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**Environmental Engineering (EE);
Measurement methods for energy efficiency
of router and switch equipment**

Reference

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Keywords

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Foreword

This final draft ETSI Standard (ES) has been produced by ETSI Technical Committee Environmental Engineering (EE), and is now submitted for the ETSI standards Membership Approval Procedure.

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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Introduction

The present document defines the energy consumption metrics and measurement methods for router and Ethernet switch equipment.

1 Scope

The present document defines the methodology and the test conditions to measure the power consumption of router and switch equipment.

The present document is applicable to Core, edge and access routers.

Home gateways are not included in the present document.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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The following referenced documents are necessary for the application of the present document.

[1] ATIS-0600015.03.2009: "Energy Efficiency for Telecommunication Equipment: Methodology for Measurement and Reporting for Router and Ethernet Switch Products".

[2] ATIS-0600015: "Energy Efficiency for Telecommunication Equipment: Methodology for Measurement and Reporting - General Requirements".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI EN 300 132-2: "Environmental Engineering (EE); Power supply interface at the input to telecommunications and datacom (ICT) equipment; Part 2: Operated by -48 V direct current (dc)".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

aggregation mode: mode in which, a few (typically higher bandwidth) ports on the equipment are considered UPLINK ports; while majority (typically lower bandwidth) ports are considered user ports

NOTE: In this configuration the data flow is strictly from user ports to uplink ports and vice versa. User ports do not communicate with each other through this equipment.

core mode: mode in which all ports are considered similar and have similar bandwidth

NOTE: In this configuration the data flow is so that each port communicate with one another.

maximum configuration: configuration with maximum capacity where whole slots of the equipment are configured with maximum interface bandwidth line cards, all of the interfaces can work at the maximum data rate

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AC	Alternating Current
ATM	Asynchronous Transfer Mode
DC	Direct Current
EE	Energy Efficiency
EEER	Equipment Energy Efficiency Ratio
EER	Energy Efficiency Rating
EUT	Equipment Under Test
FDDI	Fibre Distributed Data Interface
FE	Fast Ethernet
GE	Giga Ethernet
IMIX	Internet MIX traffic
IP	Internet Protocol
MPU	Main Processing Unit
NDR	Non Drop Rate
OSI	Open System Interconnection
PAR	Peak to Average Ratio
PoE	Power other Ethernet
QoS	Quality of Service

4 Equipment Classification

4.1 Router

Routers are typical packet switching equipment running at the network layer of OSI layer 3. The router selects the optimal route according to the destination address of the received packet through a network and forwards the packet to the next router. The last router is responsible for sending the packet to the destination host.

Routers connect different physical networks and manually configure and run standard protocols to obtain the information of each subnet such as label, number of devices, names and addresses, etc. and thus generate and maintain a live forwarding routing table. Based on this table, each IP packet passing these routers will be assigned an optimal path according to the longest matching rules and be forwarded to the right path, if the path searching of the packet fails, this packet will be abandoned.

The router can connect two or more independent and flexible logical networks using different data packets method and media access method. Routers have not any requirements for hardware in each subnet but run the software using the same network layer protocol.

In light of the router different application scenarios, they can be classified into core routers, service routers, broadband access routers, and aggregation routers (Core, Edge, access routers in ATIS 0600015.03.2009 [1] classification).

Routers have the following typical features:

1) Provide multiple protocols on network layer to connect different types of networks.

2) Provide multiple types of interfaces so as to realize the conversion between the packets with different encapsulations and transmission across different networks.

3) Support packet fragmentation and reassembly.

4) Provide large-scale packet buffers so as to support QoS and traffic engineering.

5) Provide large-scale routing tables and support large-scale Layer 3 services within intra-networks or inter-networks.

4.2 Switch

Switches generally refer to equipment that exchange information in a communications system. They include Ethernet switches, ATM switches, FDDI switches, and token ring switches, Ethernet switch is widely used because of fast development of Ethernet technologies and its low costs, therefore, switches in the present document refer to Ethernet switches.

Switches are typical packet switching devices at the data link layer of OSI layer 2. Based on the destination data link layer addresses in the Layer 2 switching tables, each received packet, will be assigned an optimal path according to the accurate matching rule and be forwarded to the right path, if the path searching of the packet fails, this packet will be sent to the broadcast domain to which it belongs. The Layer 2 switching table is generated by switch network self-learning.

The main function of switches is packet switching at the data link layer, but with the development of network technologies, the relationship between network hierarchy and hardware equipment has become ambiguous, it is not limited to Layer 2 services, the routing function is also integrated into most switches to support Layer 3 services, if the path searching of packets entering the switch fails in Layer 2, then it will be delivered to the routing module for path searching and forwarding in Layer 3. For example, some high-level switches also have the routing function, the little differences between switch and router lie in routing items and performance specifications.

Switches have the following typical features:

1) Support data link layer protocols, such as 802.3, Ethernet II, etc.

2) Provide Ethernet optical and electrical interfaces with different data rates.

3) Packet buffers are not large and low requirements for QoS and traffic engineering are allowed.

4) Demand a large-scale Layer 2 switching table and low requirements for the Layer 3 routing table.

5 Definitions of the Equipment Energy Efficiency Ratio for Router and Switch

Based on the routers and switches energy consumption measurements and research, it is showed that the main influencing factors of their energy consumption are the quantity of service boards configured, traffic configuration, traffic load and ambient conditions.

These factors should be taken into account when defining the energy efficiency indicators.

Therefore, Energy Efficiency Ratio of Equipment (EEER) is defined as the throughput forwarded by 1 watt, unit: Gbps/Watt. A higher EEER corresponds to a better the energy efficiency.

Depending on the equipment type application or usage, one shall configure the product in Aggregation mode (uplink/downlink ports) as described in figure 1 or in Core mode (all ports to all ports) as described in figure 2.

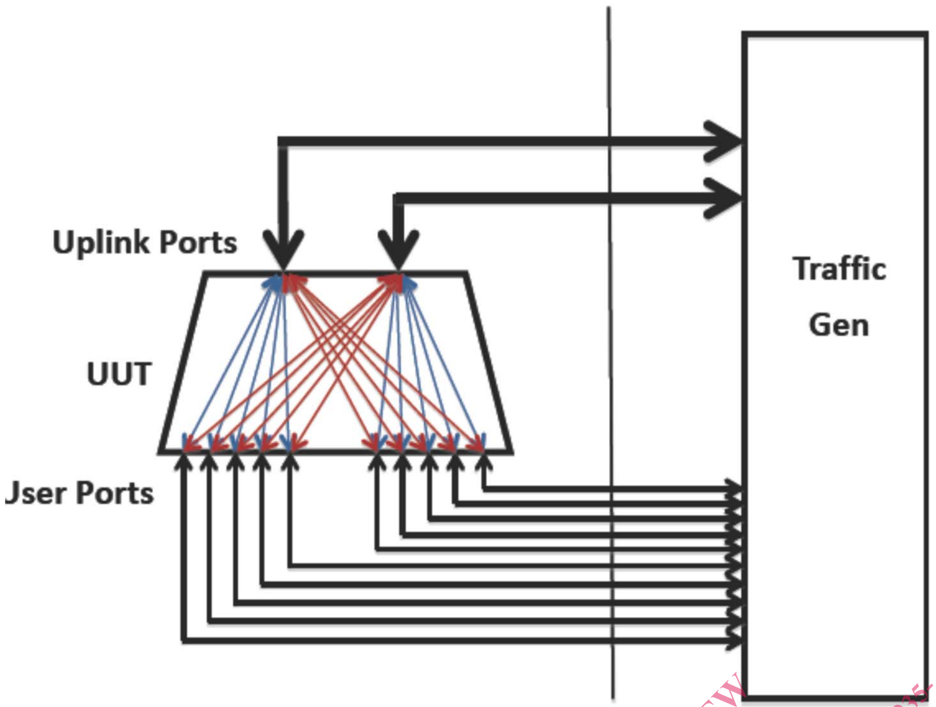

Figure 1: Aggregation mode functionality

Aggregation mode: in this mode, a few (typically higher bandwidth) ports on the equipment are considered uplink ports; while majority (typically lower bandwidth) ports are considered user ports. In this configuration the data flow is strictly from user ports to uplink ports and vice versa. User ports do not communicate with each other through this equipment.

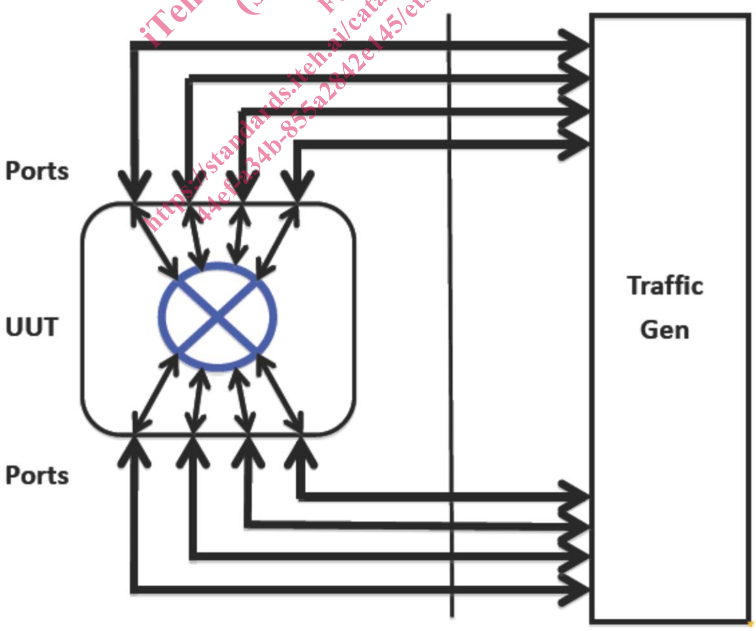

Figure 2: Core mode functionality

Core mode: in this mode all ports are considered similar and have similar bandwidth. In this configuration the data flow is so that each port communicates with one another. This is also called full mesh configuration.

For modular systems with 6 or more modules, it is allowed to permit a multi mesh configuration instead of a full mesh to facilitate the modular test method, provided that there is more than one mesh with at least three modules per mesh.

For EUT with 40 GBs speed ports or higher, it is permitted to use vertical "snake"/cascade topology except one port on each line card which should be used for mesh traffic. Use throughput numbers on meshed ports for total system throughput calculation.

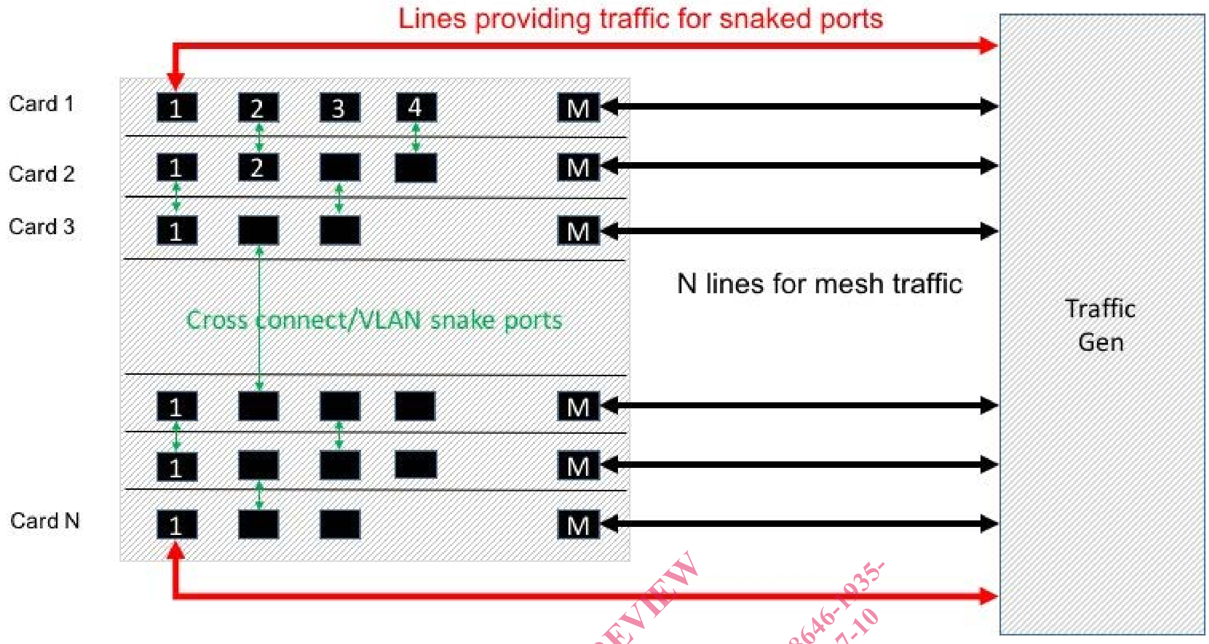

Figure 3

EEER definition for:

$$EEER = Ti/Pi$$

Where:

$$T_i = \sum_{j=1}^{m} B_j T_j$$

Table 1: Traffic load level and weight multipliers

	Traffic load level percentage of maximum load			Weight factor		
Equipment type	high	medium	Low	B_1	B_2	B_3
Core equipment	100 %	30 %	0 %	0,1	0,8	0,1
Edge/access	100 %	10 %	0 %	0,1	0,8	0,1

- B_j: Weight multipliers for different traffic level, see table 1; the summation of B_1 to B_3 equal to 1.
- T_i: Total capacity of the interfaces for a fixed configuration model (the sum of interface bandwidth).
- Ti for a core functionality mode: Total weighted throughput is the sum of all interface throughputs measured in full mesh traffic topology.
- Ti for an aggregation mode: The weighted sum of uplink port throughputs, measured in uplink/downlink mesh configuration.
- P_i: Weighted power for different traffic loads (independent of usage model or equipment type).

The weighted power Pi is calculated as:

$$P_i = \sum_{j=1}^{m} B_j P_j$$