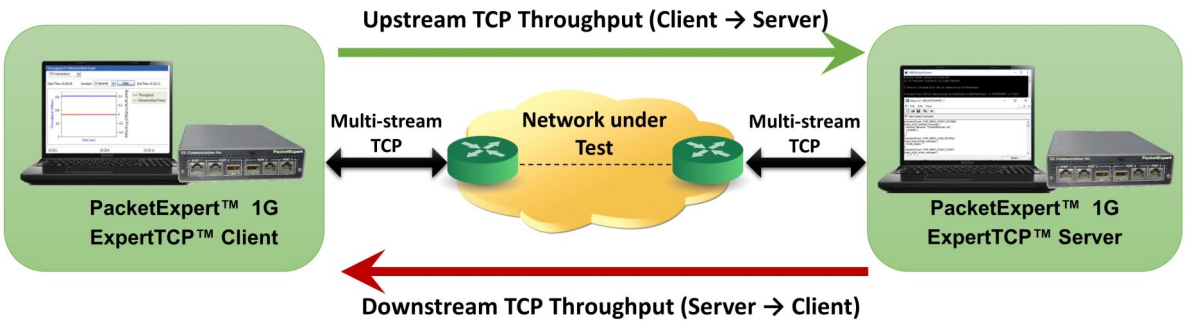
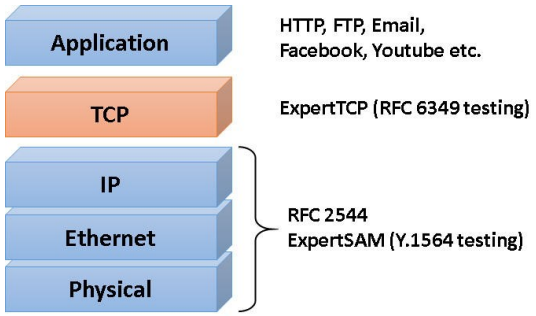
# ExpertTCP™ - TCP Throughput Testing (RFC 6349)




## Overview

IP Network operators and Service providers need to verify that their networks are performing well and meet the Service Level Agreements (SLA) with the customers. To verify Ethernet/IP based networks, current widely used standards are RFC 2544 or Y.1564. However, both these standards are meant for testing at Layer2 or Layer3 (Ethernet or IP layers).

Though these tests are necessary, they are not sufficient, because they do not cover testing at TCP layer. Most web based applications like HTTP, FTP, E-mail etc. run over TCP. Even many modern web applications like Facebook, YouTube, and the like use TCP.




Even if service provider networks are tested using RFC 2544 or Y.1564, customers may still face problems with TCP throughput. The TCP throughput may not match the throughput at the Ethernet/IP layer. This is because TCP throughput depends on factors like the TCP Window Size, buffer size of intermediate network nodes etc. Also, impairments like latency and packet drops causes TCP retransmissions, severely affecting the TCP throughput. So, there is a gap in the current testing methods and to cover the gap, RFC 6349 frame work has been devised.

GL's PacketExpert™ 1G and PacketExpert™ 10G platforms have been enhanced to support RFC 6349 based TCP Throughput test methodology referred to as ExpertTCP™ for both 10Gbps and 1Gbps networks.

ExpertTCP™ testing is performed using the **RFC 6349** standard to measure TCP throughput, RTT and optimal window size. To conduct this test, users need two PacketExpert™ devices — one as the client and the other as the server. The ExpertTCP™ test covers both upload (Client to Server) and download (Server to Client), measuring TCP throughput and efficiency.

The application has capability to generate and analyze up to 12 UDP streams of traffic of various packet lengths. It also performs bi-directional TCP throughput measurements in combination with another unit at the remote location (other end of the network), that acts as the TCP server, as depicted in the figure above. Many real-world networks are not symmetrical. There may be significant differences between upstream and downstream directions.

Simultaneous bi-directional testing/unidirectional testing can be performed. Results are reported for both directions. The server at the remote location is completely controlled by the client side (located locally). User configures both client and server locally, and the results are displayed locally, avoiding the hassles of configuring the test at multiple locations.

For more information, refer to ExpertTCP™ 1G/10G webpage.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## Features

- Supports Path MTU, Baseline RTT and TCP Throughput tests
- Hardware FPGA based TCP implementation supports full duplex bidirectional wirespeed TCP (up to 1 Gbps in both directions simultaneously)
- Supports multiple TCP connections (up to 16 TCP connections)
- Upstream (Local to Remote), Downstream (Remote to Local) and Bi-directional tests supported
- Test asymmetrical path with separate set of configurations for Upstream and Downstream
- Complete remote control - user needs to interact only with Local side - all results/statistics (both local and remote side) provided on local side
- Detailed run time statistics with Graphs for easy visualizations
- RFC 6349 specified metrics - TCP Efficiency, Buffer Delay Percentage, TCP Transfer Time ratio
- Command Line Interface for automated testing and remote accessibility using API clients C#, Python and MAPS™ Client Server architecture

## Functional Procedures

ExpertTCP™ (RFC 6349) specifies the TCP Throughput test to be conducted in 3 steps:

- Path MTU Discovery
- Determine Baseline RTT
- Conduct TCP Throughput test

ExpertTCP™ supports all 3 tests in a seamless one touch way. User can configure the parameters and simply start the test. ExpertTCP™ will run through all the three tests and report the results. It also includes an option to configure the Upstream and Downstream test direction.

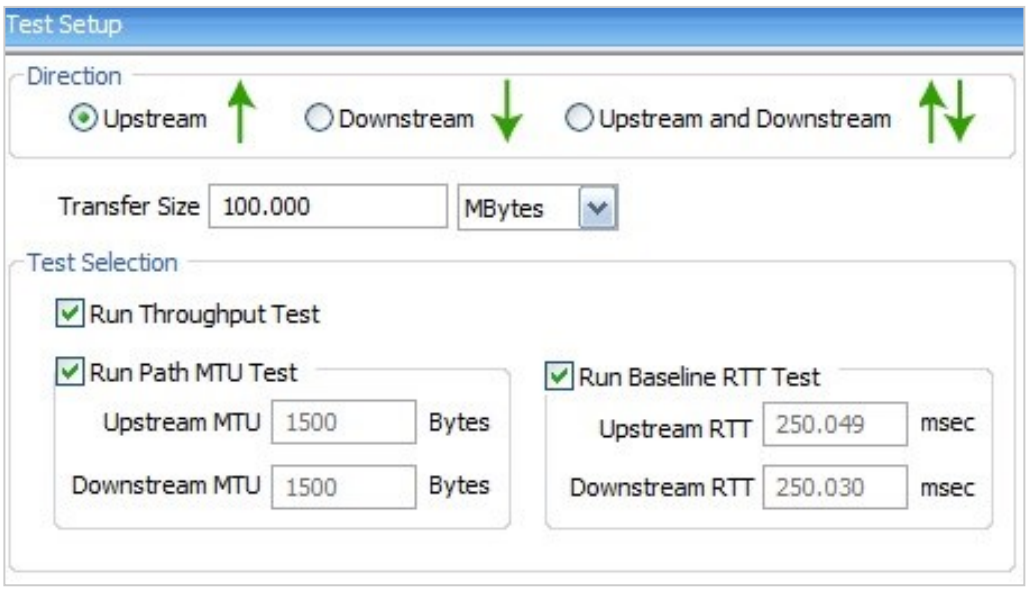
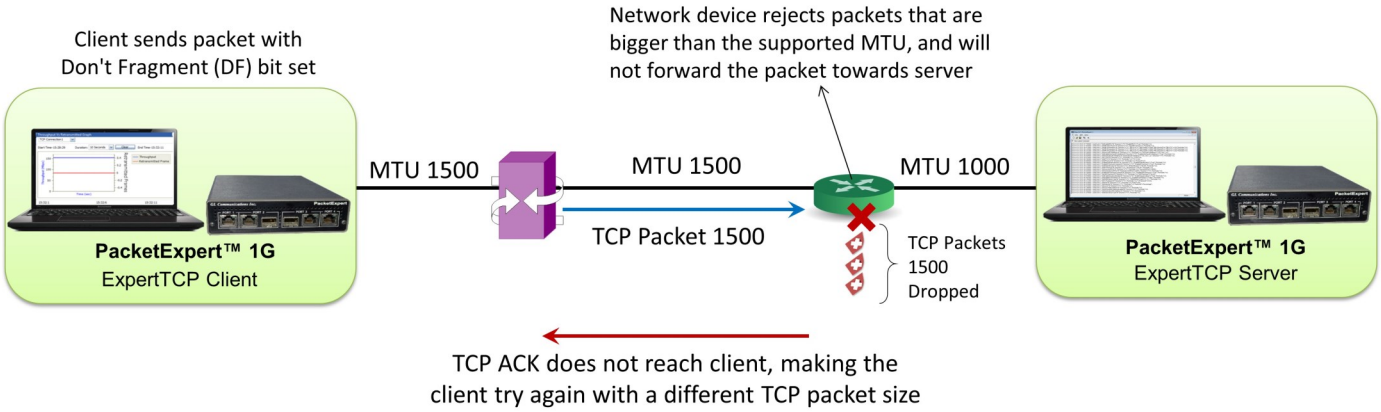


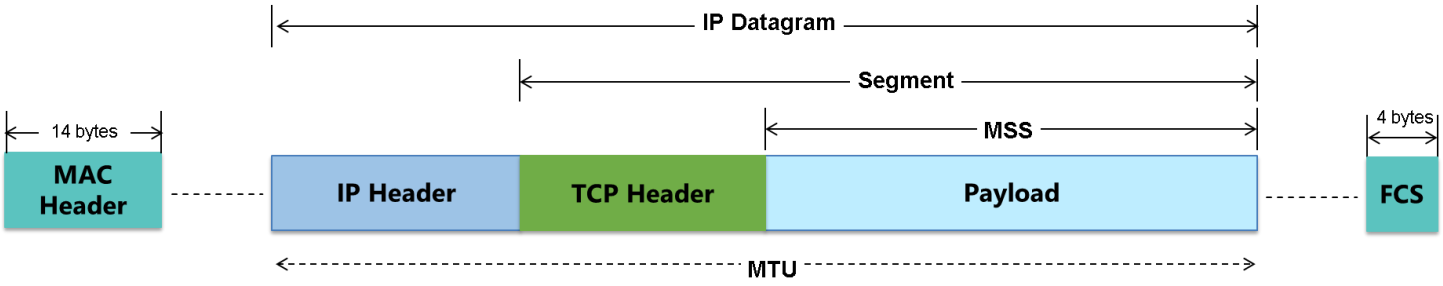

**Figure: Test Selection and Status**

## Path MTU Discovery

As per RFC 6349, the first step is to discover the Path Maximum Transmission Unit (MTU). This is because the TCP Throughput test has to be conducted at the Path MTU, else the TCP segments can fragment, adversely affecting the test results.

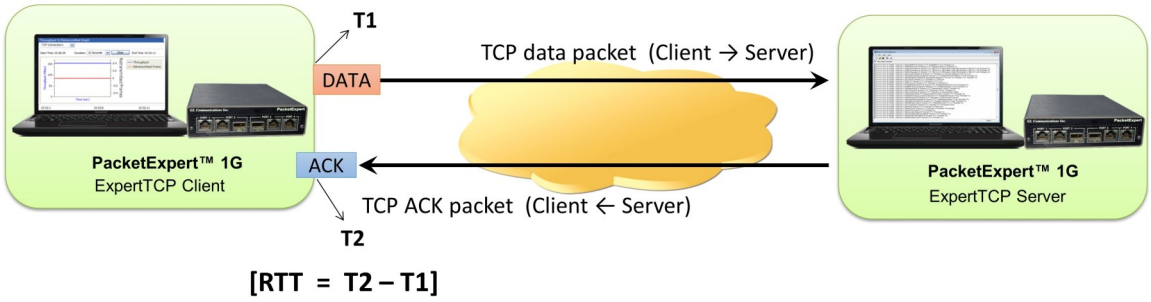



ExpertTCP™ discovers the Path MTU for both directions (Upstream/Downstream) separately. It follows a method similar to the one specified in the RFC 4821 (Packetization Layer Path MTU Discovery) standard, but uses TCP instead of ICMP. Path MTU determines the Maximum Segment Size (MSS) that TCP can use during the test.




## Determine Baseline RTT

This step establishes the inherent, non-congested Round-Trip Time (RTT) of the end-to-end network path. TCP RTT is the time taken for a TCP data packet to reach the other end, and for the corresponding ACK packet to reach the sender.



The RTT is an important metric in TCP, as the path RTT determines how much data can be sent out on the wire before an ACK can be received. This measurement is used to provide estimates of the TCP Receiver Window (TCP RWND) that should be used during subsequent Throughput test.

ExpertTCP™ performs Baseline RTT test separately for each direction and automatically calculates the optimum TCP RWND size based on the results. The Bandwidth Delay Product (BDP) and the RWND are displayed for user reference.

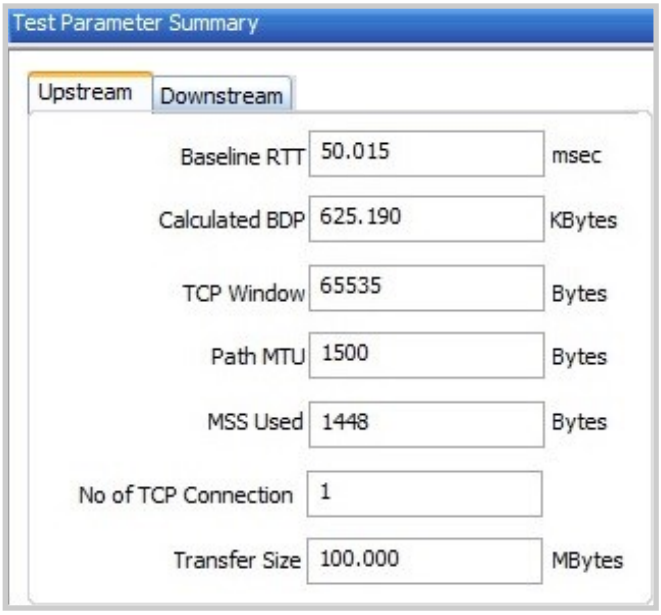



**Figure: Upstream Downstream Test Parameter Summary**

### Conduct TCP Throughput Test

In this step, single/multiple TCP connection Throughput tests are conducted and the TCP Throughput is determined. The TCP RWND (Receiver Window) used during this step, is calculated from the Baseline RTT value measured during the previous Baseline RTT test. For multiple TCP connections, the calculated RWND is distributed among the connections. Up to 8 TCP connections are supported on 1G platform, whereas up to 16 TCP connections are supported on 10G platform.

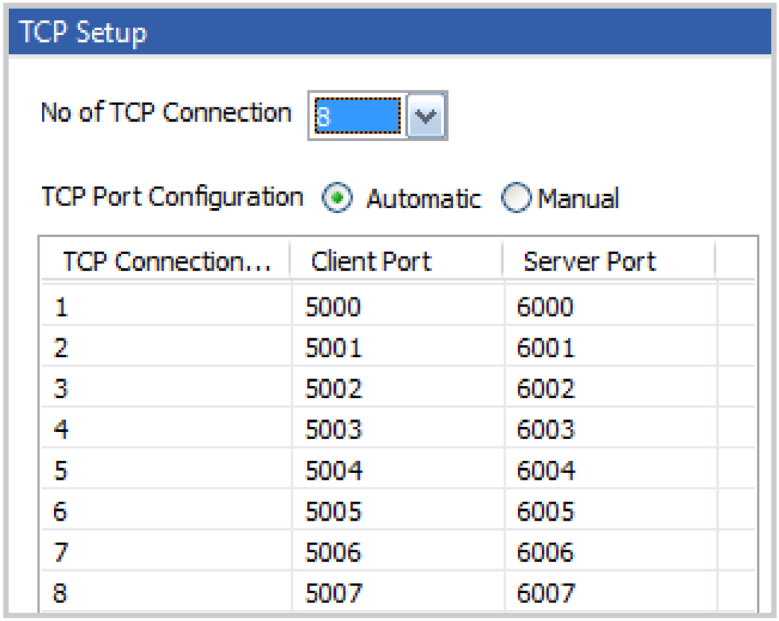
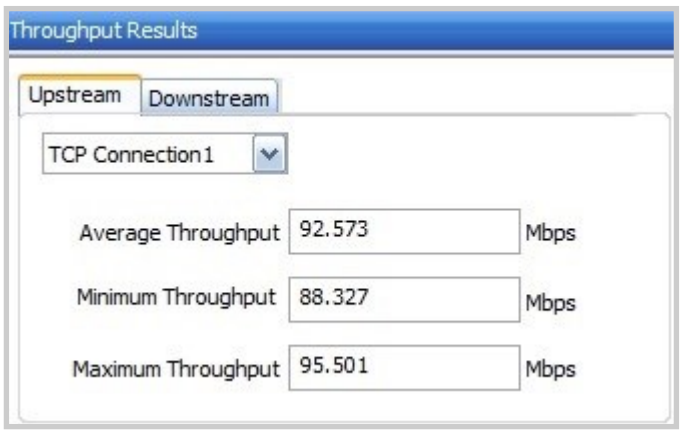
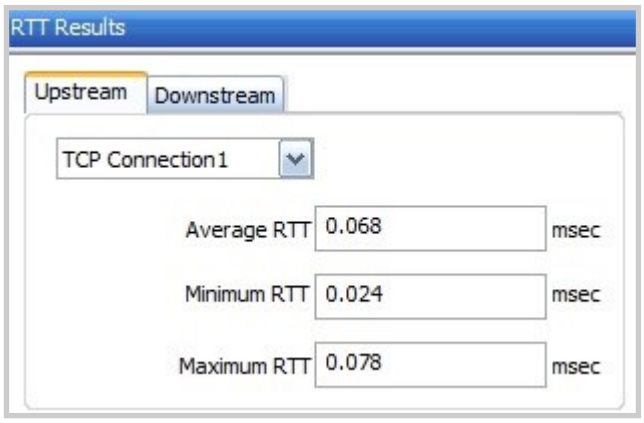



**Figure: Conduct TCP Throughput Test**

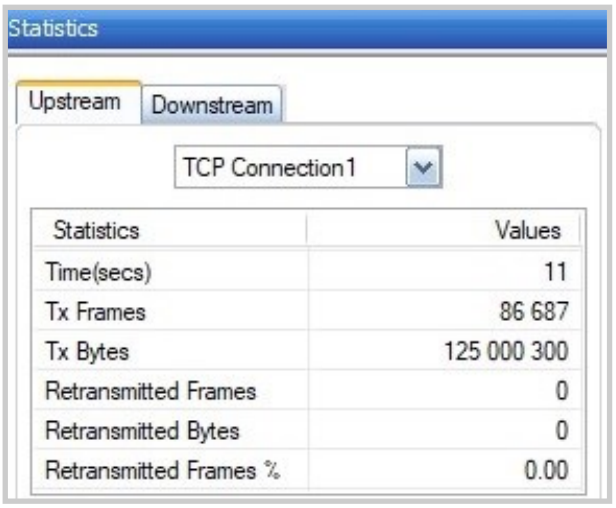
## Statistics and Results

Various statistics at runtime such as minimum, maximum and average Throughput, and RTT measurements per connection provide detail insight into the performance.

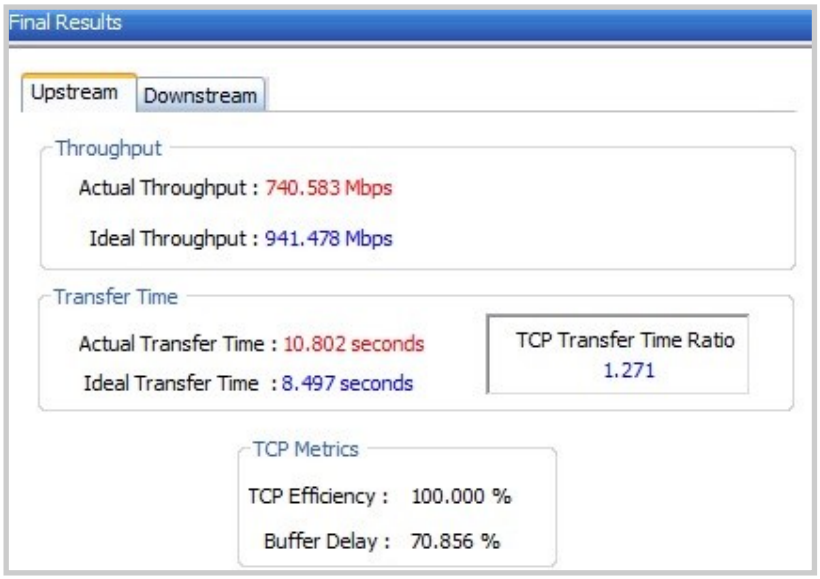



The statistics information on number of frames and bytes Transmitted, and Retransmitted per connection, gives a snapshot of the performance.




The final Results include the comparison of the actual Throughput/Transfer time with the ideal values. The three RFC 6349 TCP metrics defined in the specification - Transfer Time Ratio, TCP Efficiency and Buffer Delay are reported here.



## Statistics and Results (*Contd.*)

The following overall test statistics are displayed -

- Path MTU (Upstream, Downstream)
- Baseline RTT (Upstream, Downstream)
- Throughput (Upstream, Downstream)
- TCP status
  - Connecting
  - Unreachable IP
  - Destination Port busy
  - Connected
  - Connection close

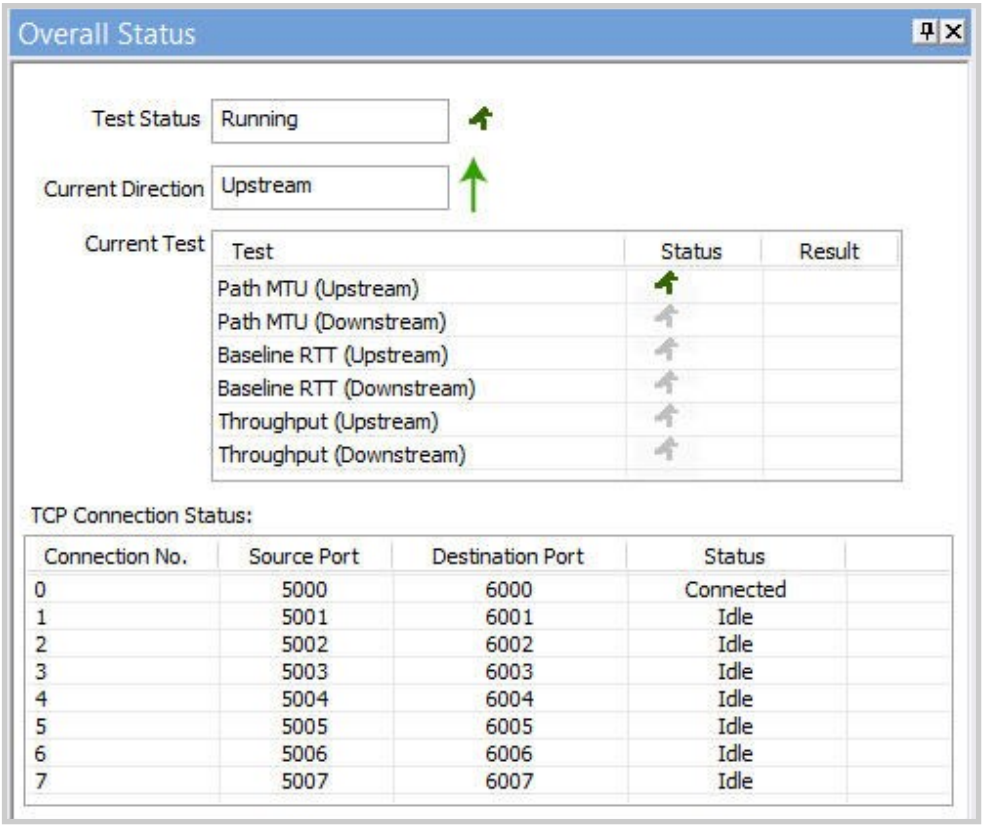



**Figure: Upstream, Downstream Results**

## Command Line Interface (CLI)

PacketExpert™ is enhanced to support Command Line Interface (CLI) requires additional license (CXE100) to access all the functionalities remotely using C#, Python clients and MAPS™ CLI Server/Client architecture.

The CLI supports all the PacketExpert™ test modules including - All Port Bert, Bert Loopback, All Port Loopback, RFC 2544, Record Playback, ExpertSAM™, PacketBroker, Multi Stream Traffic Generator and Analyzer.

# Graphs

Various graphs are available for visualizations. Throughput graph plots the Throughput over time. All connections are plotted in a single graph for a comprehensive view of the overall performance.

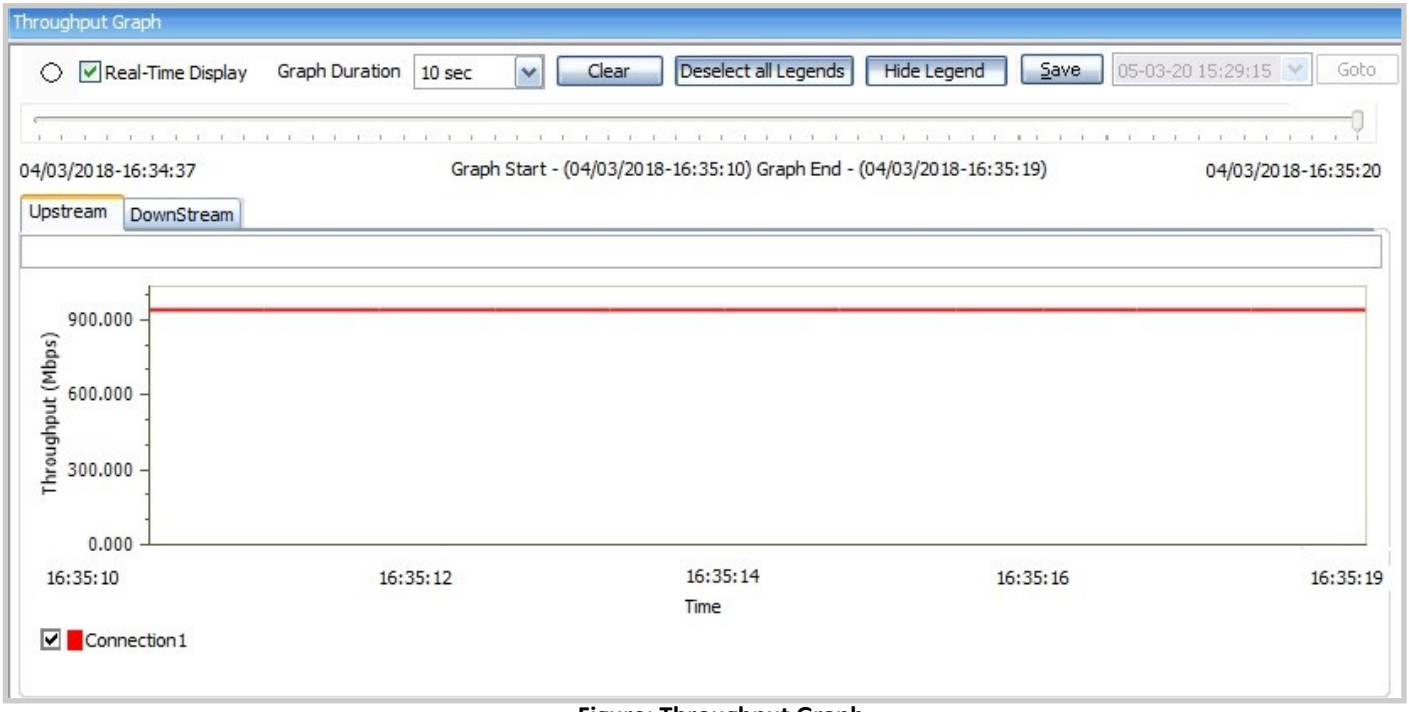



**Figure: Throughput Graph**

Throughput vs. Retransmissions graph provides insight into how Retransmissions are affecting the Throughput.

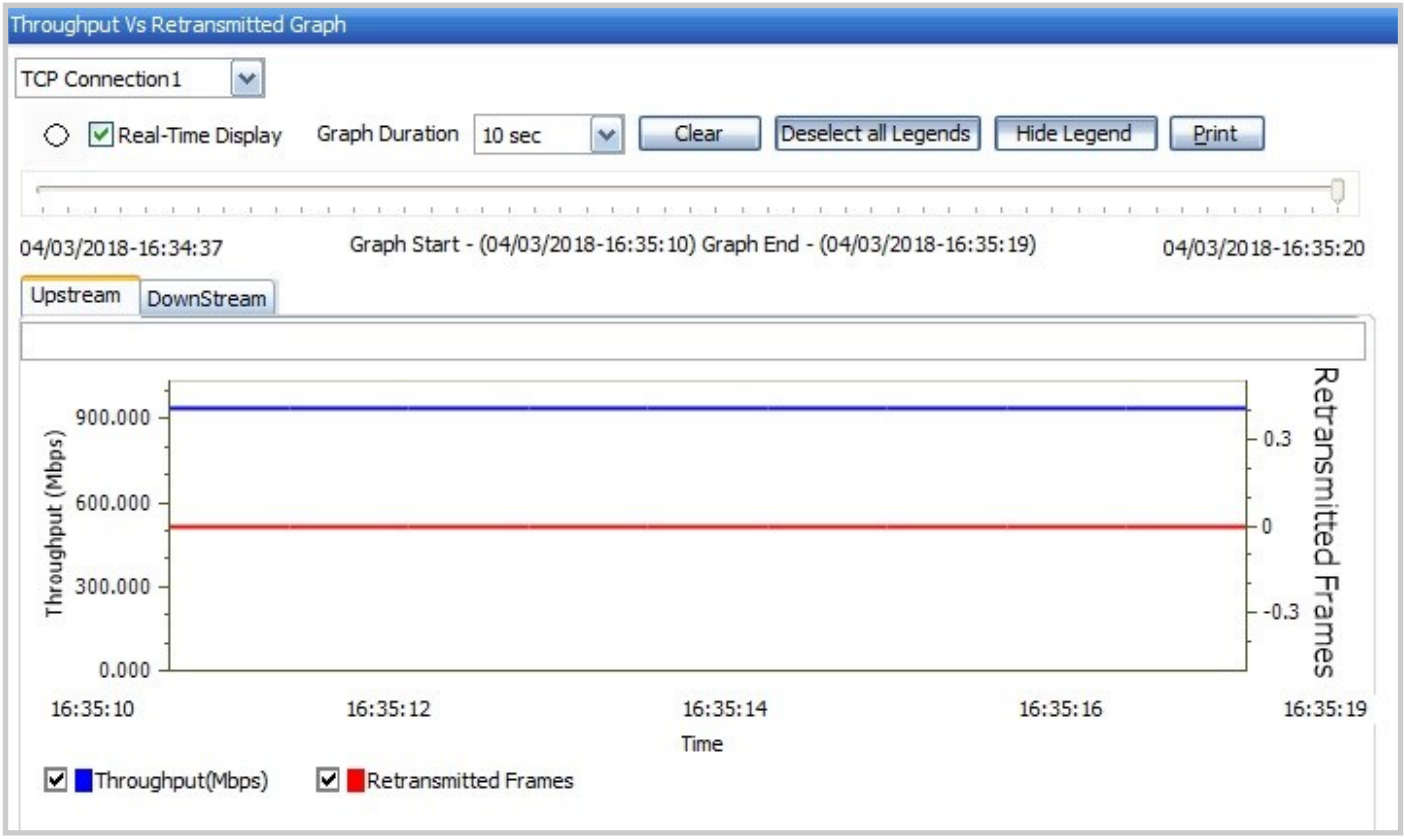



**Figure: Throughput vs. Retransmitted Graph**

# Graphs (*Contd.*)

The Throughput vs. RTT graph visualizes how the RTT variation affects the TCP Throughput.

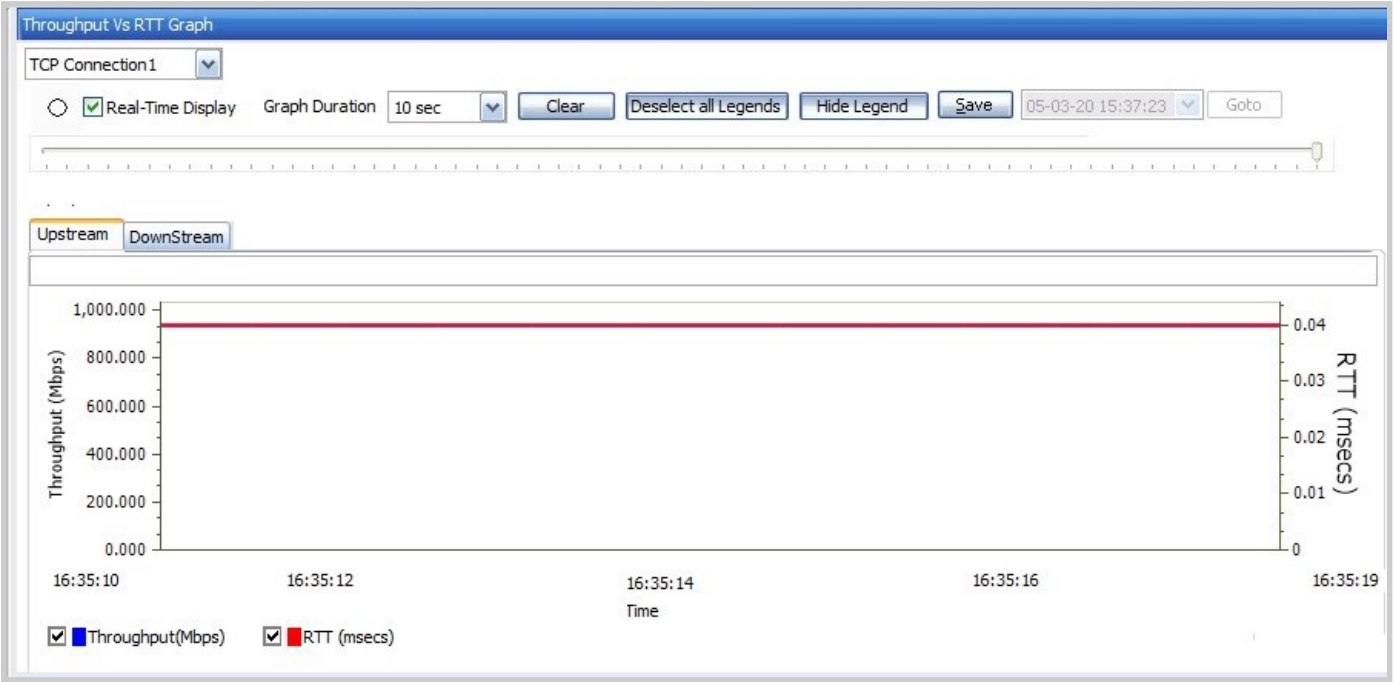
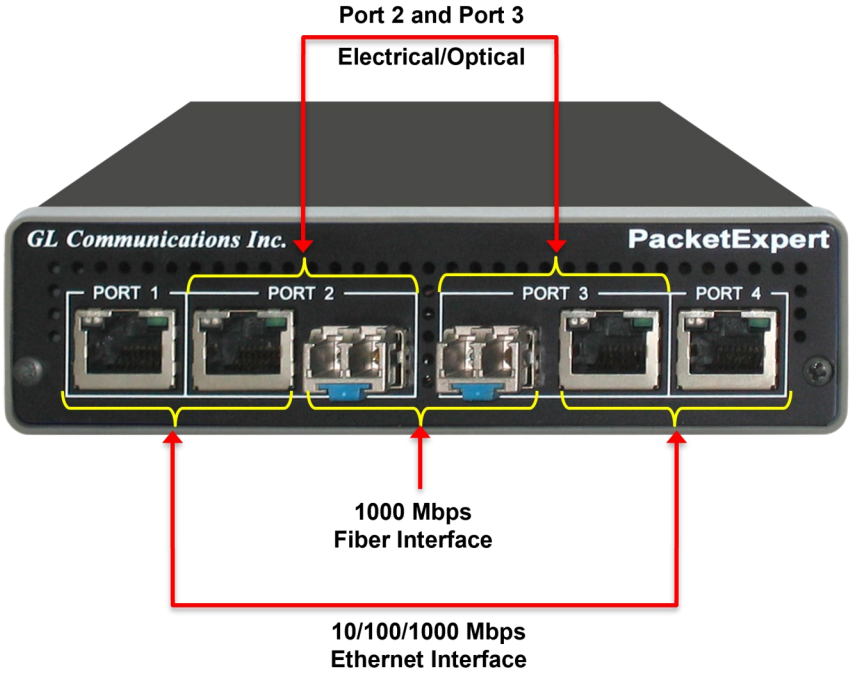



**Figure: Throughput vs. RTT Graph**

# Portable PacketExpert™ 1G Specifications




| | |
|---|---|
| **Interfaces** | • 2 x 10 / 100 / 1000 Base-T Electrical only<br>• 2 x 1000 Base-X Optical OR 10/100/1000 Base-T Electrical<br>• Single Mode or Multi Mode Fiber SFP support with LC connector |
| **Protocols** | • RFC 2544 compliance |
| **Bus Interface** | • USB 2.0 or USB 3.0 |
| **Power** | • +12 Volts (Medical Grade), 3 Amps |
| **Temperature** | • Operating Temperature: +5 to +40C<br>• Non-Operating Temperature: -30 to +60C |
| **Humidity** | • Operating Humidity: 0% to 80% RH<br>• Non-Operating Humidity: 0% to 95% RH |
| **Altitude** | • Operating Altitude: Up to 10,000 feet<br>• Non-Operating Altitude: Up to 50,000 feet |
| **Physical Specification** | • Length: 8.45 in. (214.63 mm)<br>• Width: 5.55 in. (140.97 mm)<br>• Height: 1.60 in (40.64 mm)<br>• Weight: 1.66 lbs. (0.75 kg) |

# mTOP™ PacketExpert™ 1G Rack Specifications

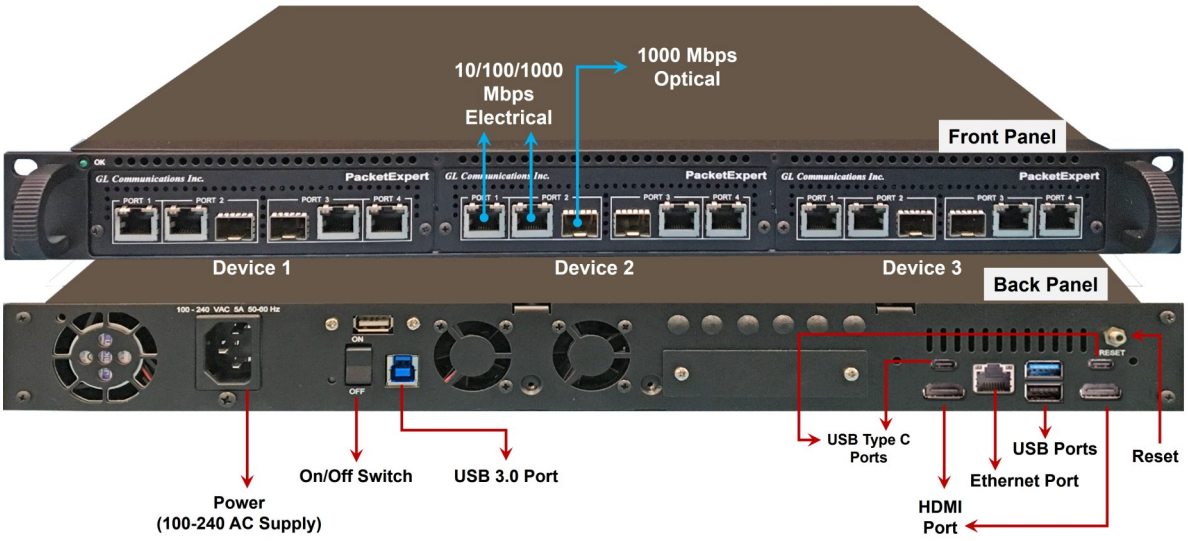



**Figure: 1U mTOP™ Rack Based 1G Hardware Unit (3 PXE100s)**

| | |
|---|---|
| **Interfaces** | 12 Total Ethernet Ports (HD-PacketExpert-12)<br>• mTOP™ System (embedded SBC, 3x PXE100)<br>• PacketExpert™ 1G (PXE100) interfaces -<br>– 6x 1000 Base-X Optical OR 10/100/1000 Base-T Electrical<br>– 6x (10/100/1000) Base-T Electrical<br>24 Total Ethernet Ports (HD-PacketExpert-24)<br>• mTOP™ System (embedded SBC, 6x PXE100)<br>• PacketExpert™ 1G (PXE100) interfaces -<br>– 12x 1000 Base-X Optical OR 10/100/1000 Base-T Electrical<br>– 12x (10/100/1000) Base-T Electrical |
| **SBC Specifications** | • Intel Core i3 or optional i7 NUC Equivalent,<br>• Windows® 11 64-bit Pro Operating System<br>• USB 3.0 and USB 2.0 Ports, ATX Power Supply<br>• USB Type C Ports, Ethernet 2.5GigE port<br>• 256 GB Hard drive, 8G Memory (Min)<br>• Two HDMI ports |
| **External Dimension** | • Length: 16 Inches<br>• Width: 19 Inches<br>• Height: 2x 1U mTOP™ (HD-PacketExpert-24) or 1U mTOP™ (HD-PacketExpert-12) |
| **Power Supply** | • ATX Power Supply |
| **Order Information** | • PXE100 - PacketExpert™ Options<br>• MT001/MT001E (1U)<br>• MT001+MT002/ MT001E+MT002 (Stacked 1U) |

# mTOP™ 1G Probe Specifications

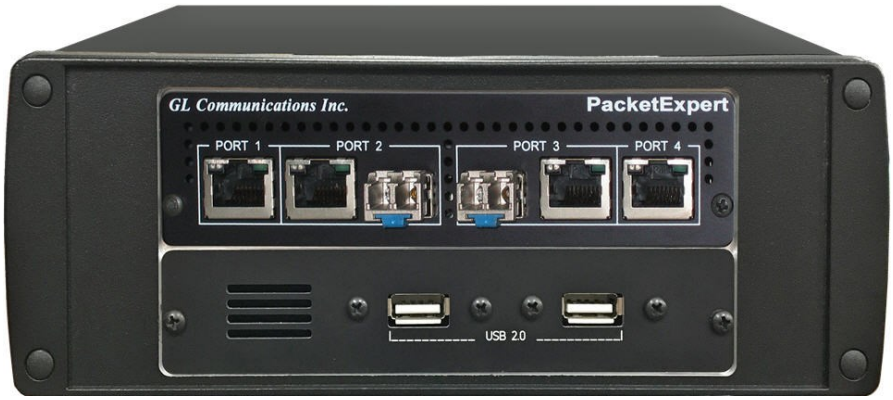



**Figure: mTOP™ Probe with 1G Hardware Unit + SBC**

| | |
|---|---|
| **Interfaces** | • 4x Total Ethernet ports<br>• 2x 10/100/1000 Base-T Electrical only<br>• 2x 1000 Base-X Optical OR 10/100/1000 Base-T Electrical<br>• Single Mode or Multi Mode Fiber SFP support with LC connector |
| **SBC Specifications** | • Intel Core i3 or optional i7 NUC Equivalent,<br>• Windows® 11 64-bit Pro Operating System<br>• USB 3.0 and USB 2.0 Ports, 12V/3A Power Supply<br>• USB Type C Ports, Ethernet 2.5GigE port<br>• 256 GB Hard drive, 8G Memory (Min)<br>• Two HDMI ports |
| **External Dimension** | • Length: 10.4 inches<br>• Height: 3 inches<br>• Width: 8.4 inches |
| **Power Supply** | • 12 volts (Medical Grade), 3 Amps |
| **Order Information** | • PXE100<br>• MT005/MT005E |

**Pelican Carry On Case**

# Buyer's Guide

| Item No | Product Description |
|---|---|
| PXE108 | ExpertTCP™ 1G |
| CXE100 | CLI support for PXE100 |

| Item No | Related Software |
|---|---|
| PXE105 | Wire speed Record/Playback 1G |
| PXE107 | PacketBroker 1G |
| PXE108 | Multi Stream Traffic Generator and Analyzer 1G |
| ETH100 | PacketCheck™ |
| PKV100 | PacketScan™ (Online and Offline) |

| Item No | Related Hardware |
|---|---|
| PXE100 | PacketExpert™ 1G Portable |
| PXE104 | PacketExpert™ - SA (4 ports) 1G |
| PXE112 | PacketExpert™ -SA (12 Ports) 1G |
| PXE124 | PacketExpert™ -SA (24 Ports) 1G |
| PKV100 | PacketScan™ (Online and Offline) |

**Note:** PCs which include GL hardware/software require Intel or AMD processors for compliance.

For more information, refer to ExpertTCP™ 1G/10G webpage.

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