ENERGY STAR® Program Requirements Product Specification for Large Network Equipment

Draft 1 Test Method Rev. June-2013

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 products under the ENERGY STAR Framework Document for Large Network Equipment.

Note: U.S. Environmental Protection Agency (EPA) and U.S. Department of Energy (DOE) intend to harmonize the content of any documents related to the LNE Test Method and Specification. Therefore, the Applicability (Scope) of the LNE ENERGY STAR program will remain consistent throughout the test method and specification development process.

3 DEFINITIONS

Unless otherwise specified, all terms used in this document are consistent with the definitions in the ENERGY STAR Large Network Equipment Framework 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) NDR: Non-drop rate
14) OSI: Open systems interconnection
15) PDU: Power distribution unit
16) PoE: Power over Ethernet

17) PSU: Power supply unit

18) RMS: Root mean square

19) SFD: Start frame delimiter

20) SFP: Small form-factor pluggable

21) UPS: Uninterruptible power supply

22) UUT: Unit under test

23) V: Volts

24) VLU: Very low utilization

25) W: Watt

B) Definitions:

1) 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].

2) 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.

3) Payload: The portion of an Ethernet frame, with a size between 46 and 1500 bytes, which holds data from higher open systems interconnection (OSI) layers (e.g., Internet Protocol (IP)).

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 interframe 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 packet load sent through the UUT.

4 TEST SETUP

Note: Based on stakeholder feedback, many of the requirements in the Test Setup section have been harmonized with the most recent release of the Alliance for Telecommunications Industry Solutions (ATIS)-0600015.2009 document, "Energy Efficiency for Telecommunication Equipment: Methodology for Measurement and Reporting – General Requirements". Other requirements in this section have been updated based on the corresponding section of the recently published ENERGY STAR Computer Servers Test Method (Rev. Apr-2013) Version 2.0.

A) Input Power: Input power shall be as specified in Table 1 and Table 2. The frequency for input power shall be as specified in Table 3.

[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 Products with Nameplate Rated Power Less Than or Equal to 1500 Watts (W)

Product Type	Supply Voltage	Voltage Tolerance	Maximum Total Harmonic Distortion
Ac single-phase powered LNE	230 V ac 115 V ac	+/- 1.0 %	2.0%, up to and including the 13th harmonic
Ac three-phase powered LNE	208 V ac 400 Vac		
Dc powered LNE rated for -48 V dc	-53 V dc	+/- 1.0 V	n/a

Table 2: Input Power Requirements for 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	230 V ac 115 V ac	+/- 4.0 %	5.0%, up to and including the 13th harmonic
Ac three-phase powered LNE	208 V ac 400 Vac		
Dc powered LNE rated for -48 V dc	-53 V dc	+/- 2.0 V	n/a

Note: Table 1 and Table 2 list commonly supported voltages by LNE products. However, there are other voltages that are not included in the tables which may soon be commonly supported by many LNE products (e.g., 380 V dc). DOE requests stakeholder feedback on whether there are voltages missing from Table 1 and Table 2 which are commonly supported by LNE products, and whether any products exist which would be incapable of being tested according to the current voltage requirements.

Table 3: Input Power Frequency Requirements

Supply Voltage	Frequency	Frequency Tolerance
115 V ac	60 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: Ambient temperature shall be within 25°C +/- 5°C.

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 following requirements for the Test Equipment shall be used for Section 6.1 which is capable of the following:

1) Number of Ports: For each data port present on the UUT, there shall be at least one corresponding data port on the Test Equipment capable of sending and receiving data to and from the UUT at the highest operable line-rate standard.

2) Data Format: The Test Equipment shall be capable of generating test data which is correctly formatted for processing by the UUT. The values of generated test data shall be randomized.

3) Generated Packet Size Statistical Distribution: The Test Equipment shall be capable of generating test data consisting of packet sizes whose generation frequency is statistically described by the Simple IMIX distribution, defined in Table 4.

4) Idle-link Period Distribution: TBD

Note: There are several ways to generate the same number of Ethernet frames that satisfy a certain "per-second" throughput requirement. For example, given a measured Max Non-Drop Rate (NDR) for a certain link, there are multiple ways to reduce the generated throughput down to 10% utilization. Two examples are: (1) Generate a constant stream of traffic at the desired rate by increasing the idle time between each transmitted frame; and (2) Generate a burst of traffic at Max NDR for 100 milliseconds (ms), followed by 900ms of idle time. The first example presents lower latency, while the second example has an idle-link period which is significantly longer than the first. It is possible that with EEE, the amount of time the links are idle can affect the power consumption at low utilization. DOE requests feedback on the impact that the length of this idle-link period between each frame may have on the energy use of the UUT. DOE also requests any information on typical traffic patterns to help develop these requirements.

Table 4: Simple IMIX Packet Distribution[2]

Packet Size (Bytes)	Proportion of Total Generated Packets	Proportion of Total Generated Bandwidth
40	7 parts (~58.3%)	6.856%
576	4 parts (~33.3%)	56.415%
1500	1 part (~8.33%)	36.729%

Note: The Preliminary Approach For Determining Energy Efficiency (Rev. Oct-2012) (Preliminary Approach Test Method) included the use of Accurate IMIX packet distribution, which has a higher correlation with measured internet traffic than Simple IMIX. Stakeholders suggested using Simple IMIX, which provides efficiency measurements similar to Accurate IMIX and is less burdensome to test. For this reason, DOE has updated the Draft 1 Test Method to use Simple IMIX as indicated in Table 4.

IMIX is based on internet traffic measured in 2001. However, other research[3] and measurements[4] have indicated that the internet's packet distribution has changed over the past 12 years. Two notable changes are: (1) A significant decrease in the occurrence of 576 byte packets; and (2) An increase in the occurrence of packet sizes around 1300 bytes.

DOE is requesting feedback on using a different packet distribution than IMIX with regards to burden and representativeness.

F) Power over Ethernet (PoE) Load: A PoE Load shall be used for PoE Load Testing, required in Section 6.2, which conforms to the following:

[2] "Table D.1: Simple IMIX", Annex D: IMIX Traffic, ATIS – 0600015.03.2013
[3] Sinha, R., Papadopoulos, C., & Heidemann, J. (2005, October 5). *Internet Packet Size Distributions: Some Observations*. Retrieved from University of Southern California: http://www.isi.edu/~johnh/PAPERS/Sinha07a.pdf
[4] "Amsterdam Internet Exchange: Frame size distribution". https://www.ams-ix.net/technical/statistics/sflow-stats/frame-size-distribution. Accessed: 04/25/2013.

1) Number of Ports: The PoE Load shall have a number of ports, each of which meet the requirements provided in Section 4.F)2), that is greater than or equal to the number of ports on the UUT that are capable of supplying PoE.

2) PoE Standards Compliance: Each port on the PoE Load shall be capable of supporting the same PoE-related Institute of Electrical and Electronics Engineers (IEEE) 802.3 standard (e.g., 802.3at[5] or 802.3af[6]) as a corresponding port on the UUT.

Note: DOE is including PoE Load testing for any product which follows the IEEE 802.3af or IEEE 802.3at standards. DOE is requesting feedback on this PoE test setup, as well as the proposed PoE Load Test.

5 TEST CONDUCT

5.1 UUT Configuration

A) Variable Load Testing: Power consumed by the UUT shall be measured while processing different data traffic levels. All testing during the Variable Load Test shall adhere to the requirements provided in the Alliance for Telecommunications Industry Solutions (ATIS)-0600015.03.2013 standard unless otherwise specified in this document. Variable Load Testing shall be conducted as follows:

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, the manufacturer shall provide detailed setup instructions and/or supporting materials (e.g., configuration files) which allow the UUT to function properly during testing.

Note: DOE recognizes that many LNE require configuration prior to first use. Therefore, DOE requests information on the initial configuration setup required for different types of LNE products. Specifically, DOE requests information to determine if most LNE can be configured based solely on detailed instructions and/or supporting materials such as configuration files.

The Preliminary Approach Test Method required all power management and/or power-saving features to be disabled during testing. However, stakeholders commented that these features should be "as shipped", since it better reflects the typical configuration that is intended for the customer. DOE agrees with the comment and has decided to allow all products to be tested "as-shipped", unless a product requires initial configuration as described in 5.1.A)1)a).

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 air flow directly surrounding the UUT during testing shall only be generated by fans or cooling devices that are standard components of the UUT. The use of

[5] IEEE 802.3at-2009: IEEE Standard for Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks - Specific requirements Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications - Amendment 3: Data Terminal Equipment (DTE) Power via the Media Dependent Interface (MDI) Enhancements

[6] IEEE 802.3af-2003: IEEE Standard for Information Technology - Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements - Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications - Data Terminal Equipment (DTE) Power Via Media Dependent Interface (MDI)

external fans or cooling devices in a manner which is inconsistent with normal data center practices is prohibited.

4) Power Supplies: All power supply units (PSUs) must be connected and operational.

a) UUTs with Multiple PSUs: All power supplies must be connected to the ac or dc power source and operational during the test. If necessary, a Power Distribution Unit (PDU) may be used to connect multiple power supplies to a single source. If a PDU is used, any overhead electrical use from the PDU shall be included in the power measurement of the UUT.

5) I/O and Network Connection: UUT ports shall be connected as indicated in Section 5.2.A)4). All UUT ports connected to the Test Equipment shall be ready to pass traffic for the entirety of each test run.

a) Number of Ports Connected: The number of ports required to be connected to the Test Equipment are as follows:

i. Full-Port Testing: The testing outlined in Section 6.1.C) shall be performed with all traffic-capable UUT ports connected to the Test Equipment.

ii. Half-Port Testing: The testing outlined in Section 6.1.D) shall be performed with half of the traffic-capable UUT ports connected to the Test Equipment. If the UUT has two separate groups of traffic-capable ports (i.e., uplink and downlink), then half of each group of ports shall be 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.

Note: DOE believes that connecting half of the data ports during testing represents a more realistic scenario for many LNE products. For example, a switch deployed in an office environment may have cabling connecting all of its downlink ports to wall-ports throughout the building, but there may not be an active device connected to all of the wall ports simultaneously (e.g. open ports in conference rooms for other users). Rather than defining which products are to be tested as full-port or half-port, the test method currently requires that all products be tested in both configurations in order to obtain more information on how the number of ports connected affects power usage. DOE estimates that adding a half-port Variable Load test will increase the overall test time by approximately one hour, and believes that the increased burden is relatively small when compared to other aspects of testing (product cost, Test Equipment cost).

b) System Management Ports: Any port on the UUT which 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.

c) Energy Efficient Ethernet (EEE): If the UUT has ports which are compliant with the IEEE 802.3az[7] standard, which provides EEE functionality, 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.

Note: DOE proposes a provision for testing with EEE since it provides the potential to reduce power consumption.

d) Workload Generation: Test equipment conforming to the requirements listed in Section 4.E) shall be used to generate traffic and collect the performance-related results according to the

[7] 802.3az-2010: IEEE Standard for Information technology-- Local and metropolitan area networks-- Specific requirements-- Part 3: CSMA/CD Access Method and Physical Layer Specifications Amendment 5: Media Access Control Parameters, Physical Layers, and Management Parameters for Energy-Efficient Ethernet

test conditions. Configure the test equipment for the correct traffic profile based on the data in Table 4.

Note: DOE has added requirements for traffic formatting during testing, which are consistent with the ATIS procedure. DOE is requesting feedback on whether there are LNE which are incompatible with the required protocols and would therefore be unable to perform the current test.

e) Physical Interface Requirements: Each data port's physical interface shall comply with the following:

i. If the data port requires a pluggable module (e.g., Small form-factor pluggable transceiver [SFP], gigabit interface converter [GBIC], XENPAK, etc.), any compatible pluggable module may be used if it is included with the UUT. If no compatible pluggable module is included as a standard component with the UUT, then the highest throughput copper-based pluggable module supported by the UUT shall be used.

ii. If the data port is capable of functioning with either a pluggable module or a non-pluggable interface, the pluggable module shall be used if it is included with the UUT in accordance with 5.1.A)5)e)i. Otherwise the non-pluggable interface shall be used.

Note: DOE is requesting stakeholder feedback on the proposed Physical Interface Requirements, as well as the method for determining which pluggable module to use during testing.

f) Cabling Requirements: Each cable shall be no longer than 5 meters in length.

B) PoE Load Test Configuration: Power consumed by the UUT shall be measured for different levels of supplied PoE. PoE Load Testing shall be conducted as follows:

1) The requirements stated in Section 5.1.A)1), 5.1.A)2), 5.1.A)3), and 5.1.A)4) shall be followed during PoE Load Testing.

2) Maximum Supported PoE Load: The UUT's maximum PoE supplying capability shall be specified by the manufacturer and/or the appropriate IEEE 802.3 standard (IEEE 802.3at or IEEE 802.3af, based on the UUT's functionality).

3) Maximum PoE Load Supplied Per Port (Max PoE per Port): The Max PoE per Port shall be defined as the Maximum Supported PoE Load divided evenly by the number of UUT ports which are capable of supplying PoE.

4) Cabling Requirements: The cable used for PoE Load Testing shall comply with the appropriate IEEE 802.3 standard (IEEE 802.3at or IEEE 802.3af, based on the UUT's functionality), and shall not exceed 5 meters in length.

5) Data Traffic: No data traffic shall be sent to the UUT during the PoE Load Test.

5.2 UUT Preparation

A) Variable Load Test Preparation: Prior to performing the Variable Load Test outlined in Section 6.1, prepare the UUT according to the following steps:

1) 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.

2) 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.

3) Configure the Test equipment for the correct traffic workload and profile as described in Table 4.

4) Connect UUT ports to the Test equipment in the appropriate topology according to the following:

a) Full mesh topology shall be used when each of the UUT's ports are designed to perform equal roles and are capable of handling the same traffic bandwidth. During testing, traffic is permitted between all ports on the UUT.

b) Dual-group partial mesh topology shall be used when the UUT's ports can be functionally partitioned into two groups, with all ports in either group capable of performing equal roles and handling the same traffic bandwidth. During testing, traffic is not permitted between any ports on the UUT which are in the same functionally partitioned group.

5) 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 and the UUT, except for PDUs as described in section 5.1.A)4)a);

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

c) Power values shall be recorded from the power meter according to Section 4.D).

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

7) Record the input RMS voltage and input frequency.

B) PoE Load Test Preparation: Prior to performing the PoE Load Test outlined in 6.2, prepare the UUT according to the following steps:

1) Record the Maximum Supported PoE Load and the Max PoE per Port, as determined in 5.1.B)2) and 5.1.B)3) respectively.

2) Ensure that the UUT conforms to the requirements provided in Section 5.2.A)2), 5.2.A)5), and 5.2.A)6).

3) Configure the PoE Test Load so that each port will draw 90% of the Max PoE per Port, as determined in Section 5.1.B)3).

Note: Due to losses in the cable, PoE loads draw less than the maximum the port supplies. In order to prevent the UUT from supplying PoE power beyond the maximum capability, DOE is requiring that the PoE Test Load be configured to 90% of the UUT's Max PoE per Port. DOE requests feedback on all aspects of the PoE load test.

4) Connect each of the UUT ports capable of supplying PoE to a PoE Test Load port using a cable that complies with Section 5.1.B)4).

6 TEST PROCEDURES FOR ALL PRODUCTS

6.1 Variable Load Energy Efficiency Testing

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) Full-Port Testing: The following steps shall be performed for Full-Port Testing. Record all measured values in the Full-Port Variable Load Test section of the test reporting template.

1) Qualification: Determine the maximum load (L_{max}) that can be sustained at Non-Drop Rate (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}.

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

a) Full Load:

i. Apply L_{max}, obtained in Section 6.11) to the UUT for 15 minutes.

ii. Record power values for the entire 15 minute test period.

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

b) Thirty Percent Load:

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

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

iii. Record power values for the entire 15 minute period.

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

c) Ten Percent Load:

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

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

iii. Record power values for the entire 15 minute period.

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

Note: The ATIS standard calls for LNE to be tested for partial utilization at either 10% or 30%, and bases the choice on product class. DOE does not currently provide product classification, and is therefore requiring that both 10% and 30% utilization levels be tested.

d) Very Low Utilization (VLU):

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

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

iii. Record power values for the entire 15 minute period.

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

Note: The Idle test, originally proposed in the Preliminary Approach Test Method, has been replaced by the VLU test. When the utilization is reduced to 0.01% of max NDR, there will be relatively long periods of inactivity on each data port representing a state that is very similar to idle. This allows a product to effectively demonstrate power-saving features (e.g., EEE) while still processing received data without error.

3) If packet loss occurs during any of the tests specified in Section 6.1C)2), the UUT must be retested beginning with Section 6.1C)1).

D) Half-Port Testing: The following steps shall be performed for Half-Port Testing. Record all measured values in the Half-Port Variable Load Test section of the test reporting template.

1) Connect half of the UUT data ports as described in Section 5.1A)5)a)ii.

2) Repeat the steps in 6.1.C)2).

6.2 PoE Load Testing

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

1) Ninety Percent PoE Load:

a) Ensure that the PoE Test Load is still configured so that each port draws 90% of the Max PoE Load per Port, as determined in Section 5.1.B)3).

b) Record the measured UUT power consumption over a five minute period.

c) Calculate and report the average measured power value (PoE_{90}).

2) Fifty Percent PoE Load:

a) Configure the PoE Test Load so that each port will draw 50% of the Max PoE per Port, as determined in Section 5.1.B)3).

b) Record the measured UUT power consumption over a five minute period.

c) Calculate and report the average measured power value (PoE_{50}).

3) Twenty Five Percent PoE Load:

a) Configure the PoE Test Load so that each port will draw 25% of the Max PoE per Port, as determined in Section 5.1.B)3).

b) Record the measured UUT power consumption over a five minute period.

c) Calculate and report the average measured power value (PoE_{25}).

7 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.

D) IEEE 802.3af-2003: IEEE Standard for Information Technology - Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements - Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications - Data Terminal Equipment (DTE) Power Via Media Dependent Interface (MDI)

E) IEEE 802.3at-2009: IEEE Standard for Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks - Specific requirements Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications - Amendment 3: Data Terminal Equipment (DTE) Power via the Media Dependent Interface (MDI) Enhancements

F) 802.3az-2010: IEEE Standard for Information technology-- Local and metropolitan area networks-- Specific requirements-- Part 3: CSMA/CD Access Method and Physical Layer Specifications Amendment 5: Media Access Control Parameters, Physical Layers, and Management Parameters for Energy-Efficient Ethernet