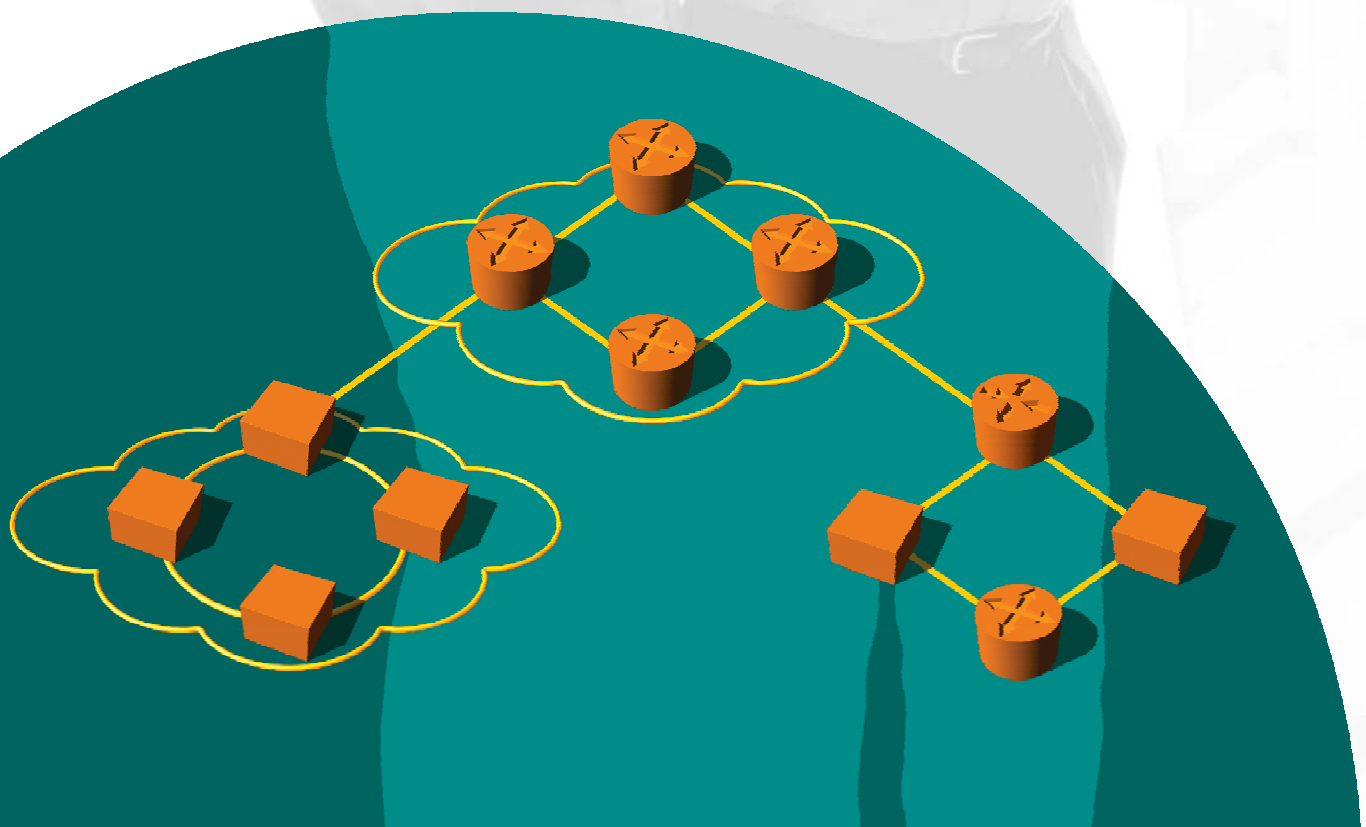


# Spirent Communications Test Methodologies

## Layer 2 Testing with RFC 2889



# Introduction

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## The Basis for Layer 2 Testing

The Layer 2 Ethernet switch is one of the most common networking devices. Layer 2 switching is associated with the Data Link Layer (Layer 2) of the standard of network programming, the Open Systems Interconnection (OSI) model. Layer 2 Ethernet switches forward traffic, also called network frames, across various network segments. Forwarding is based on information in the frame's Ethernet header.

Layer 2 switches are simple compared with sophisticated switches and routers operating at Layer 3 and higher. But even Layer 3+ switches usually have a "Layer 2 mode." In fact, it is often preferable to assure that switches and networks operate at lower layers before testing at upper layers of the OSI stack.

By testing at Layer 2 before Layer 3, network equipment manufacturers increase their success rate in development testing and quality assurance while using in-house tools. However, NEMs also need third-party tools for unbiased, hard results of switch performance. Once assured of an acceptable level of performance and scalability, NEMs market their equipment to service providers and enterprises.

To justify equipment choices and offer the highest quality services, service providers and enterprises should test according to accepted standards. After the equipment is deployed in live networks, existing equipment can be retested in the lab using the same RFC-based test tools. Regression testing allows users to compare baseline results with results obtained after the equipment or switch is updated with the latest firmware.

## Standards Promote Assuredness and Interoperability

NEMs, service providers and enterprises should quantify the performance of the Layer 2 switch by following industry standards. RFC 2889 (Benchmarking Methodology for LAN Switching Devices) is for local area switch testing. With its companion, RFC 2285 (Benchmarking Terminology for LAN Switching Devices), the RFCs together define reliable, repeatable methods for evaluating Layer 2 switch performance in 10/100/1000 Mbps and 10Gig Ethernet.

The following tests are mandatory per RFC 2889:

- Forwarding Rate
- Broadcast Handling
- Head-of-Line Blocking
- Illegal Frame Handling
- Backbone Switching

The tester must introduce simulated network traffic to the Layer 2 switch and take measurements on ports that receive traffic. Port patterns such as full mesh and partial mesh (backbone) are specified, along with different frame sizes and traffic loads. The best test tools easily create these "traffic prescriptions" and provide intuitive, meaningful results for accurate and timely reporting.

## For More Information

For more information on testing, visit us online or reach us by using the phone numbers on the back cover of this publication. Until then, best wishes with your testing.

Spirent Communications  
[www.spirentcom.com](http://www.spirentcom.com)

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# Fully Meshed Throughput, Frame Loss and Forwarding Rates

■ RFC 2889 Section 5.1

## Objective

To determine the throughput, frame loss and forwarding rates of the DUT/SUT's offered fully meshed traffic as defined in RFC 2285.

## Overview

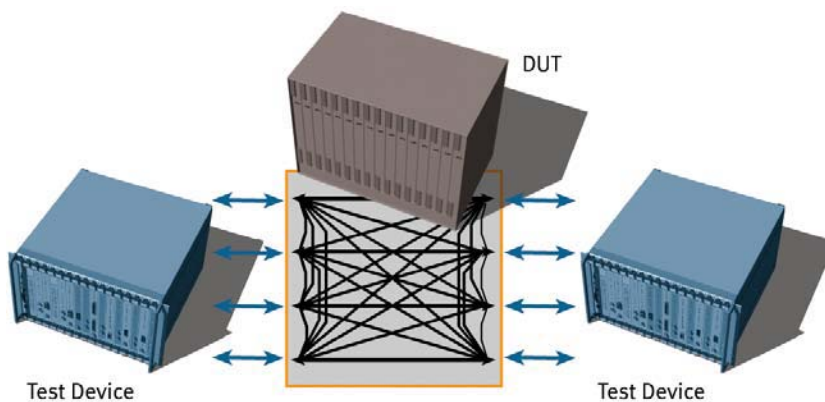
This test will determine if the L2 switch can handle a full mesh of traffic (from all-ports to all-ports) at various traffic loads. Fully meshed traffic stresses the switch fabric, fully exercises the forwarding tables and reveals weaknesses in resource allocation mechanisms.

This test is more stressful and exacting than a simple forwarding rate test, which does not penalize a switch that drops an occasional packet at all offered loads. It measures the DUT/SUT's forwarding rate and throughput on each of the recommended RFC 2889 frames sizes.

The forwarding rate test will determine the maximum number of frames per second the DUT/SUT can forward, using various loads.

The throughput test will determine the maximum load at which the DUT/SUT will forward traffic without frame loss.

## Setup



Full Mesh Traffic Pattern with an 8-port Device Under Test

## Test Steps

1. Each test port will emulate a single L2 MAC address.
2. From all test ports, send L2 Learning frames to the DUT, and verify them. Ensure the DUT will not “time out” addresses before the end of each test iteration.
3. Traffic will then be sent from every test port in a full mesh, round-robin fashion through the DUT/SUT to every other test port. Traffic pattern shown below:

Source Port	Destination Ports (order of transmission)
Port #1	2 3 4 5 6 7 8 2 3 4 ...
Port #2	3 4 5 6 7 8 1 3 4 5 ...
Port #3	4 5 6 7 8 1 2 4 5 6 ...
Port #4	5 6 7 8 1 2 3 5 6 7 ...
Port #5	6 7 8 1 2 3 4 6 7 8 ...

Port #6	7 8 1 2 3 4 5 7 8 1 ...
Port #7	8 1 2 3 4 5 6 8 1 2 ...
Port #8	1 2 3 4 5 6 7 1 2 3 ...

4. Run forwarding rate test:
  - a. Using 64-byte test packets, a relatively low traffic load, and a 30-second test duration, send packets as described in Step 3.
  - b. Observe the number of test frames per second the device successfully forwards.
  - c. Increase the load and rerun the test.
  - d. Repeat steps b and c until the maximum configured load is completed.
  - e. Report the maximum number of test frames per second that the device is observed to successfully forward to the correct destination interface at each specified load.
5. Run throughput test:
  - a. Using 64-byte packets, a starting traffic load and a 30-second test duration, send packets as described in Step 3. Determine if all packets are received.
  - b. Using a binary search algorithm, increase traffic load if no frame loss, and decrease traffic load if frame loss occurs.
  - c. Continue binary search until maximum traffic load is achieved without frame loss.
  - d. Report the maximum load (throughput) the device successfully forwards without frame loss.
6. Repeat steps 1 to 5 for each remaining recommended frame size: 128, 256, 512, 1024, 1280 and 1518.

## Test Parameters

- Frame sizes (including CRC): Recommended are 64, 128, 256, 512, 1024, 1280, 1518.
- Burst size between 1–930 frames (1 = constant load).
- Full or half duplex (10M/100M).
- Load per port in percentage (%).
- Each trial (or iteration) is 30 seconds (adjustable from 1–300).

## Test Output

- Forwarding rate (maximum frames per second) for each frame size and for each load.
- Throughput (maximum load with no frame loss) for each frame size.
- Flood count.

## Test Variables (Some variables are not RFC 2889 compliant)

- Longer trial/iteration duration.
- Tagged frames (802.1p&Q).
- Use different frame sizes from 64 to 1518 bytes.
- Use multiple frame sizes in the same test/iteration to simulate realistic traffic.
- Define Pass/Fail criteria, such as allowing for a small amount of acceptable frame loss.
- IP/UDP header (TOS/TTL/Port#).

## Sample Results

### Starting Full Mesh Forwarding Rate Test

Frame Length = 64  
 Offered Load = 15,237,939 bps (20.00% util)  
 Forwarding Rate = 416,656 frames/sec (20.00% util)

Offered Load = 30,475,878 bps (40.00% util)  
 Forwarding Rate = 833,324 frames/sec (40.00% util)

Offered Load = 76,190,084 bps (100.00% util)  
 Forwarding Rate = 2,083,322 frames/sec (100.00% util)

**Maximum Forwarding Rate (MFR) = 2,083,322 (frames/sec)**  
**Forwarding Rate at Maximum Offered Load (FRMOL) = 2,083,322 (frames/sec) at MOL of 76,190,084 (bps) 100.00 (% util)**

### Starting Full Mesh Throughput Test

(Start = 100.0 Min = 0.0 Max = 100.0 Resolution = 0.5)

Frame Length = 64

Throughput test parameters: Start = 100.0 Min = 0.0 Max = 100.0 Res = 0.5

Offered load = 76,190,084 bps (100.000% util) ILoad = 100.000% util

Frame Loss Rate = 0.000002 (1 frame)

Offered load = 38,094,848 bps (50.000% util) ILoad = 50.000% util

Frame Loss Rate = 0.000003 (1 frame)

Offered load = 24,999,936 bps (32.813% util) ILoad = 32.813% util

Frame Loss Rate = 0.000000 (0 frames)

Offered load = 25,297,305 bps (33.203% util) ILoad = 33.203% util

Frame Loss Rate = 0.000005 (1 frame)

**Binary search complete: Throughput is 24,999,936 bps (32.813% util)**

MOL = Maximum Offered Load

FR-MOL = Forwarding Rate at Maximum Offered Load

MFR = Maximum Forwarding Rate

# Partially Meshed: One to Many/Many to One

■ RFC 2889 Section 5.2

## Objective

To determine the throughput when transmitting from one-to-many ports or from many-to-one port. To measure the capability to switch frames without frame loss and determine the ability to utilize a port when switching traffic from multiple ports.

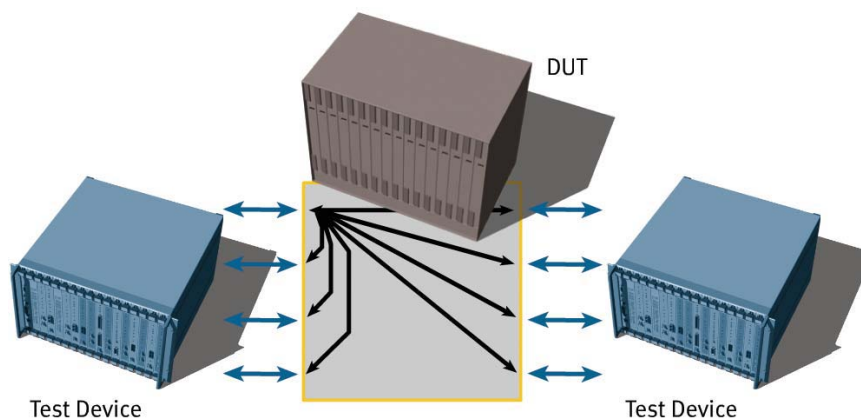
## Overview

This test will determine the forwarding rate of the L2 switch when traffic is sent from one-to-many ports, or from many-to-one. The port patterns provide a unique challenge to each of the three main logic sections of the switch: the ingress data path interface; the switch fabric that connects the ingress ports to egress ports; and, the egress data path interface.

The traffic patterns used are one-way, reverse or bidirectional. The traffic load will be stepped up on each iteration to determine the maximum forwarding rate of the DUT. Caution should be used in the many-to-one test to avoid oversubscribing the “one” port.

The test will be run for each of the RFC 2889 recommended frame sizes.

## Setup



**Partial Mesh One-To-Many/Many-To-One Traffic Pattern  
with an 8-port Device Under Test**

## Test Steps

1. Each test port will emulate a single L2 MAC address.
2. From all test ports, send L2 learning frames to the DUT and verify them. Ensure the DUT will not “time out” addresses before the end of each test iteration.
3. Determine test type:
  - a. One-to-many – One port to many ports.
  - b. Many-to-one – Many ports to one-port.

4. Determine direction of traffic flow:
  - a. One-way – Unidirectional traffic flow.
  - b. Reverse – Opposite direction of one-way.
  - c. Bidirectionally – Both directions simultaneously.
5. The test port(s) will send traffic through the DUT/SUT to the other test port(s).
6. Run forwarding rate test:
  - a. Using 64-byte test packets, a relatively low traffic load and a 30-second test duration, send packets as determined by steps 3, 4 and 5.
  - b. Observe the number of test frames per second the device successfully forwards.
  - c. Increase the load and rerun the test.
  - d. Repeat steps b and c until the maximum configured load has been completed.
  - e. Report the maximum number of test frames per second the device successfully forwards to the correct destination interface at each specified load.
7. Repeat steps 1 to 6 for each remaining recommended frame size: 128, 256, 512, 1024, 1280 and 1518.

## Test Parameters

- Frame sizes (including CRC): Recommended are 64, 128, 256, 512, 1024, 1280, 1518.
- Test type – One port to many ports, or many ports to one port.
- Traffic direction – One direction, reverse direction or both directions.
- Burst size between 1–930 frames (1 = constant load).
- Full or half duplex (10M/100M).
- Load per port in percentage (%).
- Each trial (or iteration) is 30 seconds (adjustable from 1–300).

## Test Output

- Forwarding rate (maximum frames per second) for each frame size and for each load.
- Flood count.

## Test Variables (Some variables are not RFC 2889 compliant)

- Longer trial/iteration duration.
- Tagged frames (802.1p&Q).
- Use different frame sizes from 64 to 1518 bytes.
- Use multiple frame sizes in the same test/iteration to simulate realistic traffic.
- IP/UDP (TOS/TTL/Port#).
- Define Pass/Fail criteria, such as allowing for a small amount of acceptable frame loss.

## Sample Results

### Starting Forwarding Rate test

Direction = Reverse (One to Many)

Frame Length = 64

Offered Load = 544,212 bps (10.00% util)

Forwarding Rate = 14,880 frames/sec (10.00% util)

Offered Load = 1,632,636 bps (30.00% util)

Forwarding Rate = 44,642 frames/sec (30.00% util)

Offered Load = 5,442,150 bps (100.00% util)

Forwarding Rate = 148,808 frames/sec (100.00% util)

**MFR = 148,808 (frames/sec)**

**FRMOL = 148,808 (frames/sec) at MOL of 5,442,150 (bps) 100.00 (% util)**



### **Starting Forwarding Rate test**

Direction = One (Many to One)

Frame Length = 64

Offered Load = 1,414,875 bps (2.00% util)

Forwarding Rate = 36,385 frames/sec (1.88% util)

Offered Load = 2,829,750 bps (4.00% util)

Forwarding Rate = 74,329 frames/sec (3.84% util)

Offered Load = 4,244,626 bps (6.00% util)

Forwarding Rate = 111,428 frames/sec (5.76% util)

Offered Load = 5,659,501 bps (8.00% util)

Forwarding Rate = 145,587 frames/sec (7.53% util)

**Maximum Forwarding Rate (MFR) = 145,587 (frames/sec)**

**Forwarding Rate at Maximum Offered Load (FRMOL) = 145,587 (frames/sec) at MOL of 5,659,501(bps) 8.00 (% util)**

MFR = Maximum Forwarding Rate

FR-MOL = Forwarding Rate at Maximum Offered Load

MOL = Maximum Offered Load

# Partially Meshed: Multiple Devices

■ RFC 2889 Section 5.3

## Objective

To determine the throughput, frame loss and forwarding rates of two switching devices equipped with multiple ports and one high speed backbone uplink.

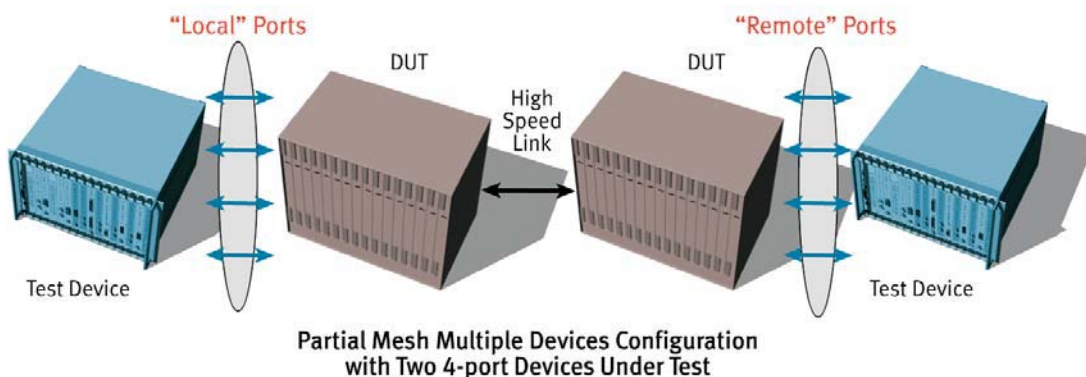
## Overview

This test will determine if two L2 switches, connected by one high-speed backbone link, can handle traffic from all ports on the “local” DUT across the backbone link to all ports on the “remote” DUT. Forwarding rates can be affected by the serialization time or packet transmission time per switch hop if packets are stored several times between source and destination. This serialization delay is incurred for every hop along the path.

RFC 2889 permits turning local traffic ON to create a full mesh traffic pattern (from all ports to all ports).

This test measures the DUT/SUT’s forwarding rate and throughput on each of the recommended RFC 2889 frames sizes. The forwarding rate test will determine the maximum number of frames per second the DUT/SUT can forward using various loads. The throughput test will determine the maximum load at which the DUT/SUT will forward traffic without frame loss.

## Setup



## Test Steps

1. Each test port will emulate a single L2 MAC address.
2. From all test ports, send L2 learning frames to the DUT and verify them. Ensure the DUT will not “time out” addresses before the end of each test iteration.
3. Determine local traffic ON or OFF:
  - a. ON indicates traffic will be sent from every test port in a full mesh, round-robin fashion through the DUT/SUT to every other test port, as described in Step 3 of the first test on Page 1 (Fully Meshed Throughput, Frame Loss and Forwarding Rates).
  - b. OFF indicates traffic will be sent in a round robin fashion from every test port on the “local” DUT to all ports on the “remote” DUT, and vice versa.
4. Run forwarding rate test:
  - a. Using 64-byte test packets, a relatively low traffic load and a 30-second test duration, send packets as described in Step 3.

- b. Observe the number of test frames per second the device successfully forwards.
  - c. Increase the load and rerun the test.
  - d. Repeat steps b and c until the maximum configured load has been completed.
  - e. Report the maximum number of test frames per second the device successfully forwards to the correct destination interface at each specified load.
5. Run throughput test:
    - a. Using 64-byte packets, a starting traffic load and a 30-second test duration, send packets as described in Step 3. Determine if all packets are received.
    - b. Using a binary search algorithm, increase traffic load if no frame loss and decrease traffic load if frame loss occurs.
    - c. Continue binary search until maximum traffic load is achieved without frame loss.
    - d. Report the maximum load (throughput) the device successfully forwards without frame loss.
  6. Repeat steps 1 to 5 for each remaining recommended frame size: 128, 256, 512, 1024, 1280 and 1518.

### Test Parameters

- Frame sizes (including CRC): Recommended 64, 128, 256, 512, 1024, 1280, 1518.
- Burst size from 1–930 frames (1 = constant load).
- Full or half duplex (10M/100M).
- Load per port in percentage (%).
- Each trial (or iteration) is 30 seconds (adjustable from 1–300).

### Test Outcome

- Forwarding rate (maximum frames per second) for each frame size and for each load.
- Throughput (maximum load with no frame loss) for each frame size.
- Flood count.

### Test Variables (Some variables are not RFC 2889 compliant)

- Longer trial/iteration duration.
- Tagged frames (802.1p&Q).
- Use different frame sizes from 64 to 1518 bytes.
- Use multiple frame sizes in the same test/iteration to simulate realistic traffic.
- Define Pass/Fail criteria, such as allowing for a small amount of acceptable frame loss.
- IP/UDP header (TOS/TTL/Port#).

## Sample Results

### Starting Partial Mesh Multiple Devices Forwarding Rate Test

LocalTraffic = Yes  
Frame Length = 64  
Offered Load = 15,237,939 bps (20.00% util)  
Forwarding Rate = 416,662 frames/sec (20.00% util)  
  
Offered Load = 30,475,878 bps (40.00% util)  
Forwarding Rate = 833,324 frames/sec (40.00% util)  
  
Offered Load = 76,190,084 bps (100.00% util)  
Forwarding Rate = 2,083,322 frames/sec (100.00% util)

**MFR = 2,083,322 (frames/sec)**

**FRMOL = 2,083,322 (frames/sec) at MOL of 76,190,084 (bps) 100.00 (% util)**

### Starting Partial Mesh Multiple Devices Throughput Test

LocalTraffic=No  
Frame Length = 64  
Throughput Test Parameters: Start = 100.0 Min = 0.0 Max = 100.0 Resolution = 0.5  
Offered load = 76,190,084 bps (100.000% util)  
Intended Load (ILoad) = 100.000% util Frame Loss  
Rate = 28.5 (17,855,864 frames)

Offered load = 38,094,848 bps (50.000% util)  
ILoad = 50.000% util  
Frame Loss Rate = 0.000013 (4 frames)

Offered load = 19,047,219 bps (25.000% util)  
ILoad = 25.000% util  
Frame Loss Rate = 0.000006 (1 frames)

Offered load = 9,523,609 bps (12.500% util)  
ILoad = 12.500% util  
Frame Loss Rate = 0.000000 (0 frames)

Offered load = 16,368,844 bps (21.484% util)  
ILoad = 21.484% util  
Frame Loss Rate = 0.000000 (0 frames)

**Binary search complete: Throughput is 16,368,844 bps (21.484% util)**

FR-MOL = Forwarding Rate at Maximum Offered Load

ILoad = Intended Load

MFR = Maximum Forwarding Rate

MOL = Maximum Offered Load

# Partially Meshed: Unidirectional Traffic

■ RFC 2889 Section 5.4

## Objective

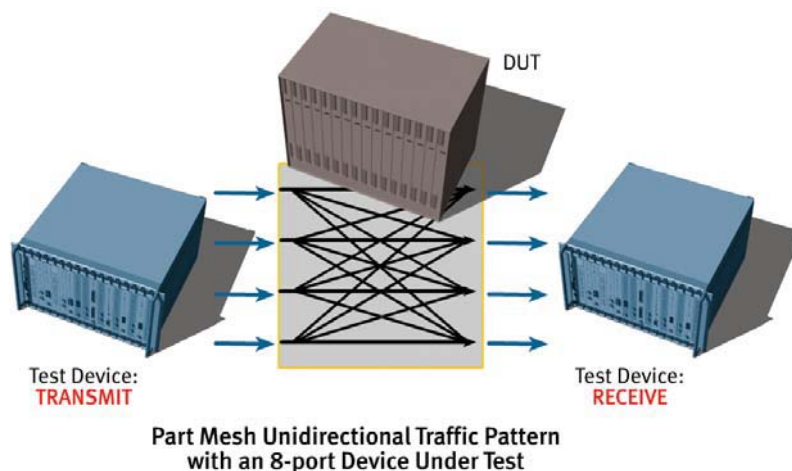
To determine the throughput of the DUT/SUT when multiple streams of one-way traffic using half of the ports on the DUT/SUT are sending frames to the other half of the ports.

## Overview

This test will determine how the L2 switch handles traffic in one direction from one half of the test ports destined to the other half of the test ports. This traffic pattern simulates a common network topology in which half of the users on a network are transmitting to each of the other half of users.

This test measures the forwarding rate and throughput of the DUT/SUT for each recommended RFC 2889 frames size. The forwarding rate test determines the maximum number of frames per second the DUT/SUT can forward, using various loads. The throughput test determines the maximum load at which the DUT/SUT forwards traffic without frame loss.

## Setup



## Test Steps

1. Each test port will emulate a single L2 MAC address.
2. From all test ports, send L2 Learning frames to the DUT, and verify them. Ensure the DUT will not “time out” addresses before the end of each test iteration.
3. Traffic is then sent in one direction from one half of the test ports destined to the other half of the test ports. Traffic must be sent in a round-robin fashion, as shown below:

<u>Source Test Port</u>	<u>Destination Test Ports (transmission order)</u>
Port #1	5 6 7 8 5 6...
Port #2	6 7 8 5 6 7...
Port #3	7 8 5 6 7 8...
Port #4	8 5 6 7 8 5...

4. Run forwarding rate test:
  - a. Using 64-byte test packets, a relatively low traffic load, and a 30-second test duration, send packets as described in Step 3.
  - b. Observe the number of test frames per second the device successfully forwards.
  - c. Increase the load and rerun the test.
  - d. Repeat steps b and c until the maximum configured load has been completed.
  - e. Report the maximum number of test frames per second the device successfully forwards to the correct destination interface at each specified load.
5. Run throughput test:
  - a. Using 64-byte packets, a starting traffic load and a 30-second test duration, send packets as described in Step 3, and determine if all packets are received.
  - b. Using a binary search algorithm, increase traffic load if no frame loss and decrease traffic load if frame loss occurs.
  - c. Continue binary search until maximum traffic load is achieved without frame loss.
  - d. Report the maximum load (throughput) the device successfully forwards without frame loss.
6. Repeat steps 1 to 5 for each remaining recommended frame size: 128, 256, 512, 1024, 1280 and 1518.

## Test Parameters

- Frame sizes (including CRC): Recommended are 64, 128, 256, 512, 1024, 1280, 1518.
- Burst size from 1–930 frames (1 = constant load).
- Full or half duplex (10M/100M).
- Load per port in percentage (%).
- Each trial (or iteration) is 30 seconds (adjustable from 1–300).

## Test Outcome

- Forwarding rate (maximum frames per second) for each frame size and for each load.
- Throughput (maximum load with no frame loss) for each frame size.
- Flood count.

## Test Variables (Some variables are not RFC 2889 compliant)

- Longer trial/iteration duration.
- Tagged frames (802.1p&Q).
- Use different frame sizes from 64–1518 bytes.
- Use multiple frame sizes in the same test/iteration to simulate realistic traffic.
- Define Pass/Fail criteria, such as allowing for a small amount of acceptable frame loss.
- IP/UDP header (TOS/TTL/Port#).

## Sample Results

### Starting Partial Mesh Unidirectional Forwarding Rate Test

Frame Length = 64

Offered Load = 7,618,969 bps (20.00% util)

Forwarding Rate = 208,331 frames/sec (20.00% util)

Offered Load = 15,237,939 bps (40.00% util)

Forwarding Rate = 416,662 frames/sec (40.00% util)

Offered Load = 38,095,052 bps (100.00% util)

Forwarding Rate = 1,041,661 frames/sec (100.00% util)

**MFR = 1041661 (frames/sec)**

**FRMOL = 1041661 (frames/sec) at MOL of 38,095,052 (bps) 100.00 (% util)**

### Starting Partial Mesh Unidirectional Throughput Test

Frame Length = 64

Throughput Test Parameters: Start = 100.0 Min = 0.0 Max = 100.0 Resolution = 0.5

Offered load = 38,095,052 bps (99.999% util)

Intended Load (ILoad) = 100.000% util

Frame Loss Rate = 0.00 (0 frames)

**Binary search complete: Throughput is 38,095,052 bps (99.999% util)**

FR-MOL = Forwarding Rate at Maximum Offered Load

ILoad = Intended Load

MFR = Maximum Forwarding Rate

MOL = Maximum Offered Load

# Congestion Control

■ RFC 2889 Section 5.5

## Objective

To determine how a DUT handles congestion, whether the device implements congestion control and whether congestion on one port affects an uncongested port.

## Overview

The DUT's ability to handle oversubscription on an egress port will be determined. Two test ports will transmit at 100 percent wire rate into the DUT. Two egress DUT ports will receive the traffic, one (uncongested port) receiving 50 percent of the total 200 percent, and the other (congested port) receiving the remaining 150 percent.

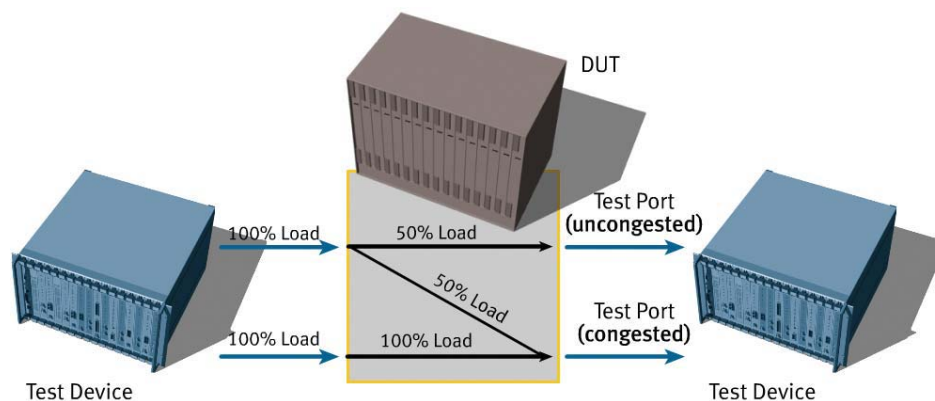
Head of line blocking (HOLB) is present if the DUT is losing frames destined for the uncongested port. If HOLB is present, packets are queued in a buffer at the input port or within the switch fabric. A packet destined for an uncongested output port can be forwarded only after all packets ahead of it in the queue are forwarded. This results in buffer overflow and packet loss for traffic streams forwarded over uncongested and congested ports. A switch without HOLB will not drop packets destined for uncongested ports, regardless of congestion on other ports. HOLB can restrict the switch's average forwarding performance.

Back pressure is defined in RFC 2285 as "any technique used by a DUT/SUT to attempt to avoid frame loss by impeding external sources of traffic from transmitting frames to congested interfaces." It is present if there is no loss on the congested port. The DUT may be trying to impede the test equipment from transmitting the frames as by using 802.3x flow control or sending preamble bits.

The DUT correctly handles this by not having HOLB or back pressure, but by throwing away the majority of traffic destined for the congested port. Full duplex testing is assumed.

Measurements provided comprise offered load from the transmitting ports, frame loss from the receiving ports and maximum forwarding rate per frame size.

## Setup



**Congestion Control Traffic Pattern with a 4-port Device Under Test**



## Test Steps

1. A minimum of four test ports and four DUT ports are required. Two test ports are transmitters, the other two are receivers  
**Note:** Multiple groups of four ports can be added to the test.
2. Each test port will emulate a single L2 MAC address.
3. From all test ports, send L2 Learning frames to the DUT, and verify them. Make sure the DUT will not “time out” addresses before the end of each test iteration.
4. Traffic is then sent from both transmitter test ports at 100 percent load.
  - a. One transmitter will send all of its traffic to one of the receiver ports. The second transmitter will send half of its traffic to one receiver port, and the other half to the other receiver port.
  - b. This will produce one of the 2 receiver DUT ports (the uncongested port) receiving 50 percent traffic from one transmitter, and the second receiver DUT port (the congested port) receiving 150 percent of the traffic.
5. Run forwarding rate/frame loss test:
  - a. Using 64-byte test packets for a 30-second test duration, send packets as in Step 4.
  - b. Report the number of test frames per second the device successfully forwards, on both the congested and uncongested port(s).
  - c. Report the frame loss rate (% of loss) on both the congested and uncongested port(s).
6. If frame loss is present on the uncongested port, then “head of line” blocking is present, and must be reported. The DUT is unable to forward traffic to the congested port and, as a result, it is also losing frames destined for the uncongested port.
7. If no frame loss is present on the congested port, then back pressure is present and must be reported. The DUT may be trying to impede the test equipment from transmitting the frames, for example using 802.3x flow control or sending preamble bits.
8. Repeat steps 2 to 7 for each remaining recommended frame size: 128, 256, 512, 1024, 1280 and 1518).

## Test Parameters

- Frame sizes (including CRC): Recommended are 64, 128, 256, 512, 1024, 1280, 1518.
- Minimum interframe gap must be used between frames in single burst.
- Full or half duplex (10M/100M).
- Load per Tx port = 100 percent.
- Each trial (or iteration) is 30 seconds (adjustable from 1–300).

## Test Outcome

- Frame loss percentage.
- Forwarding rate (maximum frames per second) for each frame size.

## Test Variables (Some variables are not RFC 2889 compliant)

- Longer trial/iteration duration.
- Tagged frames (802.1p&Q).
- Use different frame sizes from 64–1518 bytes.
- Use multiple frame sizes in the same test/iteration to simulate realistic traffic.
- Define Pass/Fail criteria.
- IP/UDP header (TOS/TTL/Port#).

## Sample Results

### Starting Congestion Control Test

Frame Length = 64

Intended Load (ILoad) = 100.0

Port Block 1 (Ports: Port 1, Port 2, Port 3 and Port 4)

Transmit Port 1 Offered Load = 76,190,105 bps (100.00% util)

Transmit Port 2 Offered Load = 76,190,105 bps (100.00% util)

Port 1 → Port 3 (uncongested) **FR = 74,404 fps** **FLR = 0.00%**

Port 1 → Port 4 (congested) **FR = 10,618 fps** **FLR = 85.73%**

Port 2 → Port 4 (congested) **FR = 138,197 fps** **FLR = 7.13%**

**Head of line blocking not observed in any port blocks.**

**Back pressure not observed in any port blocks.**

FLR = Frame Loss Rate (% of lost traffic)

FR = Forwarding Rate

ILoad = Intended Load

# Forward Pressure and Maximum Forwarding Rate

■ RFC 2889 Section 5.6

## Objective

The forward pressure test overloads a DUT/SUT port and measures the output for forward pressure. If the DUT/SUT transmits with an interframe gap less than 96 bits, then forward pressure is detected. The maximum forwarding rate test measures the peak value of the forwarding rate when the load is varied between the throughput value derived from the first test on Page 1 (Fully Meshed Throughput, Frame Loss and Forwarding Rates) and the maximum load.

## Overview

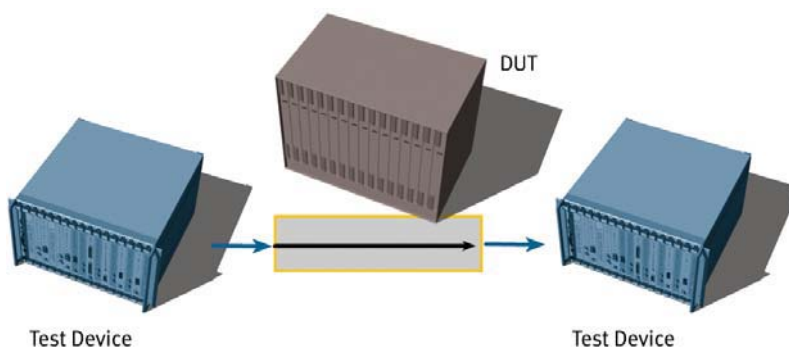
This section of the RFC comprises two tests.

The first part of the test, forward pressure, stresses the DUT by sending it traffic at higher than wire rate load, using an interframe gap of 88 bits when the IEEE 802.3 standard allows for no less than 96 bits. The DUT, on the egress port, should properly transmit per the standard with a 96-bit interframe gap. If the DUT transmits at less than 96 bits, then forward pressure is detected and must be reported.

Switches that transmit with less than a 96-bit interframe gap violate the IEEE 802.3 standard and gain an unfair advantage over other devices on the network. Other switches may not interoperate properly with the switch in violation.

The second part of the test, maximum forwarding rate, is similar to the forwarding rate test as described in the methodology on Page 1 of this journal. However, in this test, the minimum forwarding rate used should be the result of the throughput test as derived from the test on Page 1. Measurements are taken of the maximum forwarding rate per frame size.

## Setup



Unidirectional Traffic Pattern with 2 ports Under Test

## Test Steps

1. A minimum of two test ports and two DUT ports are required.  
**Note:** Groups of two ports can be added to the test.
2. Each test port will emulate a single L2 MAC address.
3. From each test port, send L2 Learning frames to the DUT, and verify them. Ensure the DUT will not “time out” addresses before the end of each test iteration.

4. Forward pressure test:
  - a. Using 64-byte test packets and a 30-second test duration, send unidirectional traffic from one test port through the DUT/SUT to the other test port. The load for each frame size is greater than the link's theoretical utilization, using an interframe gap of 88 bits.
  - b. The forwarding rate on the receiving port is measured. The rate should not exceed the link's theoretical (96-bit gap) utilization or else forward pressure must be reported.
  - c. Measurements of maximum forwarding rate per frame size are taken

**Note:** Results per port pair should be reported if using multiple groups of two ports.
5. Maximum forwarding rate test:

**Note:** The Fully Meshed Throughput test starting on Page 1 must be run first to achieve the throughput value for each frame size. If the throughput value equals the maximum load (100 percent), then the maximum forwarding rate is equal to maximum load (100 percent). Therefore, this test is not necessary to complete.

  - a. Using 64-byte test packets, the traffic load equal to the throughput value achieved in Step 1, and a 30-second test duration, send unidirectional traffic from one test port through the DUT/SUT to the other test port.
  - b. Observe the number of test frames per second the device successfully forwards.
  - c. Increase the load using as small a load increment as possible and re-run the test.
  - d. Repeat steps b and c until the maximum load has been completed.
  - e. Report the maximum number of test frames per second the device successfully forwards to the correct destination interface at each specified load.
6. Repeat steps 2 to 7 for each remaining recommended frame size: 128, 256, 512, 1024, 1280 and 1518.

## Test Parameters

- Frame sizes (including CRC): Recommended are 64, 128, 256, 512, 1024, 1280, 1518.
- Full or half duplex (10M/100M).
- Each trial (or iteration) is 30 seconds (adjustable from 1–300).
- For forwarding rate test, include:
  - Starting load equal to result from throughput test in the first test (Fully Meshed Throughput, Frame Loss and Forwarding Rates) on Page 1 of this journal.
  - Iteration step size as small as possible (increments of 1 percent).

## Test Outcome

- Forwarding rate (maximum frames per second) for each frame size and for each load.
- Forward pressure detected – True or false.
- Flood count.

## Test Variables (Some variables are not RFC 2889 compliant)

- Longer trial/iteration duration.
- Tagged frames (802.1p&Q).
- Define Pass/Fail criteria, such as allowing for a small amount of acceptable frame loss.
- Use different or multiple DUT port pairs.
- Use different frame sizes from 64 to 1518 bytes.
- Use multiple frame sizes in the same test/iteration to simulate realistic traffic.

## Results Summary

### Starting Forwarding Rate Test

Frame Length = 64

Offered Load = 12,499,968 bps (32.81% util)

Forwarding Rate = 341,796 frames/sec (32.81% util)

Offered Load = 14,404,608 bps (37.81% util)

Forwarding Rate = 393,876 frames/sec (37.81% util)

Offered Load = 16,309,452 bps (42.81% util)

Forwarding Rate = 445,961 frames/sec (42.81% util)

Offered Load = 35,357,081 bps (92.81% util)

Forwarding Rate = 966,795 frames/sec (92.81% util)

Offered Load = 37,261,721 bps (97.81% util)

Forwarding Rate = 1,018,875 frames/sec (97.81% util)

Offered Load = 38,095,032 bps (100.00% util)

**Forwarding Rate = 1,041,661 frames/sec (100.00% util)**

**MFR = 1,041,661 frames/sec (100.000% util)**

**Note:** Starting "Offered load" (in this case 32.81% for 64 byte frames) is equal to result of throughput test in the test starting on Page 1 (Fully Meshed Throughput, Frame Loss and Forwarding Rates). This should be derived for each frame size, per RFC 2889.

### Starting Forwarding Pressure Test

Port Pair: Port1 → Port2

ILoad = 150,602 fps Max Theoretical ILoad = 148,809 fps FR = 146,439 fps

**Forward pressure not observed.**

FR = Forwarding Rate

MFR = Maximum Forwarding Rate

ILoad = Intended Load

# Address Caching Capacity

■ RFC 2889 Section 5.7

## Objective

To determine in the address caching capacity of a LAN switching device as defined in RFC 2285, Section 3.8.1.

## Overview

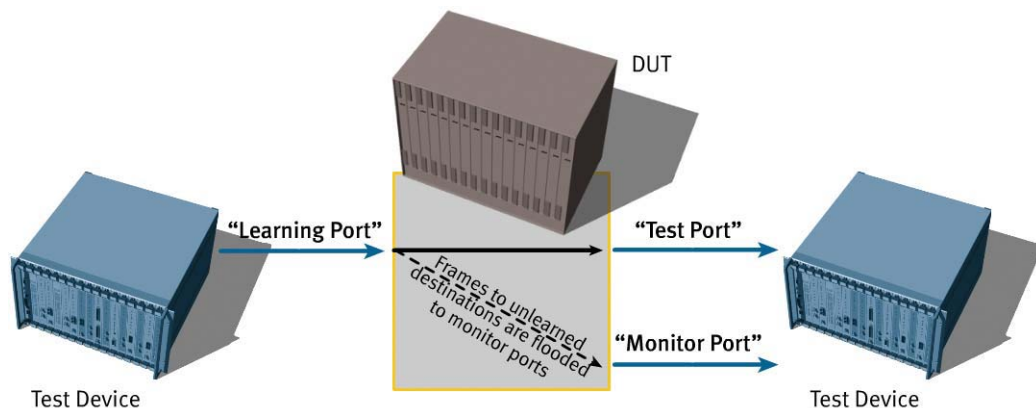
Layer 2 switches forward traffic based on the destination MAC address in the Ethernet frame. Forwarding tables, also called MAC tables, are created dynamically in the switch. These tables provide a correlation between the MAC address and a given port on the switch. These tables can be built manually (hardcoded) or by the process of sourcing traffic from a port. When traffic is sourced from a port, the switch updates the table with the frame's source MAC address and the port number. Once in the table, other ports can successfully transmit to the port that was "sourced."

If the switch tries to transmit frames with a MAC address not found in the MAC table, the switch will "flood" the frames by broadcasting them to all ports on the switch (not just the intended port). This flooded traffic can cause devastating network conditions, usually in the form of dropped packets. The maximum size of the switch forwarding table can vary from switch to switch.

This test will provide this maximum size and insight on preventing flooding on the network. This test also will determine the maximum number of addresses correctly learned by the DUT. Test packets will then be forwarded through the DUT, checking for flooding or misforwarding frames. If flooding of the frames is received on a third port (the monitor port), or any other port, then the DUT cannot handle the number of addresses sent. If no such flooding occurs, the test iteration is successful.

The binary search algorithm will determine the maximum number of addresses the DUT can handle. Measurements are taken of learning frames sent, received and flooded.

## Setup



Address Caching Capacity Traffic Pattern

## Test Steps

1. A minimum of three test ports and three DUT ports are required. One of the test ports is the learning port, another is the test port, and the third is the monitor port.
2. L2 learning frames are sent from the test equipment to the DUT and then verified.
  - a. One learning frame is sent from the “test” port.
  - b. ‘N’ learning frames are sent from the “learning” port. Each has the same destination address, but unique source addresses. Send frames at an acceptable fps rate to the DUT.

**Note:** Make sure the DUT will not “time out” addresses before the end of each test iteration.
3. At an acceptable rate to the DUT, the test port will then transmit ‘N’ test frames using the same addresses from Step 2b, except with the source/destination addresses reversed (a single source address, but unique destination address), destined for the learning port.
4. The monitoring port listens for flooded or misforwarded frames.
5. Using a binary search algorithm, determine the maximum number of addresses that are correctly learned and forwarded by the DUT without flooding or misforwarding any frames.
  - a. If the number of test frames forwarded to the learning port matches the number sent by the test port, and there are no flooded frames on any port, then the iteration passes. Select the next higher ‘N’ number of addresses in the binary search algorithm and repeat steps 2-5.
  - b. If the number of test frames forwarded to the learning port does not match the number sent by the test port, and/or there are flooded frames on any port, then the iteration fails. Select the next lower ‘N’ number of addresses in the binary search algorithm and repeat steps 2 to 5.

**Note:** A pause for x amount of seconds should be inserted before each next iteration (Step 2) so the DUT can purge/age the existing addresses.
6. Continue with the binary search until the maximum number of addresses is found, without flooding. This will determine the size of the address cache, or forwarding database, of the DUT.

## Test Parameters

- DUT Age time – Time DUT will keep learned addresses in forwarding table.
- Address learning rate – Rate at which new addresses are offered to the DUT.
  - 50 fps or less, if necessary, to guarantee successful learning.
- Initial addresses, ‘N’ – Number of unique address frames used per iteration.
- Turn off all other protocols on DUT (or you must account for them in results).
- DUT address caching capacity – Theoretical maximum.

## Test Outcome

- DUT address caching capacity (maximum addresses cached) using search algorithm.
- Flood count.

## Test Variables (Some variables are not RFC 2889 compliant)

- Source addresses sequential or non-sequential.
- Learning frames per second (higher or lower than 50 fps).
- Increment by 2 or 3 ports.
  - 2 ports include additional learning and test ports.
  - 3 ports include additional learning, test and monitor ports.
- Tagged frames (802.1p&Q).
  - Each broadcast (VLAN) domain requires a monitor port.
- Define pass/fail criteria.

## Sample Results

### Starting Address Caching Capacity Test

AddressCachingLoads is 2000:100:4096:1 (start:min:max:resolution)  
Learning rate (Intended Load) is 50 fps  
Age time is 300 seconds

Number of Addresses	Tport Transmit	Lport Receive	Tport Flood	Mport Flood	
2,000	1,998	1,998	977	2,931	Number of addresses = Number of addresses total
1,050	1,048	1,048	27	81	Tport Tx = Test port Tx addresses
575	573	573	0	0	Lport Rx = Learning port Rx adds
812	810	810	0	0	Tport Flood = Test port Rx flooded adds
931	929	929	0	0	Mport Flood = Monitor port Rx adds
990	988	988	2	6	
963	961	961	1	3	
962	960	960	0	0	

**DUT is capable of learning 962 addresses (including the 2 test port addresses).**



# Address Learning Rate

■ RFC 2889 Section 5.8

## Objective

To determine the rate of address learning of a LAN switching device.

## Overview

Before a switch can forward L2 traffic it must learn the MAC address of the destination port. Optimal address learning rates reduce traffic delays and promote efficient use of bandwidth.

This test will determine the rate, expressed in frames per second (fps), at which addresses are correctly learned by the DUT. Test packets will then be forwarded through the DUT, checking for flooding or misforwarding frames.

Learning frames will first be sent into the DUT at a given rate (fps), followed by test frames. The number of test frames received must match the number sent, without flooding.

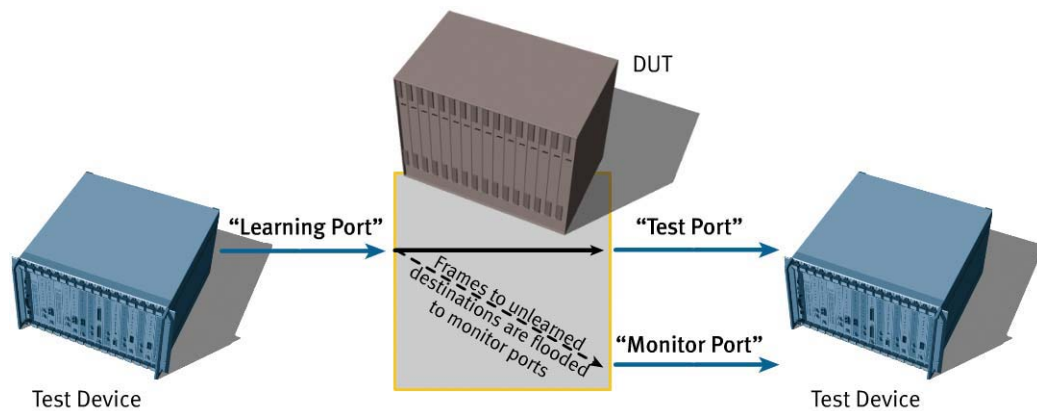
If flooding of the frames is received on a third port (the monitor port), or any other port, then the DUT cannot handle the rate at which learning frames were sent.

If no flooding of the frames occurs, then the test iteration is successful. The rate (fps) of learning frames can be increased for the next iteration.

The binary search algorithm will determine the maximum rate (fps) for which the DUT learns addresses.

Measurements are taken of learning frames sent per second, # of addresses used, # of addresses received and # of addresses flooded.

## Setup



Address Learning Rate Traffic Pattern

## Test Steps

1. A minimum of three test ports and three DUT ports are required. One test port is the learning port, another is the test port and the third is the monitor port.
2. Determine an initial rate (fps) at which learning frames are sent to the DUT.
3. Send L2 learning frames from the test equipment to the DUT.
  - a. One learning frame is sent from the “test” port.
  - b. ‘N’ learning frames are sent from the “learning” port. Each has the same destination address but unique source addresses.

**Note:** The ‘N’ number of learning frames should be the same, or less, than the maximum address capacity of the DUT as determined in the previous test (Address Caching Capacity) on Page 19.

**Note:** Ensure the DUT will not “time out” addresses before the end of each test iteration.
4. At an acceptable rate to the DUT, the test port will transmit ‘N’ test frames using the same addresses from Step 3b, except with the source/destination addresses reversed (a single source address, but unique destination address) destined for the learning port.
5. The monitoring port listens for flooded or misforwarded frames.
6. Using a binary search algorithm, determine the maximum learning rate (in fps) of the DUT.
  - a. If the number of test frames forwarded to the learning port matches the number sent by the test port, and there are no flooded frames on any port, then the iteration passes. Select the next higher learning rate (fps) in the binary search algorithm and repeat steps 3 to 6.
  - b. If the number of test frames forwarded to the learning port does not match the number sent by the test port, and/or there are flooded frames on any port, then the iteration fails. Select the next lower learning rate (fps) in the binary search algorithm and repeat steps 3 to 6.

**Note:** A pause for x amount of seconds should be inserted before each next iteration (Step 3) so the DUT can purge/age the existing addresses.
7. Continue with the binary search until the maximum learning rate (in fps) of addresses is found without flooding.

## Test Parameters

- DUT age time – Time DUT will keep learned addresses in forwarding table.
- Address learning rate – Rate (in fps) at which new addresses are offered to DUT.
- Initial addresses – Number of initial addresses at beginning of test.
- The maximum addresses used should not exceed the result of the Address Caching Capacity test (test just prior) starting on Page 19.

## Test Outcome

- DUT Address learning rate (in frames per second) using search algorithm.
- Flood count.

## Test Variables (Some variables not RFC 2889 compliant)

- Source addresses sequential or non-sequential.
- Try wire rate address learning rate, or lowest rate (1 fps).
- Use more addresses than found in Address Caching Capacity (test just prior).
  - Also try less than test just prior to see if result (fps) is higher.
- Increment by 2 or 3 ports.
  - 2 ports include additional learning and test ports.
  - 3 ports include additional learning, test and monitor ports.
- Tagged frames (802.1p&Q).
  - Each broadcast (VLAN) domain requires a monitor port.
- Define pass/fail criteria.

## Results Summary

### Starting Address Learning Rate Test

Address Learning Loads is 10000:5000:10000:1 (start:min:max:resolution)

Number of Learning frames is 962- Age time is 300 seconds

Learning Rate	Tport Transmit	Lport Receive	Tport Flood	Mport Flood	
10,000	962	962	131	393	Learning Rate = fps rate
7,500	962	962	56	168	Tport Tx = Test port Tx addresses
6,250	962	962	0	0	Lport Rx = Learning Port Rx adds
6,875	962	962	27	81	Tport Flood = Test port Rx flooded adds
6,562	962	962	13	39	Mport Flood = Monitor port Rx adds
6,332	962	962	0	0	
6,334	962	962	1	3	
6,333	962	962	0	0	

DUT is capable of learning addresses at a rate of **6,333 fps**.

# Errored Frames Filtering

■ RFC 2889 Section 5.9

## Objective

To determine the behavior of the DUT under error or abnormal frame conditions. The results of the test indicate whether the DUT filters or forwards errored frames.

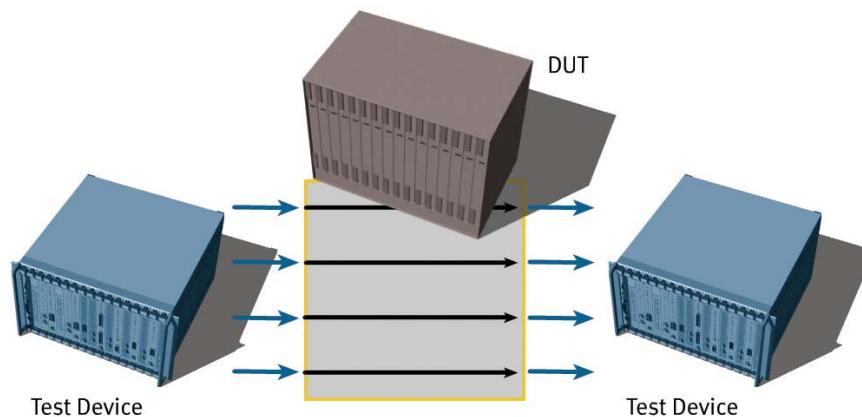
## Overview

Layer 1 and 2 switch errors can cause performance degradation. CRC errors can cause retries and delays in upper layer protocol exchanges. This test will determine if errored packets are correctly forwarded, or filtered, through the DUT. The errored packet types are:

- Oversize frames – Frames above 1518 (or 1522 if VLAN tagged) in length.
- Undersize frames – Frames less than 64 bytes in length.
- CRC errored frames – Frames with invalid CRC that fail the Frame Check Sequence Validation.
- Dribble bit errors – Frames without proper byte boundary.
- Alignment errors – Combination of CRC errored and dribble bit errored frames.

Measurements will be taken of errored frames transmitted and received for each errored packet type and frame size.

## Setup



Errored Frames Port-to-port Traffic Pattern with an 8-port DUT

## Test Steps

1. A minimum of two test ports and two DUT ports are required.
  - Note:** Groups of two ports can be added to the test if desired.
2. Each test port will emulate a single L2 MAC address.
3. From each test port, send L2 learning frames to the DUT and verify them.
  - Note:** Make sure the DUT will not “time out” addresses before the end of each test iteration.
4. Using a predetermined load and a 30-second test duration, send unidirectional test traffic from one test port through the DUT/SUT to the other test port with the following errored frames:
  - a. Oversize frames – Frames above 1518 (or 1522 if VLAN tagged) in length.

- b. Undersize frames – Frames less than 64 bytes in length.
  - c. CRC errored frames – Frames with invalid CRC.
  - d. Dribble bit errors – Frames without proper byte boundary.
  - e. Alignment errors – Combination of CRC errored and dribble bit errored frames.
5. The DUT must take the following actions for the above errored frames:
    - a. Oversize Frames should not be forwarded.
    - b. Undersize Frames must not be forwarded.
    - c. CRC errored frames should not be forwarded.
    - d. Dribble bit errors must be corrected and forwarded.
    - e. Alignment errors must not be forwarded.
  6. Take measurements on the receive side.
    - a. For each errored packet type, measurements of frames transmitted and received are recorded.
    - b. A 'Pass' or 'Fail' for each errored packet type must be reported.
  7. Repeat steps 3 to 6 using various port loads.

### Test Parameters

- Errored frames:
  - Oversize – Frames above 1518 (or 1522 if VLAN tagged) in length.
  - Undersize – Frames less than 64 bytes in length.
  - CRC errored frames – Frames with invalid CRC.
  - Dribble bit errors – Frames without proper byte boundary.
  - Alignment errors – Combination of CRC errored and dribble bit errored frames.
- Load per port in percentage (%).
- Full or half duplex (10M/100M).
- Each trial (or iteration) is 30 seconds (adjustable from 1–300).

### Test Outcome

- Pass/Fail – Frames size used, load, type of errored packet and Tx/Rx statistics.

### Test Variables (Some variables are not RFC 2889 compliant)

- Tagged frames (802.1p&Q).
- Use non-errored packets.
- Use errored packet frame sizes: 64, 128, 256, 512, 1024, 1280, 1518.
- IP/UDP header (TOS/TTL/Port#).
- Add multiple port pairs.

## Results Summary

### Starting Errored Frames Test

Frame Length = 64, 20.0% utilization

No-Error Frames Test: **Passed**

Undersize Frames Test: **Passed**

Oversize Frames Test: **Passed**

CRC Errors Test: **Passed**

Alignment Errors Test: **Passed**

Dribble Bits Test: **Passed**

Frame Length = 64, 30.0% utilization

No-Error Frames Test: **Passed**

Undersize Frames Test: **Passed**

Oversize Frames Test: **Passed**

CRC Errors Test: **Passed**

Alignment Errors Test: **Passed**

Dribble Bits Test: **Passed**

### RFC 2889 Errored Frames Test

Duration = 30

Frame Length	Intended Load	Test	Result	Transmit	Receive	Receive Triggers	Iteration
64	20	No-Error Frames	Pass	6,249,810	6,249,814	6,249,810	1
56	20	Undersize Frames	Pass	6,907,740	6	0	2
10,000	20	Oversize Frames	Pass	52,290	5	0	3
64	20	CRC Errors	Pass	6,249,810	3	0	4
64	20	Alignment Errors	Pass	5,356,980	4	0	5
64	20	Dribble Bits	Pass	5,356,980	5,356,986	5,356,980	6

# Broadcast Frame Forwarding and Latency

■ RFC 2889 Section 5.10

## Objective

To determine the throughput and latency of the DUT when forwarding broadcast traffic.

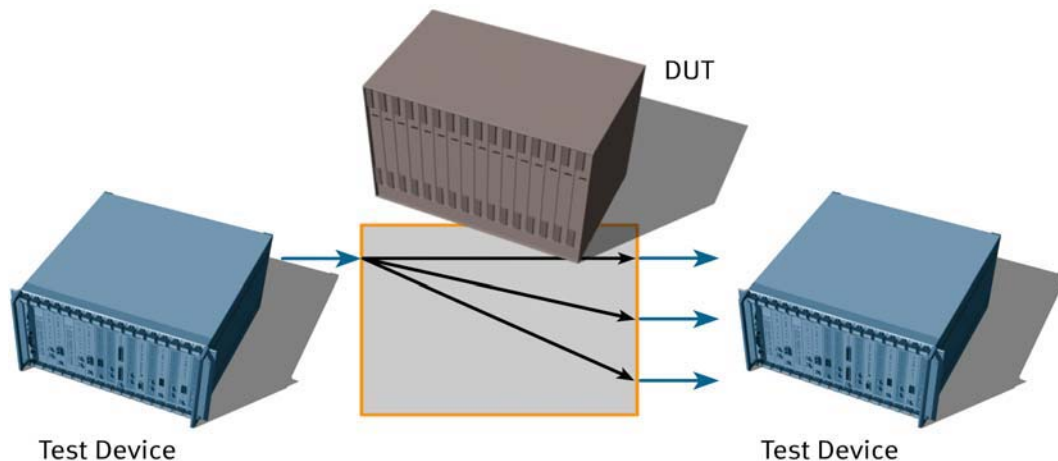
## Overview

This test will determine if the Layer 2 switch can handle broadcast traffic from one-to-many ports at various traffic loads.

Broadcasts are necessary for a station to reach multiple stations with a single packet when the specific address of each intended recipient is not known by the sending node. Network traffic, such as some ARPs, are sent as broadcasts with a MAC destination address of all Fs. These broadcasts are intended to be received by every port on the DUT. The performance of broadcast traffic on a switch may be different than the performance of unicast traffic.

The throughput test will determine the maximum load at which the DUT/SUT will forward Broadcast traffic without frame loss, as well as the latency of the traffic, for each of the recommended RFC 2889 frames sizes.

## Setup



**Broadcast Frame Forwarding and Latency  
One-to-Many Traffic Pattern with a 4-port Device Under Test**

## Test Steps

1. A minimum of two test ports and two DUT ports are required. One of the test ports will transmit broadcast frames and the remaining port(s) will receive the broadcast frames.
2. Each test port will emulate a single L2 MAC address.
3. From each test port, send L2 learning frames to the DUT and verify them.
4. Send broadcast test frames from one test port into the DUT. These frames should be forwarded through the DUT to every other test port.

5. Run throughput test:
  - a. Using 64-byte packets, a starting traffic load, and a 30-second test duration, send broadcast packets as described in Step 4 and determine if all packets are received.
  - b. Using a binary search algorithm, increase traffic load if no frame loss and decrease traffic load if frame loss occurs.
  - c. Continue binary search until maximum traffic load is achieved without frame loss.
  - d. Report the maximum load (throughput) the device successfully forwards without frame loss.
  - e. Report the latency of the traffic.
6. Repeat steps 3 to 5 for each remaining recommended frame size: 128, 256, 512, 1024, 1280 and 1518.

## Test Parameters

- Frame sizes (including CRC): Recommended are 64, 128, 256, 512, 1024, 1280, 1518.
- Burst size between 1–930 frames (1 = constant load).
- Full or half duplex (10M/100M).
- Load per port in percentage (%).
- Each trial (or iteration) is 30 seconds (adjustable from 1–300).

## Test Outcome

- Broadcast frame throughput and latency.
- Per frame size and load.
  - Throughput – Maximum load with no frame loss.
  - Latency – Average latency.

## Test Variables (Some variables not RFC compliant)

- Longer trial/iteration duration.
- Tagged frames (802.1p&Q).
- Use different frame sizes from 64–1518 bytes.
- Use multiple frame sizes in the same test/iteration to simulate realistic traffic.
- IP/UDP header (TOS/TTL/Port#).
- Define Pass/Fail criteria, such as allowing for a small amount of acceptable frame loss.

## Sample Results

### Starting Broadcast Frames Throughput and Latency Test

Throughput Test Parameters: Start = 100.0 Min = 0.0 Max = 100.0 Res = 0.5

Frame Length = 64

Offered Load = 76,190,105 bps (100.00% util)

Frame Loss Rate = (0 frames)

Forwarding Rate = 148,808 fps (100.00% util)

**Binary search complete:**

**Throughput is 76,190,105 bps (100.00% util)**

**Avg Latency is 183.585 microseconds**

Frame Length = 128

Offered Load = 86,486,220 bps (100.00% util)

Frame Loss Rate = (0 frames)

Forwarding Rate = 84,459 fps (100.00% util)

**Binary search complete:**

**Throughput is 86,486,220 bps (100.00% util)**

**Avg Latency is 172.883 microseconds**



# Glossary

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## A

**Address Caching Capacity** — The number of MAC addresses a DUT/SUT can cache and successfully forward frames to without flooding or dropping frames.

**Address Learning Rate** — The highest rate that a switch can learn new MAC addresses without flooding or dropping frames.

## B

**Backpressure** — Any technique used by a DUT/SUT to attempt to avoid frame loss by hindering external traffic sources from transmitting frames to congested interfaces.

**Back-to-Back** — Frames presented “back-to-back” have a minimum legal IFG for the given medium over a small-to-medium period of time.

**Bidirectional Traffic** — Frames presented to a DUT/SUT from all directions, with every receiving interface also transmitting.

**Bit Forwarding Device** — A device that begins to forward a frame before the entire frame has been received. Typically this is called a switch.

**Bridge** — A device that forwards data frames based on information in the data link layer.

**Bridge/Router**- A bridge/router is a network device that can function as a router and/or a bridge based on the protocol of a specific packet.

**Broadcast Forwarding Rate** — The number of broadcast frames per second that a DUT/SUT can be observed to successfully deliver to all interfaces in response to a specified offered load of frames directed to the broadcast MAC address.

**Broadcast Latency** — The time required by a DUT/SUT to forward a broadcast frame to each interface.

**Burst Size** — The number of frames sent back-to-back at the minimum legal IFG.

## C

**Constant Load** — Fixed length frames at a fixed interval time. Typically, these are back-to-back frames sent at the minimum IFG for the duration of the test.

**Cyclic Redundancy Check (CRC)** — A number derived from, and stored or transmitted with, a block of data in order to detect corruption.

## D

**Device Under Test (DUT)** — The device being tested. The forwarding device to which test packets are offered and the response measured.

## E

**Errored Frames** — Frames having errored conditions. These conditions could include oversized, undersized, misaligned or with an errored Frame Check Sequence.

## F

**Flood Count** — The flood count is the number of frames output from a DUT port that are not specifically addressed (destination MAC) to a device connected to the port.

**Forward Pressure** — Methods that violate a protocol to increase the forwarding performance of a DUT/SUT. This can be accomplished by using a smaller IFG than the protocol calls out.

**Forwarding Rate (FR)** — The forwarding rate is reported as the number of test frames per second the DUT successfully forwarded.

**Forwarding Rate as Maximum Offered Load (FRMOL)** — The observed FR at the maximum OLoad. Note that the maximum OLoad may not have occurred in the test iteration with the maximum ILoad.

**Frame Based Load** — The frame based load mechanism calculates the number of frames that should be transmitted given the port load (percent utilization) and test duration. The frames are then transmitted and the transmission is allowed to complete, regardless of the elapsed time. The frame based load mechanism is limited in this implementation because the OLoad cannot be properly calculated. The OLoad reported with this mechanism will always equal the ILoad. This mechanism should only be used when the DUT is not allowed to implement any congestion control mechanism and there are no half duplex links that will carry bidirectional traffic.

Also see: Port Loading, Time-Based Load.

**Frame Loss Rate (FLR)** — Percentage of frames that were not forwarded by the DUT, that were not forwarded due to lack of resources.

**Full Duplex** — A transmission path able to transmit signals in both directions simultaneously.

**Fully Meshed Traffic** — Frames offered to a DUT/SUT such that each interfaces receives frames addressed to all other interfaces in the test.

## H

**Half Duplex** — A transmission path capable of transmitting signals in both directions, but only in one direction at a time.

**Head Of Line Blocking (HOLB)** — Frame loss or increased delay on an uncongested output port when frames are received from an input port that is also attempting to forward frames to a congested output port.

## I

**IBG** — Interburst Gap. The gap between bursts.

**IFG** — Interframe Gap. The gap between frames on the Ethernet wire.

**ILoad** — Intended Load. The number of frames per second that the test equipment attempts to transmit to a DUT/SUT.

**IP** — Internet Protocol. The network (Layer 3) protocol of the TCP/IP protocol suite.

## L

**Latency** — For store and forward devices: The time starting when the last bit of the input frame reaches the input DUT port and ending when the first bit of the output frame is seen on the output DUT port. For bit forwarding devices: The time interval starting when the end of the first bit of the input frame reaches the input DUT port and ending when the start of the first bit of the output frame is seen on the output DUT port.

**Layer 3 Switch** — A network interconnect device that forwards frames based on network (Layer 3) addressing using the bit forwarding mechanism.

## M

**MAC** — **Media Access Control**. The lower sublayer of the OSI data link layer. The interface between a node's Logical Link Control and the network's physical layer.

**Maximum Forwarding Rate (MFR)** — The highest forwarding rate of a DUT/SUT taken from iterations of forwarding rate measurement tests.

**Maximum Offered Load (MOL)** — The highest number of frames per second that an external source can transmit to a DUT/SUT for forwarding to a specified output interface(s).

## N

**Non-Meshed Traffic** — Frames offered to a single DUT port and addressed to a single output DUT port.

## O

**OLoad** — The number of frames per second that the test equipment can be observed or measured to transmit to a DUT/SUT for forwarding to a specified output interface or interfaces. The OLoad may be less than the ILoad if the DUT implements a congestion control mechanism such as pause frames, or if one or more links are running in half duplex mode with bidirectional traffic.

**Overhead Behavior** — Processing performed for other than normal data frames.

**Overloaded Behavior** — When demand exceeds available system resources.

## P

**Partially Meshed Traffic** — Frames offered to one or more DUT ports and addressed to one or more output DUT ports, where input and output ports are mutually exclusive and mapped one-to-many, many-to-one or many-to-many.

**Port Loading** — RFC 2889 defines two approaches to loading a DUT port with test traffic. The objective of these modes is to be able to measure the OLoad. The two methods are (a) Time Based Load - Send test traffic for a specific time interval, and (b) Frame Based Load - Send a specific number of frames.

## R

**RFC** — Request For Comment. A document published by the Internet Engineering Task Force that may define a standard after passing through several phases of acceptance.

**Router** — A network device that forwards frames based on network (Layer 3) addressing.

## S

**Store and Forward Device** — A network interconnect device that receives an entire frame before beginning to forward it.

**System Under Test (SUT)** — The device/system being tested. Two or more DUTs networked together to which test packets are offered and the response measured.

## T

**Throughput** — The maximum rate at which none of the offered frames are dropped by the device.

**Time-Based Load** — The time based load mechanism is the preferred mechanism if there is any possibility of the DUT using a congestion control mechanism. With this mechanism, the test duration is strictly enforced. If any congestion control mechanism is used by the DUT or any links are half duplex with bidirectional traffic, the OLoad may be less than the ILoad.

Also see: Port Loading, Frame-Based Load

**Trial Duration** — The length of time test packets are sent to the DUT/SUT. RFC 2889 recommends 30 seconds.

## U

**UDP** — User Datagram Protocol. A connectionless transport protocol in the TCP/IP suite.

**Unidirectional Traffic** — Frames sent to DUT in one direction but not in received in reverse direction.

## V

**VLAN** — Virtual LAN. A logical grouping of two or more devices which are not necessarily on the same physical link but which share the same IP network address.

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