test results for one-way and two-way file transfer, along with the reference throughput for the line rate at which the test was conducted. All reports shall include the dictionary size, maximum string length, DTE port rate, line rate, and the selected weighting factors for one-and two-way file transfer.

The weighting should be based on the relative importance of one-way and two-way file transfers for the particular application. In this example, a weighting of 75% for one-way and 25% for two-way was selected. These weightings can be adjusted as desired, as long as their sum is 100%.

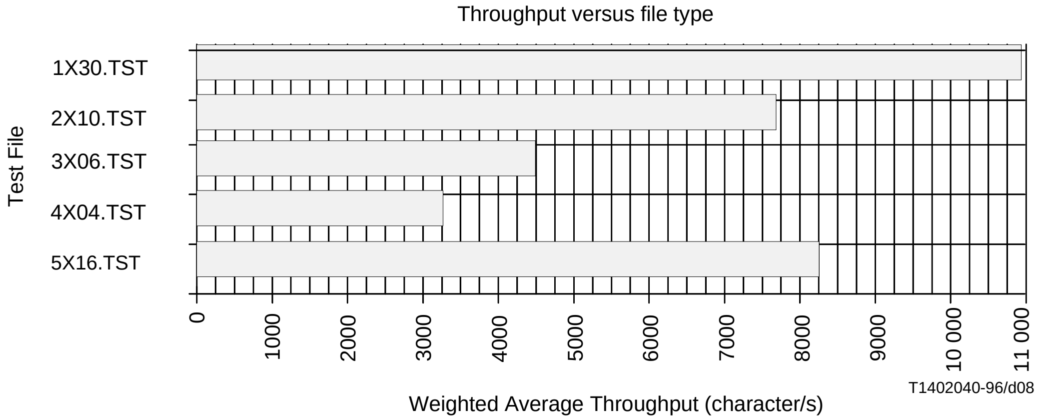

FIGURE IV.6/V.56 *ter*

Throughput presentation

The example shows the throughput values for a single modem. In a comparative evaluation, multiple modems can be compared in a single chart.

IV.3 Error ratio versus network model coverage

Results of error ratio testing as described in 6.3 are presented in a line chart showing error ratio versus network model coverage.

In the network model coverage test, error ratios are measured (or in conditional testing, sometimes derived) for each EO-EO combination and signal converter signalling rate. These may be bit-error ratios, block-error ratios, or message-error ratios. This appendix describes considerations in setting the size of the test and interpreting the results.

The example in this appendix shows the results of testing a V.34 modem at its top seven data signalling rates, using the 100-connection 99.1% coverage test described in Table 4/V.56 *bis*. In this example, a block-error ratio test consisting of 10 000 blocks of 1000 bits each was run. For each EO-EO combination, an error count was recorded when there were between 10 and 1000 errors measured in the test. If less than 10 errors were recorded, then a value of 10 is recorded. Tests with more than 1000 errors are marked “nc”. The conditional test procedure described in Annex B/V.56 *bis* was used.

Tables IV.6 through IV.12 show an example of how the raw data collected during an error-ratio test is presented in a matrix. The cells in the table contain the number of blocks in error for each EO-EO combination. A dash (“–”) in a cell indicates that a test is not required to be performed for that EO-EO combination. An empty cell indicates that the test for that particular EO-EO combination was not performed in accordance with the conditional testing procedure.

Each error count in Table IV.6 is converted to an error ratio, then paired with the corresponding EO-EO combination’s score taken from Table 4/V.56 *bis*. The result for this example is shown in Table IV.13. Note that cells in Figure IV.7 with “nc” are given the maximum error ratio of 10^{-1}; cells that are empty as a result of the conditional testing procedure are given the floor error ratio of 10^{-3}; which is calculated by dividing the minimum number of block errors (10) into the number of blocks (10 000).

The table is then sorted by ascending error ratio, and the accumulated network coverage in each row is calculated by adding the score of the row to the network coverage calculated in the line above. The resulting list is shown in Table IV.14.

The process is then repeated for each of the line rates tested. (The work is not shown here.) The result is an X-Y line plot, as shown in Figures IV.7 and IV.8.

Optionally, one particular error ratio of interest can be chosen, and a bar chart of coverage versus data rate can be plotted. This is illustrated in Figure IV.9 for a block-error ratio of 10^{-2}.

TABLE IV.6/V.56 *ter*

Example 28.8 kbit/s raw test data

IC	TLC 1	TLC 2	TLC 3	TLC 4	TLC 5	TLC 6	TLC 7
1c	183	10	10	10	nc	nc	nc
2c	10				nc	nc	nc
3c	nc	nc	nc	nc	nc	nc	nc
4c	nc	nc	nc	nc	nc	nc	nc
5c				10	nc	nc	nc
1b	232	266	398	215	nc	nc	nc
1a	nc	nc	nc	nc	nc	nc	nc
7c	nc	nc	nc	nc	nc	–	–
8c	nc	nc	nc	nc	nc	–	–
2b	172	215	253	36	nc	–	–
2a	224	nc	nc	489	nc	–	–
6c	10	10	10	nc	nc	–	–
3b	nc	nc	nc	nc	nc	–	–
3a	nc	nc	nc	nc	nc	–	–
5b			61		–	–	–
5a	10	10	nc	10	–	–	–
4b	nc	nc	–	–	–	–	–
4a	nc	nc	–	–	–	–	–
7b	nc	–	–	–	–	–	–
7a	nc	–	–	–	–	–	–
8b	nc	–	–	–	–	–	–
8a	nc	–	–	–	–	–	–
6b	–	–	–	–	–	–	–
6a	–	–	–	–	–	–	–

TABLE IV.7/V.56 *ter*

Example 26.4 kbit/s raw test data

IC	1	2	3	4	5	6	7
1c					10	nc	nc
2c						nc	nc
3c	10	10	10		nc	nc	nc
4c	nc	15	nc	10	nc	nc	nc
5c						nc	nc
1b	10	13	36	10	nc	nc	nc
1a	112	46	69	944	nc	nc	nc
7c	nc	nc	10	10	nc	–	–
8c	127	nc	10	10	nc	–	–
2b					nc	–	–
2a	10	10	10	49	nc	–	–
6c				nc	10	–	–
3b	107	83	nc	72	nc	–	–
3a	264	nc	nc	800	nc	–	–
5b					–	–	–
5a			10		–	–	–
4b	nc	nc	–	–	–	–	–
4a	nc	nc	–	–	–	–	–
7b	nc	–	–	–	–	–	–
7a	nc	–	–	–	–	–	–
8b	nc	–	–	–	–	–	–
8a	nc	–	–	–	–	–	–
6b	–	–	–	–	–	–	–
6a	–	–	–	–	–	–	–

TABLE IV.8/V.56 *ter*

Example 24.0 kbit/s raw test data

	TLC						
IC	1	2	3	4	5	6	7
1c						nc	nc
2c						11	nc
3c					10	nc	nc
4c	10	10	10		23	nc	nc
5c						nc	10
1b					10	nc	nc
1a	10	10	10	126	nc	nc	nc
7c	10	10			10	–	–
8c	10	10			10	–	–
2b					10	–	–
2a				10	10	–	–
6c				nc		–	–
3b			10	10	31	–	–
3a	10	10	19	26	nc	–	–
5b					–	–	–
5a					–	–	–
4b	16	11	–	–	–	–	–
4a	32	55	–	–	–	–	–
7b	nc	–	–	–	–	–	–
7a	nc	–	–	–	–	–	–
8b	nc	–	–	–	–	–	–
8a	nc	–	–	–	–	–	–
6b	–	–	–	–	–	–	–
6a	–	–	–	–	–	–	–

TABLE IV.9/V.56 *ter*

Example 21.6 kbit/s raw test data

TLC							
IC	1	2	3	4	5	6	7
1c							nc
2c							nc
3c						nc	nc
4c					10	nc	nc
5c						10	
1b							nc
1a				10	10	10	nc
7c						–	–
8c						–	–
2b						–	–
2a						–	–
6c				10		–	–
3b						–	–
3a			10	10	10	–	–
5b					–	–	–
5a					–	–	–
4b			–	–	–	–	–
4a	10	10	–	–	–	–	–
7b	10	–	–	–	–	–	–
7a	nc	–	–	–	–	–	–
8b	nc	–	–	–	–	–	–
8a	nc	–	–	–	–	–	–
6b	–	–	–	–	–	–	–
6a	–	–	–	–	–	–	–

TABLE IV.10/V.56 *ter*

Example 19.2 kbit/s raw test data

TLC							
IC	1	2	3	4	5	6	7
1c							
2c							
3c						nc	nc
4c						nc	nc
5c							
1b							10
1a							24
7c						–	–
8c						–	–
2b						–	–
2a						–	–
6c						–	–
3b						–	–
3a						–	–
5b					–	–	–
5a					–	–	–
4b			–	–	–	–	–
4a			–	–	–	–	–
7b		–	–	–	–	–	–
7a	nc	–	–	–	–	–	–
8b		–	–	–	–	–	–
8a	10	–	–	–	–	–	–
6b	–	–	–	–	–	–	–
6a	–	–	–	–	–	–	–

TABLE IV.11/V.56 *ter*

Example 16.8 kbit/s raw test data

TLC							
IC	1	2	3	4	5	6	7
1c							
2c							
3c						nc	10
4c						nc	nc
5c							
1b							
1a							18
7c						–	–
8c						–	–
2b						–	–
2a						–	–
6c						–	–
3b						–	–
3a						–	–
5b					–	–	–
5a					–	–	–
4b			–	–	–	–	–
4a			–	–	–	–	–
7b		–	–	–	–	–	–
7a	nc	–	–	–	–	–	–
8b		–	–	–	–	–	–
8a		–	–	–	–	–	–
6b	–	–	–	–	–	–	–
6a	–	–	–	–	–	–	–

TABLE IV.12/V.56 *ter*

Example 14.4 kbit/s raw test data

	TLC						
EO-EO	1	2	3	4	5	6	7
1c							
2c							
3c						10	
4c						nc	10
5c							
1b							
1a							10
7c						–	–
8c						–	–
2b						–	–
2a						–	–
6c						–	–
3b						–	–
3a						–	–
5b					–	–	–
5a					–	–	–
4b			–	–	–	–	–
4a			–	–	–	–	–
7b		–	–	–	–	–	–
7a	10	–	–	–	–	–	–
8b		–	–	–	–	–	–
8a		–	–	–	–	–	–
6b	–	–	–	–	–	–	–
6a	–	–	–	–	–	–	–

TABLE IV.13/V.56 *ter*

Unsorted worksheet

IC	TLC	Score	BLER	IC	TLC	Score	BLER	IC	TLC	Score	BLER
1c	1	0.22862	0.0183	3b	2	0.00115	0.1	6c	4	0.0009	0.1
2c	1	0.07544	0.001	3a	2	0.00115	0.1	3b	4	0.0005	0.1
3c	1	0.04278	0.1	5b	2	0.00081	0.001	3a	4	0.0005	0.1
4c	1	0.02162	0.1	5a	2	0.00081	0.001	5b	4	0.00035	0.001
5c	1	0.01978	0.001	4b	2	0.00058	0.1	5a	4	0.00035	0.001
1b	1	0.01288	0.0232	4a	2	0.00058	0.1	1c	5	0.03976	0.1
1a	1	0.01288	0.1	1c	3	0.0497	0.001	2c	5	0.01312	0.1
7c	1	0.00782	0.1	2c	3	0.0164	0.001	3c	5	0.00744	0.1
8c	1	0.00782	0.1	3c	3	0.0093	0.1	4c	5	0.00376	0.1
2b	1	0.00644	0.0172	4c	3	0.0047	0.1	5c	5	0.00344	0.1
2a	1	0.00644	0.0224	5c	3	0.0043	0.001	1b	5	0.00224	0.1
6c	1	0.00414	0.001	1b	3	0.0028	0.0398	1a	5	0.00224	0.1
3b	1	0.0023	0.1	1a	3	0.0028	0.1	7c	5	0.00136	0.1
3a	1	0.0023	0.1	7c	3	0.0017	0.1	8c	5	0.00136	0.1
5b	1	0.00161	0.001	8c	3	0.0017	0.1	2b	5	0.00112	0.1
5a	1	0.00161	0.001	2b	3	0.0014	0.0253	2a	5	0.00112	0.1
4b	1	0.00115	0.1	2a	3	0.0014	0.1	6c	5	0.00072	0.1
4a	1	0.00115	0.1	6c	3	0.0009	0.001	3b	5	0.0004	0.1
7b	1	0.00069	0.1	3b	3	0.0005	0.1	3a	5	0.0004	0.1
7a	1	0.00069	0.1	3a	3	0.0005	0.1	1c	6	0.00795	0.1
8b	1	0.00069	0.1	5b	3	0.00035	0.0061	2c	6	0.00262	0.1
8a	1	0.00069	0.1	5a	3	0.00035	0.1	3c	6	0.00149	0.1
1c	2	0.11431	0.001	1c	4	0.0497	0.001	4c	6	0.00075	0.1
2c	2	0.03772	0.001	2c	4	0.0164	0.001	5c	6	0.00069	0.1
3c	2	0.02139	0.1	3c	4	0.0093	0.1	1b	6	0.00045	0.1
4c	2	0.01081	0.1	4c	4	0.0047	0.1	1a	6	0.00045	0.1
5c	2	0.00989	0.001	5c	4	0.0043	0.001	1c	7	0.00696	0.1
1b	2	0.00644	0.0266	1b	4	0.0028	0.0215	2c	7	0.0023	0.1
1a	2	0.00644	0.1	1a	4	0.0028	0.1	3c	7	0.0013	0.1
7c	2	0.00391	0.1	7c	4	0.0017	0.1	4c	7	0.00066	0.1
8c	2	0.00391	0.1	8c	4	0.0017	0.1	5c	7	0.0006	0.1
2b	2	0.00322	0.0215	2b	4	0.0014	0.0036	1b	7	0.00039	0.1
2a	2	0.00322	0.1	2a	4	0.0014	0.0489	1a	7	0.00039	0.1
6c	2	0.00207	0.001								

TABLE IV.14/V.56 *ter*

Sorted and accumulated scores

IC	TLC	Score	Coverage	BLER	IC	TLC	Score	Coverage	BLER	IC	TLC	Score	Coverage	BLER
1c	2	0.1143	0.11431	0.001	4c	1	0.0216	0.78893	0.1	2a	3	0.0014	0.96709	0.1
2c	1	0.0754	0.18975	0.001	3c	2	0.0213	0.81032	0.1	7c	5	0.0013	0.96845	0.1
1c	3	0.0497	0.23945	0.001	2c	5	0.0131	0.82344	0.1	8c	5	0.0013	0.96981	0.1
1c	4	0.0497	0.28915	0.001	1a	1	0.0128	0.83632	0.1	3c	7	0.0013	0.97111	0.1
2c	2	0.0377	0.32687	0.001	4c	2	0.0108	0.84713	0.1	4b	1	0.0011	0.97226	0.1
5c	1	0.0197	0.34665	0.001	3c	3	0.0093	0.85643	0.1	4a	1	0.0011	0.97341	0.1
2c	3	0.0164	0.36305	0.001	3c	4	0.0093	0.86573	0.1	3b	2	0.0011	0.97456	0.1
2c	4	0.0164	0.37945	0.001	1c	6	0.0079	0.87368	0.1	3a	2	0.0011	0.97571	0.1
5c	2	0.0098	0.38934	0.001	7c	1	0.0078	0.8815	0.1	2b	5	0.0011	0.97683	0.1
5c	3	0.0043	0.39364	0.001	8c	1	0.0078	0.88932	0.1	2a	5	0.0011	0.97795	0.1
5c	4	0.0043	0.39794	0.001	3c	5	0.0074	0.89676	0.1	6c	4	0.0009	0.97885	0.1
6c	1	0.0041	0.40208	0.001	1c	7	0.0069	0.90372	0.1	4c	6	0.0007	0.9796	0.1
6c	2	0.0020	0.40415	0.001	1a	2	0.0064	0.91016	0.1	6c	5	0.0007	0.98032	0.1
5b	1	0.0016	0.40576	0.001	4c	3	0.0047	0.91486	0.1	7b	1	0.0006	0.98101	0.1
5a	1	0.0016	0.40737	0.001	4c	4	0.0047	0.91956	0.1	7a	1	0.0006	0.9817	0.1
6c	3	0.0009	0.40827	0.001	7c	2	0.0039	0.92347	0.1	8b	1	0.0006	0.98239	0.1
5b	2	0.0008	0.40908	0.001	8c	2	0.0039	0.92738	0.1	8a	1	0.0006	0.98308	0.1
5a	2	0.0008	0.40988	0.001	4c	5	0.0037	0.93114	0.1	5c	6	0.0006	0.98377	0.1
5b	4	0.0003	0.41023	0.001	5c	5	0.0034	0.93458	0.1	4c	7	0.0006	0.98443	0.1
5a	4	0.0003	0.41058	0.001	2a	2	0.0032	0.9378	0.1	5c	7	0.0006	0.98503	0.1
2b	4	0.0014	0.41198	0.003	1a	3	0.0028	0.9406	0.1	4b	2	0.0005	0.98561	0.1
5b	3	0.0003	0.41233	0.006	1a	4	0.0028	0.9434	0.1	4a	2	0.0005	0.98618	0.1
2b	1	0.0064	0.41877	0.017	2c	6	0.0026	0.94602	0.1	3b	3	0.0005	0.98668	0.1
1c	1	0.2286	0.64739	0.018	3b	1	0.0023	0.94832	0.1	3a	3	0.0005	0.98718	0.1
2b	2	0.0032	0.65061	0.021	3a	1	0.0023	0.95062	0.1	3b	4	0.0005	0.98768	0.1
1b	4	0.0028	0.65341	0.021	2c	7	0.0023	0.95292	0.1	3a	4	0.0005	0.98818	0.1
2a	1	0.0064	0.65985	0.022	1b	5	0.0022	0.95516	0.1	1b	6	0.0004	0.98863	0.1
1b	1	0.0128	0.67273	0.023	1a	5	0.0022	0.9574	0.1	1a	6	0.0004	0.98908	0.1
2b	3	0.0014	0.67413	0.025	7c	3	0.0017	0.9591	0.1	3b	5	0.0004	0.98948	0.1
1b	2	0.0064	0.68057	0.026	8c	3	0.0017	0.9608	0.1	3a	5	0.0004	0.98988	0.1
1b	3	0.0028	0.68337	0.039	7c	4	0.0017	0.9625	0.1	1b	7	0.0003	0.99027	0.1
2a	4	0.0014	0.68477	0.048	8c	4	0.0017	0.9642	0.1	1a	7	0.0003	0.99066	0.1
3c	1	0.0427	0.72755	0.1	3c	6	0.0014	0.96569	0.1	5a	3	0.0003	0.99101	0.1
1c	5	0.0397	0.76731	0.1										

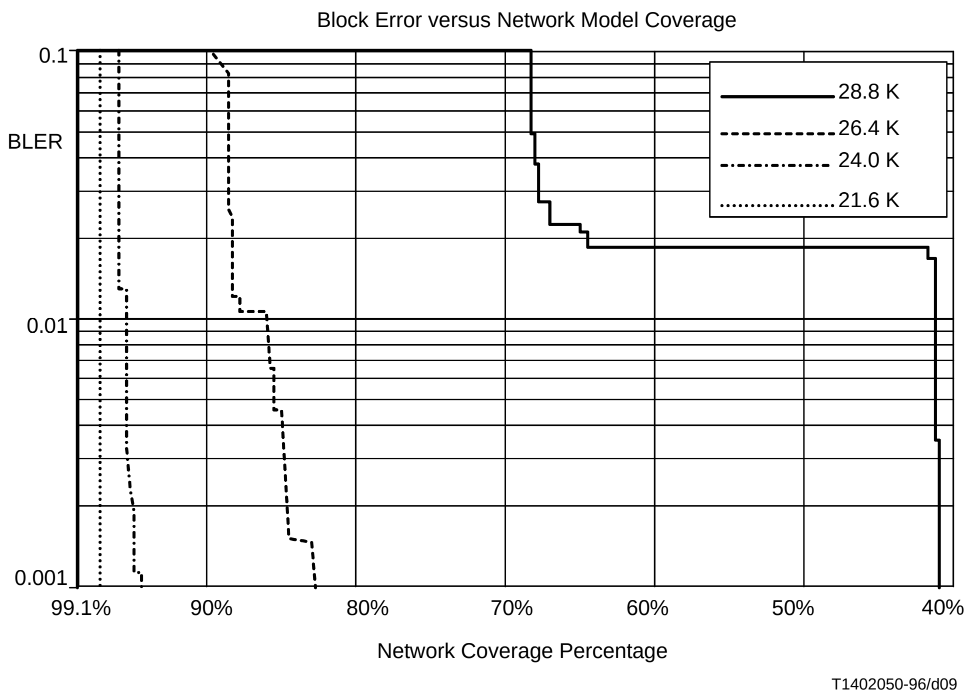

FIGURE IV.7/V.56 *ter*

Error ratio versus NMC (21.6 K-28.8 K)

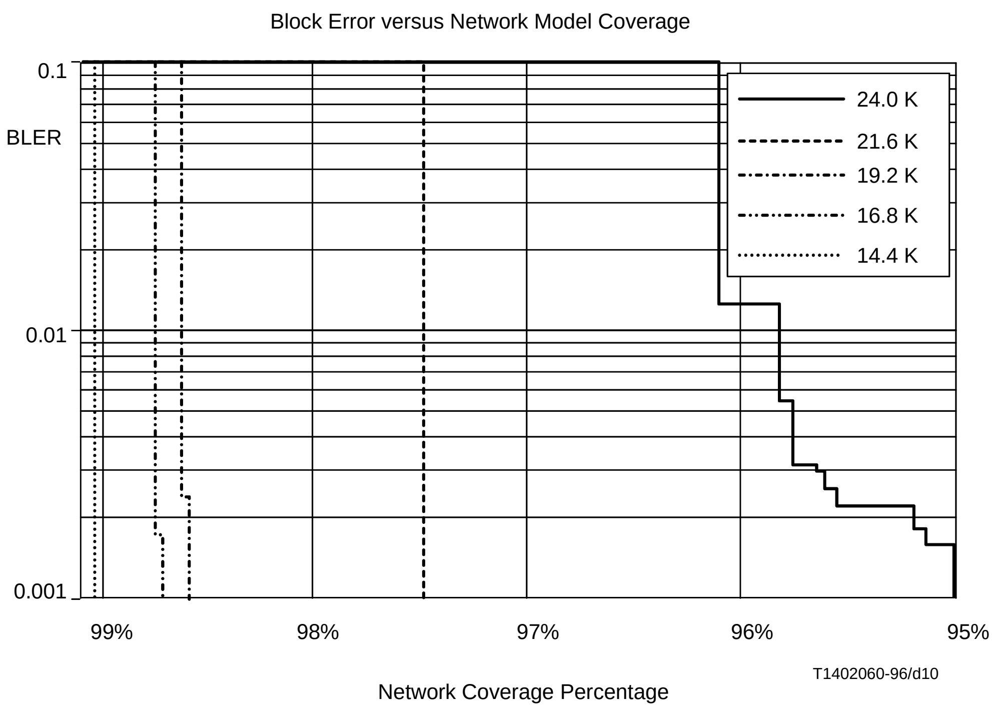

FIGURE IV.8/V.56 *ter*

Error ratio versus NMC (14.4 K-24.0 K)

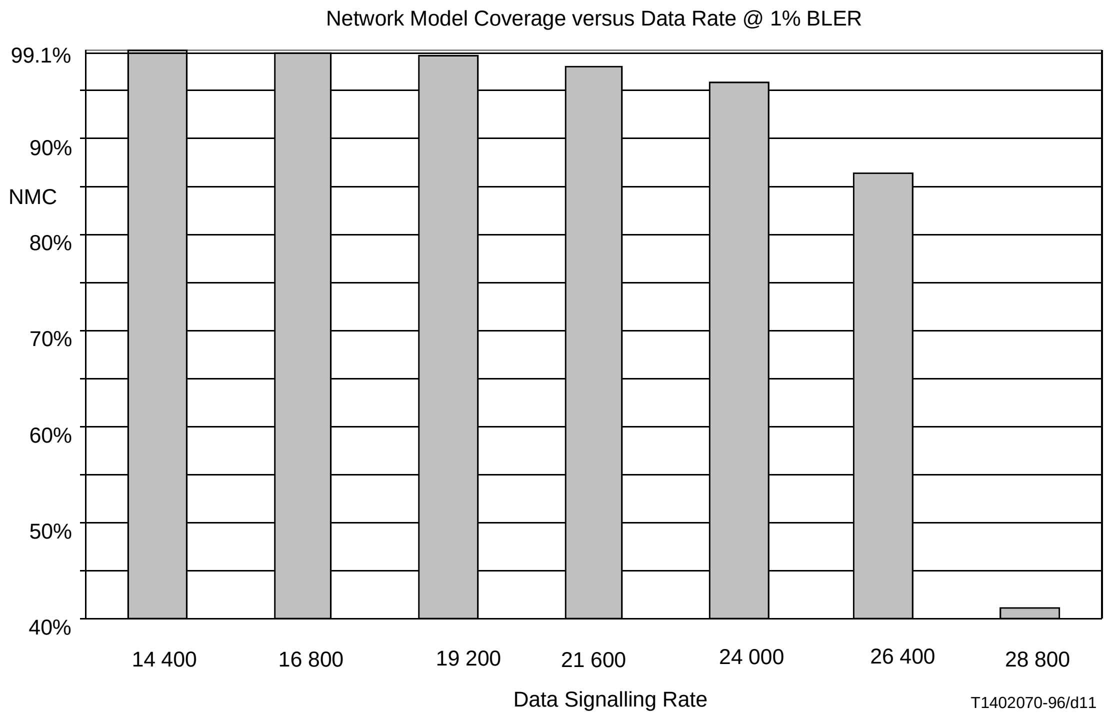

FIGURE IV.9/V.56 *ter*

NMC versus signalling rate at 0.01 Error Ratio

IV.4 Connect reliability versus test loop combinations

The Connect reliability versus test loop combinations test described in 6.4 evaluates the ability of the modem to connect and successfully complete a V.42 *bis* negotiation on each of the seven test loop combinations defined in Recommendation V.56 *bis*. During these tests, the impairment combination used is 1c, which represents the largest percentage of the network model. By cycling through the test loop combinations, the received-signal level, echoes, and linear distortion seen by the modem varies. The effect of these variations on modem connect reliability and connection startup time can be observed.

During the test, the period of time is recorded for each successful connection from when the answering modem goes off-hook to when the first stop bit of the last character of the data block is received.

Table IV.15 contains sample measurements for the 119 test runs. Table IV.16 summarizes the data, and presents percentage of overall successful connections and successful connections for each test loop combination. The success percentage number for the total is a weighted average of the numbers for the test loop combinations, using the likelihood of occurrence scores defined in Recommendation V.56 *bis* as the weighting factors. This is done so that test loop combinations 5, 6, and 7, which have a likelihood of occurrence score of less than 10%, do not unduly influence the total success percentage. Average, shortest, and longest transfer time measurements are also listed for all successful connections and successful connections for each test loop combination.

Figure IV.10 plots the percentage of successful connections for each test loop combination. Figure IV.11 are "timeline" plots of the shortest, average, and longest transfer times for each test loop combination and for all successful connections.

NOTE – The overall call completion ratio calculated using the results from 119 connection attempts is accurate to better than ±9% at a confidence level of 95%. For the same confidence level, the call completion ratio taken individually by test loop combination is:

TLC 1 ±15%
TLC 2 ±20%
TLC 3 ±30%

TLC 4 ± 30%
TLC 5 ± 30%
TLC 6 ± 30%
TLC 7 ± 30%

Particularly in the case of TLCs 3 through 7, the results are so statistically coarse that a measurement difference of 20% in call completion ratio is not significant. When individual call completion ratio by TLC measurements are going to be used to differentiate the performance of two or more modems, the number of trials per TLC should be increased. It is recommended that a minimum of 100 trials per TLC (700 total) be used in such a situation.

TABLE IV.15/V.56 *ter*

Connect reliability raw data

Run	TLC 1	TLC 2	TLC 3	TLC 4	TLC 5	TLC 6	TLC 7
1	5.41	5.41	5.71	5.42	6.41	5.92	5.81
2	5.40	5.40	5.72	5.40	fail	16.30	fail
3	5.42	5.41	fail	5.45	fail	5.40	15.30
4	5.45	5.40	5.71	5.51	5.78	5.42	5.55
5	5.40	5.42	5.75	5.47	5.91	5.45	5.54
6	5.41	5.45	5.69	fail	5.81	6.21	9.67
7	5.40	5.40	5.54	5.61	fail	7.56	fail
8	5.41	5.41	5.48	5.78	9.24	5.46	10.12
9	5.40	5.40	5.68	5.46	6.26	5.48	fail
10	5.42	5.42	5.51	5.59	9.87	6.01	fail
11	5.45	5.45					
12	6.21	5.40					
13	5.41	5.41					
14	5.40	5.40					
15	5.41	5.41					
16	5.40	5.40					
17	5.42	5.42					
18	5.45	5.45					
19	5.40	5.40					
20	5.41	5.40					
21	5.40	5.41					
22	5.41	5.40					
23	5.40	5.42					
24	5.42						
25	5.45						
26	5.40						
27	5.41						
28	5.40						
29	5.41						
30	5.40						
31	5.42						
32	5.45						
33	5.40						
34	5.41						
35	5.40						
36	5.41						
37	5.40						
38	5.42						
39	5.45						
40	5.40						
41	5.41						
42	5.40						
43	5.41						
44	5.40						
45	5.42						
46	5.45						

TABLE IV.16/V.56 *ter*

Connect reliability summary

Test loop combination	LOO Score	Trials	Success	Success percentage	Shortest time	Longest time	Average time
TLC 1	0.46	46	46	100%	5.40	6.21	5.43
TLC 2	0.23	23	23	100%	5.40	5.45	5.41
TLC 3	0.1	10	9	90%	5.48	5.75	5.64
TLC 4	0.1	10	9	90%	5.40	5.78	5.52
TLC 5	0.08	10	7	70%	5.78	9.87	7.04
TLC 6	0.016	10	10	100%	5.40	16.30	6.92
TLC 7	0.014	10	6	60%	5.54	15.30	8.67
Overall		119	110	95%	5.40	16.30	5.87

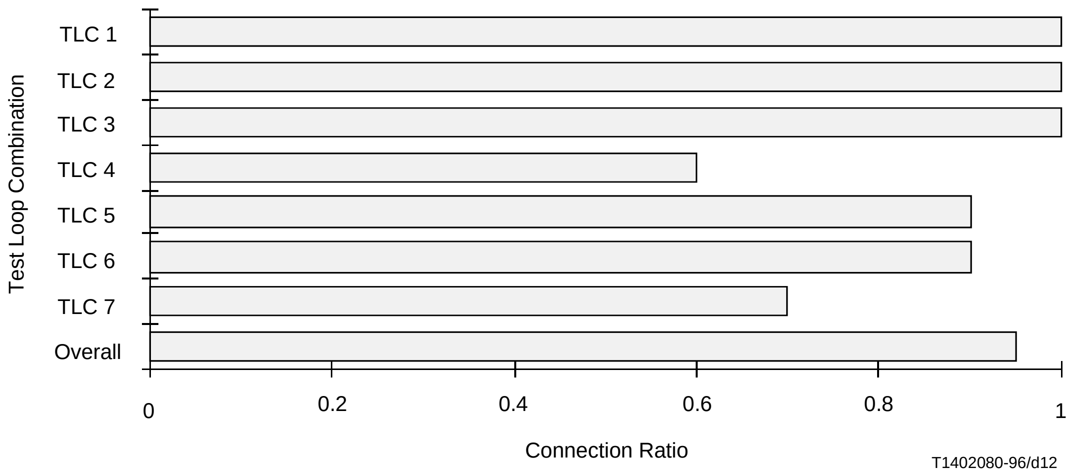

FIGURE IV.10/V.56 *ter*

Connect percentages

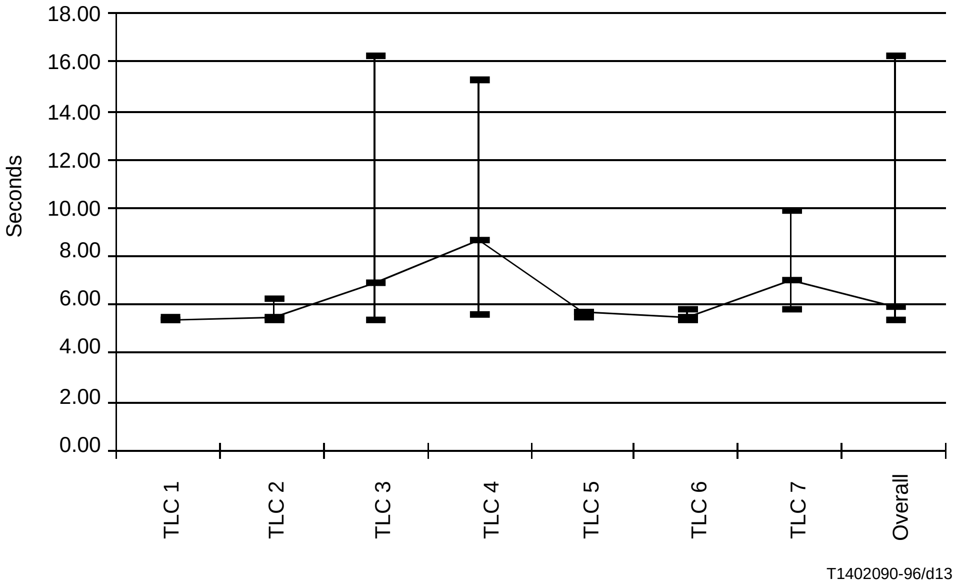

FIGURE IV.11/V.56 *ter*

Transfer time

IV.5 Character echo delay

The character echo delay tests described in 6.5 provide data on the impact of buffering, V.42 transmission decisions, and V.42 *bis* processing on response-time delays in menu-based applications.

Table IV.17 contains example raw data for the various modes of operation. Table IV.18 contains averages of the 100 trials for TIMER1 and TIMER2 in each mode. Figure IV.12 is a bar chart showing the response time for the transfer in each direction and the contribution to the total time.

The measurements for error control mode and compression mode have the greatest potential for variation between modems, as they are strongly dependent on the characteristics of the specific V.42 and V.42 *bis* implementations used. For example, the specific data-forwarding criteria used for short (i.e. single-character) V.42 frames can have a great effect on these measurements. (See also Appendix II/Recommendation V.42.)

IV.6 Block acknowledge delay

The block acknowledge delay tests described in 6.6 provide data on the impact of buffering, V.42 transmission decisions, and V.42 *bis* processing on real-time delays in transaction processing applications and non-windowed file transfer protocols such as XMODEM, KERMIT, and Point-to-Point Protocol. These protocols transmit a block of data and then wait for an acknowledgement before sending the next block.

Table IV.19 contains example raw data for the various modes of operation. Table IV.20 contains averages of the 100 trials for TIMER 1, TIMER 2, and TIMER 3 in each mode. Figure IV.13 is a bar chart showing the response time for the transfer in each direction and the contribution to the total time.

As is the case with the Character echo delay tests, the Block acknowledge delay test in direct mode measures the inherent delay of the EO-EO combination and the modem modulation method. Buffered mode includes additional delays introduced by the modem-to-DTE interface at each end. Error control mode and compression mode tests measure different characteristics of the V.42 and V.42 *bis* implementation, since the block length is significantly longer than one character (and is longer than the default V.42 frame length).

TABLE IV.17/V.56 *ter*

Character echo delay raw data

Trial	Direct		Normal		Error control		Compression	
	Timer 1	Timer 2	Timer 1	Timer 2	Timer 1	Timer 2	Timer 1	Timer 2
1	55	109	55	109	59	125	56	127
2	55	110	55	110	59	126	56	127
3	54	109	54	109	60	125	57	126
4	55	110	55	110	61	125	57	127
5	55	110	55	110	59	125	56	127
6	54	109	55	109	68	134	56	127
7	54	109	55	110	59	125	62	127
8	55	109	55	109	59	140	56	127
9	55	110	55	110	60	125	56	135
10	55	109	55	109	59	125	56	127
11	55	109	55	109	59	125	56	127
12	55	110	55	110	59	126	56	127
13	54	109	54	109	60	125	57	126
14	55	110	55	110	61	125	57	127
15	55	110	55	110	59	125	56	127
16	54	109	55	109	68	134	56	127
17	54	109	55	110	59	125	62	129
18	55	109	55	109	59	140	56	127
19	55	110	55	110	60	125	56	135
20	55	109	55	109	59	125	56	127
21	55	109	55	109	58	125	56	127
22	54	110	55	110	59	126	56	127
23	54	109	54	109	60	125	57	126
24	55	110	55	110	61	125	57	127
25	55	110	55	110	59	125	56	127
26	54	109	55	109	68	134	56	127
27	54	109	55	110	59	125	62	128
28	55	109	57	109	59	140	56	127
29	55	110	55	110	60	125	56	135
30	55	109	55	109	59	125	56	127
31	55	109	55	113	59	125	56	127
32	55	110	55	110	59	126	56	127
33	54	109	54	109	60	125	57	126
34	55	110	55	110	61	125	57	127
35	55	110	55	110	59	125	56	127
36	54	109	55	109	68	134	56	127
37	54	109	55	110	59	125	62	127
38	55	109	55	109	59	140	56	127
39	55	110	55	110	60	125	56	135
40	55	109	55	109	59	125	56	127
41	55	109	55	109	59	125	56	127
42	55	110	55	110	59	126	56	127
43	54	109	54	109	60	125	57	126
44	55	110	55	110	61	125	57	127
45	55	110	55	110	59	125	56	127
46	54	109	55	109	68	134	56	127
47	54	109	55	110	59	125	62	127
48	55	109	55	109	59	140	56	127
49	55	110	55	110	60	125	56	135
50	55	109	55	109	59	125	56	127
51	55	109	55	109	59	125	56	127
52	55	110	55	110	59	126	56	127
53	54	109	54	109	60	125	57	126
54	55	110	55	110	61	125	57	127
55	55	110	55	110	59	125	56	127
56	54	109	55	109	68	134	56	127
57	54	109	55	110	59	125	62	129
58	55	109	55	109	59	140	56	127
59	55	110	55	110	60	125	56	125
60	55	109	55	109	59	125	56	127
61	55	109	55	109	58	125	56	127
62	54	110	55	110	59	126	56	127
63	54	109	54	109	60	125	57	126
64	55	110	55	110	61	125	57	127

TABLE IV.17/V.56 *ter (concluded)*

Character echo delay raw data

Trial	Direct Timer 1	Direct Timer 2	Normal Timer 1	Normal Timer 2	Error control Timer 1	Error control Timer 2	Compression Timer 1	Compression Timer 2
65	55	110	55	110	59	125	56	127
66	54	109	55	109	68	134	56	127
67	54	109	55	110	59	125	62	128
68	55	109	57	109	59	140	56	127
69	55	110	55	110	60	125	56	135
70	55	109	55	109	59	125	56	127
71	55	109	55	113	59	125	56	127
72	55	110	55	110	59	126	56	127
73	54	109	54	109	60	125	57	126
74	55	110	55	110	61	125	57	127
75	55	110	55	110	59	125	56	127
76	54	109	55	109	68	134	56	127
77	54	109	55	110	59	125	62	127
78	55	109	55	109	59	140	56	127
79	55	110	55	110	60	125	56	135
80	55	109	55	109	59	125	56	127
81	54	110	55	110	59	126	56	127
82	54	109	54	109	60	125	57	126
83	55	110	55	110	61	125	57	127
84	55	110	55	110	59	125	56	127
85	54	109	55	109	68	134	56	127
86	54	109	55	110	59	125	62	128
87	55	109	57	109	59	140	56	127
88	55	110	55	110	60	125	56	135
89	55	109	55	109	59	125	56	127
90	55	109	55	113	59	125	56	127
91	55	110	55	110	59	126	56	127
92	54	109	54	109	60	125	57	126
93	55	110	55	110	61	125	57	127
94	55	110	55	110	59	125	56	127
95	54	109	55	109	68	134	56	127
96	54	109	55	110	59	125	62	127
97	55	109	55	109	59	140	56	127
98	55	110	55	110	60	125	56	135
99	55	109	55	109	59	125	56	127
100	54	109	55	110	59	125	62	128

TABLE IV.18/V.56 *ter*

Character echo delay averages

All times are in milliseconds

Mean values		
	Timer 1	Timer 2
Direct	54.7	109.4
Normal	55.0	109.6
Error Control	60.3	127.5
Compression	56.9	127.8

TABLE IV.19/V.56 *ter*

Block acknowledge delay raw data

Trial	Direct			Normal			Error control			Compression		
	Timer 1	Timer 2	Timer 3	Timer 1	Timer 2	Timer 3	Timer 1	Timer 2	Timer 3	Timer 1	Timer 2	Timer 3
1	55	148	206	55	148	206	59	190	250	56	292	351
2	55	148	206	55	148	206	59	190	251	56	290	350
3	54	147	206	54	147	206	60	191	251	57	290	348
4	55	148	207	55	148	207	61	190	251	57	291	349
5	55	148	206	55	148	206	59	190	251	56	289	352
6	54	147	205	55	148	205	68	191	250	56	290	354
7	54	149	206	55	149	206	59	191	252	62	291	351
8	55	148	206	55	148	206	59	191	250	56	295	352
9	55	148	207	55	148	207	60	190	251	56	290	352
10	55	148	206	55	148	206	59	190	251	56	291	352
11	55	147	206	55	147	206	59	190	253	56	290	358
12	55	148	206	55	148	206	59	190	251	56	288	360
13	54	149	206	54	149	206	60	191	250	57	290	357
14	55	149	207	55	149	207	61	192	254	57	291	357
15	55	148	206	55	148	206	59	190	251	56	291	356
16	54	148	206	55	148	206	68	191	251	56	291	355
17	54	148	206	55	148	206	59	191	250	62	290	354
18	55	147	206	55	149	206	59	191	252	56	293	354
19	55	148	206	55	148	206	60	190	251	56	290	353
20	55	148	206	55	148	206	59	197	258	56	293	351
21	55	148	206	55	148	206	58	190	250	56	292	351
22	54	147	206	55	148	206	59	190	251	56	290	350
23	54	148	207	54	148	207	60	191	251	57	290	348
24	55	148	206	55	148	206	61	190	251	57	291	349
25	55	147	205	55	147	205	59	190	251	56	289	352
26	54	149	206	55	149	206	68	191	250	56	290	354
27	54	148	206	55	148	206	59	191	252	62	291	351
28	55	148	207	57	148	207	59	191	250	56	295	352
29	55	148	206	55	148	206	60	190	251	56	290	352
30	55	147	206	55	149	206	59	190	251	56	291	352
31	55	148	206	55	148	206	59	190	253	56	290	358
32	55	149	206	55	149	206	59	190	251	56	288	360
33	54	149	207	54	149	207	60	191	250	57	290	357
34	55	148	206	55	148	206	61	192	254	57	291	355
35	55	148	206	55	148	206	59	190	251	56	291	356
36	54	148	206	55	148	206	68	191	251	56	291	355
37	54	147	206	55	147	206	59	191	250	62	290	354
38	55	148	206	55	148	206	59	191	252	56	293	354
39	55	148	206	55	148	206	60	190	251	56	290	353
40	55	148	206	55	148	206	59	198	256	56	293	351
41	55	147	206	55	148	206	59	190	250	56	292	351
42	55	148	207	55	148	207	59	190	251	56	290	350
43	54	148	206	54	148	206	60	191	251	57	290	348
44	55	147	205	55	149	205	61	190	251	57	291	349
45	55	149	206	55	149	206	59	190	251	56	289	352
46	54	148	206	55	148	206	68	191	250	56	290	354
47	54	148	207	55	148	207	59	191	252	62	291	351
48	55	148	206	55	148	206	59	191	250	56	295	352
49	55	147	206	55	149	206	60	190	251	56	290	352
50	55	148	206	55	148	206	59	190	251	56	291	352
51	55	149	206	55	149	206	59	190	253	56	290	358
52	55	149	207	55	149	208	59	190	251	56	288	360
53	54	148	206	54	148	206	60	191	250	57	290	357
54	55	148	206	55	148	206	61	192	254	57	291	355
55	55	148	206	55	148	206	59	190	251	56	291	356
56	54	147	206	55	150	207	68	191	251	56	291	355
57	54	148	206	55	148	206	59	191	250	62	290	354
58	55	148	206	55	148	206	59	191	252	56	293	402
59	55	148	206	55	148	206	60	190	251	56	290	353
60	55	147	206	55	149	206	59	192	252	56	293	351
61	55	148	207	55	148	207	58	190	250	56	292	351
62	54	148	206	55	148	206	59	190	251	56	290	350
63	54	147	205	54	147	205	60	191	251	57	290	348
64	55	149	206	55	149	206	61	190	251	57	291	349

TABLE IV.19/V.56 *ter (concluded)*

Block acknowledge delay raw data

Trial	Direct			Normal			Error control			Compression		
	Timer 1	Timer 2	Timer 3	Timer 1	Timer 2	Timer 3	Timer 1	Timer 2	Timer 3	Timer 1	Timer 2	Timer 3
65	55	148	206	55	148	206	59	190	251	56	289	352
66	54	148	207	55	148	207	68	191	250	56	290	354
67	54	148	206	55	148	206	59	191	252	62	291	351
68	55	147	206	57	149	206	59	191	250	56	295	352
69	55	148	206	55	148	206	60	190	283	56	330	395
70	55	149	206	55	149	206	59	190	251	56	291	352
71	55	149	207	55	149	207	59	190	253	56	290	358
72	55	148	206	55	148	206	59	190	251	56	288	360
73	54	148	206	54	148	206	60	191	250	57	290	357
74	55	148	206	55	148	206	61	192	254	57	291	355
75	55	147	206	55	150	206	59	190	251	56	291	356
76	54	148	206	55	148	206	68	191	251	56	291	355
77	54	148	206	55	148	206	59	191	250	62	290	354
78	55	148	206	55	148	206	59	191	252	56	293	354
79	55	147	206	55	147	206	60	190	251	56	290	353
80	55	148	207	55	148	207	59	190	252	56	293	351
81	54	148	206	55	148	206	59	190	250	56	292	351
82	54	147	205	54	149	205	60	190	251	57	290	350
83	55	149	206	55	149	206	61	191	251	57	290	348
84	55	148	206	55	148	206	59	190	251	56	291	349
85	54	148	207	55	148	207	68	190	251	56	289	352
86	54	148	206	55	148	206	59	191	250	62	290	354
87	55	147	206	57	149	206	59	191	252	56	291	351
88	55	148	206	55	148	206	60	191	250	56	295	352
89	55	149	206	55	149	206	59	190	251	56	290	377
90	55	149	207	55	149	207	59	190	251	56	291	352
91	55	148	206	55	148	206	59	190	253	56	290	358
92	54	148	206	54	148	206	60	190	251	57	288	360
93	55	148	206	55	148	206	61	191	250	57	290	357
94	55	147	206	55	150	208	59	192	254	56	291	355
95	54	148	206	55	148	206	68	190	251	56	291	501
96	54	148	206	55	148	207	59	191	251	62	291	355
97	55	148	206	55	148	206	59	191	250	56	290	354
98	55	148	206	55	148	206	60	191	252	56	293	354
99	55	147	206	55	148	206	59	190	251	56	290	353
100	54	148	206	55	148	206	59	197	258	62	293	351

TABLE IV.20/V.56 *ter*

Block acknowledge delay averages

All times are in milliseconds

Mean values			
	Timer 1	Timer 2	Timer 3
Direct	54.7	147.9	206.1
Normal	55.0	148.2	206.2
Error Control	60.3	190.7	251.6
Compression	56.9	291.2	356.1

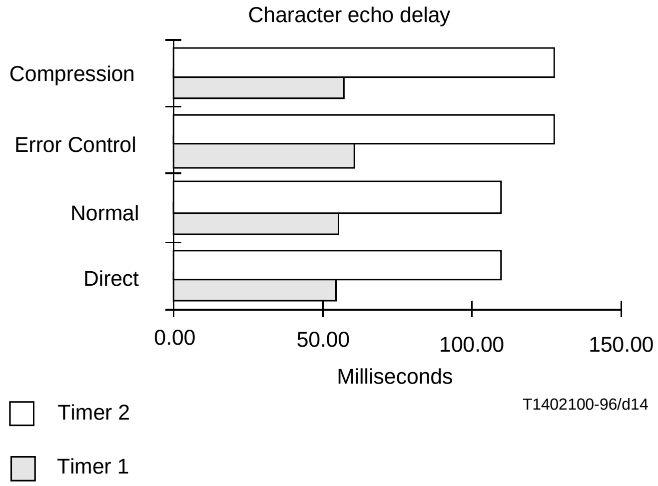

FIGURE IV.12/V.56 *ter*

Character echo delay averages

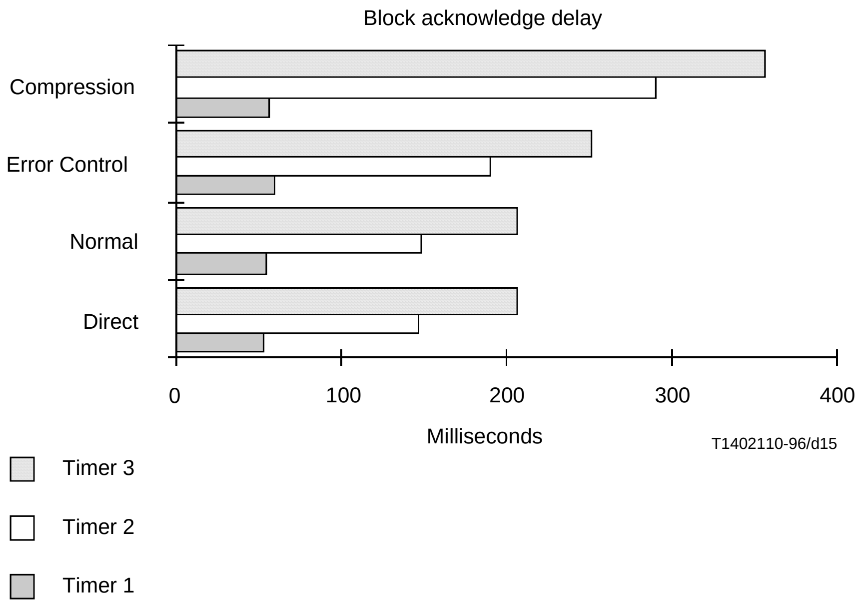

FIGURE IV.13/V.56 *ter*

Block acknowledge delay averages

Appendix V

Call initiation considerations

In every test described in this appendix, the procedures call for connections to be initiated by modem A. This appendix describes why this was done. It also provides guidance as to when to initiate calls with modem B instead of, or in addition to, initiating calls with modem A.

These considerations only apply to those procedures which test signal converter performance: Error-ratio versus network model coverage and Throughput versus network model coverage. Procedures that do not test signal converter performance – Throughput versus file type, Character echo delay, and Block acknowledge delay – do not require that a particular modem, or both modems, initiate calls.

V.1 Duplex bandsplitting modems

For bandsplitting duplex modems (modems that use the modulation methods V.21, V.22, V.22 *bis*, 103 type, and 212 type) the initiating modem normally transmits data on the low band of the channel and receives on the high band of the channel. (Many bandsplitting modems have the ability to reverse this by prearrangement.) The modulators and demodulators exhibit different performance characteristics depending on the band being used.

Because the band is split, any general-purpose channel-based performance tests have to be done such that both high-band and low-band channels are tested individually in order to characterize the modem's performance in both originate and answer mode.

Such dual-mode testing is excessive for most applications in which these slower-speed modems are used; there is a small population of modems which answer calls exclusively, and a large population of modems which originate calls exclusively. (Examples of such applications: automated credit card authorization, remote mail, enhanced information provider access, remote form entry, remote cardiac monitoring and analysis, and hotel pay-per-view billing.) Other applications use a central polling modem and a number of remote stations which accept calls. (Examples of such applications: water system control, polled data collection stations.)

Channel-based performance tests should be tailored to the application. If the modem under test is going to be used primarily to answer calls, then the tests should be performed as specified in this appendix: all calls being originated by modem A. If the modem under test is going to be used primarily to originate calls, then the calls should be originated by modem B instead of modem A. Dual-mode testing is appropriate when the modem will be used both to originate and to answer calls.

V.2 Duplex echo-cancelling modems

V.32, V.32 *bis* and V.34 modems use the entire channel bandwidth in both directions at the same time. To accomplish this, the modems use echo cancelling to separate the transmitted and received signals properly.

For echo-cancelling modems to work properly, they sample the channel and find all the echoes on the circuit. Then they calculate the correct amplitude and delay for an equal-and-opposite signal so that the remote signal can be isolated and decoded.

There is no other potential difference between a modem operating in the originate mode or in the answer mode. This is because in both modes the same modulator and demodulator is used.

Any advantage which a modem might have while working in either the answer or originate mode is implementation dependent, and beyond the scope of this appendix.

When performing throughput or error-ratio tests on echo-cancelling modems, it makes no difference which modem initiates the call.

V.3 Normative test procedure rationale

At the time this appendix was being prepared, the emphasis of testing has been on those modems that comply with Recommendations V.32, V.32 *bis* and V.34, and on echo-cancelling proprietary modulations. These are echo-canceller-based modulation methods. It is the opinion of the ITU-T SG 14 that this was sufficient grounds to incorporate the assumption that echo-cancelling modems are being tested into the standard test procedures.

Based on the preceding analysis, for performance testing it makes no difference which modem initiates the call. Having modem A initiate the calls in the remainder of the tests is an arbitrary decision.

Appendix VI

RTS/CTS flow control

RTS/CTS flow control is an interface method in which the V.24 circuits 133 (ready for receiving) and 106 (clear to send) are used by the DTE and modem, respectively, to indicate readiness to accept additional data. It is known as "RTS/CTS" instead of "RFR/CTS" because circuit 133 (ready for receiving) is typically implemented as an alternative use of the same pin on the EIA-232-E interface as circuit 105 (request to send). Commonly used UARTs label this output as RTS rather than RFR.

When the DTE is ready to accept data, it holds circuit 133 in the ON condition. When the DTE is temporarily unable to accept additional data, it holds circuit 133 in the OFF condition; the modem retains data in its internal buffers until circuit 133 is turned back ON. When the DTE stops the flow of data in error-control modes, this may cause the modem to stop the flow of data from the other modem (and, as a result, stop the flow of data from the other DTE) until local circuit 133 is asserted and sufficient buffer space is emptied.

When the modem is ready to accept data, it holds circuit 106 in the ON condition. When the modem is temporarily unable to accept additional data (e.g. because the modem's buffers are full), it holds circuit 106 in the OFF condition and the DTE suspends transmission of data until circuit 106 returns to the ON condition.

Appendix VII

Modem overview

The purpose of this appendix is to provide a brief overview of the functional blocks in a typical 2-wire duplex modem, and explain what effect the functioning of each block has on the results obtained from the tests defined in this Recommendation.

VII.1 Review of modem functionality

The major functional components in a typical modem are the signal converter, the control function, and the interface circuits. Figure VII.1 shows the interrelationship of these components:

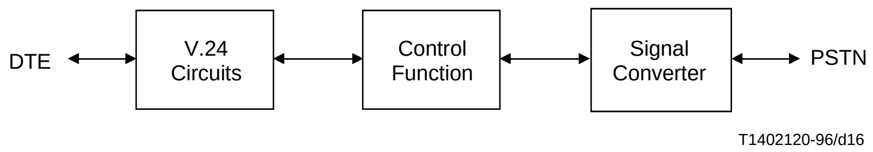

FIGURE VII.1/V.56 *ter*

Modem functional blocks

The **V.24 circuits** permit the DTE and the modem to exchange data, control information, and status information. The V.24 circuit functionality is commonly implemented using a serial interface such as EIA/TIA-232 or EIA/TIA-574, but other interfaces are possible such as a direct connection to an internal bus in a computer, a connection via a SCSI port, or a connection via a local area network.

The **control function** performs several tasks in the modem:

- it implements a user interface that allows configuration and control of modem operation, via command sets such as TIA/EIA-602 or V.25 *bis*, V.24 control leads, hard-wired strapping options, etc.;
- it monitors and controls operation of the signal converter – depending on the operating mode and configuration of the modem, it may initiate retrains and/or signalling rate changes in the signal converter, when appropriate; and
- it implements some type of asynchronous-to-synchronous conversion when an asynchronous DTE interface is used, as in modems with synchronous signal converters (which include virtually all non-FSK modems). This can be something as straightforward as an async-to-sync converter that operates in accordance with Recommendation V.14. Alternately, this could encompass V.42 error control with optional V.42 *bis* data compression.

The **signal converter** (commonly referred to as the "data pump") performs the modulation and demodulation that converts between digital data and analogue signals that can be transferred across the PSTN. In most modern voiceband modems, the signal converter is implemented using digital signal processing techniques. The modulation standard(s) implemented in the signal converter determine the rate at which data can be transferred across the PSTN between the two modems. For standard modems, this can range from 0-300 bit/s (Recommendation V.21) to 28 800 bit/s (Recommendation V.34).

The control function is commonly implemented in a separate processor from that used for the signal converter, although the two functional blocks are sometimes implemented on a single processor capable of performing both simultaneously. A key difference between the control function and the signal processor is the processing power required by each of them.

The processing power required by the control function is strongly dependent on the type of data being processed. For instance, more processor resources are necessary to accomplish duplex data compression and decompression as compared to half-duplex operation. If the available processor resources are not sufficient, then data throughput will decrease.

The processor resources required by the signal converter for a given modulation method and signalling rate are independent of the type of data being transferred. (In most signal converters, the first operation performed on the data to be transmitted is scrambling the data to make the data stream appear random; the converter has no knowledge whether the bitstream represents data or just an idle line.) Different implementations of a signal converter can vary greatly in the amount of processor resources required, depending on such factors as the desired level of performance and the efficiency of the implementation.

VII.2 Operating modes

For the tests defined in this Recommendation, the modem is configured to one of five operating modes: synchronous, direct, buffered, error control, and compression. This subclause describes each of these in detail, and the reason for performing each of the tests defined in this Recommendation.

VII.2.1 Synchronous mode

Figure VII.2 shows a modem configured for synchronous mode.

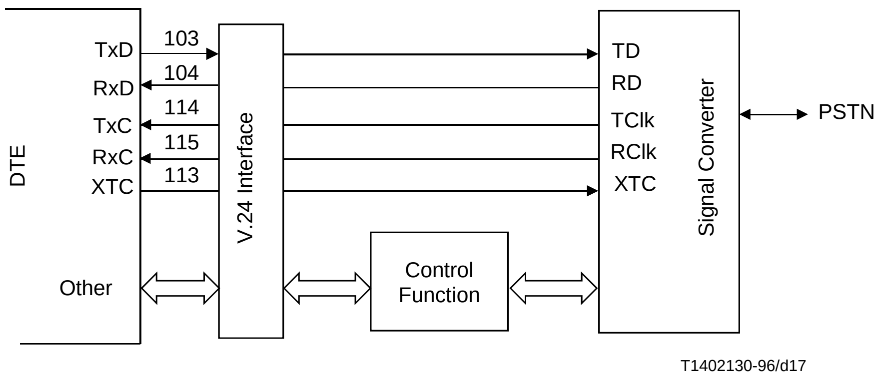

FIGURE VII.2/V.56 *ter*

Synchronous mode

Data is exchanged directly between the DTE and the signal converter. The control function does no processing of the data in either direction. In this mode, the control function assumes a strictly supervisory role. For instance, before a connection is established, the control function will answer or originate a call. During a connection, the control function may monitor the received signal quality as reported by the signal converter, and can initiate or respond to a retrain or a signalling rate change, if allowed.

Note that Figure VII.2 assumes a synchronous signal converter, where the V.24 clock signals 114, 115, and optionally 113, are present. For FSK modems, these circuits are usually not present; in such cases, it is the receiving DTE's responsibility to recover the clock signal from the received data stream. In addition, the transmitting DTE must send data in a form that allows this to be accomplished.

Proprietary schemes implemented by some manufacturers for the compression of synchronous data, a function normally associated with the control function, are outside the scope of this Recommendation.

In this Recommendation, the following procedure uses synchronous mode:

Error ratio versus network model coverage: This test is the best way to evaluate the performance of the modem's signal converter separately from the other functional blocks of the modem. Because data is transferred directly between the DTE and the signal converter, errors generated in the signal converter from imperfect modulation and demodulation due to network conditions will not be hidden by V.42 error correction. In addition, asynchronous-to-synchronous converters are absent: they can make it difficult for the receiving DTE to resynchronize on the test pattern after an error.

VII.2.2 Direct mode

Figure VII.3 shows a modem configured for direct mode.

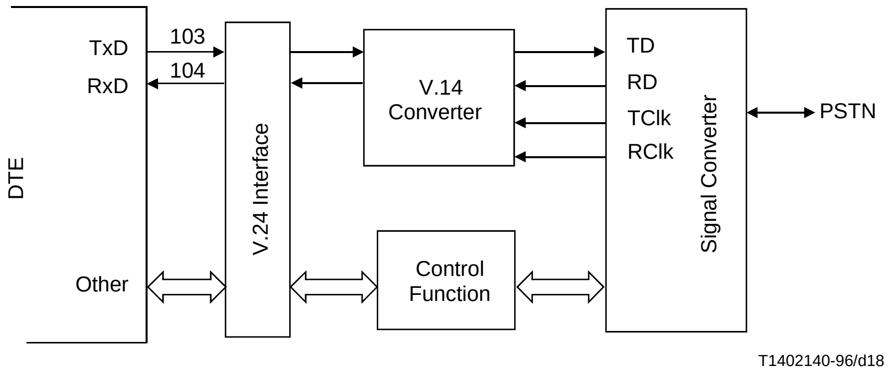

FIGURE VII.3/V.56 *ter*

Direct mode

In direct mode, the control function does minimal processing of the data. It performs asynchronous-to-synchronous conversion in accordance with Recommendation V.14. The DTE port rate is equal to the that of the signal converter.

Some modems do not support direct mode this way; instead, they interpose a very small buffer between the DTE and the V.14 converter. While the interposed-buffer implementation of direct mode is functionally equivalent, additional real-time delay is introduced by the buffer.

Direct mode does not use any error control and data compression features which may be present in the modem. Direct mode is useful in certain applications, such as remote data recording stations, where the DTE incorporates an automatic sensor that is continually transmitting a stream of data. When the flow of data from a source cannot be stopped, the latency associated with flow control cannot be tolerated.

In this Recommendation, the following procedures use direct mode:

Character echo delay: This procedure, when performed using direct mode, provides a baseline measurement for the delay generated by the signal converters, the PSTN channel, V.14 converters, and any delay introduced by data management in the modems. By comparing the direct mode measurement to that obtained in other modes, the delay generated by other control function components can be determined.

Block acknowledge delay: As with Character echo delay, this procedure, when performed using direct mode, yields a baseline measurement to which measurements in other modes can be compared.

VII.2.3 Buffered mode

Figure VII.4 shows a modem configured for buffered mode.

Buffered mode adds bidirectional character buffering and flow control to the control function. Flow control is implemented with the V.24 circuits 106 and 133, or with circuits 103 and 104 when using software flow control protocol.

With the addition of buffering, the signalling rate at the DTE interface need not match the rate of the signal converter. In typical usage, the DTE interface rate is set to the highest rate supported by both the DTE and the modem, and remains at this rate throughout the call. The control function is then free to initiate, and respond to, rate changes of the signal converter line rate in order to maximize the modem’s port rate in the face of prevailing network conditions.

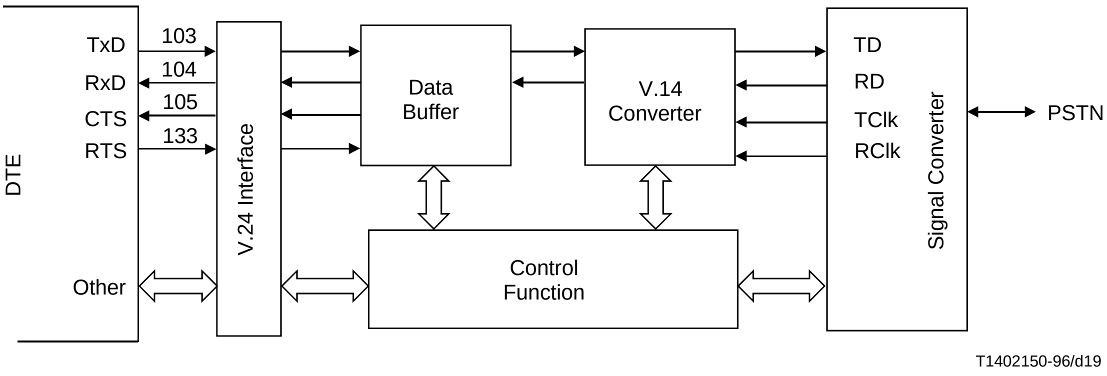

FIGURE VII.4/V.56 *ter*

Buffered mode

Buffered mode does not use any error control and data compression features which may be present in the modem. It is used when a DTE-to-DTE error control procedure is implemented, and especially when only a very small data packet is transferred during the connection. In such cases, the brief transmission time does not justify the time it takes to complete a V.42 negotiation.

Buffered mode is the "fallback" mode, if permitted, that results when a modem attempts an error control negotiation and fails to complete the protocol handshake.

In this Recommendation, the following procedures use buffered mode:

Character echo delay: Compared to direct mode measurement, buffered mode measurements include an additional delay associated with the buffering at each end. In the modem from which a character is transmitted, the incoming character must first be completely assembled and moved to the buffer, however briefly, before it is transferred serially to the V.14 converter. Thus, a delay equal to ten bit times at the DTE port rate is added at the transmitting end. A similar delay is associated with the receiving end. Because the DTE port rates are typically higher than that of the line rate of the signal converters, these two additional delays should be minimal.

Block acknowledge delay: The additional delays also take place during this procedure when it uses buffered mode. In addition, modems with small buffers can be detected during this test: if the transmitting modem deasserts circuit 106 while the DTE is sending the 133-character block, then the buffer cannot be much larger than this.

VII.2.4 Error control mode

Figure VII.5 shows a modem configured for error control mode.

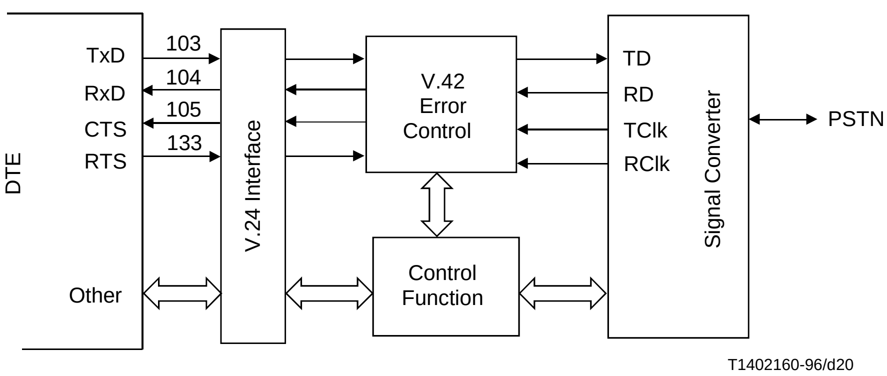

FIGURE VII.5/V.56 *ter*

Error control mode

Error control mode replaces the V.14 converter shown in buffered mode with a functional block that implements V.42 error control. Asynchronous characters are packed into synchronous HDLC Information frames, and reliably transferred between modems using the V.42 error control protocol. The uncertain latency associated with retransmission of missing or incorrectly received frames mandates the use of buffering and flow control.

Data throughput for error control mode will be higher than that of either direct or buffered mode. Start and stop bits are not transferred between modems, but the 20% savings are reduced by the overhead introduced by the HDLC Information frame and zero-bit insertion, and by the time required to recover from any error detected by V.42. The throughput improvement assumption holds true if the signal converter error rate is low (i.e. at or below 10^{-3}).

NOTE – "Error control" provides for error-free data transfer only between the two V.42 error-control functions. Errors that occur within the DTE or between the DTE and the V.42 error-control functions are not detected, and therefore cannot be corrected by the modems.

In this Recommendation, the following procedures use error control mode:

Throughput versus network model coverage: In this procedure, the control function is configured so that its ability to adapt the signal converter's line rate to network conditions is fully enabled. This configuration matches that of the typical asynchronous application in which the data is already compressed. With error control enabled, errors detected by V.42 cause retransmissions which lower throughput. Thus, this procedure measures the performance of the modem against the PSTN model in asynchronous applications by measuring the end-to-end throughput.

By doing these tests with data compression disabled, the effects of infrequent errors on the signal converters that might otherwise be obscured by the effects of data compression can be measured. Thus, for the Throughput versus network model coverage tests, the procedure using error control mode provides a more precise evaluation of the performance of the signal converter in asynchronous applications than does the procedure using compression mode.

Character echo delay: The small delay associated with the V.14 converters is replaced with the delay through the V.42 function in the two modems. Note that only a single character is being transmitted in either direction during this test – much less than the Information frame size in V.42. Thus, the modem must detect the fact that only a single character is being sent, and transmit a one-character V.42 Information frame in a timely manner. The manner in which different modems accomplish this will vary, with resulting differences in the measured round trip delay time.

Block Acknowledge Delay: The same data forwarding conditions that occur in the Character echo delay procedure occur here as well.

VII.2.5 Compression mode

Figure VII.6 shows a modem configured for compression mode.

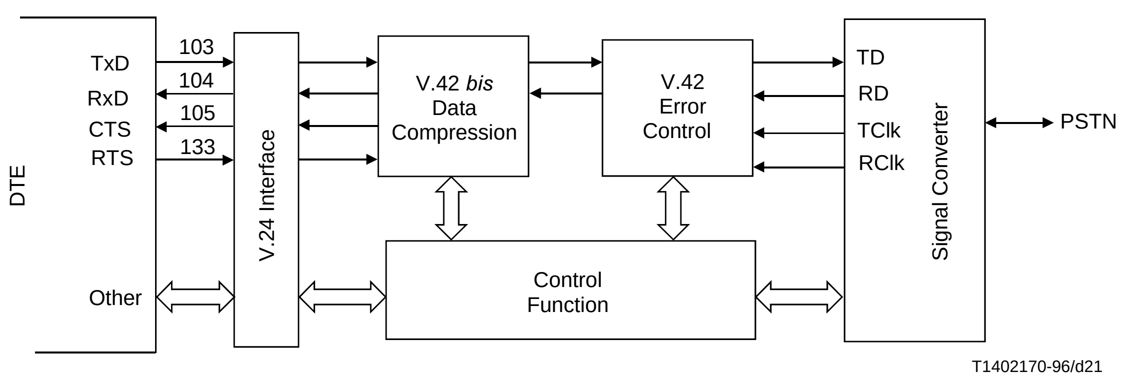

FIGURE VII.6/V.56 *ter*

Compression mode

Information is compressed using Ziv-Lempel encoding, per Recommendation V.42 *bis*, as it is received from the DTE and the compressed form supplied to the V.42 error control function. At the receiving modem, the information delivered by the V.42 function is then decoded per Recommendation V.42 *bis* before it is delivered to the remote DTE. V.42 *bis* data compression is never used without error control, since a single bit error in the compressed data stream will translate into a very large number of errors in the uncompressed data stream.

The addition of data compression greatly increases the processing power that the control function requires. The Ziv-Lempel algorithms are compute intensive; in addition, the data compression achieved allows a higher DTE port rate to be utilized effectively, thus increasing the processing requirements for this portion of the control function as well.

In this Recommendation, the following procedures use compression mode:

Throughput versus network model coverage: This test most closely resembles how a modem is used in typical asynchronous applications. It provides an end-to-end test of the complete modem system in data mode. The results obtained during this test are influenced by the performance of the signal converter, V.42, V.42 *bis*, and the monitoring and control portions of the control function.

Throughput versus File Type: These procedures evaluate the performance of the V.42 and V.42 *bis* components of the control function separately from the performance of the signal converter. Both one-way and two-way tests are performed. Because the two-way tests make a greater processing load on the control function, the throughput measured on the two-way tests will often be less than that measured on the corresponding one-way test.

Connect Reliability versus Test Loop Combinations: This procedure complements the Throughput versus network model coverage procedure by evaluating the ability of the modem to successfully reach data mode. Repeated call attempts are made for each of the seven test loop combinations defined in Recommendation V.56 *bis*. If the call attempt results in a successful compression mode connection, then a small amount of data is transferred. The time it takes the modem to complete the handshake and transfer the specified data is measured in order to determine how much network time the modem uses to transfer small amounts of data.

A compression mode connection is the combination of a successful modem handshake and a successful V.42 negotiation. In order to do this, the signal converter must have the ability to reliably train over a range of network conditions, and the control function must set the signal converter signalling rate to one that results in a low enough error rate that a V.42 negotiation can be completed. Conversely, in order to complete the data transfer in a timely manner, the signal converter must finish handshaking without resorting to inordinately long training sequences, and the chosen signalling rate must not be so low that the data transfer phase of the connection consumes too much time.

By performing the test over each of the seven test loop combinations defined in Recommendation V.56 *bis*, the receive level, echo levels, and linear distortion experienced by the modems is varied over a representative range of conditions that a modem will experience in typical user installations.

Character echo delay: The real-time delay for sending a single character in compression mode versus error control mode is increased by the time it takes to encode the character. Because the characters transmitted are chosen at random, the V.42 *bis* function will stay in transparent mode. Occasionally, the transmitted character will be equal to the current V.42 *bis* escape character; this collision causes the transmission time to increase slightly as a two-octet V.42 *bis* Escape In Data sequence must be sent instead of the character itself.

Block acknowledge delay: The random data used in this test should result in little difference between the error control mode result and the compression mode result. However, limitations in processing power available in the control function for the V.42 *bis* function can result in additional delays in the transmission of the data block.

Appendix VIII

Circuit identification cross-reference

Table VIII.1 identifies each V.24 interface circuit used in this Recommendation. In addition, the EIA/TIA-232-E circuit mnemonic and the circuit designation used by UART vendors is also included in the table.

TABLE VIII.1/V.56 *ter*

Circuit identification cross-reference

V.24 Circuit number	EIA/TIA-232 circuit mnemonic	Common mnemonic	Circuit name
102	AB	GND	Signal Common
103	BA	TD	Transmitted Data
104	BB	RD	Received Data
105	CA	RTS	Request to Send
106	CB	CTS	Ready for Sending
107	CC	DSR	Data Set Ready
108/1	CD	DTR	Connect Data Set to Line
108/2	CD	DTR	Data Terminal Ready
109	CF	DCD	Data Channel Received Line Signal Detector
113	DA	BMC	DTE Transmitter Signal Element Timing
114	DB	TC	DCE Transmitter Signal Element Timing
115	DD	RC	DCE Receiver Signal Element Timing
125	CE	RI	Calling [Ringing] Indicator
133			Ready for Receiving

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Series B	Means of expression
Series C	General telecommunication statistics
Series D	General tariff principles
Series E	Telephone network and ISDN
Series F	Non-telephone telecommunication services
Series G	Transmission systems and media
Series H	Transmission of non-telephone signals
Series I	Integrated services digital network
Series J	Transmission of sound-programme and television signals
Series K	Protection against interference
Series L	Construction, installation and protection of cables and other elements of outside plant
Series M	Maintenance: international transmission systems, telephone circuits, telegraphy, facsimile and leased circuits
Series N	Maintenance: international sound-programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Telephone transmission quality
Series Q	Switching and signalling
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminal equipments and protocols for telematic services
Series U	Telegraph switching
Series V	**Data communication over the telephone network**
Series X	Data networks and open system communication
Series Z	Programming languages