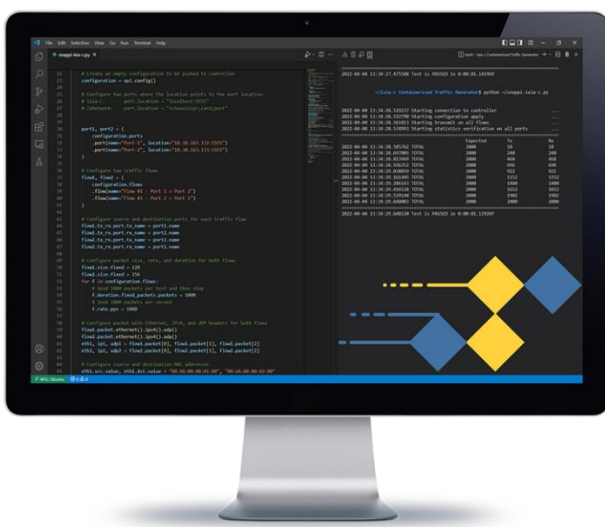# Keysight Elastic Network Generator

Agile and composable network test system designed for continuous integration

New Rules to Measure Network Behavior

The world today runs on top of computer networks. They are an enormous advantage of the modern economy, but also present increasing challenges when it comes to reliability, security, performance, and operational overhead. Faced with this pressure, the best network operators are adopting a concept of Infrastructure as a Code (IaaC) and running their networks as interconnected sets of programmable elements. With this paradigm shift, continuous validation of control functions and resulting network behavior becomes an absolute requirement.

Traditional closed test systems lack interoperability and flexibility of deployment options, making it difficult to apply them to IaaC. This slows innovation and limits adaptability to the growing demands of highly distributed modern applications. We need a new language to establish rules of network behavior and tools to measure it. This language must be open, vendor neutral and developer friendly. The tools must also integrate with modern Continuous Integration / Continuous Deployment (CI/CD) workflows and support a range of runners from developer laptops to software jobs in the public and private clouds, from hardware QA and certification labs to data center and edge locations for network service activation.

To meet these challenges, Keysight founded a vendor neutral Open Traffic Generator (OTG) API project (https://otg.dev) and is redefining network infrastructure testing with Keysight Elastic Network Generator. The OTG API transforms network infrastructure testing to address the demand for an automation-friendly, open and intent-based approach and is enabling cross-industry co-design of test suites in open networking projects such as OpenConfig, SAI, SONiC, SONiC-DASH, and DENT.

KEYSIGHT

Keysight Elastic Network Generator (KENG)

KENG is an agile, lightweight, and composable network test platform designed for continuous integration. It supports vendor neutral Open Traffic Generator models and APIs, integrates with several network emulation platforms, and drives a range of Keysight's network infrastructure test software products and hardware load modules and appliances.

Write Once, Run Anywhere

Keysight Elastic Network Generator provides an abstraction over various test port implementations – Ixia-c software, UHD400T white-box and purpose-built IxOS hardware. A test package written in Open Traffic Generator API can be run using any of supported test port types without modifications.
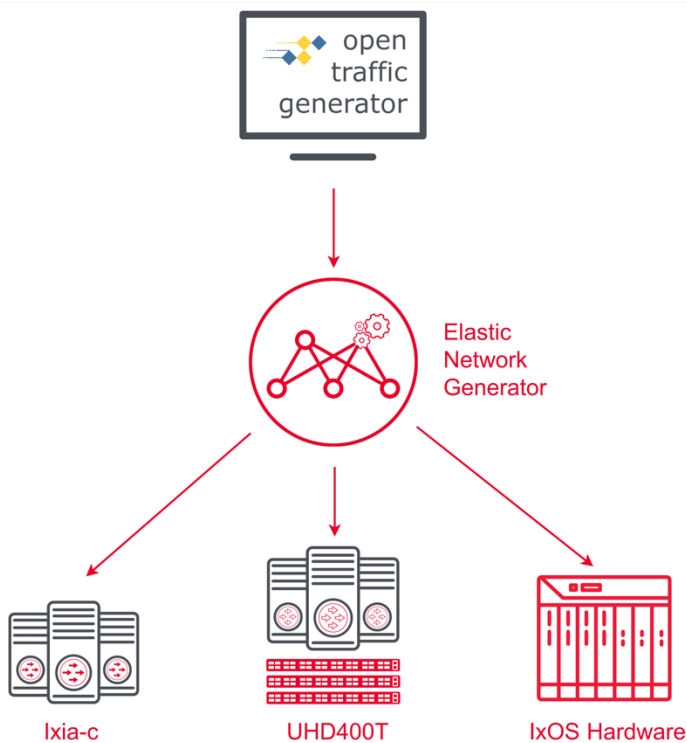

Figure 1. Keysight Elastic Network Generator Test Port Abstraction

Ability to easily change a type of test port removes contention for access to more expensive hardware ports while developing test packages. It also allows running the CI pipeline with a software image of a Device Under Test (DUT) for faster pass-or-fail iterations before installing a new firmware on a hardware and running full regression.

Highlights

- Implements Open Traffic Generator (OTG) API to incorporate test cases from the field into the design and development cycles to avoid costly, repetitive issues.

- Introduces Compliance-as-a-Code workflow, ensuring seamless equipment qualification and interoperability.

- Emulates key layer 2-3 control plane protocols and generates a rich stack of data plane traffic.

- Abstracts software, white-box, and hardware test port options.

- Reduces time-to-test with fast API response time and agile developer experience.

- Accelerates network validation by integrating with popular network emulation software.

- Deploys as a modular architecture based on containers and microservices.

Key Features

- Runs Linux x86 hardware on the software product.
- Includes software traffic generation and protocol emulation capabilities.
- Controls Keysight network test hardware.
- Supports test frameworks like Pytest or Golang test.
- Integrates easily into CI/CD pipelines like Jenkins, GitHub, GitLab.
- Uses DPDK to generate high traffic rates on a single CPU core.
- Emulates key data center protocols with high scale of sessions and routes.
- Uses 3rd party libraries to add headers for unsupported protocols as necessary.
- Patterns to modify common packet header fields to generate millions of unique packets.
- Tracks flows based on common packet header fields.
- Offers configurable frame sizes.
- Provides rate specification in pps (packets per second) or % line-rate.
- Delivers the ability to send traffic bursts.
- Provides statistics per port and per flow.
- Measures one way latency (min, max, average) on a per flow basis.
- Captures packets and writes to PCAP or analyzes in the test logic.

Open Traffic Generator API

The powerful automation capabilities available within **Keysight Elastic Network Generator** are one of its key strengths. These capabilities enable software engineers to accelerate the development and testing cycles for containerized or virtualized network devices. The same capabilities also help network developers to quickly validate complex network configuration changes in a repeatable manner as per the DevOps and CI / CD principles.

Both categories of users prefer to write the test scripts only once and then run those scripts everywhere across hardware / virtual / containerized environments. The test script development process is simplified when using a model-based declarative API which describes what is the test goal and not how that goal should be achieved. When the API is based on open standards that are vendor agnostic and can be implemented across different test tools, it is much easier to select the best tool which supports that API.
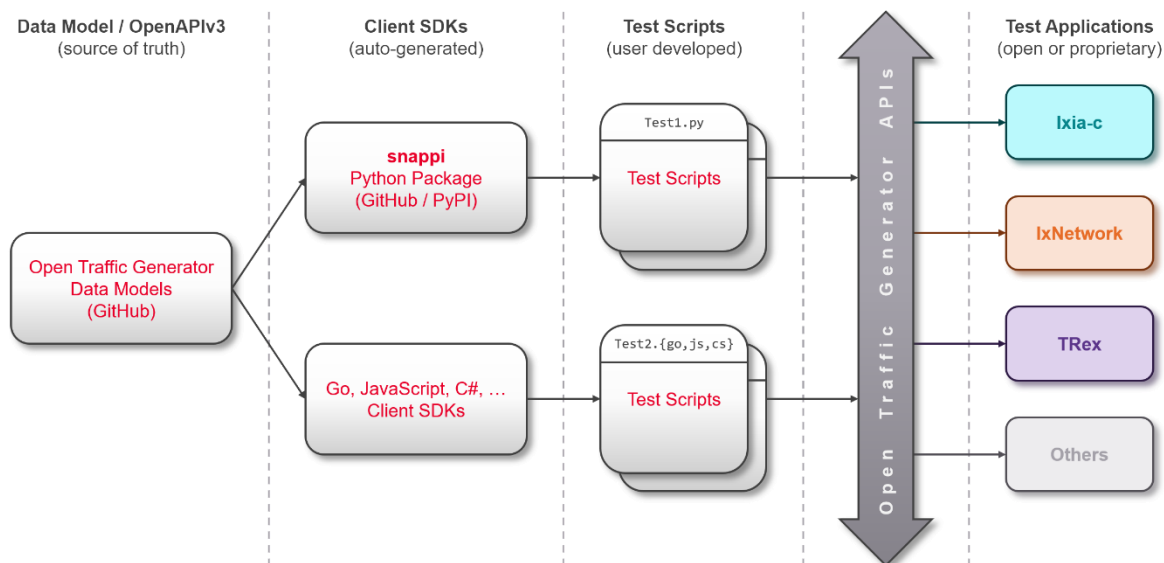

Figure 2. Layers of the Open Traffic Generator API ecosystem

All the above are made possible starting from the Open Traffic Generator API (OTG API) data models which are based on the Open API v3 definitions. These data models are the single source of truth that define the generic structure of a network test tool.

Next, the test script development process is simplified, and the user experience is improved thanks to the auto-generated Client SDKs available for multiple languages. Examples include snappi (for Python) or gosnappi (for Go). Script developers write their tests in snappi or gosnappi and execute them with one of the test tools that understand these languages.

Keysight Elastic Network Generator natively runs such scripts regardless of the client SDKs (snappi / gosnappi / others) used during the development process and regardless of the underlying transport channel (Rest API / gRPC / gNMI). With its native implementation, the scripts are executed very fast, and the API response time is in the milliseconds range. Other test tools can also implement a native OTG API server or rely on a plugin to translate the OTG API scripts to their native scripting language.

Network Emulation Integration

Keysight Elastic Network Generator is a modern test tool with a brand-new architecture based on containers / micro-services / open-source interfaces that you can deploy inside a multitude of software environments. Because of its modular design that includes few mandatory elements and several optional elements, those environments can range from a small-scale device test running on a laptop to a large-scale complex network validation running in any private or public cloud.
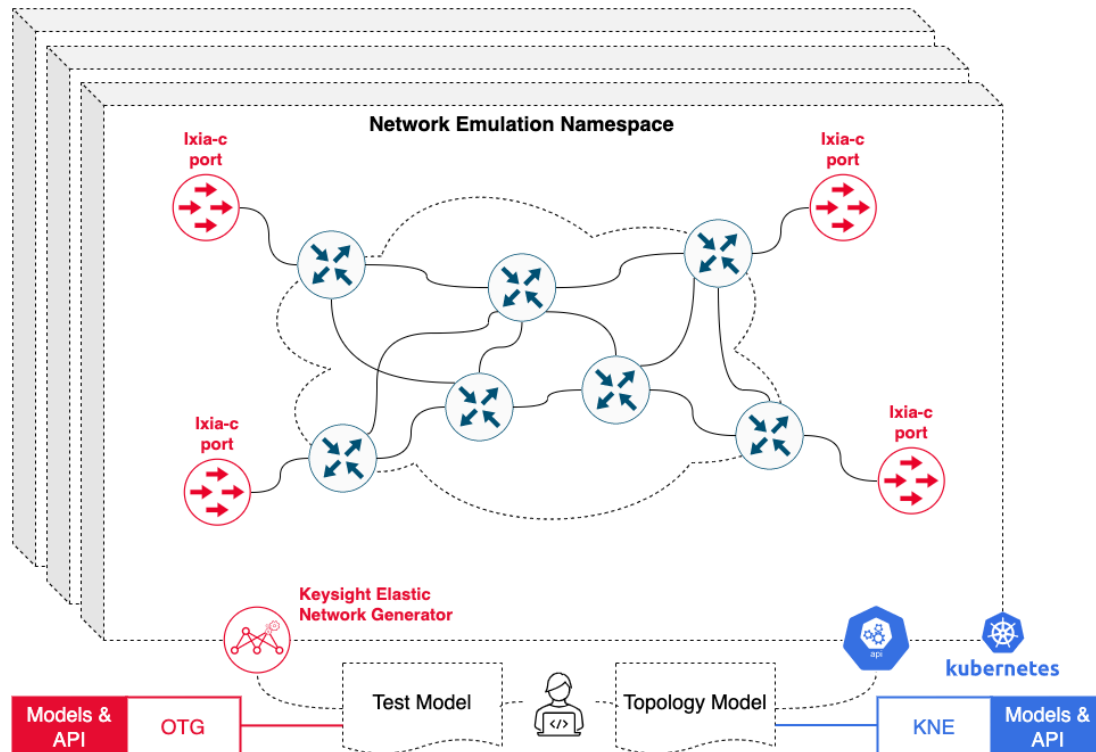

Figure 3. Ixia-c test ports in Kubernetes Network Emulation

The basic environment required to operate the tool consists of a **Linux Host running Container Engine software**. The traffic generated by the tool can be sent directly over the Linux Host Ethernet interfaces or directed towards various overlay networks. However, many of these network connections cannot forward all routing protocol frames and they prevent the correct execution of the test scripts. A direct virtual link is needed between all containers involved in the test which can transport any frame generated by the containerized network devices.

Most of the vanilla container orchestration tools do not have sufficient capabilities to create such a direct link. This is why various solutions for large scale **network emulation** in a containerized environment have been designed. These solutions are in charge of orchestrating the test tool containers along with the network device containers, creating virtual links between these elements as required by the network topology, and isolating the whole test environment from other similar test environments. Examples of such network emulation solutions include Kubernetes Network Emulation or Containerlab and **Keysight Elastic Network Generator** that is seamlessly integrated with both of these ecosystems.

Product Capabilities

Controller, APIs and test port types

A test program interacts with the Keysight Elastic Network Generator controller via northbound APIs. The controller coordinates execution of the test by the test ports and reports measured metrics back to the test program. The APIs exposed by the controller are universal among all types of test ports and provide a common user experience independent of the type used.

Controller capabilities

Capability	Specification
Northbound APIs	Open Traffic Generator (OTG) over HTTPs and gRPC transport – configuration, control, metrics, capture gNMI over gRPC transport – metrics
API data models	OTG – OpenAPIv3: https://github.com/open-traffic-generator/models gNMI – YANG: https://github.com/open-traffic-generator/models-yang
Graphical user interface	Not included. It is possible to use a 3rd party or develop a custom GUI with use of vendor neutral OTG API.
Session concurrency	Single concurrent test session (configuration) per controller.
Test concurrency	To execute multiple parallel tests, run multiple copies of the controller – one per test.
Controller form factor	Docker container(s). Multiple controllers can be run in parallel on the same host or VM, using dedicated container namespaces.
Client concurrency	Multiple concurrent clients per single controller are supported (with limitations).
Test ctate ownership	The controller keeps the state of the test execution, the client shall act in a stateless manner.
Test port ownership	A test port is reserved by a controller based on the list of ports specified in its current configuration. The port is released once a new configuration that doesn't contain the port is applied, or if the controller is no longer running.

Types of test ports

Supported types of test ports are listed below. Only ports of the same type can be used together in a test.

Test port pype	Form factor	Supported models	Capabilities
Ixia-c software	Docker containers	Ixia-c Traffic Engine Ixia-c Protocol Engine	Stateless traffic generator and L2-3 protocol emulator
UHD400T	Composable test ports based on white-box switch hardware traffic generator and protocol emulation software	UHD400T fixed chassis Ixia-c Protocol Engine	Stateless traffic generator and L2-3 protocol emulator
IxOS hardware	Hardware test ports based on IxOS chassis/appliances	Novus QSFP28 AresONE 400GE AresONE-S 400GE	Stateless traffic generator and L2-3 protocol emulator

Licensing

Licensed capability	Community edition	Ixia-c software	UHD400T	IxOS hardware
License requirement	Not required	Valid set of licenses is required depending on the current test configuration		
Supported test port types	Ixia-c	Any license edition	Depends on the license edition	
Test seat concurrency	Uncounted	Number of running Controller instances with a configuration that exceeds capabilities of the Community Edition.		
Data plane capabilities	Any supported by Ixia-c	Any supported by KENG for use with Ixia-c	Any supported by KENG for use with UHD400T	Any supported by KENG for use with IxOS hardware
Data plane performance	Up to 4 of 1/10GE ports	Limited by licensed Software Traffic Port Capacity in Data Plane License Units (KENG-DPLU). Number of required units is determined as a sum of configured port speeds (1, 10, 25, 40, 50, 100GE). Maximum port performance might be less than configured port speed.	Any number of available ports with performance determined by UDH400T hardware	Any number of available ports with performance determined by IxOS hardware
Control plane capabilities	ARP, IPv6 NDP, BGP	Any supported by KENG for use with Ixia-c	Any supported by KENG for use with UHD400T	Any supported by KENG for use with IxOS hardware
Control plane scale	Up to 4 BGP sessions	Limited by licensed Software Protocol Scale in Control Plane License Units (KENG-CPLU), or up to the technical limits supported by KENG and Ixia-c if Unlimited Control Plane License is available (KENG-UNLIMITED-CP). Number of required units is determined as a sum of configured protocol sessions. Configurations exceeding 50 protocol sessions will consume KENG-UNLIMITED-CP license if available and 50 KENG-CPLU. If KENG-UNLIMITED-CP is not available, an exact required number of KENG-CPLU will be consumed.		Up to the technical limits supported by KENG and IxOS hardware

Data plane

Keysight Elastic Network Generator supports traffic generation and measurement that ensures precision and performance. The data plane implementation is tightly integrated with the control plane protocols and it automatically generates packets that match the emulated topologies. Different types of test ports (Ixia-c, UHD400T, IxOS hardware) may support a subset of the capabilities, consult with the product documentation. The Ixia-c traffic performance is provided through built-in support for DPDK Performance Acceleration.

Data plane traffic capabilities

Capability	Specification	
Mapping source / destination	One-to-one, Mesh	
Link aggregation	Static LAG, LAG with LACP	
Traffic types	Endpoint port Endpoint device	(Raw traffic – all packet headers can be manually crafted) (Ethernet packet headers depend on linked emulated routers, with ARP/IPv6 ND support)

Capability	Specification
Traffic duration	Burst, continuous, fixed packets, fixed seconds
Traffic frame size	Fixed, increment, random, weighted pairs (IMIX)
Traffic header stack	MAC, VLAN, MPLS, ARP, IPv4/v6, TCP/UDP/ICMP/ICMPv6, PPP, GRE, IGMPv1, ETHERNETPAUSE, PFCPAUSE, VXLAN, CUSTOM HEX
Traffic payload pattern	Constant size / Custom HEX
Traffic rate	Percentage line rate, Packets per second, Bit rate (bps, Kbps, Mbps, Gbps)
Maximum number of OTG flows per test port	256
Ixia-c traffic performance	Depends on underlying hardware and software stack. High performance requires use of DPDK Passthrough mode with compatible drivers and may range from 10Gbps at smaller frame sizes to more than 100Gbps with frames size of 9000 bytes.
UHD400T and IxOS hardware traffic performance	Depends on capabilities of the hardware model and interface speed. Consult with documentation for the hardware used.

Data plane measurement capabilities

Measurement	Port metrics	Flow metrics
Counters	Frames Tx Frames Rx Bytes Tx Bytes Rx	Frames Tx Frames Rx Bytes Tx Bytes Rx
Rate	Frame Rate Tx Frame Rate Rx Byte Rate Tx Byte Rate Rx	Frame Rate Tx Frame Rate Rx - -
Latency		Min Latency (ns) Avg Latency (ns) Max Latency (ns)
Time stamps		First timestamp Last timestamp
Egress tracking		Rx port name tag Metric tags for each traffic header

Control plane

Keysight Elastic Network Generator emulates a set of networking protocols which are critical for data center network operation. Each test port, depending on the type, is capable of emulating hundreds of interfaces or routers with thousands of control plane protocol. Combined with traffic generation and measurement capabilities, this enables the verification of advertised topologies and networks for functionality and performance. Different types of test ports (Ixia-c, UHD400T, IxOS hardware) may support a subset of the capabilities, so please refer to the product documentation. For details about the performance and scale of each test port type, refer to the product documentation.

Control plane specifications

Technology	Protocol
Test ports	LLDP LAG with LACP
Emulated device interfaces	IPv4 (ARP / PING reply) IPv6 (NDP / PING reply)
Emulated device routing	BGPv4 / BGPv6 ISISv4 / ISISv6 (L1 & L2) RSVP P2P LSPs
BGP capabilities	Route announcement, withdrawal, re-advertisement / MD5 authentication / Learned routes retrieval / Extended communities / Graceful restart
ISIS capabilities	Route advertisement / Learned routes retrieval
RSVP P2P LSP capabilities	Refresh and bundle extensions

Product Prerequisites and Compatibility

System requirements

System resource	Controller (with gNMI enabled)	Ixia-c Traffic Engine port	Ixia-c Protocol Engine port
CPU architecture	x86_64		
Operating system	Linux (Centos 7+ or Ubuntu 18+ have been tested)		
Runtime	Docker Engine 19+ or Compatible K8s runtime		
Minimum dedicated CPU, millicores	20 m	200 m	200 m
Minimum RAM	40 MiB	60 MiB	350MiB
Recommended RAM for high-scale configurations	300 MiB	150 MiB	1500 MiB
Recommended RAM for high-scale configurations in high-performance DPDK mode	300 MiB	500 MiB	Not supported

Compatibility and limitations

Feature	Compatibility and limitations
Ixia-c Traffic Engine high-performance DPDK mode compatible network interface cards (NIC)	Intel 350, 5xx, 7xx, 8xx Mellanox ConnectX-4, ConnectX-5, ConnectX-6, ConnectX-7 Mellanox BlueField-2, BlueField-3 Cisco VIC
Ixia-c Traffic Engine high-performance DPDK mode supported virtualization	SR-IOV, PCI passthrough. Intel 350 NIC is not supported for DPDK mode with virtualization
Ixia-c Traffic Engine high-performance DPDK mode protocol emulation support	Ixia-c Protocol Emulation is not available
IxOS hardware test ports	Only Linux-based IxOS chassis are supported
IxOS Hardware supported	AresONE-S; NOVUS 5-speed; NOVUS QSFP28
Minimum IxOS version	9.30.3001.12
Maximum number of emulated devices per IxOS hardware test port	10,000
Release compatibility between KENG components	See https://github.com/open-traffic-generator/ixia-c/releases

Ordering Information

Subscription bundles

Capability	Developer 939-9001	Team 939-9002	System 939-9003
Software traffic port capacity [1]	**50GE**	**400GE**	**800GE**
Test concurrency [2]	1 seat	8 seats	16 seats
Software & UHD400T protocol scale	Limited	Limited	Unlimited
Works with UHD400T hardware	✗	✔	✔
Works with IxOS hardware	✗	✗	✔
Included quantity of KENG-DPLU units	50	400	800
Included quantity of KENG-CPLU units	50	400	800
Included quantity of KENG-UNLIMITED-CP units	0	0	16

1. **Maximum data plane performance** of software test ports may be less than the included software traffic port capacity, depending on configuration.
2. **Test seat concurrency** applies to quantity of running controller instances with a configuration that exceeds capabilities of the Keysight Elastic Network Generator Community Edition.

Part numbers

P/N	Description
939-9001	**Keysight Elastic Network Generator DEVELOPER Bundle (12-Months Floating Worldwide License, Keysight software support subscription).** – Includes **1** concurrent test seat(s). Includes the following capabilities: Control Plane (all supported protocols), Data Plane (all supported traffic). Available capabilities may depend on the test port type used in the configuration. – Supports **IXIA-C software** test ports. Includes **50GE** of combined **IXIA-C** traffic port capacity. Enables support for **Limited IXIA-C** Control Plane performance. Combined IXIA-C traffic port capacity is determined as a sum of configured test port speeds with possible values: 100GE, 50GE, 40GE, 25GE, 10GE, 1GE. Requires license term to be specified (must be purchased in multiples of years, list price is per unit per year). TAA Compliant.
939-9002	**Keysight Elastic Network Generator TEAM Bundle (12-Months Floating Worldwide License, Keysight software support subscription).** – Includes **8** concurrent test seat(s). Includes the following capabilities: Control Plane (all supported protocols), Data Plane (all supported traffic). Available capabilities may depend on the test port type used in the configuration. – Supports **IXIA-C software** and **UHD400T hardware** test ports. Includes **400GE** of combined **IXIA-C** traffic port capacity. Enables support for **Limited IXIA-C** and **UHD400T** Control Plane performance. Maximum Data Plane performance of UHD400T ports is determined by the platform hardware specifications. Combined IXIA-C traffic port capacity is determined as a sum of configured test port speeds with possible values: 100GE, 50GE, 40GE, 25GE, 10GE, 1GE. Requires license term to be specified (must be purchased in multiples of years, list price is per unit per year). TAA Compliant.
939-9003	**Keysight Elastic Network Generator SYSTEM Bundle (12-Months Floating Worldwide License, Keysight software support subscription).** – Includes **16** concurrent test seat(s). Includes the following capabilities: Control Plane (all supported protocols), Data Plane (all supported traffic). Available capabilities may depend on the test port type used in the configuration. – Supports **IXIA-C software**, **UHD400T** and **IXOS hardware** test ports. Includes **800GE** of combined **IXIA-C** traffic port capacity. Enables support for **Unlimited** Control Plane performance. Maximum Data Plane performance of UHD400T ports is determined by the platform hardware specifications. Maximum Data Plane performance and Control Plane scale of IXOS hardware ports is determined by the hardware specifications. Combined IXIA-C traffic port capacity is determined as a sum of configured test port speeds with possible values: 100GE, 50GE, 40GE, 25GE, 10GE, 1GE. Refer to the data sheet for supported IXOS hardware. Requires license term to be specified (must be purchased in multiples of years, list price is per unit per year). TAA Compliant.

Summary

Keysight Elastic Network Generator

- Offers an open and highly flexible test platform that can run on software, hardware, and white boxes, reducing time-to-test by as much as four times.
- Delivers a vendor-neutral API that facilitates collaboration between vendors and their customers, ensuring high quality of co-designed solutions.
- Lowers the barrier for network automation professionals to enhance NetDevOps practices with continuous validation using the community edition at no cost.

Further Information

Keysight resources

- KENG and Ixia-c online documentation: https://ixia-c.dev/
- KENG product page: https://www.keysight.com/us/en/products/network-test/protocol-load-test/keysight-elastic-network-generator.html
- UHD400T product page: https://www.keysight.com/us/en/products/network-test/network-test-hardware/uhd400t.html
- UHD400T Data Sheet: https://www.keysight.com/us/en/assets/3123-1396/data-sheets/Keysight-s-UHD400T.pdf

Open Traffic Generator resources

- Open Traffic Generator project: https://otg.dev
- Examples of using OTG and KENG: https://github.com/open-traffic-generator/otg-examples

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