ENERGY STAR Test Procedure for Small Network Equipment

Second Revision
March 29, 2010

Note: This second draft test procedure is intended for stakeholder review and to commence initial data collection for Small Network Equipment (SNE). EPA's goal for this document is to generate feedback based on actual test experience to refine and simplify the test procedure. Specific guidance on the intent, goals, and timeline for this effort and this document are listed below.

- Purpose: Data collected as part of this outreach will be used to develop a proposed structure for efficiency requirements in the specification. Further, it is EPA's goal that data collected would be from a broad set of products, allowing EPA to learn more about the product types identified in the framework document.
- Desired outcomes: EPA intends for stakeholders to run the procedure on a range of their equipment and to forward to EPA both test data acquired using the procedure and written suggestions on any further revisions to the procedure. EPA will review both comments and data to simplify the test method into a final version, which will be published as part of the ENERGY STAR SNE product specification.
- Scope for testing with this document: Stakeholders are asked to test a broad range of their available equipment that fit the categories proposed in the framework document: routers, switches, access points, broadband modems, integrated home access devices/gateways, Wi-Fi extenders, and optical network termination devices. Testing a single representative product for each category will suffice, though addition date is welcomed.
- Format of responses: All responses must be forwarded to EPA via email at networking@energystar.gov. Written comments on suggested modifications to the procedure must be grouped by subsection (e.g., 4.1, 5.2). Data must be submitted via the accompanying data collection form.
- How data will be handled: As standard practice in ENERGY STAR data collection efforts, identifying information regarding the source of data, manufacturer name, and model name/number will be masked prior to an aggregated dataset being shared publically. An example from another specification development effort is available at http://www.energystar.gov/ia/partners/prod_development/revisions/downloads/computer/Version5.0_Computer_Data.xls.
- Timeline: Data and comments will be due on **May 14, 2010**.

Feedback on this procedure and collected data should be forwarded to networking@energystar.gov.

1. Overview

The following protocol shall be followed when testing products for compliance with the Version 1.0 ENERGY STAR Small Network Equipment (SNE) specification.

2. Applicability

Products must be tested with hardware and software in the default "as-shipped" configuration, unless otherwise specified in this document.

Note: Consistent with other ENERGY STAR programs, all testing will be conducted with SNE configured as it ships by default to customers unless otherwise specified in this procedure. EPA includes this requirement to ensure that only those energy-saving features likely to be utilized by an end user are active during testing. All configuration changes that result in a product being tested outside of its as-shipped state should be noted on the accompanying data collection template.

3. Definitions

Note: Definitions will ultimately be included in *Section 1* of the SNE specification. Unless otherwise specified, terms used in this test procedure are as defined in the Small Network Equipment Specification Framework Document.

Below are additional terms referenced in this draft test procedure:

IAD: An acronym for "integrated access device," a device combining modem, switch, and/or router capability. To be included in the draft specification in place of IHAD.

Link Rate: The maximum raw bit rate possible on the link (e.g., 1000BASE-T Ethernet supports 1 Gb/s in each direction [2 Gb/s total], IEEE 802.11g supports 54 Mb/s total).

UUT: An acronym for "unit under test," which in this case refers to the network equipment being tested.

WLAN Test Client: A device that is capable of establishing an 802.11x link with an AP and transmitting data to and from the AP.

4. Test Setup

4.1. Quality Control

EPA recommends that all testing be conducted in facilities that follow quality control guidelines specified in ISO/IEC 17025, and that all test equipment be annually calibrated by an accredited laboratory.

Note: Please note that ENERGY STAR will be hosting a series of discussions about enhanced testing requirements for all ENERGY STAR products. You are encouraged to participate in these broad discussions, as well as discussions specific to small network equipment. More information on upcoming meetings will be posted on the ENERGY STAR Web site at www.energystar.gov/mou.

4.2. Reporting

A. Power Measurements - All power figures shall be reported in watts, accurate to the second decimal place. For loads greater than or equal to 10 W, three significant figures shall be reported.

4.3. Instrumentation

Note: The Power Analyzer, Measurement Accuracy, and Test Condition requirements reference provisions for IEC 62301 (2005), *Household electrical appliances – Measurement of standby power*. These requirements are widely applied for ENERGY STAR testing where measurement of low power levels is required. EPA is aware of ongoing efforts to revise this standard and will reflect changes as necessary in the final test procedure.

A. Power Analyzer[1] - Power analyzers used for testing must meet the following requirements:

1. Current crest factor > 3 throughout the rated operating range. Analyzers that do not specify current crest factor must be capable of measuring a current spike of at least 3 times the maximum amperage measured during any 1-second sample;
2. Frequency response of at least 3 kHz;
3. Power resolution of 1 mW or better; and
4. Lower bound on the current range of 10mA or less.

In addition to the above requirements, the following attributes are recommended:

1. Calibration with a standard traceable to the U.S. National Institute of Standards and Technology (NIST); and
2. Capable of averaging power measurements over any user selected time interval (this is usually done with an internal calculation dividing accumulated energy by time within the analyzer, which is the most accurate approach) or capable of integrating energy over any user selected time interval and integrating with a resolution of 1 second or less.

B. Measurement Accuracy - Measurements of power of 0.5 W or greater shall be made with an uncertainty of less than or equal to 2% at the 95% confidence level. Measurements of power of less than 0.5 W shall be made with an uncertainty of less than or equal to 0.01 W at the 95% confidence level. The power measurement instrument shall have a resolution of:

1. 0.01 W or better for power measurements of 10 W or less;
2. 0.1 W or better for power measurements greater than 10 W up to 100 W; and
3. 1 W or better for power measurements greater than 100 W.

C. Test Conditions

Table 1: Test Conditions

Supply Voltage	**Maximum Power**	**≤1.5 kW**	**> 1.5 kW**
	North America/Taiwan:	115 (± 1%) V ac, 60 Hz (± 1%)	115 (± 4%) V ac, 60 Hz (± 1%)
	Europe/Australia/ New Zealand:	230 (± 1%) V ac, 50 Hz (± 1%)	230 (± 4%) V ac, 50 Hz (± 1%)
	Japan:	100 (± 1%) V ac, 50 Hz (± 1%)/60 Hz (± 1%)	100 (± 4%) V ac, 50 Hz (± 1%)/60 Hz (± 1%)
Total Harmonic Distortion (THD) (Voltage)		< 2% THD	< 5% THD
Ambient Temperature	23°C ± 5°C		
Relative Humidity	10 – 80%		
Atmospheric Pressure	Above 24.5 inHg (aka < 5500 ft altitude)		

[1] *Characteristics of approved meters taken from IEC 62301 Ed 1.0: Measurement of Standby Power*

Reference:

- IEC 62301 Ed. 1.0: Household Electrical Appliances – Measurement of Standby Power, Sections 4.2, 4.3, 4.4.

4.4. Data Source/Transfer Requirements

A network traffic generator shall be used to simulate traffic and monitor the reliability of links. The generator shall be configured for the correct traffic topology and traffic profile, and as follows:

1. All data transfers shall occur via UDP;
2. The "data rate" is the total average bits per second passing over a link in both directions. Data rates are expressed as the rate of data in the UDP data frame;
3. Test traffic shall contain random data in a variety of datagram (or frame) sizes based on an Internet traffic mix (IMIX) sent at random intervals. See references for more information;
4. Data shall be evenly split between both directions (transmission and reception) for a given link unless specified otherwise in this test procedure;
5. Port numbers for the data traffic shall be randomly selected in advance of each test from the available pool of valid UDP ports. Once selected, port numbers shall not be changed for the duration of testing.

Table 2: Data Source/Transfer References

References	Description
http://spcprev.spirentcom.com/documents/4079.pdf	Spirent, Test Methodology Journal, IMIX (Internet Mix) Journal, March 2006
http://www.ixiacom.com/library/test_plans/display?skey=testing_pppox	IXIA Library: Test Plans, Broadband PPPoX and L2TP Testing

5. UUT Configuration

5.1. Supplied Power Configuration

A UUT that can be powered by either mains power or low-voltage dc shall be powered from the mains. Low voltage dc shall be used only for devices that do not offer a mains power option.

1. Mains-powered - If the UUT is shipped with an external power supply, or powered directly by mains ac, power consumption of UUT shall be measured and tested between the ac power source and the UUT.
2. Low-voltage Dc Powered - For products powered by standard low-voltage dc (e.g., Power over Ethernet [IEEE 802.3af or .3at], or USB), the following protocol applies:
   - If the UUT supports LLDP for PoE for its power supply, the PoE source shall also support LLDP for PoE. See Figure 1.
   - If a manufacturer-supplied low-voltage dc power supply is shipped with the UUT, it shall be used for testing.
   - If there is no power supply shipped with the UUT, a commercially available device (e.g., PoE power injector or powered USB hub) shall be used for testing. If the UUT manufacturer sells an appropriate standard low-voltage dc supply, then a model from the UUT manufacturer must be used. The brand and model number of the power supply shall be recorded on the test data sheet. The selected power supply shall be considered the external power supply for the unit for purposes of testing.

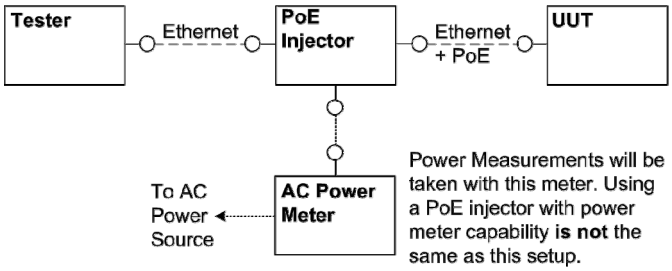

Figure 1: Low-voltage Dc Power Setup.

5.2. Wired Port UUT Configuration

Only Ethernet ports are considered network ports for the purpose of testing. Ethernet connectivity and all other wired ports shall be configured for testing as follows:

1. Alternative LAN Technologies - Non-Ethernet wired ports (e.g., HPNA, MoCA, USB, analog connections, POTS, audio), shall not be connected, unless a secondary device and cable are shipped with the UUT (e.g., an external disk with a USB connection).
2. Network Link Maintenance - The UUT's WAN port shall be connected to a live source. Network links shall be continuously maintained, with the exception of brief lapses when transitioning between link speeds.
3. Ethernet Port Connection Rate - Ethernet ports shall be connected at the maximum supported link rate unless otherwise specified in this test procedure.
4. Ethernet Cabling - Ethernet cables used in testing shall be Cat5e and shall be 2 meters in length.
5. Power over Ethernet (PoE) - PoE capability shall be configured in the default setting as it is shipped to the customer.
6. Efficient Networking Protocols - If the UUT supports IEEE 802.3az protocol, all connected devices must support the protocol; if the UUT supports LLDP for .3az, all connected devices must support LLDP.

Note: In a future revision of the specification, EPA intends to consider covering other wired LAN physical layers in the test procedure if they are commonplace on the market.

5.3. Wireless UUT Configuration

The UUT shall be tested with wireless network configuration settings set to their as-shipped defaults. Any features that require special configuration to achieve intended function (i.e., initial setup before use as indicated in a reference manual) shall be configured per the following requirements. If additional required settings are not listed below, the setting type and option shall be recorded in the test report.

1. SSID: As-shipped, or assigned a random value as required by the UUT;
2. Network Encryption: As-shipped, or 128-bit WPA2 as required by the UUT;
3. Network Key: As shipped, or assigned a random value as required by the UUT;
4. Network Channel: A supported channel shall be selected and maintained for the duration of testing;
5. Interference Mitigation: Interference robustness or other interference mitigation technology shall be as-shipped or set to "ON" if configuration required by UUT.

6. Wireless Link Precedence:

   a. *Single instantaneous frequency band support*: The first supported wireless standard and frequency band from the following list shall be used for access point testing. Only one band shall be active during the test:

      (i.) IEEE 802.11n (5 GHz, 2 channels bonded if supported).

      (ii.) IEEE 802.11n (2.4 GHz, single, unbounded channel).

      (iii.) IEEE 802.11g (2.4 GHz).

      (iv.) IEEE 802.11b (2.4 GHz).

      (v.) IEEE 802.11a (5 GHz).

   b. *Simultaneous instantaneous frequency band support*: The first supported pair of wireless standards and frequency bands from the following list shall be used for access point testing:

      (i.) IEEE 802.11n (2.4 GHz single channel, 5 GHz bonded channels if supported).

      (ii.) IEEE 802.11g (2.4 GHz), IEEE 802.11n (5 GHz bonded channels if supported).

      (iii.) IEEE 802.11g (2.4 GHz), IEEE 802.11a (5 GHz).

      (iv.) IEEE 802.11b (2.4 GHz), IEEE 802.11a (5GHz).

   c. *Alternative configurations*: If a device does not support any configuration listed above, the test client shall provide a configuration. The configuration shall be recorded in the test report.

Note: Access points often support multiple standards and multiple frequency bands. The above section provides a standard protocol for selection of wireless standard and frequency band to ensure that test results are comparable across products.

5.4. UUT Wired Network Settings

The UUT shall be tested with wired network configuration settings set to their as-shipped defaults. Any features that require special configuration to achieve intended function (i.e., initial setup before use as indicated in a reference manual) shall be configured per the following requirements. If additional required settings are not listed below, the setting type and option shall be recorded in the test report.

1. Enable Network Address Translation (NAT) for IPv4 networks;
2. Enable IPv6 Link Local, Neighbor Solicitation, Neighbor Discovery, Router Solicitation and Router Advertisement;

Note: This condition is intended to provide local IPv6 functionality inside IPv4 gateway scenario.

3. Enable Single Class C Subnet;
4. Enable single hop (router TTL + 1) to source on WAN side;
5. Enable DHCP, if available, and have the UUT autonomously assign each configured test client an address by the DHCP service in the router, or manually assign addresses in a manner typical of DHCP (incremental, 3 day TTL, etc); the WAN port should be configured via DHCP or manually assigned if not supported;
6. Disable Internet Protocol Security (IPsec);
7. Disable features not in compliance with IEEE 802.3 standards;

Note: For the initial data collection, manufacturers with non-compliant features should repeat the test with the device in the as-shipped condition. EPA will assess this information to better understand the power impact of these features.

8. WAN connections and corresponding link speeds shall be selected in the order specified in Table 3. If UUT is not capable of the specified link speed, set the UUT to operate at the maximum possible speed.

Table 3: WAN Connection Precedence and Default Link Speeds

Connection Type	Test Speed Down	Test Speed Up	Media Type
DOCSIS (Cable)	12 Mbps	3 Mbps	Coax
PON	1 Gbps	1 Gbps	Fiber
MoCA	20 Mbps	*TBD*	Coax
DSL	6 Mbps	1 Mbps	Copper (Twisted Pair)
HPNA	60 Mbps	60 Mbps	Coax
WiMAX (802.16e)	60 Mbps	15 Mbps	Wireless
Ethernet (802.3)	1 Gbps	1 Gbps	Copper (Twisted Pair)

Note: EPA encourages further feedback on Table 3, specifically the list of connection types, suggested additions, and appropriate speeds for both. Below are additional areas of inquiry.

Should the wireless be listed as available maximum rate?

Do any of the other technologies have link rates that are not selectable?

Does MoCA have different up/down rates?

5.5. UUT Preparation

The UUT shall be configured for testing as follows:

1. Test Report - Record the manufacturer and model name of the UUT. Record all basic information about the UUT's configuration including, but not limited to, the settings listed Sections 5.1 through 5.4.

2. Network Connection - Connect the UUT to network resources as follows (the UUT must maintain live links in all specified connections for the duration of testing):

   a. *Modem (DSL, Cable, or ONT)*: See Figure 3: *Modem setup*.

      (i.) Connect the UUT's WAN port to test client at the rate specified in Table 3. If the UUT has multiple WAN connections, select according to the precedence specified in Table 3.

      (ii.) Connect one LAN port to the test client. If Ethernet is available, the Ethernet port shall be used. If more than one Ethernet port is present, the first non-uplink Ethernet port shall be used.

   b. *Switch/Router*: See Figure 4: *Switch or router test setup.*

      (i.) Connect two of the UUT's available ports to the test client and ensure that live links are maintained for the duration of testing on all connections.

(ii.) If a UUT port is identified as the uplink or WAN port, it shall be one of the two ports connected for testing. Otherwise, the first port shall be used as the uplink port.

c. *IAD or Access Point*:

(i.) *Access Points*: Connect the uplink Ethernet port to the test source at the highest available link rate and ensure that live links are maintained for the duration of testing.

(ii.) *IADs*: Ensure a WAN port is connected according to the priority outlined in Table 3 and ensure that live links are maintained for the duration of testing. Connect the first Ethernet port to the test source at the highest available link rate. Traffic for this test will pass over the Ethernet link and not the WAN link.

(iii.) *UUTs with external removable antennas*: (see Figure 5: *AP setup with removable antennas shown* and Figure 6: *IAD test setup for wireless testing with removable antennas*)

(a.) Remove all antennas.

(b.) Connect an RF coaxial cable to each antenna port. The cable shall be connected through an appropriate RF attenuator to a WLAN client simulator. The attenuation and test client transmit power shall be set such that the received signal strength is -50dBm ± 3dB at both the test client and the AP. If received signal strength information is unavailable from the AP and/or the test client, use RF test equipment to determine the appropriate settings.

(c.) If the AP has multiple antennas for a single band, an appropriate number of cables shall be connected to achieve the maximum supported data rate (i.e., one cable for 802.11a/b/g and ≥1 cable for 802.11n).

(iv.) *UUTs without removable antennas*: (see Figure 7: *AP setup with fixed antennas*)

(a.) Place the UUT inside a shielded enclosure large enough to fit the UUT without making contact with the enclosure walls. The enclosure must sufficient have RF, Ethernet, and power feed-throughs to service the UUT.

(b.) Connect antennas to the RF feed-throughs on the inside of the enclosure.

(c.) Connect cables to the exterior feed-throughs via appropriate RF attenuators to achieve a signal strength of -50dBm ± 3dB. The test client transmit power shall be set to ensure that the received signal strength at the AP is -50dBm ± 3dB. If received signal strength information is unavailable from the AP and/or the test client, use RF test equipment to determine the appropriate settings.

(d.) If the AP has multiple antennas for a single band, an appropriate number of cables and antennas shall be connected to achieve the maximum supported data rate (i.e., 1 cable/antenna for 802.11a/b/g and ≥1 cable/antenna for 802.11n).

(v.) If the UUT requires an access point controller for normal operation, an access point controller from the same manufacturer as the UUT shall be added to the network for testing. If the UUT is capable of full operation without an access point controller, it shall be tested without a controller on the test network.

(vi.) Record sufficient details of the test setup to allow for the test to be independently re-created and verified.

3. Power Analyzer Connection

a. Connect the power analyzer or analyzers to an ac or dc voltage source set to the appropriate voltage and frequency for the test.

b. Plug the UUT into the measurement power outlet on the power analyzer, as follows:

(i.) No other devices (e.g., power strips or UPS units) may be connected between the meter and the UUT;

(ii.) If the UUT uses an external power supply (EPS), the EPS is considered part of the UUT. Plug the EPS input into the measurement power outlet on the meter;

(iii.) The power analyzer shall remain connected until all testing is complete.

5.6. Test Client Setup

The tests outlined in Section 6 require the use of network tester equipment (the *test client*) capable of supporting the protocols used during testing. The test client may consist of several discrete pieces of test equipment used together to test Ethernet, WAN, and wireless links. This section is intended to provide guidelines for test client configuration to be applied to the specific pieces of equipment serving the UUT.

1. Configure the test client Ethernet ports to be DHCP clients with unique, random MAC addresses.
2. Configure the WAN port or uplink Ethernet port to assign a random IPv4 address to the UUT. A static IPv4 address may be set in the UUT if the test client is unable to support random address assignment. IPv6 may be used if IPv4 support is not present in the test client hardware. If the device is configured for DHCP pass-through functionality, the test client shall assign addresses through the UUT.
3. Configure the test client to send traffic using UDP.
4. Configure the test client to provide statistics on data reliability (% of packets received successfully).
5. Configure the test client to transmit variable length packets or frames using the basic IMIX given in Table 4 (see Table 2 for references).

Table 4: IMIX Packet Length Distribution

Datagram Size (IP Length) Bytes	Frame Length Bytes	% of total packets
40	64	61%
576	594	23%
1500	1518	16%

6. Configure the test client to test in a modified aggregation mode. All traffic will pass over a single link (the uplink or WAN port), and this traffic will be evenly divided between the other connected Ethernet ports. See Figure 8: *Data distribution for multilink tests.*.
7. If the UUT has wireless capability, then the test client shall be capable of functioning as a wireless client for the wireless standard(s) specified in Section 5.3.
8. Configure data connections to the test client as specified in Section 5.5.
9. Record the test equipment used for the test client and provide a functional diagram of the test equipment and UUT configuration, including all connections in the test setup.

6. Power Consumption Tests

6.1. Procedure Structure

1. Section 6.3.A shall be completed for all SNE products. Other applicable sections of the test procedure shall be completed in order and as specified in Table 5.

Table 5: Test Procedure Structure

	6.3.A All Devices - Idle	6.3.B Wired Network – WAN	6.3.C Wired Network – LAN	6.5.D Wireless Network - LAN
Modem	X	X		
IAD	X	X	X	X
Switch/Router	X		X	
Wireless Product	X			X
Wired/Wireless Product	X		X	X

2. If a step in the test procedure specifies a transfer rate that is not supported by both link directions, that step may be skipped, and an annotation made in the test data sheet.

3. If a step in the test procedure specifies a transfer rate that is supported in *only one* link direction, use the specified transfer rate in the supported link direction, and use the maximum possible transfer rate in the other link direction.

For example, if the specified data rates are 0.5 Mb/s, 5 Mb/s and 50 Mb/s and a device has an asymmetric link supporting 8 Mb/s in downlink and 2 Mb/s in uplink, the device will be tested with the following data rates:

Procedure Specified Rate	Downlink Rate	Uplink Rate
0.5 Mb/s	0.5 Mb/s	0.5 Mb/s
5 Mb/s	5 Mb/s	0.5 Mb/s
50 Mb/s	Not tested	Not Tested

Figure 2: Sample Test Scenario – Asymmetric 8 Mb/s Downlink and 2 Mb/s Uplink.

4. If an uplink or WAN Ethernet port is identified on the UUT, it shall be used as the uplink port in Section 6.3.C. Otherwise, the first port shall be used as the uplink port in this test. If present, additional Ethernet ports shall be connected sequentially, and there shall be no open Ethernet ports between occupied Ethernet ports.

6.2. Power Measurement Procedure

The following procedure shall be used for each test component in Section 6.3:

1. Reset the power analyzer (if necessary).
2. Begin recording elapsed time.
3. Set the analyzer to begin accumulating true power values at an interval of greater than or equal to 1 reading per second.
4. Accumulate power values for 5 minutes and record the average (arithmetic mean) value observed during that 5 minute period.
5. Record the test procedure step and measurements on the test report. If a step is repeated at an additional link rate, provide the additional measurements in the test report in an additional column labeled with the link rate for that column.

6.3. Power Consumption Tests

The following tests specify that power measurements be taken at several different data rates and at different link rates. If a test requests a data rate in excess of the link rate, refer to Section 6.1.

A. All Devices – Idle

Note: This test is the base level test of the device in the minimum configuration without active data links.

1. Turn on the UUT and complete all required UUT configuration requirements from Section 5.
2. Per Section 6.2, measure the power of the UUT.

B. Wired Network – WAN

Note: This section is intended to test the modem functionality of the device at different utilization levels. A logarithmic set of port throughputs is used to ensure broad coverage of device capability. Asymmetric links are accounted for through the instructions given in Section 6.1.

1. If the UUT only supports WAN connection (IADs only), connect one Ethernet port. Ensure all Ethernet ports are connected at their highest supported link rate. Measure and record the power consumption.
2. Run data at 0.5 Mb/s (0.25 Mb/s in each direction) between the WAN and LAN ports. Measure and record the power consumption.
3. Run data at 1.0 Mb/s (0.5 Mb/s in each direction) between the WAN and LAN ports. Measure and record the power consumption.
4. Run data at 5 Mb/s (2.5 Mb/s in each direction) between the WAN and LAN ports. Measure and record the power consumption.
5. Run data at 10 Mb/s (5 Mb/s in each direction) between the WAN and LAN ports. Measure and record the power consumption.
6. Run data at 100 Mb/s (50 Mb/s in each direction) between the WAN and LAN ports. Measure and record the power consumption.
7. Run data at 1000 Mb/s (500 Mb/s in each direction) between the WAN and LAN ports. Measure and record the power consumption.
8. If the Ethernet port in use supports a 1 Gb/s link rate (i.e., 1000BASE-T Ethernet), repeat Section B with the port set for a 100 Mb/s link rate (i.e., 100BASE-T Ethernet).

Note: EPA anticipates that scaling the data transfer rate in this procedure will demonstrate the power savings attainable through use of IEEE 802.3az at 1 Gb/s.

C. Wired Network – LAN: Complete 1-3 below as applicable for the UUT. For special cases, refer to Table 6.

Table 6: Wired Network – LAN: Test Selection

UUT Port Configuration	1. Minimum Ports Test	2. Half Ports Test	3. Full Ports Test
1 Port	n/a – Test according to Section 6.3.B		
2 Ports	n/a	n/a	Complete test with 2 ports
3 Ports	Complete test with 2 ports	n/a	Complete test with 3 ports
4 Ports	Complete test with 2 ports	n/a	Complete test with 4 ports
≥ 5 Ports	Complete test with 2 ports	Complete test with half of the available ports (round up to the nearest whole number of ports)	Complete test with all ports

1. Minimum Ports Tests: Test with minimum ports in use, at all supported speeds, as applicable.
   a. Connect two LAN ports. Ensure the Ethernet ports are connected at their highest supported link rate. Measure and record the power consumption.
   b. Run data at 1.0 Mb/s (0.5 Mb/s in each direction) between the LAN ports. Measure and record the power consumption.
   c. Run data at 10.0 Mb/s (5.0 Mb/s in each direction) between the LAN ports. Measure and record the power consumption.
   d. Run data at 100 Mb/s (50.0 Mb/s in each direction) between the LAN ports. Measure and record the power consumption.
   e. Run data at 1000 Mb/s (500 Mb/s in each direction) between the LAN ports. Measure and record the power consumption.
2. Half Ports Tests: Test with half of ports in use, at all supported speeds, as applicable. See Figure 8: *Data distribution for multilink tests.*
   a. If the UUT has more than two Ethernet ports, connect half of the Ethernet ports (round up to the nearest whole number of ports). Connect each port sequentially (e.g., a 5-port product would have ports 1-3 connected and 4, 5 disconnected). The UUT's Ethernet or other LAN ports must be connected at their highest supported link rate. If the UUT specifies an uplink port, the specified port must be one of the used ports; otherwise, the first port is the uplink port. Measure and record the power consumption.
   b. Run data at 1.0 Mb/s (0.5 Mb/s in each direction) between the LAN ports. Measure and record the power consumption.
   c. Run data at 10.0 Mb/s (5.0 Mb/s in each direction) between the LAN ports. Measure and record the power consumption.
   d. Run data at 100 Mb/s (50.0 Mb/s in each direction) between the LAN ports. Measure and record the power consumption.
   e. Run data at 1000 Mb/s (500 Mb/s in each direction) between the LAN ports. Measure and record the power consumption.

3. Full Ports Tests: Test with all ports used and at all of the following speeds supported by the UUT.

   a. Connect all UUT Ethernet ports. The Ethernet ports must be connected at their highest supported link rate. Measure and record the power consumption.

   b. Run data at 1.0 Mb/s (0.5 Mb/s in each direction) between the LAN ports. Measure and record the power consumption.

   c. Run data at 10.0 Mb/s (5.0 Mb/s in each direction) between the LAN ports. Measure and record the power consumption.

   d. Run data at 100 Mb/s (50.0 Mb/s in each direction) between the LAN ports. Measure and record the power consumption.

   e. Run data at 1000 Mb/s (500 Mb/s in each direction) between the LAN ports. Measure and record the power consumption.

4. If the highest supported link rate is 1 Gb/s (i.e., 1000BASE-T Ethernet), repeat Section C with all links set to support 100 Mb/s traffic (i.e., 100BASE-T Ethernet).

D. Wireless Network - WLAN

Note: The wireless tests are intended to target the general set of 802.11 APs.

1. Ensure only one Ethernet port is connected to the UUT.
2. Establish a single client device in the test client. The WLAN type must be consistent with the priority listed in Section 5.3 and shall be configured for the highest supported link rate. Record the supported rate for the network port, the wireless link, and the version of 802.11 being used for this test. Measure and record the power consumption.
3. Run data at 0.1 Mb/s (0.05 Mb/s in each direction) between the LAN port and the WLAN client. Measure and record the power consumption.
4. Run data at 1.0 Mb/s (0.5 Mb/s in each direction) between the LAN port and the WLAN client. Measure and record the power consumption.
5. Run data at 10 Mb/s (5 Mb/s in each direction) between the LAN port and the WLAN client. Measure and record the power consumption.
6. Run data at 100 Mb/s (50 Mb/s in each direction) between the LAN port and the WLAN client. Measure and record the power consumption.
7. To test for other versions of 802.11, repeat Section D at the highest supported link rate for the tested 802,11 version.

7. Performance Evaluation

Performance capabilities shall be evaluated using the tests listed below as applicable to the functions and features of the UUT. UUT configuration shall be as specified in Section 5.

1. Ethernet Throughput - Using a test setup consistent with Section 6.3.C, find the maximum data rate supported by the UUT for which there is no packet loss. Report this rate as the measured maximum throughput.
2. Maximum Number of Wireless Clients - Using a test setup consistent with Section 6.3.D, find the maximum number of clients supported by the UUT. Clients shall be evenly split between bands if there is simultaneous dual band support. No data shall be passed other than that required to setup clients. Report this number as the maximum number of wireless clients.

3. Maximum Number of NAT Clients - Report the maximum number of supported NAT clients. Report if an additional switch was required, the number of wireless NAT and the number of wired NAT clients. The addition of downstream switches to the test setup and/or combination of tests similar to Sections 6.3.C and 6.3.D may be required to achieve a large number of NAT clients. No data shall be passed other than that required to setup the clients.

Note: This section is intended to provide manufacturers a way to demonstrate expanded capabilities in high performance devices.

8. Reporting

8.1. Data Reporting Requirement

The test results shall be reported to EPA or the European Commission, as appropriate, taking care to ensure that all required information is included.

8.2. Required Information

The following characteristics shall be reported:

1. Manufacturer and model name;
2. Basic configuration information;
3. Powering options (e.g., direct ac, external ac-dc power supply, standard low-voltage dc). If powered over Ethernet, whether LLDP for PoE is supported;
4. Number and type of all wired data and network ports. Additional related details (e.g., Ethernet speed, LLDP for 802.3az);
5. Feature activity conflicts;
6. Number and type of wireless network support including supported bands, simultaneous band support, supported standards, and MIMO configuration. Additional details as required;
7. Supported network traffic functions (e.g., firewall, VPN, VOIP functionality for POTS ports);
8. Mass storage options integral to or shipped with the UUT;
9. Any special equipment ratings (e.g., IEC 61850 / IEC61000 and IEEE1613, KEMA).

Note: As referenced in the power measurement procedure, EPA intends to develop a data collection form to accompany the test procedure that will provide the required recording format for all included tests.

9. Test Configuration Figures and Diagrams

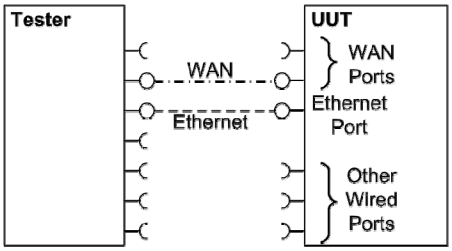

Figure 3: Modem setup.

*WAN port selected based on **Table 3**. Only 1 WAN port connected.*

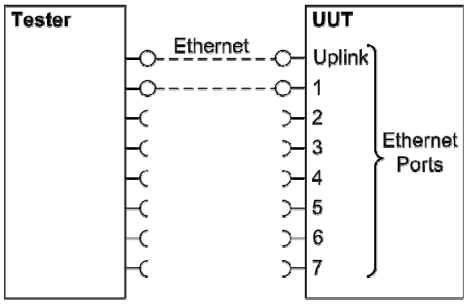

Figure 4: Switch or router test setup.

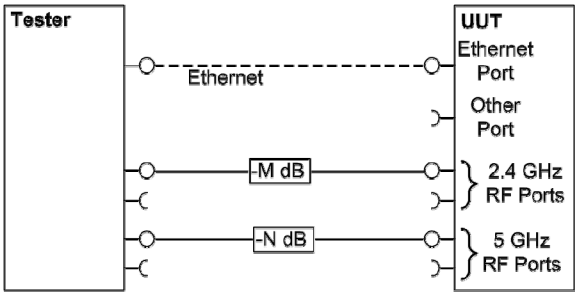

Figure 5: AP setup with removable antennas shown.

Attenuation is set according to Section 5.5.c. Test configured for 802.11g (2.4 GHz) and 802.11a (5 GHz) with one RF connection required for each to achieve maximum throughput.

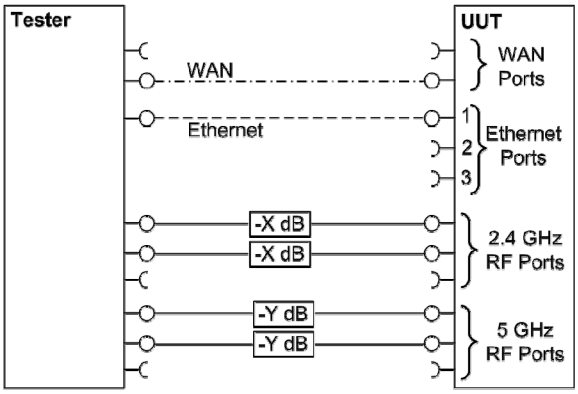

Figure 6: IAD test setup for wireless testing with removable antennas.

Use WAN port identified in **Table 3** *but no data passes over the WAN link. The first Ethernet shall be used for data transfer. Test configured for 2x3 MIMO (802.11n). Two streams are supported requiring two RF connections for maximum throughput in each band.*

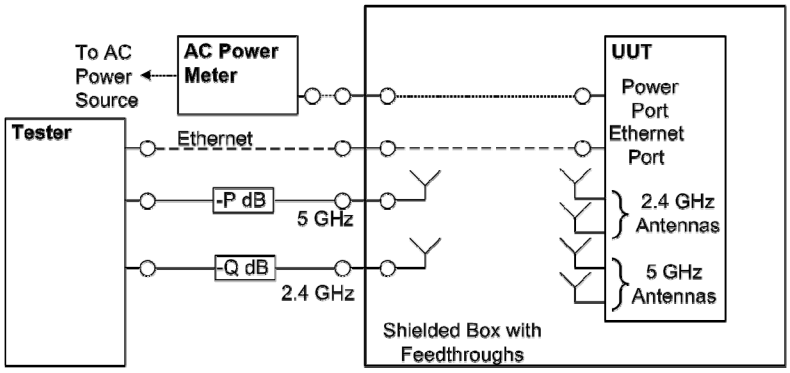

Figure 7: AP setup with fixed antennas.

Attenuation is set according to Section 5.5.c. Test configured for 802.11g (2.4 GHz) and 802.11a (5 GHz) with one antenna connection required for each to achieve maximum throughput.

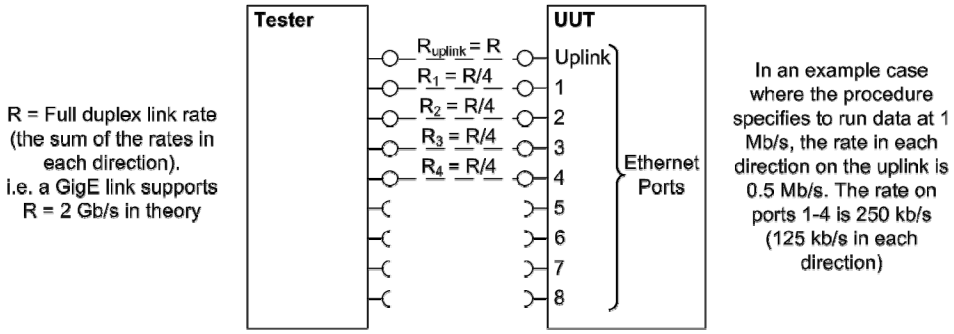

Figure 8: Data distribution for multilink tests.

Half port test case shown.

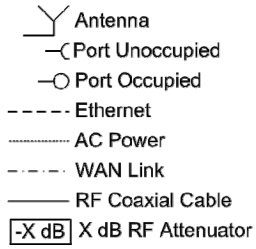

Figure 9: Legend for all figures.

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