TECHNICAL REPORT

DSL Forum TR-031

ADSL ANSI T1.413-1998 Conformance Testing

March 2000

Notice:

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ADSL ANSI T1.413-1998
Conformance Testing

1. Introduction

This document defines tests to verify an ADSL modem U interface conforms to ANSI T1.413-1998. These tests are organized in a hierarchical model beginning with physical media dependent measurements and concluding with ATM Transmission Convergence layer measurements. Section 3 lists electrical conformance tests for ANSI T1.413-1998, while Section 4 details initialization tests for ANSI T1.413-1998, and Section 5 lists tests of the ATM TC layer.

2. Test Format

2.1 Overview

These test proposals have been developed to help vendors evaluate the compatibility of their ADSL products based on initialization procedures. These tests do not determine if a product conforms to an ADSL standard. Rather, they provide one method to isolate initialization problems within an ADSL device. Successful completion of all tests contained within this document does not guarantee complete conformance to the standards or interoperability with other ADSL devices.

Organization of Tests
The test descriptions contained in this document have been structured to simplify the execution of testing, ensuring consistent execution. Each test description contains a series of elements that are of an informational or descriptive nature. Each test contains the following:

Test Number
Specifies the number of the current test and provides a simple global identification system.

Test Label
The label associated with each test follows a hierarchical domain-naming algorithm, with subgroups separated by periods. More specific identifiers are located to the left; higher order identifiers are located to the right. For example, the "Insertion Loss" test is identified by the following label:

insertion_loss.voice_band.dmt.adsl

Purpose
The purpose is a short statement that describes what the test hopes to achieve. The purpose is written at the functional level. For example, the purpose statement for the "Insertion Loss" test is:

To measure and determine if the insertion loss, at 1004Hz, from the source to the termination for each of the test loops shown in figure 1 (at the end of this test) is acceptable according to ANSI T1.413-1998.

References
The reference section lists cross-references to the ADSL standard and other relevant documentation that might be useful in understanding and evaluating the test and its results.

Resource Requirements
The resource requirements section specifies the test equipment that will be needed to perform the test.

Discussion
The discussion section describes what should happen during a test, and provides information necessary to understand the test.

Test Setup
The setup section describes what equipment was used and how it was connected. A block diagram is included for clarification.

Procedure
The procedure section of the test description contains the step-by-step instructions for carrying out the test.

Observable Results
The observable results section lists what the tester should see as a result of the test.

Possible Problems
The possible problems section describes problems that may arise and how to remedy them. This section is included only with tests where issues arise.

3. Electrical Parametric Tests

3.1 Scope

These tests are designed to ensure that no problems occur due to improper loading of the POTS splitter and ATU-C/R.

Overview: Improper impedance matching can cause problems both with the digital data in the ADSL band and with the analog data in the voice band. These problems can be avoided by following the recommendations provided in ANSI T1.413-1998. Provided in this document are tests for the following voice band characteristics:

- Insertion Loss
- Attenuation Distortion
- Delay Distortion
- Return Loss
- Longitudinal Balance
- Transparent Testing Capacitance

ADSL band tests included in this document are ADSL band attenuation and input impedance. A DC resistance test is also included in this document.

3.2 Test # 3.001

Test Label: resistance.dc.dmt.adsl

Purpose: To verify that the DC input impedance of the ADSL splitter at the U-R or U-C interface conforms to the referenced standard.

References: ANSI T1.413-1998 Annex E.

Resource Requirements:

- ATU-R/C unit (UUT) with splitter (internal or external)
- Multimeter (and necessary jumpers/connectors)
- Function generator (and necessary jumpers/connectors)

Discussion: Correct impedance levels under a variety of conditions are necessary for interoperation between devices. Improper impedance matching and termination can cause reflections that create noise and thus degrade the overall signal, to the extent that it may become impossible to interpret or distinguish received data.

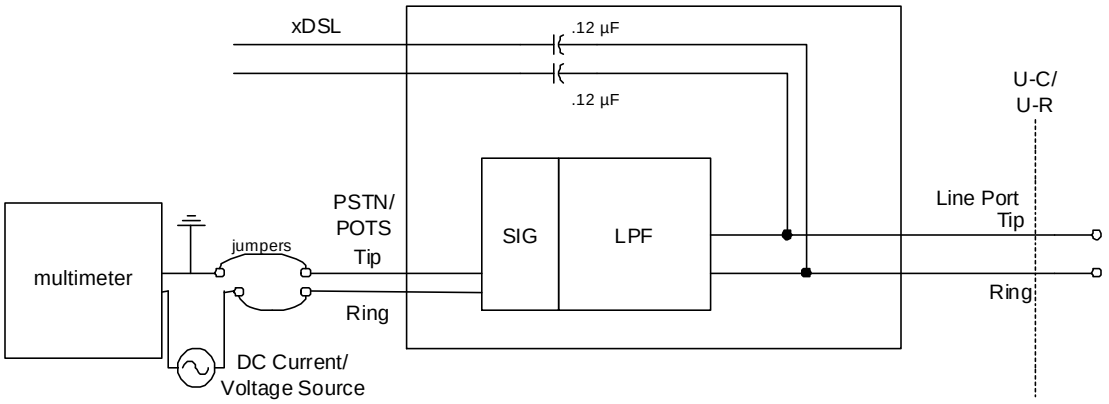
The DC characteristics of an ADSL device, either ATU-C or ATU-R, and corresponding splitter, must be consistent throughout all implementations in order for interoperability to be achieved. The DC input impedance of an ATU-R or ATU-C at the U-R or U-C interface, respectively, must be greater than or equal to 5 MΩ. In addition:

- The DC resistance from tip to ring at the PSTN or POTS interface, with the U-C or U-R interface shorted, respectively, shall be less than or equal to 25Ω. This is actually just measurement of the resistance of the wires themselves because the splitter will be in parallel with a short at the U-C or U-R interface.
- The DC resistance from tip or ring to ground at the PSTN or POTS interface, with U-C or U-R interface open, respectively, shall be greater than or equal to 5 MΩ.

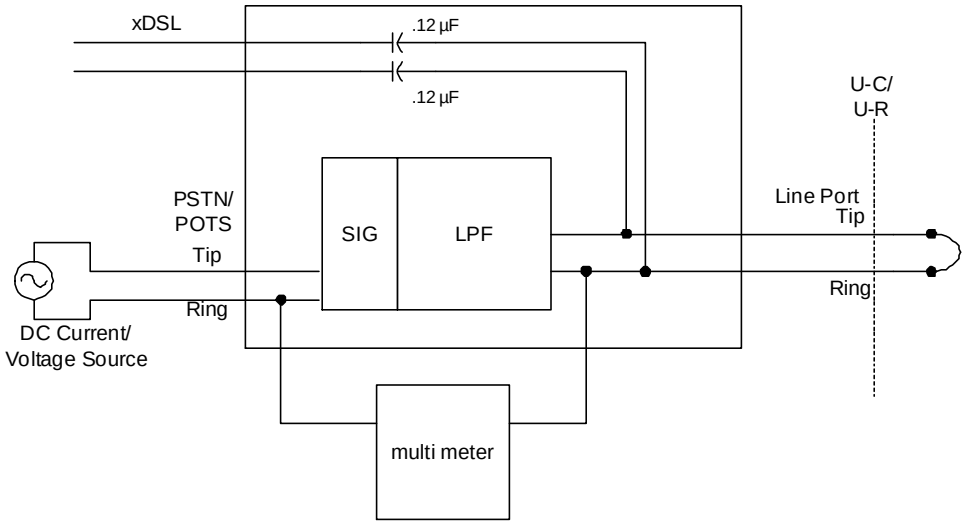
These requirements must be maintained for all POTS loop currents in the range 0mA to 100mA, and DC differential loop voltages in the range 0V to minus 60V.

Test Setups:

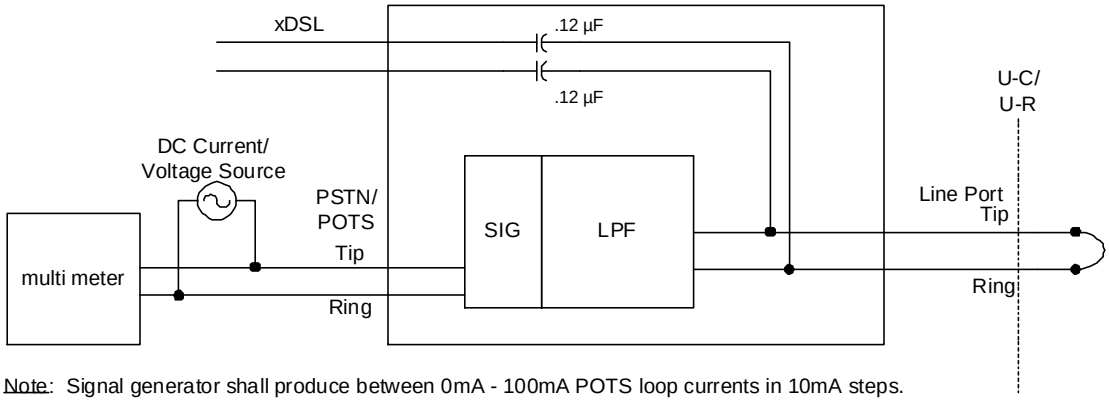
Setup 1. DC Ring to Ground/Tip to Ground Resistance Measurement at the PSTN/POTS Interface.



Setup 2. DC Input Resistance at the PSTN/POTS interface.



Setup 3. DC Tip to Ring Resistance Measurement at the PSTN/POTS Interface.



Note: Signal generator shall produce between 0mA - 100mA POTS loop currents in 10mA steps.

Note: The capacitors are for the external POTS Splitter w/o the HPF function only. Internal Splitter function external splitters with a complete HPF function may incorporate this capacitance in the input to the HPF function. The D.C. blocking capacitors are optional on splitters integrated within the equipment closely associated with the ATU-C (i.e. DSLAM).

Note: The setups shown above can be applied to both an ATU-R and an ATU-C.

Procedure: If results cannot be printed, a table is included on the last page – all results should be recorded.

- Connect the function generator and multimeter as shown in the first test setup.
- Open the U-C or U-R interface.
- Connect the jumpers appropriately and measure the DC resistance from ring to ground.
- Reverse the jumpers and measure the DC resistance from tip to ground.
- Connect the function generator and multimeter as shown in the second test setup.
- Short the U-C or U-R interface.
- Measure the DC input resistance of the UUT.
- Connect the function generator and multimeter as shown in the third test setup.
- Short the U-C or U-R interface.
- Measure the DC resistance from ring to tip.
- Repeat the procedure above varying the loop current, where applicable, in 10mA steps from 0mA to 100mA.

- Repeat the procedure above generating differential DC voltages in the range 0V to minus 60V in 5V increments.

Observable Results:

- The DC resistance from tip to ground or from ring to ground, with U-C or U-R interface open, should be greater than or equal to 5MΩ for all loop currents in the range 0mA to 100mA and all differential DC loop voltages in the range 0V to minus 60V.
- The DC input resistance of the UUT should be greater than or equal to 5MΩ for all loop currents in the range 0mA to 100mA and all differential DC loop voltages in the range 0V to minus 60V.
- The DC resistance from tip to ring with U-C or U-R interface shorted should be less than or equal to 25Ω for all loop currents in the range 0mA to 100mA and all differential DC loop voltages in the range 0V to minus 60V. This measurement is actually the total resistance of just the tip and ring wires.

DC Resistance Pass/Fail		Ring to Ground (Setup 1)											Tip to Ground (Setup 1)										
		Loop Current (mA)											Loop Current (mA)										
		0	10	20	30	40	50	60	70	80	90	100	0	10	20	30	40	50	60	70	80	90	100
Differential DC Voltage (V)	0																						
	5																						
	10																						
	15																						
	20																						
	25																						
	30																						
	35																						
	40																						
	45																						
	50																						
	55																						
	60																						

DC Resistance Pass/Fail		Input (Setup 2)											Tip to Ring (Setup 3)										
		Loop Current (mA)											Loop Current (mA)										
		0	10	20	30	40	50	60	70	80	90	100	0	10	20	30	40	50	60	70	80	90	100
Differential DC Voltage (V)	0																						
	5																						
	10																						
	15																						
	20																						
	25																						
	30																						
	35																						
	40																						
	45																						
	50																						
	55																						
	60																						

3.3 Test # 3.002

Test Label: insertion_loss.voice_band.dmt.adsl

Purpose: To measure and determine if the insertion loss, at 1004Hz, from the source to the termination for each of the test loops shown in figure 1 (at the end of this test) is acceptable according to ANSI T1.413-1998.

References:

- ANSI T1.413-1998 Annex E.
- ANSI T1.601.
- T1 TR No. 28 (CSA Loops).

Resource Requirements:

- The following devices:
  - ATU-R/C unit (UUT) with splitter (internal or external)
  - CRO or Multimeter (and necessary jumpers/connectors)
  - Function generator (and necessary jumpers/connectors)
  - Two decade boxes (or 600 and 900Ω ± 1% terminations)
  - The following circuit elements:
    - Seven 0.12μF ± 2.5% capacitors
    - Two 0.10μF ± 2.5% capacitors
    - Two 0.47mH ± 5% inductor
    - Two 100Ω ± 1% resistor
    - All necessary wiring tools and connectors

Discussion: The insertion loss is the amount of loss added to a signal due to the addition of a splitter and high pass impedance (ZHP) to the system. This measurement shall be taken at a frequency of 1004Hz and on both the remote and central office splitters. This measurement must also be taken for each splitter using each of the test loops shown in figure 1, which is shown at the end of this test.

The ZHPs are actually xDSL band terminations implemented to facilitate testing of the splitter independently of the modem. The circuit diagrams of the ZHPs, for both the remote and central office splitters, are shown in Test setups 1 and 2. The ZHPs can only be added if the splitter is external to the modem. Assume that internal splitters have been properly terminated.

To properly measure the insertion loss, a measurement must first be taken without the splitter and ZHP connected. This measurement can then be compared to the same measurement taken with the splitter and ZHP connected to find the insertion loss. When testing the voice band of a remote or CO splitter, it is important to terminate the connections properly (improper termination causes reflections, *etc.* as discussed in Test 3.001) The voice band of a remote splitter should be terminated with an impedance of 600Ω and the voice band of a CO splitter should be terminated with an impedance of 900Ω.

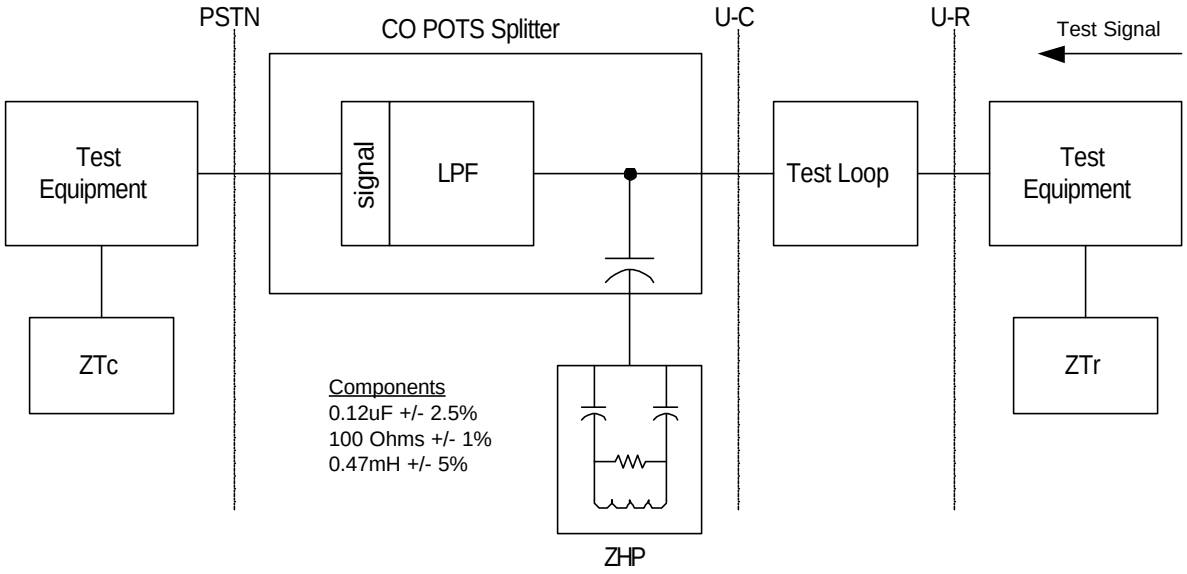
The tolerances for insertion loss are shown in the table below.

Short Loop	ZTc = 900Ω	ZTr = 600Ω	Less than 1.0dB CO end
Long Loop	ZTc = 900Ω	ZTr = 600Ω	Less than 0.75dB CO end
Short Loop	ZTc = 900Ω	ZTr = 600Ω	Less than 1.0dB remote end
Long Loop	ZTc = 900Ω	ZTr = 600Ω	Less than 0.75dB remote end

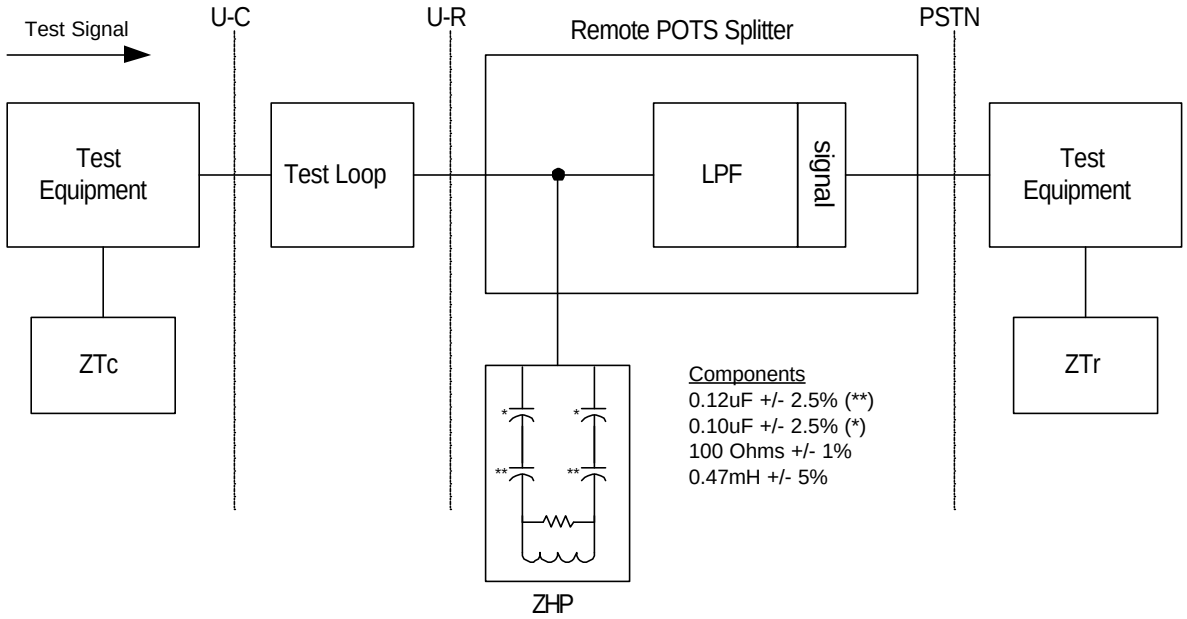
NOTE:
Short loops are defined as 0, 0.5kft, 2.0kft, 5kft pairs of 26 AWG cables.
Long loops are defined as ANSI T1.601 loops 7, 9, 13, and T1 TR No. 28 CSA Loops 4, 6, 7, 8.

Test Setups:

Setup 1. Setup for Transmission Measurements on the CO Splitter in the Voice Band



Setup 2. Setup for Transmission Measurements on the Remote Splitter in the Voice Band

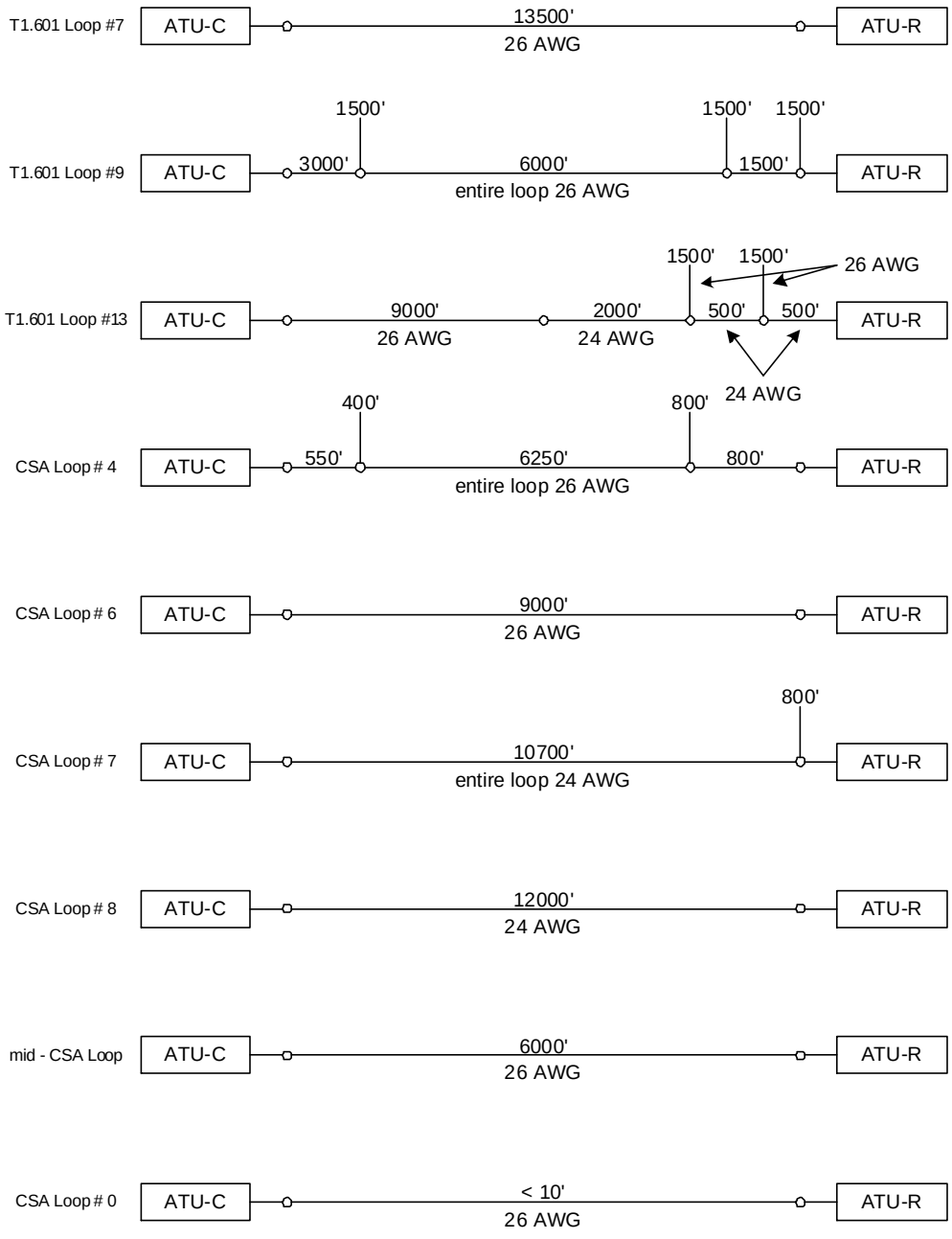


Procedure: If results cannot be printed, a table is included on the last page – all results should be recorded.

- Using the devices listed in the resource requirements section, perform the following measurements:
  - Using test loop 1, construct the circuit shown in setup 1 without the splitter and ZHP.
  - Transmit a 1004Hz signal of known magnitude from the remote end.
  - Measure the received signal at the CO end using a CRO or multimeter.

- Insert the splitter and ZHP.
- Transmit a 1004Hz signal of known magnitude from the remote end.
- Measure and compare the received signal to the transmitted signal using a CRO or a multimeter.
- Perform the above procedure on the remote splitter (*i.e.*, transmit from the CO end).
- Perform the above procedure on each of the loops shown in figure 1.
- Convert all results to decibel scale if necessary.

Figure 1. Test Loops



Observable Results:

- The insertion loss for both the remote and CO end splitters, using each of the test loops shown in figure 1, should lie within the range specified by the table in the discussion section.

	Loop 1 (all measurements in dB)				Loop 2 (all measurements in dB)				Loop 3 (all measurements in dB)			
Splitter	No splitter, loss =	splitter, loss =	Insertion Loss	Pass/Fail	no splitter, loss =	splitter, loss =	Insertion Loss	Pass/Fail	no splitter, loss =	splitter, loss =	Insertion Loss	Pass/Fail
Remote												
CO												

	Loop 4 (all measurements in dB)				Loop 5 (all measurements in dB)				Loop 6 (all measurements in dB)			
Splitter	No splitter, loss =	splitter, loss =	Insertion Loss	Pass/Fail	no splitter, loss =	splitter, loss =	Insertion Loss	Pass/Fail	no splitter, loss =	Splitter, loss =	Insertion Loss	Pass/Fail
Remote												
CO												

	Loop 7 (all measurements in dB)				Loop 8 (all measurements in dB)				Loop 9 (all measurements in dB)			
Splitter	No splitter, loss =	splitter, loss =	Insertion Loss	Pass/Fail	no splitter, loss =	splitter, loss =	Insertion Loss	Pass/Fail	no splitter, loss =	splitter, loss =	Insertion Loss	Pass/Fail
Remote												
CO												

3.4 Test # 3.003

Test Label: attenuation_distortion.voice_band.dmt.adsl

Purpose: To measure and determine if the attenuation distortion, or the variation of insertion loss with frequency, from the source to the termination for each of the test loops shown in figure 1 is acceptable according to ANSI T1.413-1998.

References:

- ANSI T1.413-1998 Annex E.
- ANSI T1.601.
- T1 TR No. 28 (CSA Loops).

Resource Requirements:

- ATU-R/C unit (UUT) with splitter (internal or external)
- The following devices:
  - CRO or Multimeter (and necessary jumpers/connectors)
  - Function generator (and necessary jumpers/connectors)
  - Two Decade boxes (or 600 and 900Ω ± 1% terminations)
  - The following circuit elements:
    - Seven 0.12μF ± 2.5% capacitors
    - Two 0.10μF ± 2.5% capacitors
    - Two 0.47mH ± 5% inductor
    - Two 100Ω ± 1% resistor
    - All necessary wiring tools and connectors

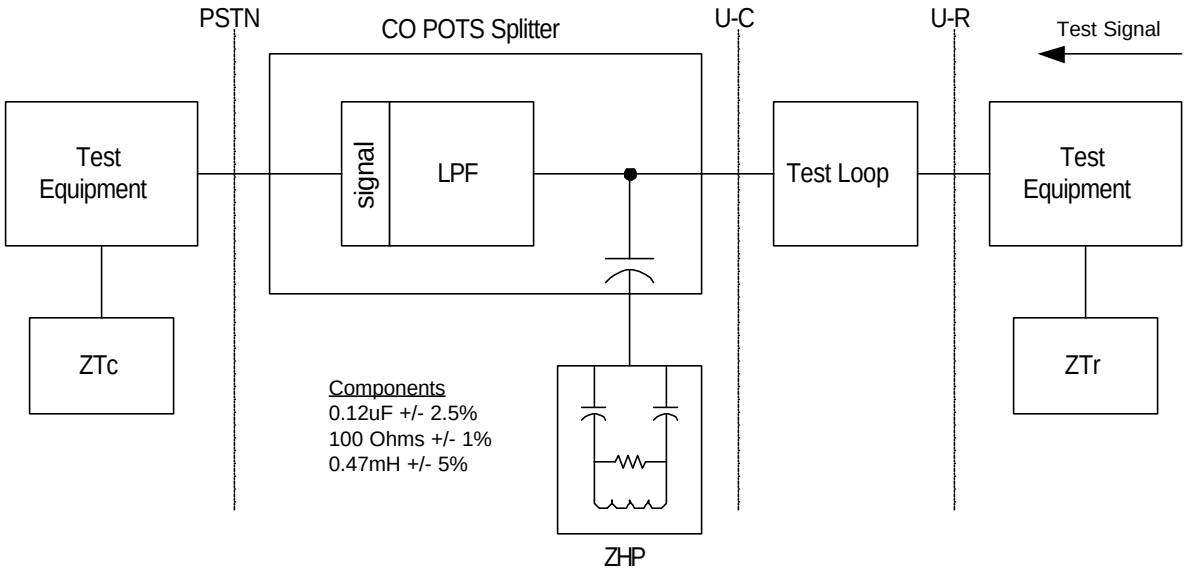
Discussion: ANSI T1E1.413-1998 specifies that the attenuation distortion, or variation in insertion loss with frequency from the insertion loss measured at 1004Hz, for both splitters and all test loops shall fall within the constraints of the following table. The frequency range 3.4kHz to 4.0kHz is rarely used in the telephony world; consequently, the boundaries for this range, as specified by ANSI T1.413-1998, are slightly less strict.

				0.2 - 3.4kHz		3.4 - 4.0kHz	
Short Loop	CO Splitter	ZTc = 900Ω	ZTr = 600Ω	+1.5	-1.5	+2.0	-2.0
Long Loop	CO Splitter	ZTc = 900Ω	ZTr = 600Ω	+0.5	-1.5	+1.0	-1.5
Short Loop	R Splitter	ZTc = 900Ω	ZTr = 600Ω	+1.5	-1.5	+2.0	-2.0
Long Loop	R Splitter	ZTc = 900Ω	ZTr = 600Ω	+0.5	-1.5	+1.0	-1.5

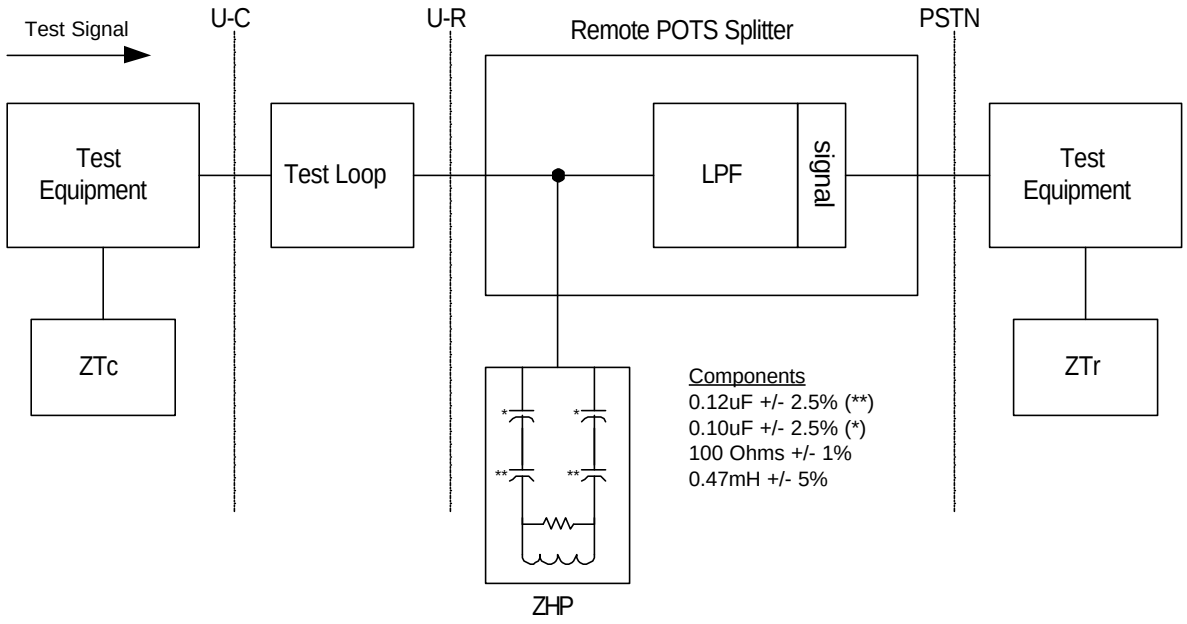
NOTE:
Attenuation is a positive value; gain is a negative value.
Short loops are defined as 0, 0.5kft, 2.0kft, 5kft pairs of 26 AWG cables.
Long loops are defined as ANSI T1.601 loops 7, 9, 13, and T1 TR No. 28 CSA Loops 4, 6, 7, 8.

Test Setups: Test setups, for both the CO and the Remote end splitters, are shown on the following page.

Setup 1. Setup for Transmission Measurements on the CO Splitter in the Voice Band



Setup 2. Setup for Transmission Measurements on the Remote Splitter in the Voice Band



Procedure: If results cannot be printed, a table is included on the next page – all results should be recorded.

- Using the devices listed in the resource requirements section, perform the following measurements:
  - Using test loop 1, construct the circuit shown in setup 1 without the splitter and ZHP.
  - Transmit frequency-varying signal (from 200Hz to 3.4kHz) of known magnitude from the remote end.
  - Measure the received signal at the CO end using a CRO or multimeter.
  - Insert the splitter and ZHP.
  - Transmit a frequency-varying signal (from 200Hz to 3.4kHz) of known magnitude from the remote end.
  - Measure and compare the received signal over the specified frequency range to the insertion loss measurement at 1004Hz.
  - Perform the above procedure using a signal varying in frequency from (3.4 to 4.0kHz).
  - Perform the above procedure on the remote splitter (*i.e.*, transmit from the CO end).
  - Perform the above procedure on each of the loops shown in figure 1.
  - Convert all results to decibel scale if necessary.

Observable Results:

- The results should coincide with the table shown in the discussion section.

				0.2 - 3.4kHz		3.4 - 4.0kHz	
Short Loop	CO Splitter	ZTc = 900Ω	ZTr = 600Ω				
Long Loop	CO Splitter	ZTc = 900Ω	ZTr = 600Ω				
Short Loop	R Splitter	ZTc = 900Ω	ZTr = 600Ω				
Long Loop	R Splitter	ZTc = 900Ω	ZTr = 600Ω				

3.5 Test # 3.004

Test Label: delay_distortion.voice_band.dmt.adsl

Purpose: To determine if the requirements of ANSI T1.413-1998 for delay distortion are met for both the CO and Remote POTS splitters.

References:

- ANSI T1.413-1998 Annex E

Resource Requirements:

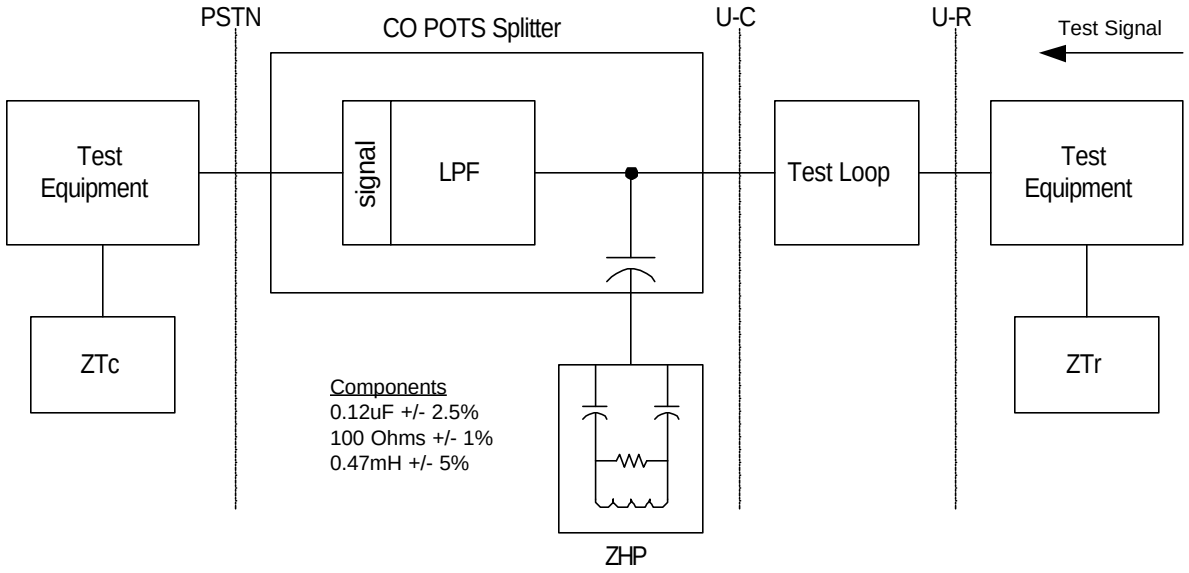
- ATU-R/C unit (UUT) with splitter (internal or external)
- The following devices:
  - CRO or Multimeter (and necessary jumpers/connectors)
  - Function generator (and necessary jumpers/connectors)
  - Two decade boxes (or 600Ω and 900Ω ± 1% terminations)
  - The following circuit elements:
    - Four 0.12μF ± 2.5% capacitors
    - Two 0.10μF ± 2.5% capacitors
    - Two 0.47mH ± 5% inductor
    - Two 100Ω ± 1% resistor
    - All necessary wiring tools and connectors

Discussion: ANSI T1.413-1998 specifies that the increase in delay distortion caused by the POTS splitter in each of the test loops should be less than the indicated values in the table below. The delay distortion should be measured using the test setups provided in this document.

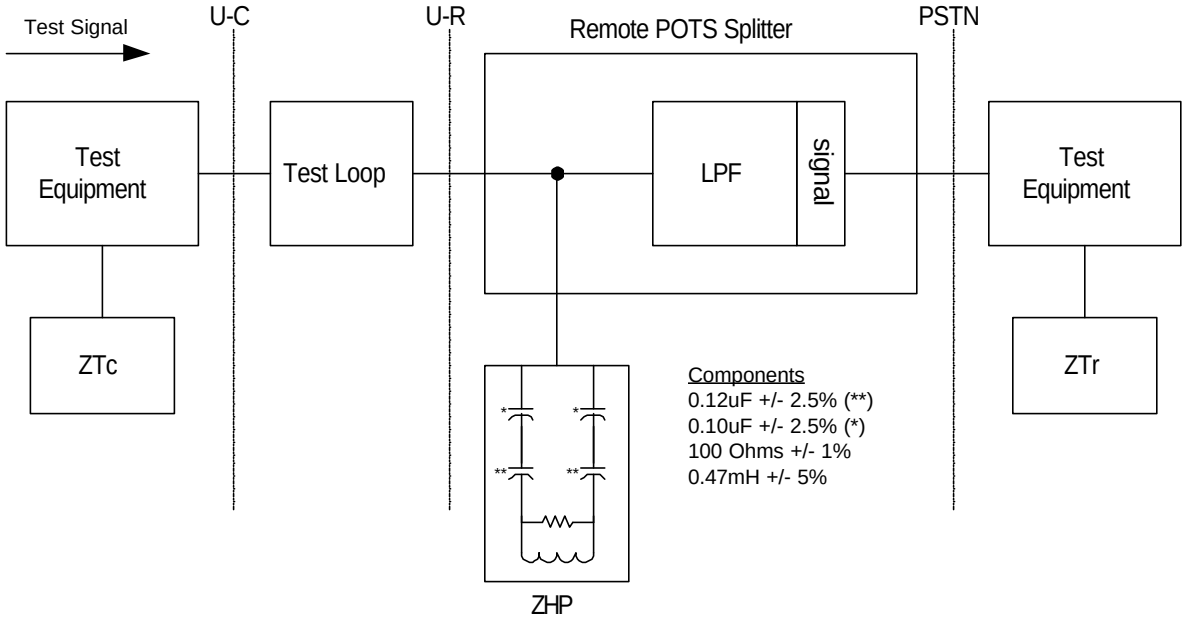
				0.6 – 3.2 kHz	0.2 – 4.0 kHz
Short Loop	CO Splitter	ZTc = 900	ZTr = 600	200 μS	250μS
Long Loop	CO Splitter	ZTc = 900	ZTr = 600	200 μS	250 μS
Short Loop	R Splitter	ZTc = 900	ZTr = 600	200 μS	250 μS
Long Loop	R Splitter	ZTc = 900	ZTr = 600	200 μS	250μS

Test Setups: These test setups include both the CO and the Remote end splitters and are shown below.

Setup 1. Setup for Transmission Measurements on the CO Splitter in the Voice Band



Setup 2. Setup for Transmission Measurements on the Remote Splitter in the Voice Band



Procedure: If results cannot be printed, a table is provided on the next page – all results should be recorded.

- Using the devices listed in the resource requirements section, perform the following measurements:
  - Construct the circuit as shown in the CO splitter test setup diagram.
  - Transmit frequency-varying signal (from 0.6 to 3.2 kHz) of known magnitude from through the POTS line port interface.
  - Measure the received signal using the multimeter and record the results.
  - Construct the circuit as shown in the Remote POTS splitter test setup diagram.
  - Transmit frequency-varying signal (from 0.6 to 3.2 kHz) of known magnitude from through the POTS line port interface.
  - Repeat the above procedure for the remote end splitter.
  - Repeat the above, only this time transmit a frequency-varying signal from 0.2 to 4.0 kHz.

Observable Results:

- For both CO and Remote splitters, the delay distortion should be no more than what is indicated in the delay distortion table.

				0.6 – 3.2 kHz	0.2 – 4.0 kHz
Short Loop	CO Splitter	ZTc = 900	ZTr = 600		
Long Loop	CO Splitter	ZTc = 900	ZTr = 600		
Short Loop	R Splitter	ZTc = 900	ZTr = 600		
Long Loop	R Splitter	ZTc = 900	ZTr = 600		

3.6 Test # 3.005

Test Label: return_loss.voice_band.dmt.adsl

Purpose: To determine if the requirements of ANSI T1.413-1998 for return loss are met for both the CO and Remote POTS splitters.

References:

- ANSI T1.413-1998 Annex E
- A device capable of measuring all required data.

Resource Requirements:

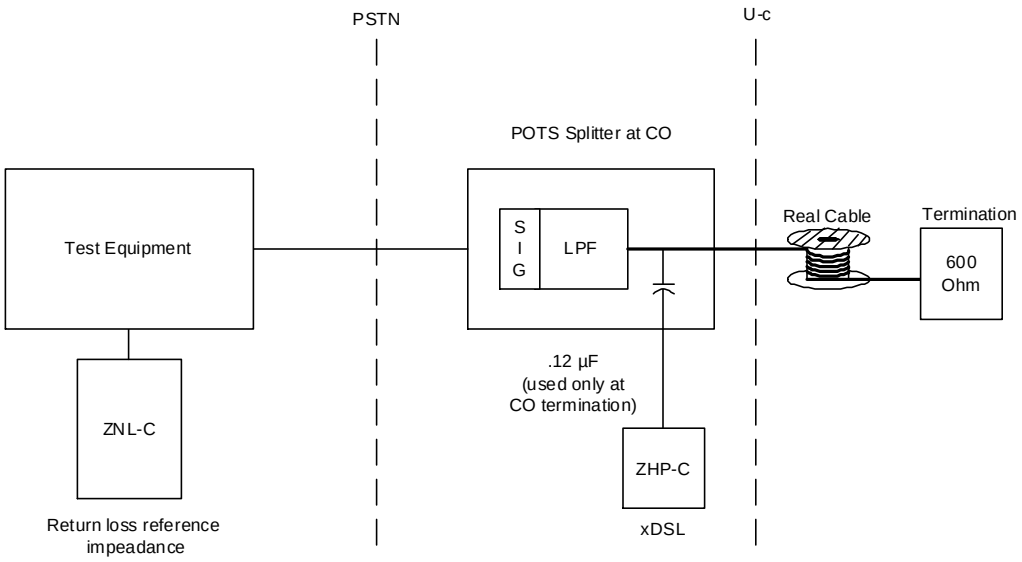
- ATU-R/C unit (UUT) with splitter (internal or external)
- The following devices:
  - CRO or Multimeter (and necessary jumpers/connectors)
  - Function generator (and necessary jumpers/connectors)
  - Decade box (or 600/900Ω ± 1% terminations)
  - The following circuit elements:
    - Four 0.12μF ± 2.5% capacitors
    - Two 0.10μF ± 2.5% capacitors
    - Two 0.47mH ± 5% inductor
    - Three 100Ω ± 1% resistors
    - 800, 1330, and 348 Ω resistors
    - 50 and 100 nF capacitors
    - All necessary wiring tools and connectors

Discussion: ANSI T1.413-1998 specifies the return loss of each splitter under certain conditions. These conditions are either with or without the ZHP attached for short and long loops. The table below specifies the minimum return losses in decibels. Individual frequencies start at 2.2 kHz and sweep to 3.4 kHz.

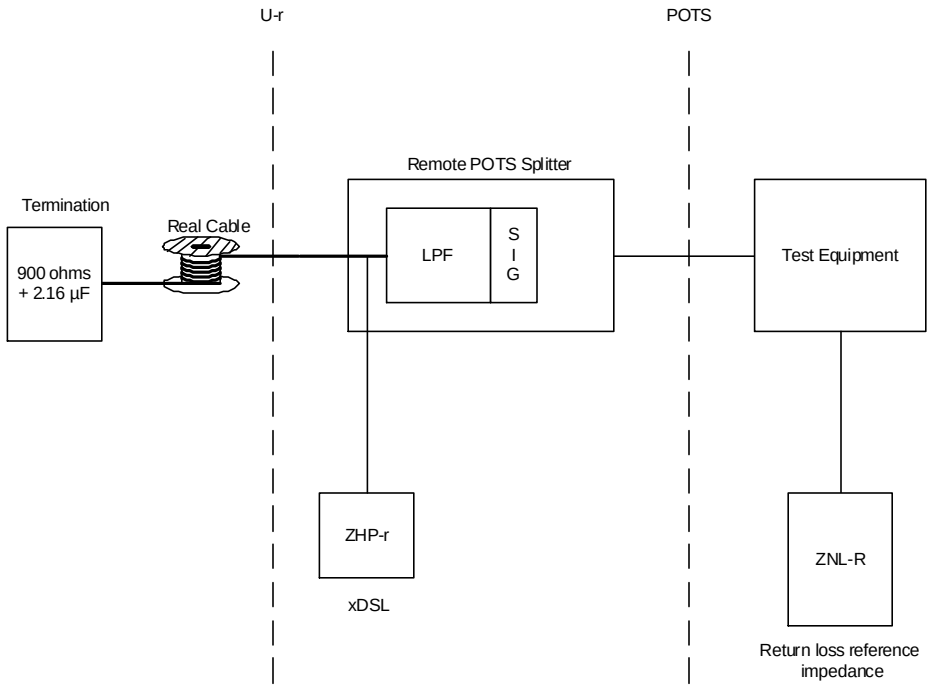
	Zref	Zterm	ERL (dB)	SRL-L (dB)	SRL-H (dB)	Comments
CO splitter	ZNL-c	600 ohm	8	5	5	
CO splitter	ZNL-c	600 ohm	N/A	N/A	2	single frequency
RT splitter	ZNL-r	900 ohm+2.16 μF	6	5	3	
RT splitter	ZNL-r	900 ohm+2.16 μF	N/A	N/A	2	single frequency

Test Setups: These test setups include both the CO and the Remote end splitters and are shown in the figures on the next page.

Test Setup 1: CO POTS Splitter Return Loss



Test Setup 2: Remote POTS Splitter Return Loss



1. ZNL-c consists of an 800-ohm resistor in parallel with the series connection of 100-ohm resistor and a 50 nF capacitor (non-loaded loop model as seen from CO). These values come from the Telcordia Technologies LSSGR as a reference impedance for non-loaded cable.

2. ZNL-r consists of a 1330-ohm resistor in paralleled with the series connection of a 348-ohm resistor and a 100 nF capacitor (non-loaded loop model as seen from RT).
3. ZHP-c is the impedance presented to the POTS connection by an ATU-C through the capacitance of the POTS splitter DC blocking capacitors. ZHP-c is defined in previous tests.
4. ZHP-r is the impedance presented to the POTS connection by and ATU-R. ZHP-r is defined in previous tests

Procedure: If results cannot be printed, a table is provided on the next page – all results should be recorded.

- Using the devices listed in the resource requirements section, perform the following measurements:
  - Construct the circuit as shown in the CO splitter test setup diagram (setup 1).
  - Measure the impedance using the multimeter and record the results.
  - Construct the circuit as shown in the Remote POTS splitter test setup diagram (setup 2).
  - Measure the impedance using the multimeter and record the results.

Observable Results:

- For both CO and Remote splitters, the return loss should be no less than what is indicated in the return loss table.

	Zref	Zterm	ERL (dB)	SRL-L (dB)	SRL-H (dB)	Comments
CO splitter	ZNL-c	600 ohm				
CO splitter	ZNL-c	600 ohm				single frequency
RT splitter	ZNL-r	900 ohm+2.16 μF				
RT splitter	ZNL-r	900 ohm+2.16 μF				single frequency

3.7 Test # 3.006

Test Label: longitudinal_balance.voice_band.dmt.adsl

Purpose: To determine if the requirements of ANSI T1.413-1998 for longitudinal balance are met for both the CO and Remote POTS splitters.

References:

- ANSI T1.413-1998 Annex E
- IEEE Standard 455
- A device capable of measuring all required data.

Resource Requirements:

- ATU-R/C unit (UUT) with splitter (internal or external)
- The following devices:
  - CRO or Multimeter (and necessary jumpers/connectors)
  - Function generator (and necessary jumpers/connectors)
  - Decade box (or 600/900Ω ± 1% terminations)
  - The following circuit elements:
    - Two 100Ω ± 1% resistors
    - CO Line Card
    - LB Test Source and Load
    - All necessary wiring tools and connectors

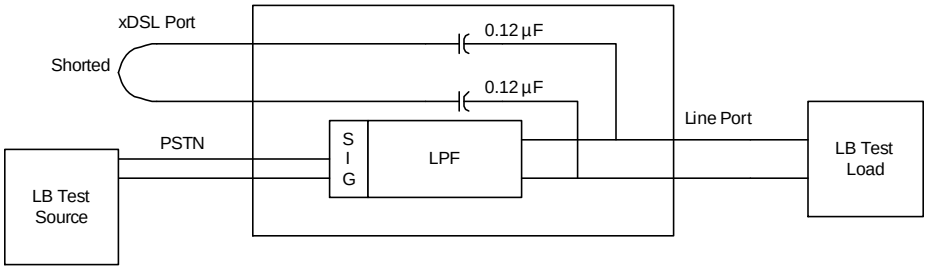
Discussion: There are two different techniques that can be used to measure the longitudinal balance of the POTS splitter. The first technique treats the POTS splitter as a separate unit which requires using the 2 PORT testing technique. The second technique would require treating the POTS splitter, ATU-C, and the CO line card combination as a one port network. This technique is the 1 PORT testing technique. It is an alternative method for measuring the longitudinal balance of the CO POTS splitter.

The longitudinal balance (without loops) of the POTS splitter shall be measured in accordance to IEEE Standard 455. The measurement shall be taken in either direction between the POTS/PSTN and the line port as a two port device. If DC blocking capacitors are included as part of the splitter function on the xDSL port, then the xDSL port shall be shorted. In any other case, however, the xDSL port should be open. Before testing, a test circuit balance (calibration) of 77 dB (58 + 19 dB) will be achieved to insure 1 dB accuracy. The applied longitudinal voltage shall be no more than 3V peak-to-peak due to maintenance signatures. The longitudinal balance shall be no more than 58 dB for frequencies between 0.2 – 1 kHz with a straight-line level decreasing to 53 dB at 3 kHz. There shall be a DC bias current of 25 mA applied to the circuit as well.

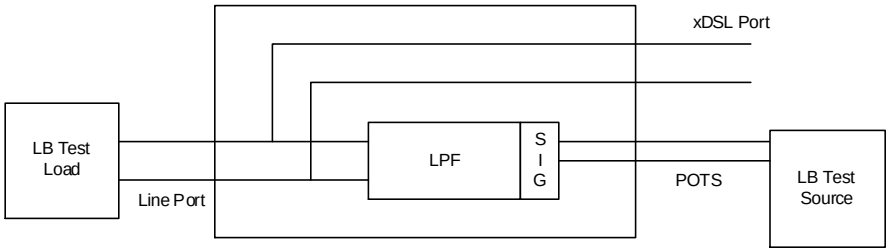
The 1 PORT testing technique shall be used to test the CO splitter when the splitter, ATU-C and the CO line card combination are treated as a one port network. The longitudinal balance of the combined POTS splitter shall be measured in accordance to IEEE standard 455. Again the applied longitudinal balance shall be no more than 3.0 V peak-to-peak. The balance shall be no more than 52 dB for frequencies between 0.2 – 3 kHz. In order to generate a DC bias current of 25 mA, a DC POTS load shall be used. To insure 1 dB accuracy, a test circuit balance of 71 dB (52 + 19 dB) shall be achieved before actual testing begins.

Test Setups: These test setups include both the CO and the Remote end splitters for two port testing, and the CO splitter, ATU-C and CO line card combination for one port testing.

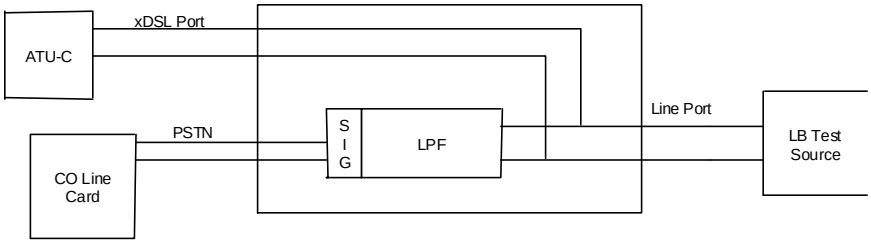
Test Setup 1: Longitudingal Balance CO Test Setup



Test Setup 2 : Longitudinal Balance Remote Test Setup



Test Setup 3: Longitudinal Balance CO Test Setup for 1 Port Networks



Procedure: If results cannot be printed, a table is provided on the next page – all results should be recorded.

- Using the devices listed in the resource requirements section, perform the following measurements:
  - Construct the circuit as shown in the CO splitter test setup diagram (setup 1).
  - All measurements shall be taken in accordance to IEEE Standard 455.
  - Construct the circuit as shown in the Remote POTS splitter test setup diagram (setup 2).
  - All measurements shall be taken in accordance to IEEE Standard 455.
  - Construct the circuit as shown in the CO splitter for one-port networks test setup diagram (setup 3).
  - All measurements shall be taken in accordance to IEEE Standard 455.

Observable Results:

- For 2 PORT testing of the CO and Remote splitters, the balance should be greater than 58 dB for frequencies between 0.2 –1kHz with a strait line level decreasing to 53 dB at 3 kHz.
- For 1 PORT testing of the CO splitter, ATU-C and CO line card combination, the balance should be greater than 52 dB for frequencies between 0.2 – 3 kHz.

	Balance at 0.2 – 1 kHz	Balance strait line level at 3 kHz
CO Splitter		
Remote Splitter		
	Balance .02 – 3 kHz	
CO Splitter, CO Line Card and ATU-C Combo (1 PORT Testing)		

3.8 Test # 3.007

Test Label: transparent_testing_cap.voice_band.dmt.adsl

Purpose: To determine if the requirements of ANSI T1.413-1998 for transparent testing capacitance are met for both the CO and Remote POTS splitters.

References:

- ANSI T1.413-1998 Annex E
- Reference manuals related to or for the testing equipment in use.

Resource Requirements:

- ATU-R/C unit (UUT) with splitter (internal or external)
- The following devices:
  - CRO or Multimeter (and necessary jumpers/connectors)
  - Function generator (and necessary jumpers/connectors)
  - Decade box (or 600/900Ω ± 1% terminations)
  - The following circuit elements:
    - Two 100Ω ± 1% resistors
    - All necessary wiring tools and connectors

Discussion: An input impedance is defined for a special, narrow frequency band. This is to allow the current metallic test systems to continue to test with current test capabilities. A limit on the maximum capacitance seen by the metallic line testing system is set. This is so that the metallic test systems can still test POTS services with the same accuracy and dependability as they do at the present time.

In the frequency range 20 – 30 Hz, the capacitance present at either the POTS or PSTN interface shall be at a maximum of 250 nF. Included in this amount is the capacitance of the two POTS splitters with attached modems. These are specified as tip to ring capacitance. The overall admittance of the POTS or PSTN port shall be capacitive.

The following maximums and minimums shall be met for tip to ring capacitance:

POTS splitter, either CO or Remote, without the modem connected:

- 90 nF Max
- 20 nF Min

Modem input allowance, including the DC blocking capacitors at the CO end:

- 35 nF Max
- 20 nF Min

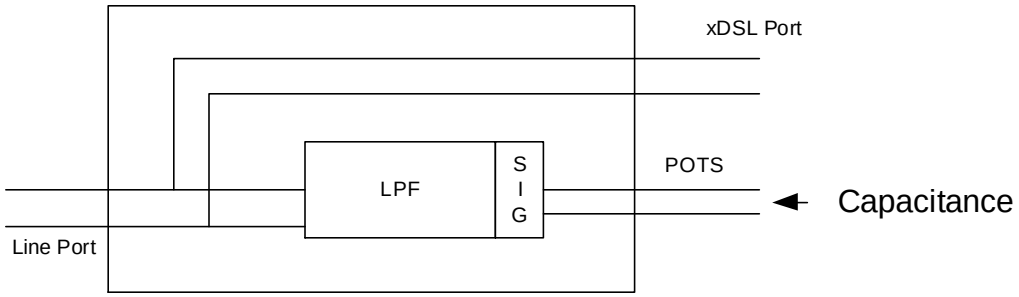
Modem with integral POTS splitter function or external POTS splitter with both HPF and LPF functions, are the sum of the above:

- 125 nF Max
- 40 nF Min

When measuring the capacitance to ground, there should be no designed AC path to ground. For the sake of accurate testing, the maximum stray capacitance to ground from either leg of the POTS Splitter shall be less than 1.0 nF.

Test Setups: This test setup is a general test diagram for either POTS splitter.

Test Setup : Capacitance Test



Procedure: If results cannot be printed, a table is provided on the next page – all results should be recorded.

- Using the devices listed in the resource requirements section, perform the following measurements:
  - Construct the circuit as described in the test setup diagram.
  - Measure the capacitance looking into the POTS interface of the POTS splitter.

Observable Results:

- From the frequency range 20 – 30 Hz, the capacitance looking into the POTS interface should be 250 nF.
- The following maximums and minimums should be met:

POTS splitter, either CO or Remote, without the modem connected:

- 90 nF Max
- 20 nF Min

Modem input allowance, including the DC blocking capacitors at the CO end:

- 35 nF Max
- 20 nF Min

Modem with integral POTS splitter function or external POTS splitter with both HPF and LPF functions, are the sum of the above:

- 125 nF Max
- 40 nF Min

- For the maximum stray capacitance to ground from either leg of the POTS splitter should be less than 1.0 nF.

	Measured Capacitance	Min./Max. Capacitance (nF)
CO Splitter w/o modem		20/90
Input allowance w/ DC blocking capacitors at CO end		20/35
Modem with integral POTS splitter function, or POTS splitter with both HPF and LPF functions		40/125
Stay Capacitance to ground		Max cap. should be < 1

3.9 Test # 3.008

Test Label: adsl_band_attenuation.adsl_band.dmt.adsl

Purpose: To measure the ADSL band attenuation of both the central office and remote splitters, and to determine if the results are acceptable according to ANSI T1.413-1998.

References:

- ANSI T1.413-1998 Annex E.

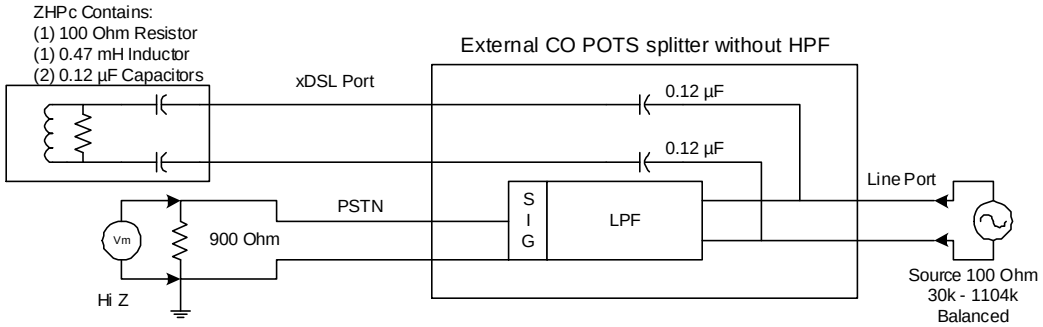
Resource Requirements:

- ATU-R/C unit (UUT) with splitter (internal or external)
- The following devices:
  - CRO or Multimeter (and necessary jumpers/connectors)
  - Function generator (and necessary jumpers/connectors)
  - One or two Decade box(es) (or 600/900Ω ± 1% terminations)
  - The following circuit elements:
    - Four 0.12µF ± 2.5% capacitors
    - Two 0.10µF ± 2.5% capacitors (for ZHP remote end only)
    - Two 0.47mH ± 5% inductors
    - Two 100Ω ± 1% resistors
    - All necessary wiring tools and connectors

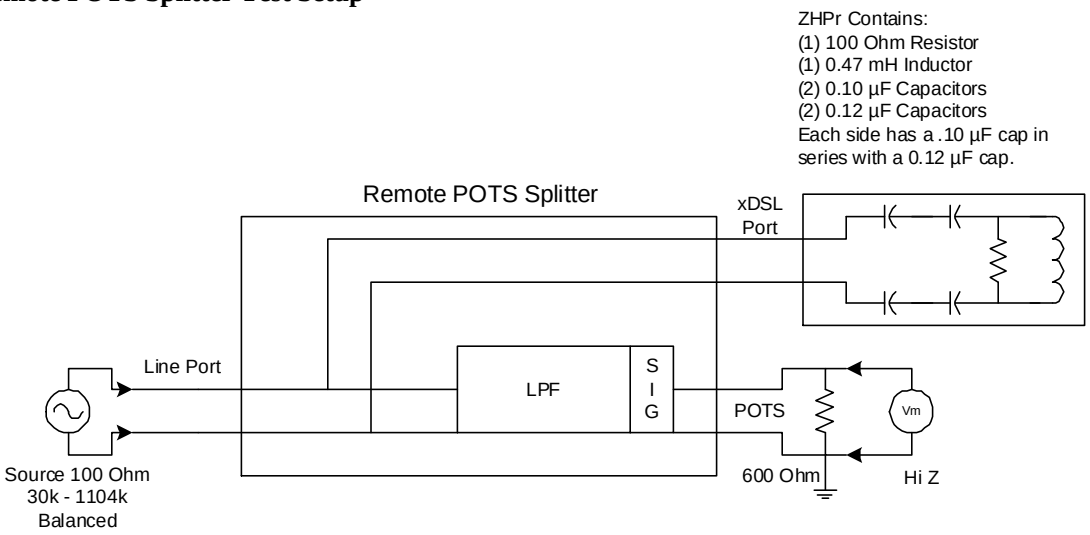
Discussion: The insertion loss of the low-pass filter and ZHP is the difference in attenuation measured with and without the filter. This insertion loss will be greater than 65 dB from 30k to 300 kHz and 55 dB from 300 to 1104 kHz with an input level of 10 dBm.

Test Setups: These test setups include both the CO and the Remote end splitters and are show in the following diagrams.

CO POTS Splitter Test Setup



Remote POTS Splitter Test Setup



Procedure: If results cannot be printed, a table is provided on the next page – all results should be recorded.

- Using the devices listed in the resource requirements section, perform the following measurements:
  - Construct the circuit as shown in the CO POTS splitter test setup diagram.
  - Transmit frequency-varying signal (from 30kHz to 300kHz) of known magnitude from through the line port interface.
  - Measure the received signal using the multimeter and record the results.
  - Transmit frequency-varying signal (from 300kHz to 1104kHz) of known magnitude from through the line port interface.
  - Measure the received signal using the multimeter and record the results.
  - Convert measurements into decibels.
  - Construct the circuit as shown in the Remote POTS splitter test setup diagram.
  - Repeat the above procedure.

Observable Results:

- For both CO and Remote splitters, the insertion loss of the low-pass filter should be greater than 65 dB from 30kHz to 300kHz.
- For both CO and Remote splitters, the insertion loss of the low-pass filter should be 55 dB from 300kHz to 1104kHz.

3.9.1.1.1 CO Splitter insertion loss			
Frequency Range	Vin	Vm	Decibels
30 kHz – 300 kHz			
300 kHz – 1104 kHz			
REMOTE SPLITTER INSERTION LOSS			
Frequency Range	Vin	Vm	Decibels
30 kHz – 300 kHz			
300 kHz – 1104 kHz			

3.10 Test # 3.009

Test Label: input_impedance.adsl_band.dmt.adsl

Purpose: To measure the input impedance (*i.e.,* the loading of ADSL signal path) of both the central office end and remote end splitters, and to determine if the results are acceptable according to ANSI T1.413-1998.

References:

- ANSI T1.413-1998 Annex E.

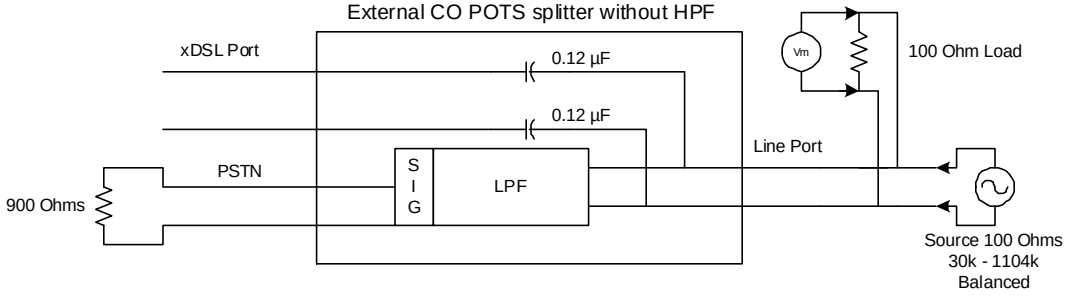
Resource Requirements:

- ATU-R/C unit (UUT) with splitter (internal or external)
- The following devices:
  - CRO or Multimeter (and necessary jumpers/connectors)
  - Function generator (and necessary jumpers/connectors)
  - Decade box (or 600/900Ω ± 1% terminations)
  - The following circuit elements:
    - Two 100Ω ± 1% resistors
    - All necessary wiring tools and connectors

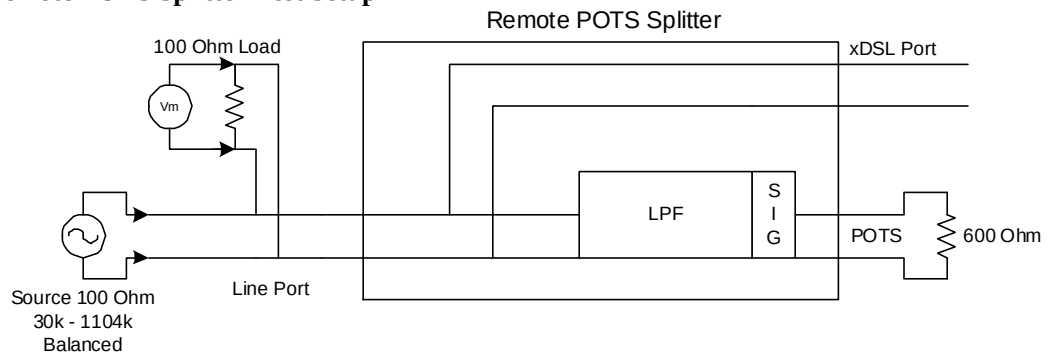
Discussion: The insertion loss caused by the low-pass filter in the band from 30 to 1140 kHz between nominal impedances with an input level of –10 dB and shall be no more than 0.25 dB.

Test Setups: These test setups include both the CO and the Remote end splitters and are show in the following diagrams.

CO POTS Splitter Test Setup



Remote POTS Splitter Test Setup



Procedure: If results cannot be printed, a table is provided on the next page – all results should be recorded.

- Using the devices listed in the resource requirements section, perform the following measurements:
  - Construct the circuit as shown in the CO POTS splitter test setup diagram.
  - Transmit frequency-varying signal (from 30kHz to 1104kHz) of known magnitude through the line port interface.
  - Measure the received signal using the multimeter and record the results.
  - Convert measurements into decibels.
  - Construct the circuit as shown in the Remote POTS splitter test setup diagram.
  - Repeat the above procedure.

Observable Results:

- For both CO and Remote splitters, the input impedance of the low-pass filter should be no more than 0.25 dB from 30kHz to 1104kHz, where the input level is –10 dB.

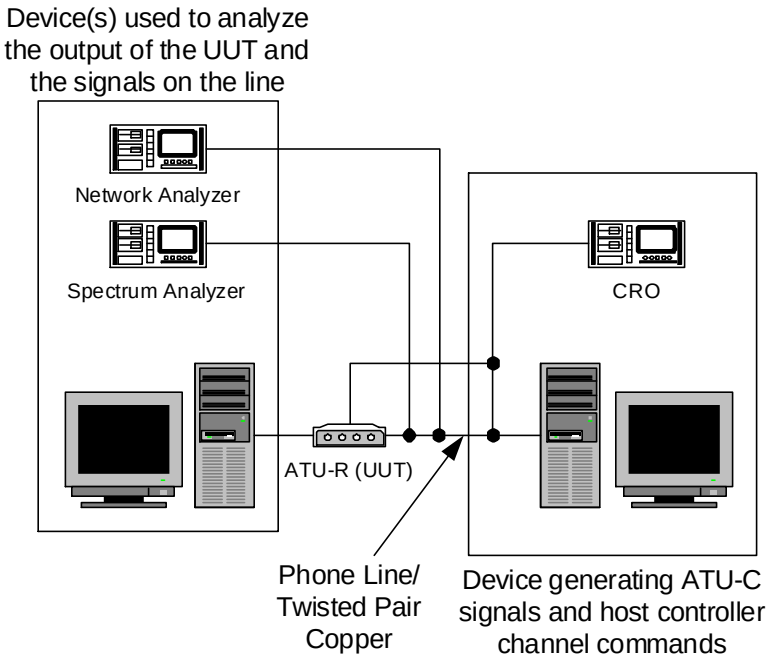
CO SPLITTER INPUT IMPEDANCE			
Frequency Range	Vin	Vm	Decibels
30 kHz – 1104 kHz			
REMOTE SPLITTER INPUT IMPEDANCE			
Frequency Range	Vin	Vm	Decibels
30 kHz – 1104 kHz			

4. Initialization Tests based on ANSI T1.413-1998

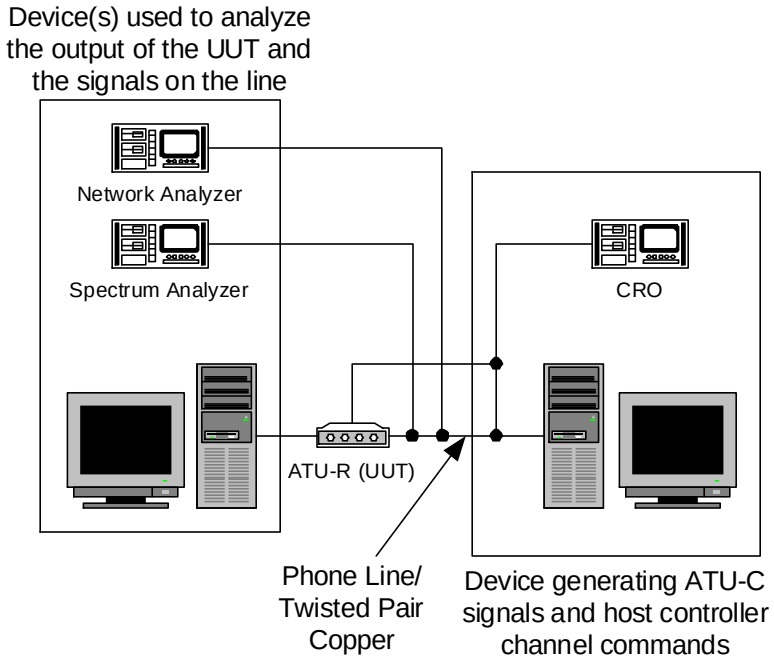
4.1 Test Setups

The following test setups are utilized in this test document:

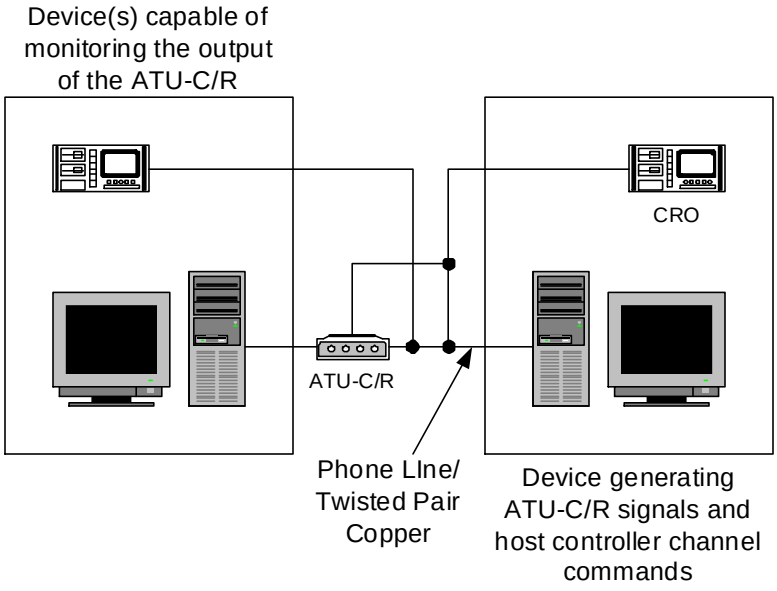
4.1.1 Test Setup 1



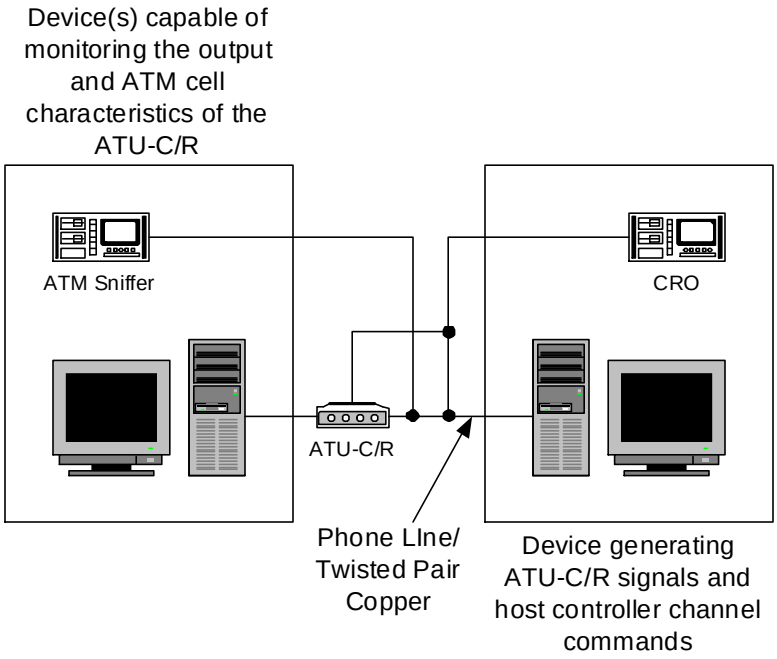
4.1.2 Test Setup 2



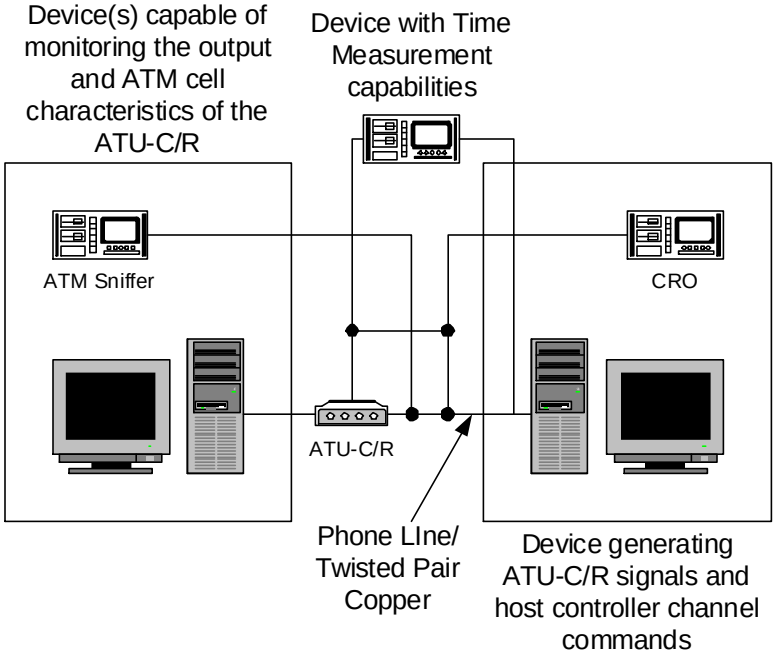
4.1.3 Test Setup 3



4.1.4 Test Setup 4



4.1.5 Test Setup 5

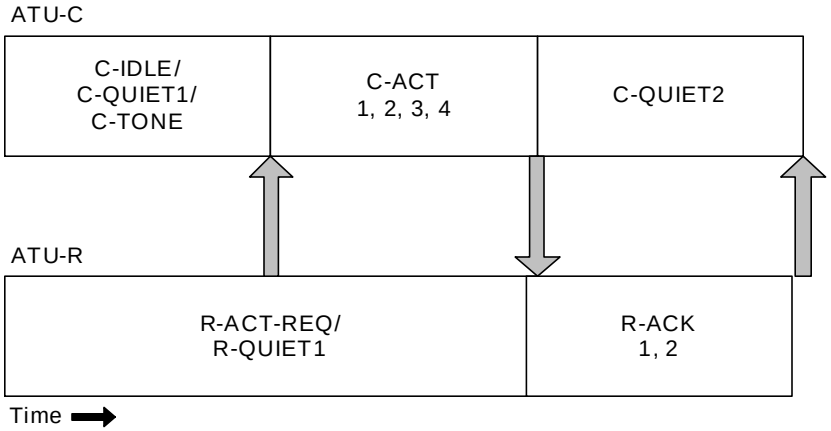


4.2 ATU-R Initialization Tests

4.2.1 Activation and Acknowledgement

Scope: The following tests cover the transition between states in the Activation and Acknowledgement section of the ADSL DMT ATU-R initialization sequence.

Overview: These tests are designed to verify the various state transitions and actions required during the Activation and Acknowledgement section of the ADSL DMT ATU-R initialization sequence. Following successful completion of the Activation and Acknowledgement section, Transceiver Training begins. The Activation and Acknowledgement state transitions, for both the ATU-R and the ATU-C, are shown below.



NOTE: A state is defined throughout this document as a period of time in which a certain signal is transmitted. Only one signal is transmitted during any given state. The duration of any particular state and corresponding signal are always equal.

4.2.1.1 Test # 4.001

Test Label: r_act_req.activiation.atu_r.dmt.adsl

Purpose: To verify that the ATU-R transmits the R-ACT-REQ signal.

References: ANSI T1.413-1998 section 9.3.1.

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state ATU-R
- Device capable of capturing and viewing the output of the ATU-R

Discussion: The ATU-R should transmit the R-ACT-REQ signal indefinitely while in the R-ACT-REQ state. The transmit cycle consists of 128 symbol periods of the R-ACT-REQ signal followed by 896 symbols of silence. The ATU-R shall continue this cycle until either the C-ACT signal or the C-TONE signal is detected from the ATU-C.

The R-ACT-REQ signal is defined as a single frequency sinusoid at 34.5kHz. The amplitude of the R-ACT-REQ signal is such that the transmit power level is –1.65dB for the first 64 symbols, 20dB lower for the second 64 symbols, and 0 for the remaining 896 symbols (R-ACT-REQ resembles a burst).

The R-QUIET1 state follows R-ACT-REQ if the ATU-R detects C-TONE signal from the ATU-C. Alternatively, the R-ACK state follows R-ACT-REQ if the ATU-R detects C-ACT signal.

Test Setup: Test setup 1.

Procedure:

- ATU-R should enter R-ACT-REQ state immediately following power-up and an optional selftest.
- Observe the R-ACT-REQ signal from the ATU-R.

Observable Results:

- The R-ACT-REQ signal should cycle between 128 symbol periods of signal and 896 symbol periods of silence. The signal should be at a frequency of 34.5kHz, with an amplitude as specified above.

4.2.1.2 Test # 4.002

Test Label: r_ack.activation.atu_r.dmt.adsl

Purpose: To verify that the ATU-R enters the R-ACK state from the R-ACT-REQ state, upon successful detection of the C-ACT signal transmitted by the ATU-C.

References: ANSI T1.413-1998 section 9.3.3.

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R

Discussion: The ATU-R should enter the R-ACK state (ATU-R acknowledge state) from the R-ACT-REQ state upon successful detection of a C-ACTIVATE signal from the ATU-C. Three acknowledge signals are specified: R-ACK1, R-ACK2, and R-ACK3. The table below defines R-ACK1 and R-ACK2, while R-ACK3 is left for further study.

	4.2.1.2.1 With C-ACT1 or C-ACT3 (Loop timing at the ATU-C)		**4.2.1.2.2 With C-ACT2 or C-ACT4 (Loop timing at the ATU-R)**	
	R-ACK1	R-ACK2	R-ACK1	R-ACK2
C-QUIET3	Quiet	Pilot	Pilot* Quiet*	Pilot
C-QUIET4	Quiet	Pilot	Pilot	Pilot
C-QUIET5	Quiet	Pilot	Quiet	Pilot

R-ACK1, R-ACK2, and R-ACK3 are single frequency sinusoids at 43.125kHz, 51.75kHz, and 60.375kHz, respectively. The amplitude of any of the R-ACK signal shall be such that the transmitted power is –1.65dBm for the first 64 symbols and 20dB lower for the second 64 symbols. The total duration of any R-ACK signal is 128 symbol periods. The R-QUIET2 state immediately follows R-ACK.

*If R-ACK1 is transmitted and loop timing is to be performed at the ATU-R, state C-QUIET3 is split into two sub-states (C-QUIET3A, C-PILOT1A).

NOTE: C-ACTIVATE is generic term for any one of the four defined C-ACT signals (C-ACT1, 2, 3, or 4).
NOTE: Following the R-ACK state, activation and acknowledgement is complete and transceiver training begins.

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-R (the ATU-R should enter the R-ACT-REQ state).
- Send a C-ACTIVATE signal to the ATU-R (see ATU-C initialization for more details on the C-ACTIVATE signal).
- Observe the output of the ATU-R after sending the C-ACTIVATE signal.

Observable Results:

- The ATU-R should enter the R-ACK state.
- The R-ACK signal should be a sinusoid with frequency and amplitude as specified above.
- The duration of the R-ACK signal should be 128 symbol periods.

4.2.1.3 Test # 4.003

Test Label: r_quiet1.activation.atu_r.dmt.adsl

Purpose: To verify that the ATU-R enters the R-QUIET1 state from the R-ACT-REQ state upon successful detection of the C-TONE signal from the ATU-C.

References: ANSI T1.413-1998 section 9.3.2.

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R

Discussion: The ATU-R should enter the R-QUIET1 state upon successful detection of the C-TONE signal. The duration of the R-QUIET1 state shall be no greater than 240,000 symbol periods (approximately 60 seconds) or until the C-ACT signal is received from the ATU-C. If a C-ACTIVATE signal is not detected, the ATU-R shall remain in the R-QUIET1 state for the duration of the 60-second timeout and return to the R-ACT-REQ state. If a C-ACTIVATE signal is detected the ATU-R shall immediately enter the R-ACK state.

NOTE: QUIET and IDLE states/signals are defined throughout this document as having 0 volts output from a transceiver digital to analog converter (DAC).

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-R.
- Send C-TONE to the ATU-R unit to force the R-QUIET1 state.
- Allow the R-QUIET1 state to timeout.
- Return to the R-QUIET1 state with a C-TONE signal.
- Send a C-ACTIVATE signal to the ATU-R.

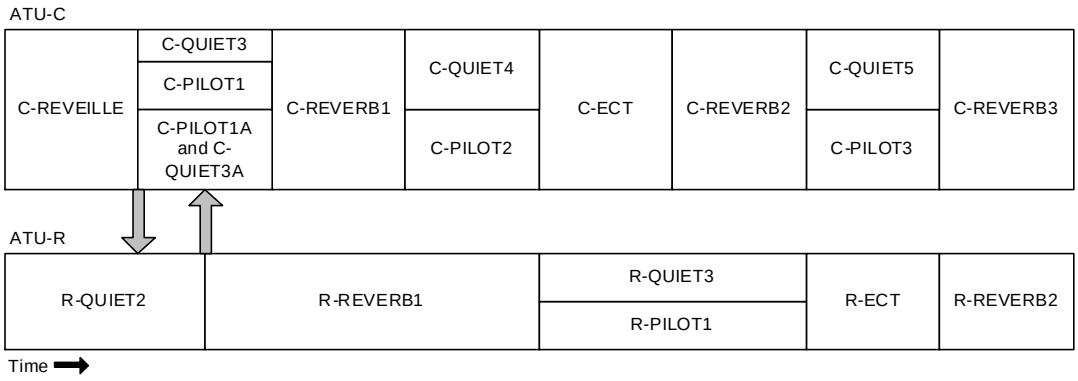
Observable Results:

- ATU-R should re-enter R-ACT-REQ state after the 60 second timeout.
- ATU-R should enter R-ACK immediately following detection of the C-ACTIVATE signal.

4.2.2 Transceiver Training

Scope: The following tests cover the transition between states in the Transceiver Training section of the ADSL DMT ATU-R initialization sequence.

Overview: These tests are designed to verify the various state transitions and actions required during the Transceiver Training section of the ADSL DMT ATU-R initialization sequence. Beginning with the transmission of the R-REVERB1 signal, the ATU-C and ATU-R states are synchronized. Following successful completion of the Transceiver Training section, Channel Analysis begins. The Transceiver Training state transitions are shown below.



4.2.2.1 Test # 4.004

Test Label: r_quiet2.transceiver_training.atu_r.dmt.adsl

Purpose: To verify that the ATU-R properly transitions from the R-ACK state to the R-QUIET2 state to the R-REVERB1 state.

References: ANSI T1.413-1998 section 9.5.1.

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R

Discussion: Immediately following transmission of the R-ACK signal the ATU-R should enter the R-QUIET2 state. The ATU-R should enter the R-REVERB1 state from R-QUIET2 if it has received all of C-REVEILLE signal, and any part of C-QUIET3, C-PILOT1, or C-PILOT1A\C-QUIET3A signal needed for dependable detection. One of these three signals shall be transmitted by every ATU-C. The signal is dependent upon the ATU-C itself and the loop timing characteristics.

The ATU-R should reset to the R-ACT-REQ state if any of the above requirements are not met within a maximum of 4000 symbol periods.

Issue 1 ATU-C implementations permit a maximum R-QUIET2 signal duration of 256 symbol periods. To ensure there are no backward compatibility problems, Issue 2 modems that extend the duration of the R-QUIET2 signal beyond 256 symbol periods shall be capable of detecting a timeout from an Issue 1 ATU-C, and should consequently reset to the R-ACT-REQ state and ensure that the next R-QUIET2 signal is less than 256 symbol periods. The R-QUIET2 delay allows the ATU-R to synchronize its time base.

ATU-R's that extend the duration of the R-QUIET2 signal to greater than 1024 symbol periods indicate that they will perform pilot acquisition before transmitting the R-REVERB1 signal. ATU-R's that restrict the duration of the R-QUIET2 signal to less than 256 symbol periods indicate that they will not perform pilot acquisition before transmitting the R-REVERB1 signal.

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-R, continuing initialization.
- While the ATU-R is in the R-QUIET2 state, send the C-REVEILLE signal, followed by either the C-QUIET3, C-PILOT2, or C-PILOT2A\C-QUIET3A signal.
- Reset the ATU-T, returning to the R-QUIET2 state.
- Allow the ATU-R to timeout (while in the R-QUIET2 state).

Observable Results:

- The ATU-R should enter the R-QUIET2 state immediately following R-ACK.
- The ATU-R should enter the R-REVERB1 state when the C-REVEILLE signal and any part of the corresponding C-QUIET3, C-PILOT2, or C-PILOT1A\C-QUIET3A signal that is necessary for detection has been received.
- The ATU-R should return to the R-ACK-REQ state upon the 4000 symbol period timeout of the R-QUIET2 state.
- Duration past 256 symbol periods may cause problems in Issue 1 modems.

Possible Problems:

- Problems may arise with Issue 1 components. Issue 1 components provide for a maximum R-QUIET2 signal duration of 256 symbol periods, whereas Issue 2 components allow an extension of the R-QUIET2 signal up to 4000 symbol periods.

4.2.2.2 Test # 4.005

Test Label: r_reverb1.transceiver_training.atu_r.dmt.adsl

Purpose: To verify proper operation of the ATU-R during the R-REVERB1 state.

References: ANSI T1.413-1998 section 9.5.2.

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R

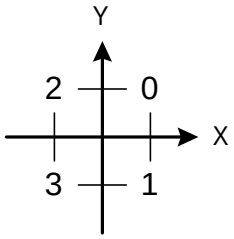
Discussion: The R-REVERB1 signal is a 64 bit pseudo random sequence used to allow the ATU-R to measure the upstream wideband power in order to adjust the ATU-C's transmit power level, properly adjust the receiver gain, synchronize its receiver, and train its equalizer. The pseudo random sequence is generated using the following relations:

$$dn = 1, \text{ for } n = 1 \text{ to } 6$$

$$dn = dn\text{-}5 \oplus dn\text{-}6, \text{ for } n = 7 \text{ to } 64$$

The first two bits of dn represent the DC and Nyquist subcarriers and therefore have 0 power associated with them. Each of the following pairs of bits are used to define the Xi and Yi, for i = 1 to 32, with the index of i (where i starts) being vendor discretionary, of a 4-QAM constellation point, as shown in the table below. See ANSI T1.413-1998 section 9.5.2, for details.

dn, dn+1	Decimal label	Xi, Yi
0, 0	0	+, +
0, 1	1	+, -
1, 0	2	-, +
1, 1	3	-, -



The R-REVERB1 signal has a transmit power spectral density (PSD) of -38dBm/Hz. The R-REVERB1 signal is transmitted for 4096 symbol periods. The first 512 symbols coincide with the C-QUIET3 or C-PILOT1 signal in time, the second 512 symbols coincide with C-REVERB1, and the remaining 3072 symbols coincide with C-QUIET4 or C-PILOT2. If the C-ACT1 or C-ACT2 signal was previously detected, the ATU-R should enter the R-QUIET3 state immediately following R-REVERB1. If the C-ACT3 or C-ACT4 signal was previously detected, the ATU-R can enter either the R-QUIET3 or R-PILOT1 state immediately following R-REVERB1 (subject to vendor discretion).

Test Setup: Test setup 1.

Procedure:

- Send C-ACT1 to the ATU-R to force the R-ACK state.

Observable Results:

- Immediately following the R-QUIET2 state, the ATU-R should enter the R-REVERB1 state.
- The duration of the R-REVERB1 state should be 4096 symbol periods.
- The nominal transmit power of the used band during the R-REVERB1 state should be 38dBm/Hz.

4.2.2.3 Test # 4.006

Test Label: r_quiet3_from_c_act1_2.transceiver_training.atu_r.dmt.adsl

Purpose: To verify proper transition from the R-REVERB1 state to the R-QUIET3 state upon reception of either the C-ACT1 or C-ACT2 signal.

References: ANSI T1.413-1998 sections 9.5.2 and 9.5.3.

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R

Discussion: Following the R-REVERB1 state, the ATU-R should immediately enter the R-QUIET3 state if C-ACT1 or C-ACT2 was previously detected.

The R-QUIET3 signal is transmitted for 2048 symbols. The first 512 symbols coincide with the C-ECT signal in time, and the remaining 1536 symbols coincide with the C-REVERB2 signal in time. The final symbol may be shortened by any number of samples that is an integer multiple of four in order to accommodate transmitter to receiver frame alignment. The R-ECT state immediately follows R-QUIET3.

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-R to the R-ACT-REQ state.
- Continue ATU-R initialization, sending the C-ACT1 signal.
- Reset the ATU-R to the R-ACT-REQ state.
- Continue ATU-R initialization, sending the C-ACT2 signal.

Observable Results:

- If the C-ACT1 or C-ACT2 signals are properly detected, the ATU-R should enter the R-QUIET3 state for a duration of 2048 symbol periods immediately following R-REVERB1.

4.2.2.4 Test # 4.007

Test Label: r_pilot1.transceiver_training.atu_r.dmt.adsl

Purpose: To verify proper transition from the R-REVERB1 state to the R-PILOT1 state upon reception of either the C-ACT3 or C-ACT4 signal.

References: ANSI T1.413-1998 section 9.5.2 and 9.5.4.

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R

Discussion: Following the R-REVERB1 state, the ATU-R should immediately enter the R-PILOT1 state if either C-ACT3 or C-ACT4 was detected previously.

R-PILOT1 is a single frequency sinusoid at 69kHz, with a duration of 2048 symbols. The first 512 symbols coincide with the C-ECT signal in time, and the remaining 1536 symbols coincide with the C-REVERB2 signal in time. The final symbol may be shortened by any number of samples that is an integer multiple of four in order to accommodate transmitter to receiver frame alignment. The R-ECT state immediately follows R-PILOT1.

NOTE: The ATU-R may only enter the R-PILOT1 state if C-ACT3 or C-ACT4 was previously detected. The ATU-R does, however, have the option of entering the R-QUIET3 state instead of the R-PILOT1 state at the vendor's discretion.

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-R to the R-ACT-REQ state.
- Continue ATU-R initialization, sending the C-ACT3 signal.
- Reset the ATU-R to the R-ACT-REQ state.
- Continue ATU-R initialization, sending the C-ACT4 signal.

Observable Results:

- If the C-ACT3 or C-ACT4 signals are properly detected, the ATU-R should enter the R-PILOT1 state for a duration of 2048 symbols immediately following R-REVERB1, if defined by the vendor to do so.

4.2.2.5 Test # 4.008

Test Label: r_ect.transceiver_training.atu_r.dmt.adsl

Purpose: To verify that the R-ECT signal does not utilize subcarriers 1-4 (recommended), and if it does that the R-ECT signal is transmitted at a lower power level than that which would normally be used.

References: ANSI T1.413-1998 section 9.5.5.

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R

Discussion: R-ECT is a vendor-defined signal used to train the echo canceller at the ATU-R. The echo canceller is necessary for manufacturers that choose to use echo cancelling, rather than frequency division duplexing, as a means of separating the upstream and downstream signals. It is recommended (not required) that subcarriers 1-4 not be used for this signal due to limitations of the POTS low-pass filter. If these subcarriers are used, then the R-ECT signal should be transmitted at a lower power level than that which would normally be used. ANSI T1.413-1998 does not define what the lower power level is. Although this signal is vendor-defined, it is limited in duration to 512 symbol periods. The R-REVERB2 state immediately follows R-ECT.

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-R to the R-ACT-REQ state.
- Continue sending appropriate signals to force the ATU-R to transition through the initialization sequence to the R-ECT state.
- The ATU-R should use subcarriers other than subcarriers 1-4 (recommended, not required).

Observable Results:

- If subcarriers 1-4 are used, the power levels of the signals should be substantially decreased.
- Following the R-QUIET3 or R-PILOT1 state, the ATU-R should immediately enter the R-ECT state. The duration of the R-ECT signal should be exactly 512 symbols.

4.2.2.6 Test # 4.009

Test Label: r_reverb2.tranceiver_training.atu_r.dmt.adsl

Purpose: To verify proper transition from the R-ECT state to the R-REVERB2 state.

References: ANSI T1.413-1998 section 9.5.6.

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R

Discussion: The R-REVERB2 signal is the same signal as R-REVERB1. The R-REVERB2 signal is used by the ATU-R to perform timing recovery and receiver equalizer training.
The duration of the R-REVERB2 signal should be between 1024 and 1056 symbol periods. The R-SEGUE1 state immediately follows R-REVERB2.

NOTE: Following the R-REVERB2 state, transceiver training will be complete and channel analysis begins.

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-R to the R-ACT-REQ state.
- Continue ATU-R initialization, sending the appropriate signals to force the ATU-R to enter the R-REVERB2 state.

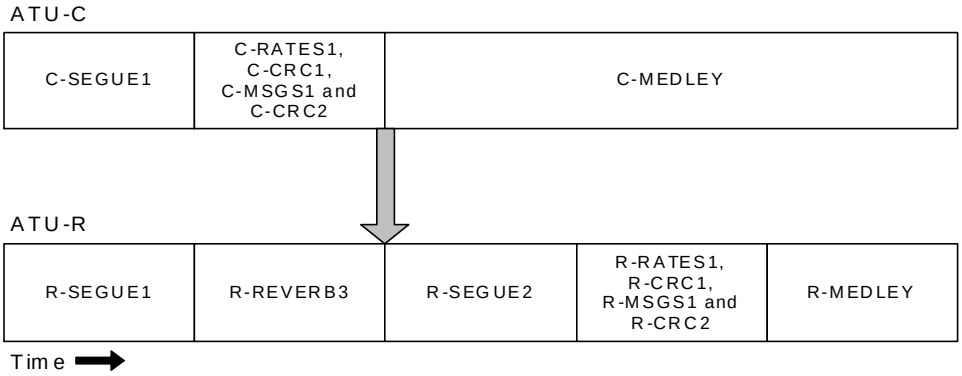
Observable Results:

- Immediately following the R-ECT state, the ATU-R should enter the R-REVERB2 state for a duration of between 1024 and 1056 symbol periods.

4.2.3 Channel Analysis

Scope: The following tests cover the transition between states in the Channel Analysis section of the ADSL DMT ATU-R initialization sequence.

Overview: These tests are designed to verify the various state transitions and actions required during the Channel Analysis section of the ADSL DMT ATU-R initialization sequence. The ATU-R shall reset to the R-ACT-REQ state if a timeout occurs or if a any errors in the received control data are indicated by the C-CRC1 and C-CRC2 checksums. Following successful completion of the Channel Analysis section, Exchange begins. The Channel Analysis state transitions are shown below.



4.2.3.1 Test # 4.010

Test Label: r_segue1.channel_analysis.atu_r.dmt.adsl

Purpose: To verify proper transition from the R-REVERB2 state to the R-SEGUE1 state, and to verify the content of the R-SEGUE1 signal.

References: ANSI T1.413-1998 section 9.7.1.

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R

Discussion: The R-SEGUE1 signal is generated by a tone-by-tone 180-degree phase reversal of the R-REVERB1 signal. The R-SEGUE1 signal is transmitted for 10 symbol periods. The ATU-R should enter the R-REVERB3 state immediately following R-SEGUE1.

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-R to the R-ACT-REQ state.
- Continue ATU-R initialization, sending the appropriate signals to force the ATU-R to enter the R-SEGUE1 state.

Observable Results:

- Immediately following the R-REVERB2 state, the ATU-R should enter the R-SEGUE1 for a duration of 10 symbol periods.

4.2.3.2 Test # 4.011

Test Label: r_reverb3.channel_analysis.atu_r.dmt.adsl

Purpose: To verify that the ATU-R responds properly while in the R-REVERB3 state.

References: ANSI T1.413-1998 section 9.7.2 and 9.7.3.

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R

Discussion: While in the R-REVERB3 state, the ATU-R shall wait 4000 symbol periods for the ATU-C to transmit the upstream and downstream rate information, C-RATES1, and a checksum, C-CRC2. If C-RATES1 and C-CRC2 are not detected within 4000 symbol periods, the ATU-R should return to the R-ACT-REQ state. If these signals are detected, the ATU-R is to remain in the R-REVERB3 state for 20 symbol periods before entering the R-SEGUE2 state. The R-REVERB3 signal is similar to the R-REVERB1 signal and is the first ATU-R signal to include a cyclic prefix with every symbol.

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-R to the R-ACT-REQ state.
- Continue ATU-R initialization.
- Allow the R-REVERB3 state to timeout.
- Return to the R-REVERB3 state.
- Send C-CRC2 to the ATU-R.

Observable Results:

- The ATU-R should return to the R-ACT-REQ state after 4000 symbol periods when allowed to timeout.
- ATU-R should go to R-SEQUE2 20 symbol periods after the detection of C-CRC2.

4.2.3.3 Test # 4.012

Test Label: r_segue2.channel_analysis.atu_r.dmt.adsl

Purpose: To verify proper transition from the R-REVERB3 state to the R-SEGUE2 state.

References: ANSI T1.413-1998 section 9.7.3.

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R

Discussion: ATU-R should enter the R-SEGUE2 state from the R-REVERB3 state, after a 20 symbol period delay, if the C-CRC2 signal is detected, and should timeout and reset to the R-ACT-REQ state if C-CRC2 is not detected within 4000 symbol periods. The R-SEGUE2 signal is similar to the R-SEGUE1 signal, except that a cyclic prefix is included with every transmitted symbol. The R-RATES1 state immediately follows R-SEGUE2.

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-R to the R-ACT-REQ state.
- Send appropriate signals to continue ATU-R initialization.
- Send the C-CRC2 signal to the ATU-R.
- Repeat without sending the C-CRC2 signal.

Observable Results:

- The ATU-R should enter the R-SEGUE2 state from the R-REVEB3 state after a delay of 20 symbol periods.
- The ATU-R should timeout and reset if the C-CRC2 signal is not detected within 4000 symbol periods.

4.2.3.4 Test # 4.013

Test Label: r_rates1.channel_analysis.atu_r.dmt.adsl

Purpose: To verify that the ATU-R enters the R-RATES1 state immediately following R-SEGUE2, and to verify proper transmission of the R-RATES1 signal.

References: ANSI T1.413-1998 section 9.7.4.

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R

Discussion: The R-RATES1 signal is used to transmit four upstream data rate options to the ATU-C. The ATU-C controls the communication link, therefore the relevant data fields in the R-RATES1 signal should match those of the C-RATES1 signal. The four options and their respective data fields are shown in the table below.

		Option 1			Option 2			Option 3			Option 4		
	Pre-fix	Bf	Bi	RRSD	Bf	Bi	RRSDI	Bf	Bi	RRSDI	Bf	Bi	RRSD
# of bytes	4	3	3	5	3	3	5	3	3	5	3	3	5

Each byte of the Bf field specifies the number of bytes in the fast buffer in a particular upstream sub-channel, *i.e.*, LS0, LS1, and LS2. The Bi field represents the same quantities for the interleaved buffer. The RRSD field consists of five bytes: the RSf field defines the number of parity bytes per symbol in the upstream fast buffer, RSi field defines the number of parity bytes per symbol in the upstream interleaved buffer, the S field defines the upstream number of symbols per codeword, the D field defines the upstream interleave depth, and the final filed is a byte consisting of eight zeros.

All fields are transmitted least significant bit first. The R-RATES1 signal is transmitted 1 bit per symbol, therefore the total duration of the R-RATES1 signal is 384 symbol periods (because there are 384 total bits in the R-RATES1 signal). The ATU-R shall enter the R-CRC1 state immediately following R-RATES1.

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-R to the R-ACT_REQ state.
- Send the appropriate signals to continue ATU-R initialization.

Observable Results:

- The ATU-R should enter the R-RATES1 state immediately following the R-SEGUE2 state.
- The information contained in the R-RATES1 data field should be transmitted least significant bit first, should be encoded, and should include a cyclic prefix.
- The data in the R-RATES1 field should correspond to the data transmitted by the ATU-C in the C-RATES1 field.
- The duration of the R-RATES1 signal should be 384 symbol periods (because there are a total of 384 bits).

4.2.3.5 Test # 4.014

Test Label: r_crc1.channel_analysis.atu_r.dmt.adsl

Purpose: To verify that the ATU-R enters the R-CRC1 state immediately following R-RATES1.

References: ANSI T1.413-1998 section 9.7.5.

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R
- Device capable of computing logical values of logical functions

Discussion: The R-CRC1 signal is 16 bit cyclic redundancy code used for detection of errors in the reception of R-RATES1 at the ATU-C. R-CRC1 is generated in the following manner:

$$c(D) = a(D)D^{16} \text{ modulo } g(D),$$

where $a(D) = a0D^{348} + a1D^{347} + ...$, is the 348 bits of the R-RATES1 message

and $g(d) = D^{16} + D^{12} + D^5 + 1$ is the CRC generator polynomial

and $c(D) = c0D^{15} + c1D^{14} + c14D + c15$ is the CRC check polynomial

R-CRC1 is coded using the same method as R-RATES1 and uses the same CRC and generator polynomials as C-CRC1. The duration of R-CRC1 is 16 symbol periods. The ATU-R shall enter the R-MSGS1 state immediately following R-CRC1.

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-R to the R-ACT-REQ state.
- Send the appropriate signals to continue ATU-R initialization.

Observable Results:

- The ATU-R should enter R-CRC1 immediately following R-RATES1.
- The duration of the R-CRC1 signal should be 16 symbol periods and should correspond to the bit pattern generated using the formulas above.

4.2.3.6 Test # 4.015

Test Label: r_msgs1.channel_analysis.atu_r.dmt.adsl

Purpose: To verify that the ATU-R enters the R-MSGS1 state immediately following R-CRC1, and to verify the fields of the R-MSGS1 signal.

References: ANSI T1.413-1998 section 9.7.6.

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R

Discussion: The R-MSGS1 signal is a 48 bit message, m = {m47, m46, ... m1, m0}, containing initialization information. The least significant bit, m0, is transmitted first. The R-MSGS1 signal is defined by the table below.

Suffix(ces) of mi	Parameter
47-44	Reserved for future use
43-28	Vendor Identification
27,26	Reserved for future use
25-23	T1.413-1998 revision number
22-18	Vendor revision number
17	Trellis coding option
16	Echo cancelling option
15	Expanded Exchange Sequence
14	Support of higher bit rates
13	Support of dual latency, downstream
12	Support of dual latency, upstream
11	Network Timing Reference
10-9	Framing mode
8-4	Reserved for future use
3-0	Maximum number of bits per sub-carrier supported

NOTES:

1. All bits “reserved for future use” shall be set to 0.
2. Within the separate fields the lowest subscripts shall be the least significant bits.
3. Bits 25-18 shall be copied to the Revision Number eoc register.

For more information on the fields of the R-MSGS1 signal, see ANSI T1.413-1998 section 9.7.6. The R-MSGS1 signal shall be encoded using the same method as used in R-RATES1. The ATU-R shall enter the R-CRC2 state immediately following R-MSGS1.

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-R to the R-ACT-REQ state.
- Send the appropriate signals to continue ATU-R initialization.

Observable Results:

- The ATU-R should enter the R-MSGS1 state immediately following the R-CRC1 state.
- The information in the R-MSGS1 data field should be transmitted least significant bit first (m0), should be encoded, and should include a cyclic prefix.
- The duration of the of the R-MSGS signal should be 48 symbol periods (because there are a total of 48 bits).

4.2.3.7 Test # 4.016

Test Label: r_crc2.channel_analysis.atu_r.dmt.adsl

Purpose: To verify that the ATU-R enters the R-CRC2 state immediately following R-MSGS1.

References: ANSI T1.413-1998 section 9.7.7.

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R
- Device capable of computing logical values of logical functions

Discussion: The R-CRC2 signal is a 16 bit cyclic redundancy code used for detection of errors in the reception of R-MSGS1 at the ATU-C. The R-CRC2 signal is constructed in the same manner as R-CRC1. The duration of R-CRC2 is 16 symbol periods. The ATU-R shall enter the R-MEDLEY state immediately following R-CRC2.

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-R to the R-ACT-REQ state.
- Send the appropriate signals to continue ATU-R initialization.

Observable Results:

- The ATU-R should enter the R-CRC2 state immediately following R-MSGS1.
- The duration R-CRC2 should be 16 symbol periods and should correspond to the bit pattern generated using the formula discussed for R-CRC1.

4.2.3.8 Test # 4.017

Test Label: r_medley.channel_analysis.atu_r.dmt.adsl

Purpose: To verify that the ATU-R enters the R-MEDLEY state immediately following R-CRC2.

References: ANSI T1.413-1998 section 9.7.8.

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R

Discussion: R-MEDLEY is a wideband pseudo random sequence used to estimate the upstream signal-to-noise ratio (SNR) at the ATU-C. The pseudo random sequence is defined in section 9.5.2 of the standard reference. R-MEDLEY is transmitted for 16384 symbol periods. The ATU-R shall enter the R-REVERB4 state immediately following R-MEDLEY.

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-R to the R-ACT-REQ state.
- Send the appropriate signals to continue ATU-R initialization.

Observable Results:

- The ATU-R should enter the R-MEDLEY state immediately following R-CRC2.
- The duration of the R-MEDLEY signal should be 16384 symbol periods.

4.2.3.9 Test # 4.018

Test Label: r_reverb4.channel_analysis.atu_r.dmt.adsl

Purpose: To verify that the ATU-R enters the R-REVERB4 state immediately following R-MEDLEY.

References: ANSI T1.413-1998 section 9.7.9.

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R

Discussion: The R-REVERB4 signal is the same signal as R-REVERB3, with duration 128 symbol periods. The ATU-R shall enter the R-SEGUE3 state immediately following R-REVERB4.

NOTE: Following the R-REVERB4 state, channel analysis will be complete and exchange begins.

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-R to the R-ACT-REQ state.
- Send the appropriate signals to continue ATU-R initialization.

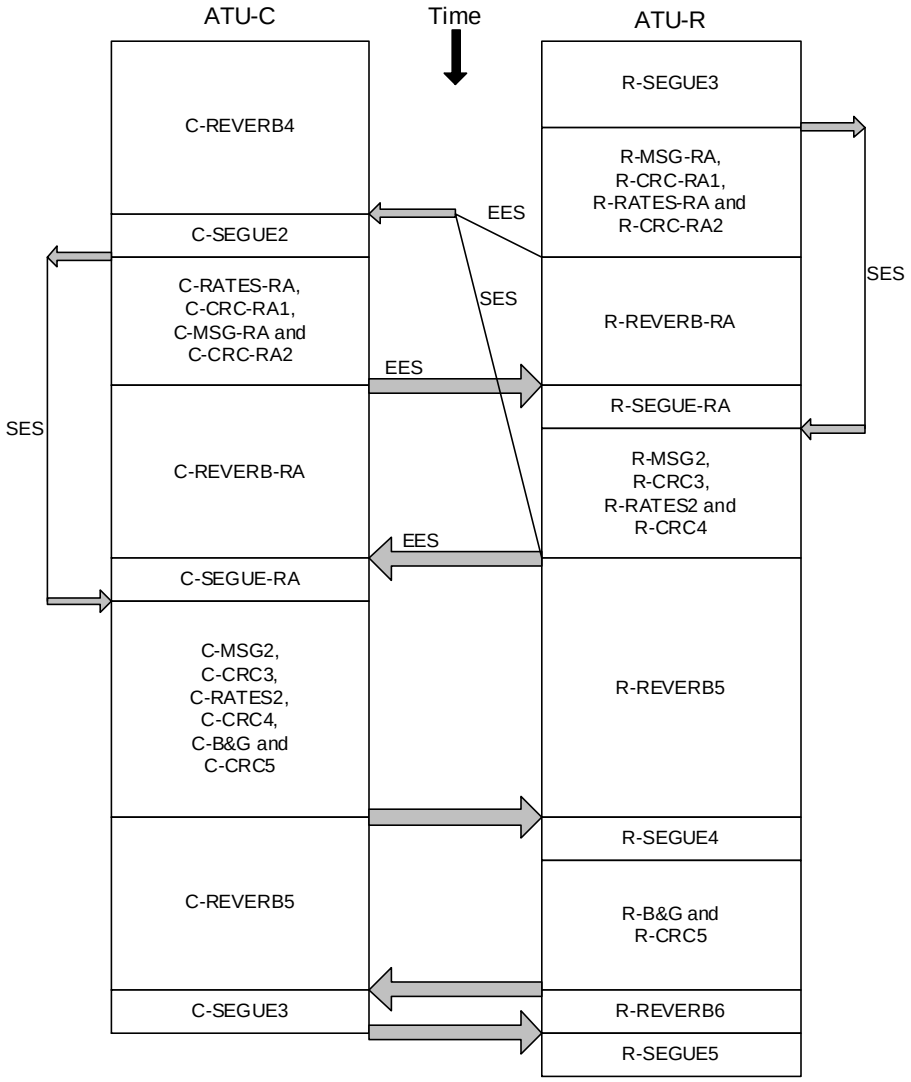
Observable Results:

- The ATU-R should enter the R-REVERB4 state immediately following R-MEDLEY.
- The duration of the R-REVERB4 signal should be 128 symbol periods.

4.2.4 Exchange

Scope: The following tests cover the transition between states in the Exchange section of the ADSL DMT ATU-R initialization sequence.

Overview: These tests are designed to verify the various state transitions and actions required during the Exchange section of the ADSL DMT ATU-R initialization sequence. The ATU-R shall reset to the R-ACT-REQ state if a timeout occurs or if a any errors in the received control data are indicated by the C-CRC1 and C-CRC2 checksums. If the short exchange sequence, SES, is to be used, testing starts with the R-SEGUE3 signal, ADSL Test 4.019, and continues with the R-MSGS2 signal, ADSL Test 4.026. If EES is to be used, testing starts with the R-SEGUE3 signal. ADSL Test 4.019, and continues to the R-MSG-RA state, ADSL Test 4.020. Following successful completion of the Exchange section, the ATU-R is ready for steady state data transmission. The Exchange state transitions are shown below.



4.2.4.1 Test # 4.019

Test Label: r_segue3.exchange.atu_r.dmt.adsl

Purpose: To verify that the ATU-R:

- enters R-SEGUE3 state immediately following R-REVERB4,
- that the R-MSGS-RA state follows the R-SEGUE3 state if the expanded exchange sequence (EES) is being used, and
- that the ATU-R enters the R-MSGS2 state from the R-SEGUE3 state if the EES is not being used.

References: ANSI T1.413-1998 section 9.9.1.

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R

Discussion: If the expanded exchange "rate adaptation" sequence (EES) is to be used, bit 15 of the C-MSGS1 signal is set to 1. The EES is used for rate adaptation or for data rates greater than 8 Mbits/s. If the ATU-C has decided that EES is to be used, then R-MSGS-RA follows R-SEGUE3. Otherwise, if the short exchange sequence (SES) is to be used, R-MSGS2 follows R-SEGUE3.

When the expanded exchange sequence (EES) or Rate Adaptation Sequence (RAS) is to be used, the sequence is as follows:

R-SEGUE3 to R-MSG-RA to R-CRC-RA1 to R-RATES-RA to R-CRC-RA2 to R-REVERB-RA to R-SEGUE-RA to R-MSG2

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-R to the R-ACT-REQ state.
- Continue ATU-R initialization.
- While in R-REVERB3, ATU-R expects a series of signals from the ATU-C, among them is C-MSGS1.
- Set bit 15 of C-MSGS1 to 1 to force EES.
- Allow states to transfer through R-SEGUE3.
- Repeat with bit 15 of C-MSGS1 set to 0 to force SES.

Observable Results:

- If EES is to be used, then R-MSGS-RA should follow R-SEGUE3.
- If SES is to be used, then R-MSGS2 should follow R-SEGUE3.
- The duration of the R-SEGUE3 signal should be 10 symbol periods.

4.2.4.2 Test # 4.020

Test Label: r_msg_ra.ees.exchange.atu_r.dmt.adsl

Purpose: To verify the transmission of the R-MSG-RA signal, following the R-SEGUE3 state, if the expanded exchange sequence is to be used.

References: ANSI T1.413-1998 section 9.9.2.

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R

Discussion: The R-MSG-RA signal is similar to the R-MSG2 signal, except that it is expanded by 48 bits. The bit assignments for the R-MSG-RA signal, which can be modelled as m = {m79, m78, ... m1, m0}, are shown in the table below.

Suffix(ces) of m	Parameter
79-56	Reserved for future use
55-49	Number of RS overhead bytes, (R)
48-40	Number of RS payload bytes, K
39-32	Number of tones carrying data (ncloaded)
31-25	Estimated average loop attenuation
24-21	Coding gain
20-16	Performance margin w/selected rate option
15-14	Reserved for future use
13-12	Maximum interleaving depth
11-0	Total number of bits per DMT symbol, (Bmax)

NOTES: 1. All bits “reserved for future use” shall be set to 0.
2. Within the separate fields the lowest subscripts shall be the least significant bits.

For more information on the fields of the R-MSG-RA signal, see the standard reference, section 9.9.2. The duration of the R-MSG-RA signal should be 10 symbol periods, corresponding to the 10 bytes of data in the R-MGS-RA data field. The ATU-R shall enter the R-CRC-RA1 state immediately following R-MSGS1.

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-R to the R-ACT-REQ state.
- Continue ATU-R initialization, selecting the expanded exchange sequence.

Observable Results:

- The ATU-R should enter the R-MSG-RA state immediately following R-SEGUE3.
- The ATU-R should transmit 80 bits of information coded as shown in the above table. The specifics of each field of the R-MSG-RA signal are described in the standard reference, section 9.9.2.
- The duration of the R-MSG-RA signal should be 10 symbol periods.

4.2.4.3 Test # 4.021

Test Label: r_crc_ra1.ees.exchange.atu_r.dmt.adsl

Purpose: To verify that the ATU-R enters the R-CRC-RA1 state immediately following R-MSG-RA in the expanded exchange sequence.

References: ANSI T1.413-1998 section 9.9.3.

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R
- Device capable of computing logical values of logical functions

Discussion: The R-CRC-RA1 signal is a 16 bit cyclic redundancy check used for detection of errors in the reception of the R-MSG-RA signal at the ATU-C. R-CRC-RA is generated in the same manner as R-CRC1. The R-CRC-RA1 should be coded in the same manner as R-MSG-RA. The duration of the R-CRC-RA1 signal should be 2 symbol periods. The ATU-R shall enter the R-RATES-RA state immediately following R-CRC-RA1.

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-R to the R-ACT-REQ state.
- Continue ATU-R initialization, selecting the expanded exchange sequence.

Observable Results:

- The ATU-R should enter the R-CRC-RA1 state immediately following R-MSG-RA.
- The duration of the R-CRC-RA1 signal should be 2 symbol periods and should correspond to the bit pattern generated using the formula discussed for R-CRC1.

4.2.4.4 Test # 4.022

Test Label: r_rates_ra.ees.exchange.atu_r.dmt.adsl

Purpose: To verify that the ATU-R enters the R-RATES-RA state immediately following R-CRC-RA1 in the expanded exchange sequence.

References: ANSI T1.413-1998 section 9.9.4.

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R

Discussion: The R-RATES-RA signal is a one byte reply to the C-RATES1 signal based on the results of the downstream channel analysis. The R-RATES-RA signal:

- sends back only the option number of the highest data rate that can be supported, based on the measured SNR of the downstream channel
- indicates that no options were selected at this time, but will be made later based on C-RATES-RA information
- indicates that none of the options requested during C-RATES1 can be implemented

The duration of the R-RATES-RA signal should be 1 symbol period. The data fields of the R-RATES-RA signal are shown in the table below. The ATU-R should enter the R-CRC-RA2 state immediately following R-RATES-RA.

Downstream	Bit pattern for R-RATES2 (MSB first)
Option 1	00010001
Option 2	00100010
Option 3	01000100
Option 4	10001000
No option selected	00000001
All options fail	00000000

NOTE: All other bit patterns not shown are reserved for future use.

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-R to the R-ACT-REQ state.
- Continue ATU-R initialization, selecting the expanded exchange sequence.

Observable Results:

- The ATU-R should enter the R-RATES-RA state immediately following R-CRC-RA1.
- The duration of the R-RATES-RA signal should be 1 symbol period.

4.2.4.5 Test # 4.023

Test Label: r_crc_ra2.ees.exchange.atu_r.dmt.adsl

Purpose: To verify that the ATU-R enters the R-CRC-RA2 state immediately following R-RATES-RA in the expanded exchange sequence.

References: ANSI T1.413-1998 section 9.9.5.

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R
- Device capable of computing logical values of logical functions

Discussion: The R-CRC-RA2 signal is a two byte cyclic redundancy code used for detection of errors in the reception of the R-RATES-RA signal at the ATU-C. The R-CRC-RA2 should be coded in the same manner as R-RATES-RA. The duration of the R-CRC-RA2 signal should be 2 symbol periods. The ATU-R shall enter the R-REVERB-RA state immediately following R-CRC-RA2.

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-R to the R-ACT-REQ state.
- Continue ATU-R initialization, selecting the expanded exchange sequence.

Observable Results:

- The ATU-R should enter the R-CRC-RA2 state immediately following R-RATES-RA.
- The duration of the R-CRC-RA2 signal should be 2 symbol periods and should correspond to the bit pattern generated using the formula discussed for R-CRC1.

4.2.4.6 Test # 4.024

Test Label: r_reverb_ra.ees.exchange.atu_r.dmt.adsl

Purpose: To verify that the ATU-R enters the R-REVERB-RA state immediately following R-CRC-RA2, and to verify proper operation of the ATU-R while in the R-REVERB-RA state of the expanded exchange sequence.

References: ANSI T1.413-1998 section 9.9.6.

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R

Discussion: The R-REVERB-RA signal is the same signal as R-REVERB3. The ATU-R shall transmit the R-REVERB-RA signal until all bits and gains information transmitted in the C-RATES-RA signal have been received and checked using the C-CRC-RA2 signal. The ATU-R shall continue to transmit the R-REVERB-RA signal for 64 symbol periods after the control data transmitted by the ATU-C has been received. The duration of the R-REVERB-RA signal is greater than 288 symbol periods and less than 4000 symbol periods. If all control signals have not been detected within 4000 symbol periods, the ATU-R shall timeout and reset to the R-ACT-REQ state. The ATU-R shall enter the R-SEGUE-RA state immediately following R-REVERB-RA.

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-R to the R-ACT-REQ state.
- Continue ATU-R initialization, selecting the expanded exchange sequence.
- Repeat, without transmitting the C-RATES-RA and C-CRC-RA2 signals.

Observable Results:

- The ATU-R should enter the R-SEGUE-RA state immediately following R-CRC-RA2.
- The ATU-R should continue to transmit the R-REVERB-RA signal for 64 symbol periods after successfully receiving the C-RATES-RA and C-CRC-RA2 signals.
- The ATU-R should timeout and reset to the R-ACT-REQ state if the C-RATES-RA and C-CRC-RA2 signals are not received within 4000 symbol periods.

4.2.4.7 Test # 4.025

Test Label: r_segue_ra.ees.exchange.atu_r.dmt.adsl

Purpose: To verify that the ATU-R enters the R-SEGUE-RA state immediately following R-REVERB-RA in the expanded exchange sequence.

References: ANSI T1.413-1998 section 9.9.7.

Resource Requirements:
- ATU-R unit (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R

Discussion: The R-SEGUE-RA signal is the same as R-SEGUE4. The duration of the R-SEGUE-RA signal is 10 symbol periods. The ATU-R shall enter the R-MSGS2 state immediately following R-SEGUE-RA.

Test Setup: Test setup 1.

Procedure:
- Reset the ATU-R to the R-ACT-REQ state.
- Continue ATU-R initialization, selecting the expanded exchange sequence.

Observable Results:
- The ATU-R should enter the R-SEGUE-RA state immediately following R-REVERB-RA.
- The duration of the R-SEGUE-RA signal should be 10 symbol periods.

4.2.4.8 Test # 4.026

Test Label: r_msgs2.exchange.atu_r.dmt.adsl

Purpose: To verify the transmission of the R-MSGS2 signal.

References: ANSI T1.413-1998 section 9.9.8.

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R

Discussion: The R-MSGS2 signal is 32 bit message sent to the ATU-C containing the total number of bits per symbol supported, the estimated downstream loop attenuation, and the performance margin with the selected rate option. The data fields of the R-MSGS2 signal, which can be modelled as m = {m31, m30, ... m1, m0}, are defined in the table below.

Suffix(ces) of m	Parameter
31-25	Estimated average loop attenuation
24-21	Reserved for future use
20-16	Performance margin with selected rate option
15-12	Reserved for future use
11-0	Total number of bits supported

NOTE:
1. All bits “reserved for future use” shall be set to 0 until defined.
2. Within the separate fields the least significant bits have the lowest subscripts.

For more information on the fields of the R-MSGS2 signal, see the standard reference, section 9.9.8. The duration of the R-MSGS2 signal should be 4 symbol periods, corresponding to the 4 bytes of data in the R-MSGS2 data field. The ATU-R shall enter the R-CRC3 state immediately following R-MSGS2.

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-R to the R-ACT-REQ state.
- Send the appropriate signals to continue ATU-R initialization

Observable Results:

- The ATU-R should enter the R-MSGS2 state immediately following: R-SEGUE-RA, if the expanded exchange sequence is being used, or R-SEGUE3 if the expanded exchange sequence is not being used.
- The duration of the R-MSGS2 signal should be 4 symbol periods.

4.2.4.9 Test # 4.027

Test Label: r_crc3.exchange.atu_r.dmt.adsl

Purpose: To verify that the ATU-R enters the R-CRC3 state immediately following R-MSGS2.

References: ANSI T1.413-1998 section 9.9.9.

Resource Requirements:

- ATU-R (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R
- Device capable of computing logical values of logical functions

Discussion: The R-CRC3 signal is a two byte cyclic redundancy code used for detection of errors in the reception of the R-MSGS2 signal at the ATU-C. The R-CRC3 should be coded in the same manner as R-MSGS2. The duration of the R-CRC3 signal should be 2 symbol periods. The ATU-R shall enter the R-RATES2 state immediately following R-CRC3.

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-R to the R-ACT-REQ state.
- Send the appropriate signals to continue ATU-R initialization.

Observable Results:

- The ATU-R should enter the R-CRC3 state immediately following R-MSGS2.
- The duration of the R-CRC3 signal should be 2 symbol periods and should correspond to the bit pattern generated using the formula discussed for R-CRC1.

4.2.4.10 Test # 4.028

Test Label: r_rates2.exchange.atu_r.dmt.adsl

Purpose: To verify that the ATU-R enters the R-RATES2 state immediately following R-CRC3.

References: ANSI T1.413-1998 section 9.9.10.

Resource Requirements:

- ATU-R (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R

Discussion: R-RATES2 is the reply C-RATES1 or C-RATES-RA, based on the results of the downstream channel analysis. The ATU-R sends back only the number of the selected data rate that can be supported, based on the signal-to-noise ratio of the downstream channel. The options and corresponding bit patterns are shown in the table below.

Downstream	Bit pattern for R-RATES2 (MSB first)
Option 1	00010001
Option 2	00100010
Option 3	01000100
Option 4	10001000
No option selected	00000001
All options fail	00000000

NOTE: All other bit patterns not shown are reserved for future use.

If none of the options requested in C-RATES1 or C-RATES-RA can be implemented, the ATU-R shall timeout and reset to the R-ACT-REQ state for retraining. The duration of the R-RATES2 signal is 1 symbol period. The ATU-R shall enter the R-CRC4 state immediately following R-RATES2.

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-R to the R-ACT-REQ state.
- Send the appropriate signals to continue ATU-R initialization.
- Repeat, transmitting all 0's in the data fields of the C-RATES1 or C-RATES-RA signals.

Observable Results:

- The ATU-R should enter the R-RATES2 state immediately following R-CRC3.
- The duration of the R-RATES2 signal should be 1 symbol period.
- The ATU-R should transmit the bit sequence 00000000, all options fail, or 00000001, no option selected, and should timeout and reset to the R-ACT-REQ state.

4.2.4.11 Test # 4.029

Test Label: r_crc4.exchange.atu_r.dmt.adsl

Purpose: To verify that the ATU-R enters the R-CRC4 state immediately following R-RATES2.

References: ANSI T1.413-1998 section 9.9.11.

Resource Requirements:

- ATU-R (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R
- Device capable of computing logical values of logical functions

Discussion: The R-CRC4 signal is a 2 byte cyclic redundancy code used for detection of errors in the reception of the R-RATES2 signal at the ATU-C. The R-CRC4 should be coded in the same manner as R-RATES2. The duration of the R-CRC4 signal should be 2 symbol periods. The ATU-R shall enter the R-REVERB5 state immediately following R-CRC4.

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-R to the R-ACT-REQ state.
- Send the appropriate signals to continue ATU-R initialization.

Observable Results:

- The ATU-R should enter the R-CRC4 state immediately following R-RATES2.
- The duration of the R-CRC4 signal should be 2 symbol periods and should correspond to the bit pattern generated using the formula discussed for R-CRC1.

4.2.4.12 Test # 4.030

Test Label: r_reverb5.exchange.atu_r.dmt.adsl

Purpose: To verify that the ATU-R enters the R-REVERB5 state, and to verify that the ATU-R takes a timeout and returns to the R-ACT-REQ state if C-B&G and C-CRC5 are not detected within 4000 symbol periods.

References: ANSI T1.413-1998 section 9.9.12.

Resource Requirements:

- ATU-R (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R

Discussion: While in the R-REVERB5 state, the ATU-R shall wait for 4000 symbol periods for the ATU-C to transmit bits and gains information, C-B&G, and a checksum, C-CRC5. If these signals are not detected after 4000 symbol periods, the ATU-R is to return to the R-ACT-REQ state for retraining. If C-CRC5 is detected, the ATU-R is to remain in the R-REVERB5 state for an additional 64 symbol periods before entering the R-SEGUE4 state.

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-R to the R-ACT-REQ state.
- Send appropriate signals to continue ATU-R initialization.
- Allow the R-REVERB5 state to timeout.
- Return to the R-REVERB5 state.
- Send C-B&G and C-CRC5 to the ATU-R.

Observable Results:

- The ATU-R should enter the R-REVERB5 state immediately following R-CRC4.
- The ATU-R should reset to the R-ACT-REQ state after 4000 symbol periods when allowed to timeout.
- ATU-R should enter the R-SEGUE4 state 64 symbol periods after the reception of C-CRC2.
- The duration of the R-REVER5 state should be less than 4000 symbol periods.

4.2.4.13 Test # 4.031

Test Label: r_segue4.exchange.atu_r.dmt.adsl

Purpose: To verify that the ATU-R enters the R-SEGUE4 state immediately following R-REVERB5.

References: ANSI T1.413-1998 section 9.9.13.

Resource Requirements:

- ATU-R (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R

Discussion: The ATU-R transmits the R-SEGUE4 signal to notify the ATU-C that it is about to enter the R-B&G state. The duration of the R-SEGUE4 signal is 10 symbol periods. The ATU-R shall enter the R-B&G state immediately following R-SEGUE4.

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-R to the R-ACT-REQ state.
- Send the appropriate signals to continue ATU-R initialization.

Observable Results:

- The ATU-R should enter the R-SEGUE4 state immediately following R-REVERB5.
- The duration of the R-SEGUE4 signal should be 10 symbol periods.

4.2.4.14 Test # 4.032

Test Label: r_b&g.exchange.atu_r.dmt.adsl

Purpose: To verify that the ATU-R enters the R-B&G state immediately following R-SEGUE4.

References: ANSI T1.413-1998 section 9.9.14.

Resource Requirements:

- ATU-R (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R

Discussion: The R-B&G signal is used to transmit the bits and gains information of the downstream sub-carrier channels to the ATU-C. Each sub-carrier will have two numbers associated with it. Bi represents the number of bits to be coded by the ATU-C onto the i'th sub-carrier, and gi represents the scale factor that shall be coded onto the i'th sub-carrier, relative to the gain that was used for the sub-carrier during C-MEDLEY. For more information on the R-B&G signal, see the standard reference, section 9.9.14. The duration of the R-B&G signal is 510 symbol periods. The ATU-R shall enter the R-CRC5 state immediately following R-B&G.

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-R to the R-ACT-REQ state.
- Send the appropriate signals to continue ATU-R initialization.

Observable Results:

- The ATU-R should enter the R-B&G state immediately following R-SEGUE4.
- The duration of the R-B&G signal should be 510 symbol periods.

4.2.4.15 Test # 4.033

Test Label: r_crc5.exchange.atu_r.dmt.adsl

Purpose: To verify that the ATU-R enters the R-CRC5 state immediately following R-B&G, and to verify that the ATU-R takes a timeout and returns to the R-ACT-REQ state if C-SEGUE3 is not detected within 4000 symbol periods.

References: ANSI T1.413-1998 section 9.9.15.

Resource Requirements:

- ATU-R (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R
- Device capable of computing logical values of logical functions

Discussion: The R-CRC5 signal is a 2 byte cyclic redundancy code used for detection of errors in the reception of the R-B&G signal at the ATU-C. The R-CRC5 should be coded in the same manner as R-B&G. The duration of the R-CRC5 signal should be 2 symbol periods. The ATU-R shall enter the R-REVERB6 state immediately following R-CRC4.

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-R to the R-ACT-REQ state.
- Send the appropriate signals to continue ATU-R initialization.

Observable Results:

- The duration of the R-CRC3 signal should be 2 symbol periods and should correspond to the bit pattern generated using the formula discussed for R-CRC1.
- The ATU-R should enter the R-REVERB6 state immediately following transmission of the R-CRC5 signal.

4.2.4.16 Test # 4.034

Test Label: r_reverb6.exchange.atu_r.dmt.adsl

Purpose: To verify that the ATU-R enters the R-REVERB6 state immediately following R-CRC5.

References: ANSI T1.413-1998 section 9.9.16.

Resource Requirements:

- ATU-R (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R

Discussion: The ATU-R remains in the R-REVERB6 state until all 10 symbols of the C-SEGUE3 signal have been received. The maximum duration of the R-REVERB6 signal is 4000 symbol periods. If the C-SEGUE3 signal has not been received within 4000 symbol periods, the ATU-R shall timeout and reset to the R-ACT-REG state. The ATU-R shall enter the R-SEGUE5 state immediately following R-REVERB6.

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-R to the R-ACT-REQ state.
- Send the appropriate signals to continue ATU-R initialization.
- While the ATU-R is in the R-REVERB6 state, allow the ATU-R to timeout by not transmitting the C-SEGUE3 signal.
- Reset the ATU-R to the R-ACT-REG state.
- Send the appropriate signals to continue ATU-R initialization.

Observable Results:

- The ATU-R should enter the R-REVERB6 state immediately following R-CRC5.
- While in the R-REVERB6 state, the ATU-R should timeout and reset to the R-ACT-REQ state if the C-SEGUE3 signal is not detected within 4000 symbol periods.
- ATU-R should enter the R-SEGUE5 state immediately following reception of C-SEGUE3.
- The duration of the R-REVERB6 signal should be less than 4000 symbol periods.

4.2.4.17 Test # 4.035

Test Label: r_segue5.exchange.atu_r.dmt.adsl

Purpose: To verify that the ATU-R enters the R-SEGUE5 state immediately following R-REVERB6.

References: ANSI T1.413-1998 section 9.9.17.

Resource Requirements:

- ATU-R (UUT)
- Device capable of generating ATU-C signals and host controller channel commands
- Device capable of monitoring the state of the ATU-R
- Device capable of capturing and viewing the output of the ATU-R

Discussion: The purpose of the R-SEGUE5 signal is to notify the ATU-C that the ATU-R is about to enter steady state data transmission, or the R-SHOWTIME state. The duration of the R-SEGUE5 signal is 10 symbol periods.

NOTE: This signal ends the exchange sequence. The ATU-R has completed initialization and will enter the steady state data transmission state, R-SHOWTIME.

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-R to the R-ACT-REQ state.
- Send the appropriate signals to continue ATU-R initialization.

Observable Results:

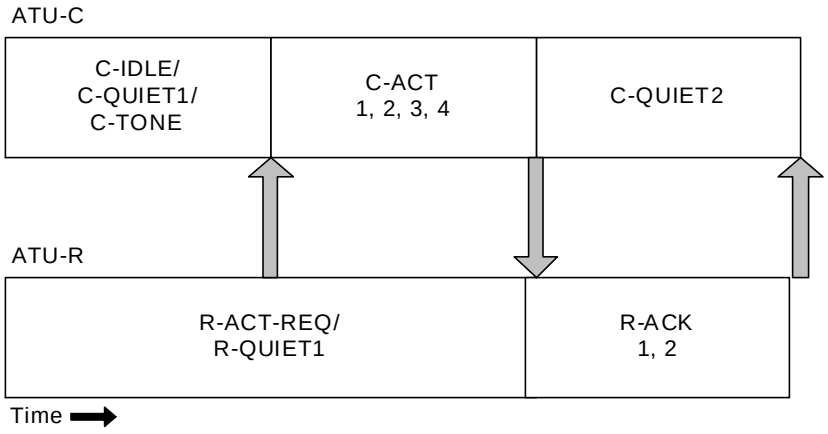
- The ATU-R should enter the R-SEGUE5 state immediately following R-REVERB6.
- The duration of the R-SEGUE 5 signal should be 10 symbol periods.
- The ATU-R should cycle through the entire initialization sequence.
- The ATU-R has completed initialization and should enter the steady state data transmission state, R-SHOWTIME.

4.3 ATU-C Initialization Tests

4.3.1 Activation and Acknowledgement

Scope: The following tests cover the transition between states in the Activation and Acknowledgement section of the ADSL DMT ATU-C initialization sequence.

Overview: These tests are designed to verify the various state transitions and actions required during the Activation and Acknowledgement section of the ADSL DMT ATU-C initialization sequence. Following successful completion of the Activation and Acknowledgement section, Transceiver Training begins. The Activation and Acknowledgement state transitions, for both the ATU-C and the ATU-R, are shown below.



4.3.1.1 Test # 4.036

Test Label: c_quiet.activation.atu_c.dmt.adsl

Purpose: To verify that the ATU-C enters the C-QUIET1 state, upon power up, immediately following the optional C-SELFTEST state.

References: ANSI T1.413-1998 section 9.2.1.1.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: The ATU-C shall enter the C-QUIET1 state upon power up. A host controller may force the ATU-C to enter an optional vendor discretionary selftest state, C-SELFTEST, prior to the C-QUIET1 state.

Test Setup: Test setup 2.

Procedure:

- Power up the ATU-C.
- Reset the ATU-C.
- Send a host controller command signal forcing the ATU-C to enter the C-SELFTEST state.

Observable Results:

- The ATU-C should enter the C-QUIET1 state if the host controller does not issue a selftest signal.
- The ATU-C should enter the C-SELFTEST state, followed by the C-QUIET1 state, if the host controller issues a selftest signal.

4.3.1.2 Test # 4.037

Test Label: c_idle.activation.atu_c.dmt.adsl

Purpose: To verify that the ATU-C enters the C-IDLE state, following the C-QUIET1 state, if forced by the host controller, and to verify that ATU-C operates properly while in the C-IDLE state.

References: ANSI T1.413-1998 section 9.2.12.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: The ATU-C shall enter the C-IDLE state only if forced by a host command. While in the C-IDLE state, the ATU-C should ignore the R-ACT-REQ signal from the ATU-R, *i.e.,* the ATU-C should not enter the C-ACTIVATE state. The ATU-C may enter the C-TONE state upon detection of the R-ACT-REQ signal. The ATU-C shall remain in the C-IDLE state indefinitely until the host controller forces one of the following states: C-TONE, C-QUIET1, C-ACT, or C-SELFTEST.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C.
- Send the c:idle_ignore host controller channel command to the force the ATU-C into the C-IDLE state.
- Send the c:tone host controller command signal to the ATU-C.
- Reset the ATU-C, sending appropriate host controller commands to force the C-IDLE state.
- Send the c:quiet1 host controller command signal to the ATU-C.
- Reset the ATU-C, sending appropriate host controller commands to force the C-IDLE state.
- Send a c:activate host controller command signal to the ATU-C.
- Reset the ATU-C, sending appropriate host controller commands to force the C-IDLE state.
- Send the c:selftest host controller command signal to the ATU-C.

Observable Results:

- The ATU-C should enter the C-IDLE state upon receipt of the c:idle host controller command.
- The ATU-C should enter the C-TONE state upon receipt of the c:tone host controller command.
- The ATU-C should enter the C-QUIET1 state upon receipt of the c:quiet1 host controller command.
- The ATU-C should enter a C-ACTIVATE state upon receipt of the c:activate host controller command.

The ATU-C should enter a C-SELFTEST state upon receipt of the c:selftest host controller command.

4.3.1.3 Test # 4.038

Test Label: c_tone.activation.atu_c.dmt.adsl

Purpose: To verify that the ATU-C returns to the C-IDLE state after sending the C-TONE signal.

References: ANSI T1.413-1998 section 9.2.1.3.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: The ATU-C can only enter the C-TONE state if the host controller command c:tone is transmitted while the ATU-C is in the C-IDLE state. The C-TONE signal is defined as a single frequency sinusoid at 310.5kHz. This signal is to insure that the ATU-R does not transmit R-ACT-REQ. The duration of the C-TONE signal is 128 symbol periods with no cyclic prefix. Immediately following transmission of the C-TONE signal, the ATU-C shall return to the C-IDLE state.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C, sending appropriate host controller commands to force the C-IDLE state.
- Send the c:tone host controller command signal to the ATU-C.

Observable Results:

- The ATU-C should enter the C-IDLE state and remain in the C-IDLE state until the c:tone host controller command signal is transmitted, at which time the ATU-C should enter the C-TONE state and transmit the C-TONE signal for 128 symbol periods.
- The ATU-C should return to the C-IDLE state immediately following transmission of the C-TONE signal, *i.e.*, the output of the ATU-C DAC should be 0 volts.

4.3.1.4 Test # 4.039

Test Label: c_activate.activation.atu_c.dmt.adsl

Purpose: To verify that the ATU-C operates properly while in the C-ACTIVATE state, *i.e.*, transmitting one of the following activation signals C-ACT1, C-ACT2, C-ACT3, or C-ACT4.

References: ANSI T1.413-1998 section 9.2.2.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals and
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: Each ATU-C unit is designed to transmit one specific C-ACTIVATE signal (shown in the table below) only, based on the location of loop timing and the requirement of a pilot signal during the ATU-R states R-QUIET3 or R-PILOT.

Loop timing is performed by only one of the two transceivers, and is defined as tying a transceiver's analog to digital converter (ADC) clock to the clock of the received signal and tying the local digital to analog clock (DAC) to the ADC clock. Thus, all clocks within the loop shall be synchronized. Any given ATU-C shall transmit one and only one C-ACTIVATE signal. The following table shows the conditions for each C-ACTIVATE signal.

Signal	Location of Loop Timing	Pilot Required?	Frequency of Signal
C-ACT1	ATU-C	NO	207 kHz
C-ACT2	ATU-R	NO	189.75 kHz
C-ACT3	ATU-C	Vendor Discretionary	224.25 kHz
C-ACT4	ATU-R	Vendor Discretionary	258.75 kHz

Each C-ACTIVATE signal does not contain a cyclic prefix, and is defined as a single frequency sinusoid transmitted at the frequency shown in the above table. The duration of any C-ACTIVATE signal shall be 128 symbol periods. The C-QUIET2 state immediately follows C-ACTIVATE.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C, sending appropriate host controller commands or ATU-R activation signals (R-ACT-REQ) to force the C-ACTIVATE state.
- Measure the frequency of the ensuing C-ACTIVATE signal

Observable Results:

- The frequency of the C-ACTIVATE signal should match one of the frequencies, corresponding to a particular C-ACTIVATE signal, as shown in the above table.
- The duration of any given C-ACTIVATE signal should be 128 symbol periods.

4.3.1.5 Test # 4.040

Test Label: c_quiet2.activation.atu_c.dmt.adsl

Purpose: To verify that the ATU-C operates properly while in the C-QUIET2 state.

References: ANSI T1.413-1998 section 9.2.3

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: The ATU-C shall enter the C-QUIET2 state immediately following C-ACT (C-ACTIVATE). The duration of the C-QUIET2 signal shall be 128 symbol periods. Following C-QUIET2, the ATU-C shall enter the C-REVEILLE state if the R-ACK signal is detected within 128 symbol periods. If the R-ACK signal is not detected within the specified 128 symbol periods of C-QUIET2, the ATU-C shall return to the C-ACT state. The ATU-C shall return to the C-ACT state no more than twice if R-ACK is not detected. If R-ACK is not detected a third time, the ATU-C shall return to the C-QUIET1 state.

NOTE: The duration of the C-QUIET2 state shall always be 128 symbol periods. If a signal is detected before completion of the 128 symbol periods of C-QUIET2, the full duration will be maintained, followed by a response to the received signal.

NOTE: Following the C-QUIET2 state, activation and acknowledgement is complete and transceiver training begins.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C, sending the appropriate host controller commands or ATU-R activation signals (R-ACT-REQ) to force the C-ACT state, which will automatically be followed by the C-QUIET2 state.
- Send the R-ACK signal to the ATU-C.
- Reset the ATU-C, returning to the C-QUIET1 state.
- Allow the 128 symbol period duration of the C-QUIET2 signal to expire (do not transmit the R-ACK signal).
- Do not reset the ATU-C. Force the ATU-C into the C-QUIET2 state a second time and allow the 128 symbol period duration to run out (do not transmit the R-ACK signal).
- Do not reset the ATU-C. Force the ATU-C into the C-QUIET2 state a third time and allow the 128 symbol period duration to run out (do not transmit the R-ACK signal).

Observable Results:

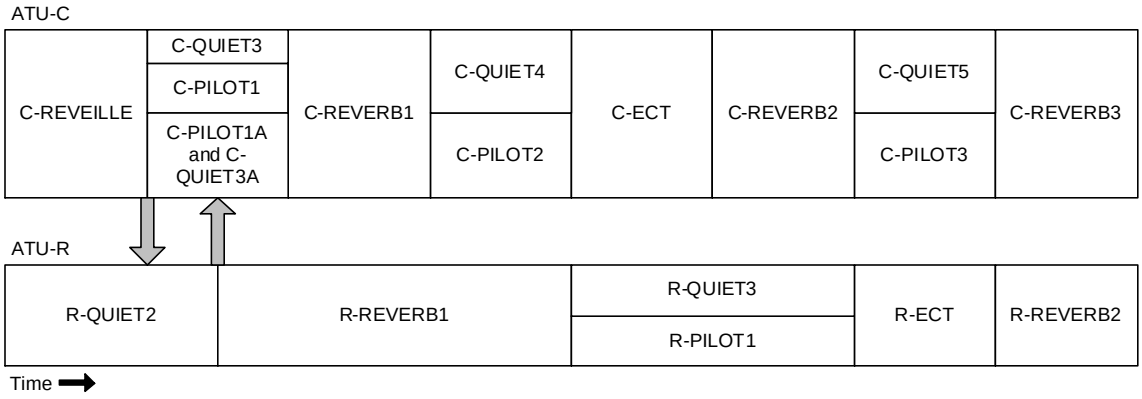
- The ATU-C should remain in the C-QUIET2 state for 128 symbol periods.
- The ATU-C should enter the C-REVEILLE state after 128 symbol periods.
- The ATU-C should return to the C-ACT state immediately following the duration of the 128 symbol periods of C-QUIET2.
- The ATU-C should return to the C-QUIET2 state. The ATU-R should enter the C-ACT state immediately following the duration of the 128 symbol periods of C-QUIET2.

- The ATU-C should return to the C-QUIET2 state once more. The ATU-C should enter the C-QUIET1 state immediately following the third duration of the 128 symbol periods of C-QUIET2.

4.3.2 Transceiver Training

Scope: The following tests cover the transition between states in the Transceiver Training section of the ADSL DMT ATU-C initialization sequence.

Overview: These tests are designed to verify the various state transitions and actions required during the Transceiver Training section of the ADSL DMT ATU-C initialization sequence. Beginning with the transmission of the R-REVERB1 signal, the ATU-C and ATU-R states are synchronized. Following successful completion of the Transceiver Training section, Channel Analysis begins. The Transceiver Training state transitions are shown below.



4.3.2.1 Test # 4.041

Test Label: c_reveille.transceiver_training.atu_c.dmt.adsl

Purpose: To verify that the ATU-C enters the correct state from the C-REVEILLE state.

References: ANSI T1.413-1998 section 9.4.1.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the state of the ATU-C

Discussion: The C-REVEILLE state is transmitted by the ATU-C to let the ATU-R know that it has properly received the R-ACK signal. The ATU-C can enter 3 different states following the C-REVEILLE state, based on the following criteria:

- C-QUIET3 if R-ACK1 was detected and the ATU-C is performing loop timing
- C-PILOT1A if R-ACK1 was detected and the ATU-R is performing loop timing
- C-PILOT1 if R-ACK2 was detected.

The C-REVEILLE signal does not contain a cyclic prefix, and is defined a single frequency sinusoid at 241.5kHz. The duration of the C-REVEILLE signal is 128 symbol periods.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C, continuing initialization.
- Send the R-ACK1 signal to the ATU-C while the ATU-C is in the C-ACT state.
- Reset the ATU-C, continuing initialization.
- Send the R-ACK2 signal to the ATU-C while the ATU-C is in the C-ACT state.
- Reset the ATU-C, continuing initialization.
- Send the R-ACK3 signal to the ATU-C while the ATU-C is in the C-ACT state.

Observable Results:

- The ATU-C should enter the C-QUIET3 state immediately following C-REVEILLE if R-ACK1 was detected.
- The ATU-C should enter the C-PILOT1A state immediately following C-REVEILLE if R-ACK2 was detected.
- The ATU-C should enter the C-PILOT1 state immediately following C-REVEILLE if R-ACK3 was detected.

4.3.2.2 Test # 4.042

Test Label: c_quiet3.transceiver_training.atu_c.dmt.adsl

Purpose: To verify that the ATU-C operates properly if in the C-QUIET3 state.

References: ANSI T1.413-1998 section 9.4.2.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: Following the C-REVEILLE state, the ATU-C shall enter the C-QUIET3 state if R-ACK1 was detected and loop timing is to be performed at the ATU-C.

NOTE: This test applies only to ATU-C's that meet the above requirements.

The C-QUIET3 state allows the ATU-C to measure the aggregate received upstream power on subcarriers 7-18 of R-REVERB1 and calculate a downstream power spectral density (PSD). While in the C-QUIET3 state, the ATU-C starts a synchronization timer within 16 symbol periods after the detection of the R-REVERB1 signal. This timer will be used to coordinate the transition of states in the ATU-C and ATU-R. The ATU-C shall enter the C-REVERB1 state 512 symbol periods after it has started its synchronization timer. Thus, the duration of the C-QUIET3 signal is greater than 512 symbol periods with a maximum value less than 4436 symbol periods. The exact duration is dependent on the duration of R-QUIET2. The C-REVERB1 state follows C-QUIET3.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C, sending C-ACT1 or C-ACT3 and R-ACK1 where appropriate (these signals should cause the ATU-C to enter the C-QUIET3 state).
- Send the R-REVERB1 while the ATU-C is in the C-QUIET3 state.

Observable Results:

- The ATU-C should measure the received upstream power on sub-carriers 7-18.
- The ATU-C should start a synchronization timer within 16 symbols of detecting the R-REVERB1 signal.
- The duration of the C-QUIET3 signal should be between 512 and 4436 symbol periods.
- The transition between ATU-C and ATU-R states should be synchronized from this point on.

4.3.2.3 Test # 4.043

Test Label: c_pilot1.transceiver_training.atu_c.dmt.adsl

Purpose: To verify that the ATU-C operates properly in the C-PILOT1 state.

References: ANSI T1.413-1998 section 9.4.3.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: Following the C-REVEILLE state, the ATU-C shall enter the C-PILOT1 state if R-ACK2 was detected.

NOTE: This test applies only to ATU-C's that meet the above requirements.

The C-PILOT1 signal is defined as a single frequency sinusoid where the frequency is 276kHz. The C-PILOT1 state allows the ATU-C to measure the aggregate received upstream power on sub-carriers 7-18 of R-REVERB1 and calculate a downstream power spectral density (PSD). While in the C-PILOT1 state, the ATU-C starts a synchronization timer within 16 symbol periods after the detection of the R-REVERB1 signal. This timer will be used to coordinate the transition of states in the ATU-C and ATU-R. The ATU-C shall enter the C-REVERB1 state 512 symbol periods after it has started its synchronization timer. Thus, the duration of the C-PILOT1 signal is greater than 512 symbol periods with a maximum value less than 4436 symbol periods. The exact duration is dependent on the duration of R-QUIET2. The C-REVERB1 state follows C-PILOT1.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C, sending R-ACK2 where appropriate (these signals should cause the ATU-C to enter the C-PILOT1 state).
- Send the R-REVERB1 while the ATU-C is in the C-PILOT1 state.

Observable Results:

- The ATU-C should measure the received upstream power on sub-carriers 7-18.
- The ATU-C should start a synchronization timer within 16 symbols of detecting the R-REVERB1 signal.
- The duration of the C-PILOT1 signal should be between 512 and 4436 symbol periods.
- The transition between ATU-C and ATU-R states should be synchronized from this point on.

4.3.2.4 Test # 4.044

Test Label: c_pilot1a\c-quiet3a.transceiver_training.atu_c.dmt.adsl

Purpose: To verify that the ATU-C operates properly in the C-PILOT1A\C-QUIET3A state.

References: ANSI T1.413-1998 sections 9.4.4 and 9.4.5.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: Following the C-REVEILLE state, the ATU-C shall enter the C-PILOT1A state if R-ACK1 was detected and loop timing is to be performed at the ATU-R.

NOTE: This test applies only to ATU-C's that meet the above requirements.

The C-PILOT1A state allows the ATU-C to measure the aggregate received upstream power on sub-carriers 7-18 of R-REVERB1 and calculate a downstream power spectral density (PSD). While in the C-PILOT1A state, the ATU-C starts a synchronization timer within 16 symbol periods after detection of the R-REVERB1 signal. This timer will be used to coordinate the transition of states in the ATU-C and ATU-R.

The ATU-C exits the C-PILOT1A state and enters the C-QUIET3A state immediately following the start of the synchronization timer. The ATU-C will remain in the C-QUIET3A state for 496 to 512 symbol periods. Thus, the total duration of both the C-PILOT1A and C-QUIET3A signals is greater than 512 symbol periods and has maximum value less than 4436 symbol periods. The exact duration is dependent on the duration of R-QUIET2. C-PILOT1A is defined as a single frequency sinusoid at 276kHz. The C-REVERB1 state follows C-QUIET3A.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C, sending C-ACT2 or C-ACT4 and R-ACK1 where appropriate (these signals should cause the ATU-C to enter the C-PILOT1 state).
- Send the R-REVERB1 while the ATU-C is in the C-PILOT1A state.

Observable Results:

- The ATU-C should measure the received upstream power on sub-carriers 7-18.
- The ATU-C should start a synchronization timer within 16 symbols of detecting the R-REVERB1 signal, exit the C-PILOT1A state and enter the C-QUIET3A state.
- The duration of both the C-PILOT1A\C-QUIET3A state should be between 512 and 4436 symbol periods.
- The transition between ATU-C and ATU-R states should be synchronized from this point on.

4.3.2.5 Test # 4.045

Test Label: c_reverb1.transceiver_training.atu_c.dmt.adsl

Purpose: To verify that the ATU-C enters the C-REVERB1 state.

References: ANSI T1.413-1998 section 9.4.6.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: The ATU-C should enter the C-REVERB1 state following either the C-QUIET3, C-PILOT1, or C-PILOT1A\C-QUIET3A state. The C-REVERB1 state allows the ATU-R receiver to adjust its gain control. See the standard reference, section 9.4.6 for the periodic data pattern transmitted during the C-REVERB1 state. The duration of the C-REVERB1 signal is 512 repeating symbol periods. Following C-REVERB1, the ATU-C shall enter:

- The C-QUIET4 state if R-ACK1 was detected and loop timing is performed at the ATU-C
- The C-PILOT2 state if R-ACK1 was detected and loop timing is performed at the ATU-C, or if R-ACK2 was detected

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C and continue initialization.

Observable Results:

- The ATU-C should enter the C-REVERB1 state immediately following the C-QUIET3, C-PILOT1, or C-PILOT1A\C-QUIET3A state (the exact state previous to C-REVERB1 is specific to any particular ATU-C).
- The duration of the C-REVERB1 signal should be 512 repeating symbol periods (*i.e.*, it is a periodic signal).

4.3.2.6 Test # 4.046

Test Label: c_quiet4.transceiver_training.atu_c.dmt.adsl

Purpose: To verify that the ATU-C makes the proper transition from the C-REVERB1 state to the C-QUIET4 state if R-ACK1 was detected and loop timing is to be performed at the ATU-C.

References: ANSI T1.413-1998 section 9.4.7.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: Following the C-REVERB1 state, the ATU-C shall enter either the C-QUIET4 state or the C-PILOT2 state, depending on the ATU-C and the loop timing characteristics. The ATU-C shall enter the C-QUIET4 state if R-ACK1 was detected and loop timing is performed at the ATU-C, *i.e.*, C-ACT1 or C-ACT3 was transmitted.

NOTE: This test applies only to ATU-C's that meet the above requirements.

The duration of the C-QUIET4 signal should be 3072 symbol periods. The C-ECT state immediately follows C-QUIET4.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C and continue initialization.

Observable Results:

- The ATU-C should enter the C-QUIET4 state immediately following the C-REVERB1 state.
- The duration of the C-QUIET4 signal should be 3072 symbol periods.

4.3.2.7 Test # 4.047

Test Label: c_pilot2.transceiver_training.atu_c.dmt.adsl

Purpose: To verify that the ATU-C makes the proper transition from the C-REVERB1 state to the C-PILOT2 state if R-ACK1 was detected and loop timing is to be performed at the ATU-R or if R-ACK2 was detected.

References: ANSI T1.413-1998 section 9.4.8.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: Following the C-REVERB1 state, the ATU-C shall enter either the C-QUIET4 state or the C-PILOT2 state, depending on the ATU-C and the loop timing characteristics. The ATU-C shall enter the C-PILOT2 state if R-ACK1 was detected and loop timing is performed at the ATU-R, *i.e.*, C-ACT2 or C-ACT34 was transmitted or if R-ACK2 was detected.

NOTE: This test applies only to ATU-C's that meet the above requirements.

The C-PILOT2 is the same signal as C-PILOT1; a single frequency sinusoid at 276kHz is transmitted. The duration of the C-PILOT2 signal should be 3072 symbol periods. The C-ECT state immediately follows C-PILOT2.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C and continue initialization.

Observable Results:

- The ATU-C should enter the C-PILOT2 state immediately following the C-REVERB1 state.
- The duration of the C-PILOT2 signal should be 3072 symbol periods.

4.3.2.8 Test # 4.048

Test Label: c_ect.transceiver_training.atu_c.dmt.adsl

Purpose: To verify that the ATU-C enters the C-ECT state immediately following either the C-QUIET4 state or the C-PILOT2 state.

References: ANSI T1.413-1998 section 9.4.9.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: The ATU-C shall enter the C-ECT state immediately following either the C-QUIET4 state or the C-PILOT2 state. The C-ECT state is vendor-designed signal used for training the echo canceller at the ATU-C. The ATU-R receiver should ignore the signal. The duration of the C-ECT signal is set at 512 symbol periods. The C-REVERB2 state immediately follows C-ECT.

It is recommended that sub-carriers 1-4 not be used for transmission of the C-ECT signal due to the tightly limited signal leakage through the POTS filter. If sub-carriers 1-4 are used for transmission of the C-ECT signal, they should be transmitted at a much lower power level.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C and continue initialization.

Observable Results:

- The ATU-C should enter the C-ECT state immediately following either the C-QUIET4 state or the C-PILOT2.
- The duration of the C-ECT signal should be 512 symbol periods.

4.3.2.9 Test # 4.049

Test Label: c_reverb2.transceiver_training.atu_c.dmt.adsl

Purpose: To verify that the ATU-C enters the C-REVERB2 state immediately following C-ECT.

References: ANSI T1.413-1998 section 9.4.10.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: The ATU-C shall enter the C-REVERB2 state immediately following the C-ECT state. The C-REVERB2 state allows the ATU-R to train any receiver equalizers. The C-REVERB2 signal is the same as the C-REVERB1 signal. The duration of the C-REVERB2 signal is 1536 repeating symbols, *i.e.*, it is a periodic signal. Depending on the loop timing characteristics, the ATU-C will enter either state C-QUIET5 or C-PILOT3.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C and continue initialization.

Observable Results:

- The ATU-C should enter the C-REVERB2 state immediately following the C-ECT.
- The duration of the C-REVERB2 signal should be 1536 symbol periods.

4.3.2.10 Test # 4.050

Test Label: c_quiet5.transceiver_training.atu_c.dmt.adsl

Purpose: To verify that the ATU-C makes the proper transition from the C-REVERB2 state to the C-QUIET5 state if R-ACK1 was detected.

References: ANSI T1.413-1998 section 9.4.11.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: Following the C-REVERB2 state, the ATU-C shall enter either the C-QUIET5 state or the C-PILOT3 state. The ATU-C shall enter the C-QUIET5 state if R-ACK1 was detected earlier.

NOTE: This test applies only to ATU-C's that meet the above requirements.

The duration of the C-QUIET5 signal should be 512 symbol periods. The C-REVERB3 state immediately follows C-QUIET5.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C and continue initialization.

Observable Results:

- The ATU-C should enter the C-QUIET5 state immediately following the C-REVERB2 state.
- The duration of the C-QUIET5 signal should be 512 symbol periods.

4.3.2.11 Test # 4.051

Test Label: c_pilot3.transceiver_training.atu_c.dmt.adsl

Purpose: To verify that the ATU-C makes the proper transition from the C-REVERB2 state to the C-PILOT3 state if R-ACK2 was detected.

References: ANSI T1.413-1998 section 9.4.12.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: Following the C-REVERB2 state, the ATU-C shall enter either the C-QUIET5 state or the C-PILOT3 state. The ATU-C shall enter the C-PILOT3 state if R-ACK2 was detected earlier.

NOTE: This test applies only to ATU-C's that meet the above requirements.

The C-PILOT3 is the same signal as C-PILOT1; a single frequency sinusoid at 276kHz. The duration of the C-PILOT3 signal should be 512 symbol periods. The C-REVERB3 state immediately follows C-PILOT3.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C and continue initialization.

Observable Results:

- The ATU-C should enter the C-PILOT3 state immediately following the C-REVERB2 state.
- The duration of the C-PILOT3 signal should be 512 symbol periods.

4.3.2.12 Test # 4.052

Test Label: c_reverb3.transceiver_training.atu_c.dmt.adsl

Purpose: To verify that the ATU-C enters the C-REVERB3 state immediately following either the C-QUIET5 state or the C-PILOT3 state.

References: ANSI T1.413-1998 section 9.4.13.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: The ATU-C shall enter the C-REVERB3 state immediately following either the C-QUIET5 state or the C-PILOT3 state. The C-REVERB3 state is a second training signal, and allows the ATU-R to further train any receiver equalizers and maintain synchronization. The C-REVERB3 signal is the same as the C-REVERB2 signal. The duration of the C-REVERB3 signal is 1024 repeating symbols, *i.e.*, it is a periodic signal. The C-SEGUE1 state immediately follows C-REVERB3.

NOTE: Following the C-REVERB3 state, transceiver training will be complete and channel analysis begins.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C and continue initialization.

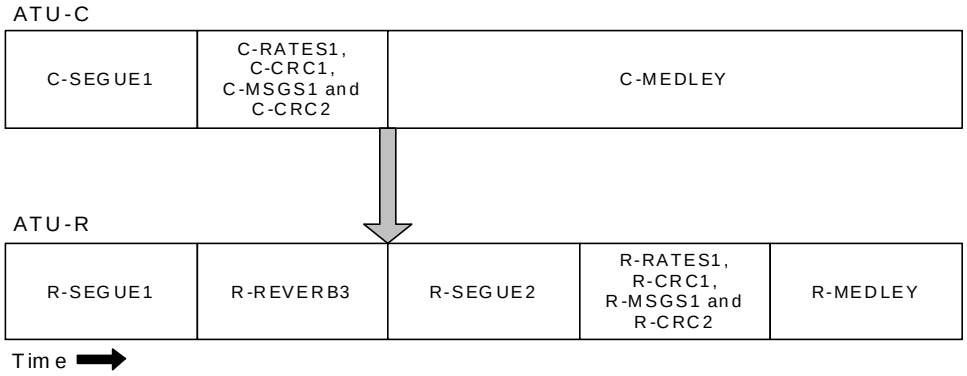
Observable Results:

- The ATU-C should enter the C-REVERB3 state immediately following either the C-QUIET5 state or the C-PILOT3 state.
- The duration of the C-REVERB3 signal should be 1024 symbol periods.

4.3.3 Channel Analysis

Scope: The following tests cover the transition between states in the Channel Analysis section of the ADSL DMT ATU-C initialization sequence.

Overview: These tests are designed to verify the various state transitions and actions required during the Channel Analysis section of the ADSL DMT ATU-C initialization sequence. The ATU-C shall reset to the R-ACT-REQ state if a timeout occurs or if a any errors in the received control data are indicated by the R-CRC1 and R-CRC2 checksums. Following successful completion of the Channel Analysis section, Exchange begins. The Channel Analysis state transitions are shown below.



4.3.3.1 Test # 4.053

Test Label: c_segue1.channel_analysis.atu_c.dmt.adsl

Purpose: To verify that the ATU-C enters the C-SEGUE1 state immediately following C-REVERB3.

References: ANSI T1.413-1998 section 9.6.1.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: The C-SEGUE1 signal is generated by a tone by tone 180 degree phase reversal of C-REVERB1. The C-SEQUE1 signal is periodic, and has a duration of the 10 symbol periods. The C-RATES1 state immediately follows C-SEGUE1.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C and continue initialization.

Observable Results:

- The ATU-C should enter the C-SEGUE1 state immediately following the C-REVERB3 state.
- The duration of the C-SEGUE1 signal should be 10 symbol periods.

4.3.3.2 Test # 4.054

Test Label: c_rates1.channel_analysis.atu_c.dmt.adsl

Purpose: To verify that the ATU-C enters the C-RATES1 state immediately following C-SEGUE1.

References: ANSI T1.413-1998 section 9.6.2.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: The C-RATES1 signal is used to transmit four downstream data rate options to the ATU-R. The four options and their respective data fields are shown in the table below.

		Option 1			Option 2			Option 3			Option 4		
	Pre-fix	Bf	Bi	RRSD	Bf	Bi	RRSD	Bf	Bi	RRSD	Bf	Bi	RRSD
# of bytes	4	10	10	10	10	10	10	10	10	10	10	10	10

Each byte of the Bf field specifies the number of bytes in the fast buffer in a particular downstream sub-channel, in the order AS0, AS1, AS2, AS3, LS0, LS1, LS2, and in a particular upstream channel in the order LS0, LS1, LS2. The Bi field represents the same quantities for the interleaved buffer.

The RRSD (or { RSf, RSi, S, D, FS(LS2)})field consists of five bytes: the RSf field defines the number of parity bytes per symbol in the downstream fast buffer, RSi field defines the number of parity bytes per symbol in the downstream interleaved buffer, the S field defines the downstream number of symbols per codeword, the D field defines the downstream interleave depth, and the FS(LS2) field is a byte consisting of eight zeros. These same five quantities are also used for the upstream channel.

All fields are transmitted least significant bit first. The C-RATES1 signal is transmitted 1 bit per symbol, therefore the total duration of the C-RATES1 signal is 992 symbol periods (because there are 992 total bits in the C-RATES1 signal). The ATU-C shall enter the C-CRC1 state immediately following R-RATES1.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C and continue initialization.

Observable Results:

- The ATU-C should enter the C-RATES1 state immediately following the C-SEGUE1 state.
- The duration of the C-RATES1 signal should be 992 symbol periods.

4.3.3.3 Test # 4.055

Test Label: c_crc1.channel_analysis.atu_c.dmt.adsl

Purpose: To verify that the ATU-C enters the C-CRC1 state immediately following C-RATES1.

References: ANSI T1.413-1998 section 9.6.3.

Resource Requirements:
- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: The C-CRC1 signal is 16 bit check signal used for detection of errors in the reception of C-RATES1 at the ATU-R. The duration of the C-CRC1 signal is 16 symbol periods. The ATU-C shall enter the C-MSGS1 state immediately following C-CRC1.

Test Setup: Test setup 2.

Procedure:
- Reset the ATU-C and continue initialization.

Observable Results:
- The ATU-C should enter the C-CRC1 state immediately following C-RATES1.
- The duration of the C-CRC1 signal should be 16 symbol periods.

4.3.3.4 Test # 4.056

Test Label: c_msgs1.channel_analysis.atu_c.dmt.adsl

Purpose: To verify that the ATU-C enters the C-MSGS1 state immediately following C-CRC1.

References: ANSI T1.413-1998 section 9.6.4.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: The C-MSGS1 signal is a 48 bit message, m = {m47, m46, ... m1, m0}, containing initialization information. The least significant bit, m0, is transmitted first. The fields of the C-MSGS1 signal are defined by the table below.

Suffix(ces) of mi	Parameter
47-44	Minimum required SNR margin
43-28	Vendor Identification
27,26	Reserved for future use
25-23	T1.413-1998 revision number
22-18	Vendor revision number
17	Trellis coding option
16	Echo cancelling option
15	Expanded Exchange Sequence
14	Reserved for future use
13-12	Set to {0,0}
11	Network Timing Reference
10-9	Framing structure
8-6	Transmit PSD during initialization
5-4	Reserved for future use
3-0	Maximum number of bits per sub-carrier

NOTES: 1. All bits “reserved for future use” shall be set to 0.
2. Within the separate fields the lowest subscripts shall be the least significant bits.

For more information on the fields of the C-MSGS1 signal, see the standard reference, section 9.6.4. The C-MSGS1 signal will be 48 symbol periods long, where each bit is encoded as a symbol. The ATU-C shall enter the R-CRC2 state immediately following C-MSGS1.

Test Setup: Test setup 1.

Procedure:

- Reset the ATU-C, continuing initialization.

Observable Results:

- The ATU-R should enter the C-MSGS1 state immediately following the C-CRC1 state.
- The duration of the C-MSGS signal should be 48 symbol periods (because there are a total of 48 bits).

4.3.3.5 Test # 4.057

Test Label: c_crc2.channel_analysis.atu_c.dmt.adsl

Purpose: To verify that the ATU-C enters the C-CRC2 state immediately following C-MSGS1.

References: ANSI T1.413-1998 section 9.6.5.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: The C-CRC2 signal is a 16 bit check signal used for detection of errors in the reception of C-MSGS1 at the ATU-R. The duration of the C-CRC2 signal is 16 symbol periods. The ATU-C shall enter the C-MEDLEY state immediately following C-CRC2.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C and continue initialization.

Observable Results:

- The ATU-C should enter the C-CRC2 state immediately following C-MSGS1.
- The duration of the C-CRC2 signal should be 16 symbol periods.

4.3.3.6 Test # 4.058

Test Label: c_medley.channel_analysis.atu_c.dmt.adsl

Purpose: To verify that the ATU-C enters the C-MEDLEY state immediately following C-CRC2.

References: ANSI T1.413-1998 section 9.6.6.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: The C-MEDLEY signal is a used for estimation of the downstream signal-to-noise ratio (SNR) at the ATU-R. The duration of the C-MEDLEY signal is 16384 symbol periods. See the standard reference, section 9.6.6, for details. The ATU-C shall enter the C-REVERB4 state immediately following C-MEDLEY.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C and continue initialization.

Observable Results:

- The ATU-C should enter the C-MEDLEY state immediately following C-CRC2.
- The duration of the C-MEDLEY signal should be 16384 symbol periods.

4.3.3.7 Test # 4.059

Test Label: c_reverb4.channel_analysis.atu_c.dmt.adsl

Purpose: To verify that the ATU-C enters the C-REVERB4 state immediately following C-MEDLEY.

References: ANSI T1.413-1998 section 9.6.7.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: The C-REVERB4 signal is similar to C-REVERB2, with the addition of cyclic prefix added to every symbol. The duration of the C-REVERB4 signal has no set value, although it is limited to less than 6000 symbol periods. If the ATU-C does not detect the R-CRC4, or R-CRC-RA2, within the 6000 symbol period limit, the ATU-C shall timeout and reset to C-QUIET1. The ATU-C shall continue to transmit the C-REVERB4 signal for an additional 80 symbol periods once R-CRC4 or R-CRC-RA2 has been detected. The ATU-C shall enter the C-SEGUE2 signal following C-REVERB4.

NOTE: The C-REVERB4 state extends into the Exchange sequence.

NOTE: The start of the transmission of the C-REVERB4 signal marks completion of channel analysis. Exchange begins during the transmission of C-REVERB4.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C and continue initialization.

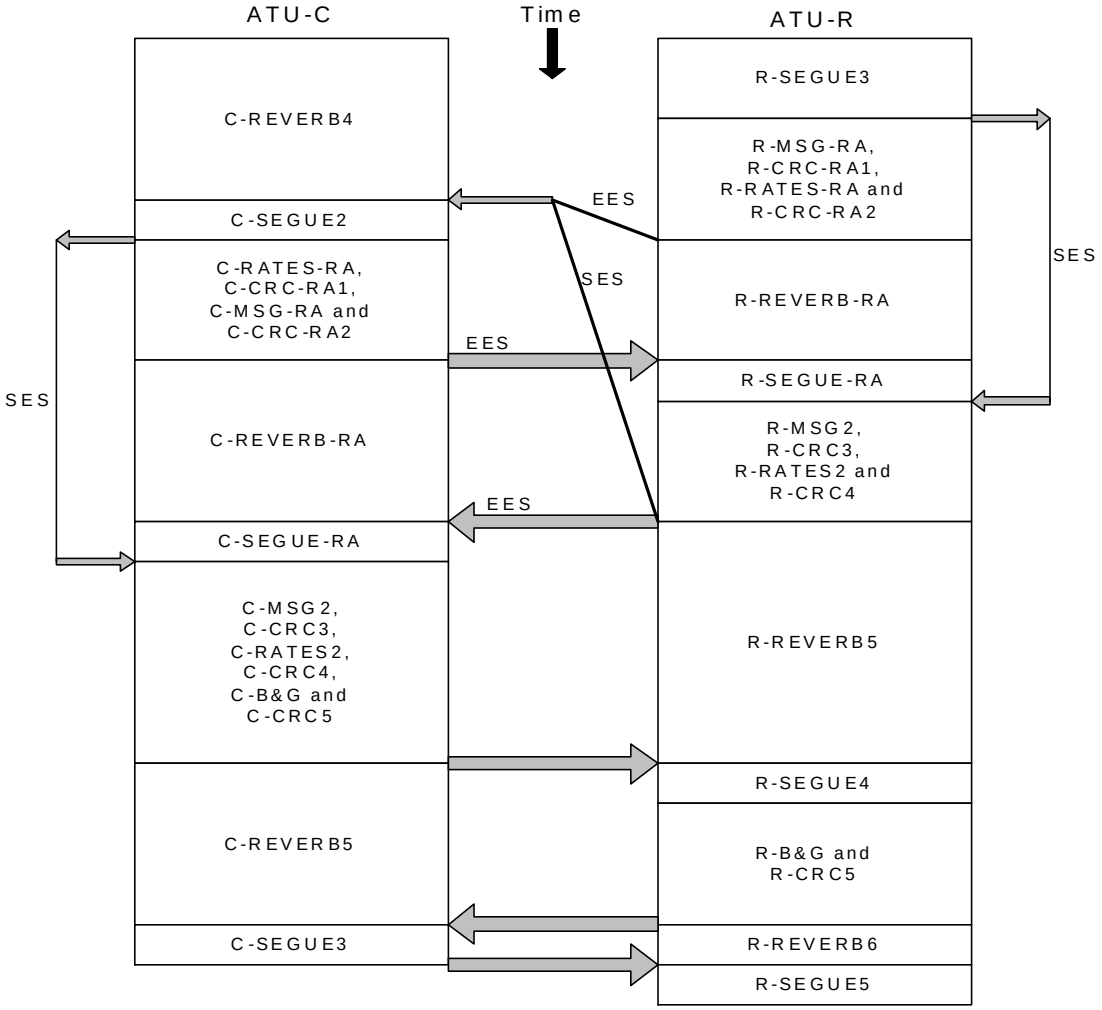
Observable Results:

- The ATU-C should enter the C-REVERB4 state immediately following C-MEDLEY.
- The duration of the C-REVERB4 signal should be less than 6000 symbol periods.
- If the signals R-SEGUE3 or R-CRC-RA2 are not detected within 6000 symbol periods, the ATU-C should reset to state C-QUIET1.

4.3.4 Exchange

Scope: The following tests cover the transition of states in the exchange section of ADSL DMT ATU-C initialization sequence.

Overview: These series of tests are designed to verify the transitions from state to state during the exchange section of ATU-C initialization. The diagram below demonstrates the expanded exchange sequence (EES) which will be used if both the ATU-C and ATU-R have a set bit 15 to 1 in C-MSG1 and R-MSG1 respectively. If bit 15 is set to 0 in C-MSG1 and R-MSG1, then EES will be bypassed, which is called short exchange sequence or SES. The ATU-C will reset to state C-QUEIT1 timeouts or errors are detected by a CRC checksum. Exchange is partly synchronized between the ATU-C and ATU-R and partly interactive. Timeouts in states C-REVERB4 (>6000 symbols), C-REVERB-RA, and C-REVERB5 (both >4000 symbols) occur. These states could be considered the interactive part. The diagram below demonstrates the state transitions.



4.3.4.1 Test # 4.060

Test Label: c_segue2.exchange.atu_c.dmt.adsl

Purpose: To verify that the ATU-C enters the C-SEGUE2 state immediately following C-REVERB4.

References: ANSI T1.413-1998 section 9.8.2.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: The C-SEGUE2 signal is the same as the C-SEGUE1 signal with the addition of a cyclic prefix. The duration of the C-SEGUE2 signal is 10 symbol periods. Following C-SEGUE2, the ATU-C shall enter the state C-RATES-RA to begin exchange of rates if the expanded exchange sequence (EES) is being used. If the EES is not being used, the ATU-C shall skip the "rate adaptation" sequence and enter state C-MSGS2.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C and continue initialization.

Observable Results:

- The ATU-C should enter the C-REVERB4 state immediately following C-MEDLEY.
- The duration of the C-REVERB4 signal should be less than 6000 symbol periods.

4.3.4.2 Test # 4.061

Test Label: c_rates_ra.ees.exchange.atu_c.dmt.adsl

Purpose: To verify that the ATU-C enters the C-RATES-RA state immediately following the C-SEGUE2 state in the expanded exchange sequence.

References: ANSI T1.413-1998 section 9.8.3.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: The purpose of C-RATES-RA is to send four new options for transport configuration in both the downstream and upstream directions. These options are based on the channel information received in R-MSG-RA. The format of C-RATES-RA is similar to C-RATES1, where the 4 byte prefix is not transmitted. The table below shows these options and their respective data fields.

	Option 1			**Option 2**			**Option 3**			**Option 4**		
	Bf	**Bi**	**RRSD**	**Bf**	**Bi**	**RRSD**	**Bf**	**Bi**	**RRSD**	**Bf**	**Bi**	**RRSD**
# of Bytes	10	10	10	10	10	10	10	10	10	10	10	10

The RRSD field is defined in the below table. There are 5 bytes for the downstream direction and 5 bytes for the upstream direction, hence the 10 total bytes for the field.

	Bit Number							
Fields	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Sf	0	0	# of parity bytes per symbol in fast buffer msb lsb					
RSi	B8*	0	# of parity bytes per symbol in interleave buffer msb lsb					
S	D9	D8	# of symbols in codeword msb lsb					
D	D7	D6	D5	D4	D3	D2	D1	D0
FS(LS2)	Value of FS(LS2) set to {00000000}							

- * msb of Bi(AS0), # of payload bytes in the AS0 bearer channel interleave buffer
- The D field indicates the interleave depth in codewords. The two msb's of the depth code word are contained in bits 7 and 6 of the S field, while the remainder of the depth codeword bits reside in the D field.

For more information, refer to reference standard section 9.8.3.

The duration of C-RATES-RA is 120 symbols, where each symbol is 8-bits long. Immediately following this state, the ATU-C shall enter state C-CRC-RA1.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C and continue initialization.
- Set bit 15 = 1 of message C-MSGS1 and message R-MSGS1 for EES mode.

Observable Results:

- The ATU-C should enter the C-RATES-RA state immediately following C-SEGUE2 in the expanded exchange sequence.
- The duration of the C-RATES-RA signal should be 120 symbol periods.

4.3.4.3 Test # 4.062

Test Label: c_crc_ra1.ees.exchange.atu_c.dmt.adsl

Purpose: To verify that the ATU-C enters the C-CRC-RA1 state immediately following C-RATES-RA while in expanded exchange sequence.

References: ANSI T1.413-1998 section 9.8.4.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: C-CRC-RA1 is a cyclic redundancy check (CRC) for the detection of errors in the reception of C-RATES-RA at the ATU-R. It's relation to C-RATES-RA1 is the same as C-CRC3 is to C-MSG2. It shall be transmitted in 2 symbols, where each symbol is 8-bits long (16-bits total). The ATU-C shall enter state C-MSG-RA following C-CRC-RA1.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C and continue initialization.
- Set bit 15 =1 in message C-MSGS1 and in message R-MSGS1for EES mode.

Observable Results:

- The ATU-C should enter the state C-CRC-RA1 immediately following C-RATES-RA.
- The duration of the C-CRC-RA1 signal should be 2 symbol periods.

4.3.4.4 Test # 4.063

Test Label: c_msg_ra.ees.exchange.atu_c.dmt.adsl

Purpose: To verify that the ATU-C enters the C-MSG-RA state immediately following C-CRC-RA1 in expanded exchange sequence.

References: ANSI T1.413-1998 section 9.8.5.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: C-MSG-RA has the same format as C-MSG1. The bit assignments are as shown in the table below.

Suffix(ces) of *mi*	**Parameter**
47-44	New minimum required signal to noise ratio margin
43-0	Reserved for future use (set to 0)
Within the separate fields the lsb's have the lowest subscript	

The 48-bit message is transmitted in 6 symbols, where each symbol is 8-bits long. The ATU-C shall enter state C-CRC-RA2 following C-MSG-RA.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C and continue initialization.
- Set bit 15 =1 of message C-MSGS1 and message R-MSGS1 for EES mode.

Observable Results:

- The ATU-C should enter the state C-MSG-RA immediately following C-CRC-RA1.
- The duration of the C-MSG-RA signal should be 6 symbol periods.

4.3.4.5 Test # 4.064

Test Label: c_reverb_ra.ees.exchange.atu_c.dmt.adsl

Purpose: To verify that the ATU-C enters the C-CRC-RA2 state immediately following state C-MSG-RA, and from state C-CRC-RA2 to state C-REVERB-RA.

References: ANSI T1.413-1998 sections 9.8.6 and 9.8.7.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: C-CRC-RA2 is a cyclic redundancy check for the detection of errors in the reception of C-MSG-RA at the ATU-R. Its relation to C-MSG-RA is the same as C-CRC3 is to C-MSG2. It will be transmitted in 2 symbols, where each symbol is 8-bits long. Following state C-CRC-RA2 is state C-REVERB-RA.

C-REVERB-RA is the same a C-REVERB4. The ATU-C will timeout within 4000 symbols and reset to C-QUIET1 if R-SEGUE-RA is not detected from the ATU-R. If the ATU-C detects R-CRC4, it will transmit C-REVERB-RA for at least another 80 symbols before moving to state C-SEGUE-RA.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C and continue initialization.
- Set bit 15 =1 of message C-MSGS1 and message R-MSGS1 for EES mode.
- Allow C-REVERB-RA to time out at 4000 symbol periods.

Observable Results:

- The ATU-C should enter the state C-CRC-RA2 immediately following state C-MSG-RA.
- The duration of C-CRC-RA2 should be 2 symbol periods.
- The ATU-C should enter the state C-REVERB-RA immediately following state C-CRC-RA2.
- The ATU-C should reset to state C-QUIET1 within 4000 symbols if R-SEGUE-RA is not detected.
- The ATU-C should transmit C-REVERB-RA for at least another 80 symbols before shifting to state C-SEGUE-RA.

4.3.4.6 Test # 4.065

Test Label: c_msgs2.exchange.atu_c.dmt.adsl

Purpose: To verify that state C-SEGUE-RA immediately follows state C-REVERB-RA. Also to test if C-MSGS2 immediately follows state C-SEGUE-RA if EES is selected in state C-SEGUE2, or if C-MSGS2 immediately follows state C-SEGUE2 if EES is not selected.

References: ANSI T1.413-1998 sections 9.8.8 and 9.8.9.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: C-SEGUE-RA is the same as C-SEGUE2. C-SEGUE-RA will transition to state C-MSGS2. If EES is not selected while in state C-MSGS1, the transition will be from state C-SEGUE2 to state C-MSGS2. State C-MSGS2 sends a 32-bit signal to the ATU-R. This message specifies the total number of bits per symbol supported, the performance margin with the selected rate option, and the estimated upstream loop attenuation. The message is defined as m = {*m31,m30,.....,m1,m0*}, where m0 is transmitted first. The table below shows the bit assignments for the 32-bit message.

Suffix(ces) of *mi*	Parameter
31-26	Estimated average loop attenuation
25-21	Reserved for future use (set to 0)
20-16	Performance margin with selected rate option
15-9	Reserved for future use (set to 0)
8-0	Total number of bits supported

Estimated average upstream loop attenuation is the calculation of the upstream channel gain of each sub-channel for computing the SNR for each tone and also the calculation of the average loop attenuation. The performance margin with selected rate option field is where the ATU-C selects one of the rates options sent from the ATU-C during C-RATES1 if EES was not selected or during C-RATES-RA if EES was selected. The total number of bits supported field is where the ATU-C receiver calculates the maximum number of bits per symbol the upstream channel can support with the performance margin defined locally (oam interface) at an error rate of 10^{-7} . For more information, refer to reference standard section C-MSGS2.

This signal is transmitted in 4 symbol periods, where each symbol is 8-bits long. The least significant byte of the signal is sent first. The ATU-C will enter state C-CRC3 following state C-MSGS2.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C and continue initialization.
- Set bit 15 =1 of message C-MSGS1 and message R-MSGS1 for EES mode.
- Repeat this process, only setting bit 15 of message C-MSGS1 or message R-MSGS1 = 0 .
- Possibly test 32-bit pattern transmitted by ATU-C while in state C-MSGS2.

Observable Results:

- The ATU-C should enter the state C-SEGUE-RA immediately following state C-REVERB-RA.
- The duration of C-SEGUE-RA should be 10 symbol periods.
- The ATU-C should enter the state C-MSGS2 immediately following state C-SEGUE-RA if EES is selected in state C-MSGS1.
- The ATU-C should enter the state C-MSGS2 immediately following state C-SEGUE2 if SES is selected.
- The duration of C-MSGS2 should be 4 symbol periods.
- The signal transmitted by the ATU-C during state C-MSGS2 should be 32-bits.

4.3.4.7 Test # 4.066

Test Label: c_crc3.exchange.atu_c.dmt.adsl

Purpose: To verify that the ATU-C enters the C-CRC3 state immediately following state C-MSGS2.

References: ANSI T1.413-1998 section 9.8.10.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: State C-CRC3 is a cyclic redundancy check for the detection of errors in the reception of the C-MSGS2 signal at the ATU-R. The cyclic redundancy check polynomials g(D) and c(D) are the same as in state C-CRC1 (refer to reference standard section 9.6.3). The 16-bit signal transmitted by the ATU-C during state C-CRC3 has a duration of 2 symbol periods, where each symbol is 8-bits long. After the ATU-C has finished transmitting C-CRC3, it will enter state C-RATES2.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C and continue initialization.

Observable Results:

- The ATU-C should enter the state C-CRC3 immediately following state C-MSGS2.
- The duration of C-CRC3 should be 2 symbol periods.

4.3.4.8 Test # 4.067

Test Label: c_rates2.exchange.atu_c.dmt.adsl

Purpose: To verify that the ATU-C enters the C-RATES2 state immediately following state C-CRC3.

References: ANSI T1.413-1998 section 9.8.11.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signal
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: If EES is used C-RATES2 is the reply to R-RATES-RA. If SES is used C-RATES2 is the reply to R-RATES1. C-RATES2 combines the selected upstream option and the selected downstream option, thus being the final decision on the rates to be transmitted in both directions. However, the ATU-C can change the downstream option that was selected in R-RATES2. The C-RATES2 signal is 8-bits long; the bit patterns are as shown in the table below.

(Downstream, Upstream)	Bit pattern for C-RATES2 (MSB first)
(option 1, option 1)	00010001
(option 1, option 2)	00010010
(option 1, option 3)	00010100
(option 1, option 4)	00011000
(option 2, option 1)	00100001
(option 2, option 2)	00100010
(option 2, option 3)	00100100
(option 2, option 4)	00101000
(option 3, option 1)	01000001
(option 3, option 2)	01000010
(option 3, option 3)	01000100
(option 3, option 4)	01001000
(option 4, option 1)	10000001
(option 4, option 2)	10000010
(option 4, option 3)	10000100
(option 4, option 4)	10001000
All options fail	00000000

Other bit patterns are not specified and will be for later use. If the options are requested during C-RATES1 or C-RATES-RA (EES) cannot be implemented, the ATU-C will return to state C-QUIET1 for retraining. C-RATES2 lasts for only one symbol period. The ATU-C should transition to state C-CRC3.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C and continue initialization.
- Set bit 15 =1 of message C-MSGS1 and message R-MSGS1 for EES mode.
- Try again, setting bit 15 = 0 of message C-MSGS1 or message R-MSGS1 for SES mode.

- Test the bit pattern transmitted by the ATU-C while in state C-RATES2.
- Retry again, this time (if possible) set states C-RATES2 or C-RATES-RA so none of the options requested can be implemented. Try this for both with EES and SES.

Observable Results:

- The ATU-C should enter the state C-RATES2 immediately following state C-CRC3.
- The duration of C-CRC-RA2 should be 1 symbol period.
- The ATU-C should enter the state C-QUIET1 if states C-RATES2 or C-RATES-RA select none of the options.

4.3.4.9 Test # 4.068

Test Label: c_crc4.exchange.atu_c.dmt.adsl

Purpose: To verify that the ATU-C enters the C-CRC4 state immediately following state C-RATES2.

References: ANSI T1.413-1998 section 9.8.12.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: C-CRC4 is a cyclic redundancy check for the detection of errors in the reception of C-RATES2 at the ATU-R. The relationship between C-CRC4 and C-RATES2 is the same as C-CRC3 and C-MSGS2. State C-CRC4 transmits a 16-bit signal in 2 symbol periods, where each symbol is 8-bits long. The ATU-C will enter state C-B&G following state C-CRC4.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C and continue initialization.

Observable Results:

- The ATU-C should enter the state C-CRC4 immediately following state C-RATES1.
- The duration of C-CRC4 should be 2 symbol periods.

4.3.4.10 Test # 4.069

Test Label: c_b&g.exchange.atu_c.dmt.adsl

Purpose: To verify that the ATU-C enters the C-B&G state immediately following state C-CRC4.

References: ANSI T1.413-1998 section 9.8.13.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: State C-B&G is used to transmit to the ATU-R the bits and gains information which are used on the upstream carriers. They have the form {b1,g1,b2,g2,....,b31,g31}. b*i* indicates the number of bits to be coded by the ATU-R transmitter onto the *i* th upstream carrier. b*i* is represented as an unsigned 4-bit integer with the index of 0 to Nmax. Nmax is the maximum number of bits that the ATU-R is prepared to adjust onto any sub-carrier (communicated in R-MEDLEY).

g*i* defines the scale factor, relative to the gain that was used for that carrier during the transmission of R-MEDLEY, that will be applied to the *i* th upstream carrier. Every g*i* will be a 12-bit fixed-point number in which the binary point is placed just before the third msb. As a quick example, let's say g*i* was 001.010000000.

b0,g0 and b32,g32 are presumed zero and not transmitted because no bits or energy will be transmitted at DC or one-half sampling rate. b16 will be set to 0 and g16 will be set to 1 because sub-carrier 16 is reserved as pilot carrier. For more information, refer to reference standard section 9.8.13.

The C-B&G information will be mapped into a 496-bit message defined by the expression m = {m495,m494,....,m1,m0} = {g31,b31,....,g1,b1}. Transmitted first is m0, while the msb g*i* and b*i* in the higher m index. The duration of C-B&C will be 62 symbol periods, where each symbol is 8-bits long. The ATU-C will then enter state C-CRC5.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C and continue initialization.

Observable Results:

- The ATU-C should enter the state C-B&G immediately following state C-CRC4.
- The duration of C-B&G should be 62 symbol periods.
- Possibly observe the g*i* and b*i* bit patterns.

4.3.4.11 Test # 4.070

Test Label: c_crc5.exchange.atu_c.dmt.adsl

Purpose: To verify that the ATU-C enters the C-CRC5 state immediately following state C-B&G.

References: ANSI T1.413-1998 section 9.8.14.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: C-CRC5 is a cyclic redundancy check for the detection of errors in the reception of C-B&G at the ATU-R. The relationship between C-CRC5 and C-B&G is the same as C-CRC3 and C-MSGS2. State C-CRC5 transmits a 16-bit signal in 2 symbol periods, where each symbol is 8-bits long. The ATU-C will then enter the state C-REVERB5.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C and continue initialization.

Observable Results:

- The ATU-C should enter the state C-CRC5 immediately following state C-B&G.
- The duration of C-CRC5 should be 2 symbol periods.

4.3.4.12 Test # 4.071

Test Label: c_reverb5.exchange.atu_c.dmt.adsl

Purpose: To verify that the ATU-C enters the C-REVERB5 state immediately following state C-CRC5.

References: ANSI T1.413-1998 section 9.8.15.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: State C-REVERB5 is basically the same as C-REVERB4 except for the fact that the maximum duration of C-REVERB5 is 4000 symbol periods. The duration of C-REVERB5 depends on the state of the ATU-R and the internal processing of the ATU-C. C-REVERB5 will be transmitted by the ATU-C until it has received, checked the reliability of, and established in the ATU-C transmitter the downstream bits and gains information contained in the R-B&G signal. If this does not occur within 4000 symbol periods, the ATU-C will timeout and reset to C-QUIET1. As soon as the ATU-C prepared to transmit according to the conditions specified in R-B&G, it will enter the state C-SEGUE3.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C and continue initialization.
- Retry this again, only this time make sure ATU-C does not receive the R-B&G signal within 4000 symbol periods.

Observable Results:

- The ATU-C should enter the state C-REVERB5 immediately following state C-CRC5.
- The duration of C-REVERB5 depends on the state of the ATU-R and the internal processing of the ATU-C.
- The ATU-C should timeout to state C-QUIET1 if R-B&G is not received, checked and established within 4000 symbol periods.

4.3.4.13 Test # 4.072

Test Label: c_segue3.exchange.atu_c.dmt.adsl

Purpose: To verify that the ATU-C enters the C-SEGUE3 state immediately following state C-REVERB5.

References: ANSI T1.413-1998 section 9.8.16.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C
- Device capable of capturing and viewing the output of the ATU-C

Discussion: The purpose of state C-SEGUE3 is to notify the ATU-R that the ATU-C is about to enter the steady-state signalling state C-SHOWTIME. The signal C-SEGUE3 is the same as the signal C-SEGUE2. C-SEGUE3 lasts for 10 symbol periods. The ATU-C will then enter the state C-SHOWTIME, signifying that initialization has been completed.

Test Setup: Test setup 2.

Procedure:

- Reset the ATU-C and continue initialization.

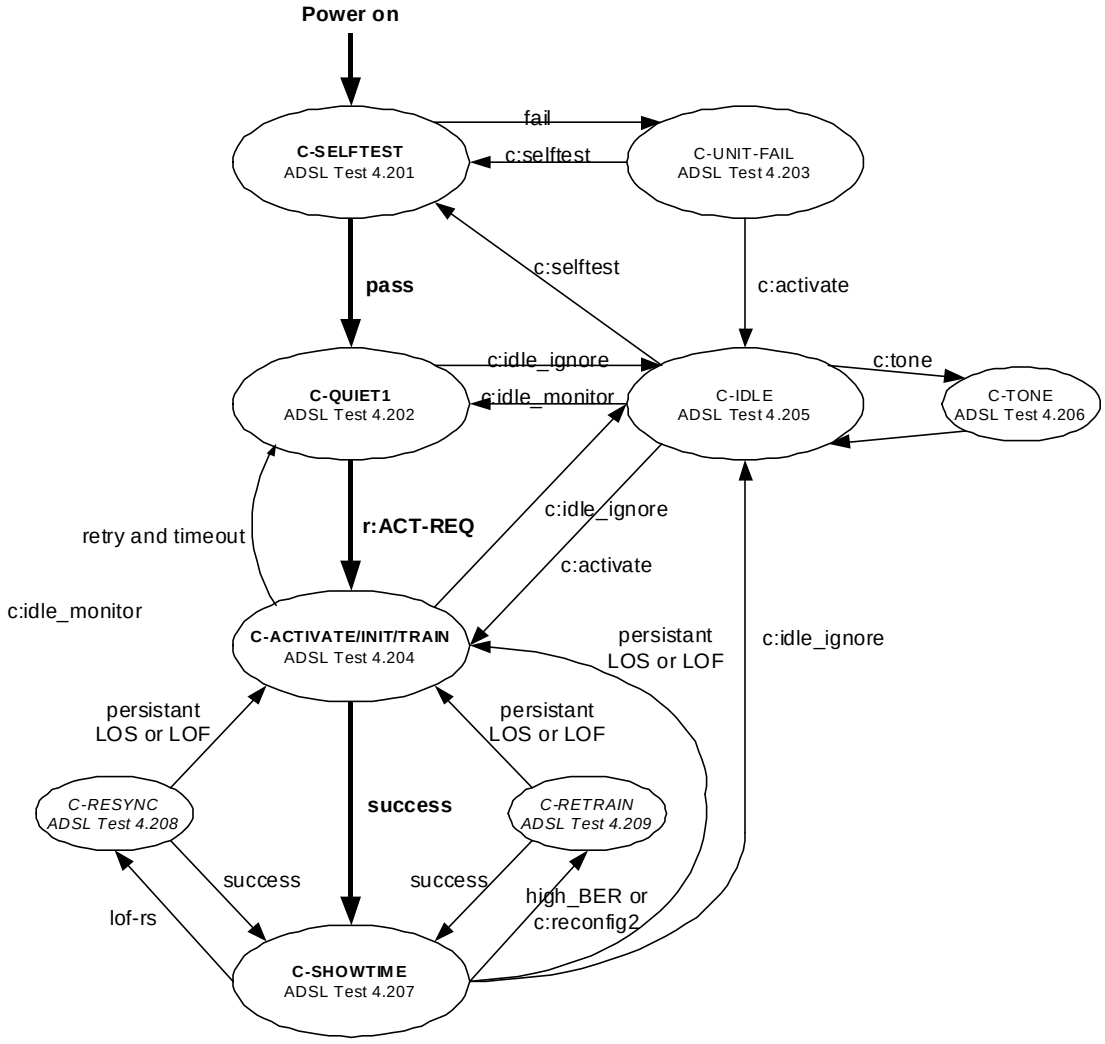
Observable Results:

- The ATU-C should enter the state C-SEGUE3 immediately following state C-REVERB5.
- The duration of C-SEGUE3 should be 10 symbol periods.
- The ATU-C should enter the state C-SHOWTIME after C-SEGUE3 has been completed.

4.3.5 ATU-C State Transitions

Scope: These tests cover the basic state transitions in the ATU-C required for interoperability with other interpretations of ANSI T1.413-1998.

Overview: These tests are designed to provide a basic layout of the states that need to be supported in order for some degree of interoperability capability to be achieved. A device that "passes" these tests provides a reasonable indication of normal operation procedure conformance to ANSI T1.413-1998 from power-up to steady state data transmission. Although correct exchange of initialization signals are necessary for interoperation, most of these procedures are contained within only one of the ATU-C's states. The state diagram for the ATU-C is shown below, with optional states and tests shown in italics, received signals from the ATU-R are preceded with a r:, and host controller command signals are preceded with a c:



4.3.5.1 Test # 4.201

Test Label: c_selftest.state_machine.atu_c.dmt.adsl

Purpose: To verify the state transitions while the ATU-C is in the C-SELFTEST state.

References: ANSI T1.413-1998 Annex A.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C

Discussion: Upon power-up, the ATU-C shall enter the C-SELFTEST state. Performing an actual diagnostic test during the C-SELFTEST state is optional, however, a SELFTEST state must exist. If the device performs a diagnostic test and "passes" the device shall enter the C-QUIET1 state. If, however, the devices "fails" the diagnostic test it shall enter the C-UNIT-FAIL state. If the vendor decides not to perform a diagnostic test during the C-SELFTEST state, the device may automatically "pass" and continue to the C-QUIET1 state at the vendor's discretion.

The state diagram for the ATU-C is shown in the test header.

Test Setup: Test Setup 3.

Procedure:

- Power up the UUT.

Observable Results:

- Depending on the vendor's implementation, the UUT shall advance to the C-UNIT-FAIL state only if a diagnostic test was performed and the unit failed. Otherwise, the UUT shall enter the C-QUIET1 state if a) the UUT performed a diagnostic test and passed, or b) the vendor chose not perform a diagnostic at all.

4.3.5.2 Test # 4.202

Test Label: c_quiet1.state_machine.atu_c.dmt.adsl

Purpose: To verify the state transitions while the ATU-C is in the C-QUIET1 state.

References: ANSI T1.413-1998 Annex A.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C

Discussion: Upon power up, the ATU-C shall transition from the C-SELFTEST state to the C-QUIET1 state only if the UUT has passed an optional diagnostic self test, or if the vendor has decided not to include a diagnostic test in their implementation.

While in the C-QUIET1 state, the ATU-C shall monitor for a host control command signal or for an activation request by the ATU-R. The host control command signal c:idle_ignore shall cause the ATU-C to transition from the C-QUIET1 state to the C-IDLE state. Upon reception of the R-ACT-REQ signal the ATU-C to enter the C-ACTIVATE/INIT/TRAIN state in which normal initialization procedures take place. No other events shall cause the ATU-C to transition from the C-QUIET1 state, except, of course, for power loss, in which case the ATU-C shall reenter the C-SELFTEST state. The C-QUIET1 state is, or C-QUIET1 signal, is defined as zero output voltage from the digital to analog converter (*i.e.*, transmitter OFF, receiver ON).

Test Setup: Test setup 3.

Procedure:

- Power up the UUT.
- When the UUT enters the C-QUIET1 state, allow the ATU-R to transmit the R-ACT-REQ signal.
- Power off the UUT and power it back up.
- When the UUT enters the C-QUIET1 state, transmit the host control command signal c:idle_ignore.

Observable Results:

- Upon reception of the R-ACT-REQ signal, the UUT should enter the C-ACTIVAT/INIT/TRAIN state and begin normal initialization procedures.
- When the UUT is reset and the host control command signal is transmitted, the UUT should enter the C-ILDE state.

4.3.5.3 Test # 4.203

Test Label: c_unit_fail.state_machine.atu_c.dmt.adsl

Purpose: To verify the state transitions while the ATU-C is in the C-UNIT-FAIL state.

References: ANSI T1.413-1998 Annex A.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C

Discussion: The ATU-C shall only enter the C-UNIT-FAIL state if the ATU-C fails the optional vendor defined diagnostic self test. While in the C-UNIT-FAIL state, the UUT shall transition back to the C-SELFTEST state if the host control command signal c:selftest is received. The UUT shall also respond to the host control command signal c:activate, in which case it shall transition to the C-IDLE state. Operation during the C-UNIT-FAIL state is vendor discretionary. The UUT may simply monitor the host control channel only, or it may opt to transmit the self test results to the host controller.

Test Setup: Test setup 3.

Procedure:

- Power up the UUT.
- Force the UUT into the C-UNIT-FAIL state, perhaps by disconnecting it from the ATU-R or device acting as the ATU-R.
- Send the host control command signal c:selftest.
- Reset the UUT, forcing the C-UNIT-FAIL state.
- Send the host control command signal c:activate.

Observable Results:

- The UUT should reenter the C-SELFTEST state if the host control command signal c:selftest is received.
- The UUT should enter the C-IDLE state if the host control command signal c:activate is received.

4.3.5.4 Test # 4.204

Test Label: c_activate_init_train.state_machine.atu_c.dmt.adsl

Purpose: To verify the state transitions while the ATU-C is in the C-ACTIVATE/INIT/TRAIN state.

References: ANSI T1.413-1998 Annex A.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C

Discussion: The C-ACTIVATE/INIT/TRAIN state consists of the ATU-C transmitting the C-ACT signal followed by the C-QUIET2 signal. The ATU-C shall continue with normal initialization procedures if the R-ACK (1 or 2) signal is detected within 128 symbol periods (the duration of C-QUIET2). If initialization procedures are successful, the ATU-C shall enter the C-SHOWTIME state, in which normal steady state data transmission takes place. For every attempt at initialization that fails, a counter (initialized upon entrance into the C-ACTIVATE/INIT/TRAIN state) shall be decremented. When the counter reaches zero the ATU-C shall abort initialization and transition back to the C-QUIET1 state. In addition, the host control command signal c:idle_ignore shall cause the ATU-C to transition to the C-IDLE state.

Test Setup: Test setup 3.

Procedure:

- Power up the UUT.
- Send the (or allow passage of) the R-ACT-REQ signal, forcing the c-ACTIVATE/INIT/TRAIN state.
- Send the host control command signal c:idle_ignore while in the C-ACTIVATE/INIT/TRAIN state.
- Reset the ATU-C, forcing the C-ACTIVATE/INIT/TRAIN state.
- Disrupt the initialization process (powering down the ATU-R perhaps) until the ATU-C initialization fail counter reaches zero.
- Reset the ATU-C, forcing the C-ACTIVATE/INIT/TRAIN state.
- Allow the ATU-C to continue with normal initialization procedures.

Observable Results:

- The ATU-C should transition to the C-IDLE state from the C-ACTIVATE/INIT/TRAIN state if the host control command signal c:idle_ignore is received. The C-DILE state is physically identical to the C-QUIET1 state (*i.e.*, transmitter/receiver off, 0Voutput from the DAC) except that while in the C-IDLE state the ATU-C shall not respond to the R-ACT-REQ signal.
- The ATU-C should transition to back to the C-QUIET1 state from the C-ACTIVATE/INIT/TRAIN state if the initialization procedures fail more than a specified number of times (*i.e.*, the initial number of the initialization fail counter).
- The ATU-C should transition to the C-SHOWTIME state from the C-ACTIVATE/INIT/TRAIN state if initialization procedures are successful.

4.3.5.5 Test # 4.205

Test Label: c_idle.state_machine.atu_c.dmt.adsl

Purpose: To verify the state transitions while the ATU-C is in the C-IDLE state.

References: ANSI T1.413-1998 Annex A.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C

Discussion: The C-IDLE signal is transmitted indefinitely until the appropriate host control command signal is transmitted, and is physically identical to the C-QUIET1 signal – transmitter and receiver OFF, 0V output from the digital to analog converter. The difference between the C-QUIET1 state and the C-IDLE state is that the UUT shall not respond to the R-ACT-REQ signal while in the C-IDLE state. The ATU-C is essentially ignoring the ATU-R while in the C-IDLE state.

In the C-IDLE state, the UUT shall respond only to host controller command signals. The UUT shall transition from the C-IDLE state to the C-SELFTEST state if the c:selftest host control command signal is received. The UUT shall transition from the C-IDLE state to the C-ACTIVATE/INIT/TRAIN state if the c:activate host control command signal is received. The UUT shall transition from the C-IDLE state to the C-TONE state if the c:tone host control command signal is received. The UUT shall transition from the C-IDLE state to the C-QUIET1 state if the c:idle_monitor host control command signal is received.

Test Setup: Test setup 3.

Procedure:

- Power up the UUT.
- Force the C-IDLE state by advancing to the C-QUIET1 state and transmitting the host control command signal c:idle_ignore.
- Transmit the host control command signal c:selftest while in the C-IDLE state.
- Repeat, transmitting the host controller command signals c:activate, c:tone, and c:idle_monitor, respectively, in place of c:selftest.

Observable Results:

- The UUT shall transition from the C-IDLE state to C-SELFTEST, C-ACTIVATE/INIT/TRAIN, C-TONE, and C-QUIET1 states respectively.

4.3.5.6 Test # 4.206

Test Label: c_tone.state_machine.atu_c.dmt.adsl

Purpose: To verify the state transitions while the ATU-C is in the C-TONE state.

References: ANSI T1.413-1998 Annex A.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C

Discussion: The C-TONE signal is defined as a single frequency sinusoid at 310.5kHz. This state is entered to notify the ATU-R not to transmit the R-ACT-REQ signal. The C-TONE signal is transmitted for 128 consecutive symbols, such that the PSD is –3.65dBm for the first 64 symbols and 24dB lower for the second 64 symbols. The UUT shall transition from the C-TONE state to the C-IDLE state if the c:tone host control command signal is received.

Test Setup: Test setup 3.

Procedure:

- Power up the UUT.
- Force the C-TONE state by entering the C-QUIET1 state and transmitting the c:idle_ignore host control command signal, followed by transmitting the c:tone host control command signal from the C-IDLE state.
- Issue the c:tone host control command signal from the C-TONE state.

Observable Results:

- The UUT shall transition from the C-TONE to the C-IDLE state upon reception of the c:tone host control command signal.

4.3.5.7 Test # 4.207

Test Label: c_showtime.state_machine.atu_c.dmt.adsl

Purpose: To verify the state transitions while the ATU-C is in the C-SHOWTIME state.

References: ANSI T1.413-1998 Annex A.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C

Discussion: The C-SHOWTIME state is where steady state data transmission occurs. The UUT shall enter the C-SHOWTIME state from the C-ACTIVATE/INIT/TRAIN state upon successful completion of normal initialization procedures. The UUT may also enter the C-SHOWTIME state from the optional vendor defined states C-RSYNC and C-RETRAIN. While in the C-SHOWTIME state the UUT shall monitor the host control channel and transition to the C-IDLE state if the c:idle_ignore host control command signal is received. The UUT shall also transition to the C-QUIET1 state if the c:idle_monitor host control command signal is received. In addition, the UUT shall monitor for eoc and aoc alarms, and shall reenter the C-ACTIVATE/INIT/TRAIN state if a persistent loss of signal (LOS) or loss of frame (LOF) is detected. Persistent LOS and LOF are declared after 2.5 ± .5 seconds of near end (UUT end) LOS or LOF failure with los (loss of signal) or sef (severely errored frame) defect still present. The los and sef defects are operations and maintenance signals.

The UUT shall also transition from the C-SHOWTIME state to the optional vendor discretionary C-RETRAIN state if a high bit error ratio (BER) is detected or the c:reconfig2 host control command signal is issued, or C-RESYNC state if a loss of frame resync/sync (lof-rs) is required by the UUT.

Test Setup: Test setup 3.

Procedure:

- Power up the UUT.
- Force the C-SHOWTIME state by entering the C-QUIET1 state and transmitting (or allowing passage of) the R-ACT-REQ signal, followed by the success completion of normal initialization procedures in the C-ACTIVATE/INIT/TRAIN state.
- While in the C-SHOWTIME state, transmit the c:idle_ignore host control command signal.
- Repeat, transmitting the c:idle_monitor host control command signal in place of c:idle_ignore.
- Repeat, creating and LOS or LOF failure (*i.e.,* disconnecting the transmission line, *etc.*).
- If the C-RESYNC state is implemented by the vendor, create a lof-rs.
- If the C-RETRAIN state is implemented by the vendor, issue the host control command signal c:reconfig2 or create a high BER.

Observable Results:

- The UUT shall transition from the C-ACTIVATE/INIT/TRAIN state to the C-SHOWTIME state upon successful completion of normal initialization procedures.
- The UUT shall transition from the C-SHOWTIME state to the C-IDLE state if the c:idle_ignore host control command signal is transmitted.
- The UUT shall transition from the C-SHOWTIME state to the –QUIET 1 state if the c:idle_monitor host control command signal is received.

- The UUT shall transition from the C-SHOWTIME state to the C-ACTIVATE/INIT/TRAIN state, for retraining, after $2.5 \pm .5$ seconds of LOS or LOF.
- The UUT shall transition from the C-SHOWTIME state to the C-RESYNC state, if it is defined, if lof-rs is detected.
- The UUT shall transition from the C-SHOWTIME state to the C-RETRAIN state, if it is defined, if the host control command signal c:reconfig2 is transmitted or a high BER is detected.

4.3.5.8 Test # 4.208

Test Label: c_resync.state_machine.atu_c.dmt.adsl

Purpose: To verify the state transitions while the ATU-C is in the optional vendor defined C-RESYNC state.

References: ANSI T1.413-1998 Annex A.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C

Discussion: The C-RESYNC state is an optional vendor defined state entered only if some algorithm, possibly based on loss of ADSL sync framing, determines that resynchronization is required. The UUT should declare a sef, and if the signal is present, meaning that LOS did not occur, attempt to find and align the synchronization pattern. If the attempt at re-synchronization is successful, the sef shall be lifted and the UUT shall enter the C-SHOWTIME state. If, however, the attempt is unsuccessful, the UUT should timeout on the sef and declare an LOF failure (persistent LOF). The UUT should then enter the C-ACTIVATE/INIT/TRAIN state for retraining. If an LOS was detected while in the C-RESYNC state, the UUT should timeout on the los and declare an LOS failure (persistent LOS). The UUT should then enter then enter the C-ACTIVATE/INIT/TRAIN state for retraining.

Test Setup: Test setup 3.

Procedure:

- Power up the UUT.
- Force the C-SHOWTIME state.

Observable Results:

- If an lof-rs occur, the UUT should enter the C-RESYNC state.
- If in the C-RESYNC state, the UUT should re-enter the C-SHOWTIME state if the synchronization pattern is recovered; else if persistent LOF or LOS is detected the UUT should enter the C-ACTIVATE/INIT/TRAIN state.

4.3.5.9 Test # 4.209

Test Label: c_retrain.state_machine.atu_c.dmt.adsl

Purpose: To verify the state transitions while the ATU-C is in the optional vendor defined C-RETRAIN state.

References: ANSI T1.413-1998 Annex A.

Resource Requirements:

- ATU-C unit (UUT)
- Device capable of generating ATU-R signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-C

Discussion: The C-RETRAIN state is an optional vendor defined state entered only if the received signal is still present and ADSL frame synchronization is maintained. The C-RETRAIN state can be automatically entered if the UUT detects a high BER or if the host control command signal c:reconfig2 is transmitted. The UUT should declare a sef, and if the signal is present, meaning that LOS did not occur, channel ID and data transport calculations shall be made. If the attempt at fast retraining is successful, the sef shall be lifted and the UUT shall enter the C-SHOWTIME state. If, however, the attempt is unsuccessful, the UUT should timeout on the sef and declare an LOF failure (persistent LOF). The UUT should then enter the C-ACTIVATE/INIT/TRAIN state for retraining. If an LOS was detected while in the C-RETRAIN state, the UUT should timeout on the los and declare an LOS failure (persistent LOS). The UUT should then enter then enter the C-ACTIVATE/INIT/TRAIN state for retraining.

Test Setup: Test setup 3.

Procedure:

- Power up the UUT.
- Transmit the c:reconfig2 host control command signal.

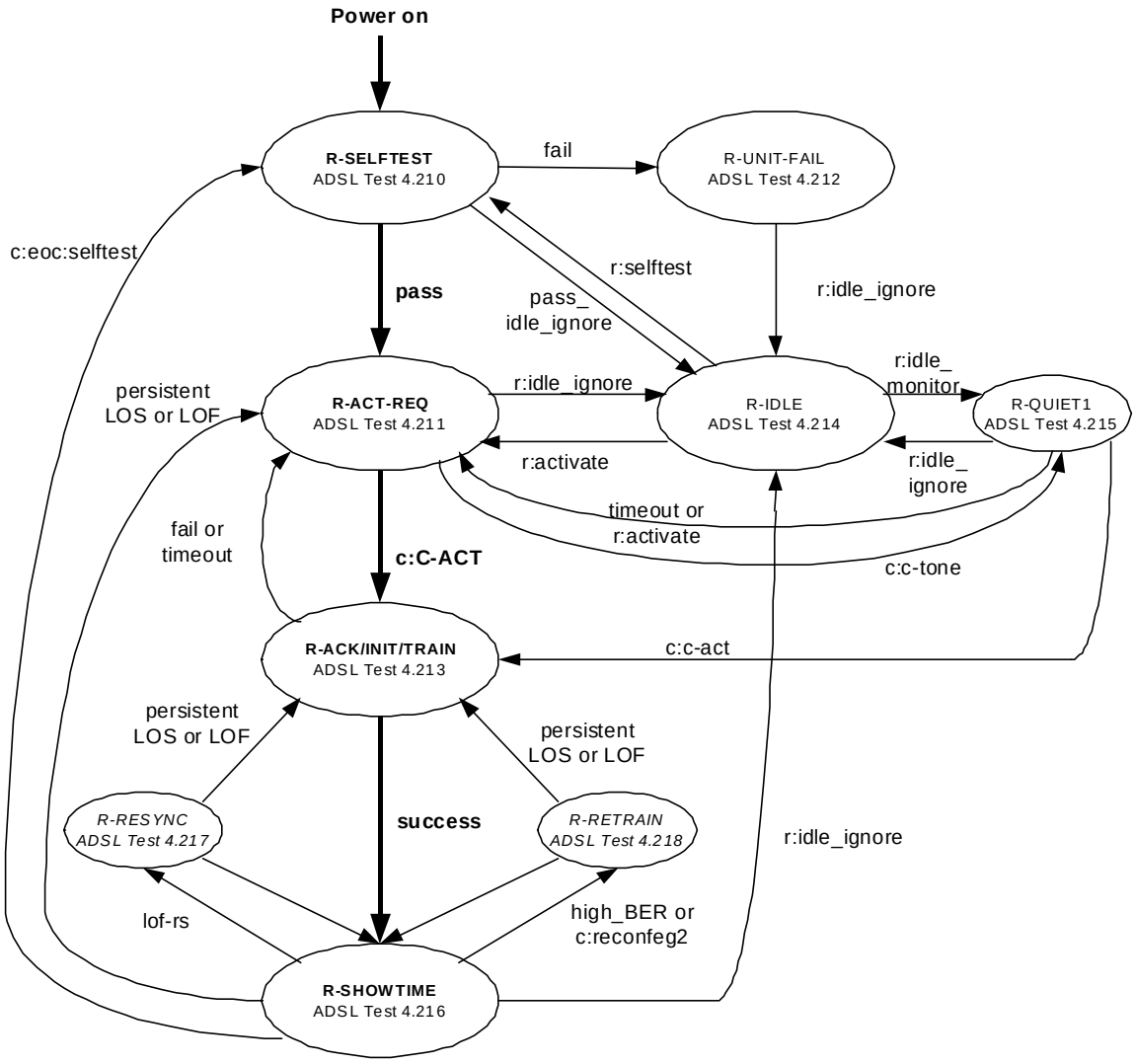
Observable Results:

- The UUT should enter the C-RETRAIN state if the host control command signal c:reconfig2 is received.
- If in the C-RETRAIN state, the UUT should re-enter the C-SHOWTIME state if the fast retrain is successful; else if persistent LOF or LOS or the fast retrain is not successful, the UUT should enter the C-ACTIVATE/INIT/TRAIN state.

4.3.6 ATU-R State Transitions

Scope: These tests cover the basic state transitions in the ATU-R required for interoperability with other interpretations of ANSI T1.413-1998.

Overview: These tests are designed to provide a basic layout of the states that need to be supported in order for some degree of interoperability capability to be achieved. A device that "passes" these tests provides a reasonable indication of normal operation procedure conformance to ANSI T1.413-1998 from power-up to steady state data transmission. Although correct exchange of initialization signals are necessary for interoperation, most of these procedures are contained within only one of the ATU-R's states. The state diagram for the ATU-R is shown below, with optional states and tests shown in italics, and received signals from the ATU-C preceded with a c:, while transmitted signals from the ATU-R are preceded with a r:.



4.3.6.1 Test # 4.210

Label: r_selftest.state_machine.atu_r.dmt.adsl

Purpose: To verify that state R-SELFTEST transitions to the proper states at the proper times.

References: ANSI T1.413-1998 Annex A

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-R

Discussion: When the ATU-R is powered up it will enter state R-SELFTEST. The ATU-R will test its components to make sure it will work properly. While in this state the transmitter and receiver will be turned off (quiet at the U-R interface). If the receiver is in automatic training mode and has passed the selftest, then the ATU-R will transition to state R-ACT-REQ. If the receiver is controlled from and external device and has passed the selftest, then the ATU-R will transition to state R-IDLE. If ATU-R does not pass the selftest, then is will transition to state R-UNIT-FAIL.

The state machine diagram for the ATU-R is shown in the section header.

Test Setup: Test setup 3.

Procedure:

- Power up the ATU-R.
- Set ATU-R in automatic training mode.
- Try this again, only set the ATU-R for external control.

Observable Results:

- Transmitter and receiver should be off.
- If the selftest passes, the ATU-R should enter state R-ACT-REQ if in automatic training mode, or R-IDLE if under external control. If the ATU-R fails the selftest, it should enter state R-UNIT-FAIL.

4.3.6.2 Test # 4.211

Label: r_act_req.state_machine.atu_r.dmt.adsl

Purpose: To verify that state R-ACT-REQ transitions to the proper states at the proper times.

References: ANSI T1.413-1998 Annex A

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-R

Discussion: While in the R-ACT-REQ state, the ATU-R will transmit a 34.5 kHz signal. This is for the case when it is desired by the user to establish a communications link. The signal will be transmitted for 128 DMT symbols, then 896 DMT symbols of silence. This process is repeated until one of two signals from the ATU-C is received. If the signal C-ACT was received, then the ATU-R will transition to state R-INIT/TRAIN when all of the C-ACT has been received. If, however, signal C-TONE was received, then the ATU-R will enter stateR-QUIET1.

While in the R-ACT-REQ state, the ATU-R will also monitor the host controller channel. If the host controller sends the signal r: idle_ignore, the ATU-R will enter state R-IDLE.

Test Setup: Test setup 3.

Procedure:

- Power up the ATU-R.
- Continue until state R-ACT-REQ has been achieved.
- Send signal C-ACT signal to ATU-R.
- Try this again, only this time send the C-TONE signal.
- Try this again, only sending the host controller signal r: idle_ignore.

Observable Results:

- The receiver should be turned on.
- The ATU-R should transmit a 34.5 kHz signal for 128 DMT symbols, and then 896 symbols of silence, then repeating this sequence.
- The ATU-R should transition to state R-INIT-TRAIN if C-ACT was detected.
- The ATU-R should transition to state R-QUIET1 if C-TONE was detected.
- The ATU-R should enter state R-IDLE if the host controller sent the signal r: idle_ignore.

4.3.6.3 Test # 4.212

Label: r_unit_fail.state_machine.atu_r.dmt.adsl

Purpose: To verify that state R-UNIT-FAIL transitions to the proper states at the proper times.

References: ANSI T1.413-1998 Annex A

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-R

Discussion: The ATU-R will only enter state R-UNIT-FAIL is if it failed the selftest. Once in state R-UNIT-FAIL, the only way out of this state is for the host controller to send an r: idle_ignore signal. This will cause the ATU-R to enter state R-IDLE.

Test Setup: Test setup 3.

Procedure:

- Power up the ATU-R.
- Somehow cause the ATU-R to fail its selftest.
- While in R-UNIT-FAIL, send host controller signal r: idle_ignore.
- Send other signals such to make sure ATU-R doesn't enter any other state.

Observable Results:

- The ATU-R should enter state R-IDLE if the host controller sends the signal r: idle_ignore.
- The ATU-R should not enter any other state if a signal different than the one above is sent.

4.3.6.4 Test # 4.213

Label: r_ack_init_train.state_machine.atu_r.dmt.adsl

Purpose: To verify that state R-ACK/INIT/TRAIN enters the proper states at the proper times.

References: ANSI T1.413-1998 Annex A

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-R

Discussion: This state represents the initialization process between the ATU-R and the ATU-C. This state begins with the transmission of the R-ACK signal. If the initialization process is a success, then the ATU-R will enter state R-SHOWTIME. If the initialization process were to fail or if any part of the sequence times out, the ATU-R will reenter state R-ACT-REQ.

Test Setup: Test setup 3.

Procedure:

- Power up the ATU-R.
- Allow ATU-R to continue to state R-ACK/INIT/TRAIN.
- For testing initialization steps, see initialization test suite.

Observable Results:

- The ATU-R should enter state R-SHOWTIME if initialization was successful.
- The ATU-R should reenter state R-ACT-REQ if any part of the initialization sequence either fails or times out.

4.3.6.5 Test # 4.214

Label: r_idle.state_machine.atu_r.dmt.adsl

Purpose: To verify that state R-IDLE enters the proper states at the proper times.

References: ANSI T1.413-1998 Annex A

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-R

Discussion: The main purpose of state R-IDLE is to monitor the host controller channel. The receiver and transmitter will be turned off while in this state. Several different host controller signals will cause R-IDLE to enter several different states. Below is a table that identifies these host controller signals and their respective state transitions.

Host Controller Signal	New State
r: selftest	R-SELFTEST
r: idle_monitor	R-QUIET1
r: activate	R-ACK-REQ

Test Setup: Test setup 3.

Procedure:

- Power up the ATU-R.
- Cause the ATU-R to enter state R-IDLE.
- Send host controller signal r: selftest.
- Retry this again, only this time send the host controller signal r: activate.
- Retry this yet another time, except send the host controller signal r: idle_monitor.

Observable Results:

- The ATU-R should reenter state R-SELFTEST if the host controller sent signal r: selftest.
- The ATU-R should enter state R-ACT-REQ if the host controller sent signal r: activate.
- The ATU-R should enter state R-QUIET1 if the host controller sent signal r: idle_monitor.

4.3.6.6 Test # 4.215

Label: r_quiet1.state_machine.atu_r.dmt.adsl

Purpose: To verify that state R-QUIET1 enters the proper states at the proper times.

References: ANSI T1.413-1998 Annex A

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-R

Discussion: While in state R-QUIET1, the transmitter will be off, and the receiver will be monitoring for the C-ACT signal. If signal C-ACT is received, then R-QUIET1 wills transition to state R-ACK/INIT/TRAIN. Once R-QUIET1 has begun, a timer will start. If C-ACT is not detected within 60 seconds, R-QUIET1will timeout and enter state R-ACT-REQ. State R-QUIET1 also monitors the host controller channel. The ATU-R will enter state R-IDLE if the host control signal r: idle_ignore is received. The ATU-R will enter state R-ACT-REQ if the host control signal r: activate is received.

Test Setup: Test setup 3.

Procedure:

- Power up the ATU-R.
- Cause the ATU-R to enter state R-QUIET1.
- Allow state R-QUIET1 to time out.
- Retry, this time sending the signal C-TONE to the ATU-R.
- Retry again, sending the host control signal r: idle_ignore.
- Retry again, sending the host control signal r: activate.

Observable Results:

- The ATU-R should enter state R-ACK/INIT/TRAIN if the ATU-C sent signal C-ACT.
- The ATU-R should enter state R-IDLE if the host controller sent signal r: idle_ignore.
- The ATU-R should enter state R-ACT-REQ if the host controller sent signal r: activate.

4.3.6.7 Test # 4.216

Label: r_showtime.state_machine.atu_r.dmt.adsl

Purpose: To verify that state R-SHOWTIME enters the proper states at the proper times.

References: ANSI T1.413-1998 Annex A

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-R

Discussion: This state signifies that steady state data transmission is taking place. This means all bit pump, bit swap, and non-intrusive reconfigurations are functioning. The ATU-R monitors alarms, eoc, aoc, and the host control channel. If, however, there is persistent LOS or LOF failure, then R-SHOWTIME will reenter state R-ACT-REQ. The ATU-C could also send through the eoc channel the signal c: eoc: selftest so that the ATU-R will enter state R-SELFTEST. Either a high BER or the c: reconfig2 will cause the ATU-R to enter state R-RETRAIN. If a lof-rs occurs, then R-SHOWTIME will enter R-RESYNC. The host control signal r: idle_ignore will cause R-SHOWTIME to enter state R-IDLE.

Test Setup: Test setup 3.

Procedure:

- Power up the ATU-R.
- Cause the ATU-R to enter state R-SHOWTIME.
- Interrupt R-SHOWTIME operation by choosing either c: eoc: selftest, c: reconfig2, or r: idle_ignore. Do this for each of the described signals.
- While in R-SHOWTIME, cause a high BER, persistent LOS or LOF, or lof-rs. Do this for each of the described problems.

Observable Results:

- The ATU-R should enter state R-ACT-REQ if persistent LOS or LOF occurs.
- The ATU-R should enter state R-SELFTEST if the ATU-C sent the signal c: eoc: selftest.
- The ATU-R should enter state R-RETRAIN if the ATU-C sent signal c: reconfig2.
- The ATU-R should enter state R-RETRAIN if a high BER was detected.
- The ATU-R should enter state R-RESYNC if lof-rs was detected.
- The ATU-R should enter state R-IDLE if the host control signal r: idle_ignore was received.

4.3.6.8 Test # 4.217

Label: r_resync.optional.state_machine.atu_r.dmt.adsl

Purpose: To verify that state R-RESYNC enters the proper states at the proper times.

References: ANSI T1.413-1998 Annex A

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-R

Discussion: The R-RESYNC state is entered when some algorithm based on loss of ADSL sync framing determines that resync is necessary. First, this state will declare a severely errored frame (sef). If the signal is still available, R-RESYNC will attempt to find the sync pattern and realign. If this process is a success, then R-RESYNC will remove the sef then enter state R-SHOWTIME. If this process is not a success, R-RESYNC will time-out on sef, declare LOF failure, and on persistent LOF failure, enter state R-ACK/INIT/TRAIN. However, if there is no signal available, R-RESYNC will time-out on los, declareLOS failure, and enter state R-ACK/INIT/TRAIN.

Test Setup: Test setup 3.

Procedure:

- Power up the ATU-R.
- Cause the ATU-R to enter state R-RESYNC.
- Allow signal to be present so that the ATU-R can look for the sync pattern.
- Try this again, but this time allow the sync pattern not to be found.
- Repeat the process, only allow the signal not to be present.

Observable Results:

- Persistent LOS or LOF should cause R-RESYNC to enter state R-ACK/INIT/TRAIN.
- If attempt to find sync pattern was successful, then R-RESYNC should enter state R-SHOWTIME.

4.3.6.9 Test # 4.218

Label: r_retrain.optional.state_machine.atu_r.dmt.adsl

Purpose: To verify that state R-RETRAIN enters the proper states at the proper times.

References: ANSI T1.413-1998 Annex A

Resource Requirements:

- ATU-R unit (UUT)
- Device capable of generating ATU-C signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the state of the ATU-R

Discussion: State R-RETRAIN can only be entered if received signal is still present and if ADSL sync framing is still maintained. This fast retrain process of this state is still being studied. When in R-RETRAIN a severely errored frame (sef) is declared and user information has been disrupted. Data framing and T-interface circuits will be reset upon entering state R-RETRAIN. If the signal is still available, channel ID and bit allocation calculations will take place. If this process is successful, then R-RETRAIN will remove the sef and enter state R-SHOWTIME. If the process is unsuccessful, R-RETRAIN will time-out on sef, declare LOF failure, on persistent LOF failures R-RETRAIN will transition to state R-ACK/INIT/TRAIN.
However if the signal is lost, R-RETRAIN will time-out on los, declare LOS failure, and on persistent LOS failure R-RETRAIN will enter state R-ACK/INIT/TRAIN.

Test Setup: Test setup 3.

Procedure:

- Power up the ATU-R.
- Cause the ATU-R to enter state R-RETRAIN.
- Allow signal to be present so that the ATU-R can look for the channel ID and bit allocation calculation.
- Try this again, but this time allow the channel ID and bit allocation calculation not to be found and calculated, respectively.
- Repeat the process, only allow the signal not to be present.

Observable Results:

- Persistent LOS or LOF should cause R-RETRAIN to enter state R-ACK/INIT/TRAIN.
- If attempt to find the channel ID and calculate the bit allocation was successful, then R-RETRAIN should enter state R-SHOWTIME.

5. ATM Cell Specific Functionalities (ATM Cell-TC Layer)

Scope: The following tests cover the cell specific functionalities of the ATM cell TC layer. Also included is a test pertaining to the handshake procedure that must take place before an ATM cell is either transmitted or received. These series of tests can be for either ATU.

Overview: These test are designed for the cell specific functions that must occur when an ATM cell is transferred in the transmit direction. Some of these functions include idle cell insertion, header error control (HEC) generation, and cell payload scrambling. Bit timing and ordering must be tested in both transmit and receive directions to ensure proper bit transport. HEC verification and cell delineation must take place at the receiving end so that errors can be corrected and so individual cells can be identified. A cell can only be sent from the ATM layer to the physical layer or vice versa if a cell handshaking procedure occurs between the two layers. A more complicated explanation of the interface elements included in this handshaking procedure can be found in Annex J of the ANSI T1.413-1998 standard. For simplicity, section 6.2.1 of the ANSI T1.413-1998 standard was used instead of the information contained in Annex J.

5.1 Test # 5.001

Test Label: cell_handshake.cell_tc.atm.dmt.adsl

Purpose: To verify that an ATU-C properly initiates and completes the handshaking procedure before sending an ATM cell to the ATM layer. Also to verify if the ATU-C transmits a cell received signal back to the ATM layer.

References: ANSI T1.413-1998 section 6.2.1.

Resource Requirements:

- ATU-R or ATU-C unit (UUT)
- Device capable of generating ATU signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the ATM cell functionality of the UUT

Discussion: At the V-C reference point, the ATU-C will have flow control functionality available. This is so that the ATU-C can control the cell flow to and from the ATM layer, represented in the graphic below by Tx_Cell_Handshake and Rx_Cell_Handshake. A cell can only be transferred from the ATM layer to the ATU-C after the ATU-C has completed Tx_Cell_Handshake. A cell can only be transferred from the ATU-C to the ATM layer after the ATU-C has completed Rx_Cell_Handshake. This is most important in avoiding cell overflow or underflow in the ATU-C and ATM layer. The diagram on the next page shows the basic ATU-C functional interfaces to the ATM layer at the V-C reference point.

Test Setup: Test setup 4.

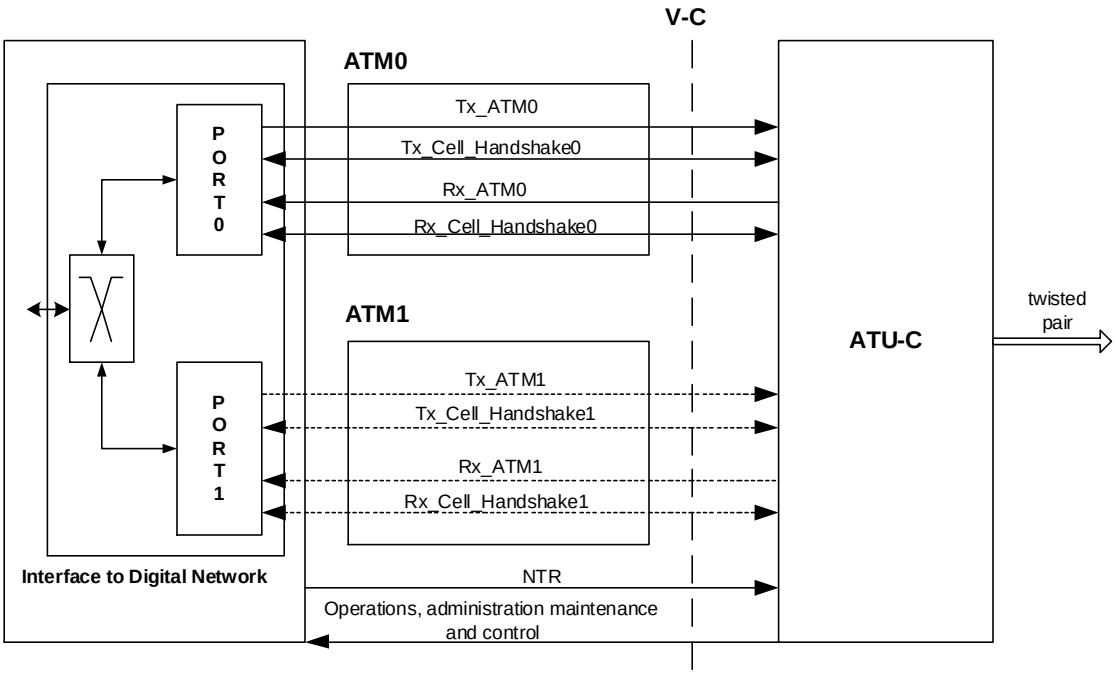
Procedure:

- Send handshake signal to ATM layer specifying that the ATU-C needs to send an ATM cell.
- Send ATM cell to ATM layer.
- Send handshake signal to ATU-C specifying that the ATM layer needs to send an ATM cell.
- Send ATM cell to ATU-C.

Observable Results:

- The ATM layer should send back a signal that indicates that it received the cell.
- The ATU-C should send back a signal that indicates that it received the cell.

Note: dotted interface lines are optional



5.2 Test # 5.002

Test Label: hec_generation.cell_tc.atm.dmt.adsl

Purpose: To verify that an ATU-C (possibly an ATU-R) generates the header error control (HEC) byte of the ATM cell header correctly.

References:

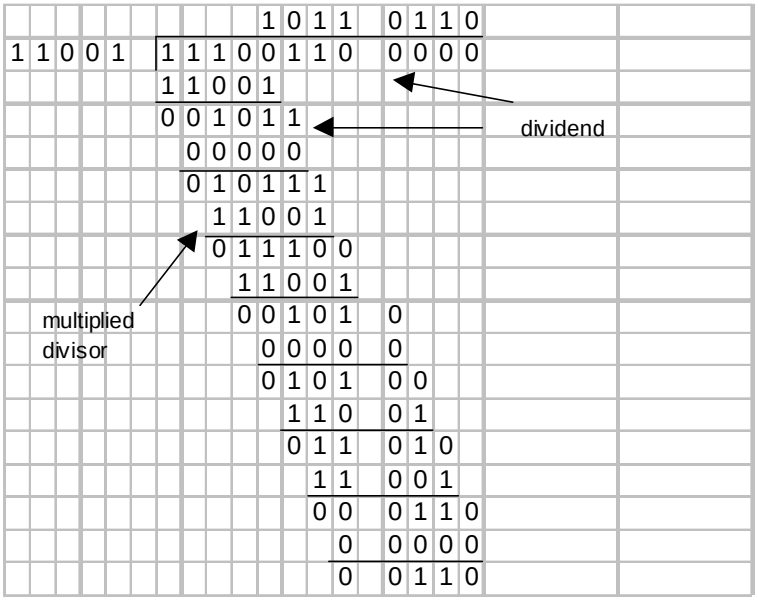
- ANSI T1.413-1998 section 6.2.3.2
- ITU-T Recommendation I.432 section 4.3.2

Resource Requirements:

- ATU-R or ATU-C unit (UUT)
- Device capable of generating ATU signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the ATM cell characteristics of the UUT

Discussion: The transmitter will calculate the HEC value across the entire 4 byte ATM cell header. Then it inserts the calculated value at the end of the 4 bytes for a total length of 5 bytes. The header error control notation is based on the property of cyclic codes. As an example, a code vector such as 10101110 can be represented as the polynomial $P(x) = x^7 + x^5 + x^3 + x^2 + x$. The content of the cell header excluding the HEC byte (32 bits) can also be represented as a polynomial. The first bit of the header would be the coefficient of the highest order term.

The HEC field is calculated by first finding the product of x^8 and the content of the header excluding the HEC field. Then this product is modulo-2 divided by the generator polynomial $x^8 + x^2 + x + 1$. The remainder of this modulo-2 division is the value of the HEC. Here is a quick example of modulo-2 division:



For modulo-2 division, if the msb of the divisor and dividend are 1, then the result is 1, or the result is 0 otherwise. The multiplied divisor is exclusive-ored with the dividend.

The content of the register of the device that computes the remainder or the division is preset to all zeros. It is then modified by the calculation of the remainder. The calculated remainder is then

exclusive-ored with the bit pattern 01010101. Then the new check bits are then inserted into the last byte of the cell header. This operation will not affect the error detection/correction capabilities of the HEC.

Test Setup: Test Setup 4.

Procedure:

- Reset ATU-C and continue initialization.
- Set ATU-C for ATM mode
- Capture ATM cell.
- Observe HEC value in last byte of the ATM cell header.

Observable Results:

- The HEC byte should be as described above.
- Possibly write test program to calculate the HEC field.

5.3 Test # 5.003

Test Label: cell_delineation.cell_tc.atm.dmt.adsl

Purpose: To verify that the cell delineation function works properly.

References:

- ANSI T1.413-1998 sections 6.2.3.5 and 7.2.2.
- ITU-T Recommendation I.432 section 4.5.1.1

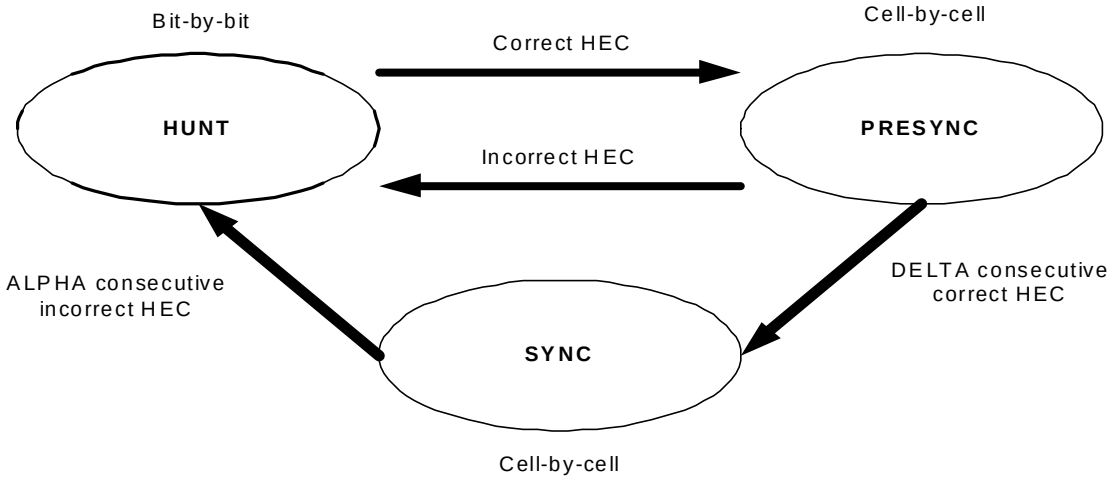
Resource Requirements:

- ATU-R or ATU-C unit (UUT)
- Device capable of generating ATU signals
- Device capable of generating host controller channel commands.
- Device capable of monitoring the ATM cell functionality of the UUT

Discussion:

Cell delineation is a function that identifies cell boundaries in the payload portion of an ATM cell. This is accomplished through the use of the Header Error Control (HEC) in the ATM cell header. A coding law, which checks the HEC in the cell header, will be used to perform cell delineation. The correlation between the 32-bit header, the 8-bit HEC field, and the shortened cyclic code with generating polynomial $x^8 + x^2 + x + 1$ is used in the cell delineation process.

The state machine for cell delineation is shown below.



Stated here are the details of this state diagram.

1. The delineation process is achieved by checking bit by bit whether the HEC coding law is respected (*i.e.*, the process result is zero) for the assumed header field. If the correct HEC is found it is assumed that one header has been found. The state machine then enters state PRESYNC. If byte boundaries are available within the receiving ATU prior to cell delineation as with the framing modes 1, 2, 3, the cell delineation process may be performed byte-byte.
2. The delineation process is performed cell by cell to check for the correct HEC while in the PRESYNC state. The process repeats until the correct HEC has been confirmed DELTA times consecutively. If one incorrect HEC is found, then the process returns to the HUNT state.

3. The delineation process is performed cell by cell to check for the correct HEC while in the SYNC state. The cell delineation process will be assumed to be lost if an incorrect HEC is obtained ALPHA times consecutively.

Test Setup: Test setup 4.

Procedure:

- Send ATM cells to UUT.
- Add incorrect HECs to ALPHA consecutive ATM cells.
- Add correct HECs to DELTA consecutive ATM cells.

Observable Results:

- The UUT should return to the HUNT state if an incorrect HEC is found while in the PRESYNC state.
- The UUT should enter the SYNC state if DELTA consecutive correct HECs are found.
- The cell delineation process should be assumed to be lost if ALPHA consecutive incorrect HECs are found.

5.4 Test # 5.004

Test Label: idle_cell_insertion.cell_tc.atm.dmt.adsl

Purpose: To verify that the cell delineation function works properly.

References:

- ANSI T1.413-1998 section 6.2.3.5 and 7.2.2.
- ITU-T Recommendation I.432 section 4.4

Resource Requirements:

- ATU-R or ATU-C unit (UUT)
- Device capable of generating ATU signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the ATM cell functionality of the UUT

Discussion: Idle cells will be inserted by the ATU-C in the transmit direction for cell rate decoupling. Cell rate decoupling is a function that provides a continuous flow by inserting these idle cells in the data stream. These idle cells will be discarded by the ATU-R. They shall also cause no action in the ATU-R receiver other than cell delineation. Idle cells are identified by the standardized pattern for the cell header, which is shown in the table below.

	Octet 1	**Octet 2**	**Octet 3**	**Octet 4**	**Octet 5**
Header Pattern	00000000	00000000	00000000	00000001	HEC = Valid Code

Test Setup: Test setup 4.

Procedure:

- Reset and continue initialization.
- Send signal to ATU-C such that it inserts idle cells in the down stream direction.
- Make sure both modems are both sets in ATM mode.

Observable Results:

- ATU-C should insert idle cells in the upstream direction.
- The ATU-R should discard these idle cells, causing no action other than cell delineation.
- Each idle cell should have the standardized cell header pattern described on the last page.

5.5 Test # 5.005

Test Label: bit_timing_and_ordering.cell_tc.atm.dmt.adsl

Purpose: To verify proper bit timing and ordering through the bearer channels.

References: ANSI T1.413-1998 section 6.2.3.4

Resource Requirements:

- ATU-R or ATU-C unit (UUT)
- Device capable of generating ATU signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the ATM cell functionality of the UUT

Discussion: When interfacing ATM data bytes to the AS0 or AS1 bearer channel, the most significant bit will be sent first. The AS0 or AS1 bearer channel data rate will be an integer multiple of 32kbits/s, with bit timing derived from the down stream modem clock.

Test Setup: Test Setup 4.

Procedure:

- Reset and continue initialization.
- Send ATM bytes to ATU bearer channel AS0 or AS1.
- Monitor bearer channel data rate.

Observable Results:

- ATM data bytes should be interfaced msb first.
- Data rates of the bearer channels should be of integer multiples of 32kb/s.
- Bit timing should be derived from downstream modem clock.

5.6 Test # 5.006

Test Label: cell_payload_scrambling.cell_tc.atm.dmt.adsl

Purpose: To verify that ATM cell payloads are scrambled and scrambled properly.

References:

- ANSI T1.413-1998 section 6.2.3.3
- ITU-T Recommendation I.432 section 4.5.3

Resource Requirements:

- ATU-R or ATU-C unit (UUT)
- Device capable of generating ATU signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the ATM cell functionality of the UUT

Discussion: To improve the security and robustness of the HEC cell delineation mechanism, the cell TC layer will scramble the cell payload field in the transmit direction. This method also randomizes the data in the data field for possible improvement of the transmission performance.

The self-synchronizing scrambler polynomial (defined as $x^{43} + 1$) has been selected to minimize the error multiplication (two) introduced by the self-synchronizing scrambler. The operation of the scrambler in relation to the HEC cell delineation state diagram is as described below:

- The scrambler randomizes the bits of the information field only
- During the 5 byte header the scrambler operation is suspended and the scrambler state retained.
- The descrambler is disabled in the HUNT state.
- The descrambler is enabled for a number of bits equal to the length of the information field, and again disabled for the following assumed header while in the PRESYNC and SYNC states.

Test Setup: Test Setup 4.

Procedure:

- Reset and continue initialization.
- Send ATM cells to ATU-C.
- Monitor cell payload field scrambling.

Observable Results:

- ATM cell payload fields should be scrambled as described above.

5.7 Test # 5.007

Test Label: hec_verification.cell_tc.atm.dmt.adsl

Purpose: To verify that the ATM cell HEC verification function operates properly.

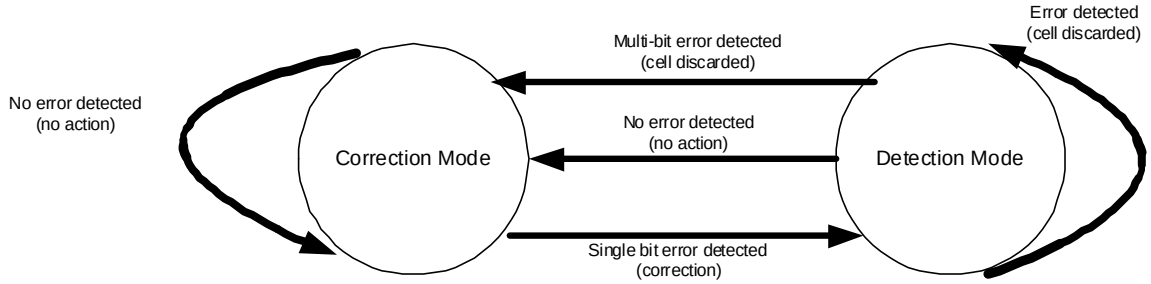
References:

- ANSI T1.413-1998 section 6.2.3.6
- ITU-T Recommendation I.432 section 4.3.1

Resource Requirements:

- ATU-R or ATU-C unit (UUT)
- Device capable of generating ATU signals
- Device capable of generating host controller channel commands
- Device capable of monitoring the ATM cell functionality of the UUT

Discussion: The header error control covers the entire cell header. The code implemented for the function is capable of either single-bit error correction or multiple-bit error detection. The default mode provides for single-bit error correction. If an error is detected, the action to be taken depends on the state of the ATU-C. In correction mode, only single-bit errors can be corrected and the receiver switches to detection mode. In detection mode, all cells with detected cell header errors are discarded. If however a header is examined and found not to be in error, the receiver switches to correction mode. Below is a diagram for the ATU-C's receiver's modes of operation.



Shown on the next page is a flowchart of the consequences of errors in ATM cell headers.

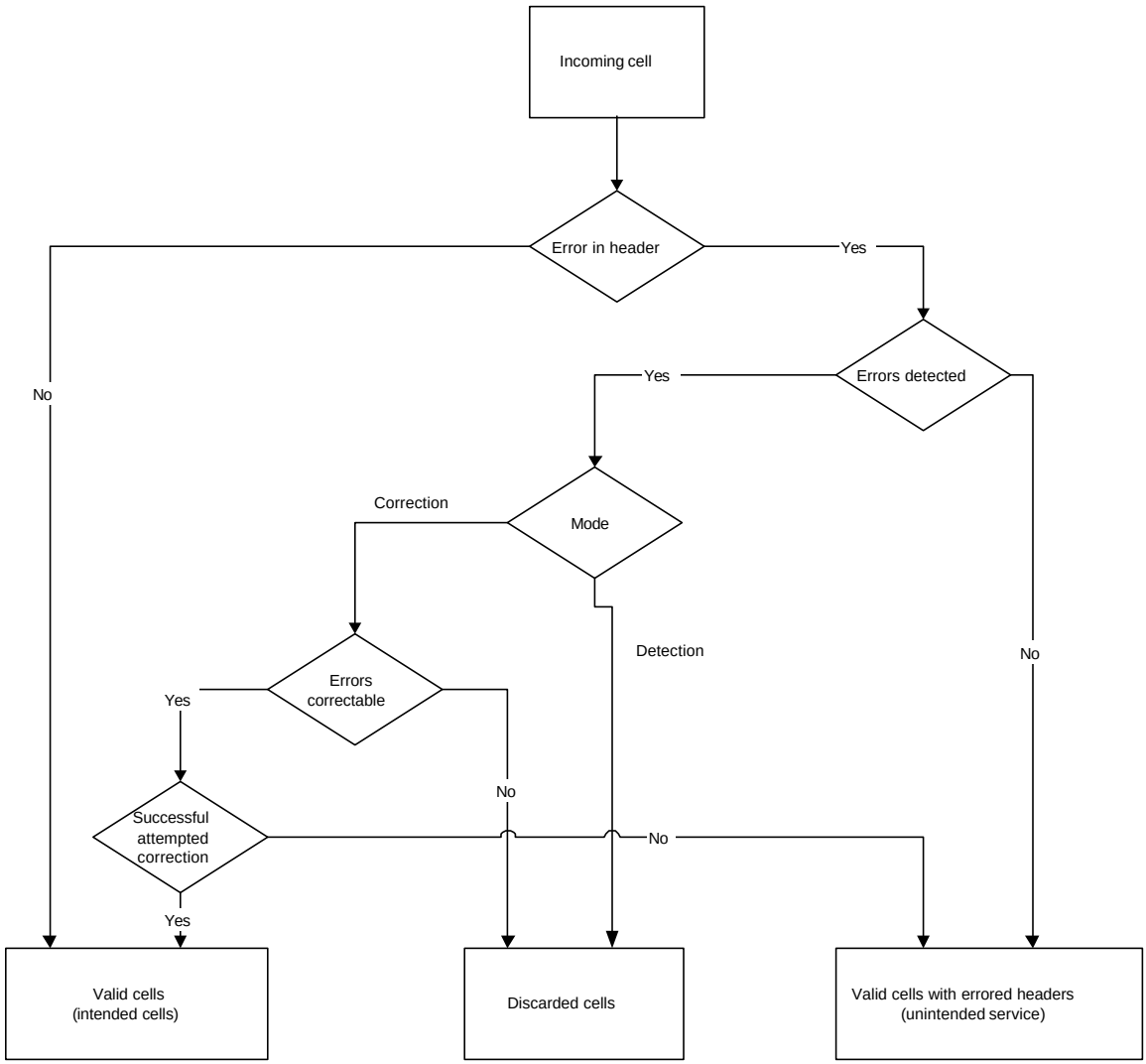
Test Setup: Test Setup 4.

Procedure:

- Reset and continue initialization.
- Send non-errored ATM cells to ATU.
- Send errored ATM cells to ATU.

Observable Results:

- ATU's receiver should follow the above state diagram and be able to make decisions based on the flowchart below:


Incoming cell
Error in header
Yes
No
Errors detected
Yes
No
Mode
Correction
Detection
Errors correctable
Yes
No
Successful attempted correction
No
Yes
Valid cells (intended cells)
Discarded cells
Valid cells with errored headers (unintended service)

5.8 Test # 5.008

Test Label: payload_transfer_delay.cell_tc.atm.dmt.adsl

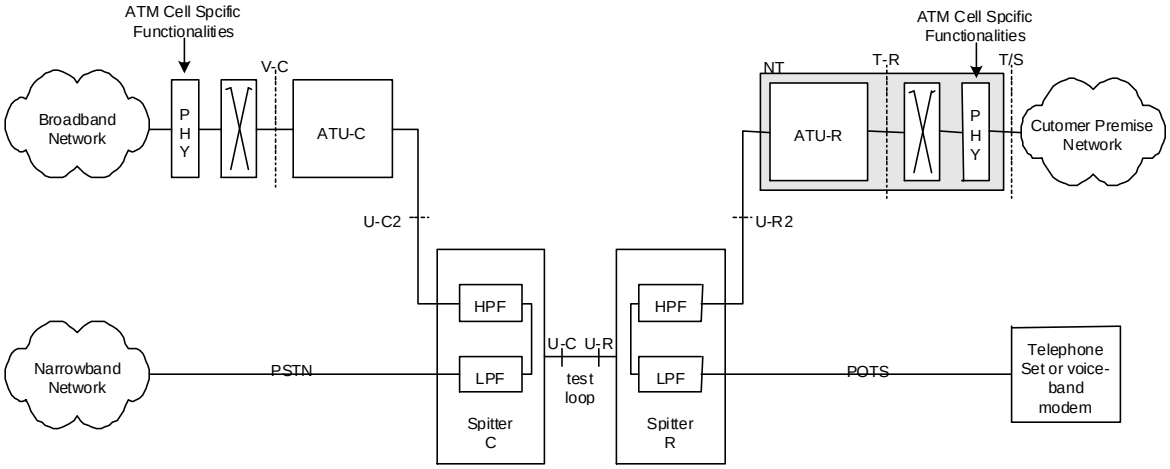
Purpose: To verify the one-way payload transfer delay of an ADSL system using each of test loops described in Test.# 3.002.

References: ANSI T1.413-1998 sections 6.2.2 and 6.6

Resource Requirements:

- ATU-R or ATU-C unit (UUT)
- Device capable of generating ATU signals
- Device capable of generating host controller channel commands
- Device capable of monitoring reference points in the ATU's
- Device capable of measuring signal transmission time

Discussion: The one-way payload transfer delay is defined as the amount of time it takes for the ADSL system to transfer payload (ATM cells *etc.*) from the T reference point at the remote end to the V reference point at the central office end. The total payload transfer delay for payload bits assigned to the fast data path shall be less than or equal to 2ms. For payload bits assigned to the interleaved data path shall be less than or equal to (4 + (S – 1)/4 + S*D/4)ms, where S is the number of DMT symbols per codeword and D is the interleave depth. See the figure below for a description of the reference points.



Test Setup: Test setup 5.

Procedure:

- Send ATM cell from ATU-C to ATU-R.
- Measure payload transfer delay.
- Send ATM cell from ATU-C to ATU-R.
- Measure payload transfer delay.
- Repeat the above procedure for the second data path, either fast or interleaved (*i.e.,* the data path not initially used).
- Repeat the above procedure for each of the test loops described in ADSL Test 3.002.

Observable Results:

- The payload transfer delay should be no more than 2 ms through the fast buffer in both directions.
- The payload transfer delay should be no more than (4 + (S – 1) / 4 + S _ D / 4) ms through the interleave buffer in both directions.