GUIDE ON THE USE OF THE OVERVOLTAGE RESISTIBILITY RECOMMENDATIONS

Summary

The Resistibility Guide assists test laboratories in implementing the correct tests for ITU-T K.20, K.21, and K.45 compliance testing. It will have four definitive sections:

1) introduction with general comments
2) definition of terms
3) general test plan flow charts
4) test circuit schematics

This guide will assist the lab engineers and technicians in developing the correct test plans for equipment being submitted for ITU-T K.20, K.21 or K.45 compliance testing. It provides the proper sequence of testing to be conducted, shows specific test sequence for single pair ports and multiple pair ports with and without primary protection in both internal and external environments:

1) symmetric single pair ports,
2) coaxial ports,
3) power ports and
4) ac mains ports

This Guide also provides a practical example, using a Home Gateway application that is subject to Recommendation ITU-T K.21. This application example contains ADSL port types, mains power port types, FXO and FXS port types, Ethernet port types, and USB port types.

1 Introduction

The testing of equipment, particularly equipment with multiple external and internal ports, is complex and lengthy. There are many tests per port and many combinations of external and internal ports to test. These tests are performed with combinations of ports terminated and coupled to earth. The purpose of this document is assist in laying out a test plan to ensure that adequate testing is performed to ensure compliance with the required recommendation.

The present document is composed of 3 parts:

- General remarks, definitions
- General test plan
- Test plan according to the family of equipment.

2 Scope

This recommendation applies to all equipment covered by the scopes of Recommendations ITU-T K.20, K.21 and K.45 recommendations.

3 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Recommendation ITU-T K.20, "Resistibility of telecommunication equipment installed in a telecommunications centre to overvoltages and overcurrents".

Recommendation ITU-T K.21, "Resistibility of telecommunication equipment installed in customer premises to overvoltages and overcurrents".

Recommendation ITU-T K.45"Resistibility of telecommunication equipment installed in the access and trunk networks to overvoltages and overcurrents".

Recommendation ITU-T K.44, "Resistibility tests for telecommunication equipment exposed to overvoltages and overcurrents – Basic Recommendation".

4 Terms, definitions and abbreviations

A consequent number of terms, definitions and abbreviations are used; consequently the operator shall refer to Recommendation ITU-T K.44, §3.

5 Information required by the test laboratory

5.1 Required level of resistibility

Normally the level of resistibility would be specified by the manufacturer or the network operator. Guidance on this choice is given in section 5/K.44.

5.2 Characteristics of the agreed primary protector

The characteristics of the “agreed primary protector” are needed to determine the characteristics of the special test protector. Normally the agreed primary protector would be specified by the manufacturer or the network operator. Guidance on a suitable primary protector is given in section 8.5/K.44.

5.3 Port classification (external or internal)

Normally the port type would be specified by the manufacturer as this is determined by the design and intended use of the port. Guidance on determining the port type is given in section A.2.1/K.44.

5.4 Port types

The port types are specified in section 7.1/K.44. The manufacturer should define the boundaries of the equipment and specify the port type of each port.

5.5 Test types

The test types are specified in section 7.2/K.44.

5.6 Test conditions

The test conditions are specified in section 7.3/K.44.

5.7 Test levels

The required test levels, to check compliance, are specified in corresponding tables of K.20, K.21 and K.45.

5.8 Test schematics

The schematics are given in Annex A/K.44.

Five groups of schematics are given in K.44 and these are:

- The generator schematics (Figures A.3-1 through A.3-6).
- The main schematics (Figures A.6.1-1 through A.6.7-4.).
- Connection of the decoupling element between the EUT and the associated equipment for the tested port (Figures A.5-3 through A.5-9).

- Connection of the decoupling element and terminating elements for associated equipment (Figures A.5-10 through A.5-16). These figures also show the coupling to ground elements for the untested port.
- Protection of the untested port (Figures A.5-7 through A.5-23).

Recommended coupling and decoupling elements are listed in Table A.5-1/K.44.

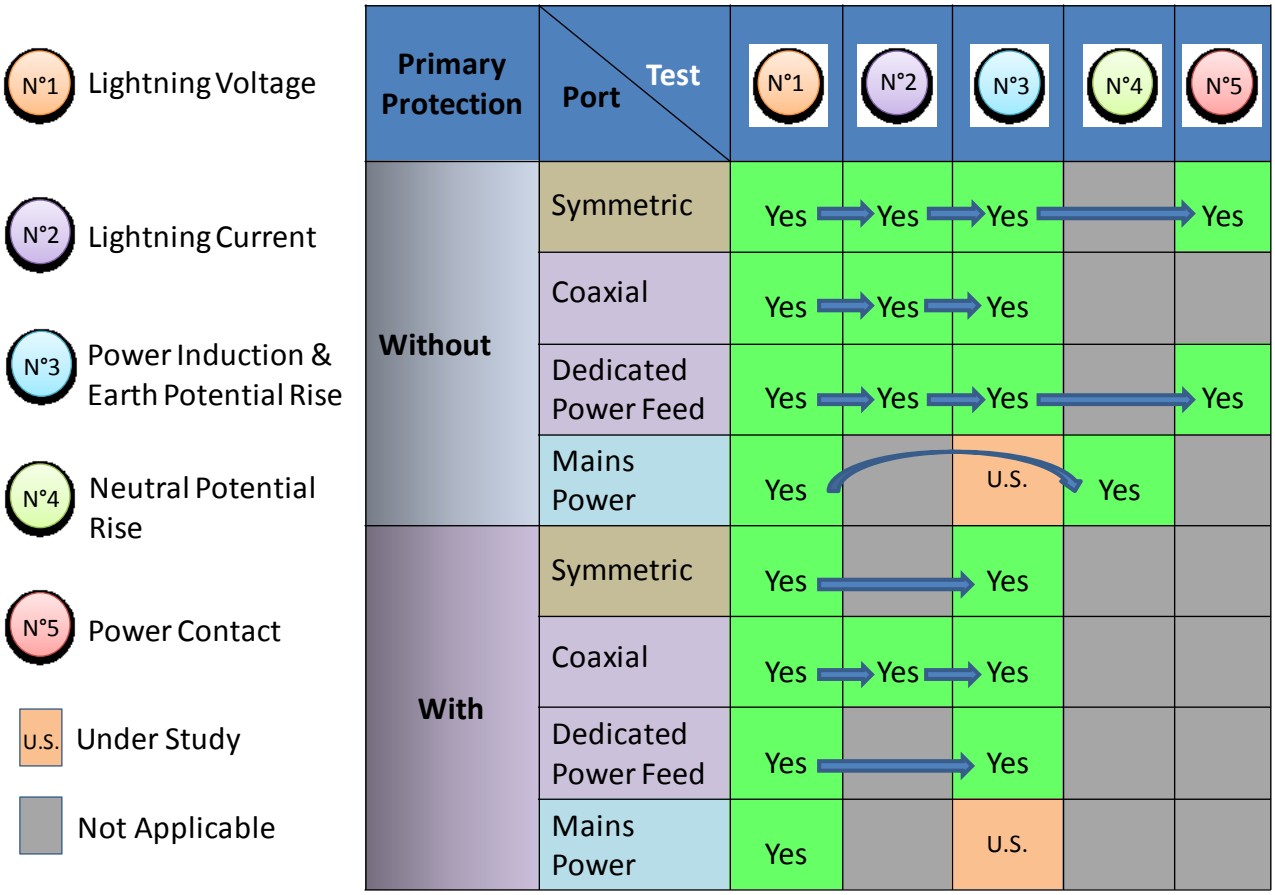
The required schematics are chosen knowing:

- The generator type,
- The type of tested port e.g. external symmetric pair,
- The types of terminated ports,
- The type of untested port coupled to earth.

6 Sequence of tests

Table 1 synthesizes the applicable tests for the external ports of equipment, with and without primary protection. Tests for external multiple pairs/ ports are further elaborated in Table 2. It clearly shows the five classes of tests, associated to each kind of port, depending on the presence or not of a primary protection device.

Table 1 – Applicable tests for an external single port

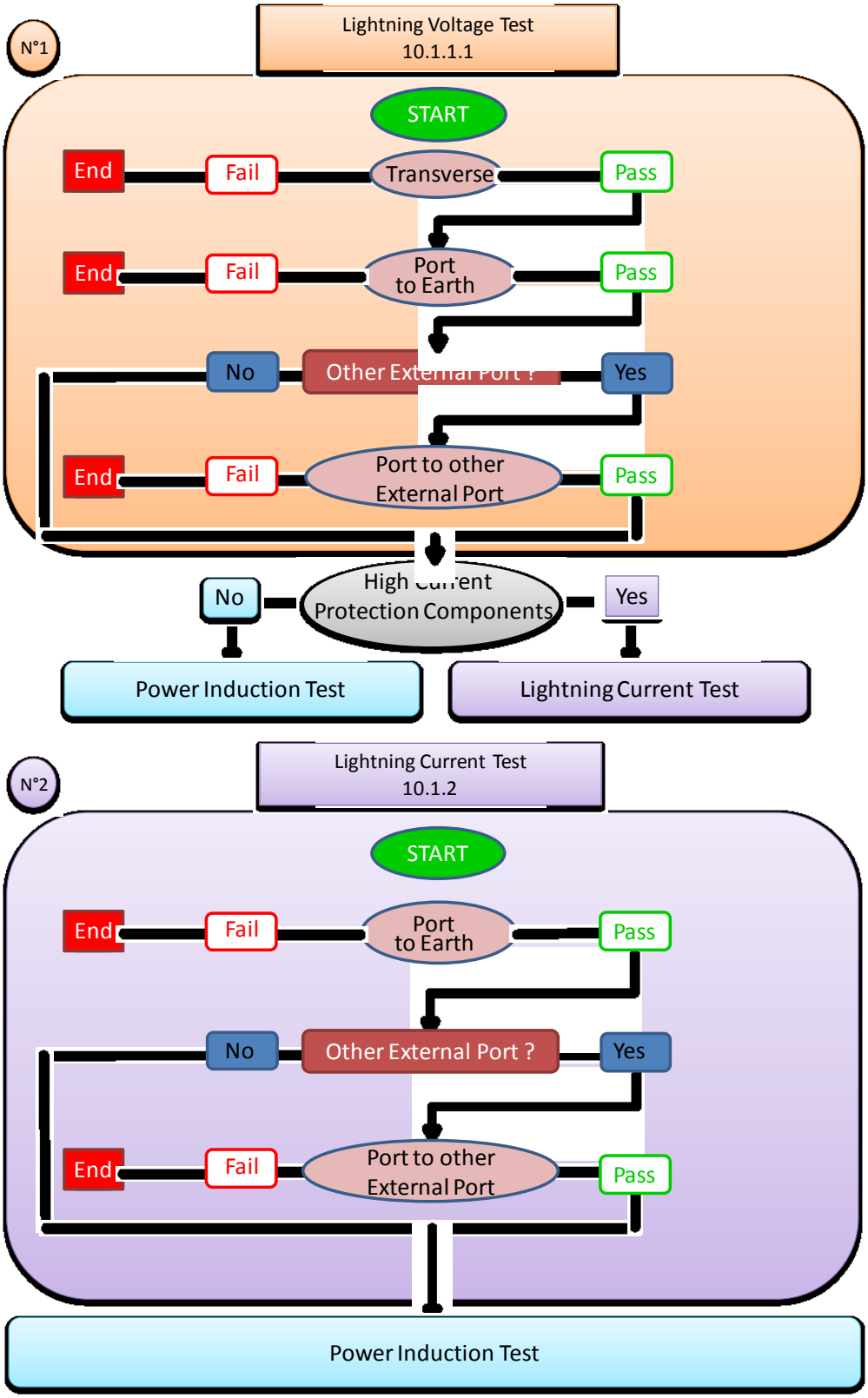


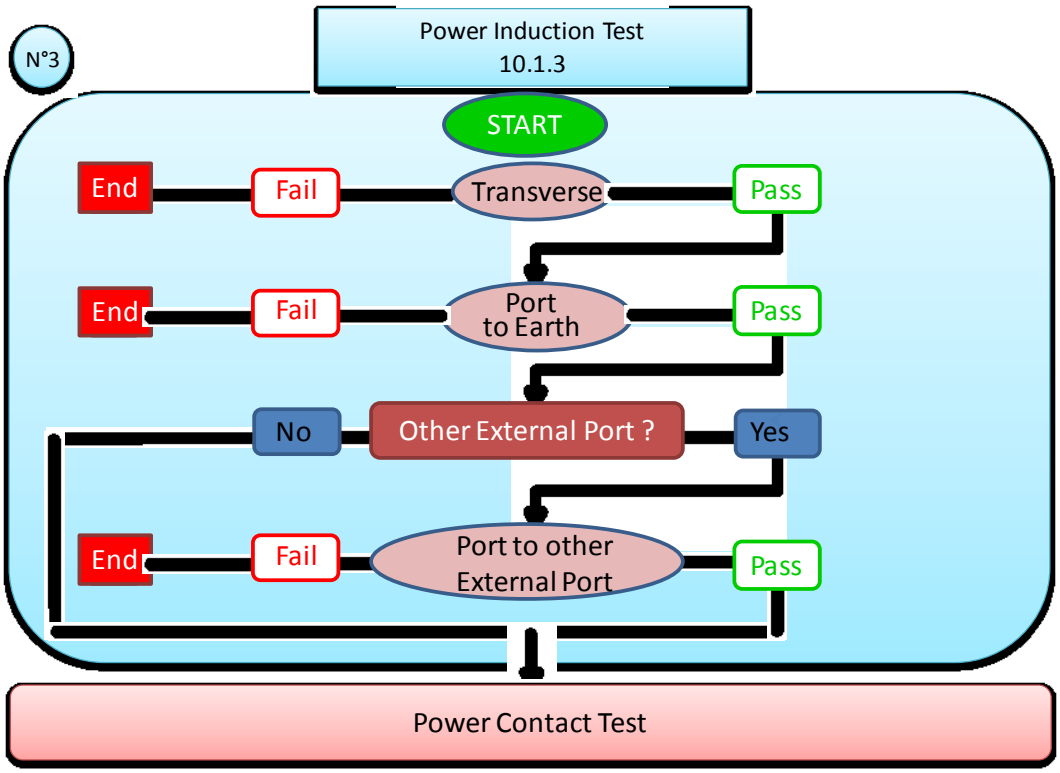
6.1 Tests for an External single pair port

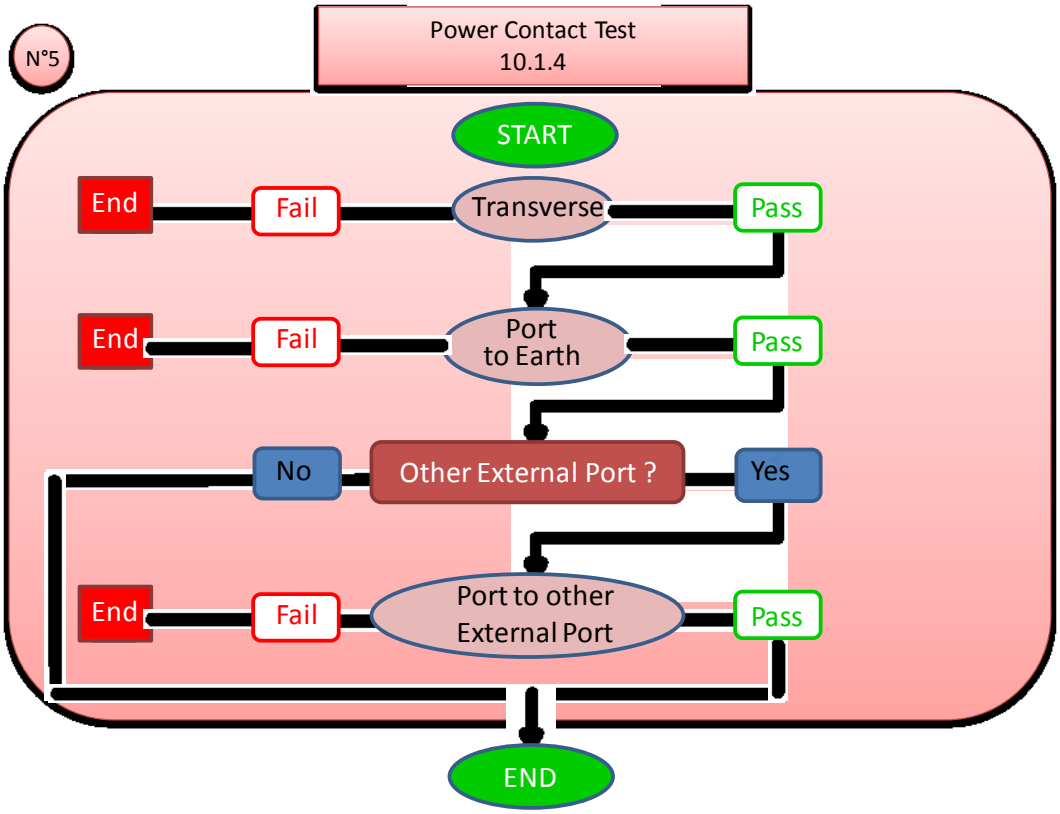
6.1.1 Without Primary Protection

6.1.1.1 Symmetric pair port

The four following flowcharts give the procedure to perform the tests relating to a symmetric pair port

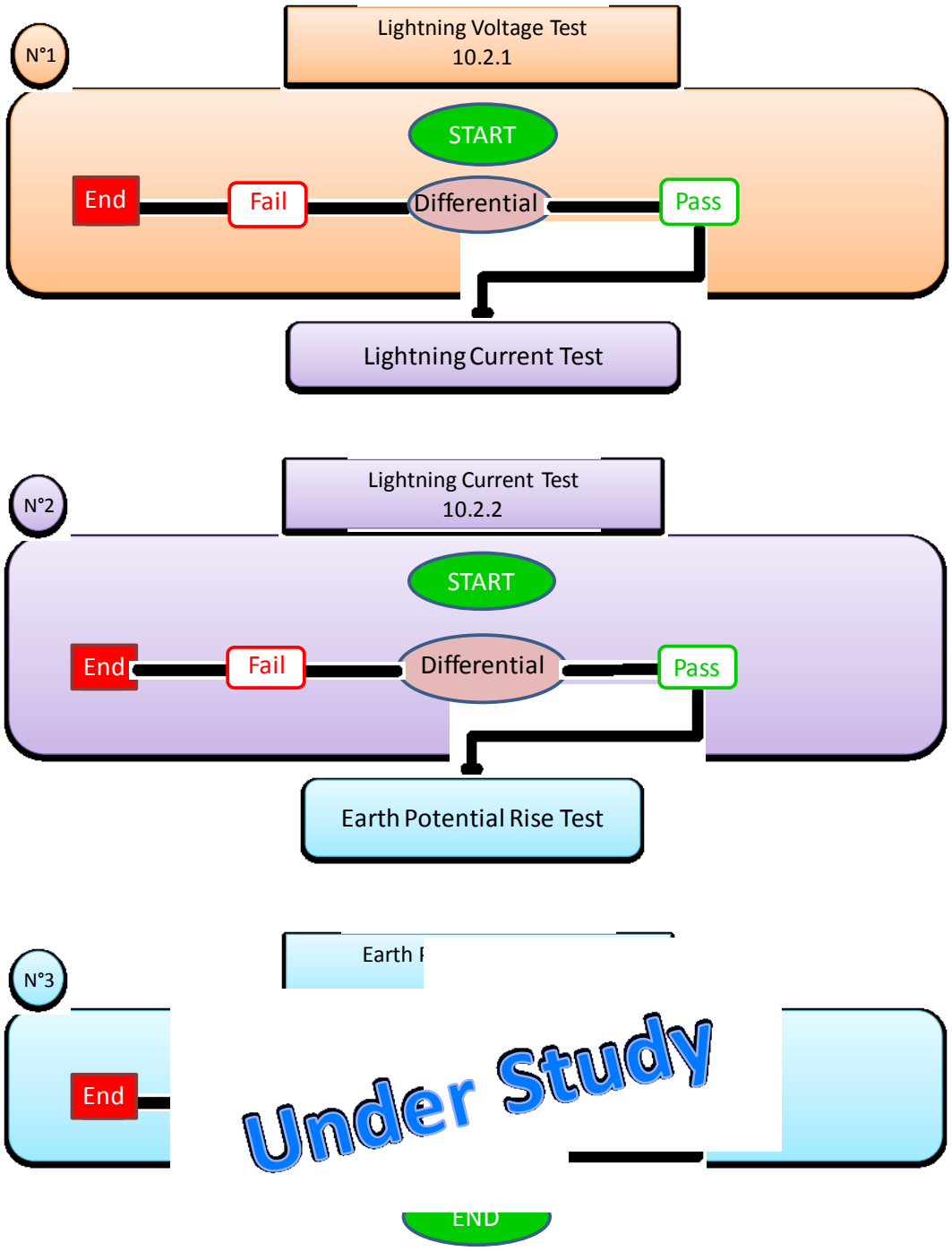



N°3
Power Induction Test
10.1.3
START
End
Fail
Transverse
Pass
End
Fail
Port
to Earth
Pass
No
Other External Port ?
Yes
End
Fail
Port to other
External Port
Pass
Power Contact Test


N°5
Power Contact Test
10.1.4
START
End
Fail
Transverse
Pass
End
Fail
Port
to Earth
Pass
No
Other External Port ?
Yes
End
Fail
Port to other
External Port
Pass
END

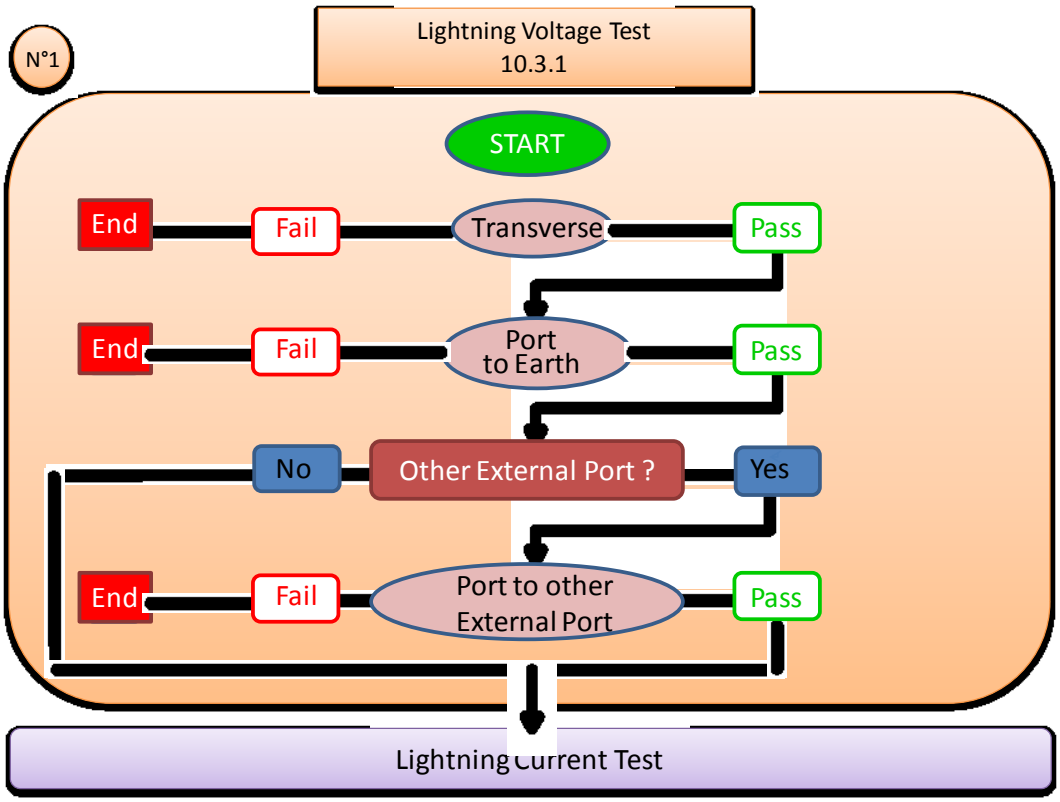
6.1.1.2 Coaxial port

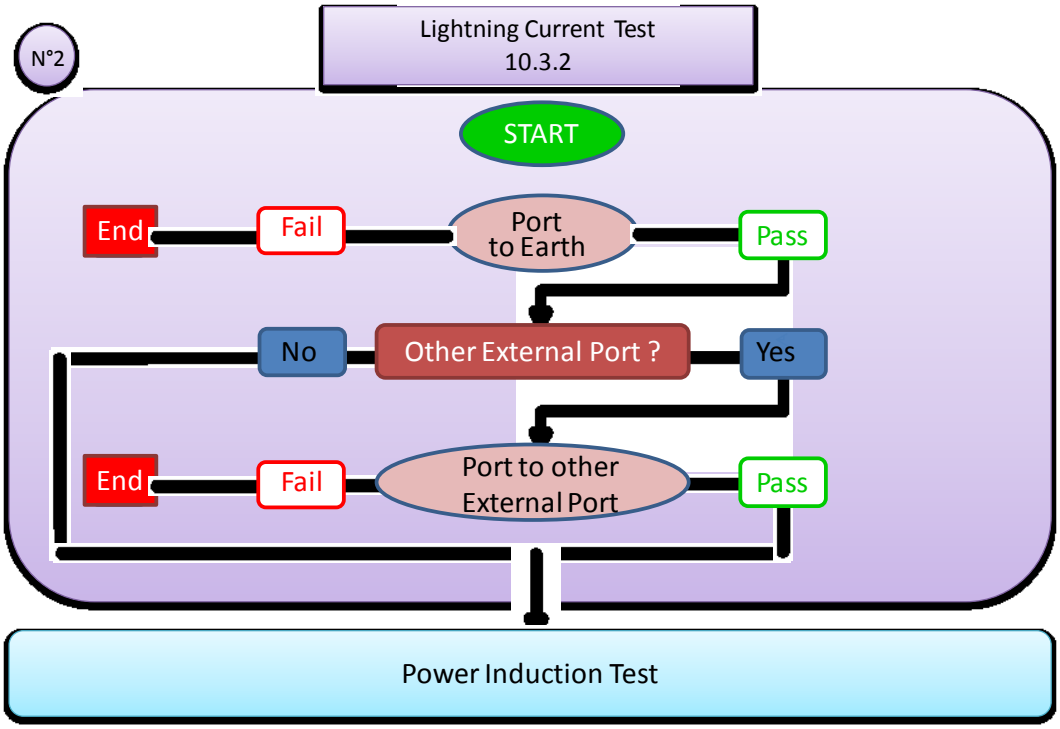
The three following flowcharts give the procedure to perform the tests relating to a coaxial port.

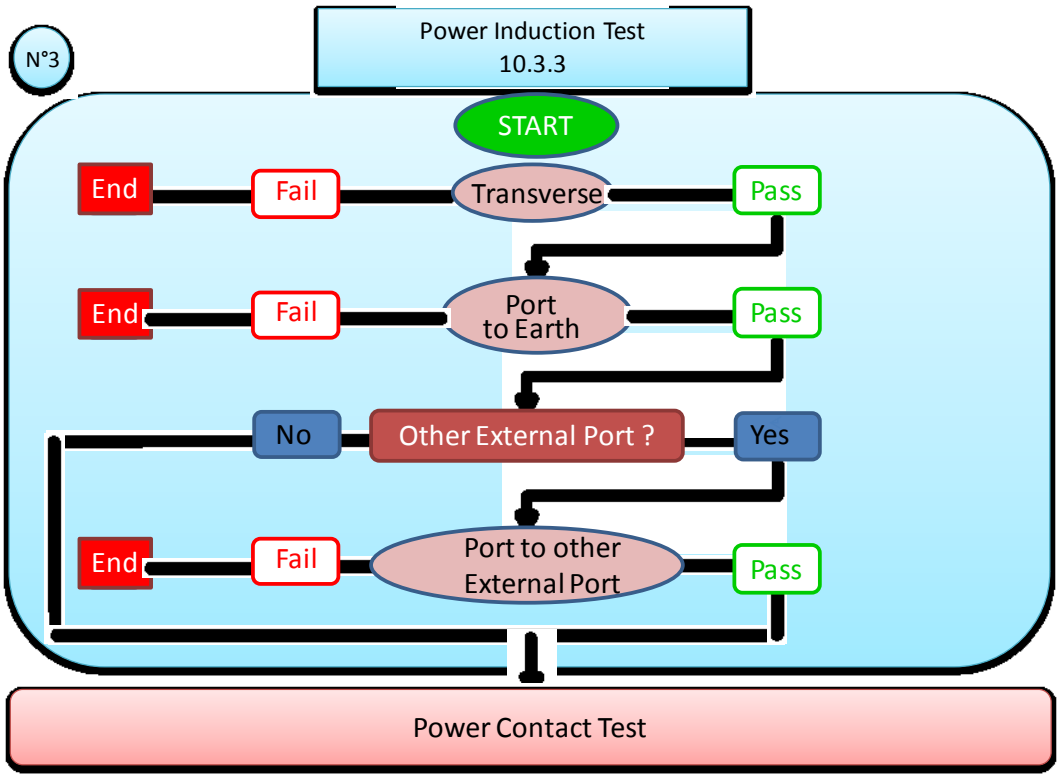


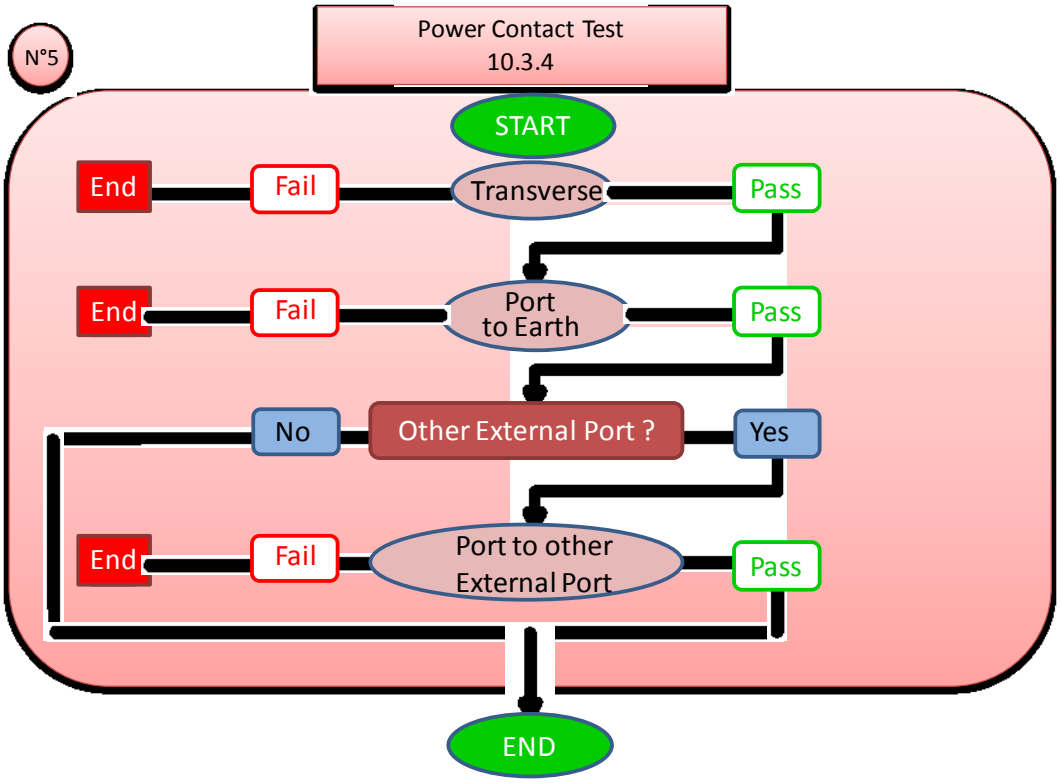
6.1.1.3 Dedicated Power Feed port

The four following flowcharts give the procedure to perform the tests relating to a dedicated power feed port.



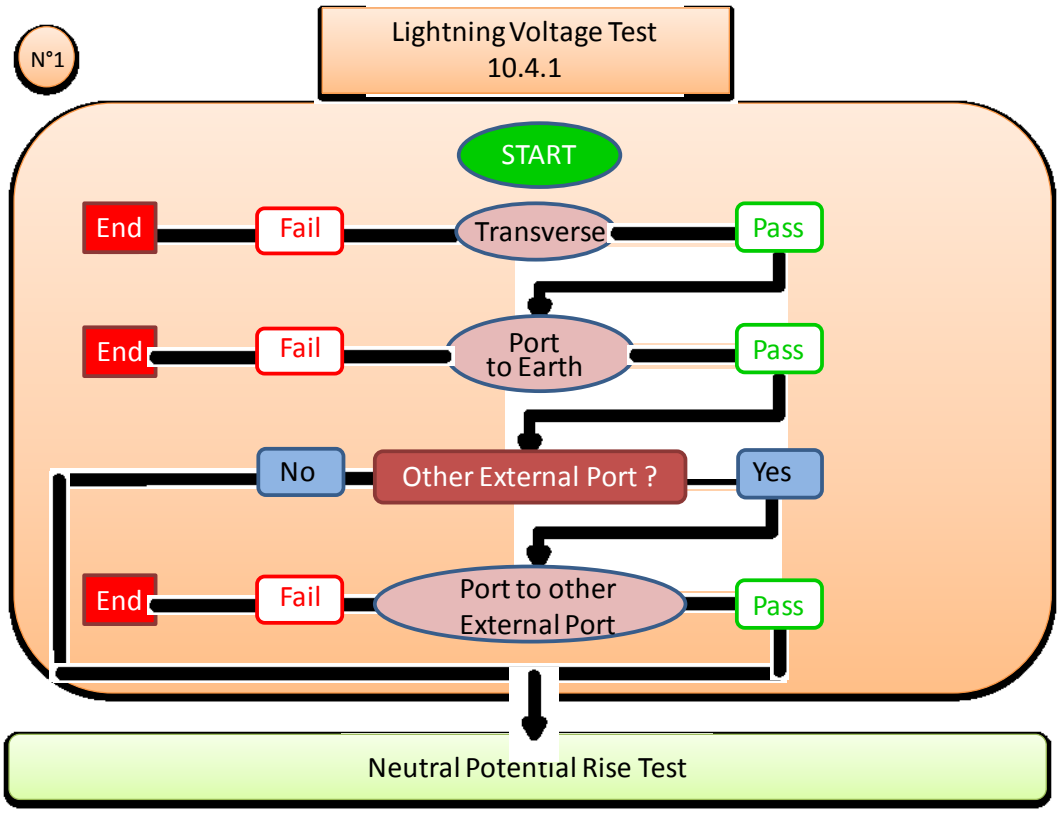


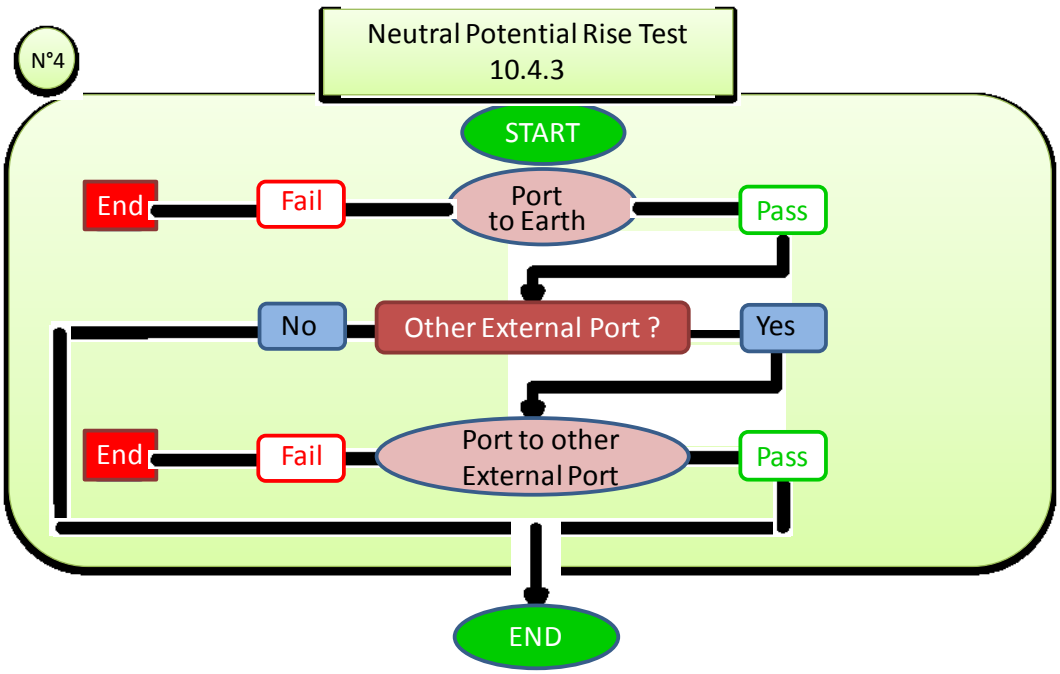

N°3
Power Induction Test
10.3.3
START
End
Fail
Transverse
Pass
End
Fail
Port
to Earth
Pass
No
Other External Port ?
Yes
End
Fail
Port to other
External Port
Pass
Power Contact Test


N°5
Power Contact Test
10.3.4
START
End
Fail
Transverse
Pass
End
Fail
Port
to Earth
Pass
No
Other External Port ?
Yes
End
Fail
Port to other
External Port
Pass
END

6.1.1.4 AC Mains Power port

The two following flowcharts give the procedure to perform the tests relating to a Mains Power port.

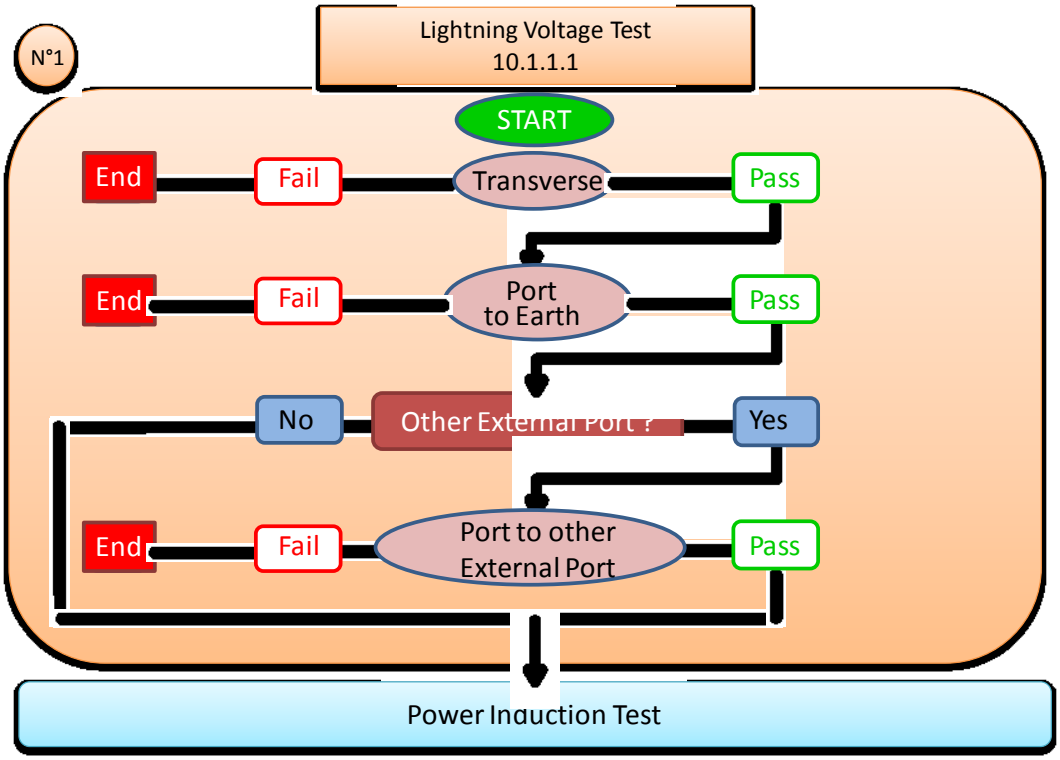


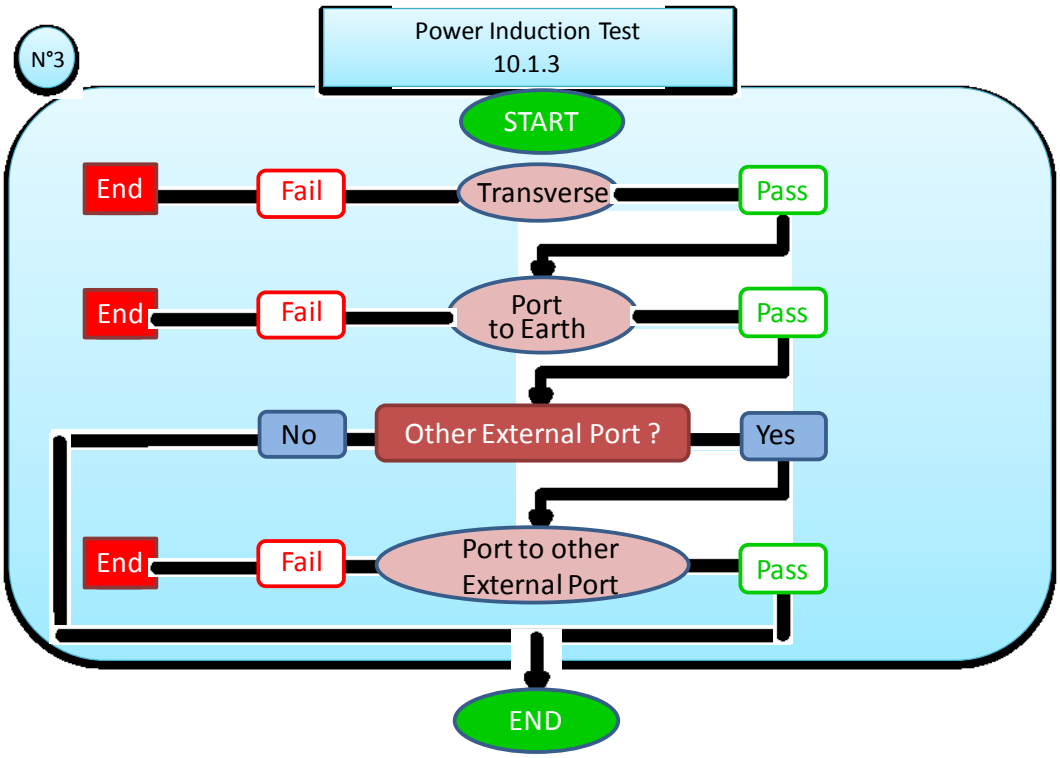


6.1.2 With Primary Protection

6.1.2.1 Symmetric pair port

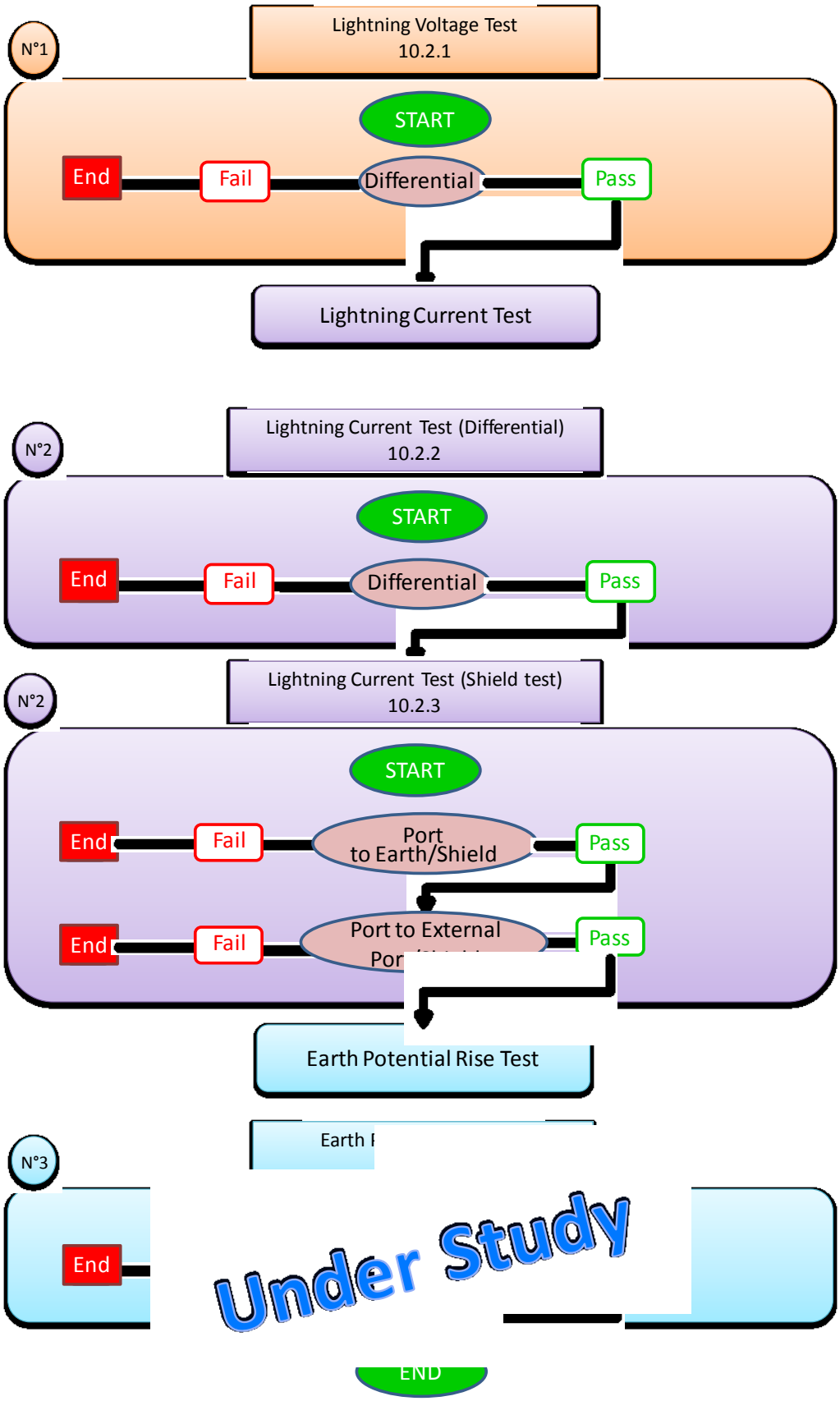
The two following flowcharts give the procedure to perform the tests relating to a symmetric pair port.





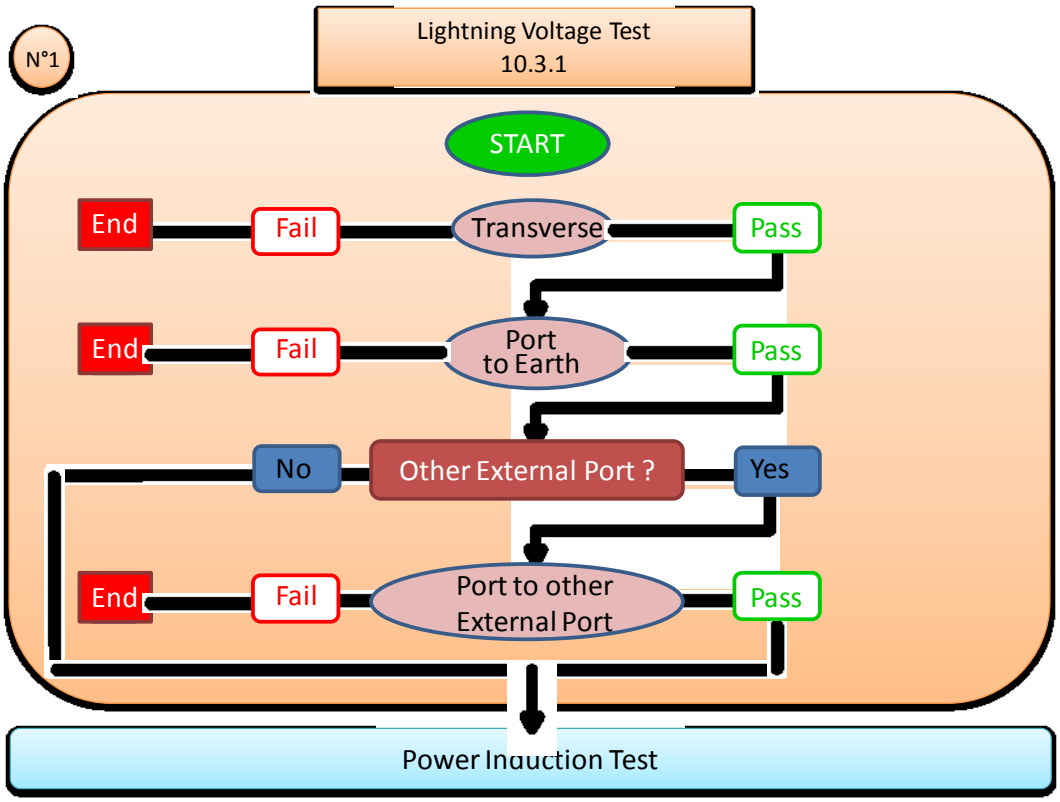
6.1.2.2 Coaxial port

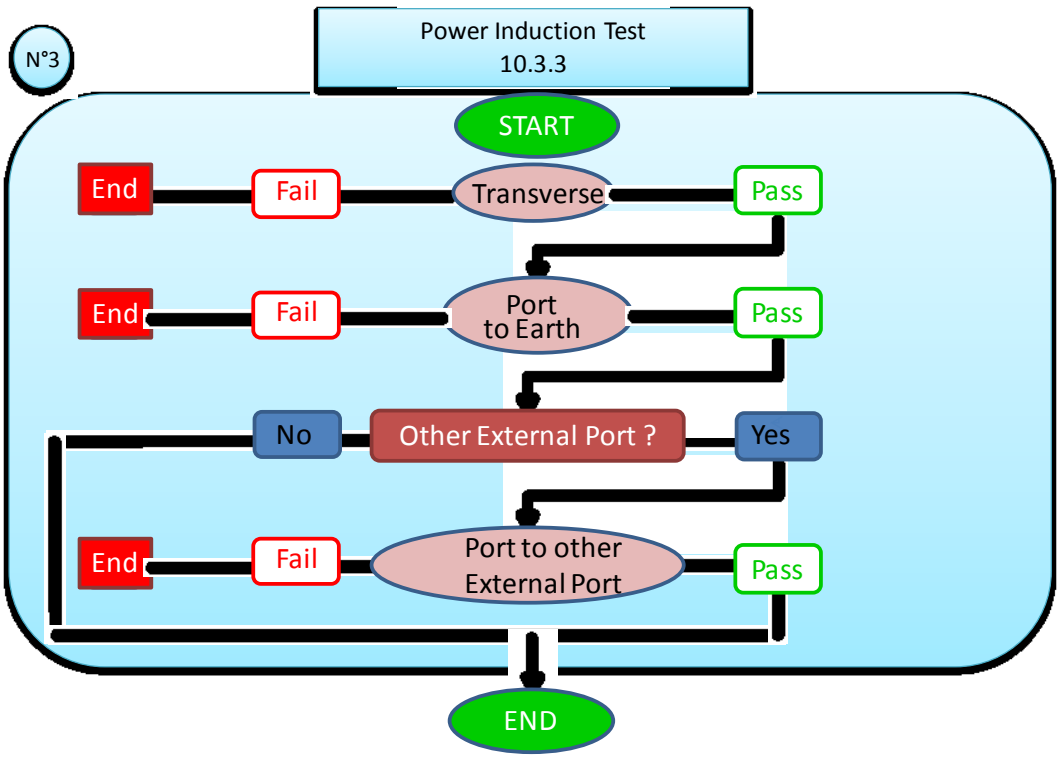
The four following flowcharts give the procedure to perform the tests relating to a coaxial port.



6.1.2.3 Dedicated Power Feed port

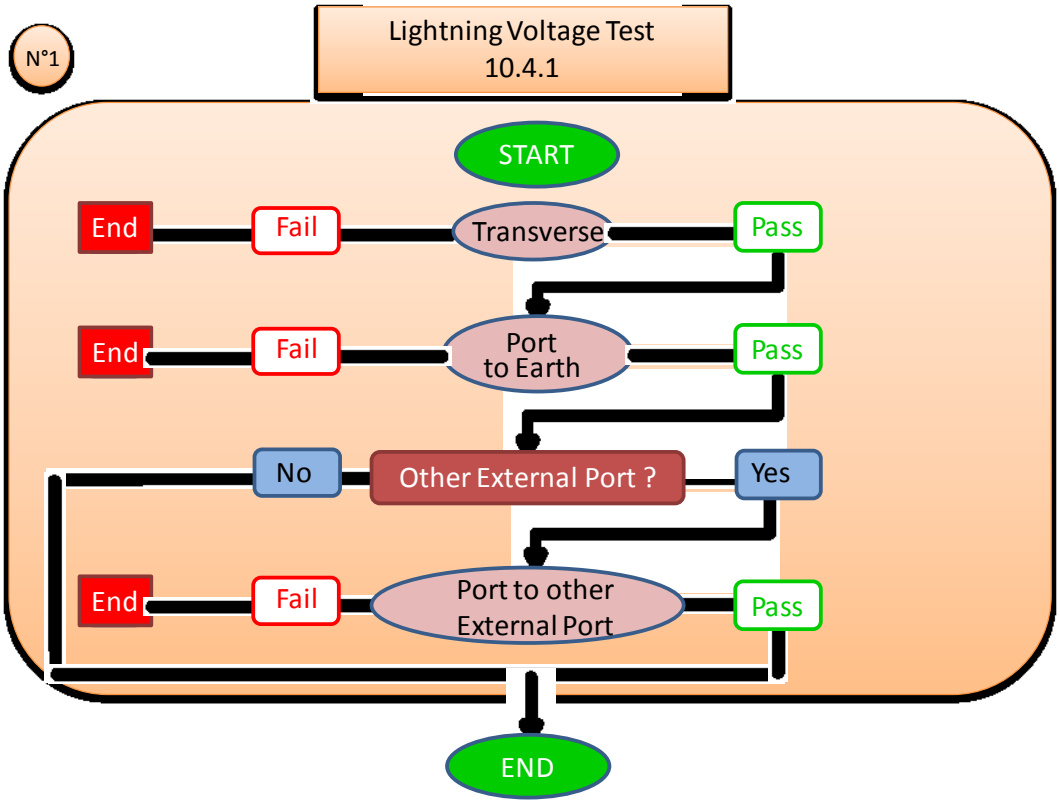
The two following flowcharts give the procedure to perform the tests relating to a dedicated power feed port.





6.1.2.4 AC Mains Power port

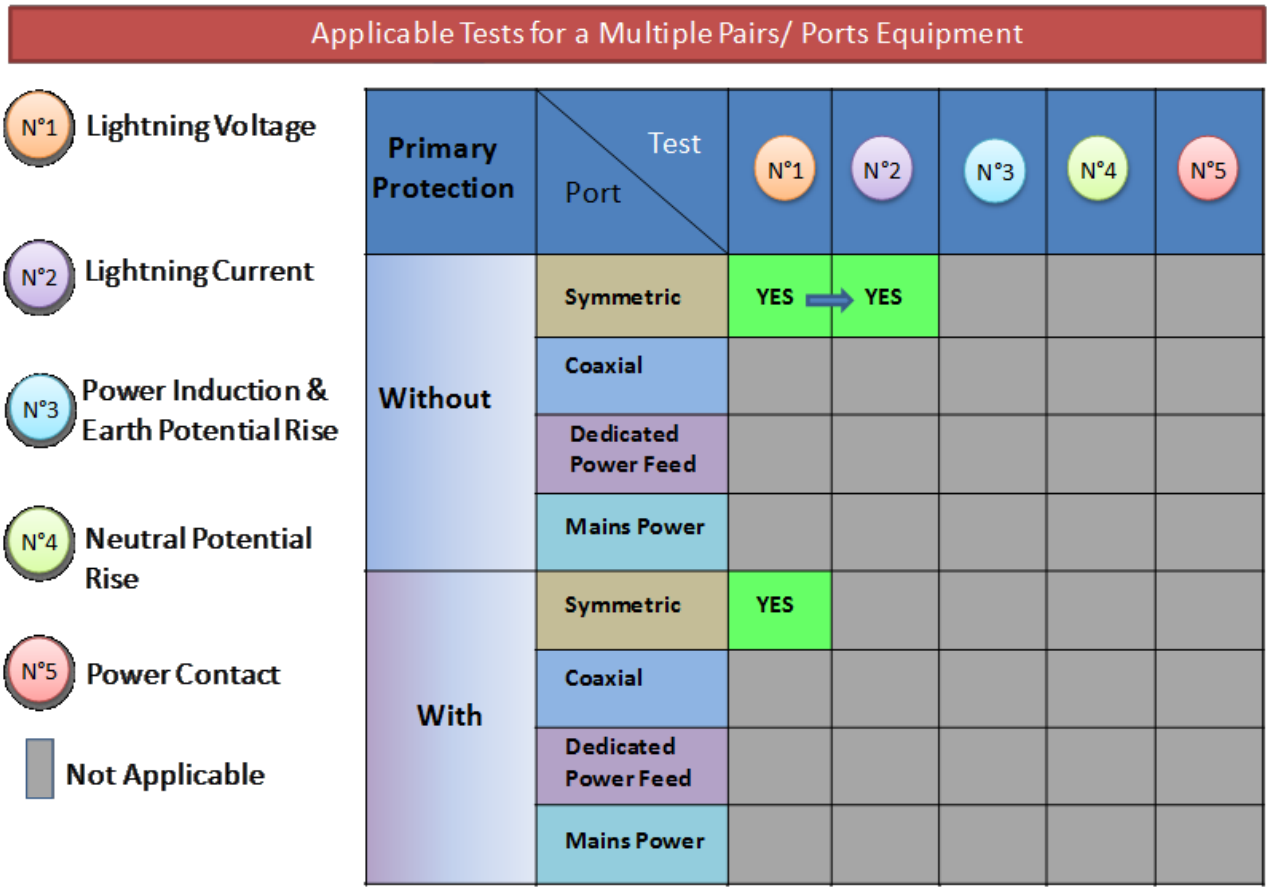
The following flowchart gives the procedure to perform the tests relating to a Mains Power port.



6.2 Tests for External multiple pairs/ ports

Table 2 summarizes the applicable tests for multiple pairs/ ports equipment.

Table 2 – Applicable tests for multiple pairs/ ports equipment

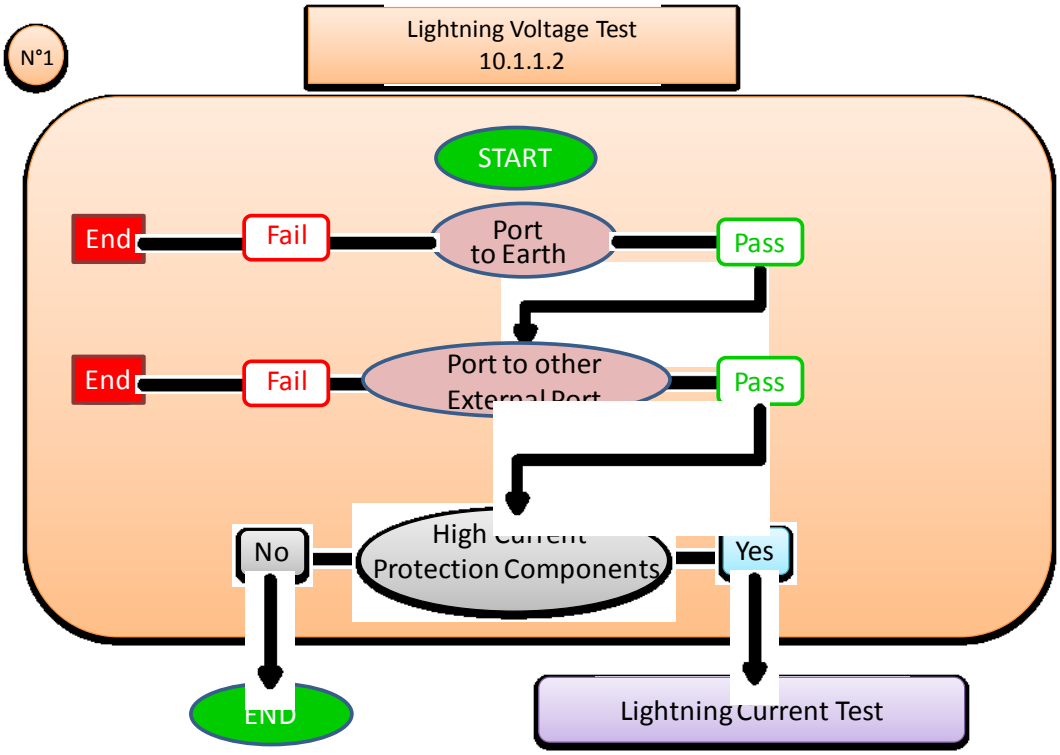


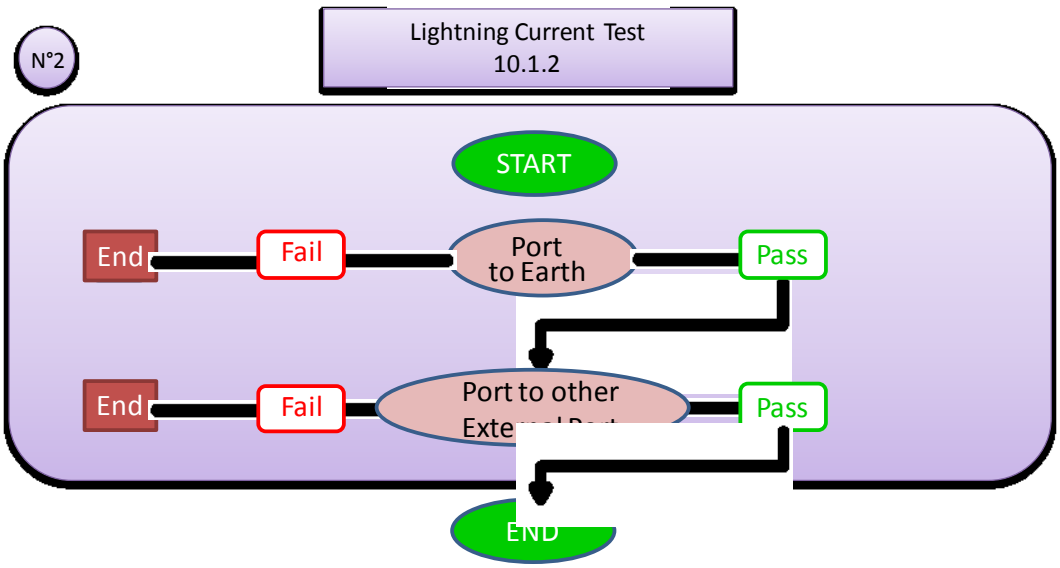
Note: Tests for External multiple pairs/ ports must be done in addition to the tests applicable for an External single pair port. More information on External multiple pairs/ ports testing can be found in section 10.1.1.2 of K.44.

Tests on multiple pairs are typically done on pairs that are located in the same street cable because all pairs are subject to lightning surges simultaneously.

6.2.1 Without Primary Protection

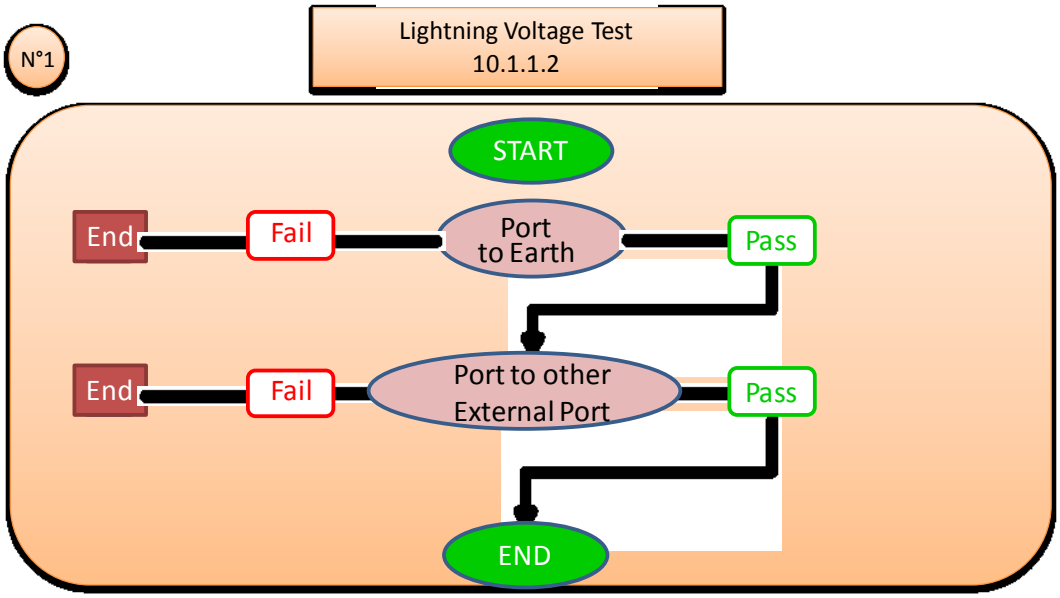
The two following flowcharts give the procedure to perform the tests relating to a symmetric pair port with multiple pairs or multiple ports of the same or different type.





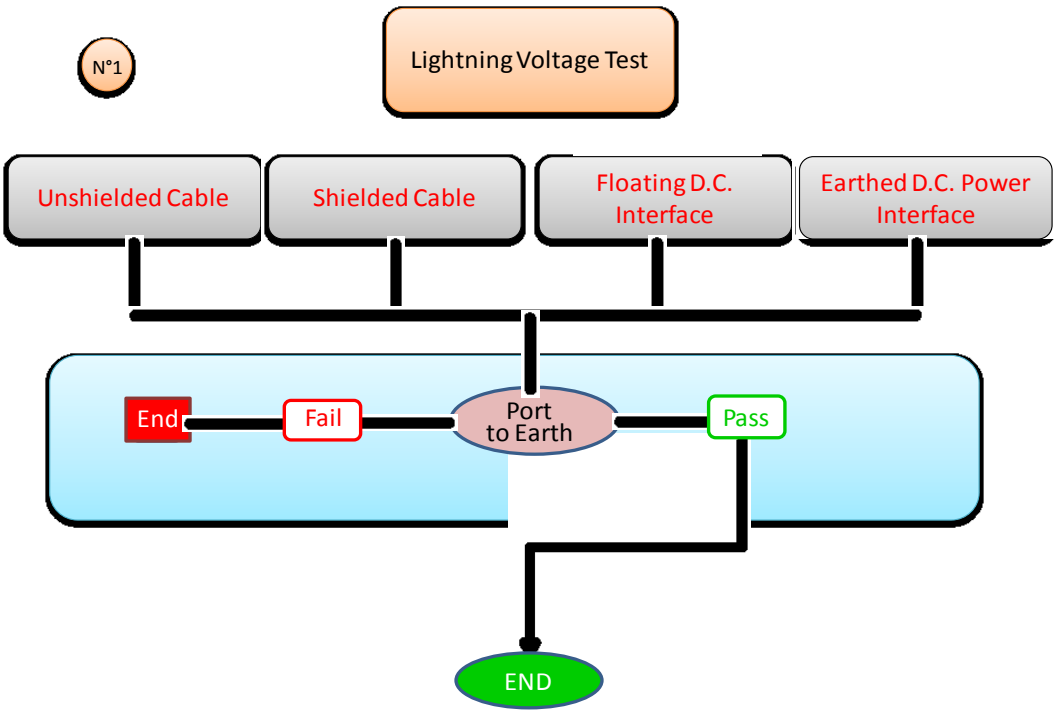
6.2.2 With Primary Protection

The following flowchart gives the procedure to perform the tests relating to a symmetric pair port with multiple pairs or multiple ports of the same or different type.

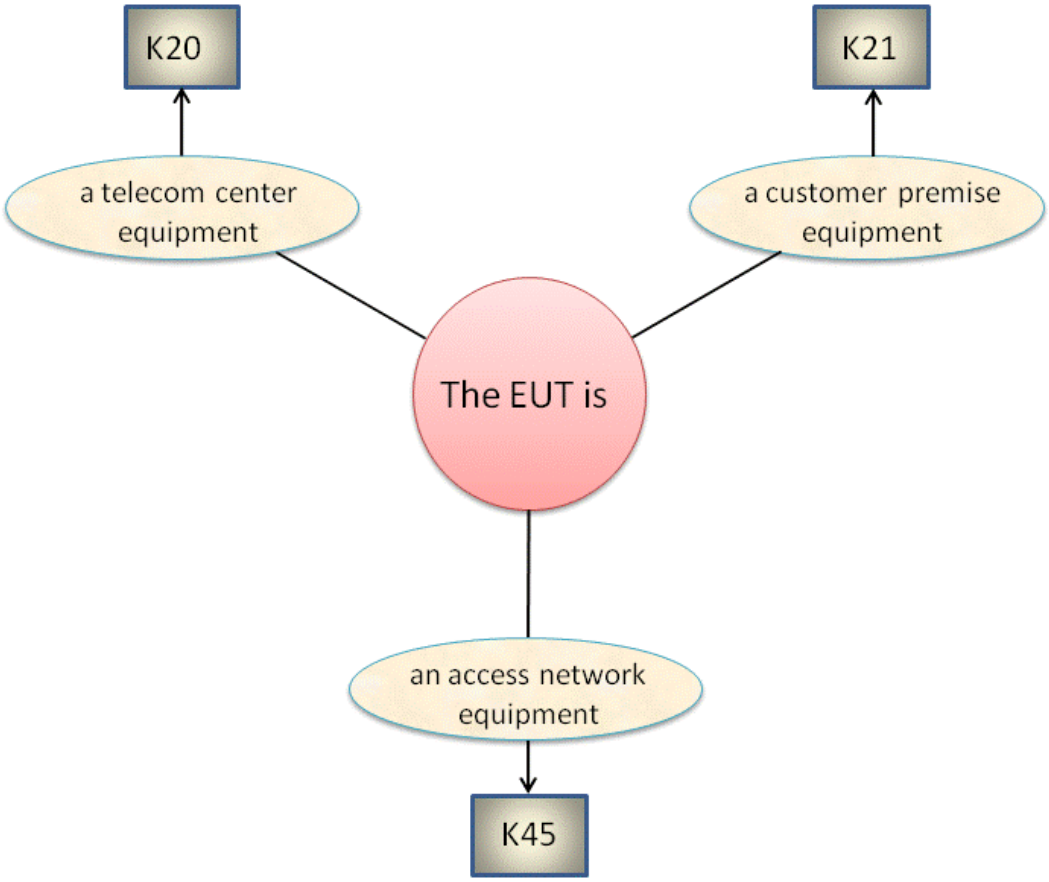


6.3 Tests for an Internal port without Primary Protection

The following flowchart summarizes the applicable tests for an internal port of equipment.



6.4 Equipment under test family



6.4.1 K.20 External port tests

N°1 Lightning Voltage

N°2 Lightning Current

N°3 Power induction

N°4 Neutral Potential Rise

N°5 Power Contact

Primary Protection \ TEST	To Port	N°1		N°2		N°3		N°4		N°5	
Without	Symmetric	2.1.1.a	2.1.1.b		2.1.5.a	2.2.1.a	2.2.1.b			2.3.1.a	2.3.1.b
	Coaxial	3.1.1		3.1.3	3.1.4	3.2.1					
	Dedicated Power Feed	4.1.1.a	4.1.1.b		4.1.5.a	4.2.1.a	4.2.1.b			4.3.1.a	4.3.1.b
	Mains Power	5.1.1.a	5.1.1.b				5.2.1	5.2.2.a			
With	Symmetric	2.1.2.a	2.1.2.b			2.2.2.a	2.2.2.b				
	Coaxial	3.1.2				3.2.2					
	Dedicated Power Feed	4.1.2.a	4.1.2.b			4.2.2.a	4.2.2.b				
	Mains Power	5.1.2.a	5.1.2.b								

Transverse/ Differential | Port (or shield) to Earth | Port (or shield) to external port | Under study | Applicable | Not applicable

6.4.2 K.20 External multiple pairs/ ports tests

N°1 Lightning Voltage

N°2 Lightning Current

Primary Protection \ TEST	To Port	N°1	N°2
Without	Symmetric	2.1.3.a	2.1.6.a
	Coaxial		
	Dedicated Power Feed		
	Mains Power		
With	Symmetric	2.1.4.a	
	Coaxial		
	Dedicated Power Feed		
	Mains Power		

Port to Earth | Applicable | Not applicable

6.4.3 K.21 External port tests

N°1 Lightning Voltage
N°2 Lightning Current
N°3 Power induction
N°4 Neutral Potential Rise
N°5 Power Contact

Primary Protection \ TEST / Port \ To		N°1			N°2			N°3			N°4		N°5		
Without	Symmetric	2.1.1.a	2.1.1.b	2.1.1.c		2.1.5.a	2.1.5.b	2.2.1.a	2.2.1.b	2.2.1.c			2.3.1.a	2.3.1.b	2.3.1.c
	Coaxial	3.1.1			3.1.3			3.2.1							
	Dedicated Power Feed	4.1.1.a	4.1.1.b	4.1.1.c		4.1.5.a	4.1.5.b	4.2.1.a	4.2.1.b	4.2.1.c			4.3.1.a	4.3.1.b	4.3.1.c
	Mains Power	5.1.1.a	5.1.1.b	5.1.1.c					5.2.1	5.2.1	5.2.2.a	5.2.2.b			
With	Symmetric	2.1.2.a	2.1.2.b	2.1.2.c				2.2.2.a	2.2.2.b	2.2.2.c					
	Coaxial	3.1.2				3.1.4	3.1.5	3.2.2							
	Dedicated Power Feed	4.1.2.a	4.1.2.b	4.1.2.c				4.2.2.a	4.2.2.b	4.2.2.c					
	Mains Power	5.1.2.a	5.1.2.b	5.1.2.c											

Transverse/ Differential
Port (or shield) to Earth
Port (or shield) to external port
Under study
Applicable
Not applicable

6.4.4 K.21 External multiple pairs/ ports tests

N°1 Lightning Voltage
N°2 Lightning Current

Primary Protection \ TEST / Port \ To		N°1		N°2	
Without	Symmetric	2.1.3.a	2.1.3.b	2.1.6.a	2.1.6.b
	Coaxial				
	Dedicated Power Feed				
	Mains Power				
With	Symmetric	2.1.4.a	2.1.4.b		
	Coaxial				
	Dedicated Power Feed				
	Mains Power				

Port (or shield) to Earth
Port (or shield) to external port
Applicable
Not applicable

6.4.5 K.45 External port tests

N°1 Lightning Voltage

N°2 Lightning Current

N°3 Power induction

N°4 Neutral Potential Rise

N°5 Power Contact

Primary Protection	To Port \ TEST	N°1			N°2			N°3			N°4		N°5		
Without	Symmetric	2.1.1.a	2.1.1.b	2.1.1.c		2.1.5.a	2.1.5.b	2.2.1.a	2.2.1.b	2.2.1.c			2.3.1.a	2.3.1.b	2.3.1.c
	Coaxial	3.1.1			3.1.3			3.2.1							
	Dedicated Power Feed	4.1.1.a	4.1.1.b	4.1.1.c		4.1.5.a	4.1.5.b	4.2.1.a	4.2.1.b	4.2.1.c			4.3.1.a	4.3.1.b	4.3.1.c
	Mains Power	5.1.1.a	5.1.1.b	5.1.1.c					5.2.1	5.2.1	5.2.2.a	5.2.2.b			
With	Symmetric	2.1.2.a	2.1.2.b	2.1.2.c				2.2.2.a	2.2.2.b	2.2.2.c					
	Coaxial	3.1.2				3.1.4	3.1.5	3.2.2							
	Dedicated Power Feed	4.1.2.a	4.1.2.b	4.1.2.c				4.2.2.a	4.2.2.b	4.2.2.c					
	Mains Power	5.1.2.a	5.1.2.b	5.1.2.c											

Transverse/ Differential — Port (or shield) to Earth — Port (or shield) to external port — Under study — Applicable — Not applicable

6.4.6 K.45 External multiple pairs/ ports tests

N°1 Lightning Voltage

N°2 Lightning Current

Primary Protection	To Port \ TEST	N°1		N°2	
Without	Symmetric	2.1.3.a	2.1.3.b	2.1.6.a	2.1.6.b
	Coaxial				
	Dedicated Power Feed				
	Mains Power				
With	Symmetric	2.1.4.a	2.1.4.b		
	Coaxial				
	Dedicated Power Feed				
	Mains Power				

Port (or shield) to Earth — Port (or shield) to external port — Applicable — Not applicable

7 Practical example

This section gives a practical example how to perform the applicable K.44 tests for a generic Home Gateway (HG) subject to K.21 requirements. This example has intentionally a large number of interfaces. This allows to explain the set-up requirements of K.44 better; the user can eliminate parts of the set-ups to test less complex products.

7.1 General description

This Home Gateway is powered by an external Class II power adapter and has an insulating housing with the following wired ports. Wireless ports are not tested for K.21 and as such not mentioned in this document. However, examination of these ports is necessary to verify compliance with Criterion A or B.

- External Ports:
  - 1x AC mains power (AC),
  - 1x ADSL (ADSL),
  - 1x analogue voice PSTN (FXO).
- Internal Ports:
  - 2x Gigabit Ethernet (GbE),
  - 3x 10/100M Ethernet (Eth),
  - 2x FXS Phone (FXS),
  - 2x USB.

No high current carrying components are equipped in the EUT.

Ports of the same type may not all be verified after the surge tests and are then only terminated, thus not necessarily connected to Auxiliary Equipment.

The testing of Ethernet ports is different from the internal port testing defined in K.21, Test 7.2 “Unshielded cable with symmetric pairs”. The nature of the coupling and grounding elements do not always allow sending traffic on the LAN and GbE ports. All tests on an Ethernet port, except for the insulation resistance test, are done in the powered condition but not operational. When the untested Ethernet port is coupled to ground, the Ethernet circuit will also be not operational. The insulation resistance test is performed with the equipment unpowered. Subsequently the equipment must be tested in an operational state, i.e. connected to Auxiliary equipment, to verify it still meets its specification.

The FXO port must be tested in its two major states : Loop Closed and Loop Open. Both states may not be relevant for all tests though.

The following items are not within the scope of this guide:

- Description of the Auxiliary equipment (AE),
- Verification method for Criterion A,
  Note: USB ports that are solely meant to be connected to a device that has no connection to ground, e.g. a memory stick, are exempted from surge testing. In this example, the USB port can be connected to any kind of device, thus also a grounded device, but for the purpose of testing and verification, a USB memory stick is used.
- Detailed set-ups for 2.2.x & 2.3.1 tests, these are quite similar to 2.1.x set-ups.
- ESD testing according to K.21.

This guide provides for each interface:

- Generator coupling element,
- Decoupling networks for tested & untested ports,
- Coupling to ground elements.

Surge test levels are not described in this guide. However, one should keep in mind that apart from the BASIC & ENHANCED test levels, K.44 also specifies in II.6 that “special” resistibility requirements may be required when mains SPD’s cannot be installed or bonding between mains and telecommunications cannot be achieved.

7.2 Importance of Clause 7.2 of K.44

This clause is very important to understand which ports must be tested, in which configuration, sequence, etc. This makes the many test configurations more understandable in the Home Gateway example.

K.44 Clause 7.2.1 transversal

- On all external ports,
- With some untested ports of each port type terminated.

K.44 Clause 7.2.2 External Port to earth

- On all external ports,
- With all untested ports terminated.
- Then repeated with each type of internal port coupled to ground in turn.

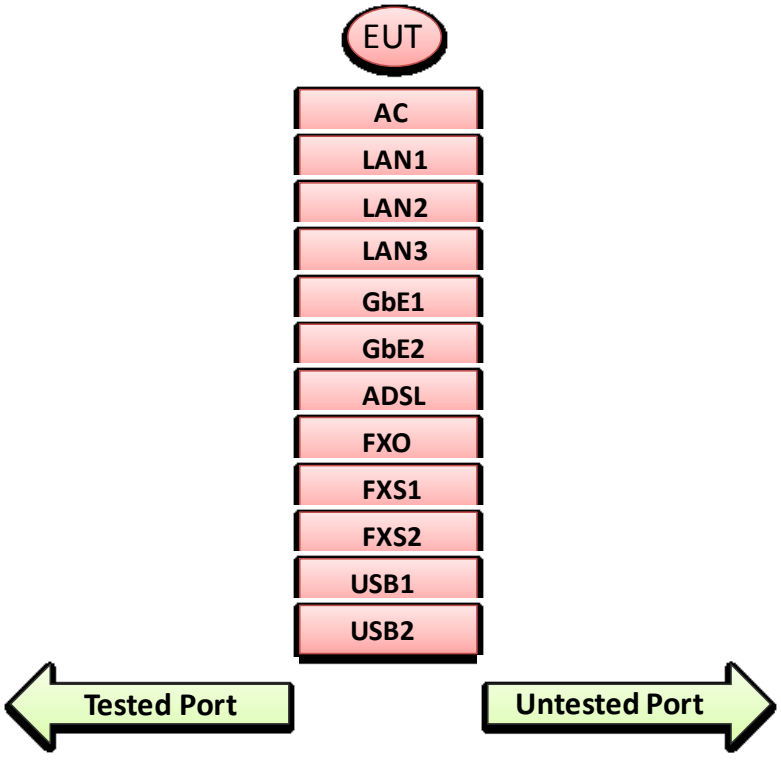
K.44 Clause 7.2.3 External Port to External port

- On all external ports,
- With all untested ports terminated & with each type of external port, including a port of the same type, coupled to ground, in turn.

K.44 Clause 7.2.4 Internal Port to Earth

- On all internal ports,
- With some untested ports of each port type terminated.
- Then repeated with each type of internal port coupled to ground in turn.

7.3 Block diagram of EUT



7.4 Definitions, abbreviations and clarifications

The connection between all circuit elements in the drawing is represented by the real number of wires or the cable shield:

- USB : cable shield (this example is for a USB2.0 cable where the cable contains 4 wires),
- ADSL, FXO, FXS : 1 pair/ 2 wires each,

- AC : L (called sometimes “A” in K.44) & N, this is an example for a Class II product, so there is no Protective Earth wire.
- LAN : 2 pairs/ 4 wires, it is assumed that the Ethernet cable has only 2 pairs,
- GbE : 4 pairs/ 8 wires,

Explanation between “EUT reference bar” and “Generator return/ Earth:

●	Solid bullet: This is the symbol used in this guide to indicate that a component, circuit element (e.g. DN or CDN) or wire is connected for the specified test set-up to the “Generator return/ Earth.
○	Open bullet: This is the symbol used in this guide to indicate that a component, circuit element (e.g. DN or CDN) or wire is connected for the specified test set-up to a floating “EUT reference bar”, thus not connected to the Generator return/ Earth.
Note: For some test set-ups of 2.1.2.c, the “EUT reference bar” and the “Generator return/ Earth” are connected to each other. This is due to the fact that for coordination tests on the AC mains port, a protection element (SPD) is put between Line and Neutral and at the same time the Neutral is connected to the Generator return/Earth, in line with Figure A.5-20/K.44.	

An appropriate coupling element can be a component (MOV, GDT, clamping diode, thyristor, ...) or nothing. In the latter case, the port is directly coupled to the Generator return/ Earth or EUT reference bar.

Auxiliary equipment at the untested ports shall not be connected to Protective Earth or the generator return/Earth, thus remain floating, otherwise the purpose of the EUT reference bar may become obsolete.

Further abbreviations used in the practical example:

- APP: Agreed Primary Protector
- STP: Special Test Protector
- GrEl: Grounding Element
- FXS: Foreign eXchange Subscriber interface
- FXO: Foreign eXchange Office interface

Examples of practical CDN's, DN's and coupling to ground elements are listed in a separate chapter.

For 2.1.1b/c tests, a conductive foil shall be wrapped around the EUT for 6kV Enhanced level testing when the STP is not equipped; for 7.1 tests, this foil is always present for Basic & Enhanced levels. In all cases, this foil is connected to the Generator return/Earth. This foil shall not be connected to ports (for example the shell/shield of a USB port) because the test requires that the connection of that port to the “Generator return/Earth” must be done “in turn”. This situation occurs for tests 2.1.1.b, 2.1.1.c and 7.1.

In this guide, every test item with or without STP (or APP) is listed on one page in one drawing except when it is necessary for clarity to split into two drawings.

On the following pages, a setup is shown for Lightning Surge tests (2.1.x) on 2 external symmetric pair ports, ADSL and FXO, each with 1 pair. The same, or similar setups can be used for Power Induction (2.2.x) and Power Contact (2.3.1).

Lightning surge tests on multiple pairs are also elaborated in this Home Gateway example.

The order of testing on the following pages is not relevant; The order as outlined in the first part of this document shall be followed.

Generator coupling elements are used to connect the surge generator with the EUT. The coupling element shall not significantly affect the open-circuit voltage nor the short-circuit current. GDT’s & MOV’s are mostly applied as coupling elements. However, coupling & decoupling elements can influence the output voltage. Therefore the output voltage value of the test generator shall be adjusted to the required voltage with the generator output resistor, coupling device and decoupling device of the TESTED port equipped, prior to connecting the EUT itself. Tests have proven that this adjustment is required for Lightning Surges, Power Induction, Power Cross and Earth Potential Rise.

For all 5.1.x.b & 5.1.x.c Lightning Surge tests on the AC power port, the output resistor shall be 2 ohm. This is different with the more common EMC test standard IEC61000-4-5 where 12 ohm is required. Some Lightning surge generators can only be set for 12 ohm in longitudinal (or port to earth) test mode.

Caution: The EUT reference bar is floating and there is a possible shock hazard. Disconnect power to the relevant equipments, or take other precautions, before changing connections or touching these equipments.

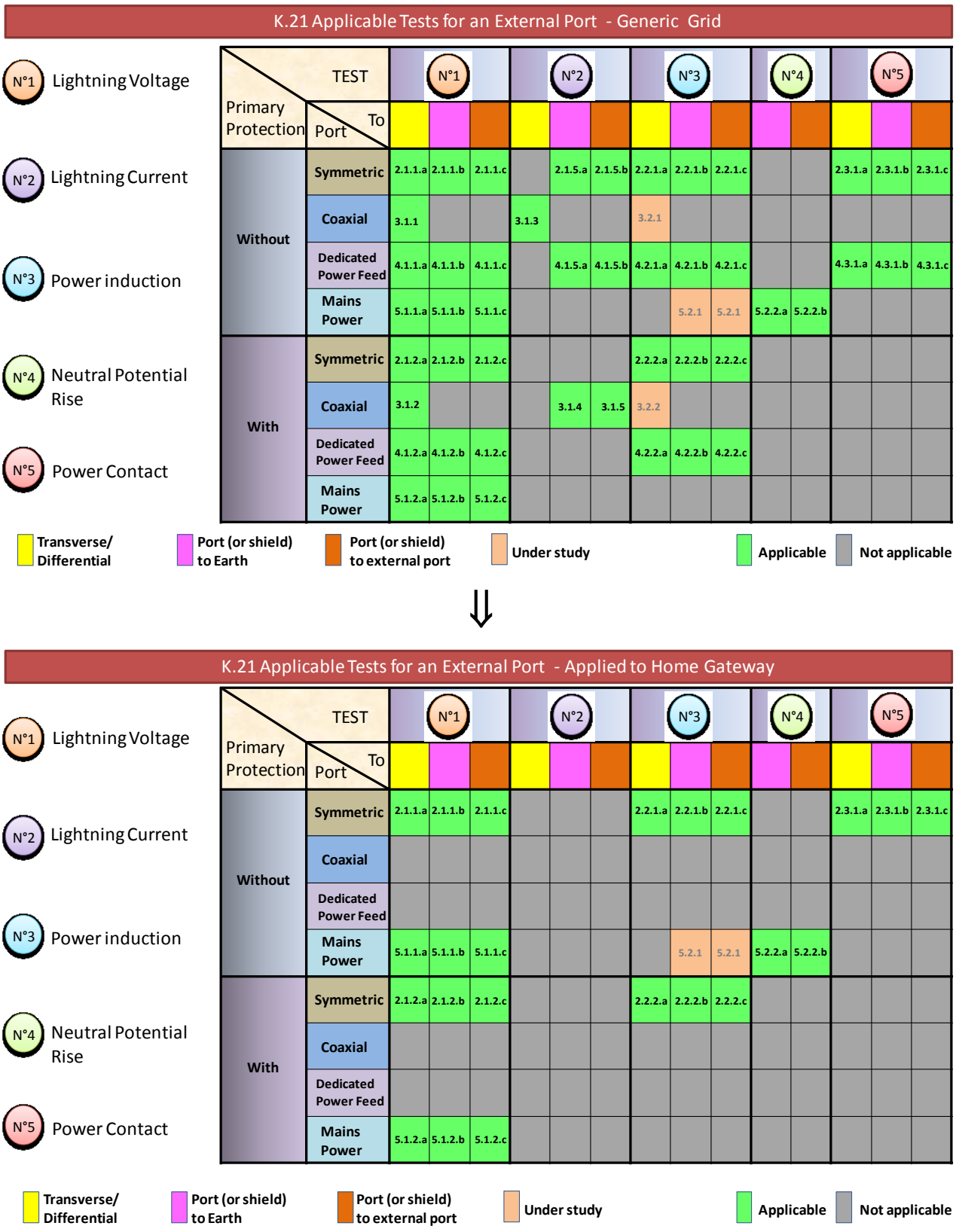
To get an estimate of the amount of testing, the number of tests is listed in the example of the Home Gateway:

- For each setup on each page,
- For each main test sub-type (2.1.x.a, 2.1.x.b, 2.1.1.c, 2.1.2.c,...),
- For each test type (2.1.x, 5.1.x, 7.1) in the following table,
- Meaning of "number of tests". Examples of definition of "one test" :
    - 2.1.1.a : 5 surges of each polarity →1 test = 10 surges,
    - 2.2.2.a : 5 times Power Induction disturbances → 1 test = 5 surges,
    - 2.3.1.a : 1 time with 8 resistors → 1 test = 8 times 15 minutes = 2 hours.
- The total test time for Lightning Surges & Power Induction is calculated based upon a 1 minute interval between each surge or pulse.
- The aim of this document is to list all test setups and test modes as required by K.21 & K.44 for this type of product, a Home Gateway, with an indication of the number of tests and the time needed to complete the tests.

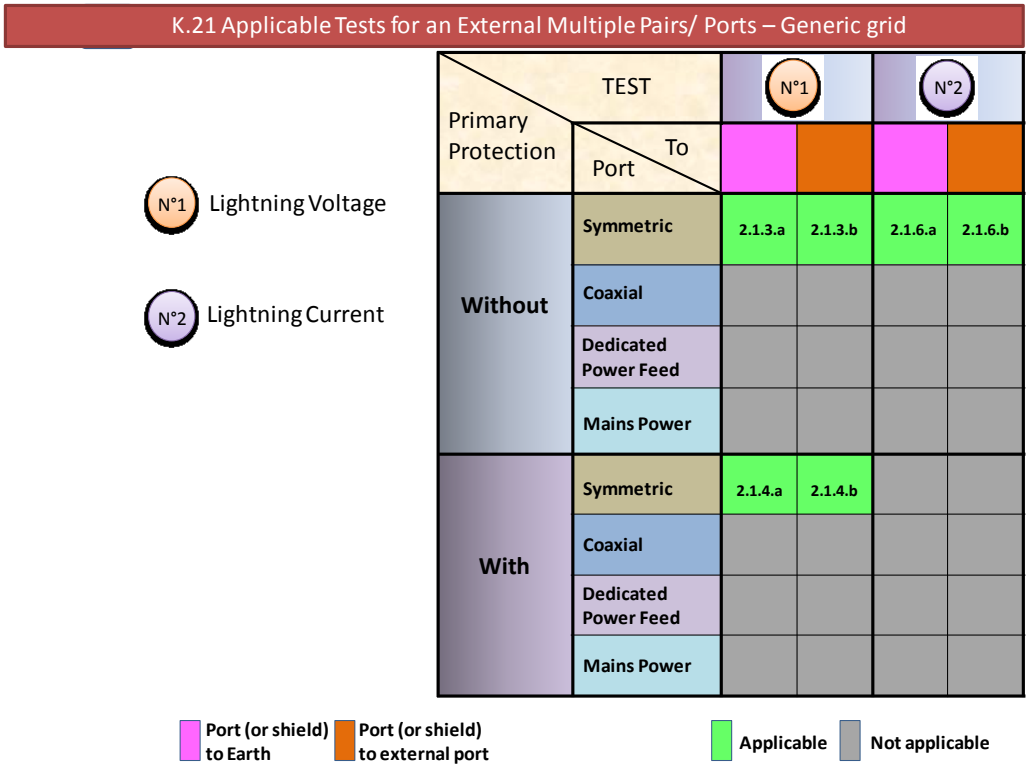
Test item	Number of tests	Number of surges	Estimation total test time (minutes)
2.1.1.a & 2.1.2.a	16	160	160
2.1.1.b & 2.1.2.b	40	400	400
2.1.1.c & 2.1.2.c	16	160	160
2.1.3.a & 2.1.4.a	20	200	200
2.1.3.b & 2.1.4.b	4	40	40
2.2.1.a & 2.2.2.a	8	40	40
2.2.1.b & 2.2.2.b	40	200	200
2.2.1.c & 2.2.2.c	16	80	80
2.3.1.a	4		480
2.3.1.b	20		2400
2.3.1.c	8		960
5.1.1.a & 5.1.2.a	4	40	40
5.1.1.b & 5.1.2.b	20	200	200
5.1.1.c & 5.1.2.c	8	80	80
5.2.2.a	10	50	50
5.2.2.b	4	20	20
7.1	30	300	300
7.2	10	100	100
Total (only effective test time)			+/-100 hours

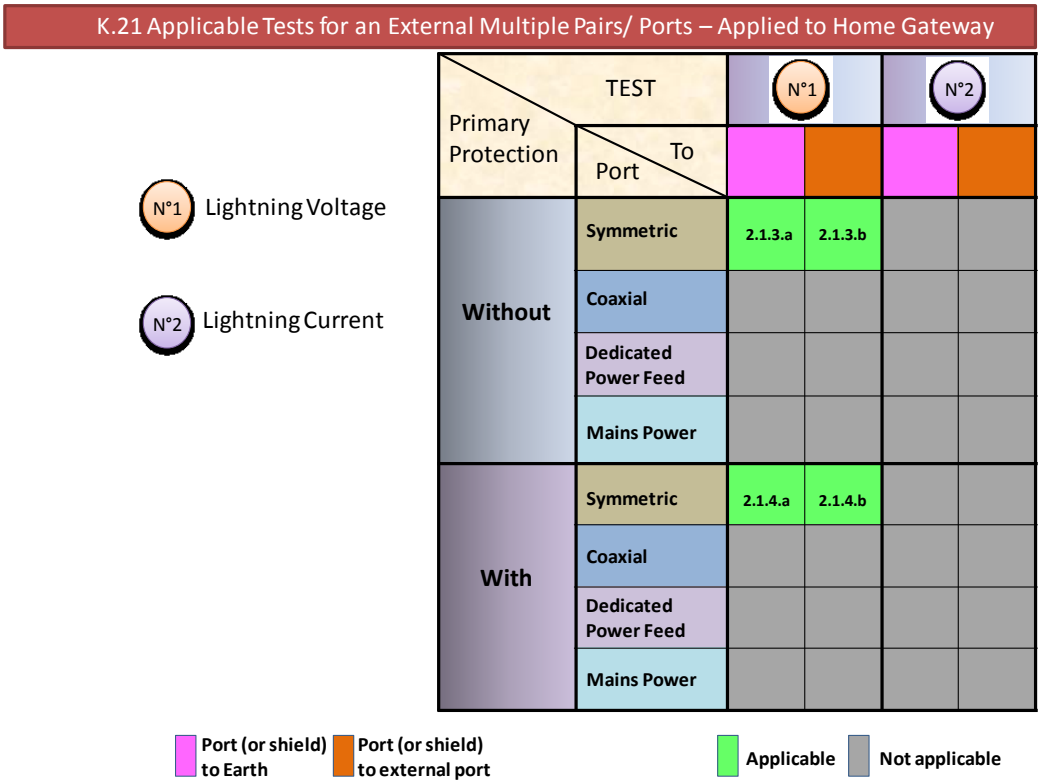
7.5 Applicable test items

7.5.1 Tests to ports connected to external cables, including the AC mains power port



7.5.2 Tests to ports connected to external cables





7.5.3 Tests to ports connected to internal cables

K.44 Clauses 7.1 and 7.2 apply. For internal Ethernet ports, Clauses A.6.7-1 and A.6.7-4 also apply.

7.5.4 LIGHTNING SURGE
External single pair port (ADSL & FXO)
Transverse 2.1.1.a (inherent) & 2.1.2.a (coordination)

7.5.4.1 General

Primary protection: The EUT is not designed to be always used with primary protection at the ADSL, FXO and AC ports. A Special Test Protector (STP) instead of a primary protector shall be used at the ADSL & FXO ports.

Coupling between test generator and EUT: One wire of the single external symmetrical pair shall be connected to the output of the test generator via a coupling element. The other wire shall be connected to the return port of the generator via a coupling element. The type of coupling element is described in chapter 7.6.

Decoupling networks between EUT and Auxiliary equipment at the tested & untested ports: see chapter 7.6.

Earthing and bonding configuration: The EUT has no earthing point that can be bonded to ground. Earthing points of decoupling networks, Agreed Primary protector and the STP shall be bonded to ground.

As a general rule, all Auxiliary equipment at the untested ports shall be left floating = no connection to ground.

During the application of the surges, Auxiliary equipment is only connected to those untested Ethernet ports (GbE and LAN) that are not coupled to ground.

The voltage waveform of the lightning surge test generator is a 10/700µs.

Total number of tests: 16

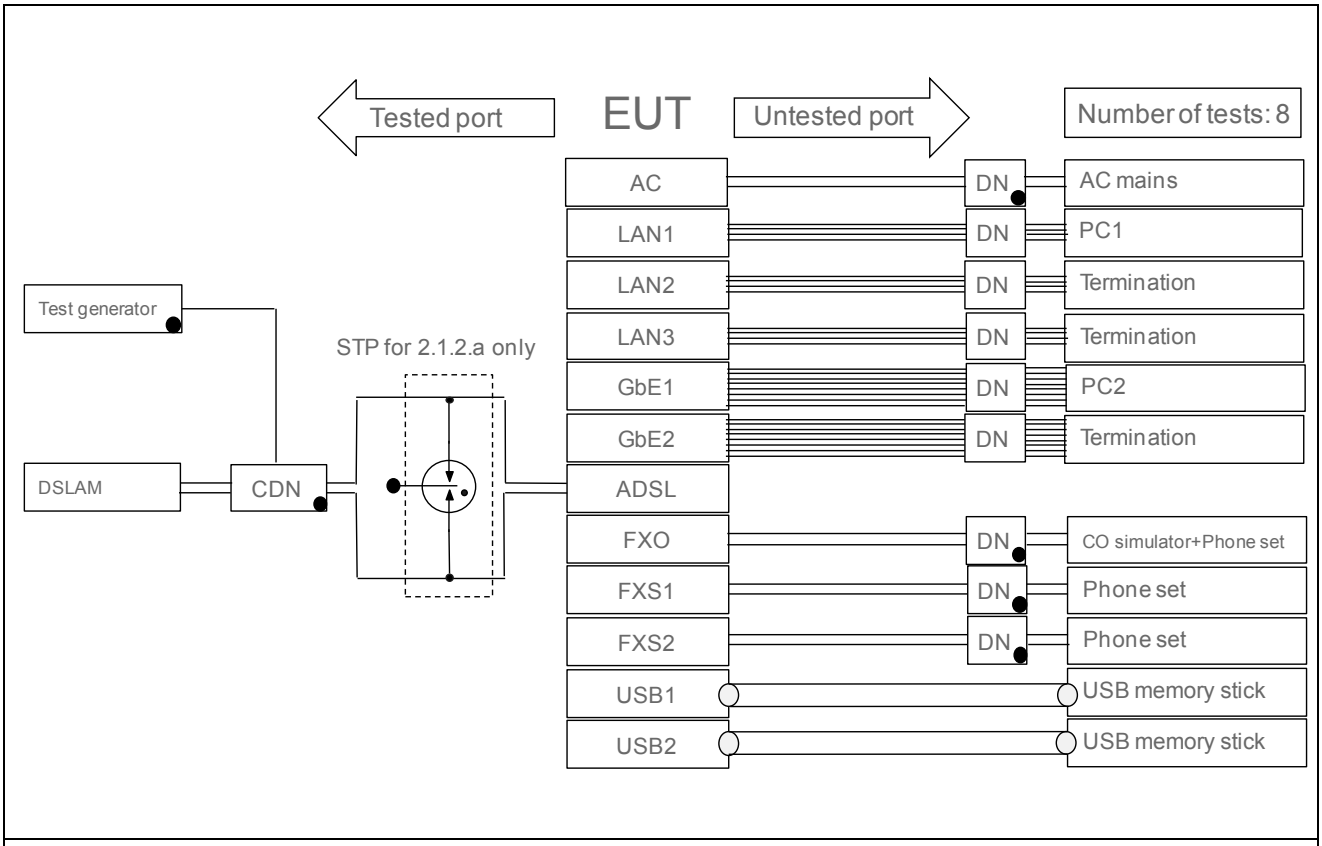


Figure 1 – Tested port ADSL, all untested ports terminated - not coupled to ground

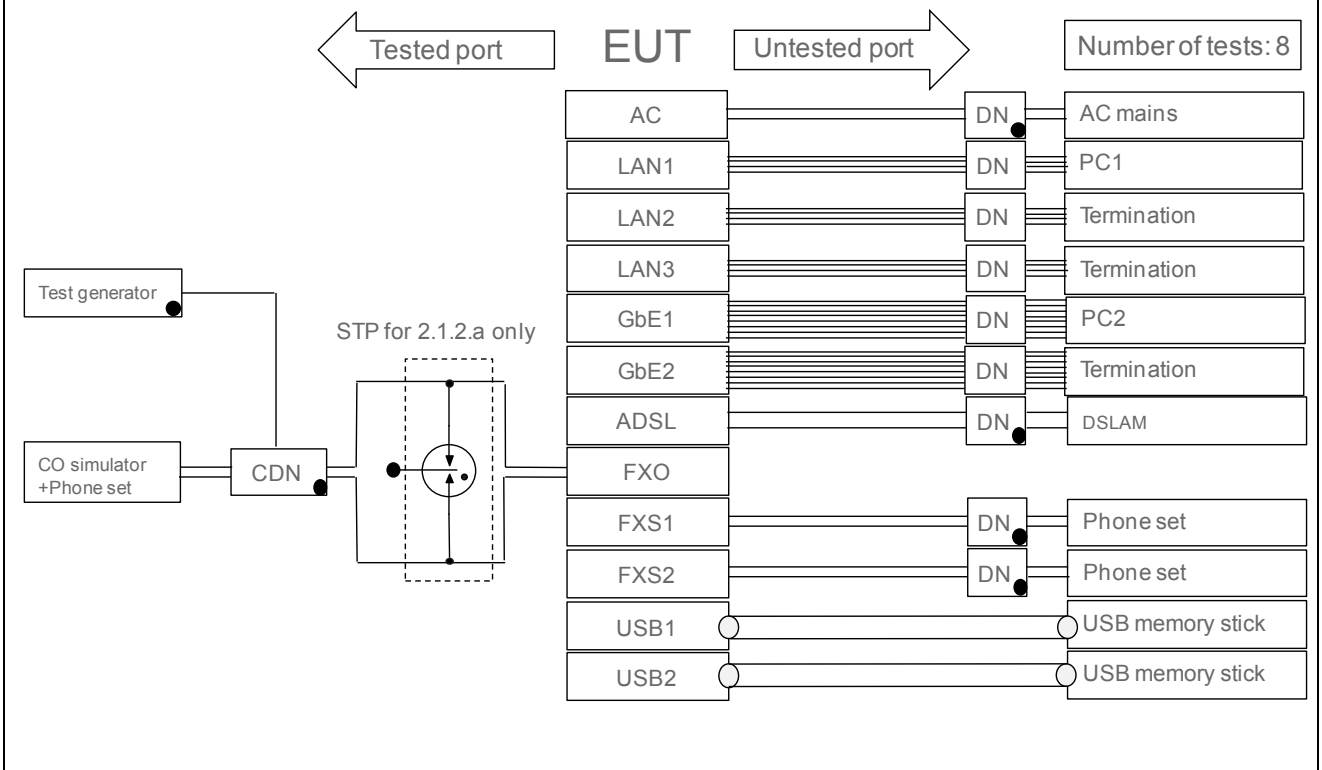


Figure 2 – Tested port FXO, all untested ports terminated - not coupled to ground

7.5.5 LIGHTNING SURGE
External single pair port (ADSL & FXO)
Port to Earth 2.1.1.b (inherent) & 2.1.2.b (coordination)

7.5.5.1 General

Primary protection: The EUT is not designed to be always used with primary protection at the ADSL, FXO and AC ports. A Special Test Protector (STP) instead of a primary protector shall be used at the ADSL & FXO ports.

Coupling between test generator and EUT: Each of both wires of the single external symmetrical pair shall be connected to the output of the test generator via a coupling element. The type of coupling element is described in chapter 7.6.

Decoupling networks between EUT and Auxiliary equipment at the tested & untested ports: see chapter 7.6.

Earthing and bonding configuration: The EUT has no earthing point that can be bonded to ground. Earthing points of decoupling networks, Agreed Primary protector and the STP shall be bonded to ground.

As a general rule, all Auxiliary equipment at the untested ports shall be left floating = no connection to ground.

During the application of the surges, Auxiliary equipment is only connected to those untested Ethernet ports (GbE and LAN) that are not coupled to ground. Untested Ethernet ports that are coupled to ground are not connected to auxiliary equipment.
After the surge test, the untested Ethernet ports that were coupled to ground are connected to auxiliary equipment and a functional verification is done.

The voltage waveform of the lightning surge test generator is a 10/700µs.

Total number of tests: 40.

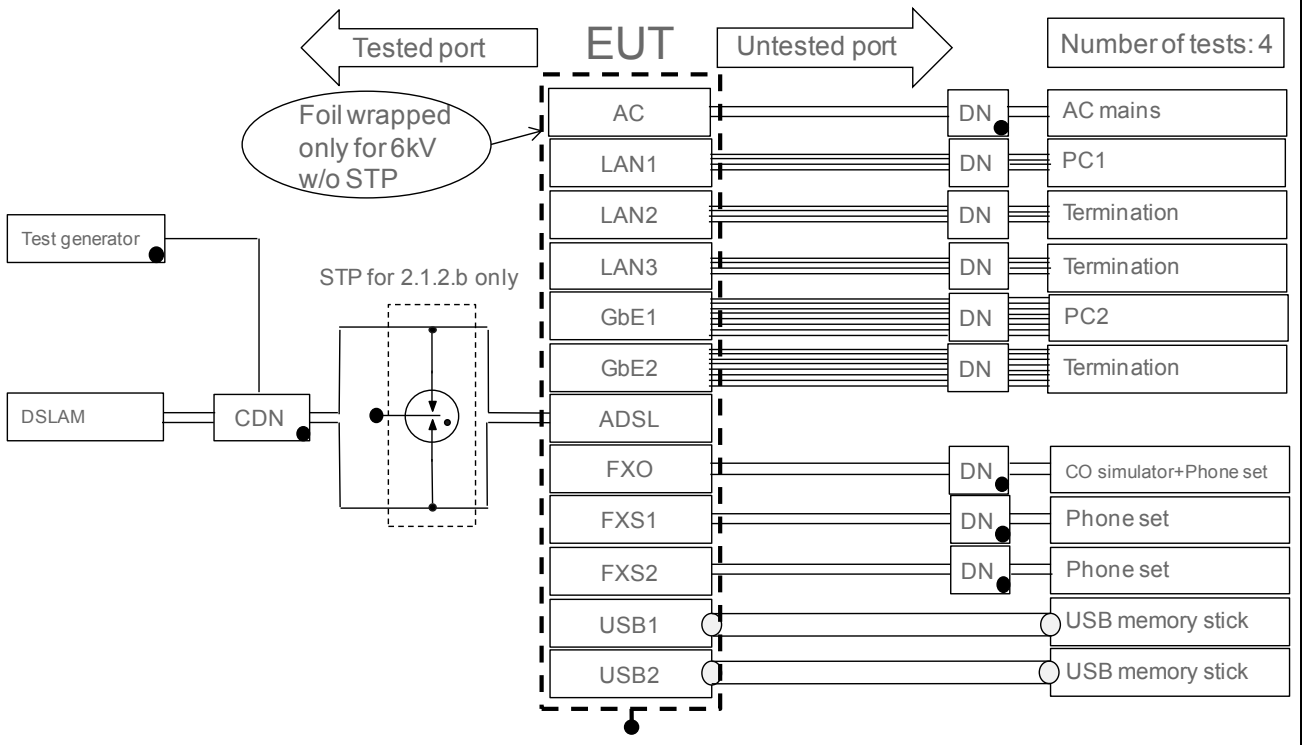


Figure 3 – Tested port ADSL, all untested ports terminated - not coupled to ground

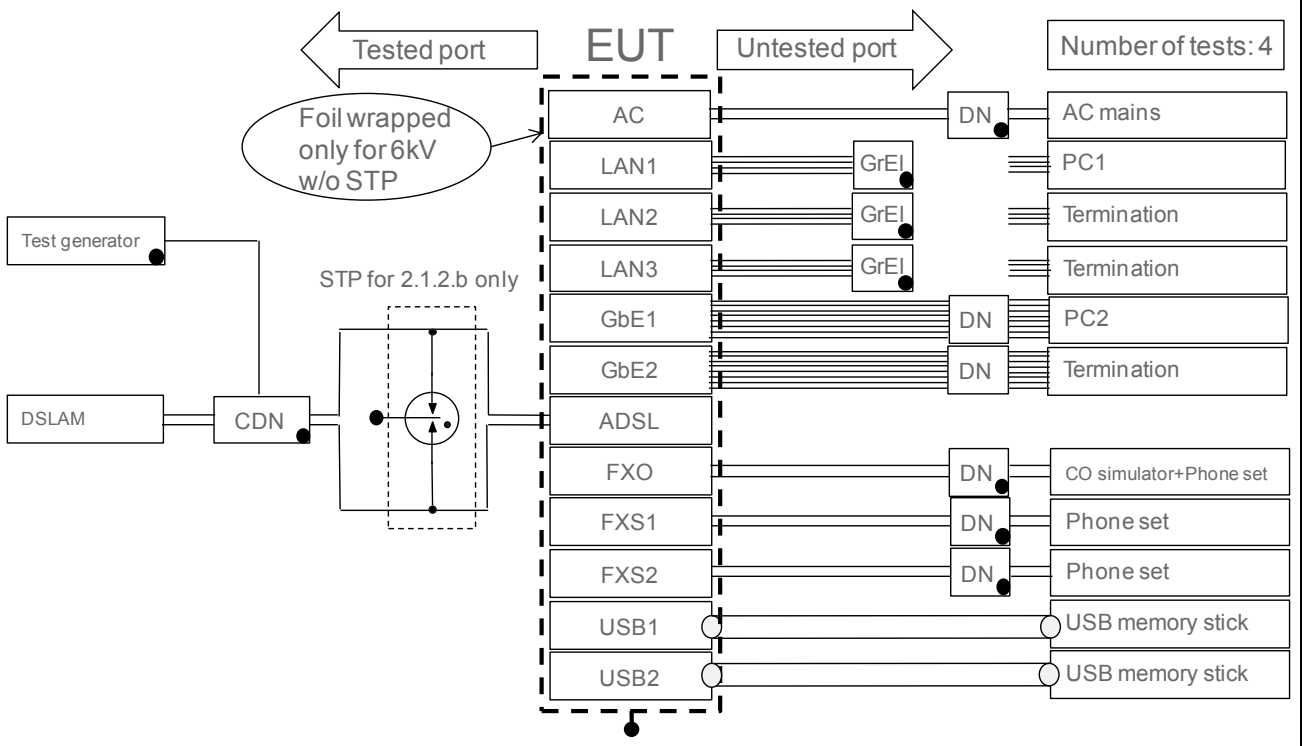


Figure 4 – Tested port ADSL, all untested ports terminated - LAN coupled to ground

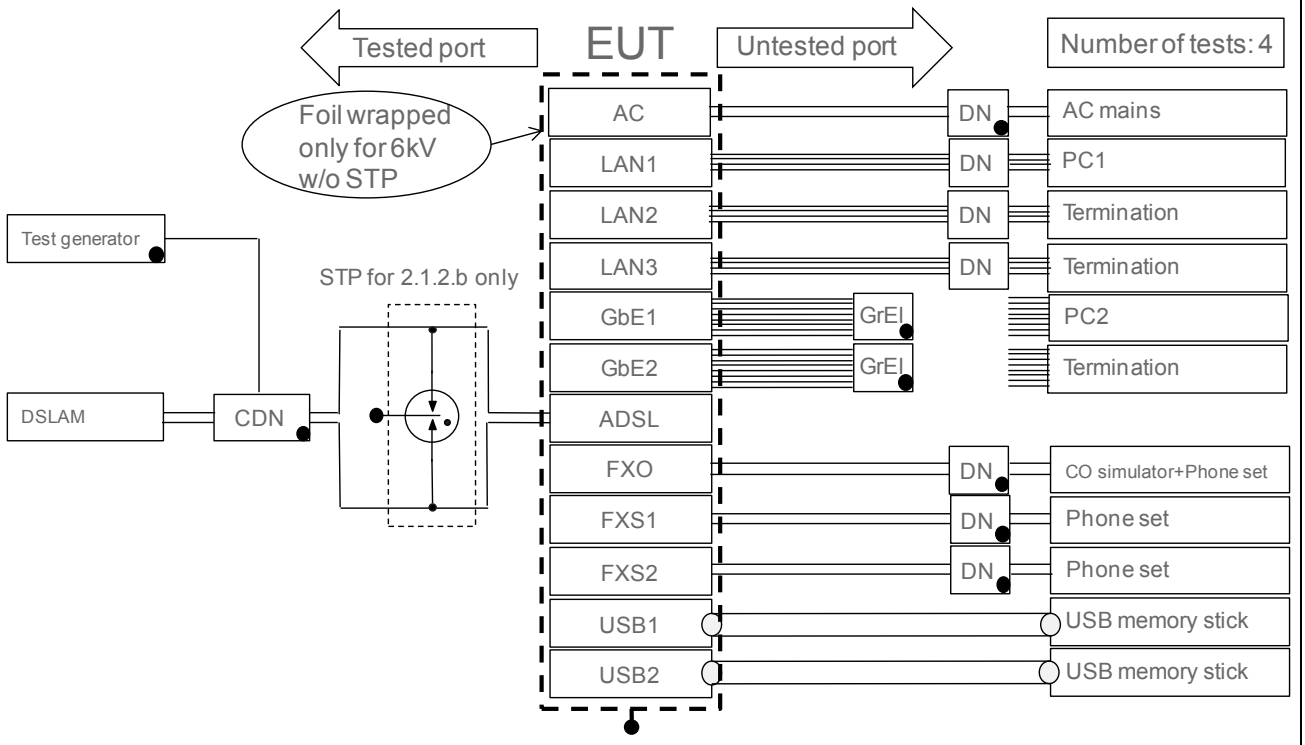


Figure 5 – Tested port ADSL, all untested ports terminated - GbE coupled to ground

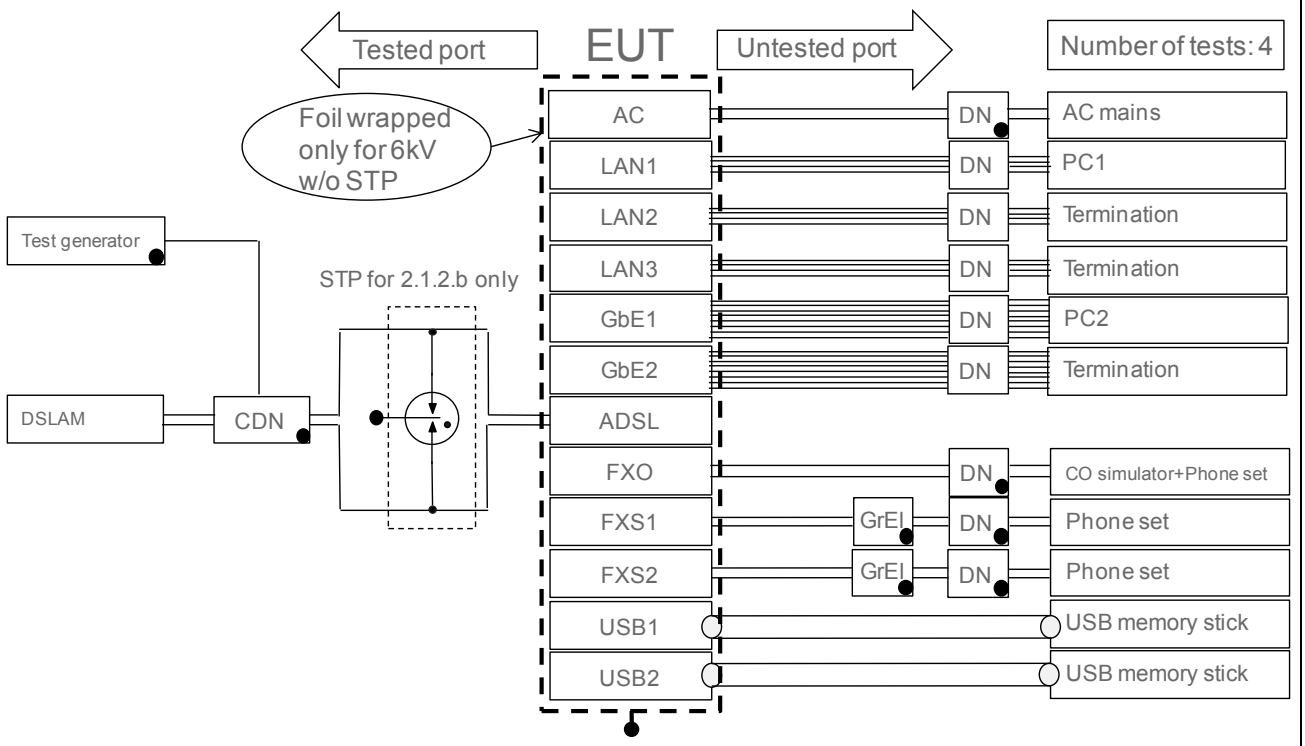


Figure 6 – Tested port ADSL, all untested ports terminated - FXS coupled to ground

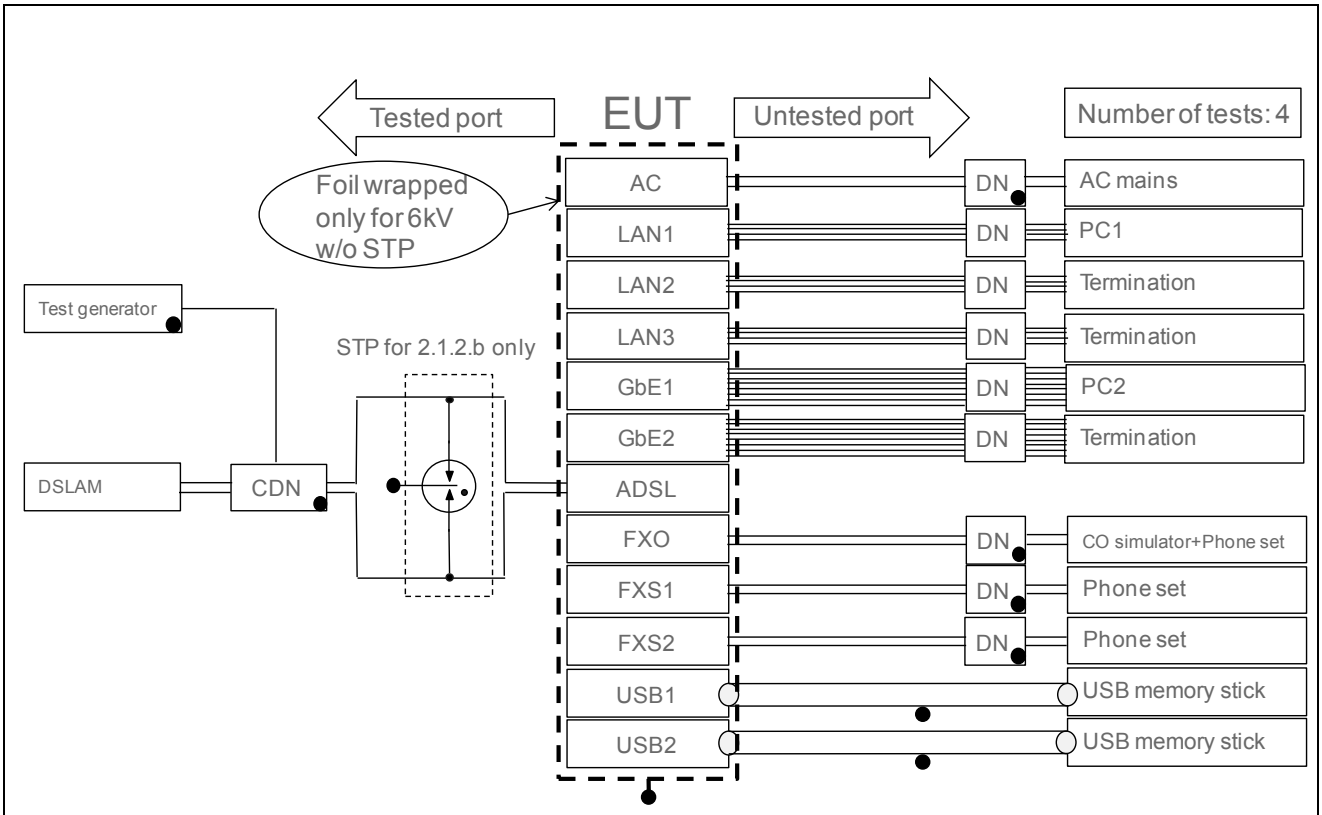


Figure 7 – Tested port ADSL, all untested ports terminated - USB coupled to ground

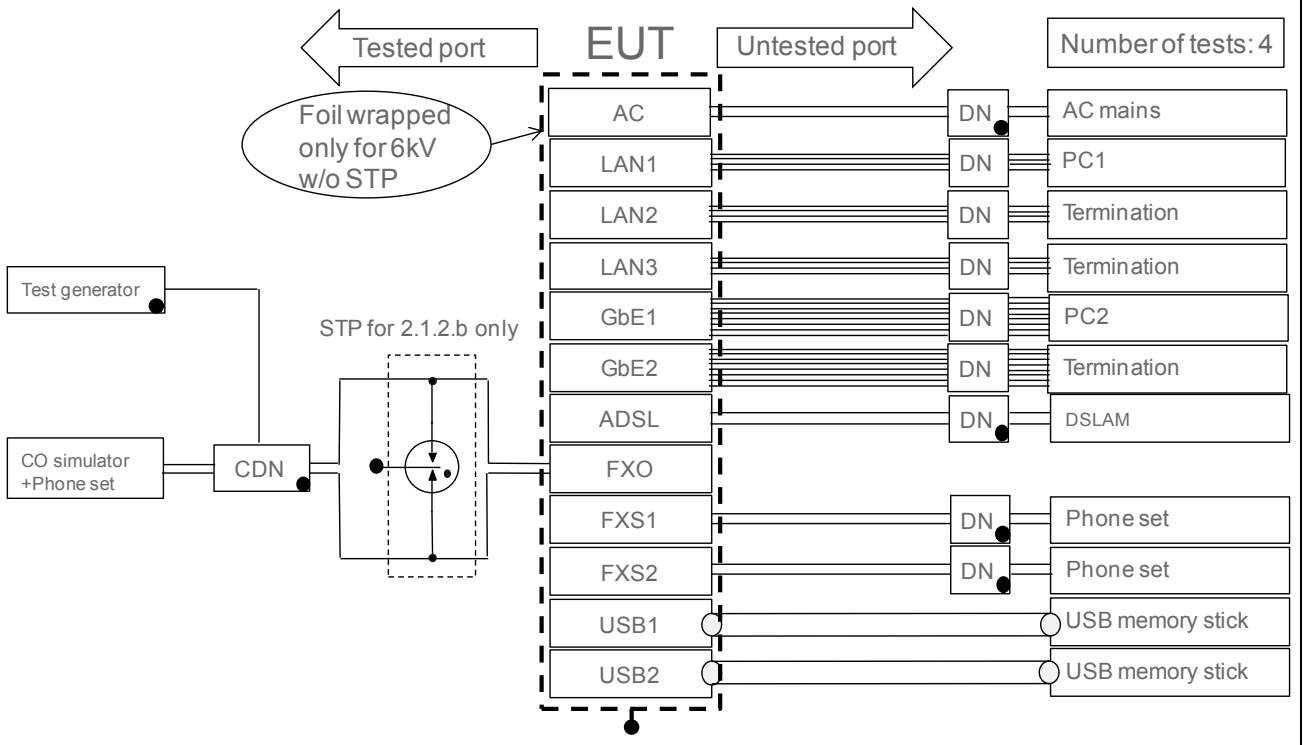


Figure 8 – Tested port FXO, all untested ports terminated - not coupled to ground

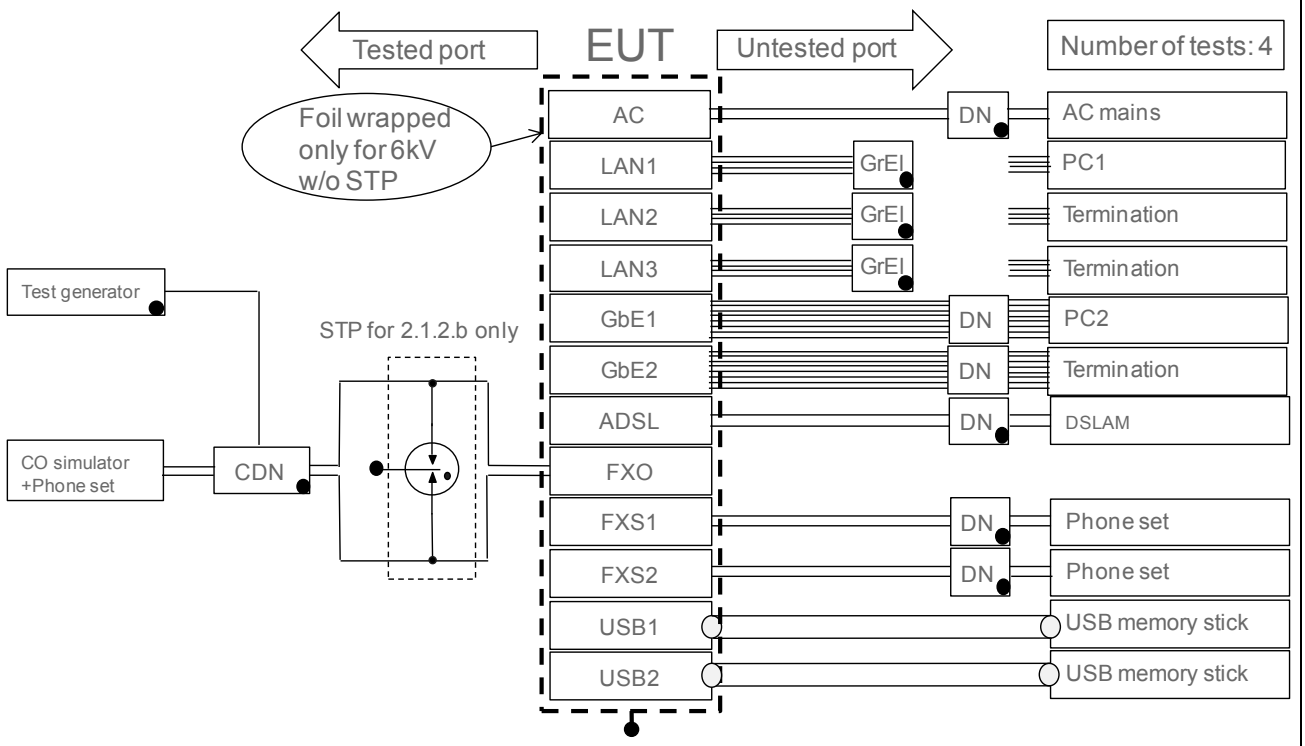


Figure 9 – Tested port FXO, all untested ports terminated - LAN coupled to ground

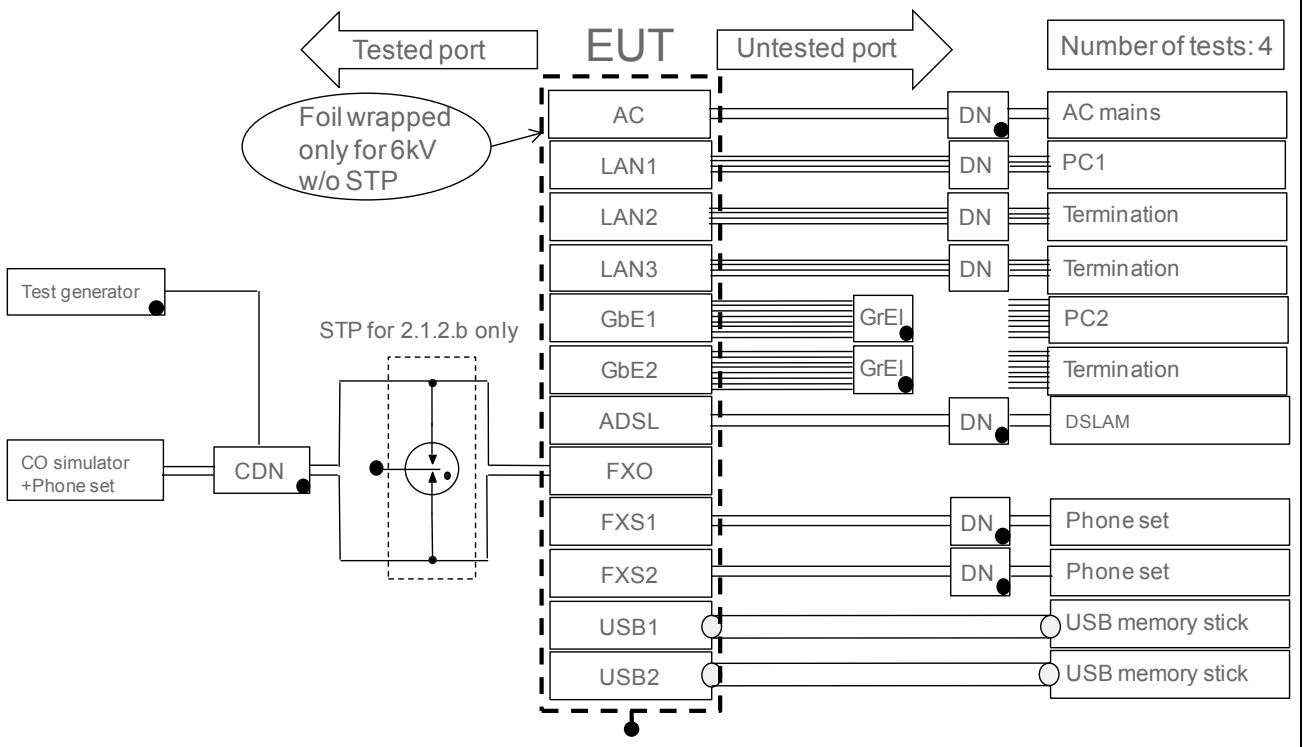


Figure 10 – Tested port FXO, all untested ports terminated - GbE coupled to ground

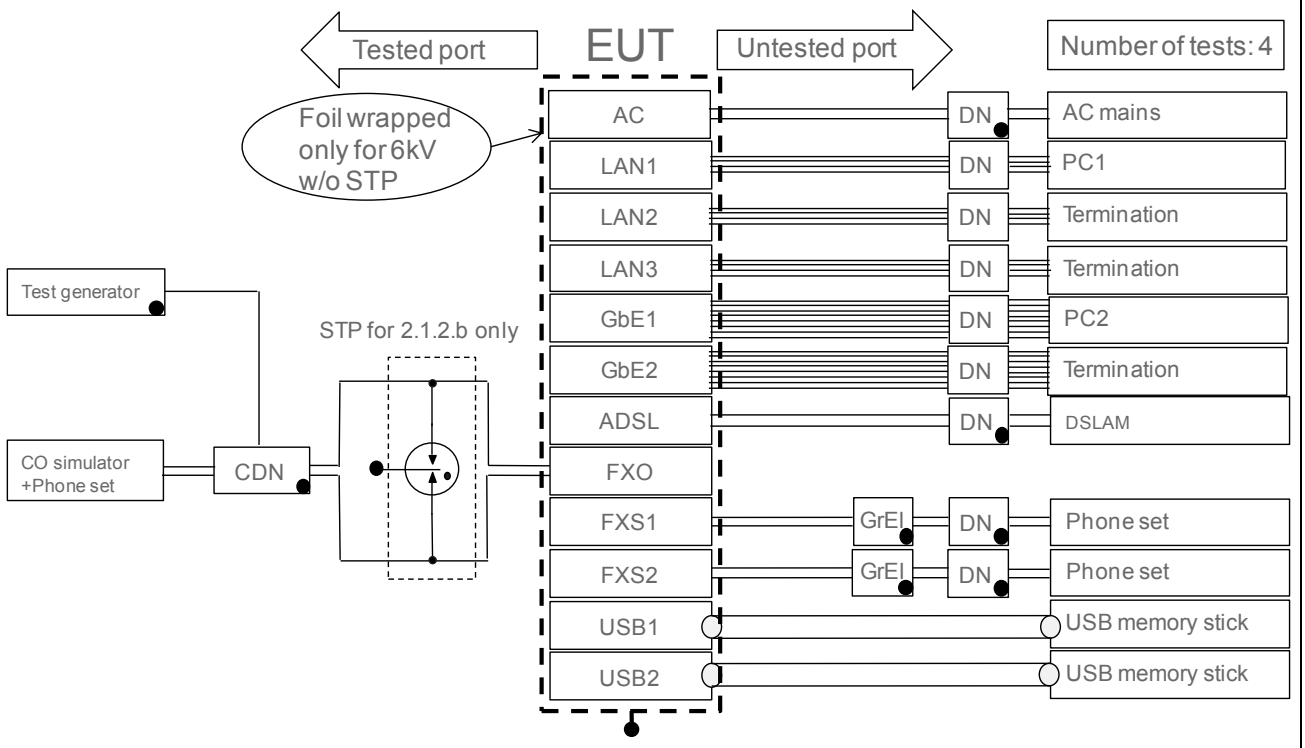


Figure 11 – Tested port FXO, all untested ports terminated - FXS coupled to ground

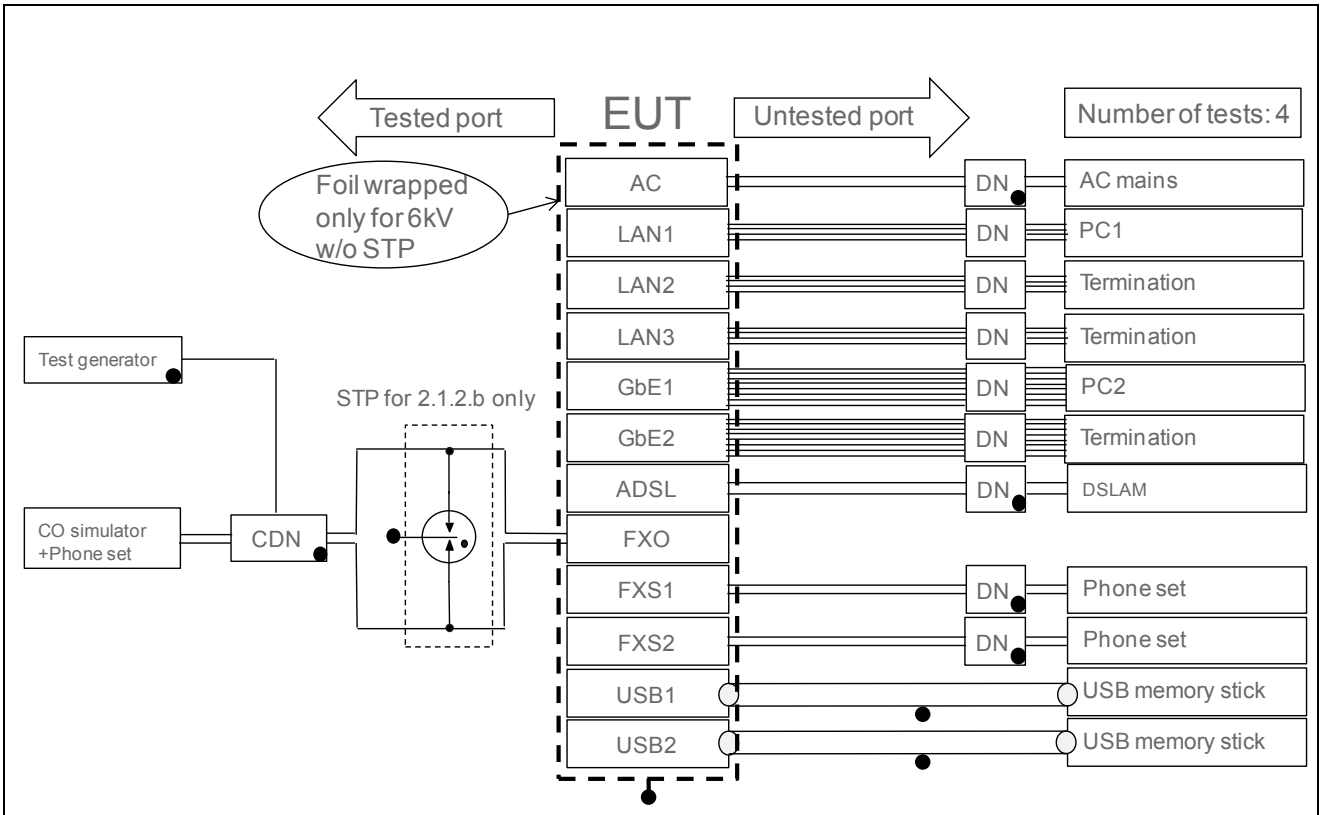


Figure 12 – Tested port FXO, all untested ports terminated - USB coupled to ground

7.5.6 LIGHTNING SURGE
External single pair port (ADSL & FXO)
Port to External port 2.1.1.c (inherent) & 2.1.2.c (coordination)

7.5.6.1 General

Primary protection: The EUT is not designed to be always used with primary protection at the ADSL, FXO and AC ports. A Special Test Protector (STP) instead of a primary protector shall be used at the ADSL & FXO ports.

Coupling between test generator and EUT: Each of both wires of the single external symmetrical pair shall be connected to the output of the test generator via a coupling element. The type of coupling element is described in chapter 7.6.

Decoupling networks between EUT and Auxiliary equipment at the tested & untested ports: see chapter 7.6.

Earthing and bonding configuration: The EUT has no earthing point that can be bonded to ground. Earthing points of decoupling networks at the untested side, APP and STP shall be connected to the floating EUT reference bar; Grounding elements shall be bonded to ground.

All Auxiliary equipment at the untested ports shall be left floating = no connection to ground.

During the application of the surges, Auxiliary equipment is only connected to those untested Ethernet ports (GbE and LAN) that are not coupled to ground.

The voltage waveform of the lightning surge test generator is a 10/700µs.

Total number of tests: 16.

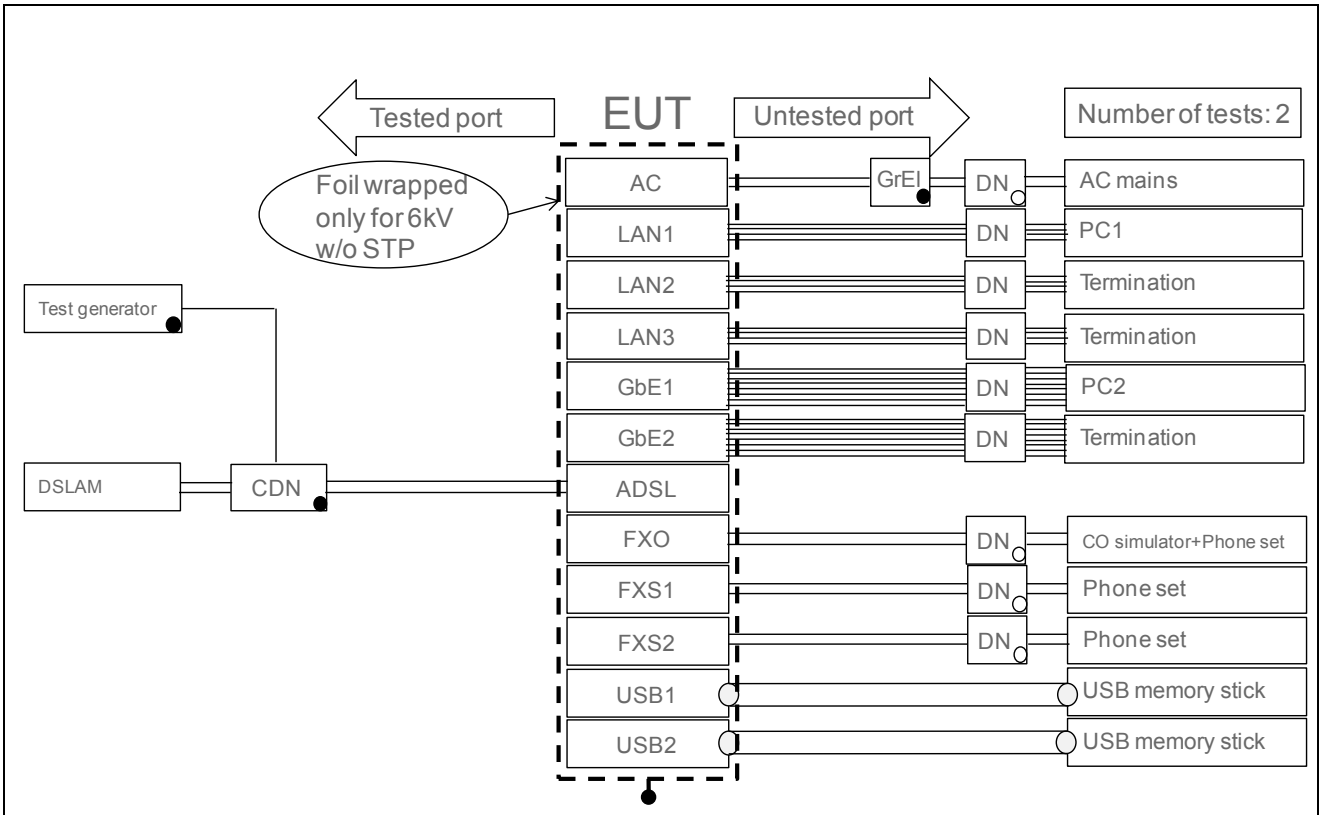


Figure 13.a – Tested port ADSL, all untested ports terminated - AC coupled to ground

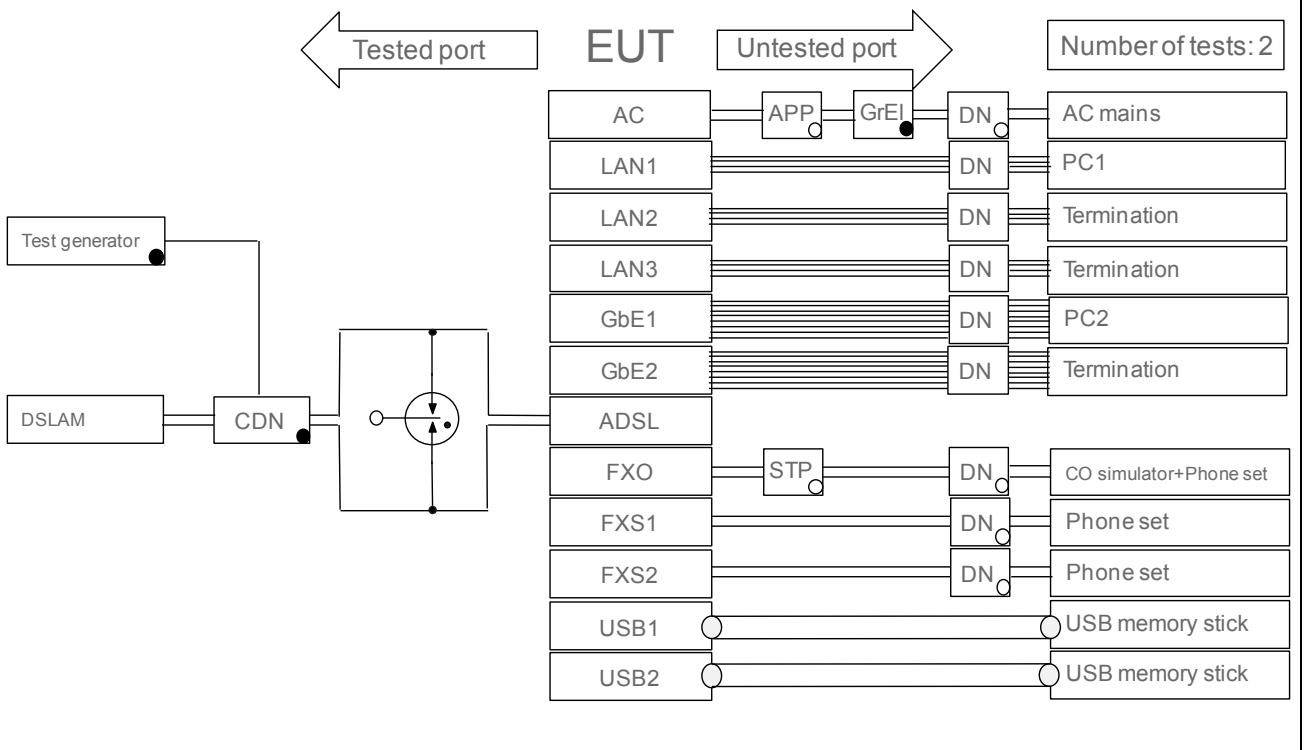


Figure 13.b – Tested port ADSL, all untested ports terminated - AC coupled to ground

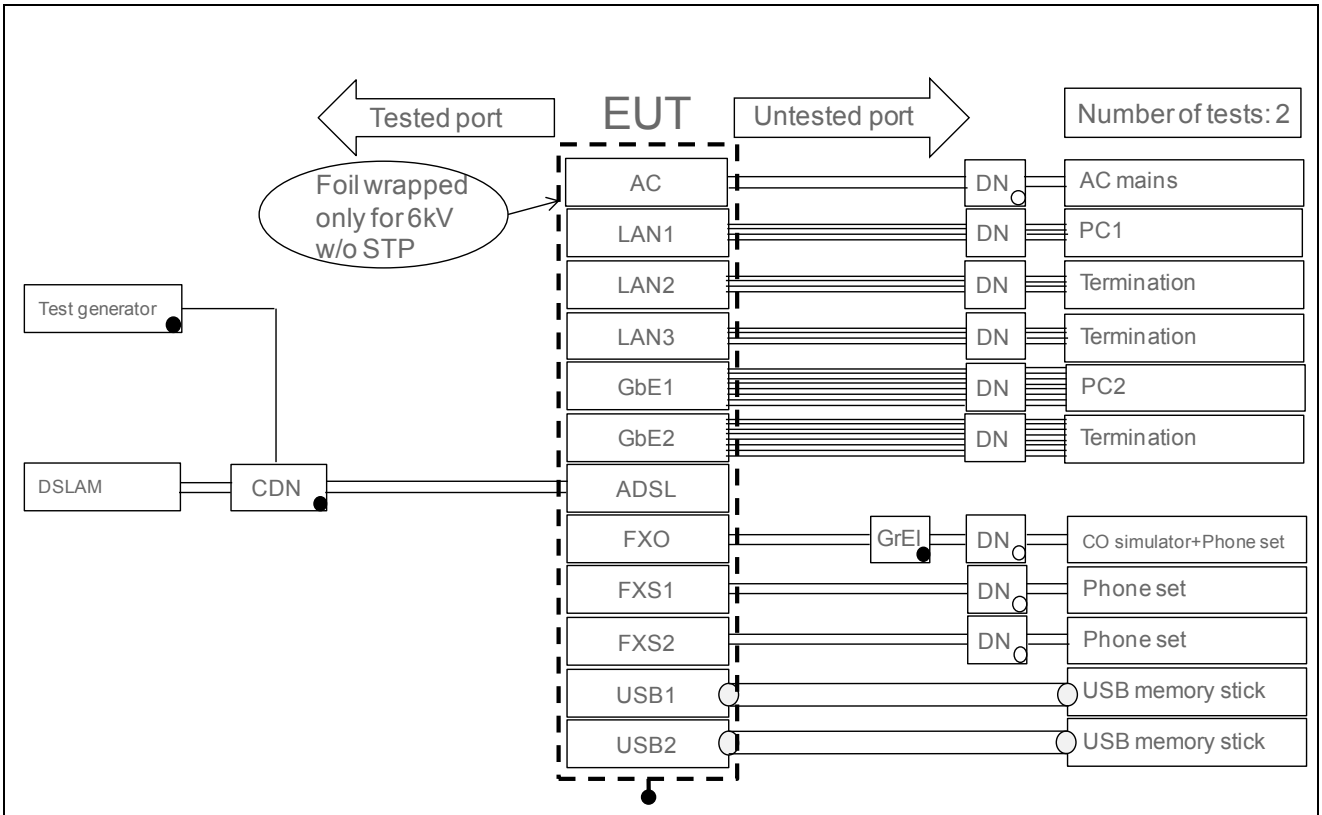


Figure 14.a – Tested port ADSL, all untested ports terminated - FXO coupled to ground

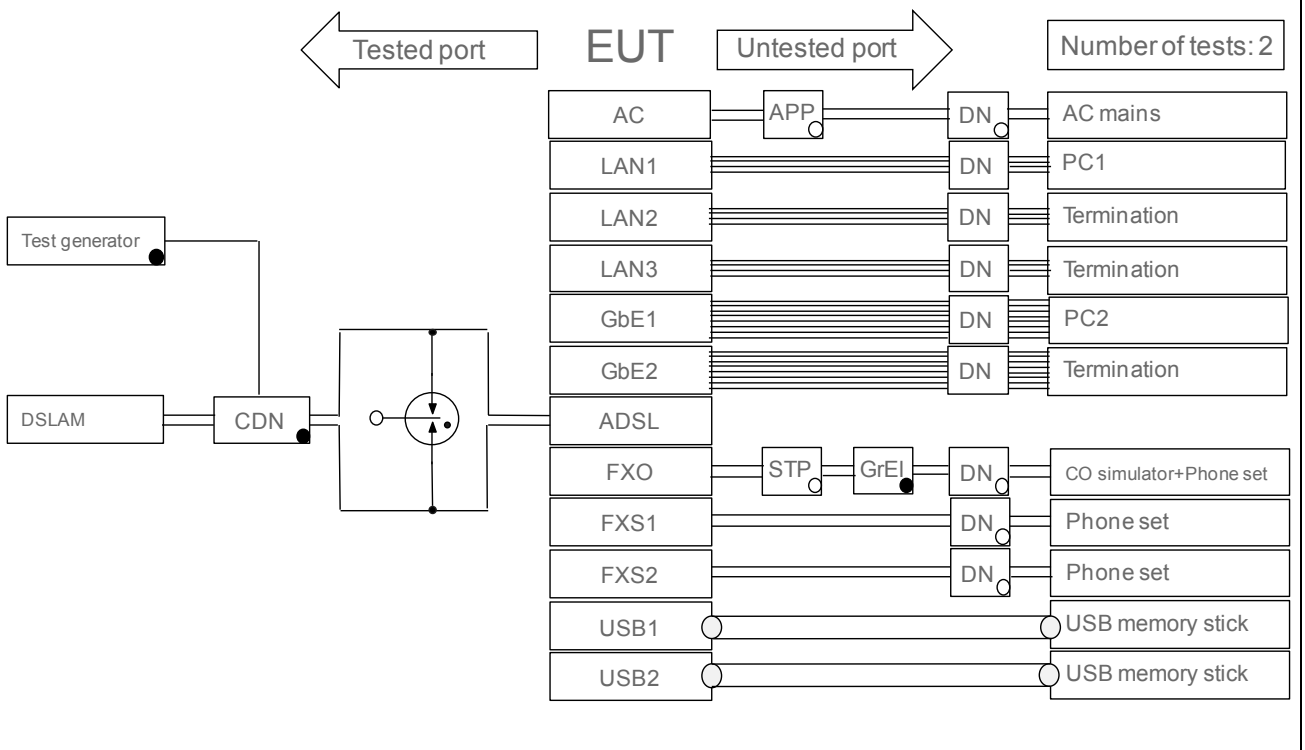


Figure 14.b – Tested port ADSL, all untested ports terminated - FXO coupled to ground

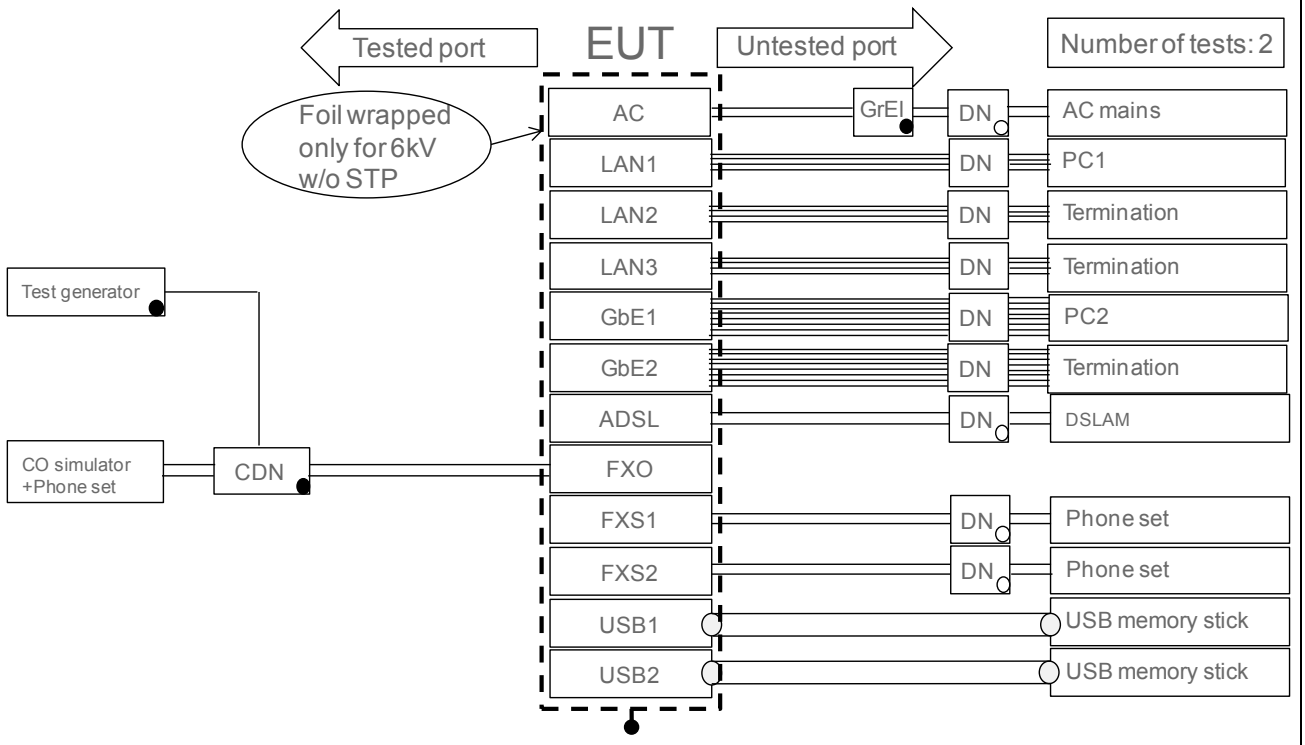


Figure 15.a – Tested port FXO, all untested ports terminated - AC coupled to ground

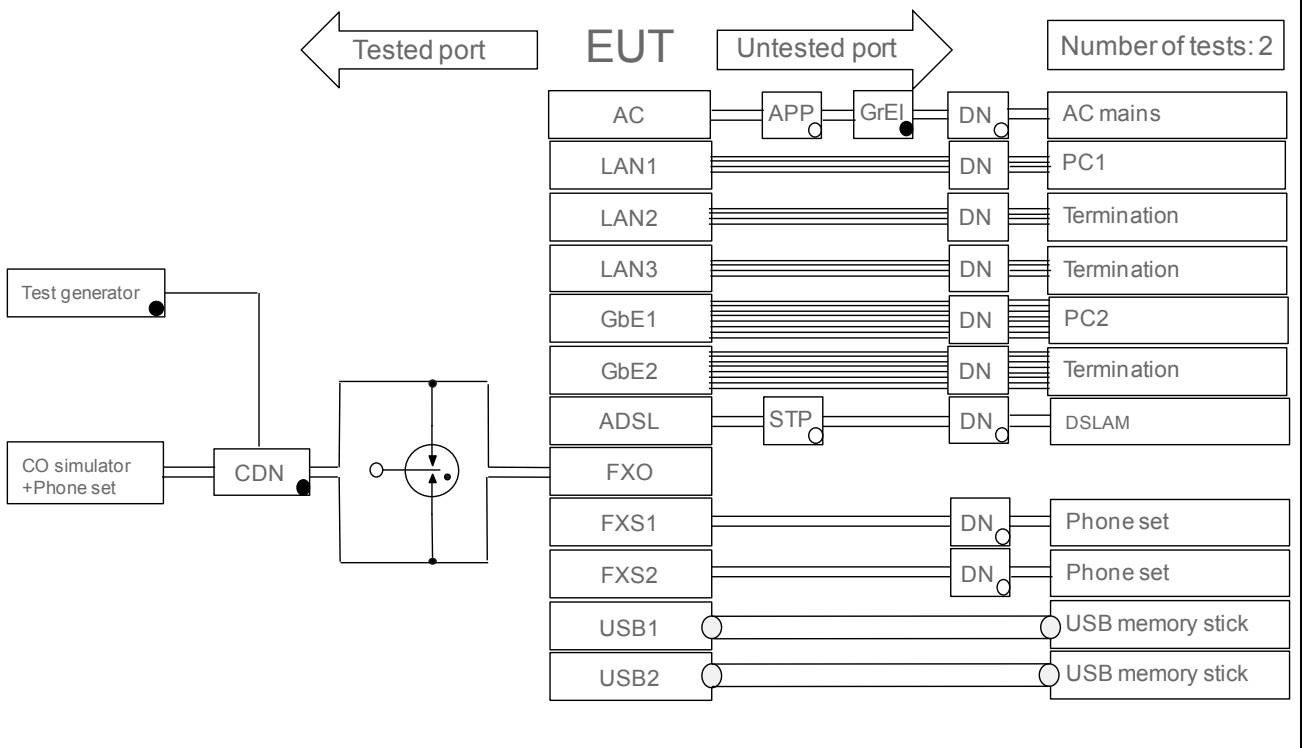


Figure 15.b – Tested port FXO, all untested ports terminated - AC coupled to ground

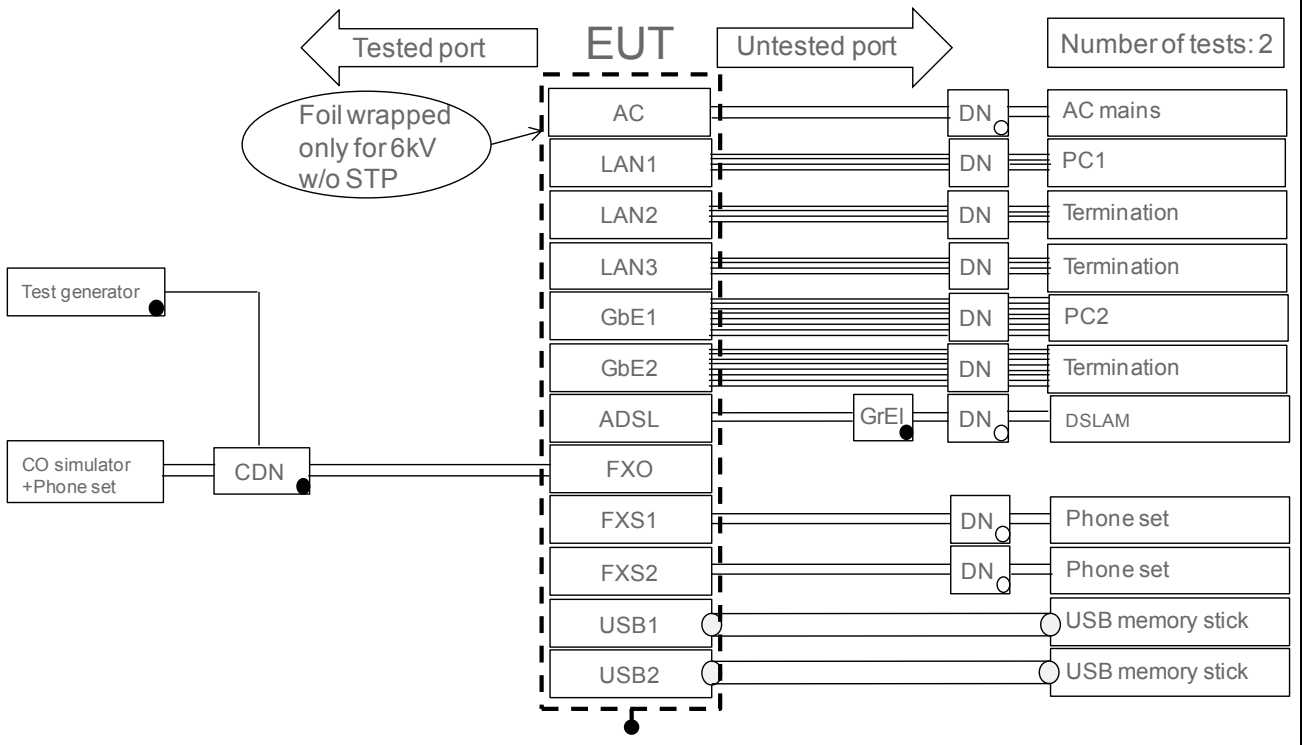


Figure 16.a – Tested port FXO, all untested ports terminated - ADSL coupled to ground

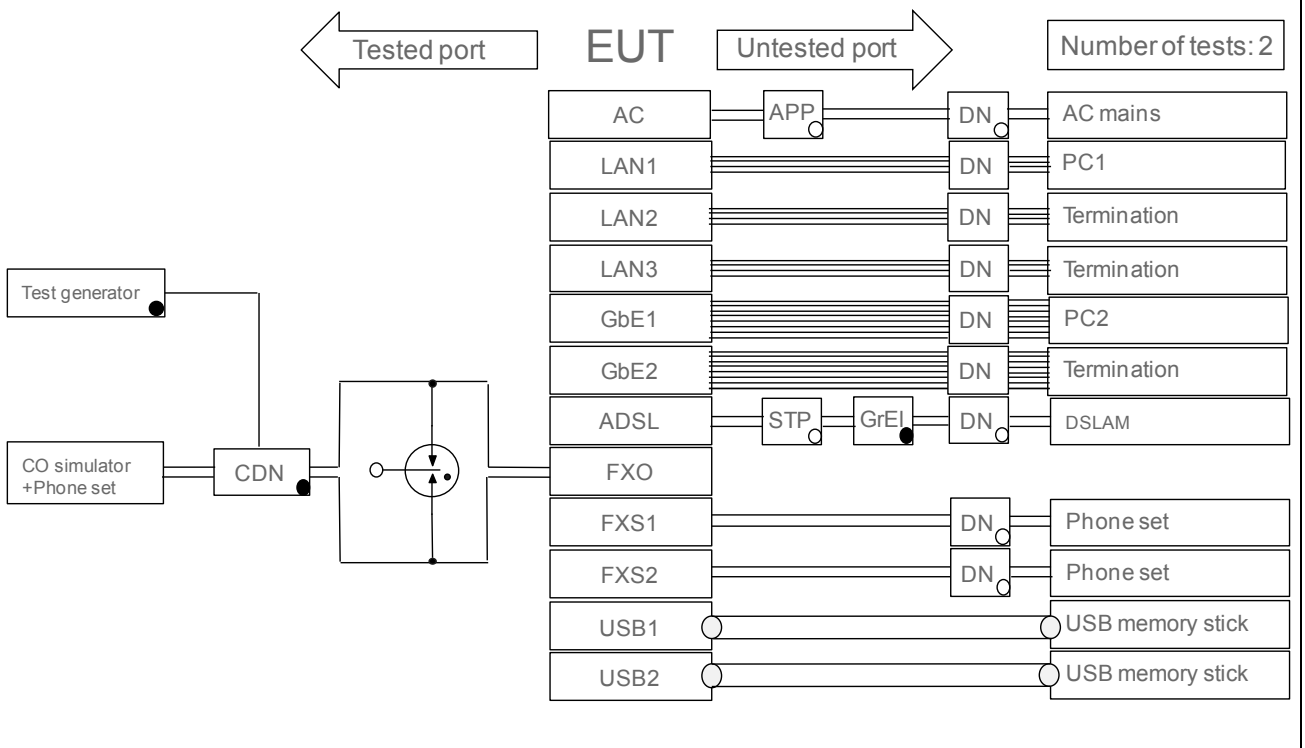


Figure 16.b – Tested port FXO, all untested ports terminated - ADSL coupled to ground

7.5.7 LIGHTNING SURGE
External multiple pairs/ ports (ADSL & FXO)
Port to Earth 2.1.3.a (inherent) & 2.1.4.a (coordination)

7.5.7.1 General

Primary protection: The EUT is not designed to be always used with primary protection at the ADSL, FXO and AC ports. A Special Test Protector (STP) instead of a primary protector shall be used at the ADSL & FXO ports.

Coupling between test generator and EUT: All wires of all external pairs shall be connected to the output of the test generator via coupling elements. The type of coupling element is described in chapter 7.6.

Decoupling networks between EUT and Auxiliary equipment at the tested & untested ports: see chapter 7.6.

Earthing and bonding configuration: The EUT has no earthing point that can be bonded to ground. Earthing points of decoupling networks, Agreed Primary protector and the STP shall be bonded to ground.

As a general rule, all Auxiliary equipment at the untested ports shall be left floating = no connection to ground.

During the application of the surges, Auxiliary equipment is only connected to those untested Ethernet ports (GbE and LAN) that are not coupled to ground. Untested Ethernet ports that are coupled to ground are not connected to auxiliary equipment.
After the surge test, the untested Ethernet ports that were coupled to ground are connected to auxiliary equipment and a functional verification is done.

The voltage waveform of the lightning surge test generator is a 10/700µs.

Total number of tests: 20.

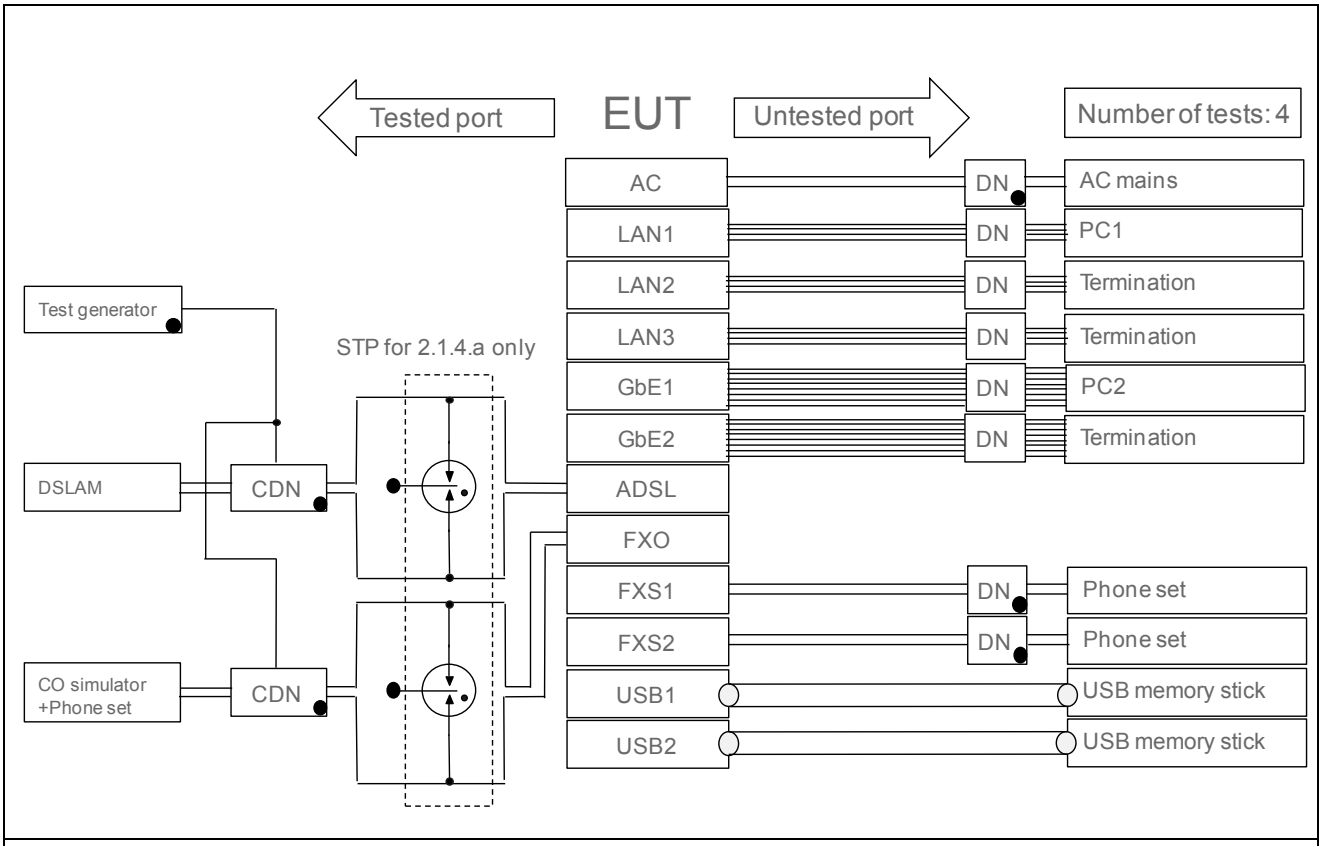


Figure 17 – Tested ports ADSL+FXO, untested ports terminated - not coupled to ground

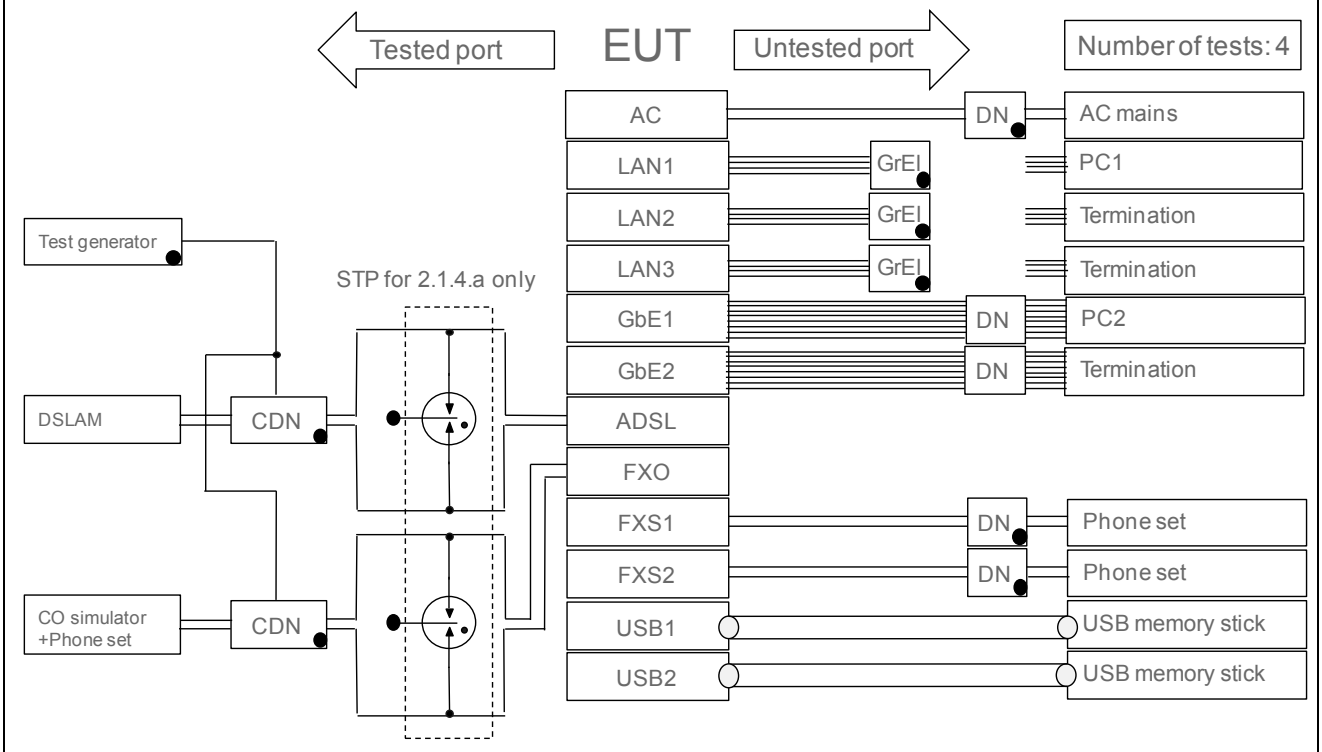


Figure 18 – Tested port ADSL+FXO, untested ports terminated - LAN coupled to ground

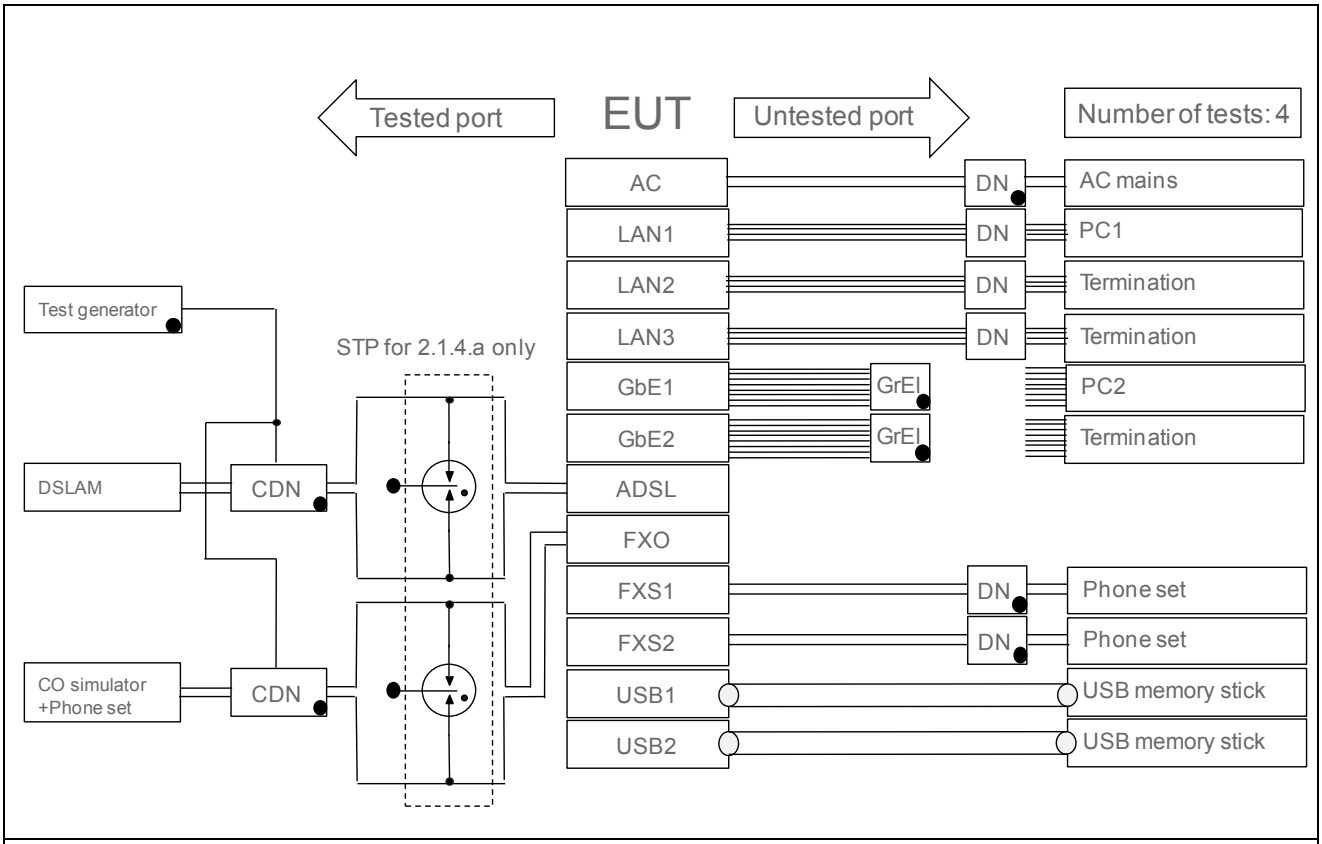


Figure 19 – Tested port ADSL+FXO, untested ports terminated - GbE coupled to ground

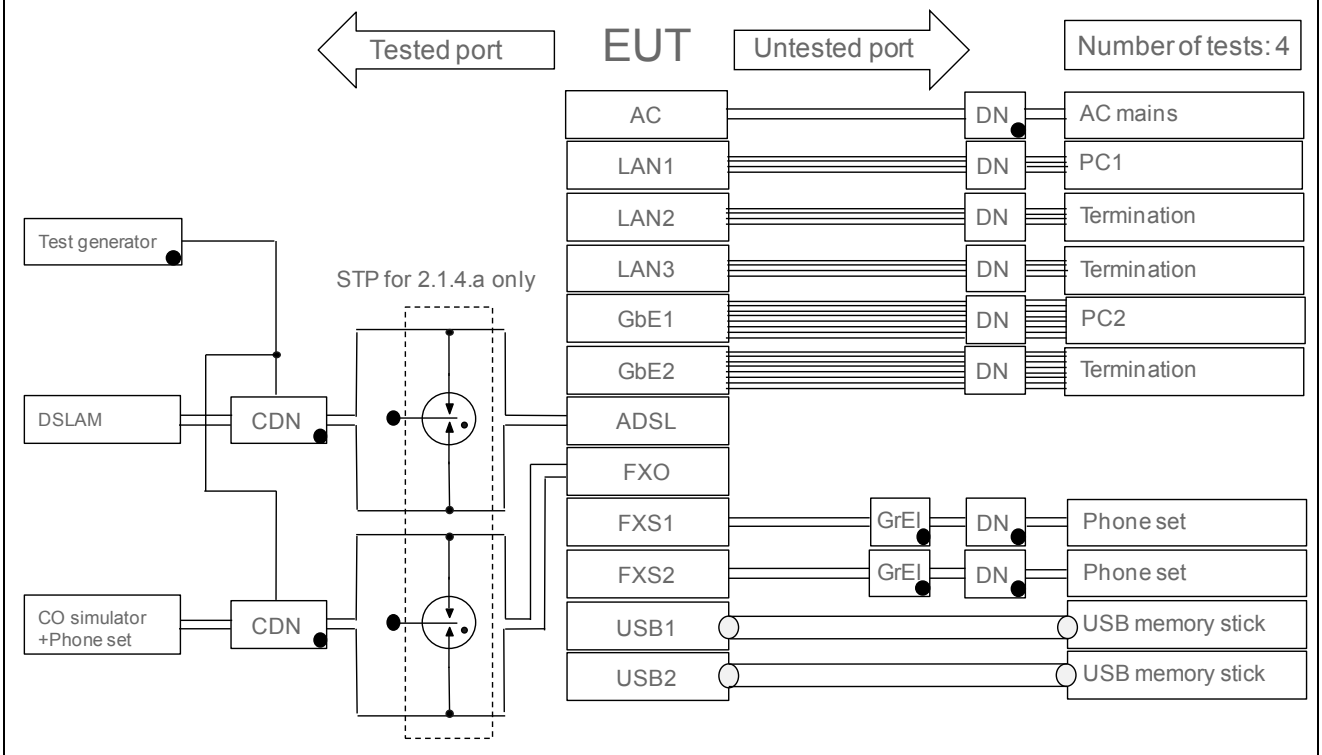


Figure 20 – Tested port ADSL+FXO, untested ports terminated - FXS coupled to ground

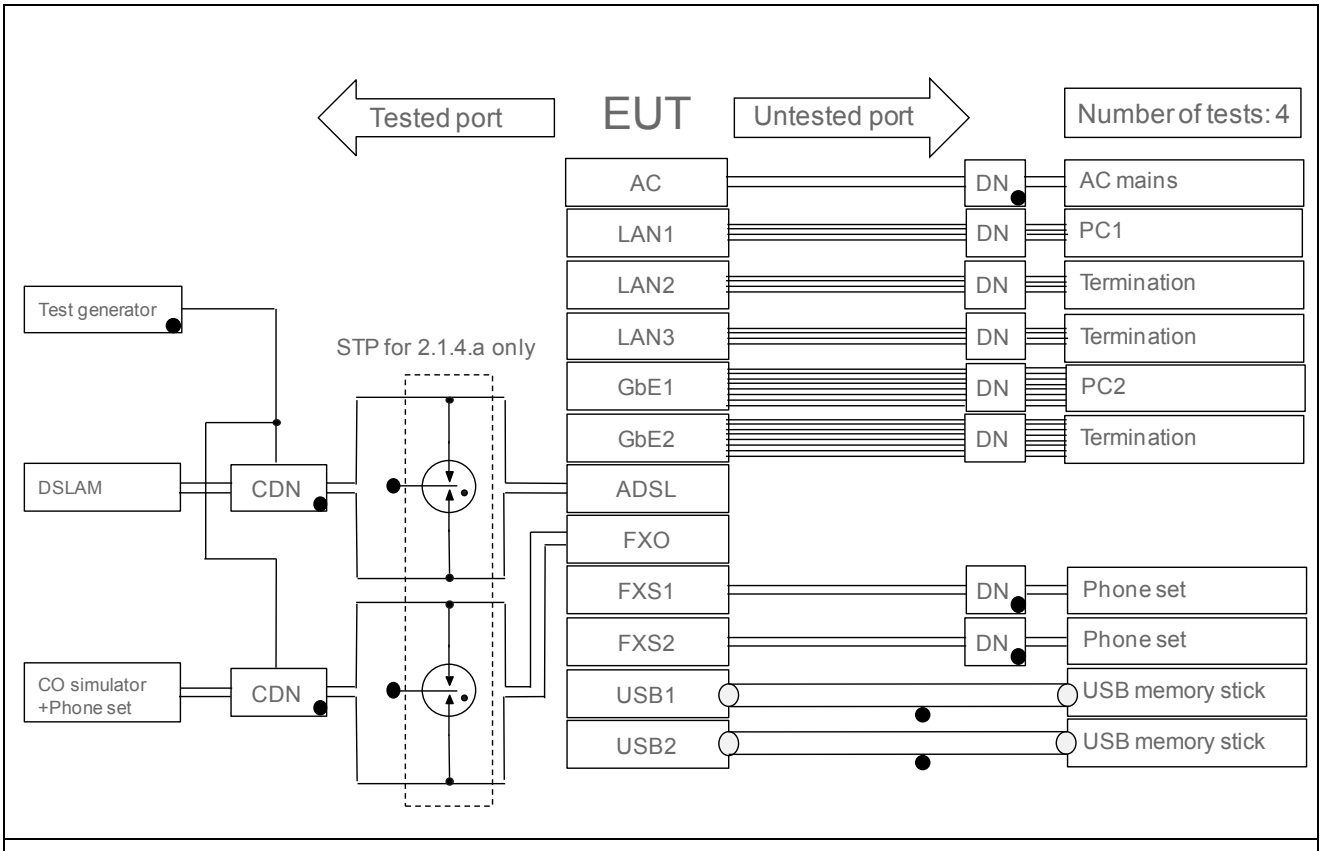


Figure 21 – Tested port ADSL+FXO, untested ports terminated - USB coupled to ground

7.5.8 LIGHTNING SURGE
External multiple pairs/ ports (ADSL & FXO)
Port to External port 2.1.3.b (inherent) & 2.1.4.b (coordination)

7.5.8.1 General

Primary protection: The EUT is not designed to be always used with primary protection at the ADSL, FXO and AC ports. A Special Test Protector (STP) instead of a primary protector shall be used at the ADSL & FXO ports.

Coupling between test generator and EUT: All wires of all external pairs shall be connected to the output of the test generator via coupling elements. The type of coupling element is described in chapter 7.6.

Decoupling networks between EUT and Auxiliary equipment at the tested & untested ports: see chapter 7.6.

Earthing and bonding configuration: The EUT has no earthing point that can be bonded to ground. Earthing points of decoupling networks at the untested side, APP and STP shall be connected to the floating EUT reference bar; Grounding elements shall be bonded to ground.

All Auxiliary equipment at the untested ports shall be left floating = no connection to ground.

During the application of the surges, Auxiliary equipment is only connected to those untested Ethernet ports (GbE and LAN) that are not coupled to ground.

The voltage waveform of the lightning surge test generator is a 10/700µs.

Total number of tests: 4.

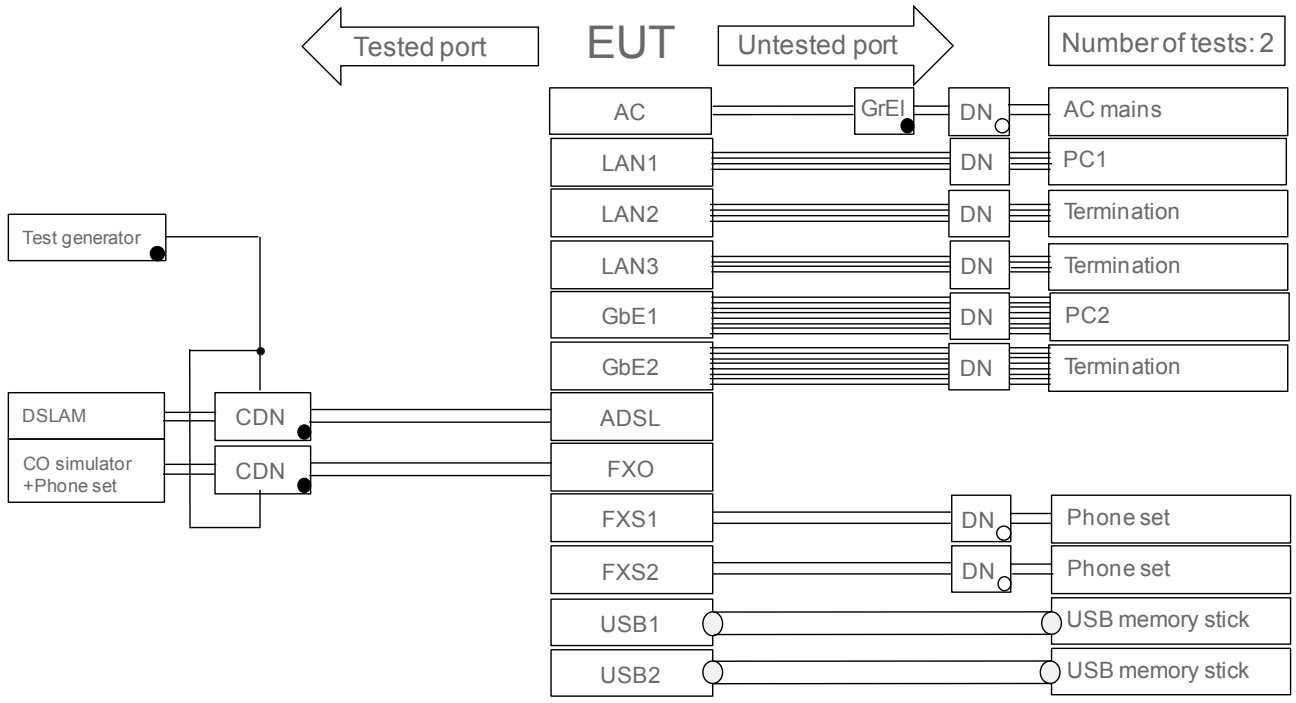


Figure 22.a – Tested port ADSL+FXO, untested ports terminated - AC coupled to ground

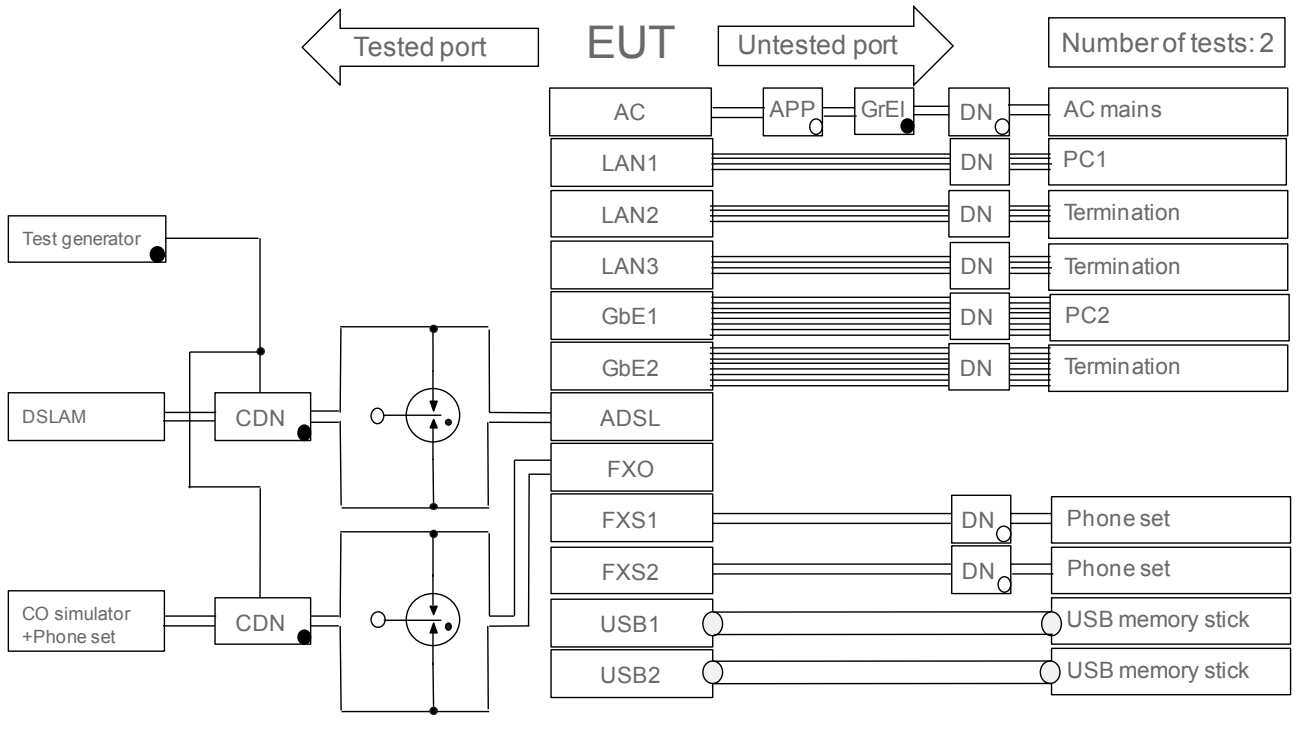


Figure 22.b – Tested port ADSL+FXO, untested ports terminated - AC coupled to ground

7.5.9 LIGHTNING SURGE
External AC mains power port (AC)
Transverse 5.1.1.a (inherent) & 5.1.2.a (coordination)

7.5.9.1 General

Primary protection: The EUT is not designed to be always used with primary protection at the ADSL, FXO and AC ports. A Special Test Protector (STP) instead of a primary protector shall be used at the ADSL & FXO ports.

Coupling between test generator and EUT: One wire of the AC primary shall be connected to the output of the test generator via a coupling element. The other wire shall be connected to the return port of the generator via a coupling element. The type of coupling element is described in chapter 7.6.
If a generator with built-in CDN is used, then this built-in CDN shall comply with the CDN described in chapter 7.6.

Decoupling networks between EUT and Auxiliary equipment at the tested & untested ports: see chapter 7.6.

Earthing and bonding configuration: The EUT has no earthing point that can be bonded to ground. Earthing points of decoupling networks and the Agreed Primary protector shall be bonded to ground.

As a general rule, all Auxiliary equipment at the untested ports shall be left floating = no connection to ground.

During the application of the surges, Auxiliary equipment is only connected to those untested Ethernet ports (GbE and LAN) that are not coupled to ground.

The voltage-current waveform of the lightning combination wave surge test generator is a 1.2/50-8/20µs.

Total number of tests: 4

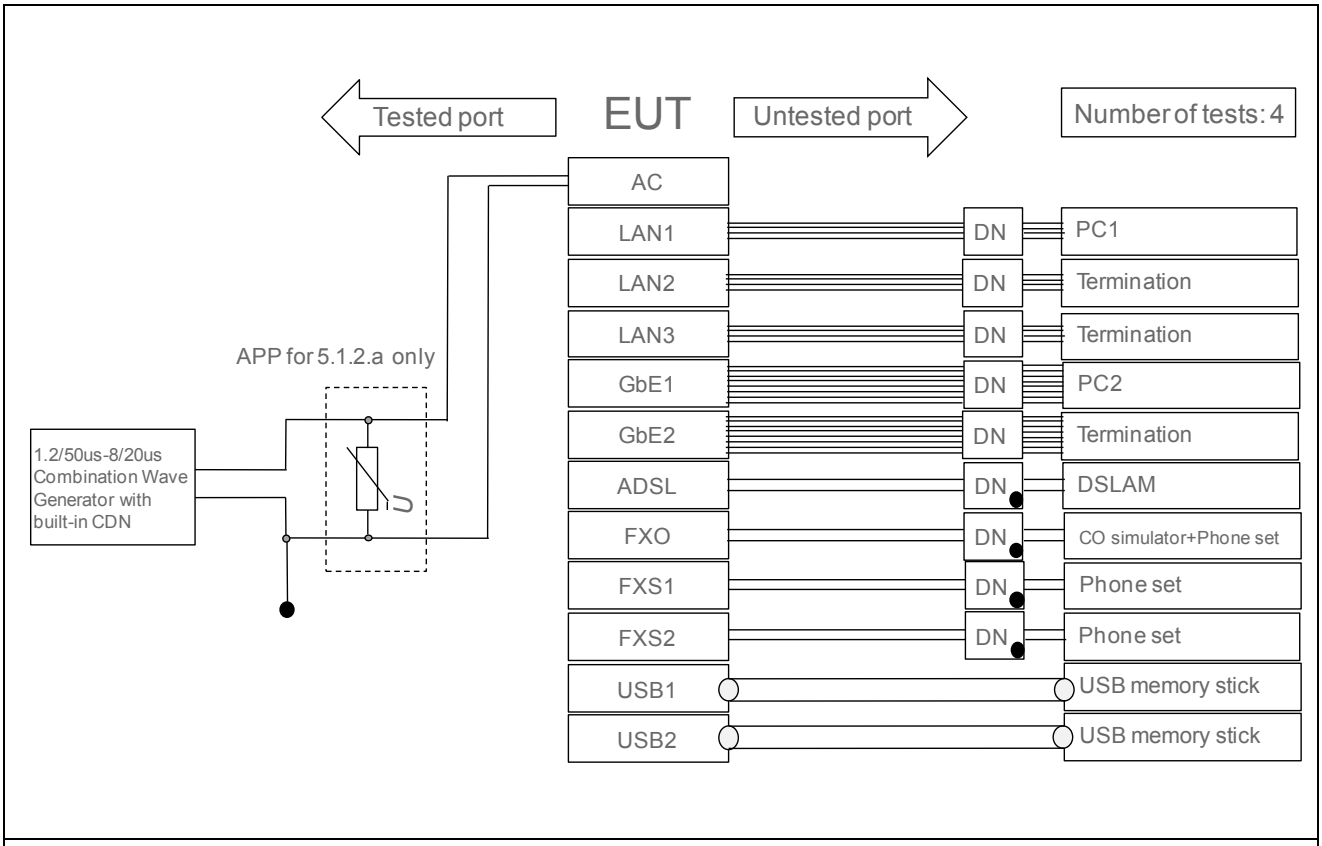


Figure 23 – Tested port AC, all untested ports terminated - not coupled to ground

7.5.10 LIGHTNING SURGE
External AC mains power port (AC)
Port to Earth 5.1.1.b (inherent) & 5.1.2.b (coordination)

7.5.10.1 General

Primary protection: The EUT is not designed to be always used with primary protection at the ADSL, FXO and AC ports. A Special Test Protector (STP) instead of a primary protector shall be used at the ADSL & FXO ports.

Coupling between test generator and EUT: Each of both wires of the AC primary shall be connected to the output of the test generator via a coupling element. The type of coupling element is described in chapter 7.6. If a generator with built-in CDN is used, then this built-in CDN shall comply with the CDN described in chapter 7.6.

Decoupling networks between EUT and Auxiliary equipment at the tested & untested ports: see chapter 7.6.

Earthing and bonding configuration: The EUT has no earthing point that can be bonded to ground. Earthing points of decoupling networks, grounding elements and the Agreed Primary Protector shall be bonded to ground.

As a general rule, all Auxiliary equipment at the untested ports shall be left floating = no connection to ground.

During the application of the surges, Auxiliary equipment is only connected to those untested Ethernet ports (GbE and LAN) that are not coupled to ground. Untested Ethernet ports that are coupled to ground are not connected to auxiliary equipment.
After the surge test, the untested Ethernet ports that were coupled to ground are connected to auxiliary equipment and a functional verification is done.

The voltage-current waveform of the lightning combination wave surge test generator is a 1.2/50-8/20µs.

Total number of tests: 20

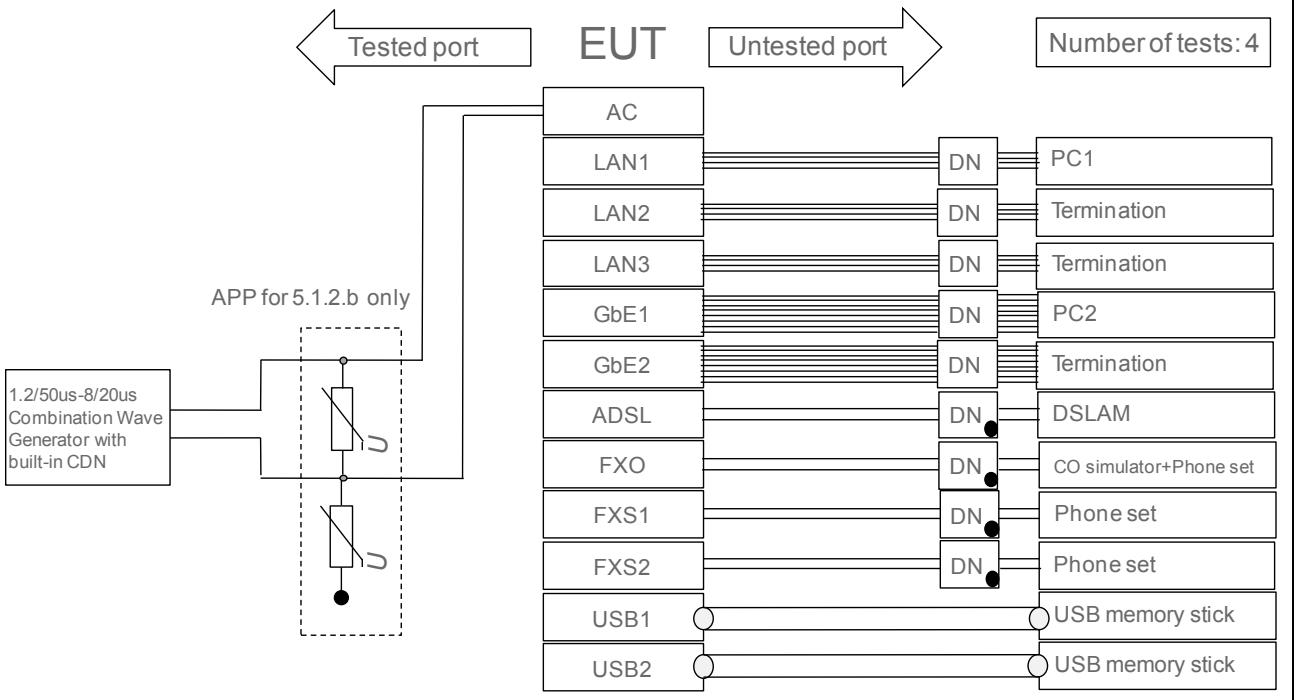


Figure 24 – Tested port AC, all untested ports terminated - not coupled to ground

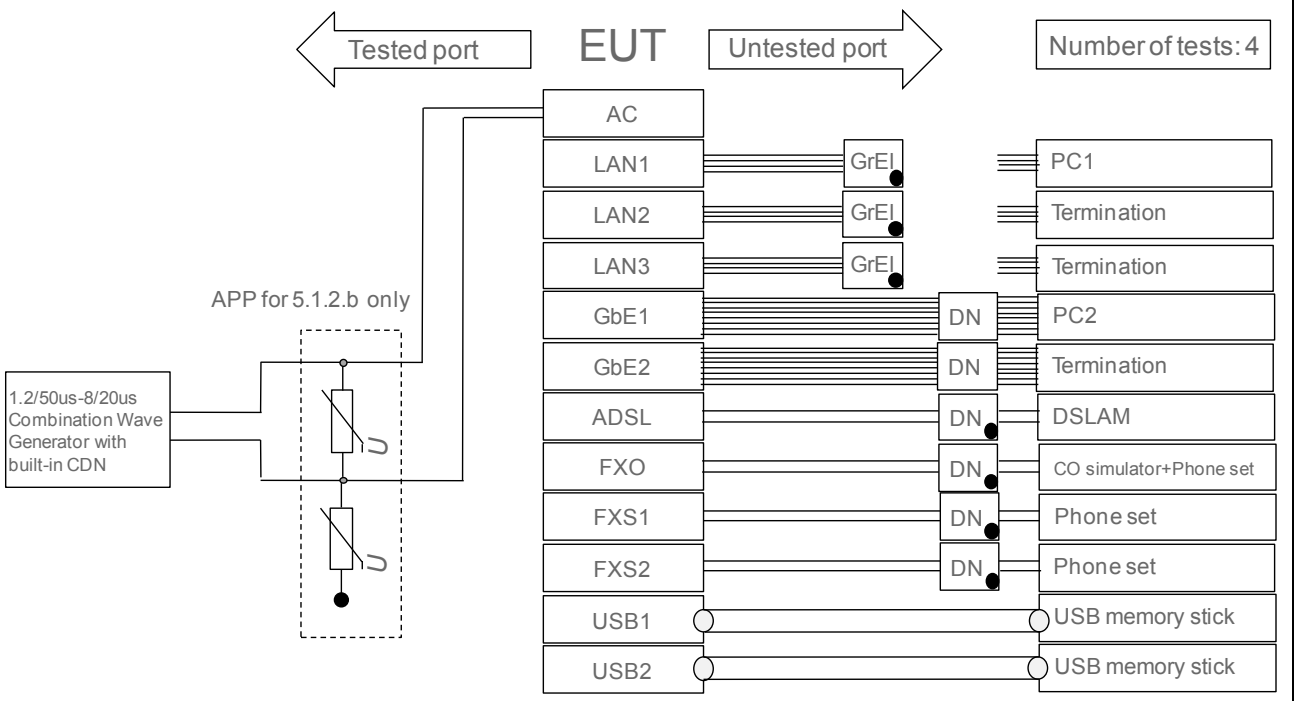


Figure 25 – Tested port AC, all untested ports terminated - LAN coupled to ground

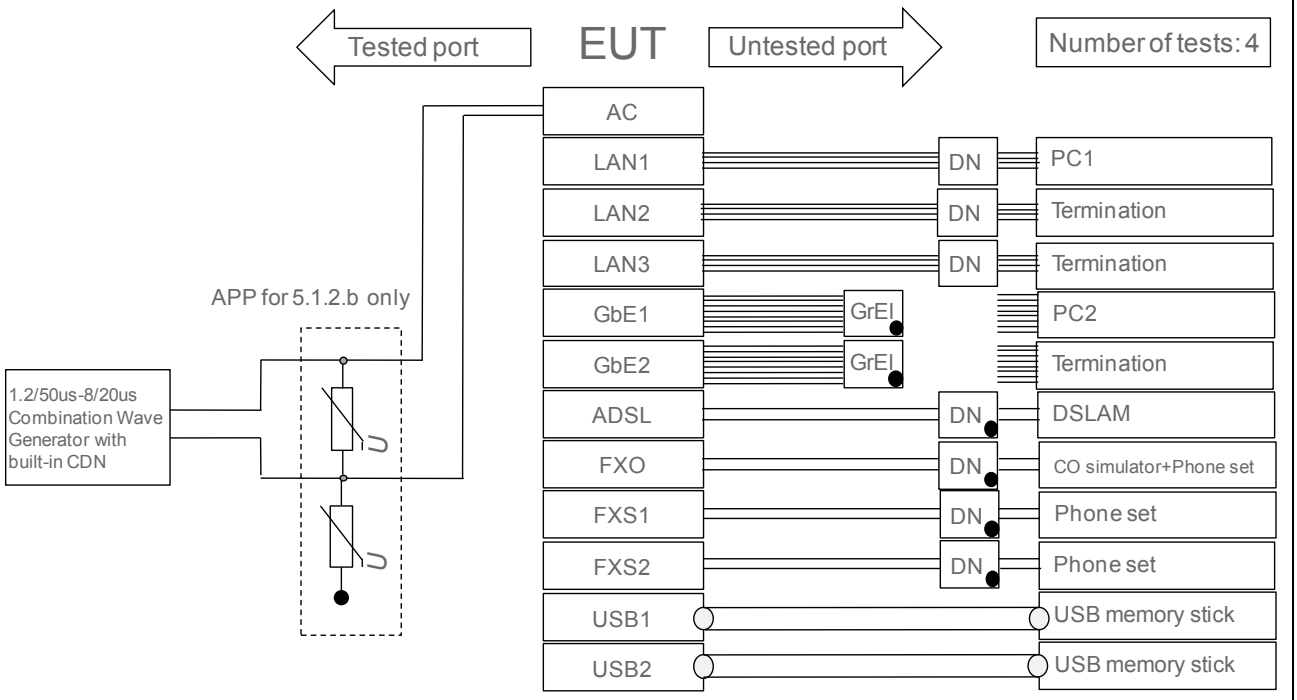


Figure 26 – Tested port AC, all untested ports terminated - GbE coupled to ground

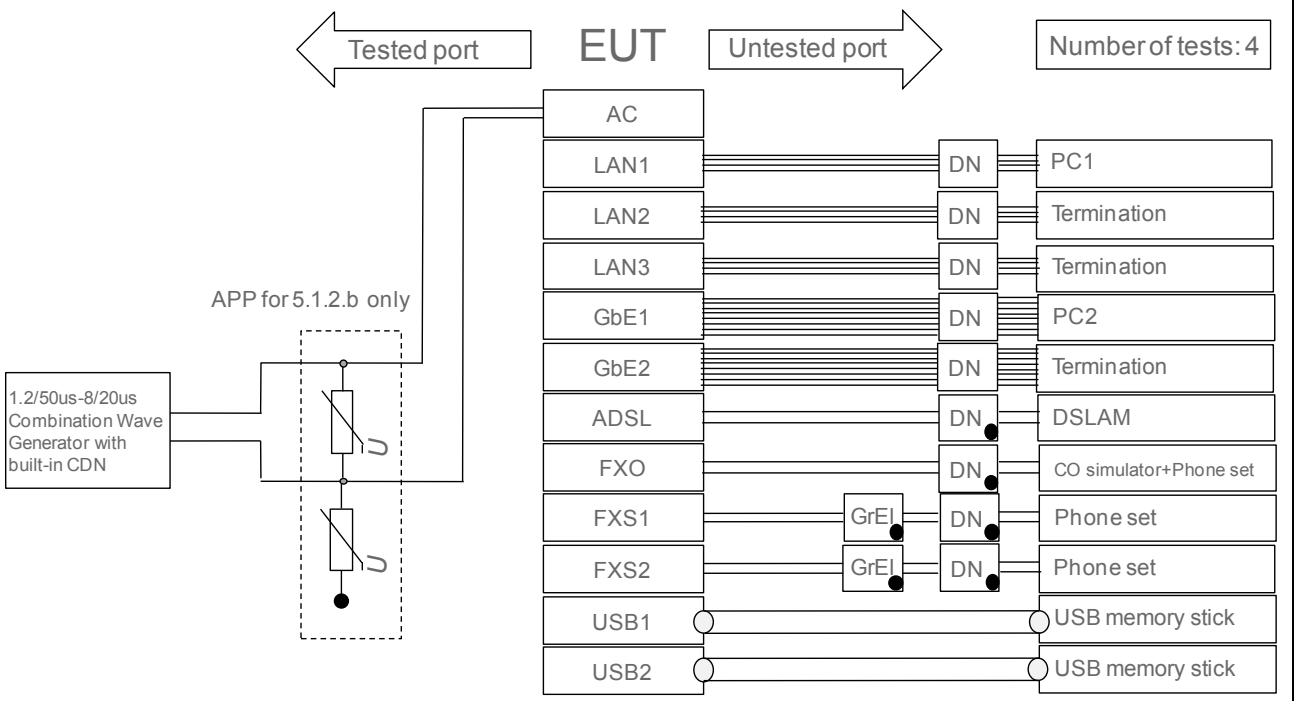


Figure 27 – Tested port AC, all untested ports terminated - FXS coupled to ground

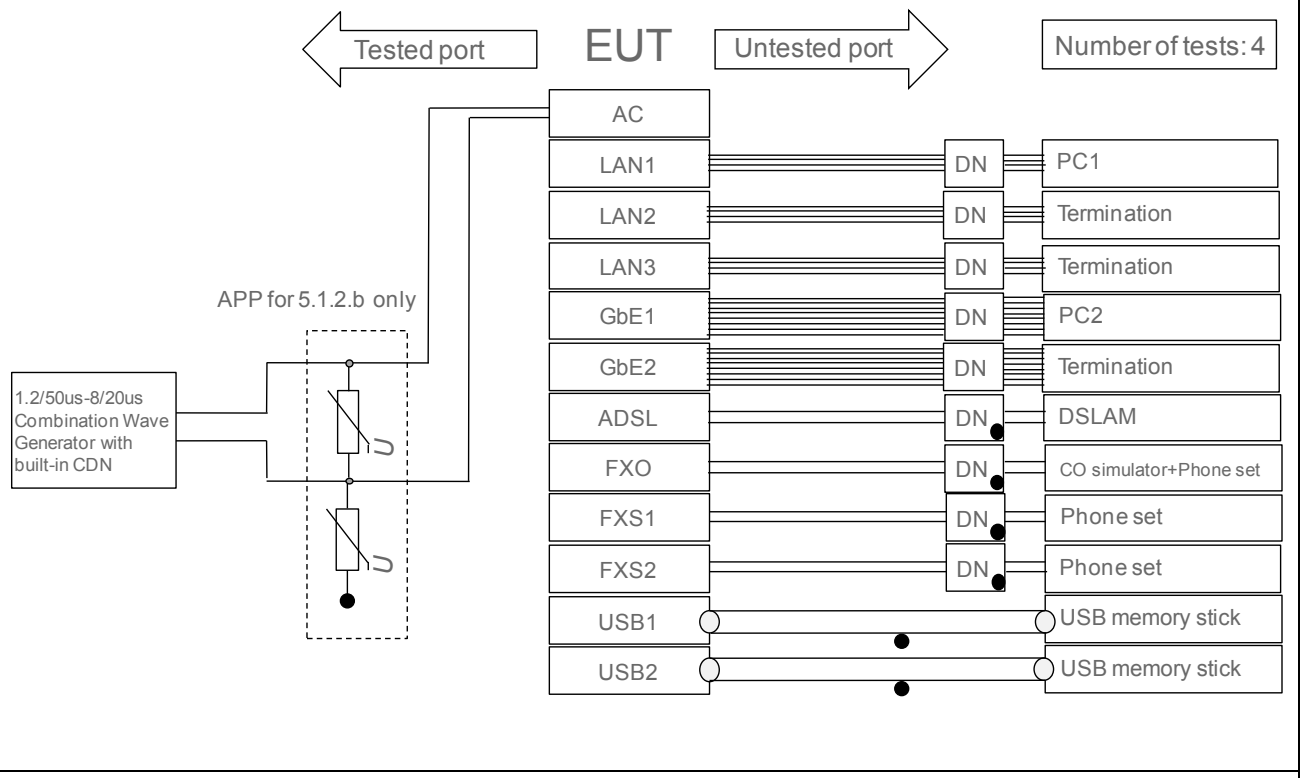


Figure 28 – Tested port AC, all untested ports terminated - USB coupled to ground

7.5.11 LIGHTNING SURGE
External AC mains power port (AC)
Port to External port 5.1.1.c (inherent) & 5.1.2.c (coordination)

7.5.11.1 General

Primary protection: The EUT is not designed to be always used with primary protection at the ADSL, FXO and AC ports. A Special Test Protector (STP) instead of a primary protector shall be used at the ADSL & FXO ports.

Coupling between test generator and EUT: Each of both wires of AC primary shall be connected to the output of the test generator via a coupling element. The type of coupling element is described in chapter 7.6. If a generator with built-in CDN is used, then this built-in CDN shall comply with the CDN described in chapter 7.6.

Decoupling networks between EUT and Auxiliary equipment at the tested & untested ports: see chapter 7.6.

Earthing and bonding configuration: The EUT has no earthing point that can be bonded to ground. Earthing points of decoupling networks at the untested side, APP and STP shall be connected to the floating EUT reference bar; Grounding elements shall be bonded to ground.

All Auxiliary equipment at the untested ports shall be left floating = no connection to ground.

During the application of the surges, Auxiliary equipment is only connected to those untested Ethernet ports (GbE and LAN) that are not coupled to ground.

The voltage-current waveform of the lightning combination wave surge test generator is a 1.2/50-8/20µs.

Total number of tests: 8

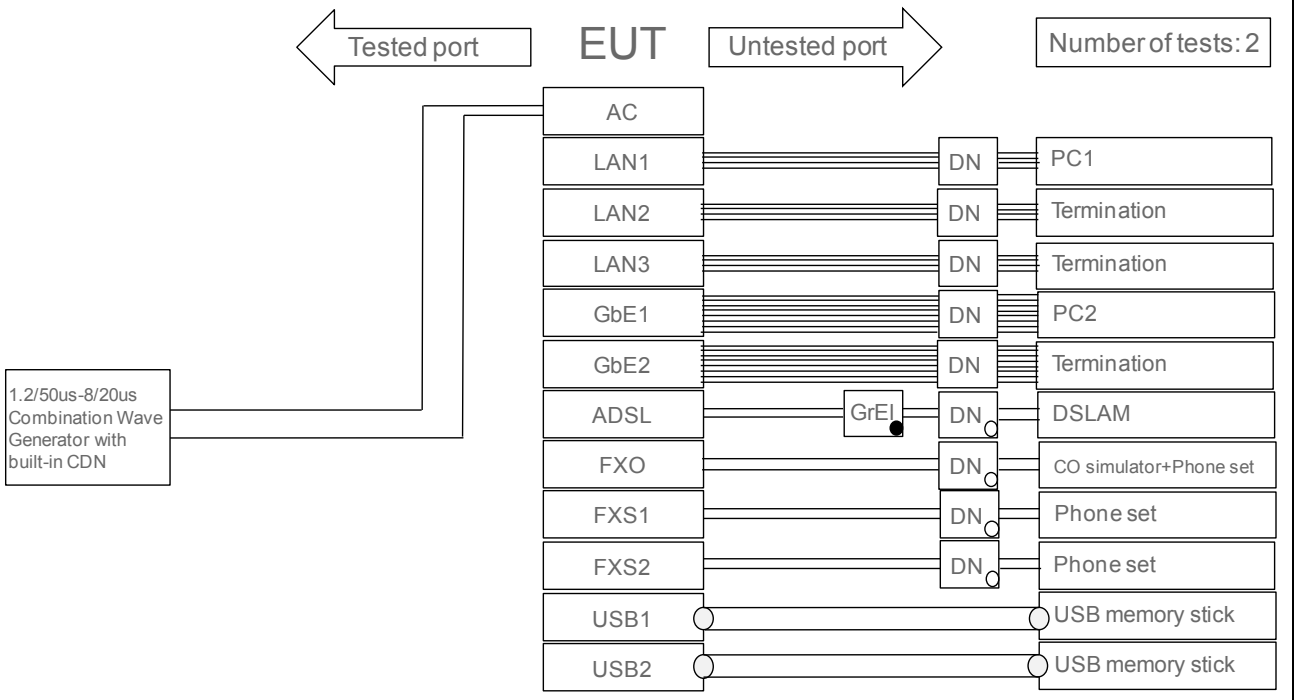


Figure 29.a – Tested port AC, all untested ports terminated - ADSL coupled to ground

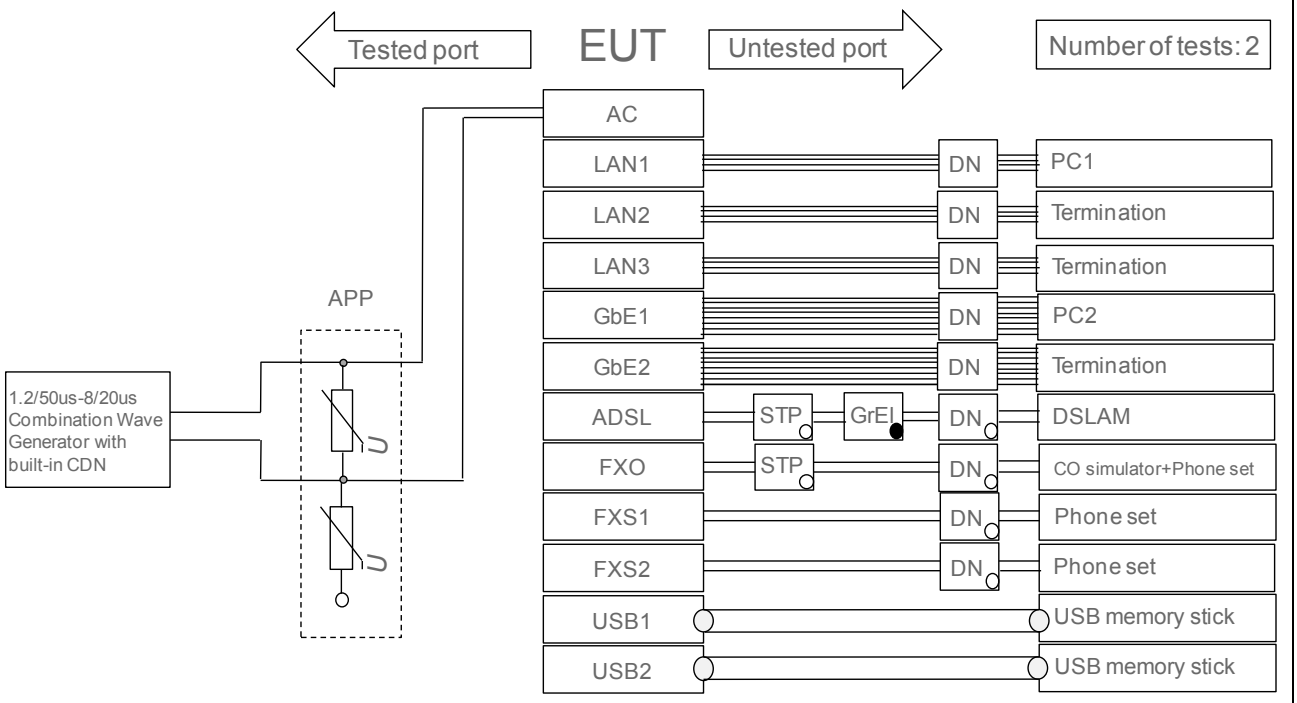


Figure 29.b – Tested port AC, all untested ports terminated - ADSL coupled to ground

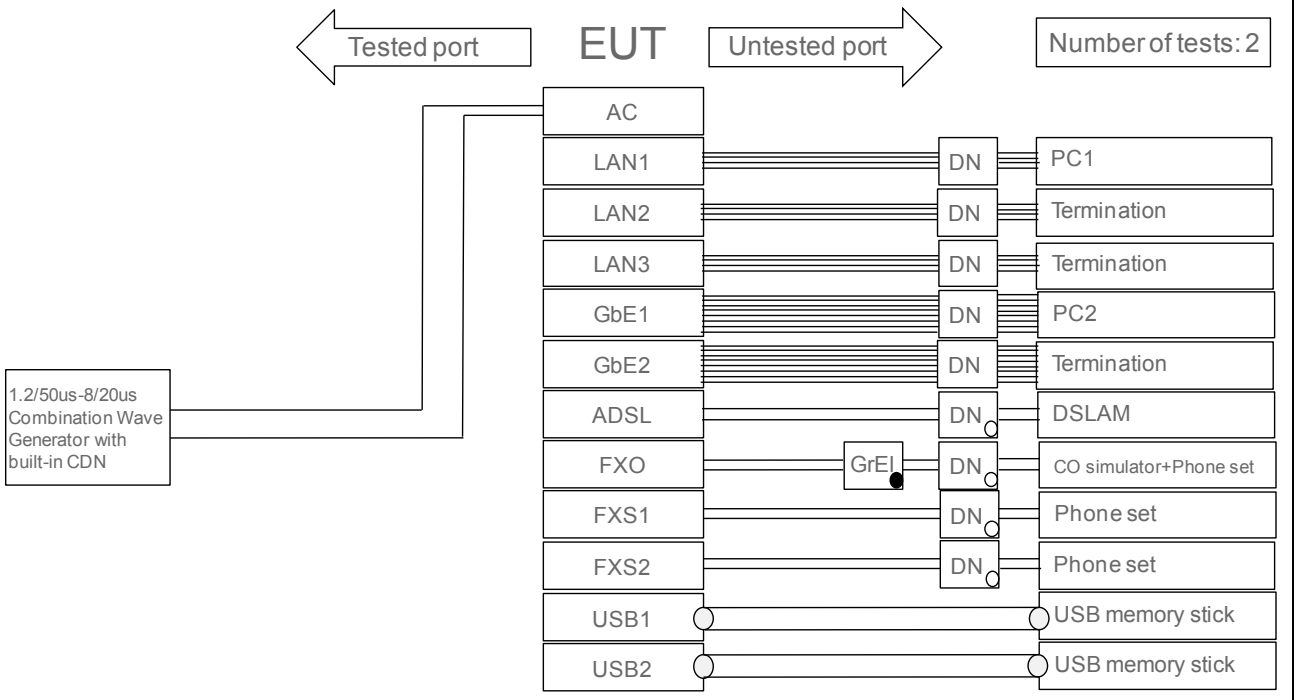


Figure 30.a – Tested port AC, all untested ports terminated - FXO coupled to ground

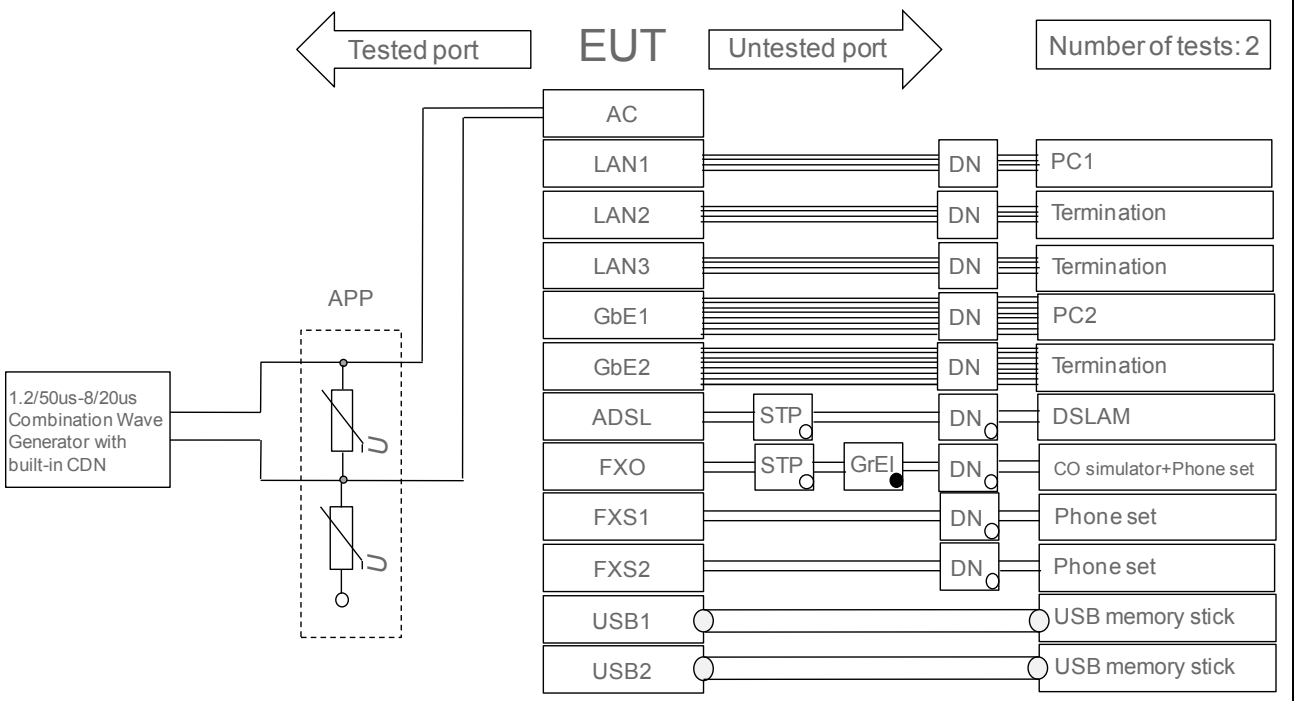


Figure 30.b – Tested port AC, all untested ports terminated - FXO coupled to ground

7.5.12 NEUTRAL POTENTIAL RISE
External AC mains power port (AC)
Port to Earth 5.2.2.a

7.5.12.1 General

Primary protection: The EUT is not designed to be always used with primary protection at the ADSL, FXO and AC ports. This test is done without Special Test Protector (STP) and without Agreed Primary Protector.

Coupling between test generator and EUT: Each of both wires of the AC primary shall be connected to the output of the test generator via a coupling element. The type of coupling element is described in chapter 7.6.

Decoupling networks between EUT and Auxiliary equipment at the tested & untested ports: see chapter 7.6.

Earthing and bonding configuration: The EUT has no earthing point that can be bonded to ground. Earthing points of decoupling networks and grounding elements shall be bonded to ground.

As a general rule, all Auxiliary equipment at the untested ports shall be left floating = no connection to ground.

During the application of the surges, Auxiliary equipment is only connected to those untested Ethernet ports (GbE and LAN) that are not coupled to ground. Untested Ethernet ports that are coupled to ground are not connected to auxiliary equipment.
After the surge test, the untested Ethernet ports that were coupled to ground are connected to auxiliary equipment and a functional verification is done.

The voltage waveform of the surge test generator is a 50Hz sine wave.

Total number of tests: 10

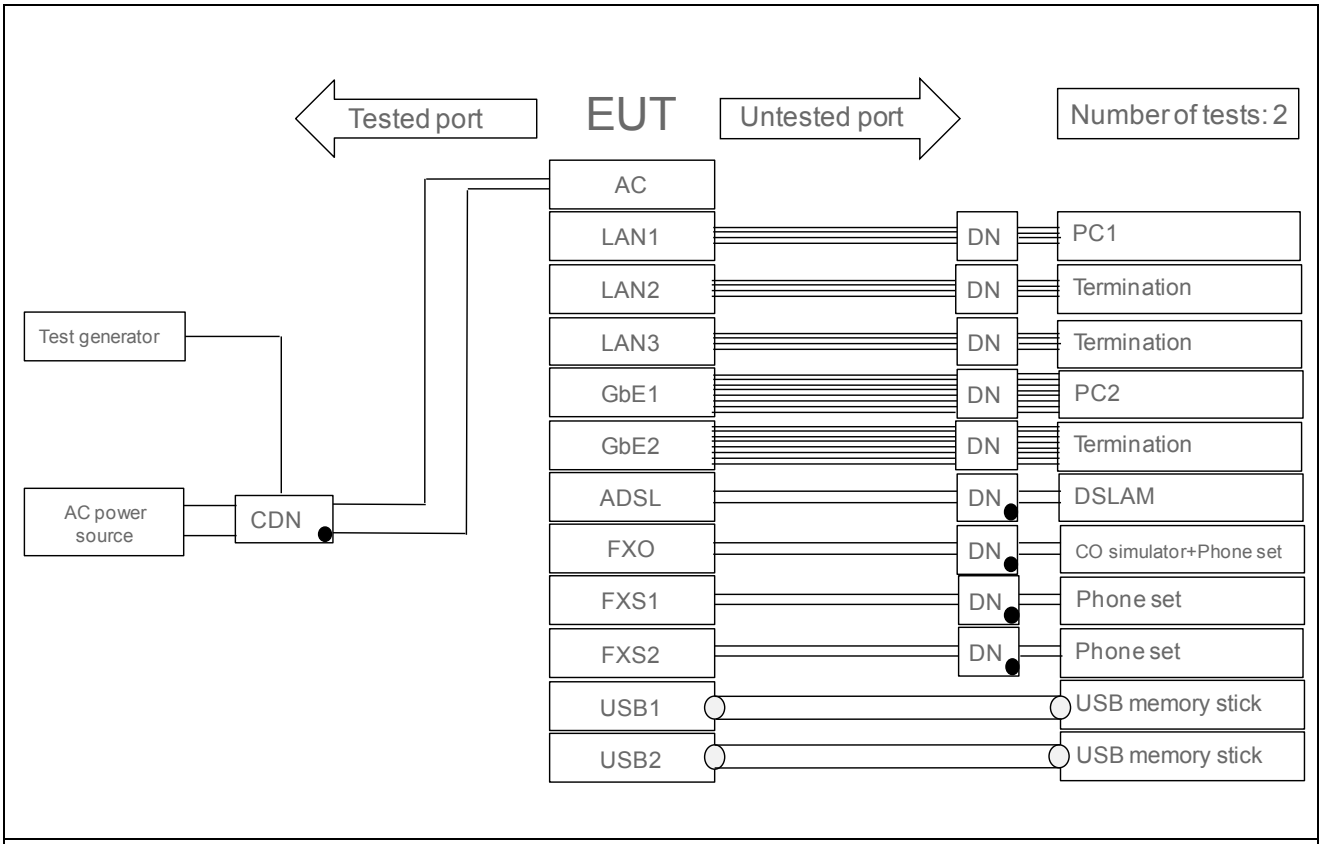


Figure 31 – Tested port AC, all untested ports terminated - not coupled to ground

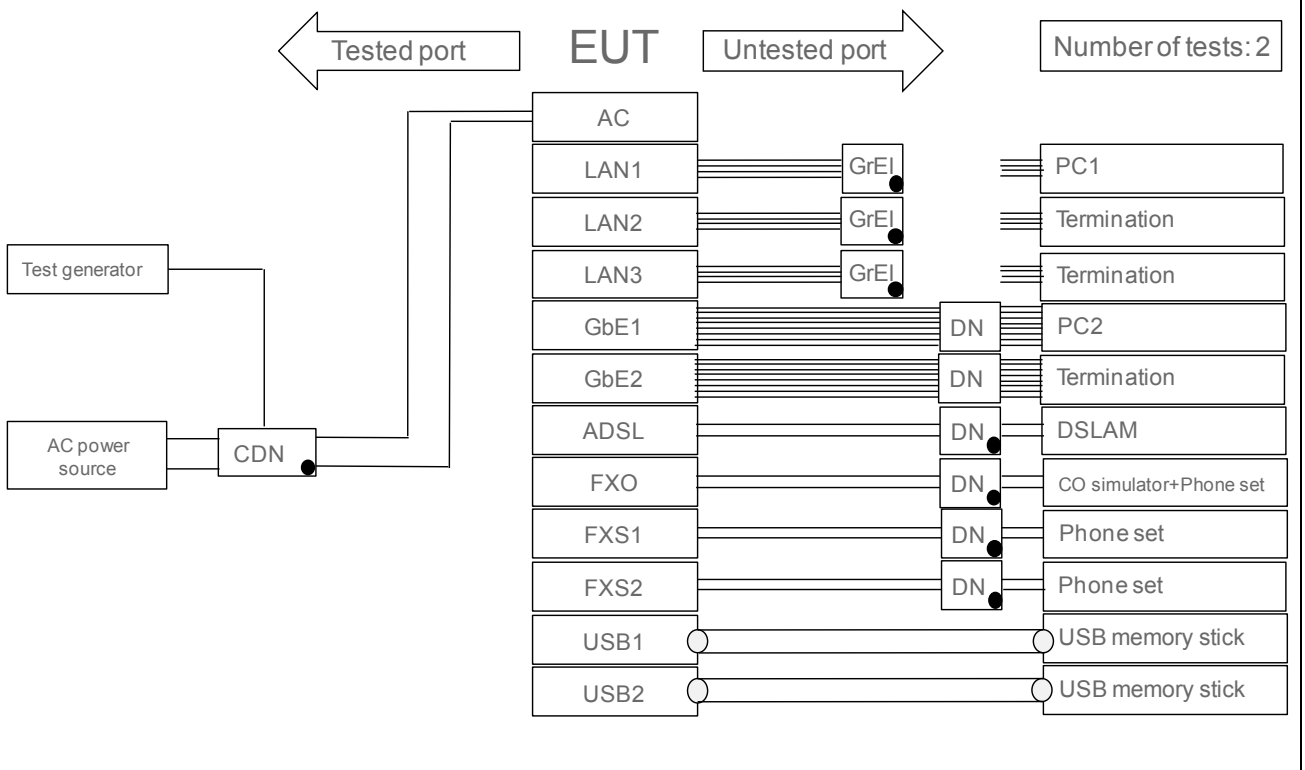


Figure 32 – Tested port AC, all untested ports terminated - LAN coupled to ground

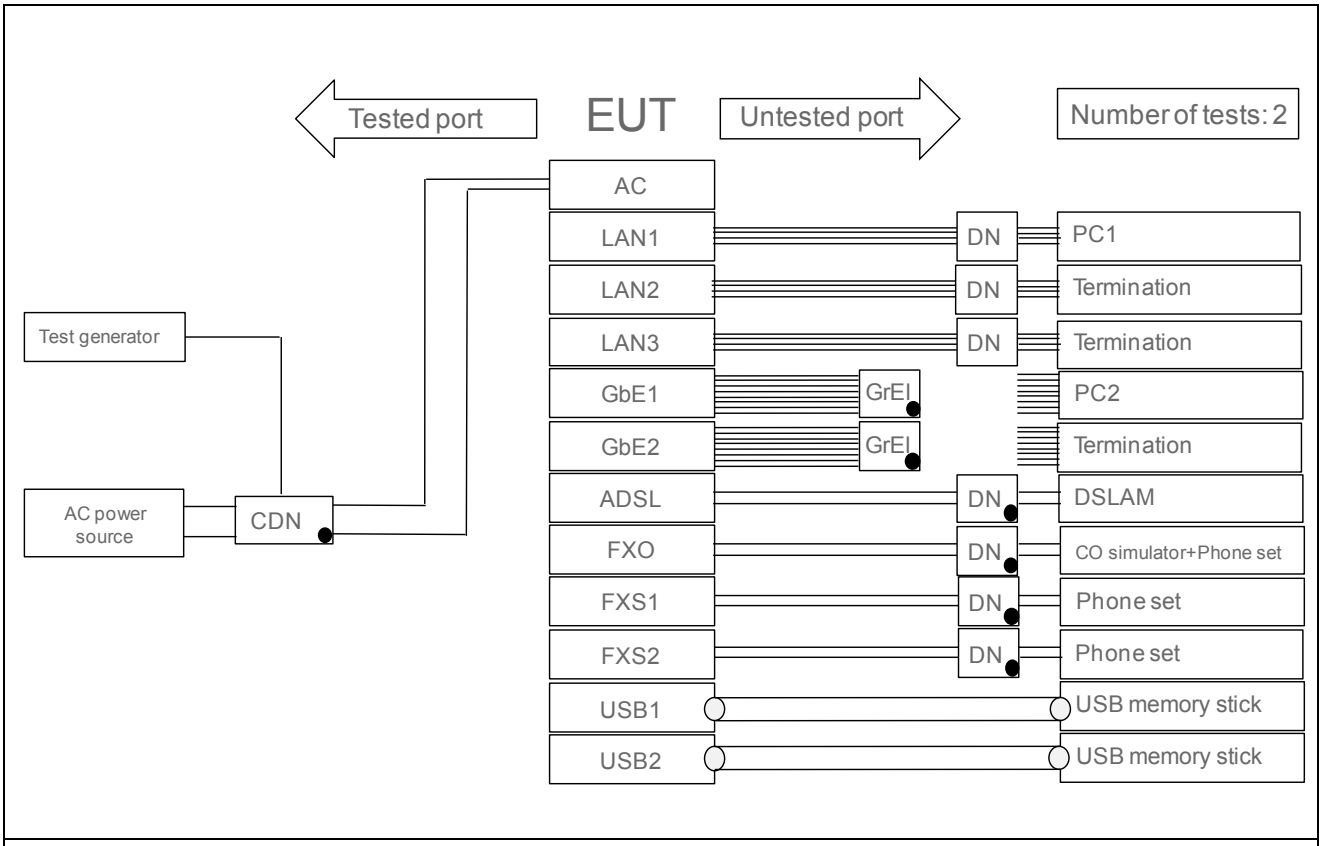


Figure 33 – Tested port AC, all untested ports terminated - GbE coupled to ground

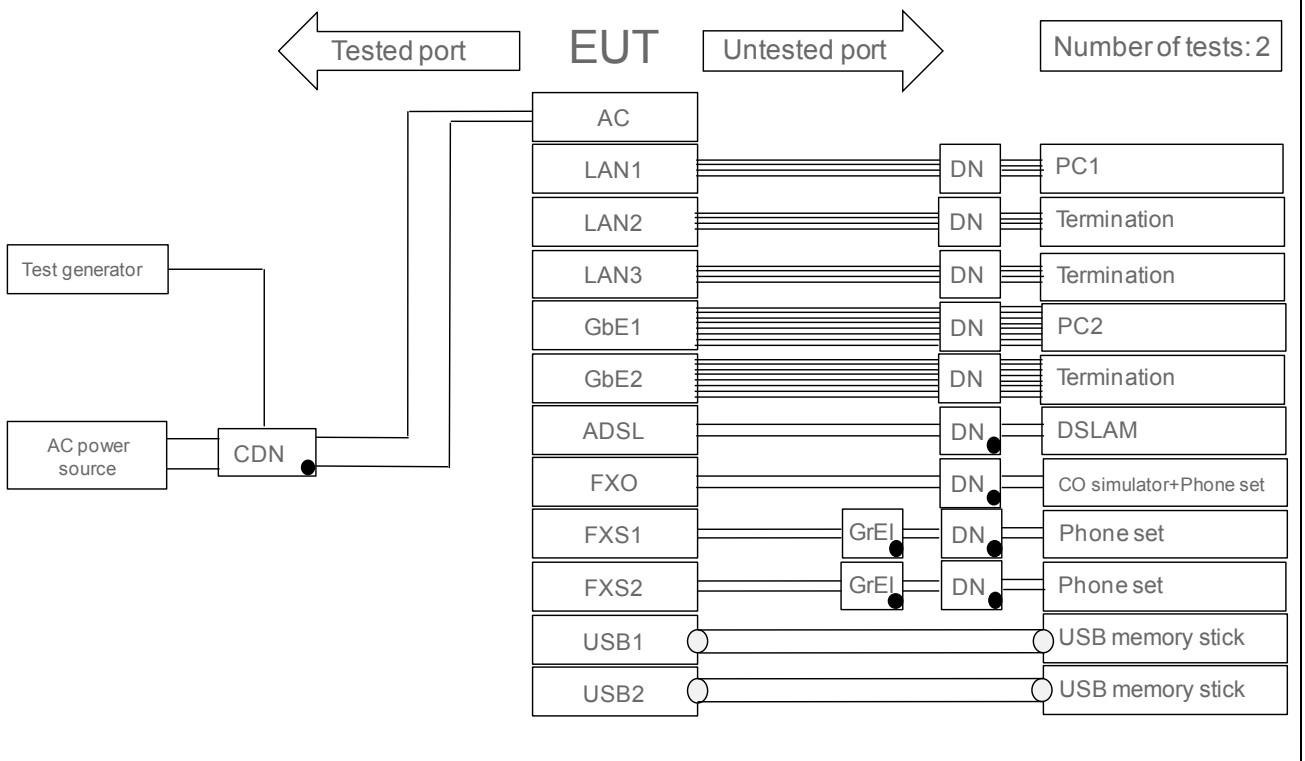


Figure 34 – Tested port AC, all untested ports terminated - FXS coupled to ground

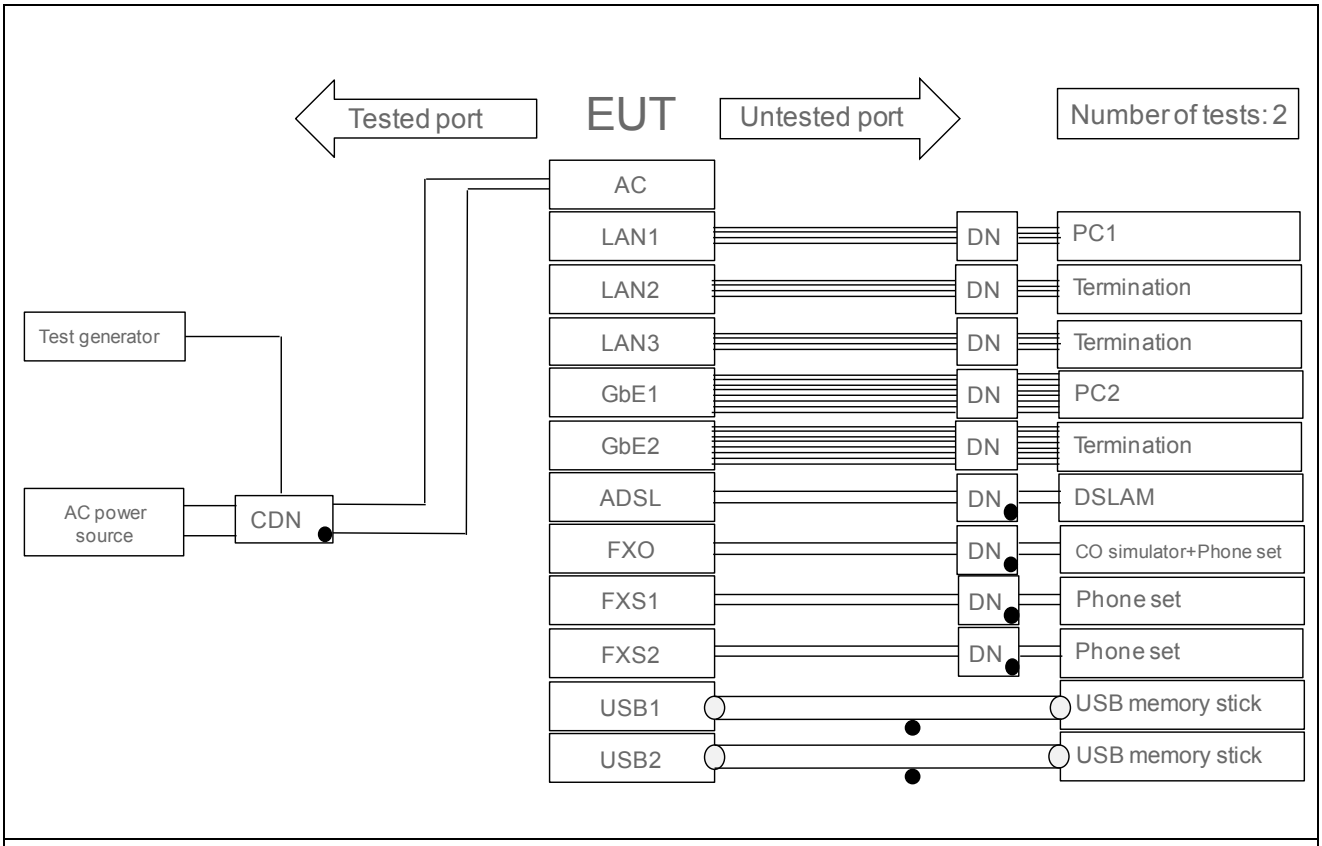


Figure 35 – Tested port AC, all untested ports terminated - USB coupled to ground

7.5.13 NEUTRAL POTENTIAL RISE
External AC mains power port (AC)
Port to External port 5.2.2.b

7.5.13.1 General

Primary protection: The EUT is not designed to be always used with primary protection at the ADSL, FXO and AC ports. This test is done without Special Test Protector (STP) and without Agreed Primary Protector.

Coupling between test generator and EUT: Each of both wires of the AC mains shall be connected to the output of the test generator via a coupling element. The type of coupling element is described in chapter 7.6.

Decoupling networks between EUT and Auxiliary equipment at the tested & untested ports: see chapter 7.6.

Earthing and bonding configuration: The EUT has no earthing point that can be bonded to ground. Earthing points of decoupling networks at the untested side shall be connected to the floating EUT reference bar; Grounding elements shall be bonded to ground.

All Auxiliary equipment at the untested ports shall be left floating = no connection to ground.

During the application of the surges, Auxiliary equipment is only connected to those untested Ethernet ports (GbE and LAN) that are not coupled to ground.

The voltage waveform of the test generator is a 50Hz sine wave.

Total number of tests: 4

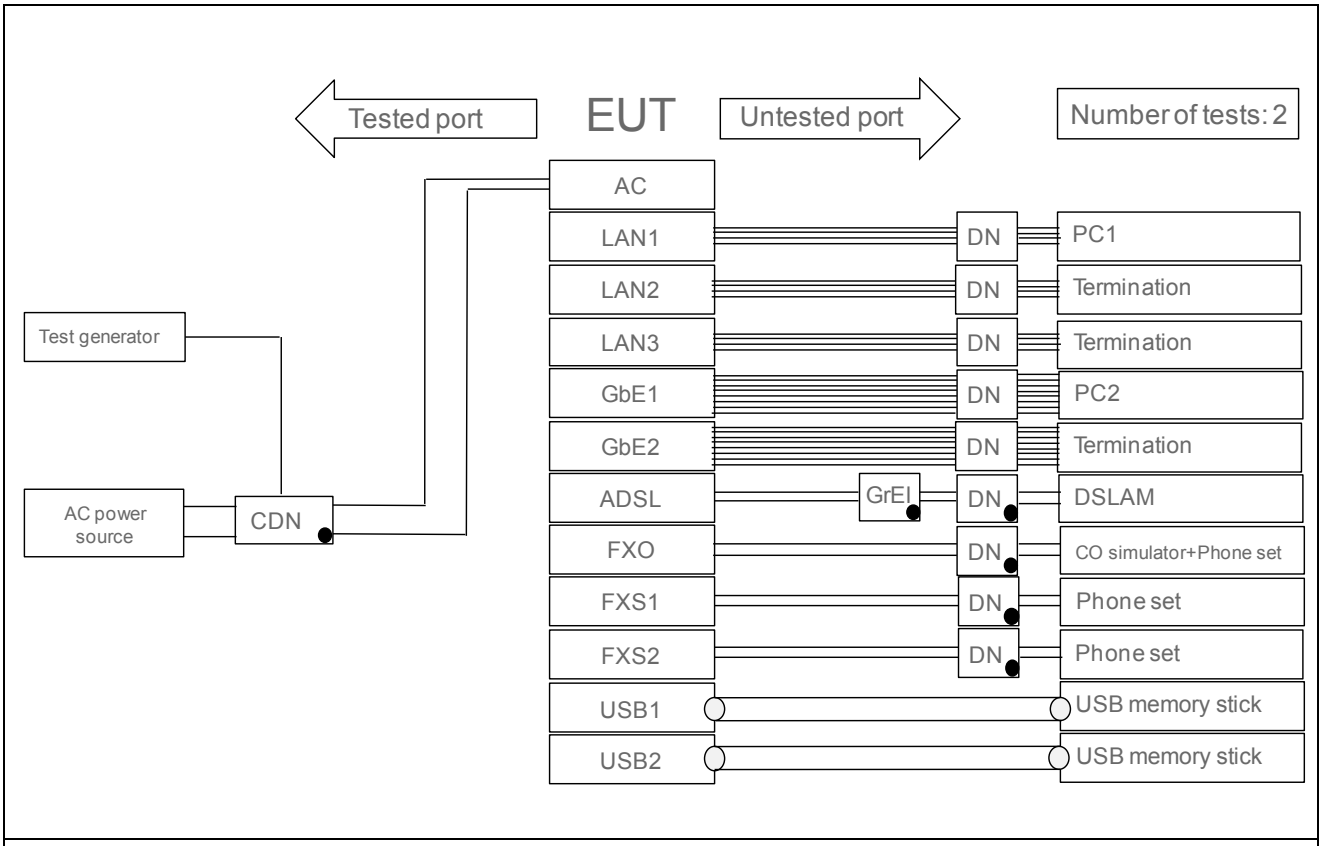


Figure 36 – Tested port AC, all untested ports terminated - ADSL coupled to ground

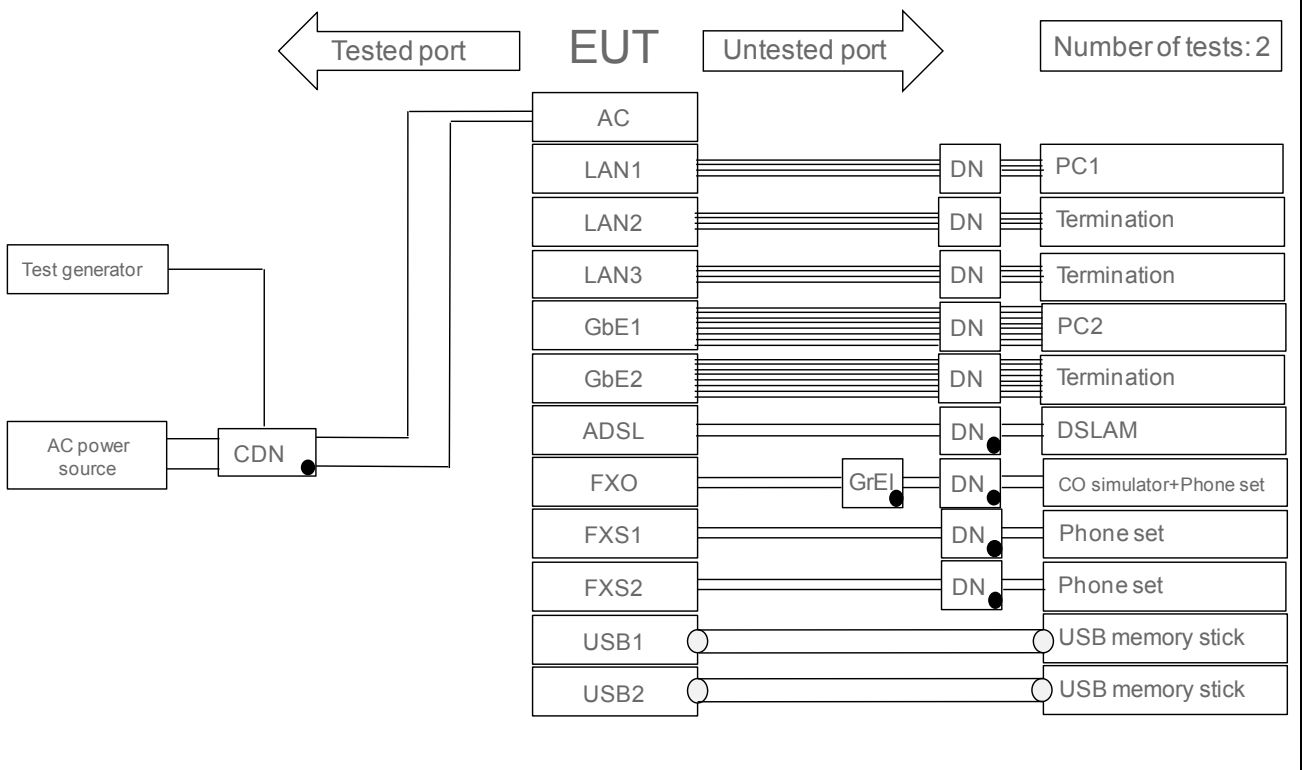


Figure 37 – Tested port AC, all untested ports terminated - FXO coupled to ground

7.5.14 LIGHTNING SURGE
Internal unshielded cable with symmetric pairs (LAN, GbE, FXS)
Port to Earth 7.1

7.5.14.1 General

Primary protection: The EUT is not designed to be always used with primary protection at the ADSL, FXO and AC ports. For these internal port tests, no primary protectors or STP are equipped on the internal nor external ports.

Coupling between test generator and EUT:

FXS: Each of the 2 wires of the single internal symmetrical pair of the FXS port shall be connected to the output of the test generator via a coupling element. The type of coupling element and way of coupling is described in chapter 7.6.

LAN and GbE: Each of the 4 or 8 wires of the internal symmetrical pairs of these Ethernet ports shall be directly connected to the output of the test generator, thus without a coupling element.

The testing of Ethernet ports is different from the internal port testing defined in K.21, Test 7.2 “Unshielded cable with symmetric pairs”. The nature of the coupling and grounding elements do not always allow sending traffic on the LAN and GbE ports. All tests on an Ethernet port except for the insulation resistance test are done in the powered condition but not operational. When the untested Ethernet port is coupled to ground, the Ethernet circuit will also be not operational. The insulation resistance test is performed with the equipment unpowered. Subsequently the equipment must be tested in an operational state, i.e. connected to Auxiliary equipment, to verify it still meets its specification.Decoupling networks between EUT and Auxiliary equipment at the tested & untested ports: see chapter 7.6.

Earthing and bonding configuration: The EUT has no earthing point that can be bonded to ground. Earthing points of decoupling networks, the conductive foil and the grounding elements shall be bonded to ground.

All Auxiliary equipment at the untested ports shall be left floating = no connection to ground.

During the application of the surges, Auxiliary equipment is only connected to those untested Ethernet ports (GbE and LAN) that are not coupled to ground. The tested Ethernet port and Untested Ethernet ports that are coupled to ground are not connected to auxiliary equipment.
After the surge test, and the insulation resistance test, the tested Ethernet port and untested Ethernet ports that were coupled to ground are connected to auxiliary equipment and a functional verification is done.

The voltage-current waveform of the lightning combination wave surge test generator is a 1.2/50-8/20µs.

Total number of tests: 30

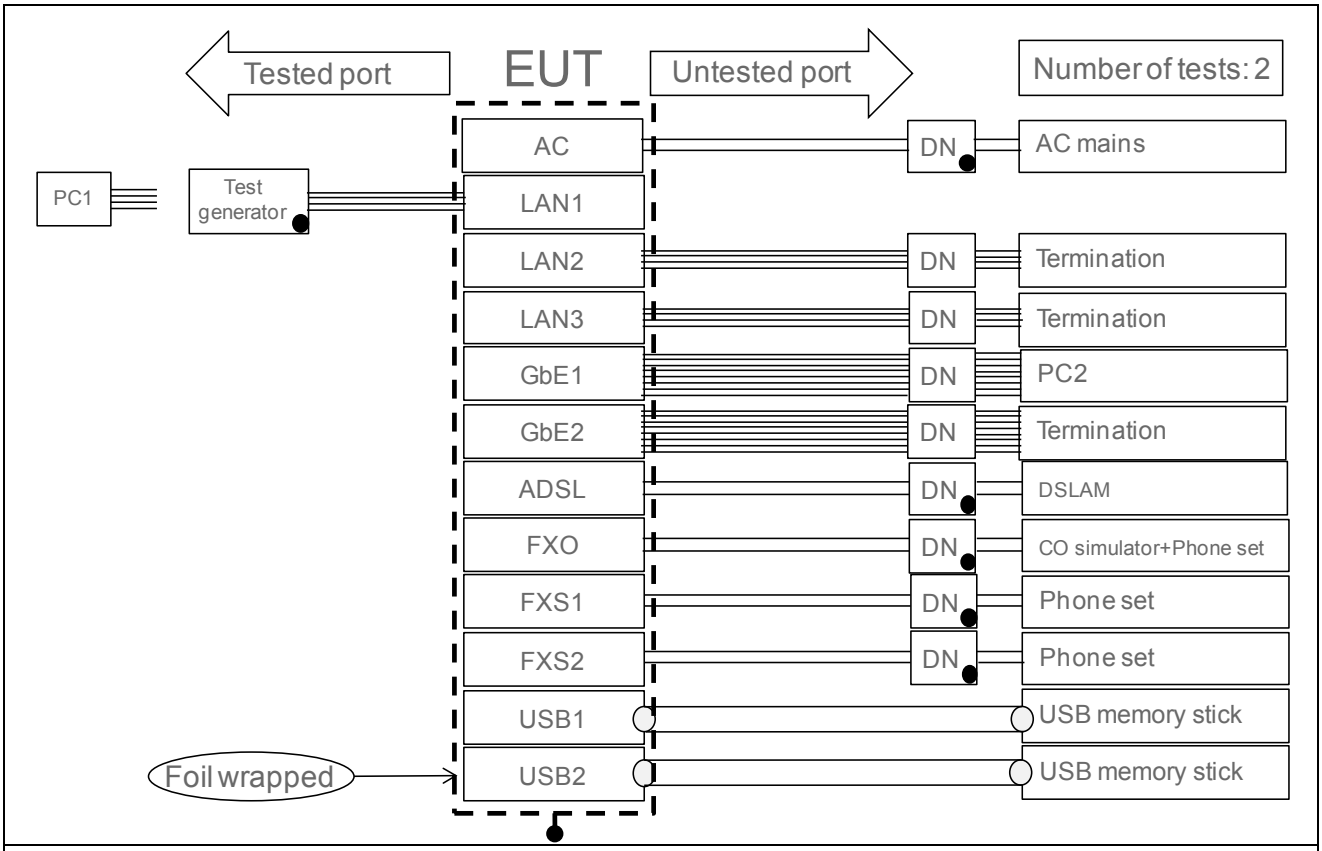


Figure 38 – Tested port LAN1, all untested ports terminated - not coupled to ground

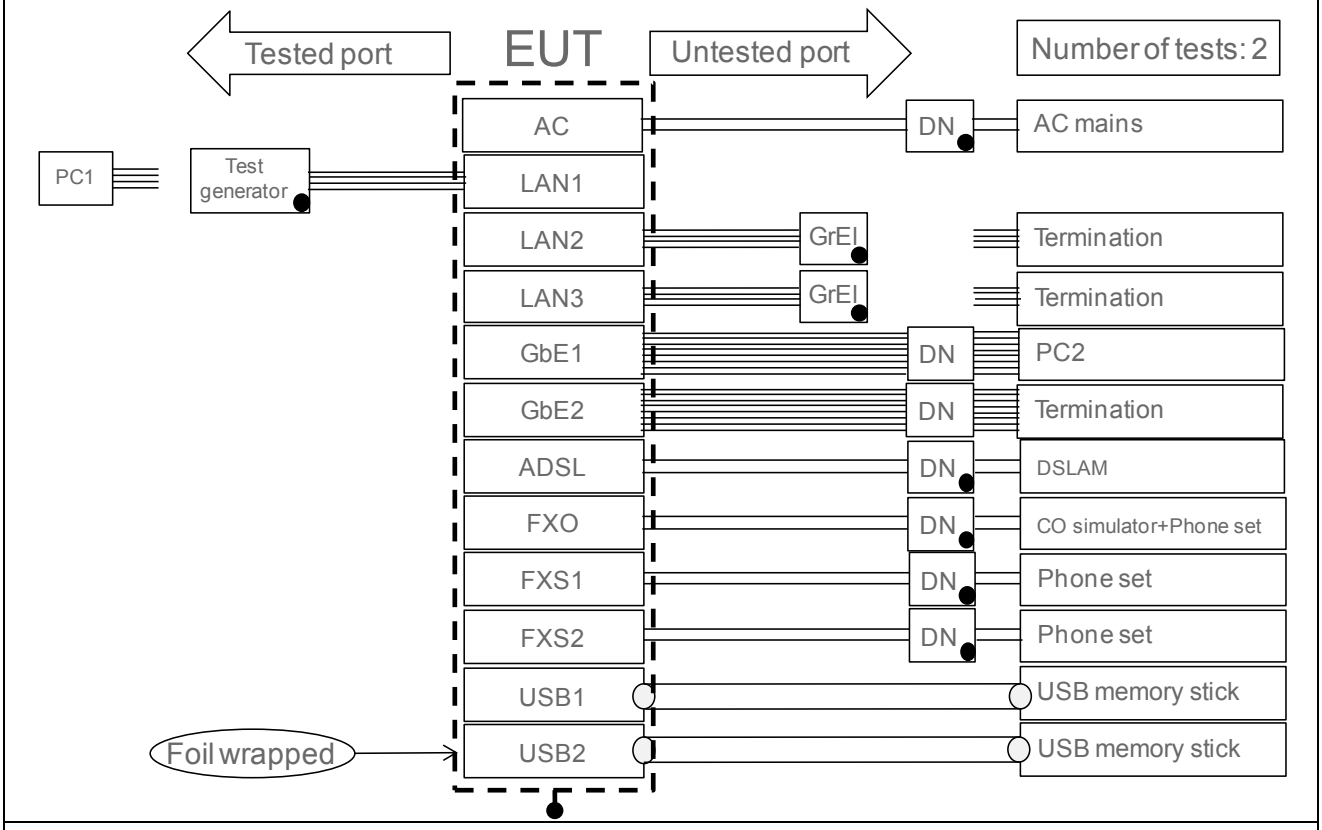


Figure 39 – Tested port LAN1, all untested ports terminated – LAN 2+3 coupled to ground

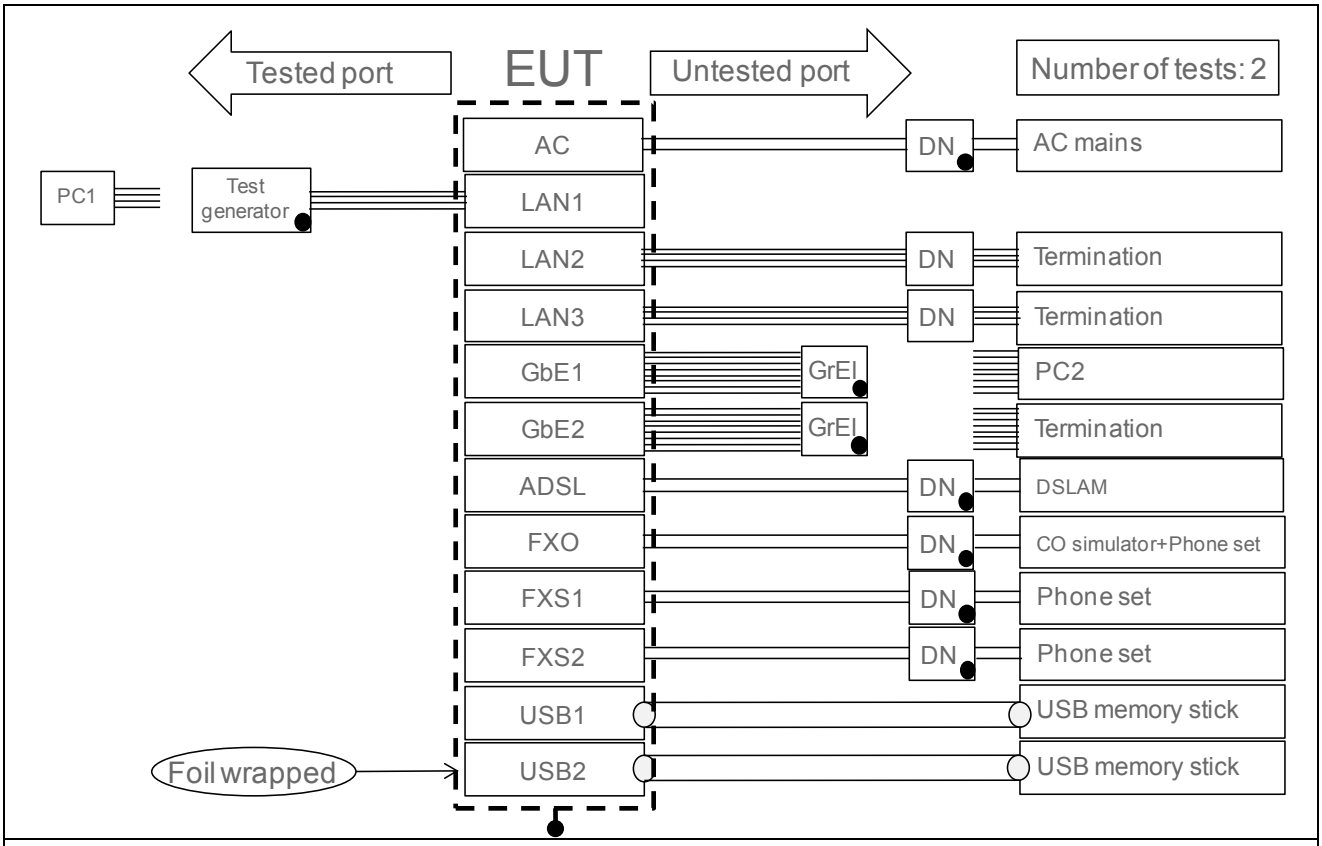


Figure 40 – Tested port LAN1, all untested ports terminated - GbE coupled to ground

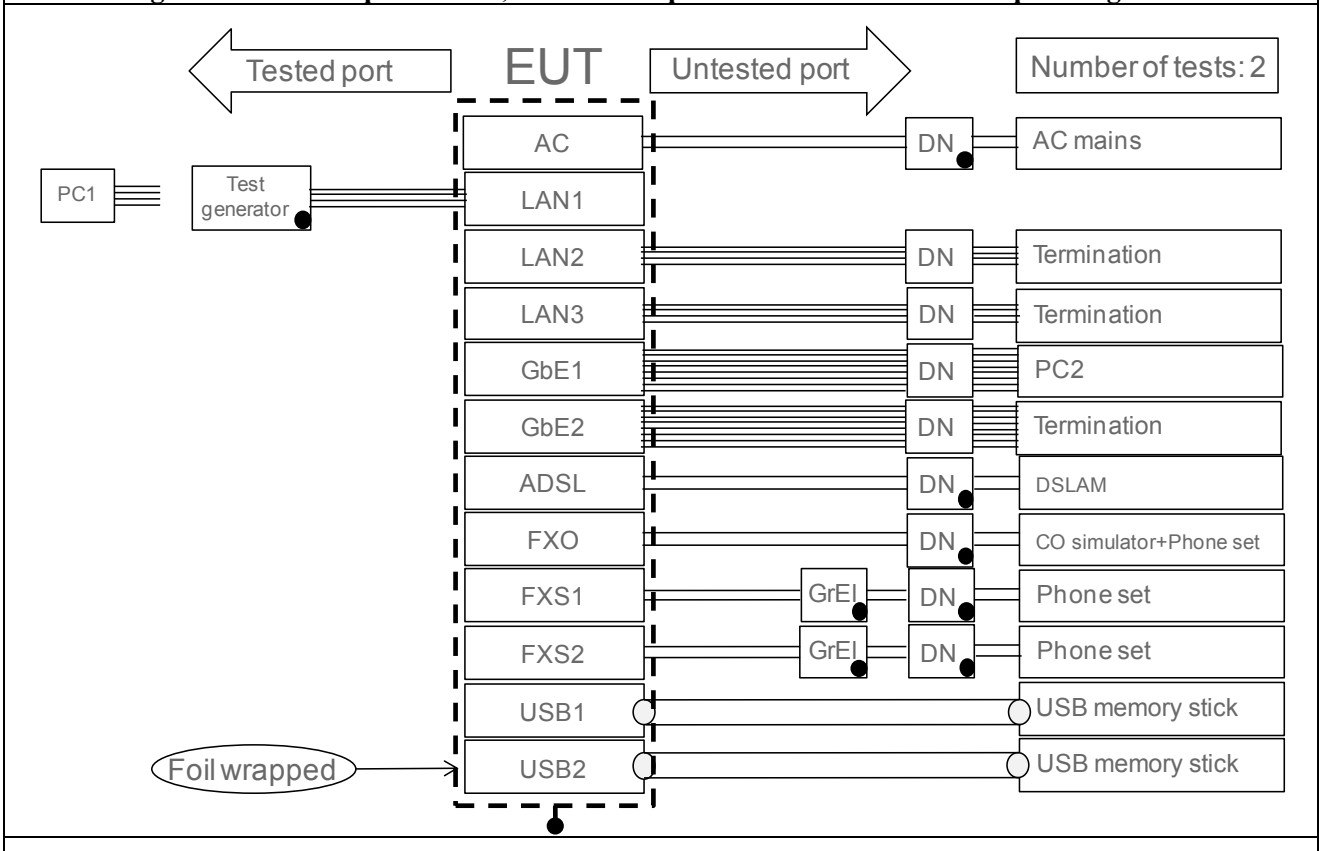


Figure 41 – Tested port LAN1, all untested ports terminated - FXS coupled to ground

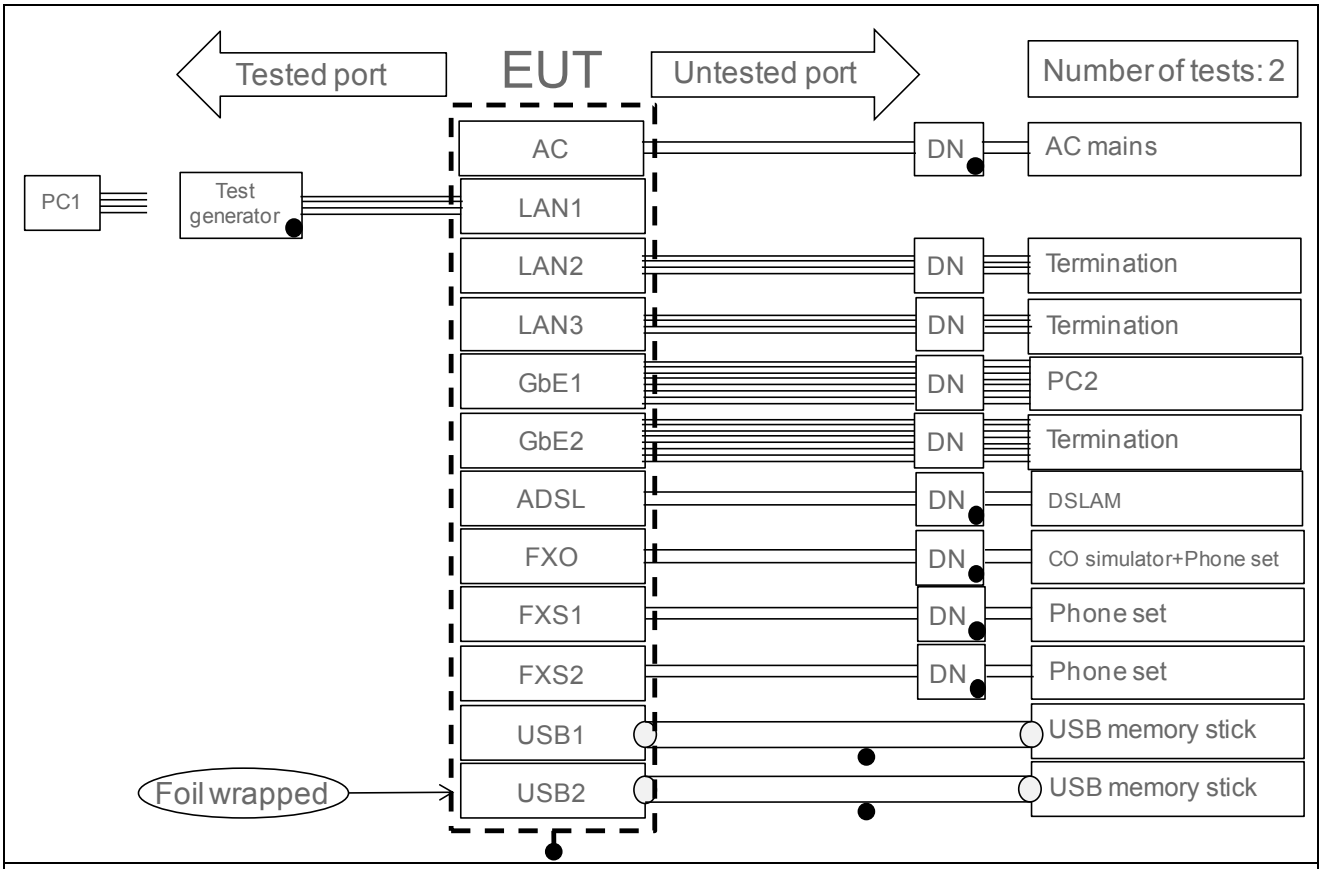


Figure 42 – Tested port LAN1, all untested ports terminated - USB coupled to ground

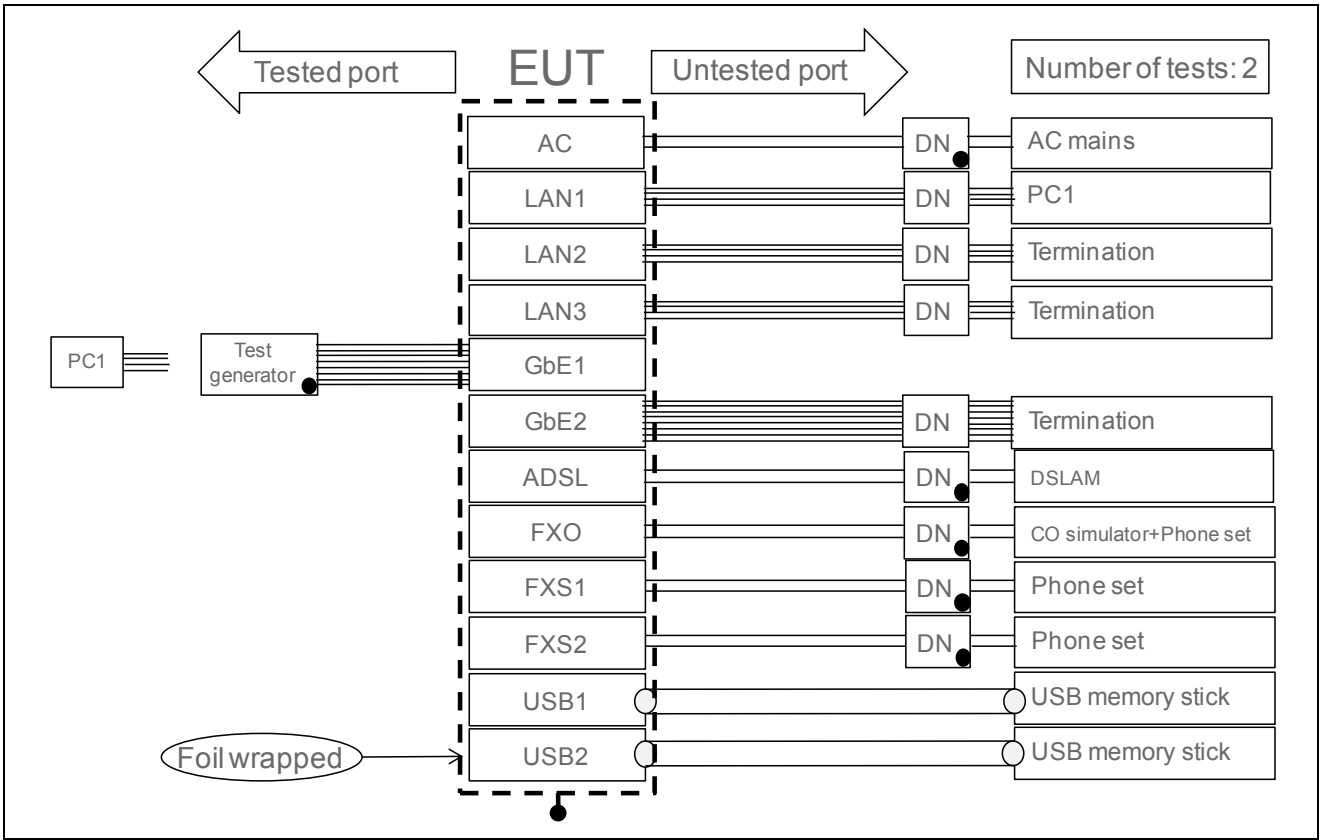


Figure 43 – Tested port GbE1, all untested ports terminated - not coupled to ground

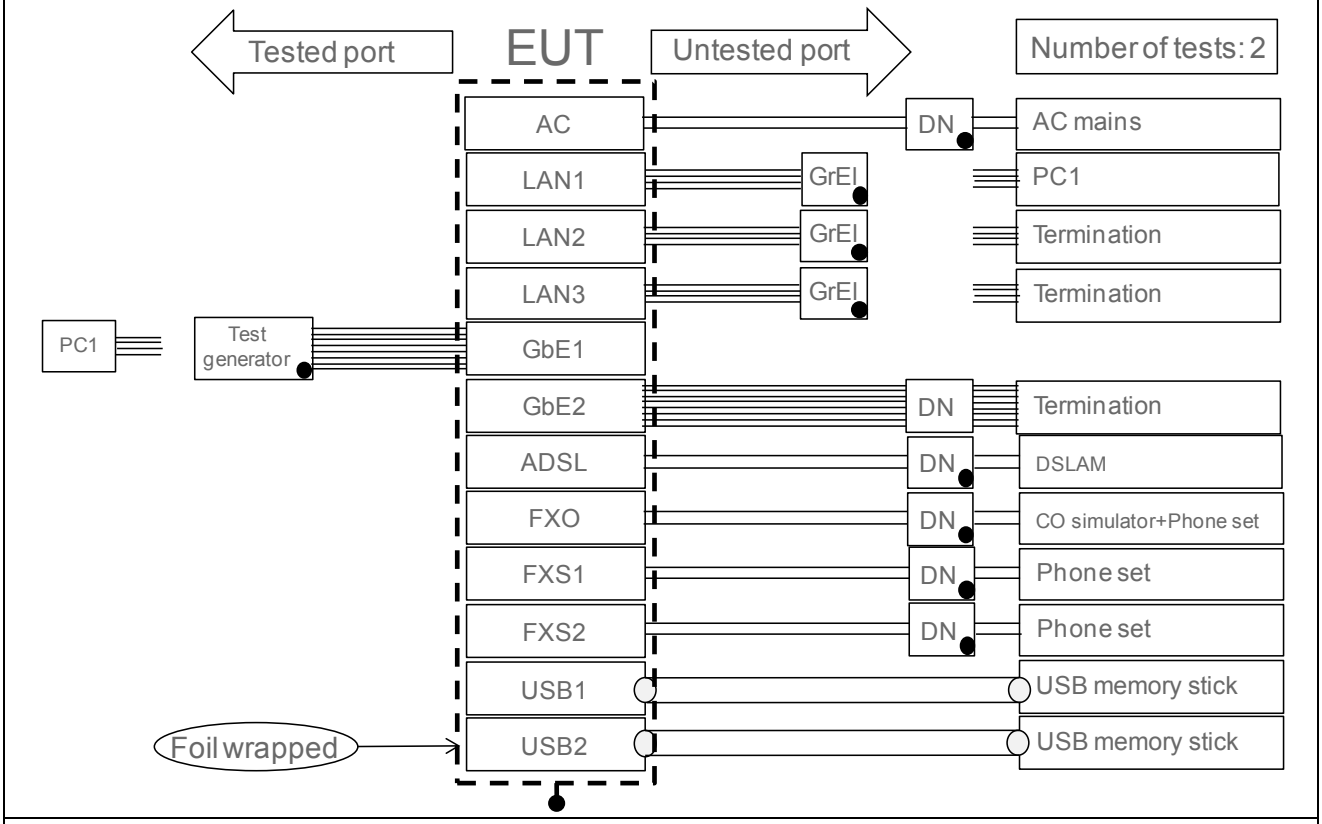


Figure 44 – Tested port GbE1, all untested ports terminated - LAN coupled to ground

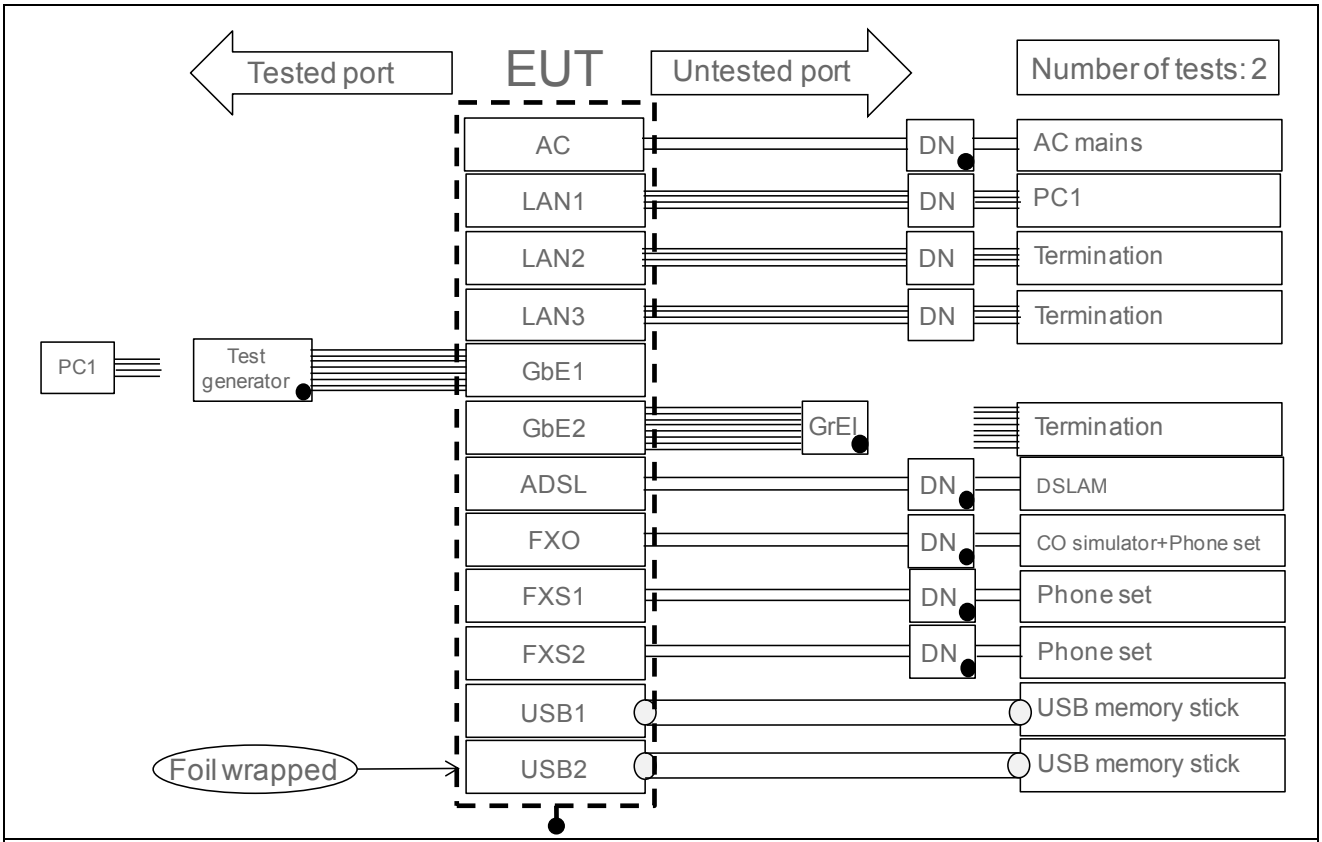


Figure 45 – Tested port GbE1, all untested ports terminated – GbE2 coupled to ground

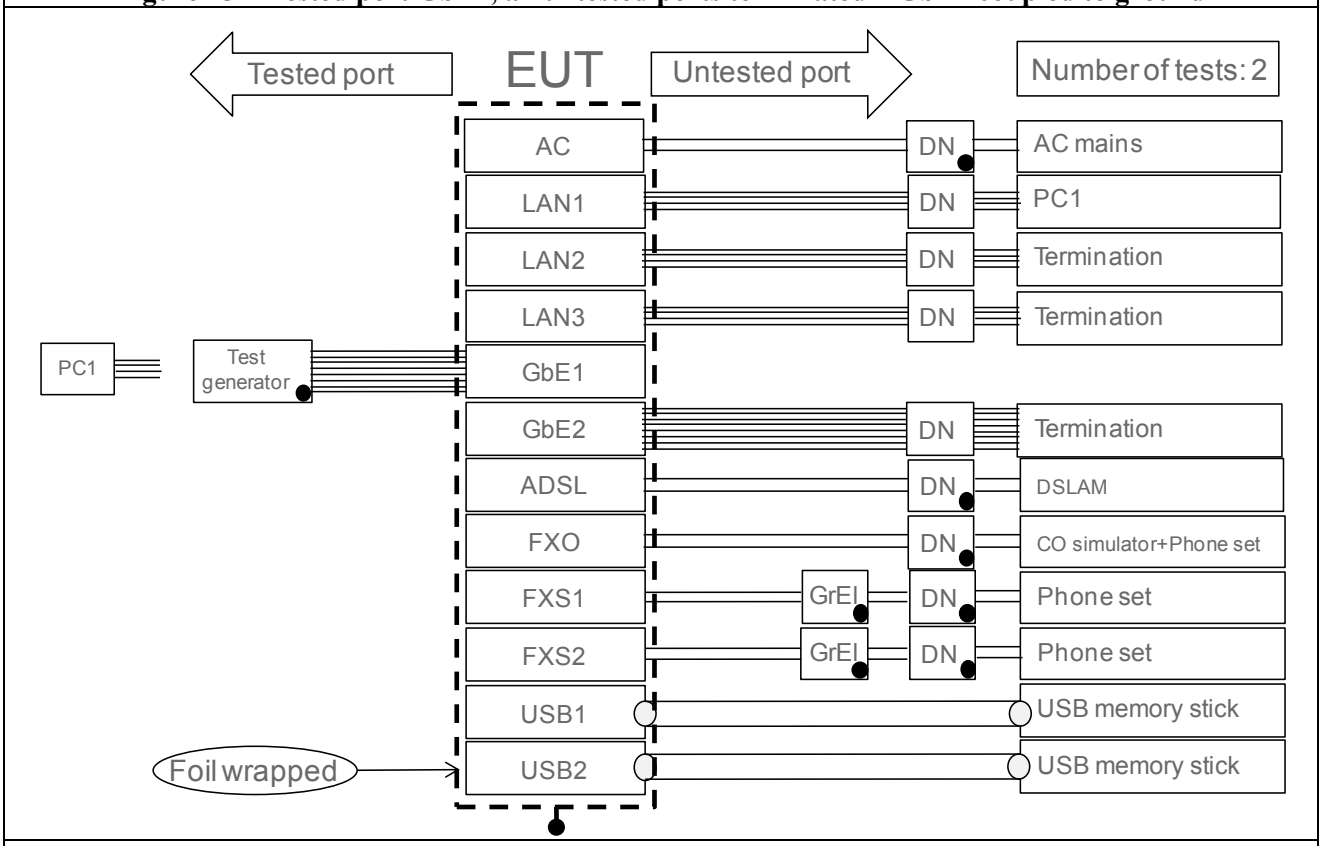


Figure 46 – Tested port GbE1, all untested ports terminated - FXS coupled to ground

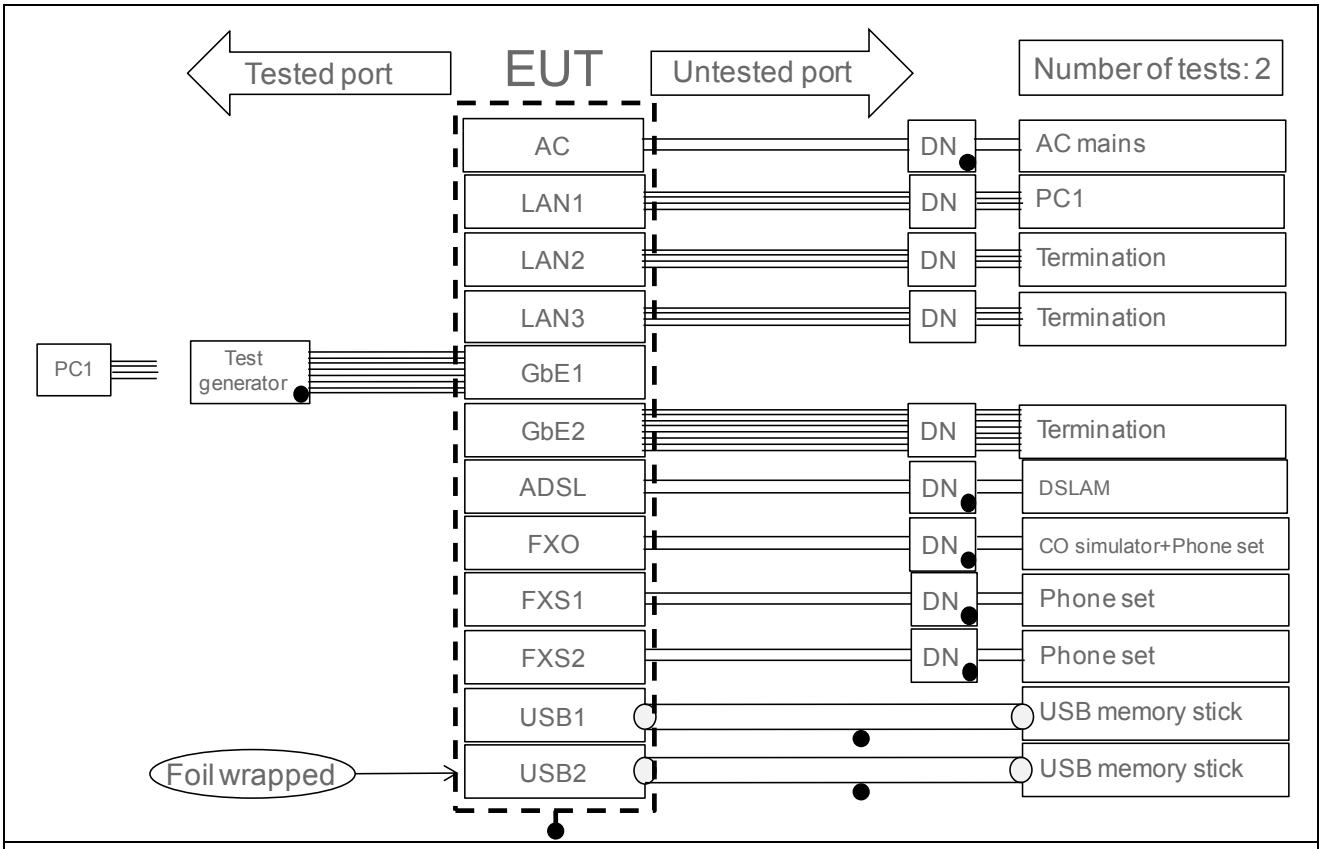


Figure 47 – Tested port GbE1, all untested ports terminated - USB coupled to ground

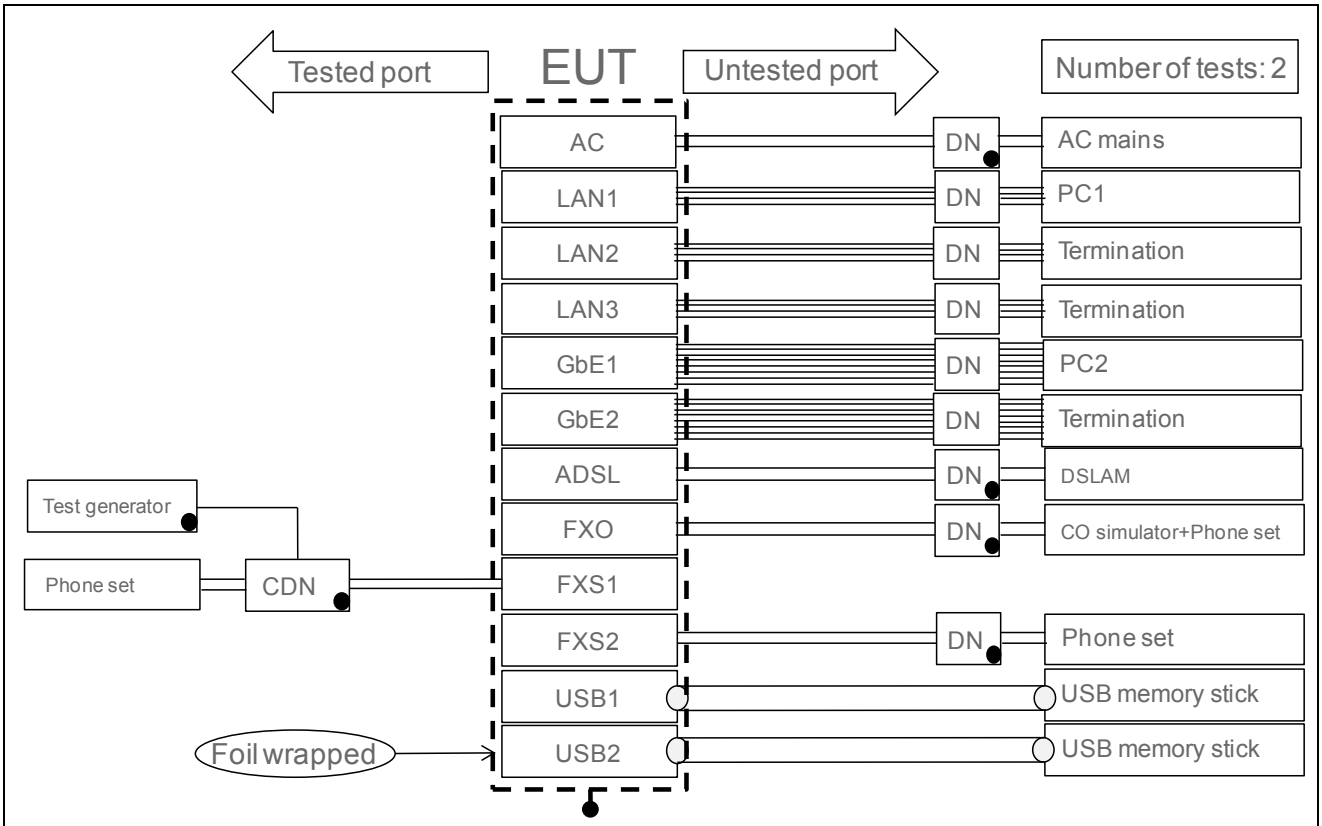


Figure 48 – Tested port FXS1, all untested ports terminated - not coupled to ground

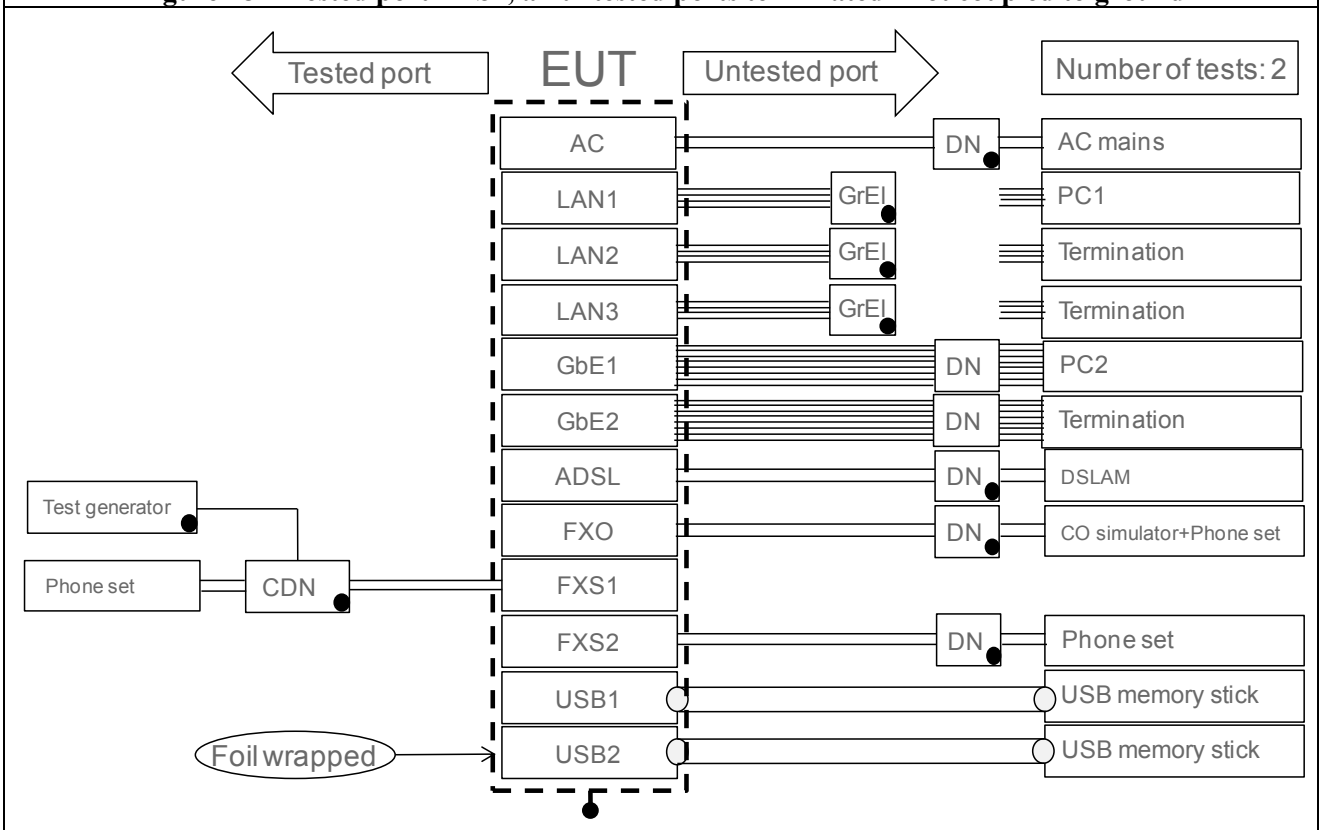


Figure 49 – Tested port FXS1, all untested ports terminated - LAN coupled to ground

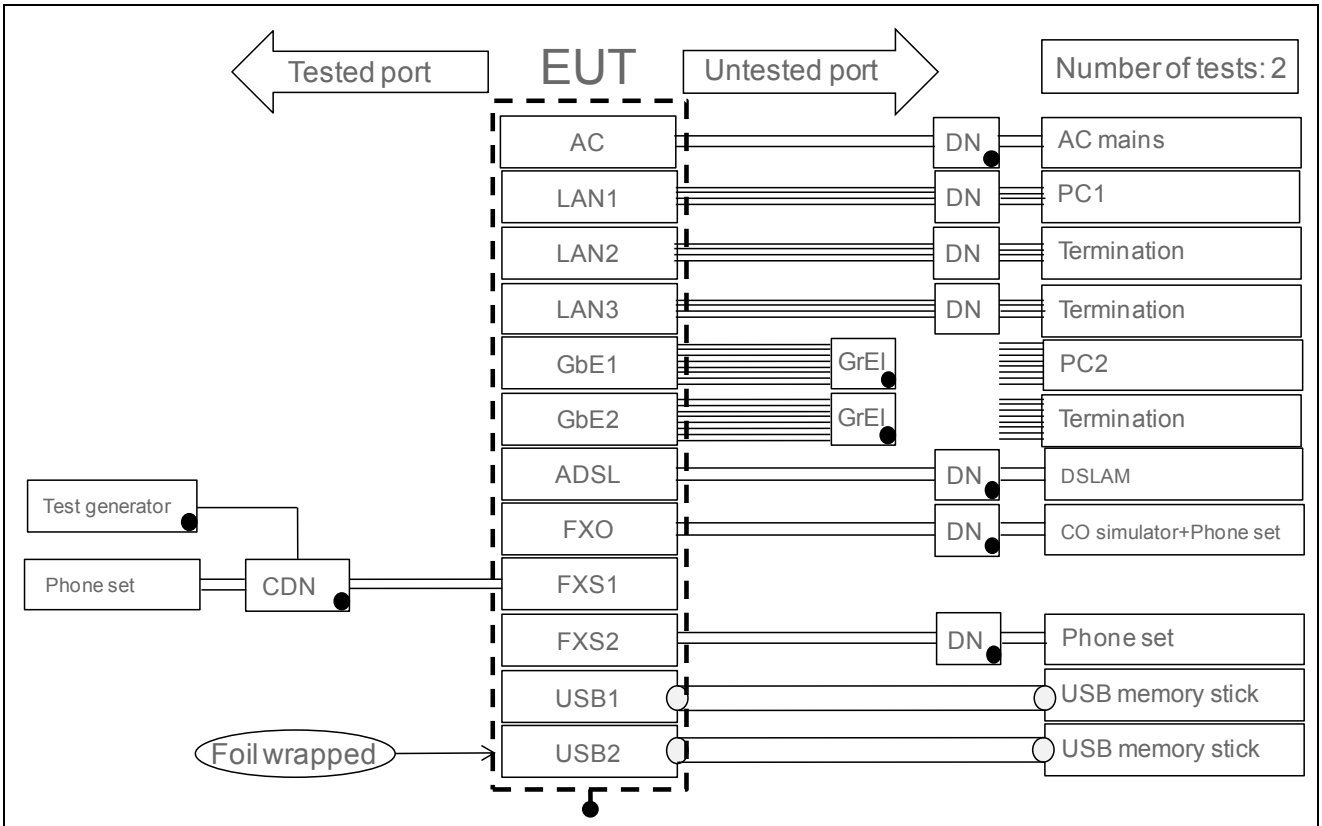


Figure 50 – Tested port FXS1, all untested ports terminated - GbE coupled to ground

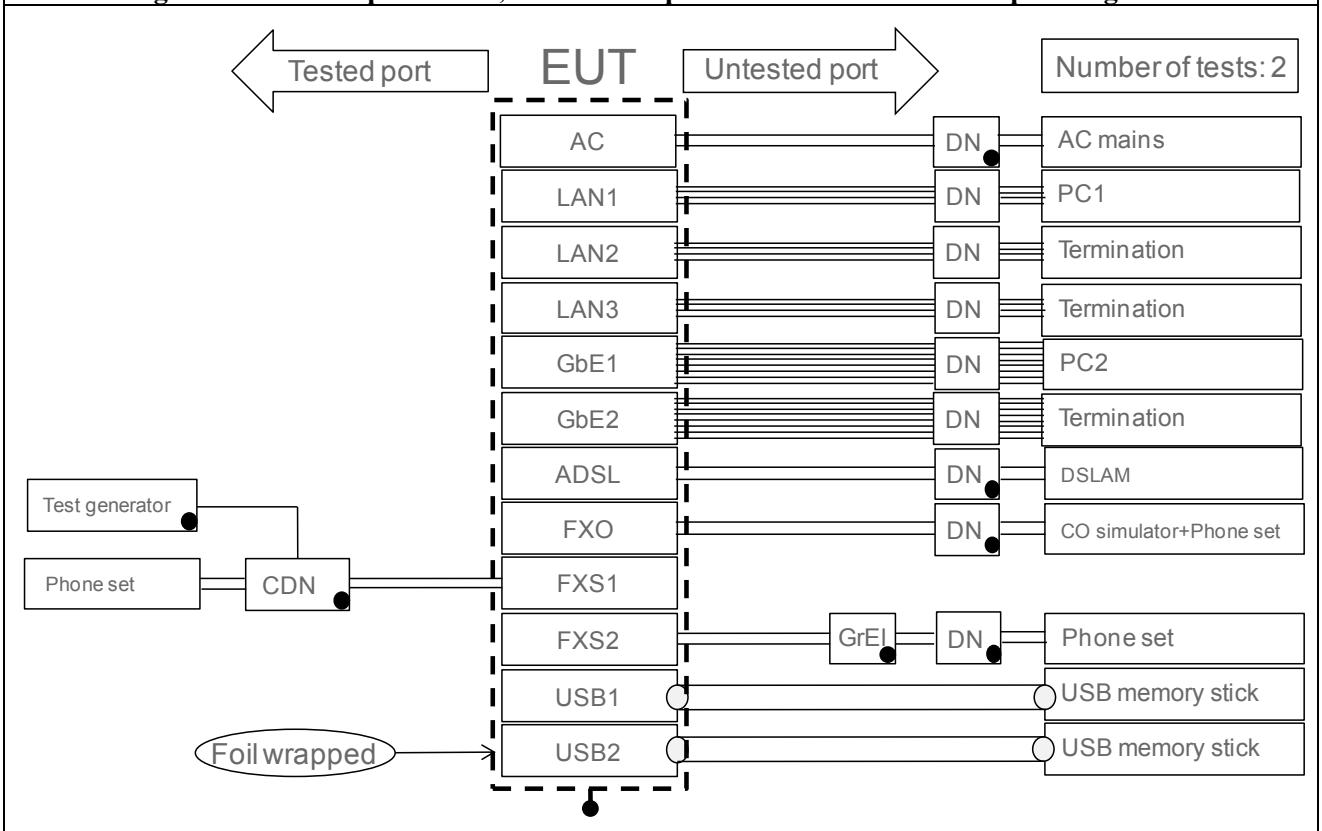


Figure 51 – Tested port FXS1, all untested ports terminated – FXS2 coupled to ground

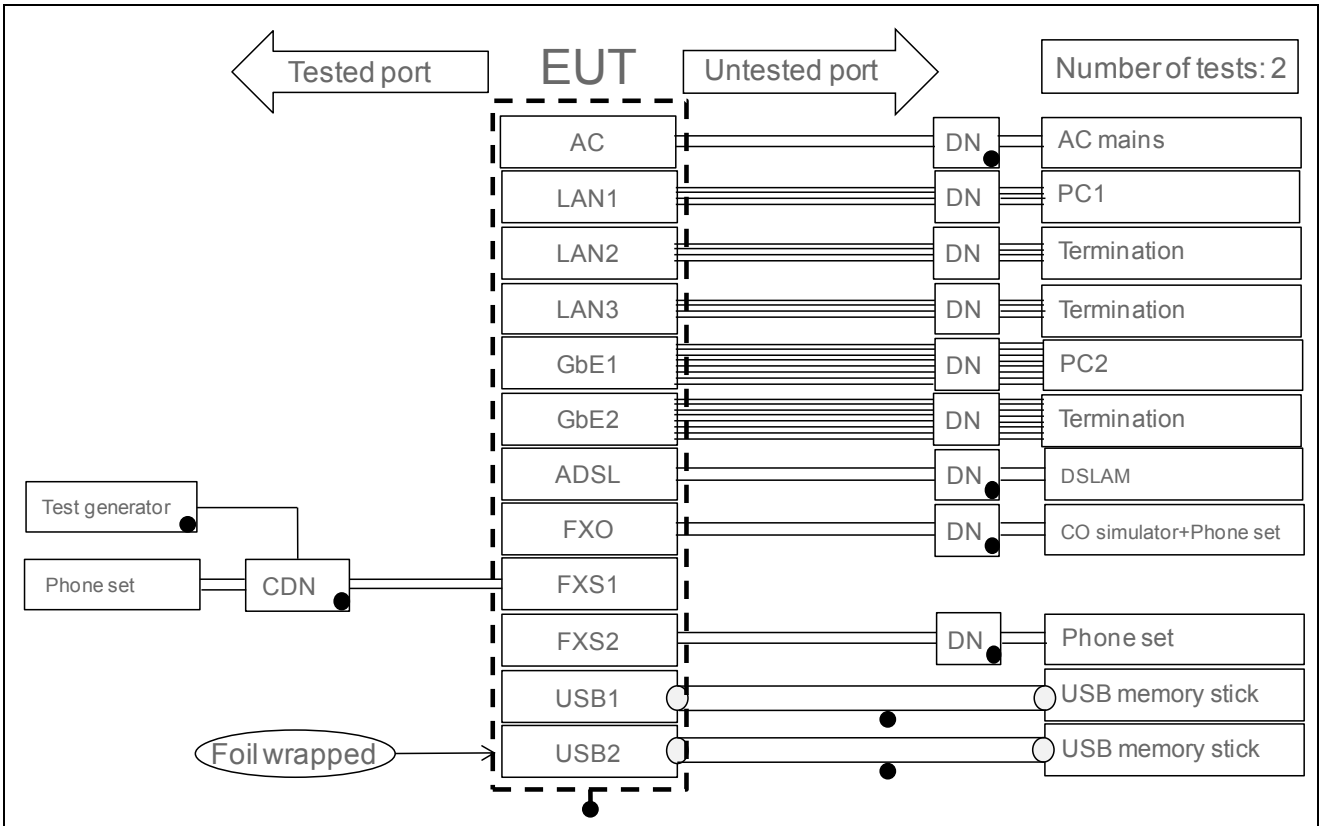


Figure 52 – Tested port FXS1, all untested ports terminated - USB coupled to ground

7.5.15 LIGHTNING SURGE
Internal shielded cable (USB)
Port to Earth 7.2

7.5.15.1 General

Primary protection : The EUT is not designed to be always used with primary protection at the ADSL, FXO and AC port. For these internal port tests, no primary protectors or STP are equipped on the internal nor external ports.

Coupling between test generator and EUT: the 4 internal wires and the shield of the shielded USB cable shall be directly connected to the output of the test generator.

Decoupling networks between EUT and Auxiliary equipment are not needed: see chapter 7.6.

Earthing and bonding configuration: The EUT has no earthing point that can be bonded to ground. Earthing points of decoupling networks, the conductive foil and the grounding elements shall be bonded to ground.

All Auxiliary equipment at the untested ports shall be left floating = no connection to ground.

During the application of the surges, Auxiliary equipment is only connected to those untested Ethernet ports (GbE and LAN) that are not coupled to ground. The tested and untested USB ports and untested Ethernet ports that are coupled to ground are not connected to auxiliary equipment.
After the surge test, the tested and untested USB ports and untested Ethernet ports that were coupled to ground are connected to auxiliary equipment and a functional verification is done

The voltage-current waveform of the lightning combination wave surge test generator is a 1.2/50-8/20µs.

The nature of the coupling method at the tested side does not allow the USB port to be operational.

Total number of tests: 10

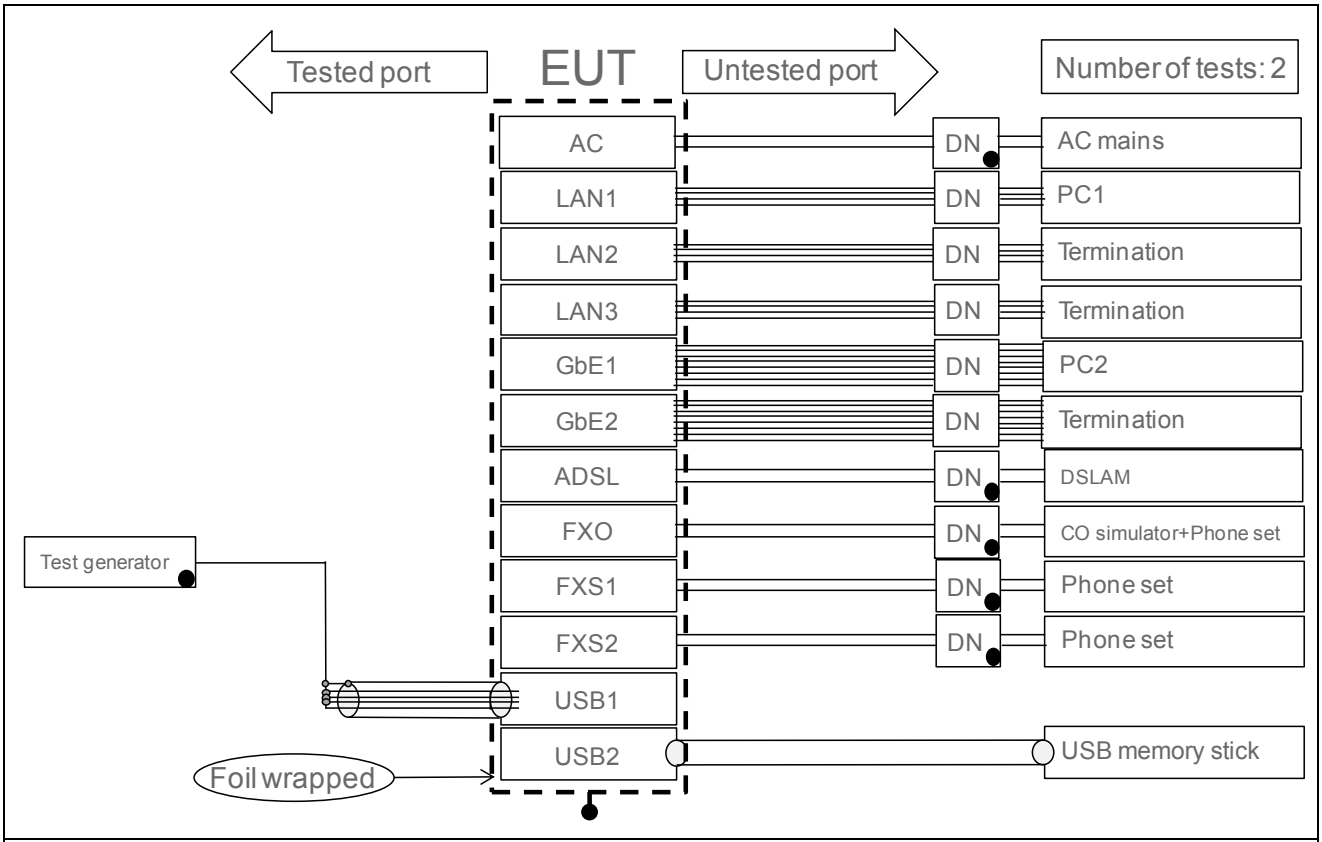


Figure 53 – Tested port USB1, all untested ports terminated – not coupled to ground

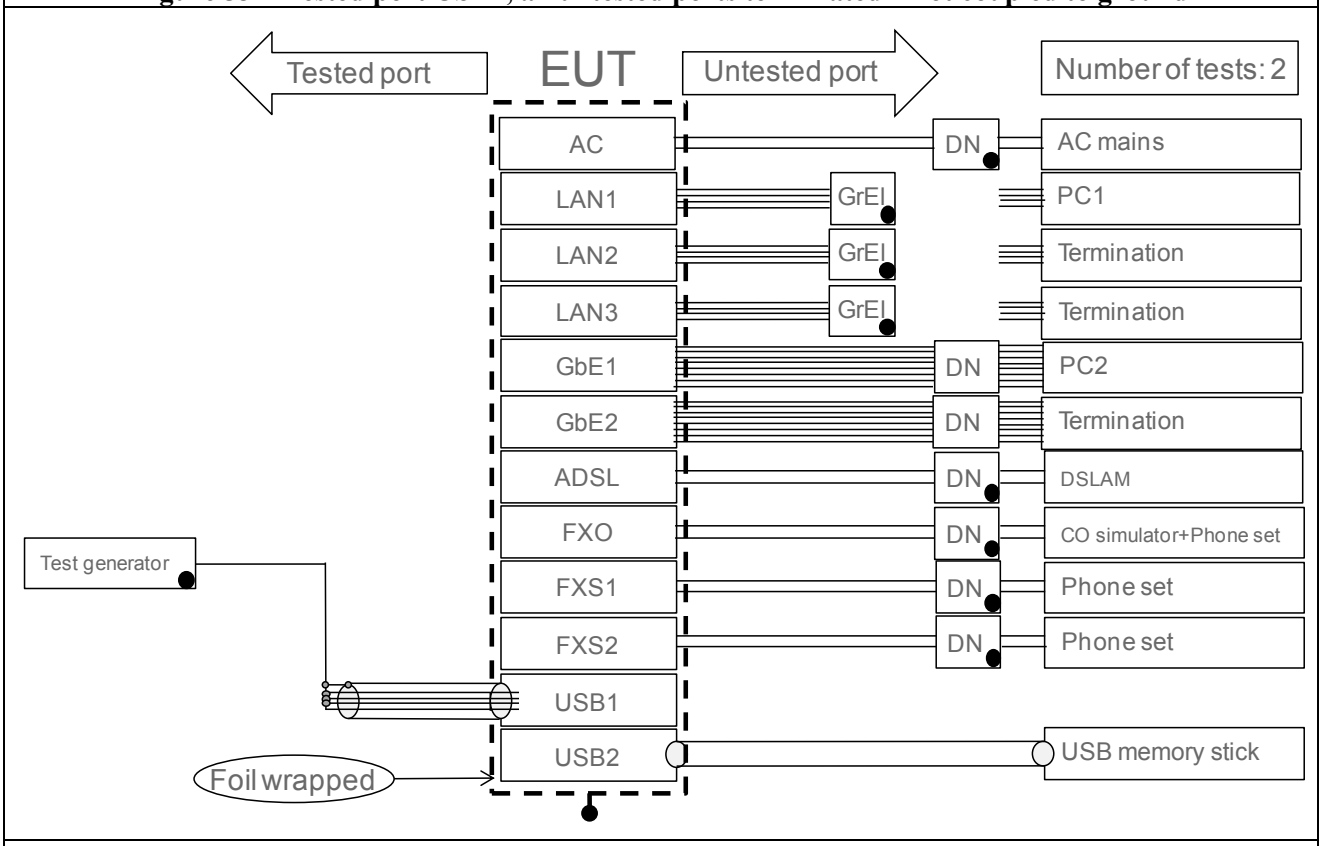


Figure 54 – Tested port USB1, all untested ports terminated – LAN coupled to ground

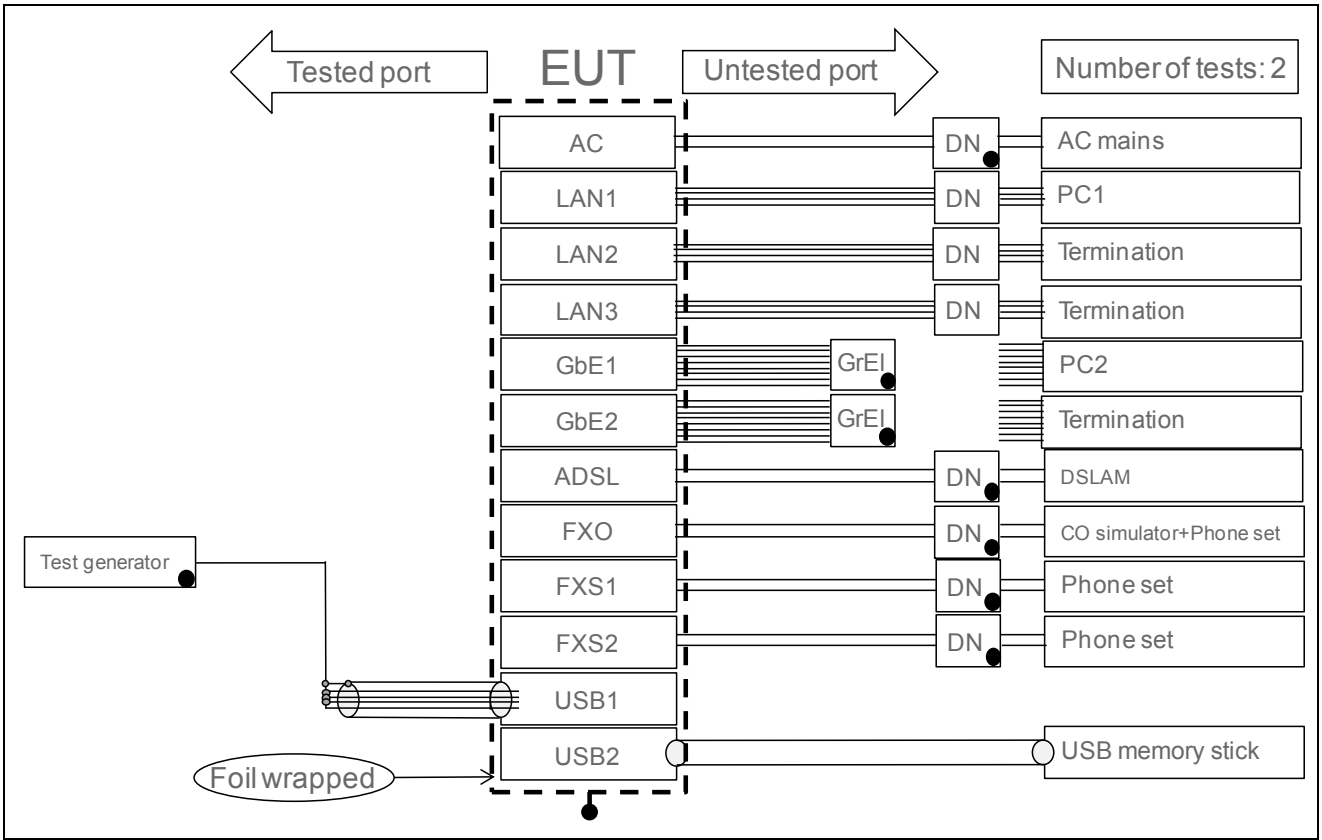


Figure 55 – Tested port USB1, all untested ports terminated - GbE coupled to ground

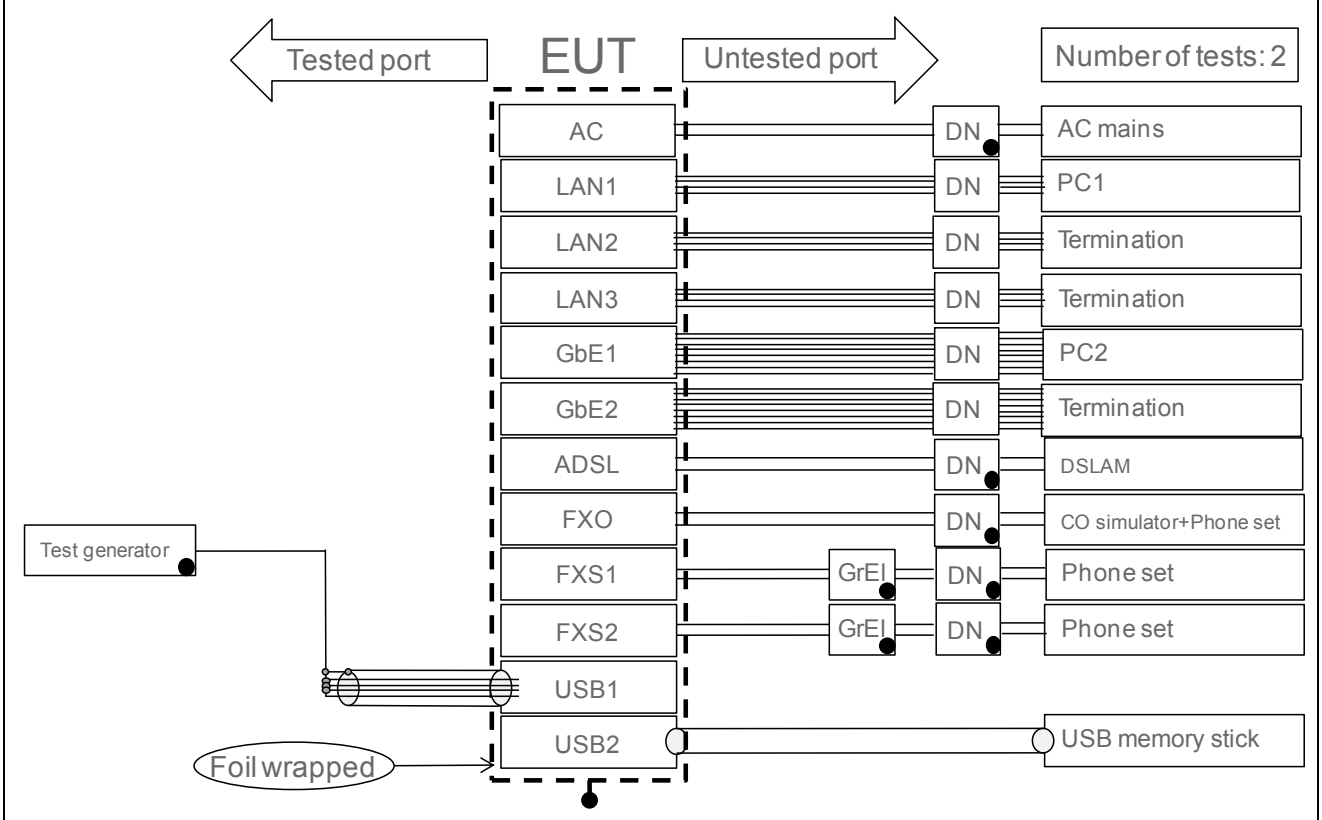


Figure 56 – Tested port USB1, all untested ports terminated – FXS coupled to ground

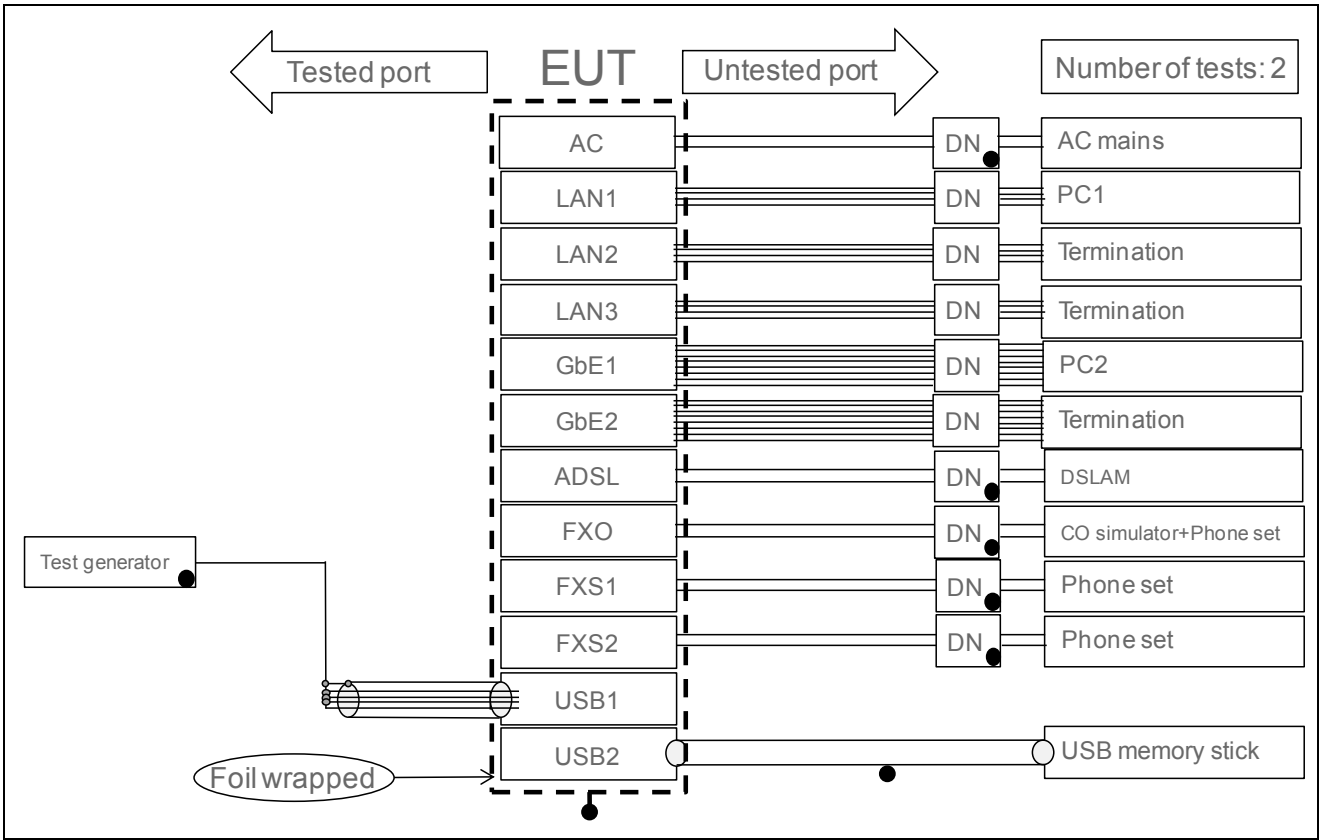


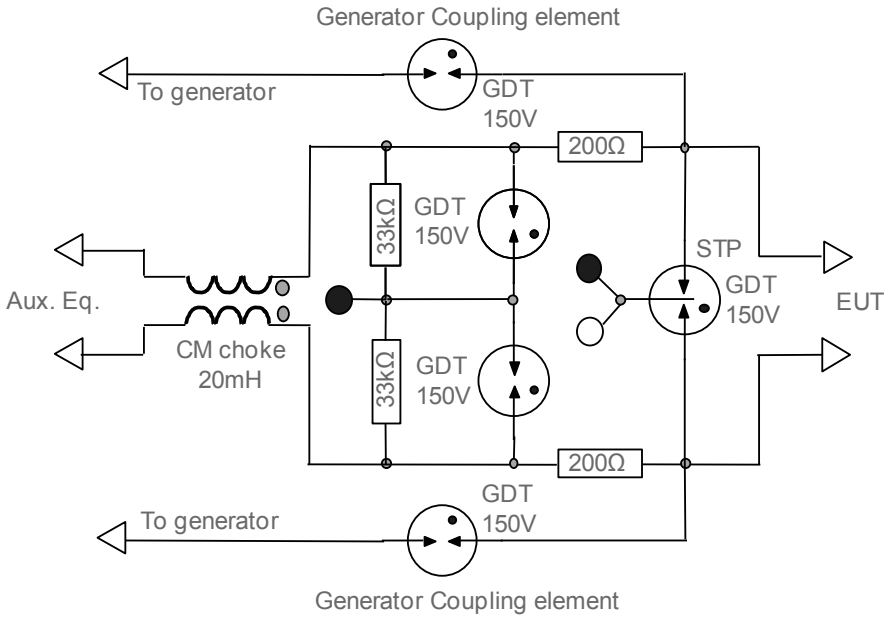
Figure 57 – Tested port USB1, all untested ports terminated – USB2 coupled to ground

7.6 Coupling elements, decoupling networks, grounding elements

7.6.1.1 General

This Clause will give an overview of generator coupling elements, grounding elements and decoupling networks used in the practical example of the previous chapter.
Values of coupling, decoupling and grounding elements have been chosen to suit the characteristics of the circuits they are used in. The pictures of the decoupling networks give an idea about the used components and power ratings.
Some decoupling networks will also deviate from the recommended networks proposed in ITU-T K.44 due to practical considerations. This means other solutions are possible to achieve the same target.

7.6.1.2 ADSL and FXO ports



Note: If equipped, the STP is connected to the Generator return/Earth except for the 2.1.2.c tests where the STP is connected to the EUT Reference bar

Figure 58 – Lightning Surges - Tested port ADSL and FXO - schematic

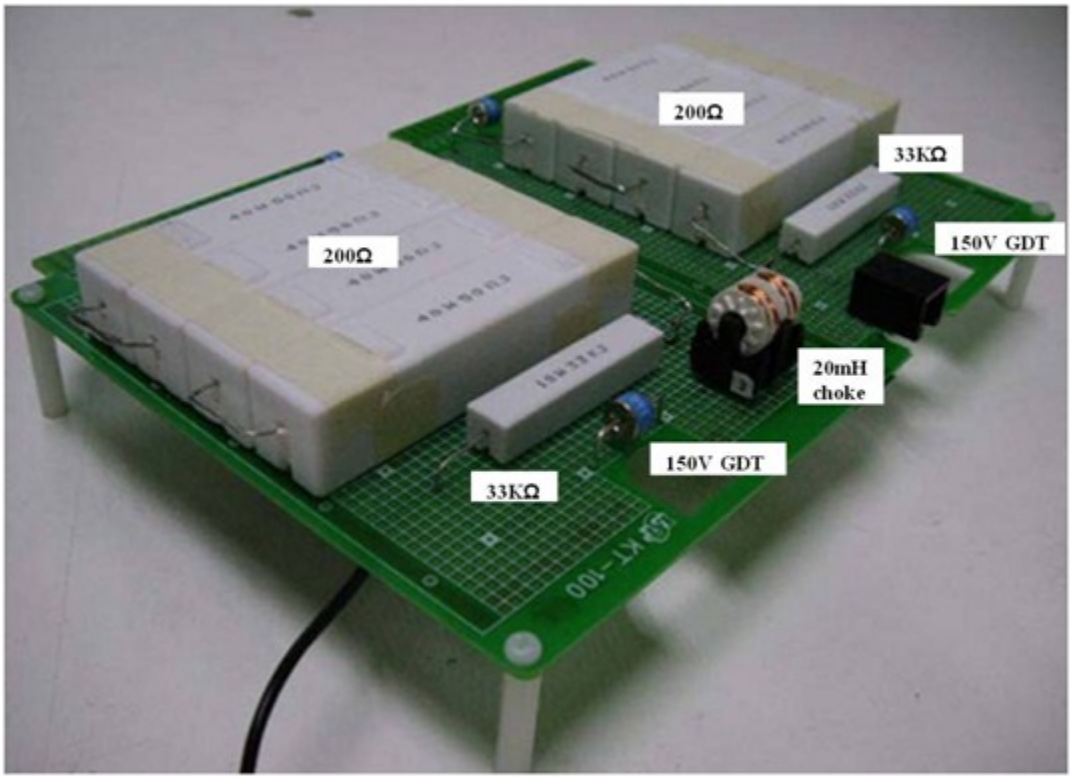
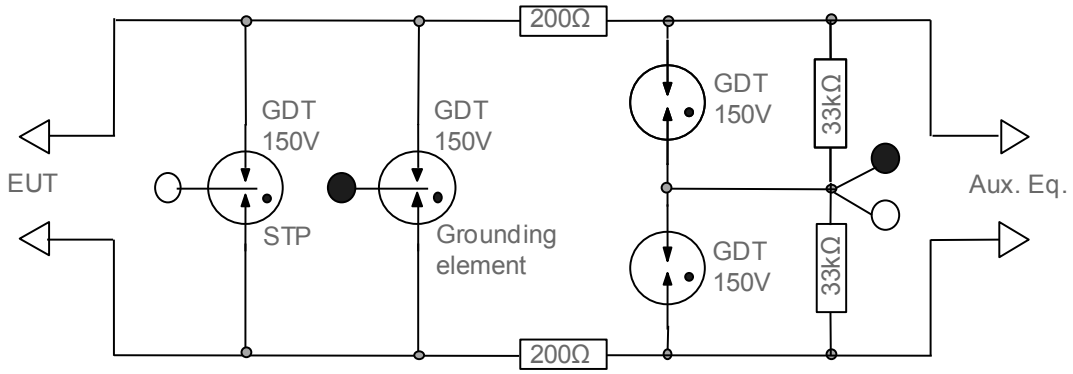


Figure 59 – Lightning Surges – Tested port ADSL and FXO - Pictures



Note 1: The grounding element is only equipped for 2.1.2.c and 5.1.2.c tests
Note 2: The decoupling network is connected to the Generator Return/ Earth, except for the 2.1.x.c, 5.1.x.c and 5.2.2.b tests where the decoupling network is connected to the EUT Reference bar
Note 3: The size of the 200 ohm resistors is larger in the Tested side due to the high energy of the Lightning surges.

Figure 60 – Lightning Surges - Untested port ADSL and FXO - schematic

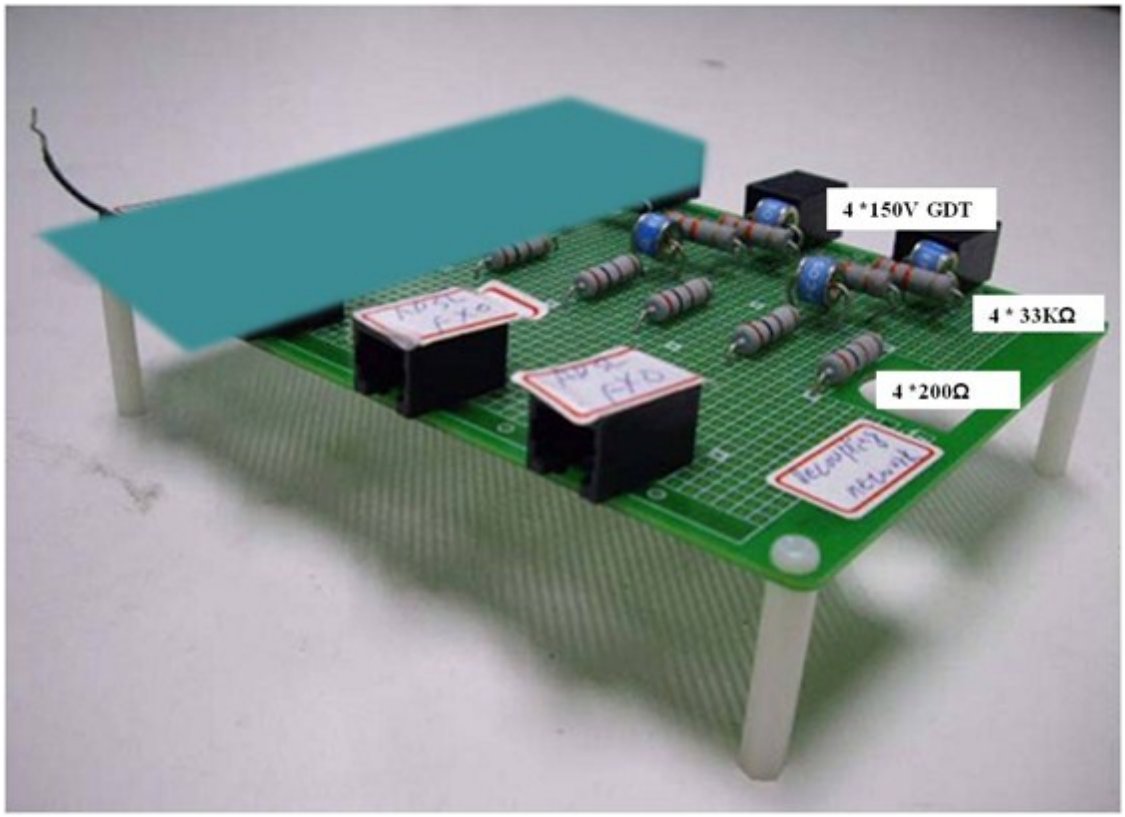
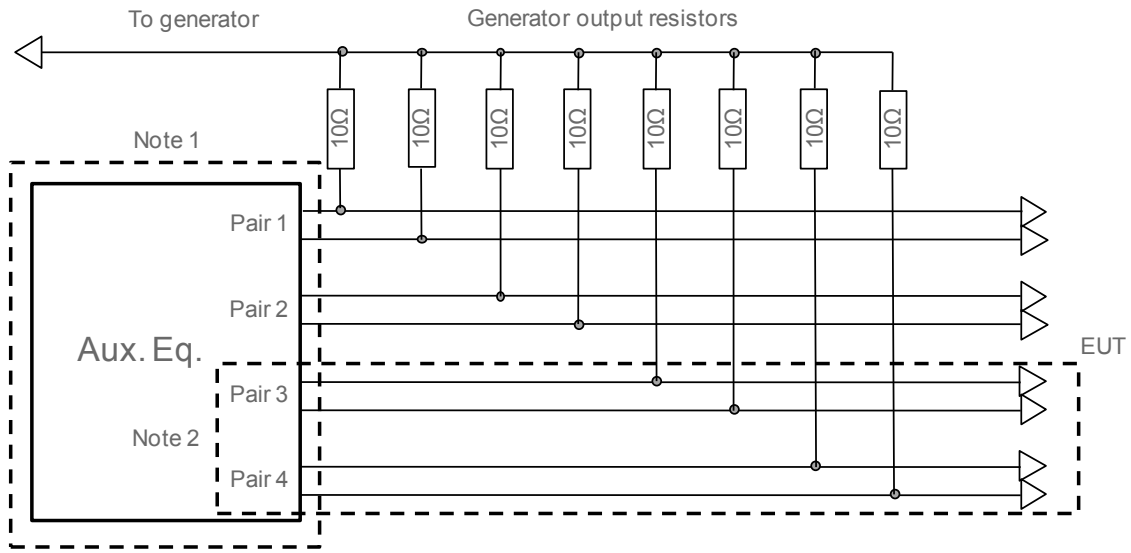


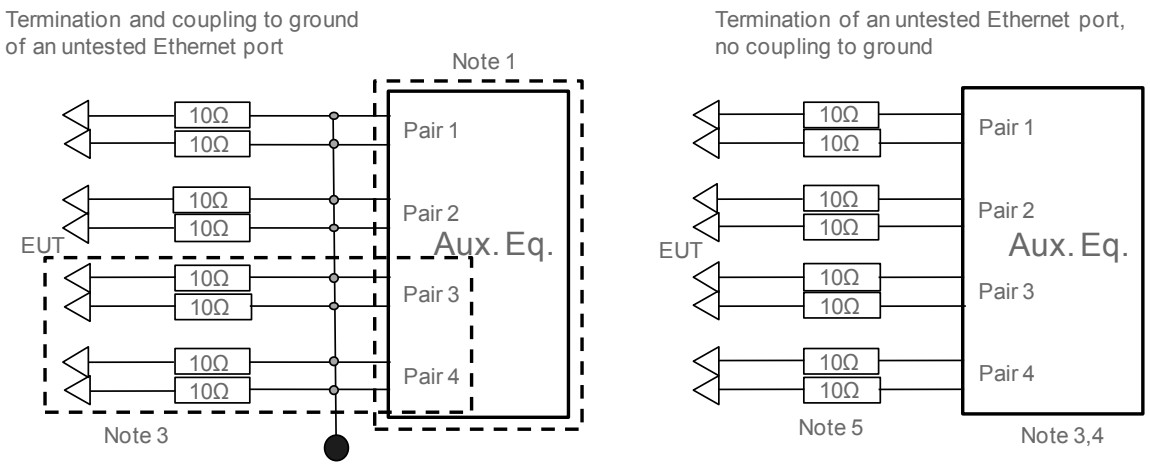
Figure 61 – Lightning Surges – Untested port ADSL and FXO - Pictures

7.6.1.3 Ethernet LAN and GbE ports



Note 1: Surge testing on ethernet is done without the Auxiliary equipment connected during the application of the surges. The Auxiliary equipment is only connected after the surge test for verification purposes.
Note 2: This drawing represents a GbE port with 4 pairs or an Eth port connected with a cable with 4 pairs. For ethernet that is only connected with a 2 pair cable, pair 3 and 4 is not equipped.

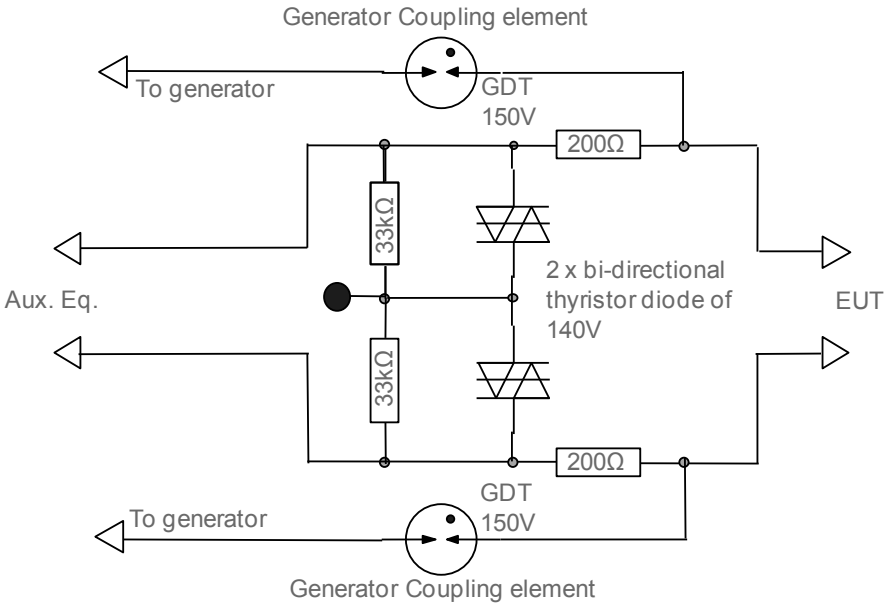
Figure 62 – Lightning Surges - Tested port LAN and GbE – schematic



Note 1: During surge testing, the untested ethernet port that is coupled to ground is not connected to Auxiliary equipment. The Auxiliary equipment is only connected after the surge test for verification purposes.
Note 2: During surge testing, the untested ethernet port that is not coupled to ground is connected to Auxiliary equipment. Then verification of the ethernet function can be done during the application of the surge on any tested port.
Note 3: This drawing represents a GbE port with 4 pairs or an Eth port connected with a cable with 4 pairs. For ethernet that is only connected with a 2 pair cable, pair 3 and 4 is not equipped.
Note 4: The Auxiliary equipment of the untested ethernet port that is not coupled to ground shall not be connected to the Generator Return/ Earth.
Note 5: These 10Ω resistors can be replaced by an ethernet cable of convenient length.

Figure 63 – Lightning Surges – Untested port LAN and GbE – schematic

7.6.1.4 FXS ports



Note 1: the bi-directional thyristor diode is a 140V type. This is due to the fact that there can be ringing voltages present on the FXS telephone port.

Figure 64 – Lightning Surges - Tested port FXS - schematic

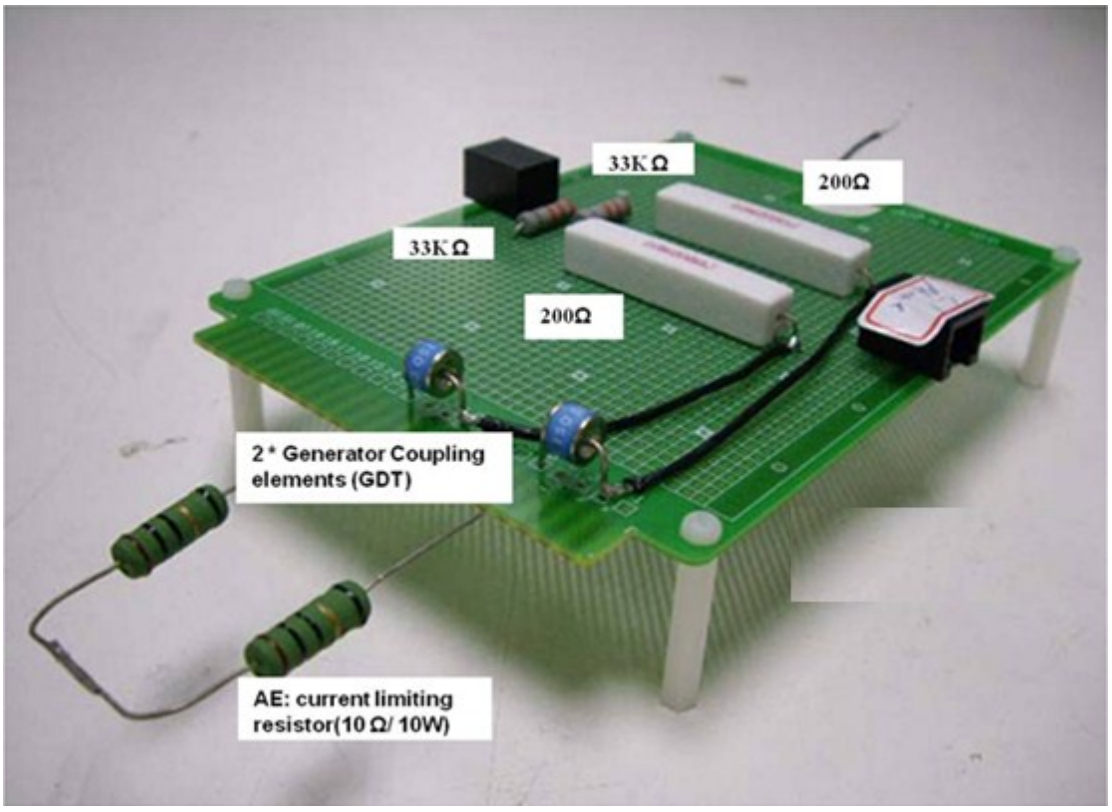
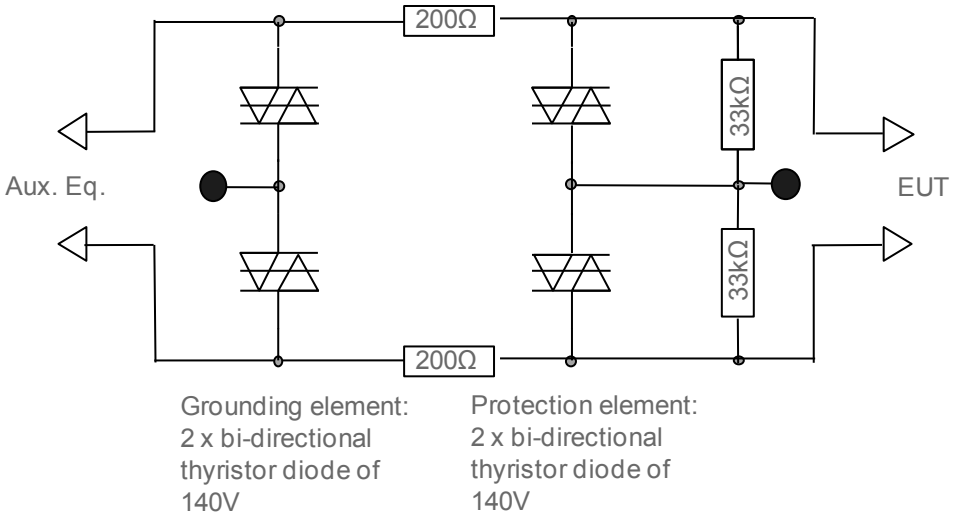


Figure 65 – Lightning Surges – Tested port FXS - Pictures



Note 1: the bi-directional thyristor diode is a 140V type. This is due to the fact that there can be ringing voltages present on the telephone port.

Figure 66 – Lightning Surges - Untested port FXS - schematic

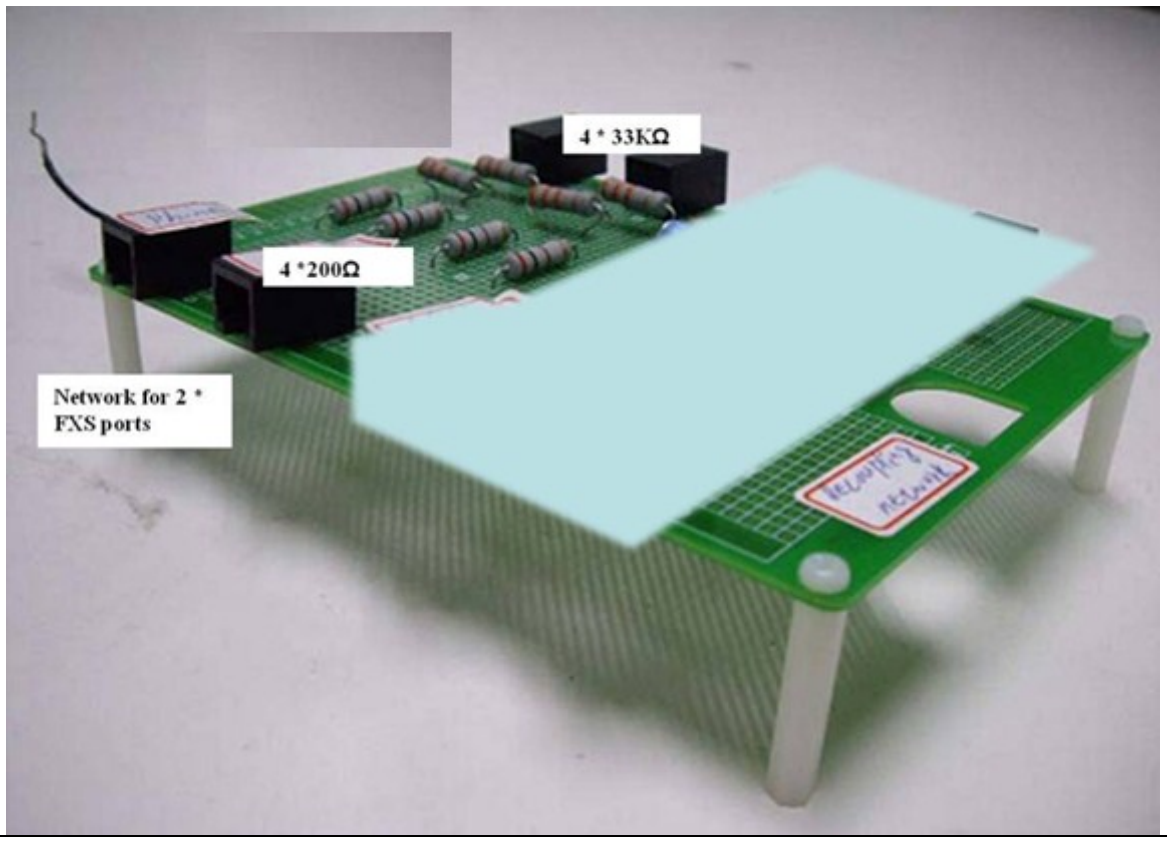
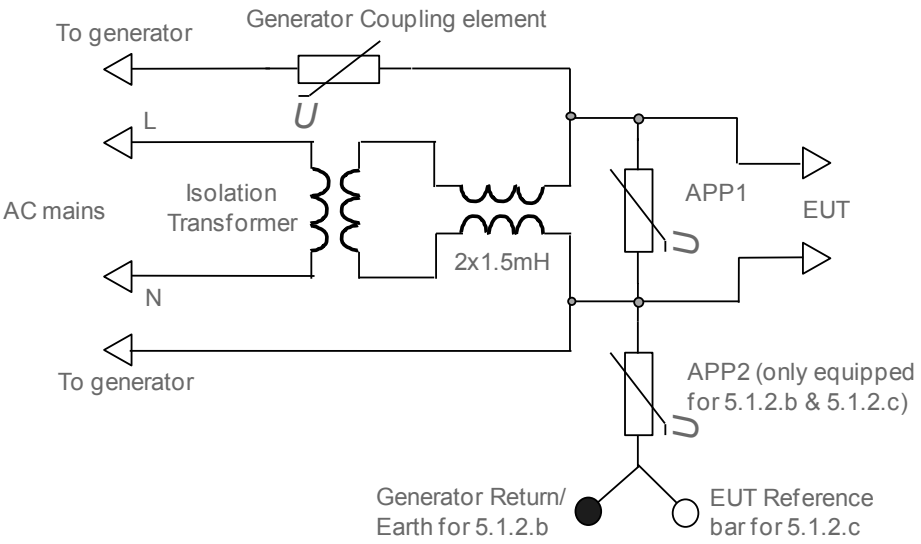


Figure 67 – Lightning Surges – Untested port FXS - Pictures

7.6.1.5 AC Mains Power port



Note 1: For tests 5.1.2.a, 5.1.2.b & 5.1.2.c, the APP1 is always equipped. The APP2 is only equipped for tests 5.1.2.b & 5.1.2.c.
Note 2: For test 5.1.2.b, APP2 is connected to the Generator Return/ Earth; for test 5.1.2.c, APP2 is connected to the EUT Reference bar.
Note 3: the Coupling and Decoupling networks at the Tested side are usually integrated in commercially available Surge generators. The use of MOV's as coupling elements must be verified carefully.

Figure 68 – Lightning Surges - Tested port AC mains power - schematic

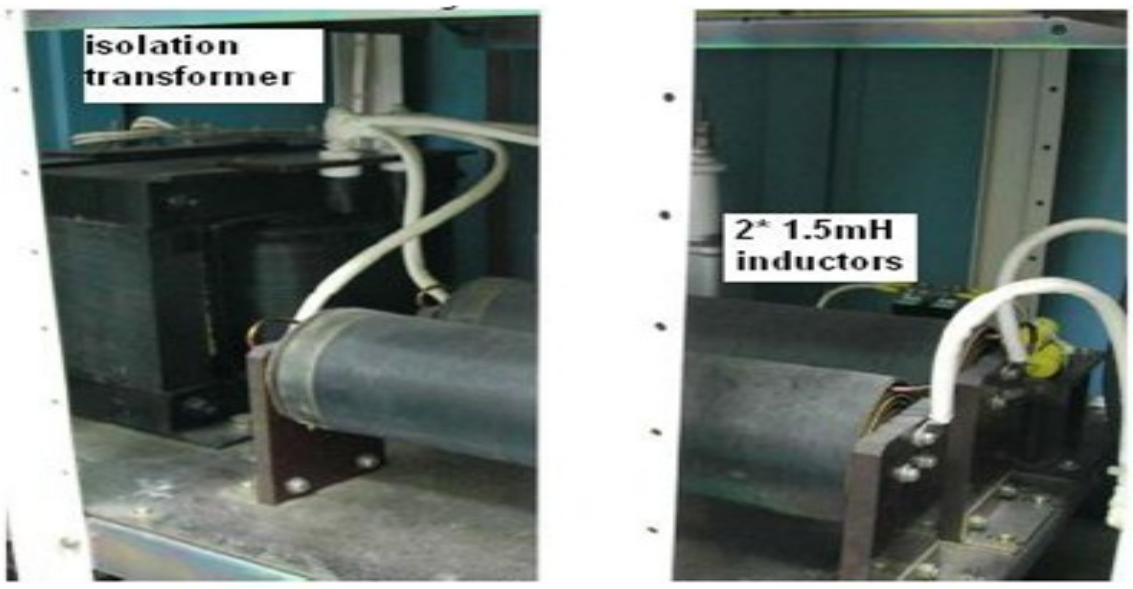
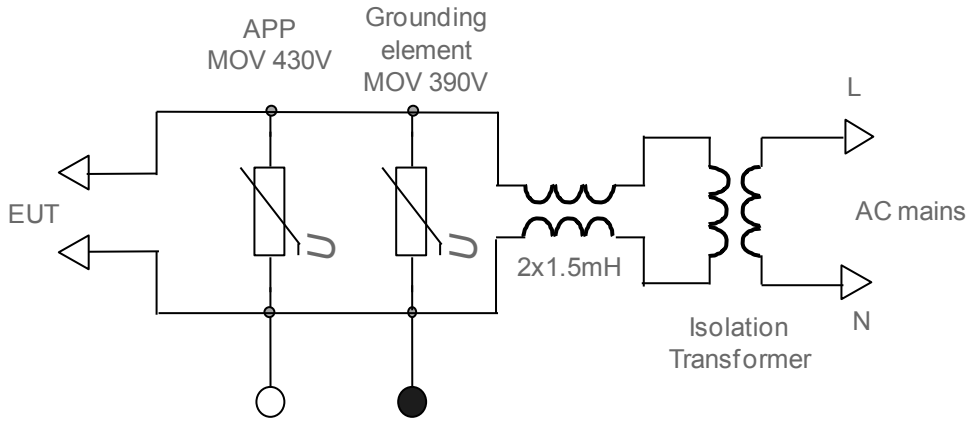


Figure 69 – Lightning Surges – Tested port AC mains power - Pictures



Note 1: The APP is only equipped for 2.1.2.c and connected to the EUT Reference bar.
Note 2: The Grounding element is only equipped for 2.1.1.c & 2.1.2.c and connected to the Generator Return/ Earth.

Figure 70 – Lightning Surges - Untested port AC mains power - schematic

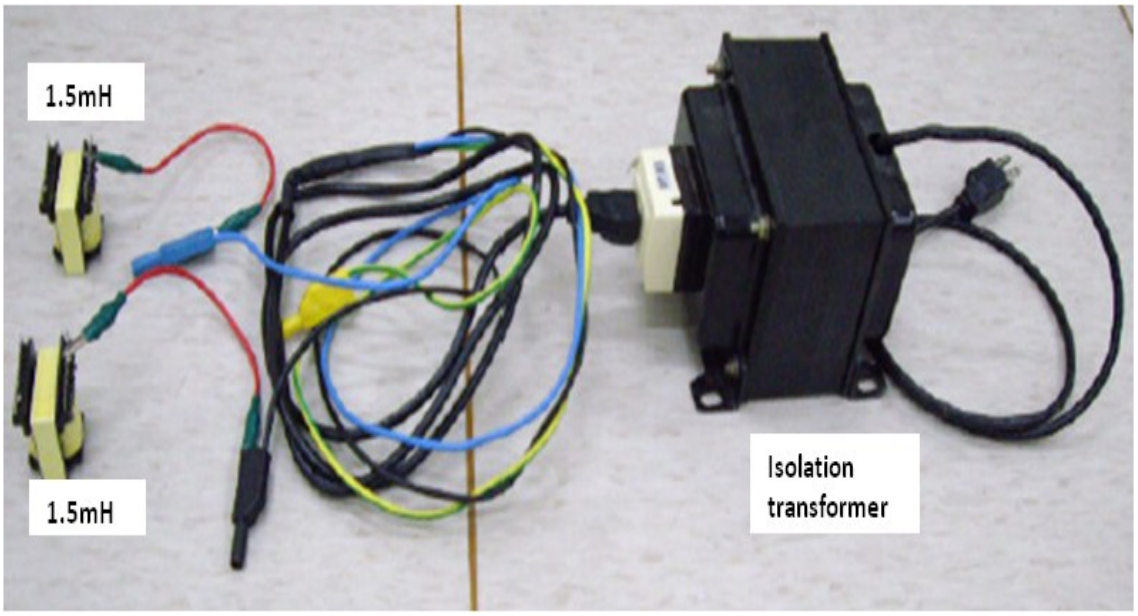


Figure 71 – Lightning Surges – Untested port AC mains power - Pictures

7.6.1.6 USB port

Grounding of the USB port is achieved by grounding the shielding of the USB cable.

Figure 72 – Lightning Surges - Untested port USB - schematic

7.7 Generator output voltage adjustment

K.44, clause A.5.1 requires that:

"The coupling element should be considered as an integral part of the test generator and should not significantly affect the open-circuit voltage nor the short-circuit current. It may be necessary to increase the test voltage to compensate for voltage drop in coupling elements."

In fact, it is not only the coupling element, but also the decoupling network that can have an influence on the output voltage and output current of the surge generator.

The following tables will focus on the adjustment of the output voltage level for K.21:

Lightning Surges 2.1.x, 5.1.x and 7.1.

Power Induction Surges 2.2.x.

Earth Potential Rise 5.2.2.

The listed values are applicable for the combination of the Generator Coupling elements and Decoupling Networks as described in the previous chapter. Other components and configurations may lead to other adjusted values of the generator output voltage.

The values in the next tables are thus only examples and should not be used to set the generator output level as such but only after measurements are done on the complete set-up.
It is advised to also verify the required short-circuit current settings but this is not included in this document.

An important message is that a generator capable to generate an open circuit voltage that is in line with a certain test level required by K.21 may not be suitable at all when coupling and decoupling networks are equipped in parallel and in series. An example of this in the next table is that a lightning surge generator needs an adjustment up to 8.3kV when a level of 6kV is needed on the connection point of the EUT. In other words: a generator capable to deliver maximum 6kV is not suitable for this K.21 6kV test.

7.7.1 K.21 2.1.x Lightning Surge generator adjustment values

K.21 clause	Basic/Enhanced	Required voltage level	Measured voltage at generator output	Measured voltage at EUT without EUT connected	Increase voltage from generator up to:	Measured voltage at EUT after increase without EUT connected
2.1.1.a	Basic/Enhanced	1.5kV	1.44kV	1.30kV	1.75kV	1.52kV
2.1.1.b	Basic	1.5kV	1.44kV	1.22kV	1.85kV	1.50kV
2.1.1.b	Enhanced	6.0kV	5.84kV	4.68kV	8.30kV	6.04kV
2.1.1.c	Basic	1.5kV	1.44kV	1.22kV	1.85kV	1.50kV
2.1.1.c	Enhanced	6.0kV	5.84kV	4.68kV	8.30kV	6.04kV
2.1.2.a	Basic	4.0kV	3.90kV	3.40kV	4.80kV	4.05kV
2.1.2.a	Enhanced	6.0kV	5.84kV	5.00kV	7.90kV	6.10kV
2.1.2.b	Basic	4.0kV	3.90kV	3.08kV	5.20kV	4.00kV
2.1.2.b	Enhanced	6.0kV	5.84kV	4.68kV	8.30kV	6.04kV
2.1.2.c	Basic	4.0kV	3.90kV	3.08kV	5.20kV	4.00kV
2.1.2.c	Enhanced	6.0kV	5.84kV	4.68kV	8.30kV	6.04kV

7.7.2 K.21 2.2.x Power induction Surge generator adjustment values

K.21 clause	Basic/Enhanced	Required voltage level	Measured voltage at generator output	Measured voltage at EUT without EUT connected	Increase voltage from generator up to:	Measured voltage at EUT after increase without EUT connected
2.2.1.a	Basic/Enhanced	600V, 0.2s	600V	586V	625V	615V
2.2.1.b	Basic/Enhanced	600V, 0.2s	600V	574V	625V	600V
2.2.1.c	Basic/Enhanced	600V, 0.2s	600V	574V	625V	600V
2.2.2.a	Basic	600V, 1.0s	600V	586V	625V	615V
2.2.2.a	Enhanced	1.5kV, 0.2s	1500V	1500V	N/A	1500V
2.2.2.a	Enhanced	450V, 2s	452V	425V	473V	451V
2.2.2.b	Basic	600V, 1.0s	600V	574V	625V	600V
2.2.2.b	Enhanced	1.5kV, 0.2s	1500V	1500V	N/A	1500V
2.2.2.b	Enhanced	450V, 2s	452V	434V	473V	450V
2.2.2.c	Basic	600V, 1.0s	600V	574V	625V	600V
2.2.2.c	Enhanced	1.5kV, 0.2s	1500V	1500V	N/A	1500V
2.2.2.c	Enhanced	450V, 2s	452V	434V	473V	450V

7.7.3 K.21 5.1.x, 5.2.2, 7.1, 7.2 Lightning surge & Earth Potential Rise generator adjustment values

K.21 clause	Basic/ Enhanced	Required voltage level	Measured voltage at generator output	Measured voltage at EUT without EUT connected	Increase voltage from generator up to:	Measured voltage at EUT after increase without EUT connected
5.1.1.a	Basic	2.5kV	2.50kV	2.39kV	2.60kV	2.49kV
5.1.1.a	Enhanced	6kV	5.84kV	4.96kV	7.30kV	6.08kV
5.1.2.a	Basic	6kV	5.84kV	4.96kV	7.30kV	6.08kV
5.1.2.a	Enhanced	10kV	N/A	8.72kV	11.70kV	10.02kV
5.1.1.b/c	Basic	2.5kV	2.50kV	2.39kV	2.60kV	2.50kV
5.1.1.b/c	Enhanced	6kV	5.84kV	5.52kV	6.50kV	6.08kV
5.1.1.b/c	Basic	6kV	5.84kV	5.52kV	6.50kV	6.08kV
5.1.2.b/c	Enhanced	10kV	N/A	9.12kV	10.90kV	10kV
5.2.2.a/b	Basic	600V	600V	600V	N/A	600V
5.2.2.a/b	Enhanced	1500V	1500V	1.52kV	N/A	1500V
7.1-FXS	Basic	1000V	1000V	916V	1100V	1010V
7.1-FXS	Enhanced	1500V	1500V	1420V	1600V	1520V
7.1-ETH	Basic	1000V	1000V	1000V	N/A	1000V
7.1-ETH	Enhanced	1500V	1500V	1500V	N/A	1000V
7.2-USB	Basic	100V	100V	100V	N/A	100V
7.2-USB	Enhanced	150V	150V	150V	N/A	150V