ENERGY STAR® Program Requirements Product Specification for Large Network Equipment

Test Method Rev. Nov-2015

1 OVERVIEW

The following test method shall be used for determining product compliance with requirements in the ENERGY STAR Eligibility Criteria for Large Network Equipment (LNE).

2 APPLICABILITY

The following test method is applicable to all eligible products covered by the scope as defined in Section 2 of the ENERGY STAR Draft 2 Eligibility Criteria for Large Network Equipment, but test requirements are dependent upon the feature set of the product under evaluation. The following guidelines shall be used to determine the applicability of each section of this document:

- One or both procedures in Section 6 shall be conducted on eligible products that are fixed products.
- The procedures in Section 7 shall be conducted on eligible products that are modular products.

3 DEFINITIONS

Unless otherwise specified, all terms used in this document are consistent with the definitions in the ENERGY STAR Large Network Equipment Specification.

A) Abbreviations and Units:

1) ac: Alternating current
2) ATIS: Alliance for Telecommunications Industry Solutions
3) bps: Bits per second
4) C: Celsius
5) dc: Direct current
6) FCS: Frame check sequence
7) GBIC: Gigabit interface converter
8) Hz: Hertz
9) IEEE: Institute of Electrical and Electronics Engineers
10) IMIX: Internet mix
11) IP: Internet protocol
12) LNE: Large network equipment
13) MAC: Medium access control
14) MUT: Module under test
15) NDR: Non-drop rate

16) OSI: Open systems interconnection

17) PDU: Power distribution unit

18) PSU: Power supply unit

19) RMS: Root mean square

20) SFD: Start of frame delimiter

21) SFP: Small form-factor pluggable

22) UPS: Uninterruptible power supply

23) UUT: Unit under test

24) V: Volts

25) VLU: Very low utilization

26) W: Watt

B) Definitions:

1) High Speed Data Port: A physical network Ethernet port that has a highest operable line-rate of at least 10 Gbps gigabits per second (Gbps).

2) Internet Mix (IMIX) Traffic: A stateless traffic profile that contains a mixture of frame sizes statistically similar to a composition observed in the Internet[1].

3) Maximum Non-Drop Rate (NDR): The highest observed system throughput, measured in bits per second (bps), at which all data packets received by the unit under test (UUT) are processed and correctly transmitted.

4) System Throughput: The sum of the data link bits processed by the UUT per second in the egress direction, including frame preamble, Start Frame Delimiter (SFD), Frame Check Sequence (FCS), and minimum interpacket gap.

5) System Utilization: The system throughput expressed as a percentage of the system's measured NDR.

6) Traffic Profile: The statistical distribution of the size/type of the data sent through the UUT.

4 TEST SETUP

A) Input Power: Input power for alternating current (ac) LNE shall be as specified in Table 1 and Table 2. Input power for direct current (dc) LNE shall be as specified in Table 3. The input power frequency for ac LNE shall be as specified in Table 4.

[1] For further information regarding IMIX, refer to Spirent Communications – Test Methodology Journal: IMIX (Internet Mix) Journal, March 2006.

Table 1: Input Power Requirements for Ac-powered Products with Nameplate Rated Power Less Than 1500 Watts (W)

Product Type	Supply Voltage	Voltage Tolerance	Maximum Total Harmonic Distortion
Ac single-phase powered LNE	115 V ac 230 V ac	+/- 1.0%	2.0%, up to and including the 13th harmonic
Ac three-phase powered LNE	208 V ac 400 Vac		

Table 2: Input Power Requirements for Ac-powered Products with Nameplate Rated Power Greater Than or Equal to 1500 W

Product Type	Supply Voltage	Voltage Tolerance	Maximum Total Harmonic Distortion
Ac single-phase powered LNE	115 V ac 230 V ac	+/- 4.0%	5.0%, up to and including the 13th harmonic
Ac three-phase powered LNE	208 V ac 400 Vac		

Table 3: Input Power Requirements for Dc-powered Products

Product Type	Supply Voltage	Voltage Tolerance
Dc powered LNE rated for -48 V dc	-53 V dc	+/- 2.0 V

Table 4: Input Power Frequency Requirements for Ac-powered Products

Supply Voltage	Frequency	Frequency Tolerance
115 V ac	60 Hertz (Hz)	+/-1.0%
230 V ac	50 Hz or 60 Hz	
208 V ac, Three-phase	60 Hz	
400 V ac, Three-phase	50 Hz or 60 Hz	

B) Ambient Temperature: The ambient temperature in front of the main airflow inlet of the UUT during all power measurement tests shall be greater than 22.0°C and less than 28.0°C.

1) Temperature Measurement Location and Accuracy: Temperature must be measured no more than 2 meters in front of (upwind of) an airflow inlet of the UUT and reported by the sensor with an overall accuracy of ± 0.5 °C or better.

C) Relative Humidity: Relative humidity shall be within 15% and 80%.

D) Power Meter: Power meters shall possess the following attributes:

1) Reporting and Measurement Units:

a) If the UUT is a dc powered LNE, the power meter shall report power, voltage, and current.

b) If the UUT is an ac powered LNE, the power meter shall report true root mean square (RMS) power, voltage, current, and power factor.

2) Calibration: The meter shall have been calibrated within a year of the test date, by a standard traceable to National Institute of Standards and Technology [USA] or a counterpart national metrology institute in other countries.

3) Crest Factor (ac powered LNE only): An available current crest factor of 3 or more at its rated range value. For power meters that do not specify the current crest factor, the power meter must be capable of measuring an amperage spike of at least 3 times the maximum amperage measured during any 1 second sample.

4) Minimum Bandwidth of Input Circuitry: 80.0 kHz.

5) Minimum Digitizing Sample Rate: 40.0 kHz.

6) Minimum Resolution:

a) 0.01 W for measurement values less than 10 W;

b) 0.1 W for measurement values from 10 W to 100 W; and

c) 1.0 W for measurement values greater than 100 W.

7) Measurement Accuracy: Power measurements shall be reported by the power meter with an overall accuracy of 1% or better for all measured power values.

E) Network Test Equipment (Test Equipment): The Test Equipment used for Section 6 and Section 7 must comply with the following requirements:

1) Number of Ports: The Test Equipment shall have at least one port for each port required to be connected to a port on the UUT, as stated in Sections 5.1.B) and 5.1.C). Each connected port on the Test Equipment shall be capable of sending and receiving data to and from the UUT at the highest operable line-rate standard corresponding to the connected port on the UUT.

2) Traffic Generation: The Test Equipment must be capable of generating traffic that complies with the requirements in Section 5.1.A)9).

5 TEST CONDUCT

5.1 UUT and Test Equipment Configuration for Variable Load Testing

All testing performed in Section 6 and Section 7 shall adhere to the requirements provided in the Alliance for Telecommunications Industry Solutions (ATIS)-0600015.03.2013 standard unless otherwise specified in this document. All testing performed in Section 6 and Section 7 shall be conducted as follows:

A) Configuration Requirements for All Products:

1) As-shipped Condition: Products shall be tested in their "as-shipped" configuration, which includes both hardware configuration and system settings, unless otherwise specified in this test method.

a) LNE Requiring Initial Configuration: If the UUT cannot be tested in its "as-shipped" condition without additional initial configuration, then the UUT shall be configured according to the instructions provided in the UUT's user manual. Any supporting materials (e.g., configuration files) that are included with the UUT or publicly available may be used if required for correct UUT functionality.

b) Mid-test UUT Reconfiguration: The UUT shall be configured prior to running the test procedures in Section 6 or Section 7. No reconfiguration of the UUT shall occur following the commencement of the procedures in Section 6 or Section 7, unless otherwise specified in this test method.

2) Measurement Location: All power measurements shall be taken at a point between the ac or dc power source and the UUT. No uninterruptible power supply (UPS) units may be connected between the power meter and the UUT.

3) Air Flow Management: Any airflow directly surrounding the UUT during testing shall only be generated by fans or cooling devices that are standard components of the UUT.

4) Power Supply Units (PSUs): All installed PSUs included with the UUT must be operational and connected to an appropriate power source, unless otherwise specified in this test method.

a) UUTs with Multiple PSUs: If the UUT has more than one PSU, then any method may be used to aggregate the power so long as the method used does not introduce a measurement error greater than 1% of the total measured power.

5) System Management Ports: Any port on the UUT that does not pass traffic, and is solely intended for device management may be connected as instructed by the manufacturer during testing. If no manufacturer instruction is provided, system management ports shall be disconnected during testing.

6) Non-Ethernet Ports: Non-Ethernet data ports shall be connected, not necessarily to the Test Equipment that generates test traffic, and are not required to pass test traffic. Any traffic passed by non-Ethernet ports shall not be included in throughput measurements.

7) I/O and Network Connection: UUT Ethernet ports shall be connected as indicated in Sections 5.1.B) and 5.1.C). All Ethernet ports connected to the Test Equipment shall be ready to pass test traffic for the entirety of the testing performed in Section 6 and Section 7.

8) Energy Efficient Ethernet (EEE): If the UUT has ports that provide EEE[2], the UUT shall be connected to network ports that also support EEE. This can be done either by having the traffic source provide the EEE ports, or placing an intermediate network device between the traffic source and UUT.

9) Traffic Generation: The traffic generated by the Test Equipment for Section 6 and Section 7 must comply with the following requirements:

   a) Packet Format: The traffic shall be formatted as Internet Protocol (IP) version 4 (IPv4[3]) with randomized IPv4 data field values. The IPv4 packets shall be transported using Ethernet[4].

   b) Generated Packet Size Statistical Distribution: The traffic shall consist of packet sizes whose generation frequency is statistically described by the Simple IMIX distribution, defined in Table 5.

   c) Idle-link Period Distribution: All traffic shall be generated so that the same interpacket gap separates each transmitted Ethernet packet. In other words, there should be a fixed spacing in time between Ethernet frames. However, frames shall not be sent to all ports simultaneously (i.e. the fixed spacing in time should not occur simultaneously on all ports).

Table 5: Simple IMIX Packet Distribution[5]

IP Packet Size (Bytes)	Ethernet Frame Size[6] (Bytes)	Proportion of Total Generated IP Packets	Proportion of Total Generated Ethernet Packet Throughput[7]
40	64	7 parts (~58.33%)	~12.83%
576	594	4 parts (~33.33%)	~53.60%
1500	1518	1 part (~8.33%)	~33.57%

[2] As defined in Clause 78 of IEEE 802.3 (originally specified in IEEE 802.3az).
[3] "Internet Protocol". Sep 1981. RFC 791.
[4] As defined in IEEE 802.3.
[5] "Table D.1: Simple IMIX", Annex D: IMIX Traffic, ATIS – 0600015.03.2013
[6] Ethernet frame sizes do not include preamble, start of frame delimiter (SFD), or minimum interpacket gap.
[7] Throughput is based on the listed Ethernet frame size plus 7-byte preamble, 1-byte SFD, and 12-byte minimum interpacket gap per transmitted packet.

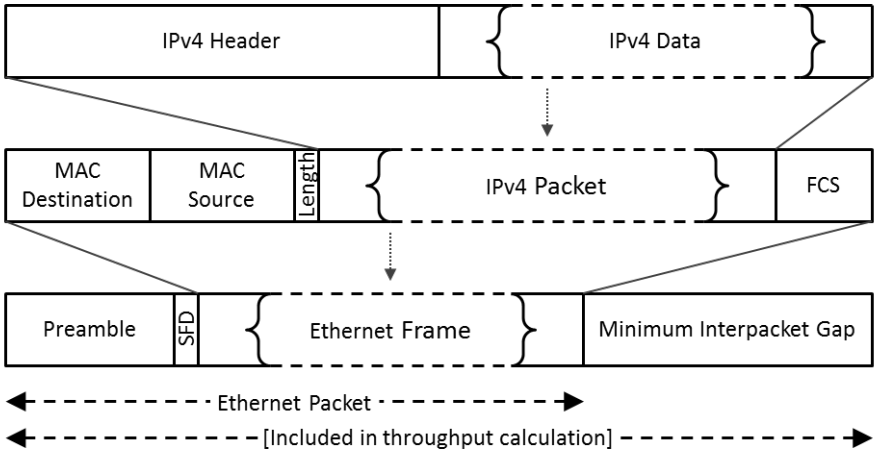

Figure 1: Relationship of Different Components of Test Data[8]

10) Cabling Requirements: Each copper-based cable used during testing shall be no longer than 5 meters in length.

11) Snaked Data Traffic Configuration Requirements: When applicable, the snaked data traffic shall be configured according to the following requirements:

a) For each group of data ports to be included in the snaked data traffic configuration that have the same maximum rated throughput rate (line speed) and same expected maximum throughput rate, there shall be a single snaked data traffic stream. For example, if the UUT has 10GbE ports and 1GbE ports, then two separate snaked data traffic streams shall be used.

b) Each snaked data traffic stream shall initiate at a Test Equipment data port, flowing to and then between UUT data ports using a combination of external physical connections (e.g., cabling) and internal virtual connections (e.g., VLAN), terminating at a Test Equipment data port. The traffic stream shall only flow between ports of the same expected maximum rated data throughput rate.

a) If the UUT is a modular product then as much as is possible for the modular system's configuration, all internal virtual connections must be made between data ports on different interchangeable modules. If the data port count or configuration makes this impossible, an appropriate alternate configuration may be used, but must be documented.

B) Fixed Products: If the UUT is a fixed product, the following requirements shall be followed as applicable:

1) Network Topology Requirements: UUT ports shall be connected to the Test Equipment using one of the following network topologies:

a) Full-mesh Topology: The full mesh topology shall be used if there are no clear designations between downlink and uplink ports listed on the UUT or if downlink and uplink ports are not indicated in materials, such as instruction manuals, provided by the manufacturer. In this configuration, traffic from each data port is permitted to flow to any other data port on the UUT.

[8] The diagram is included as an example to clarify certain terms, and is not drawn to scale. Certain optional elements not included in the diagram, such as VLAN tagging, may be used when appropriate.

b) Dual-group Partial Mesh Topology: The dual-group partial mesh topology shall be used if there are clear designations between downlink and uplink ports listed on the UUT, or if downlink and uplink ports are indicated in materials, such as instruction manuals, provided by the manufacturer. In this configuration, traffic must always flow from an uplink port to a downlink port or vice versa.

2) Products with 48 or Fewer High-speed Ports: If the UUT has 48 or fewer high-speed ports, the following requirements shall be followed as applicable:

a) Full-port Test: Section 6.1 shall be performed with all traffic-capable UUT ports connected to the Test Equipment.

b) Half-port Test in Full-mesh Configuration: If the UUT is tested in the Full-mesh configuration according to Section 5.1.B)1)a), then Section 6.2 shall be performed with half of the traffic-capable UUT ports connected to the Test Equipment. Round up to the nearest integer value if there are an odd number of ports. The ports to be connected shall be chosen at random.

c) Half-port Test in Dual-group Partial Mesh Configuration: If the UUT is tested in the Dual-group Partial Mesh configuration according to Section 5.1.B)1)b), then Section 6.2 shall be performed with half of the UUT downlink ports connected to the Test Equipment. Round up to the nearest integer value if there are an odd number of ports. The ports to be connected shall be chosen at random. All of the UUT uplink ports shall be connected during testing.

3) Products with more than 48 High-speed Ports: If a UUT has more than 48 high-speed ports, the following requirements shall be followed as applicable:

a) Full-port Test in Full-Mesh Configuration: If the UUT is tested in the Full-mesh configuration according to Section 5.1.B)1)a), then Section 6.1 shall be performed with 48 of the high-speed UUT ports connected to the Test Equipment. The ports to be connected shall be chosen at random. The remaining high-speed ports shall be configured in a snaked data traffic configuration in accordance with the requirements of Section 5.1.A)11).

b) Full-port Test in Dual-group Partial Mesh Configuration: If the UUT is tested in the Dual-group Partial Mesh configuration according to Section 5.1.B)1)b), then Section 6.1 shall be performed with 48 of the high-speed UUT ports connected to the Test Equipment. All uplink ports shall be connected to the Test Equipment, and the number of downlink ports connected to the Test Equipment shall be such that the total number of ports connected to the Test Equipment is 48. The downlink ports to be connected shall be chosen at random. The remaining downlink ports shall be connected, not necessarily to the Test Equipment that generates test traffic, and are not required to pass test traffic. Any traffic passed by these ports shall not be included in throughput measurements.

c) Half-port Test in Full-mesh Configuration: If the UUT is tested in the Full-mesh configuration according to Section 5.1.B)1)a), then Section 6.2 shall be performed with half of the traffic-capable UUT ports connected to the Test Equipment, up to 48 high-speed ports. Round up to the nearest integer value if there are an odd number of ports. The ports to be connected shall be chosen at random. If the UUT has more than 96 high-speed ports, then the remaining high-speed ports required to get the connected port count up to half of the total port count shall be achieved by configuring other high-speed ports in a snaked data traffic configuration in accordance with the requirements of Section 5.1.A)11). In this way, the total number of ports connected to the Test Equipment and connected in the snaked data traffic configuration shall be equal to half of the total number of ports.

d) Half-port Test in Dual-group Partial Mesh Configuration: If the UUT is tested in the Dual-group Partial Mesh configuration according to Section 5.1.B)1)b), then Section 6.2 shall be performed with all uplink ports and half of the downlink ports connected to the Test

Equipment. Round up to the nearest integer value if there are an odd number of ports. The ports to be connected shall be chosen at random. If the number of high-speed ports (all uplink plus half of the downlink) exceeds 48, the number of downlink ports connected to the Test Equipment shall be reduced so that the total number of high-speed ports connected to the Test Equipment is 48. If the number of downlink ports connected to the Test Equipment is less than half of the total number of downlink ports, then the remaining high-speed ports required to get the connected downlink port count up to half of the total downlink port count shall be achieved by shall connecting downlink ports, not necessarily to the Test Equipment that generates test traffic, but these ports are not required to pass test traffic. Any traffic passed by these ports shall not be included in throughput measurements.

C) Modular Products: If the UUT is a modular product, the following requirements shall be followed as applicable:

1) Interchangeable Modules Installed in Modular Products: If the UUT is a modular product, then for each distinct type of interchangeable module installed in the UUT that can change the port configuration, there must be a total of at least two (2) identical such modules installed. For example, there cannot be just one of a certain type of line card installed; there must be at least two of each type installed.

2) Modular Power Measurement Test: Section 7.1 shall be performed with two UUT ports connected to corresponding ports on the Test Equipment for each distinct stream of snaked data traffic. The ports shall be connected according to Section 5.1.A)11).

3) Modular Throughput Measurement Test for Modules with 24 or Fewer High-speed Ports: If a module has 24 or fewer high-speed ports, Section 7.2 shall be performed with all of the high-speed ports on each of the two MUTs connected to the Test Equipment.

4) Modular Throughput Measurement Test for Modules with more than 24 High-speed Ports: If a module has more than 24 high-speed ports, Section 7.2 shall be performed with 24 of the high-speed ports on each of the two MUTs connected to the Test Equipment. The 24 ports on each MUT shall be chosen at random. The remaining high-speed ports on the MUTs shall be included with the other UUT ports that are not connected to the Test Equipment when configuring the snaked data traffic streams in accordance with Section 5.1.A)11).

5.2 UUT and Test Equipment Preparation

A) Variable Load Test Preparation: Prior to performing testing outlined in Section 6 or Section 7, prepare the UUT according to the following steps:

2) Record the UUT manufacturer, model name, and configuration details including, but not limited to, number of ports, port throughput, additional built in interface ports, and number of fans.

3) If the UUT is a rack device, install it in a test rack. If the UUT is not a rack device, place it in a stable location where it will not be disturbed. Once set up, the UUT shall not be physically moved until testing is complete.

4) Configure the Test equipment for the correct traffic format and distribution as described in 5.1A)9).

5) Connect UUT ports to the Test equipment in the appropriate network topology according to Section 5.1.B) or 5.1.C), as applicable.

6) Connect the UUT to an appropriate ac or dc voltage source using the following guidelines:

a) No devices shall be connected between the power meter(s) and the UUT, except for PDUs as described in Section 5.1.A)4)a), if applicable;

b) The power meter shall remain connected until all testing is complete;

c) Power values shall be recorded from the power meter in compliance with Section 4.E).

7) If applicable, prepare the UUT according to the requirements provided in Section 5.1.A)1)a).

8) If the input voltage is ac, then record the input RMS voltage and input frequency. If the input voltage is dc, then record the reported input voltage.

B) Modular Power Measurement Test Preparation: Prior to performing testing outlined in Section 7.1, connect all UUT Ethernet ports in a snaked data traffic configuration according to the requirements in Section 5.1.A)11).

C) Modular Throughput Measurement Test Preparation: The Modular Throughput Measurement Test is performed once for each distinct type of interchangeable module installed that can change the port configuration. Prior to performing each required iteration of testing outlined in Section 7.2, prepare the UUT according to the following steps:

1) Choose two (2) of the installed interchangeable modules, each of which is identical and of the desired type to be tested in the given test iteration. These chosen interchangeable modules are referred to as the MUTs for the duration of the given test iteration.

2) Connect each data port on the MUTs according to the requirements in Sections 5.1.C)3) or 5.1.C)4), as applicable. Traffic from each data port connected to the Test Equipment shall be permitted to flow to any other data port on the MUTs. This part of the UUT configuration represents an "isolated full mesh" topology.

3) Connect all remaining data ports of the UUT (i.e., those not connected to the Test Equipment) in a snaked data traffic configuration according to the requirements in Section 5.1.A)11).

6 TEST PROCEDURE FOR ALL PRODUCTS EXCEPT MODULAR PRODUCTS

6.1 Full-port Variable Load Energy Efficiency Test

A) Power on the UUT, either by switching it on or connecting it to mains power.

B) Let the UUT stabilize for 15 minutes.

C) Determine the maximum load (L_{max}) that can be sustained at NDR. Any method may be used to obtain this value, but the method used shall be reported. There is no time limit for this run. The run is complete after L_{max} is determined. Record L_{max}.

D) The following tests shall be completed in the order specified and shall have no greater than 300 seconds idle time between them.

1) Full Load:

a) Apply $L_{max,}$ obtained in Section 6.1.C) to the UUT for 15 minutes.

b) Record power values for the entire 15-minute test period.

c) Calculate and report the average power value (P_{100}).

2) Thirty Percent Load:

a) Calculate and report the Thirty Percent Load throughput (L_{30}), by multiplying L_{max} by 0.30 ($L_{30} = 0.30 * L_{max}$)

b) Run the test for 15 minutes, applying a traffic load of L_{30}.

c) Record power values for the entire 15 minute period.

d) Calculate and report the average value (P_{30}).

3) Very Low Utilization (VLU):

a) Calculate and report the VLU throughput (L_{VLU}), by multiplying L_{max} by 10^{-4} ($L_{VLU} = 10^{-4} * L_{max}$)

b) Run the test for 15 minutes, applying a traffic load of L_{VLU}.

c) Record power values for the entire 15 minute period.

d) Calculate and report the average value (P_{VLU}).

E) If packet loss occurs during any of the tests specified in Section 6.1.D), the UUT must be retested beginning with Section 6.1.C).

6.2 Half-port Variable Load Energy Efficiency Test

A) Power on the UUT, either by switching it on or connecting it to mains power.

B) Let the UUT stabilize for 15 minutes.

C) Determine the maximum load (L_{max}) that can be sustained at NDR. Any method may be used to obtain this value, but the method used shall be reported. There is no time limit for this run. The run is complete after L_{max} is determined. Record L_{max}.

D) The following tests shall be completed in the order specified and shall have no greater than 300 seconds idle time between them.

1) Full Load:

a) Apply $L_{max,}$ obtained in Section 6.2.C) to the UUT for 15 minutes.

b) Record power values for the entire 15 minute test period.

c) Calculate and report the average power value (P_{100}).

2) Ten Percent Load:

a) Calculate and report the Ten Percent Load throughput (L_{10}), by multiplying L_{max} by 0.10 ($L_{10} = 0.10 * L_{max}$)

b) Run the test for 15 minutes, applying a traffic load of L_{10}.

c) Record power values for the entire 15 minute period.

d) Calculate and report the average value (P_{10}).

3) Very Low Utilization (VLU):

a) Calculate and report the VLU throughput (L_{VLU}), by multiplying L_{max} by 10^{-4} ($L_{VLU} = 10^{-4} * L_{max}$)

b) Run the test for 15 minutes, applying a traffic load of L_{VLU}.

c) Record power values for the entire 15 minute period.

d) Calculate and report the average value (P_{VLU}).

E) If packet loss occurs during any of the tests specified in Section 6.2.D), the UUT must be retested beginning with Section 6.2.C)

7 TEST PROCEDURE FOR MODULAR PRODUCTS

If the UUT is a Modular product, then the procedures in this section shall be performed as follows:

A) Perform the Modular Power Measurement Test in Section 7.1 once; and
B) Perform the Modular Throughput Measurement Test in Section 7.2 once for each distinct type of interchangeable module installed that can change the port configuration.

7.1 Modular Power Measurement Test

A) Power on the UUT, either by switching it on or connecting it to mains power.

B) Let the UUT stabilize for 15 minutes.

C) Determine the maximum load (L_{max}) that can be sustained simultaneously at NDR for the MUTs and each snaked data traffic stream. Any method may be used to obtain these values, but the method used shall be reported. There is no time limit for this run. The run is complete after L_{max} is determined for the MUTs and each snaked data traffic stream. Record each of these L_{max} values.

D) The following tests shall be completed in the order specified and shall have no greater than 300 seconds idle time between them.

1) Full Load:

a) Apply L_{max} values, obtained in Section 7.1.C), to the MUTs and to each snaked data traffic stream, respectively, for 15 minutes.

b) Record the total UUT power usage for the entire 15-minute test period.

c) Record the average power value (P_{100}).

2) Thirty Percent Load:

a) Calculate and report the Thirty Percent Load throughputs (L_{30}), by multiplying L_{max} values by 0.30 ($L_{30} = 0.30 * L_{max}$)

b) Run the test for 15 minutes, applying a traffic load of L_{30}.

c) Record the total UUT power usage for the entire 15-minute test period.

d) Calculate and report the average value (P_{30}).

3) Very Low Utilization (VLU):

a) Calculate and report the VLU throughputs (L_{VLU}), by multiplying L_{max} values by 10^{-4} ($L_{VLU} = 10^{-4} * L_{max}$)

b) Run the test for 15 minutes, applying a traffic load of L_{VLU}.

c) Record total UUT power usage for the entire 15-minute period.

d) Calculate and report the average value (P_{VLU}).

E) If packet loss occurs during any of the tests specified in Section 7.1.D), the UUT must be retested beginning with Section 7.1.C).

7.2 Modular Throughput Measurement Test

A) Power on the UUT, either by switching it on or connecting it to mains power.

B) Let the UUT stabilize for 15 minutes.

C) Determine the maximum load (L_{max}) that can be sustained at NDR for the MUTs and each snaked data traffic stream. Any method may be used to obtain these values, but the method used shall be reported. There is no time limit for this run. The run is complete after L_{max} is determined for the MUTs and each snaked data traffic stream. Record the combined L_{max} for the MUTs.

D) For each distinct type of interchangeable module installed in the UUT, reconfigure the UUT according to Section 5.2.C) and repeat step 7.2.C) until the maximum load of each distinct type of installed interchangeable module has been measured.

E) Calculate and report the aggregate system maximum throughput (L_{tot}) using the following equation:

$$L_{tot} = \sum_{k=1}^{N_{tot}} N_k \cdot \frac{L_{max\_k}}{2}$$

Where:

L_{tot} is the UUT aggregate system maximum throughput

N_{tot} is the total number of distinct types of interchangeable modules installed in the UUT

N_k is the total number of interchangeable modules installed in the UUT of type, "*k*"

L_{max_k} is the maximum load for the two interchangeable modules of type, "*k*", measured in Section 7.2.

8 REFERENCES

A) Alliance for Telecommunications Industry Solutions (ATIS) – 0600015.03.2013 Energy Efficiency for Telecommunication Equipment: Methodology for Measurement and Reporting for Router and Ethernet Switch Products

B) Spirent Communications – Test Methodology Journal: IMIX (Internet Mix) Journal, March 2006.

C) IEEE 802.3-2012: IEEE Standard for Ethernet.