

ARTISAN®
TECHNOLOGY GROUP

Your **definitive** source for quality pre-owned equipment.

Artisan Technology Group
(217) 352-9330 | sales@artisantg.com | artisantg.com

Full-service, independent repair center
with experienced engineers and technicians on staff.

We buy your excess, underutilized, and idle equipment
along with credit for buybacks and trade-ins.

Custom engineering
so your equipment works exactly as you specify.

- Critical and expedited services
- In stock / Ready-to-ship
- Leasing / Rentals / Demos
- ITAR-certified secure asset solutions

Expert team | Trust guarantee | 100% satisfaction

All trademarks, brand names, and brands appearing herein are the property of their respective owners.

Visit our website - *Click HERE*

Keysight Technologies

U9391C/F/G Comb Generators

U9391C (10 MHz to 26.5 GHz)

U9391F (10 MHz to 50 GHz)

U9391G (10 MHz to 67 GHz)

Technical Overview







KEYSIGHT TECHNOLOGIES

Unlocking Measurement Insights

Key Features

- Excellent amplitude and phase flatness enable it to be used as a precision calibration phase reference standard for the PNA, PNA-X, and NVNA
- NIST referenced phase calibration guarantees a reliable reference to international standards
- Embedded calibration data can be easily accessed via the plug-and-play USB interface
- The USB interface facilitates frequency divider control and calibration data retrieval via the PNA-X
- Rugged 1.85-mm, 2.4-mm, and 3.5-mm bulk-head connectors guarantee high repeatability throughout multiple connects and disconnects
- Sine to square wave converter provided as standard accessory
- Handgrip (U9391G only) designed for better gripping and as heat insulator for user handling
- Combined with Keysight Signal Optimizer software (K3101A) for wideband calibrations of signal analyzers and oscilloscopes

Description

The Keysight Technologies, Inc. U9391C/F/G comb generators were developed to provide precision phase calibration, for non-linear measurements using the PNA-X nonlinear vector network analyser (NVNA), referenced to the National Institute of Standards and Technology (NIST) standard. Additionally, the comb generators can be used to calibrate PNA and PNA-X network analyzers for phase and delay measurements of frequency converters without requiring reference or calibration mixers.

Comb generators generate frequency harmonics at integer multiples from an RF input signal. Generally, comb generators available in the open market today are made with step-recovery diodes. U9391C/F/G comb generators are based on Keysight InP MMIC technology[1] to ensure superior phase stability of the combs. A built-in frequency divider, selectable via the PNA-X, reduces the noise of the combs. You can set drive frequency at 1, 2 , 4, 8 or 16 times the pulse repetition frequency (PRF). Combining a frequency divider with a wide input signal frequency range allows for a broad range of possible harmonics spacing, making this suitable for characterizing non-linear devices. This module has a trigger output which enables synchronization with the pulse's repetition frequency. Calibration data stored inside the U9391C/F/G can be accessed directly by the PNA-X via the USB interface for phase calibration. The comb generator comes with the option of female or male output connectors.

Keysight's new patented comb generators offers the advantage of wide bandwidth output (10 MHz - 26.5 GHz, 10 MHz to 50 GHz, and 10 MHz to 67 GHz) and small minimum tone spacing (10 MHz). When driven by low phase noise sources, this comb generator will operate at frequencies lower than 10 MHz, but performance is not guaranteed. The input power and fundamental frequency have lower sensitivity than other comb generators. This means a comb generator calibrated at a single power level and frequency can be used across a wide range of input power levels and frequencies.

1. Indium phosphide monolithic microwave integrated circuit

Accurate transfer of NIST standard

Keysight characterizes the U9391C/F/G comb generators' phase standard using a precision calibration technique that is traceable to NIST. Each comb generator's amplitude and phase data is stored in the module's memory.

Comb generator configuration

U9391C/F/G comb generator are controlled via a USB connection. The units need to be powered by separate power supplies (see page 5 for more detail). The network analyzer software automatically controls the U9391C/F/G units via USB after they have been designated as phase reference and/or calibration modules. The phase calibration procedure is carried out by following the on-screen instructions on the PNA or PNA-X.

Squaring circuit

The 10 MHz reference output on the back panel of the PNA/PNA-X can be used as the driving source for comb generator. U9391-60009 sine-to-square wave converter is recommended to be used in this setup, as comb generator is not able to work at its optimum condition with input sine-wave below 100 MHz.

The sine-to-square wave converter is provided with U9391C/F/G and shall be connected between the 10 MHz reference output and the input to comb generator.

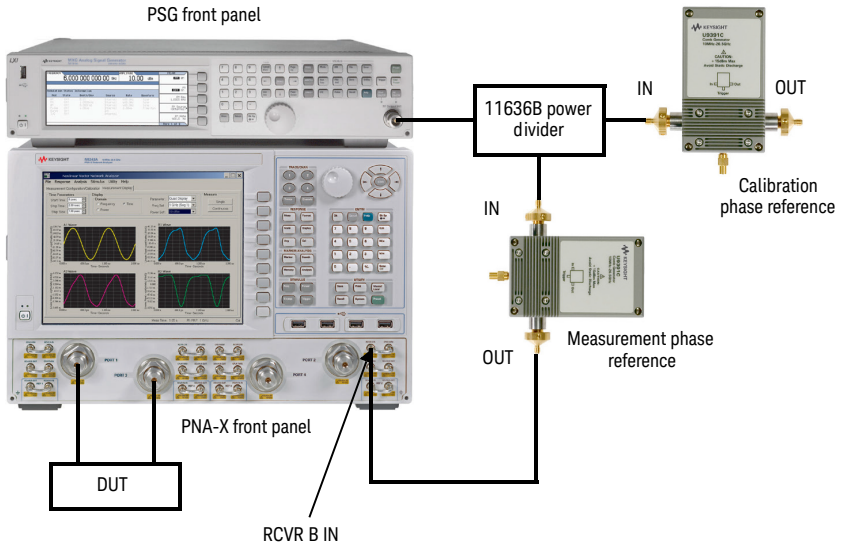
Applications

NVNA

Two units of U9391C/F/G are required to carry out non-linear measurements. One unit is used as the phase reference module and the second unit as the phase calibration module.

The U9391C/F/G units need to be powered by separate power supplies. The NVNA software automatically controls the U9391C/F/G units via USB after they have been designated as phase reference and calibration modules respectively.

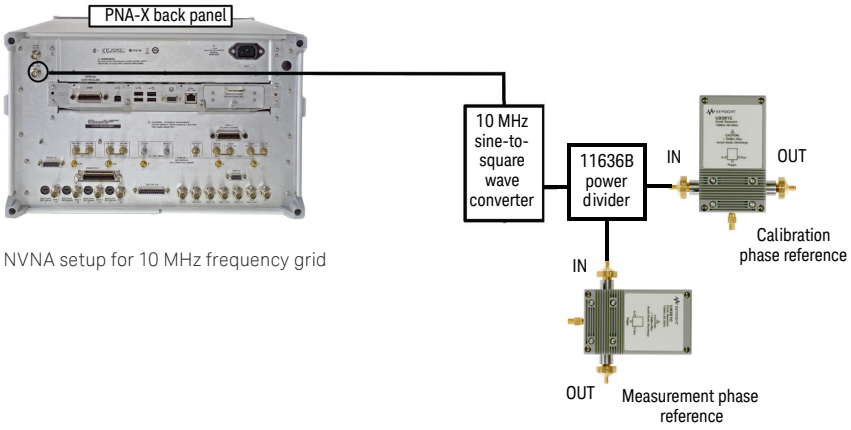
The phase calibration procedure is carried out by following the on-screen instructions on the PNA-X. After completing the calibration, the U9391C/F/G unit used for phase calibration can be disconnected. The other unit will be used as the phase reference and must remain connected while the measurement is carried out.



NVNA setup for arbitrary frequency grid

In most NVNA measurements, an external signal generator is used as driving source to drive comb generator that works as phase reference.

For measurements which require 10 MHz driving source, the 10 MHz reference output of PNA/PNA-X can be used. This setup will enable the NVNA measurement however with less accuracy in phase as compared with the conventional configuration using signal generator. The sine-to-square wave converter shall be connected between the 10 MHz output of the instrument and input to comb generator.



NVNA setup for 10 MHz frequency grid

For more information on phase reference setup for different NVNA measurement configurations, please refer to NVNA online help (http://na.support.keysight.com/pna/nvna/NVNAWebHelp/NVNAHelp.htm). For more information about NVNA application, please refer the publication document 5989-8575EN.

SMC+Phase

The scalar mixer/converter plus phase (SMC+Phase) measurement class, available on PNA and PNA-X network analyzers, provides fully calibrated conversion gain/loss, relative phase, and absolute group delay measurements of mixers and frequency converters without the need for reference mixers. To calibrate the relative phase and absolute group delay of the test setup, either a calibration mixer or a U9391 Series comb generator can be used. When using a comb generator, the calibration is done as a two-part process. In part one, a power meter, comb generator, and an S-parameter calibration kit (mechanical or ECal) are used to calibrate the magnitude and phase response of the network analyzer receivers across the full frequency range of the instrument. The calibration is typically performed directly at the test ports of the network analyzer, without the adverse effects of test cables. This first-tier calibration is very stable when the instrument is in an environment with little temperature variation, and can be used for many months. Step two adds an S-parameter calibration at the desired reference planes, and is typically performed over the frequency range of interest for a particular DUT. This second-tier calibration removes the effects of all of the adapters and cables used to connect the instrument to the DUT, and extends the magnitude and phase calibration planes of the first-tier calibration to the reference planes of the second tier calibration. When using an U9391G comb generator for calibration up to 67 GHz, an additional high-pass filter is required. Two back-to-back Keysight V281A waveguide-to-coax adapters are recommended. In SMC+Phase application, 10 MHz reference output of the PNA/PNA-X is used as the driving source to comb generator in Phase Reference Calibration. As such, U9391-60009 sine-to-square wave converter needs to be used.

For more information on SMC+Phase and phase reference calibration, please refer to PNA online help (http://na.support.keysight.com/pna/help).

Wideband calibration

U9391C/F/G comb generators used with Keysight Signal Optimizer software (K3101A) enable wideband calibrations of signal analyzers and oscilloscopes. The Signal Optimizer software can establish a calibration plane at the DUT connection for transmit and receive with Keysight U9391/F/G comb generator calibration which flattens the amplitude and phase in wideband signals at RF, uW, mmWave frequencies for 5G. This makes it easier for 5G R&D engineers who are challenged to build reliable, accurate, and repeatable test systems especially for wideband calibrations. Following the calibration instructions, engineers can perform system calibration easier and simpler than ever.

The Signal Optimizer software provides a connection diagram from customers' DUT, receiver and transmitter hardware, calibration controller PC with Signal Optimizer, and all the necessary accessories such as cables and connectors including the U9391C/F/G comb generator. This helps engineers to setup and configure the DUT and test instruments easily and quickly for complicated 5G design verification test systems.

Drive power supply

The U9391C/F/G can be powered by DC power supply via the banana plug cable provided. Table 3-1 shows the drive power supply specification of U9391C/F/G U9391C/F/G Drive Power Supply Specification

U9391C/F/G drive power supply

Model	U9391C	U9391F	U9391G
Voltage	+15 +/- 10% Vdc	+15 +/- 10% Vdc	+15 +/- 10% Vdc
Current[1]	300 mA (nominal)[2]	300 mA (nominal)[2]	850 mA (nominal)[2]

1. Current drawn by the device under normal operating condition. Higher current is required during device start up.
2. Current drawn will change when drive voltage changes.

Options

Output connectors

Option FFF – female (output port)
Option FFM – male (output port)

Specifications

Specifications refer to the performance standards or limits against which the U9391C/F/G comb generators are tested.

Typical and nominal characteristics are included for additional information only and they are not specifications:

- **Typical (typ.):** Expected performance of an average unit which does not include guardbands. It is not covered by the product warranty.
- **Nominal (nom.):** A general, descriptive term that does not imply a level of performance. It is not covered by the product warranty.

Specifications		U9391C	U9391F	U9391G
Output frequency range[1]		10 MHz to 26.5 GHz	10 MHz to 50 GHz	10 MHz to 67 GHz
Input frequency range[2]		10 MHz to 6 GHz	10 MHz to 6 GHz	10 MHz to 6 GHz
Input power range		-15 to +15 dBm	-15 to +15 dBm	-15 to +15 dBm
Min output power per picket	at 10 MHz Input PRF	-80 dBm	-95 dBm	-100 dBm
Amplitude flatness vs. output frequency	at 10 MHz Input PRF	< 12 dB	< 25 dB	< 40 dB
Amplitude flatness vs. input power		0.1dB (typical)	0.5dB (typical)	1.0 dB (typical)
Phase flatness/degree[3]	10 MHz to 3 GHz 3 GHz to 20 GHz 20 GHz to 26.5 GHz 26.5 GHz to 28 GHz 28 GHz to 38 GHz 38 GHz to 45 GHz 45 GHz to 50 GHz 50 GHz to 67 GHz	± 8.5 ± 6.5 ± 8.5	+10 /-10 +10 /-10 +10 /-10 +10 /-10 +20 /-10 +20 /-15 +20 /-15	+10 /-10 +10 /-10 +10 /-10 +20 /-10 +20 /-10 +20 /-15 +20 /-15 +35 /-35
Pulse width		< 23 ps	< 23 ps	< 23 ps
Divide ratio		1,2,4,8,16	1,2,4,8,16	1,2,4,8,16
Input return loss, S11	10 MHz to 6 Ghz	> 10 dB	> 10 dB	> 10 dB
Output return loss, S22	10 MHz to 10 GHz 10 GHz to 20 GHz 20 GHz to 26.5 GHz 26.5 GHz to 45 GHz 45 GHz to 50 GHz 50 GHz to 67 GHz	> 10 dB > 10 dB > 10 dB	> 10 dB > 10 dB > 7 dB > 7 dB > 5 dB	> 10 dB > 10 dB > 7 dB > 7 dB > 5 dB > 5 dB

1. When driven by low phase noise sources, the U9391C/F/G will operate at frequencies lower than 10 MHz, but performance is not guaranteed.
2. For operations below 100 MHz, use a square wave to drive the U9391C/F/G.
3. The specifications refer to the raw performance data. For the NVNA application, the phase performance is corrected with the calibration data.

Environmental Specifications

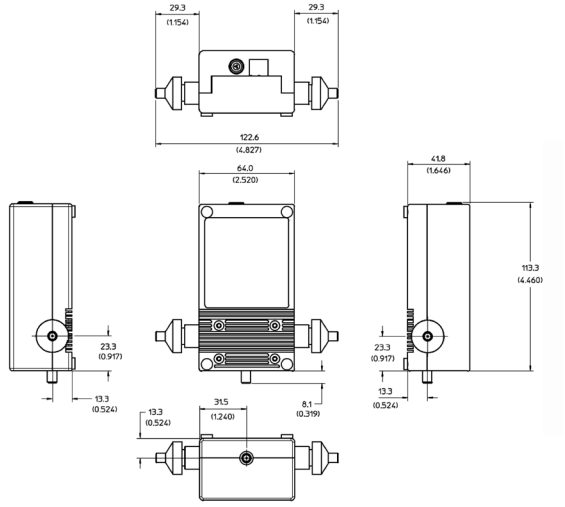
U9391C/F/G comb generators are designed to fully comply with Keysight's product operating environment specifications. The following are the summarized environmental specifications for these products.

Specifications	Limits
Temperature	
Operating	0 to +40 °C
Storage	–40 to +70 °C
Error corrected range	23 °C ±3 °C
Cycling	–65 to +85 °C, 10 cycles at 20 °C per minute. 20 minutes dwell time per MIL-STD-883F, Method 1010.8, Condition C (modified)
Relative humidity	
Operation	50% to 95% RH at 40 °C, 24 hours cycling, repeated 5 times
Storage	90% RH at 65 °C, one 24 hour cycle
Shock	
End-use handling shock	Half-sine waveform, 2-3 ms duration, 60 in/s (1.6 ms) delta-V
Transportation shock	Trapezoidal waveform, 18-22 ms duration, 337 in/s (8.56 ms) delta-V
Vibration	
Operating	Random: 5 to 500 Hz, 0.21 grms, 10 min/axis
Survival	Random: 5 to 500 Hz, 2.09 grms, 10 min/axis Swept sine: 5 to 500 Hz, 0.5 grms, 10 min/axis, 4 resonance search, 10 min dwell
Altitude	
Operating	< 4,572 meters (15,000 ft)
Storage	< 15,000 meters (50,000 ft)
ESD immunity	
Direct discharge[1]	8.0 kV per IEC 61000-4-2
Air discharge	15 kV per IEC 61000-4-2

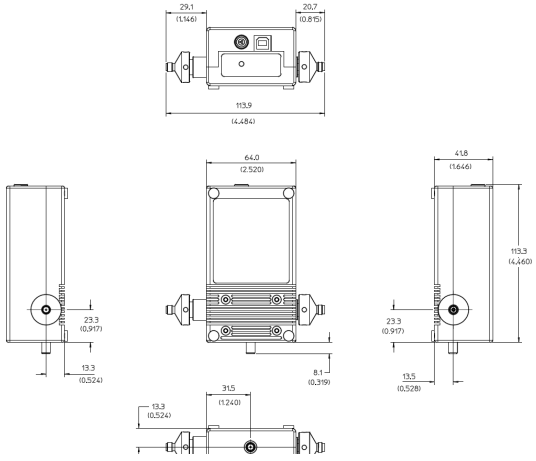
1. To outer conductor

Mechanical Dimensions

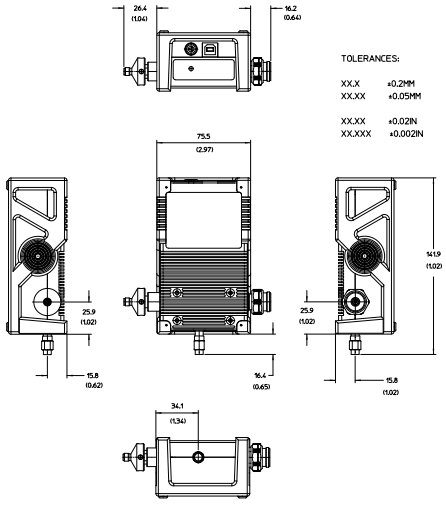
Specifications		U9391C/F/G
Pin Depth	Input	0 to -0.0508 mm (0 to -0.0020")
	Output	0 to -0.0508 mm (0 to -0.0020")
	Trigger	0 to -0.1270 mm (0 to -0.0050")
Net weight Physical weight of U9391C/F/G	U9391C/F 0.370 kg	U9391G 0.435 kg



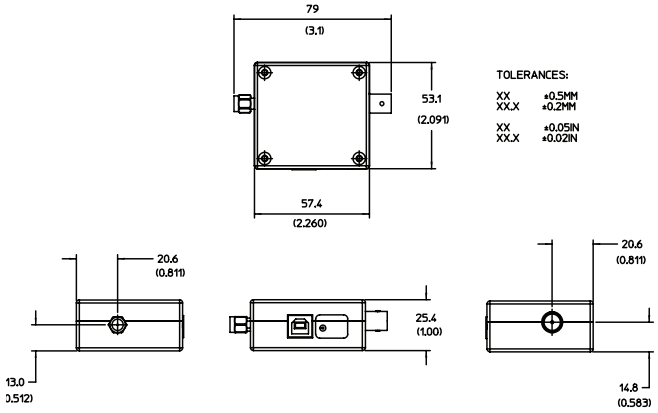
Mechanical dimension for U9391C



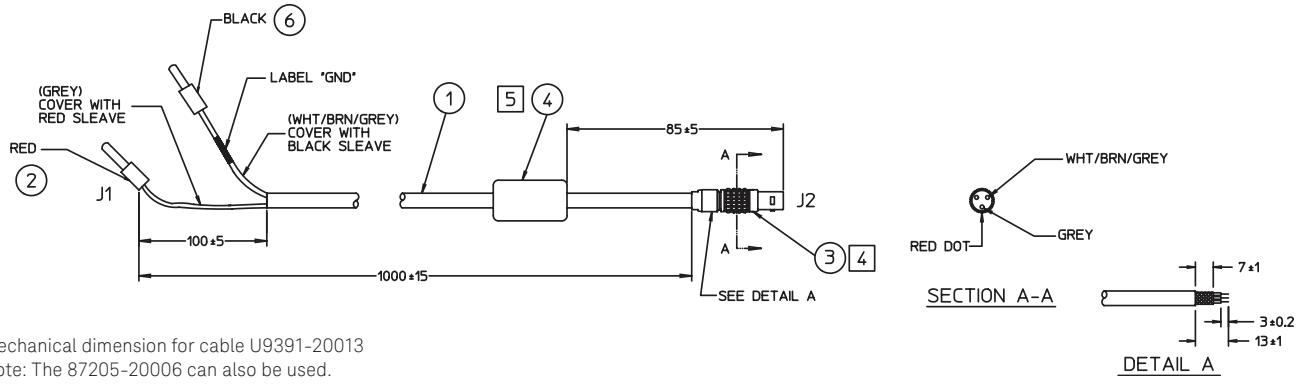
Mechanical dimension for U9391F



Mechanical dimension for U9391G



Mechanical dimension for U9391-60009 Squaring circuit for U9391 C/F/G



Mechanical dimension for cable U9391-20013
Note: The 87205-20006 can also be used.

Typical Performance

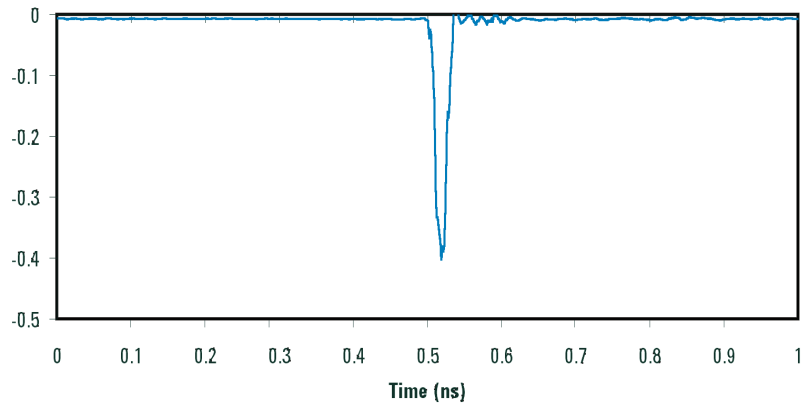


Figure 2. U9391C/F pulse

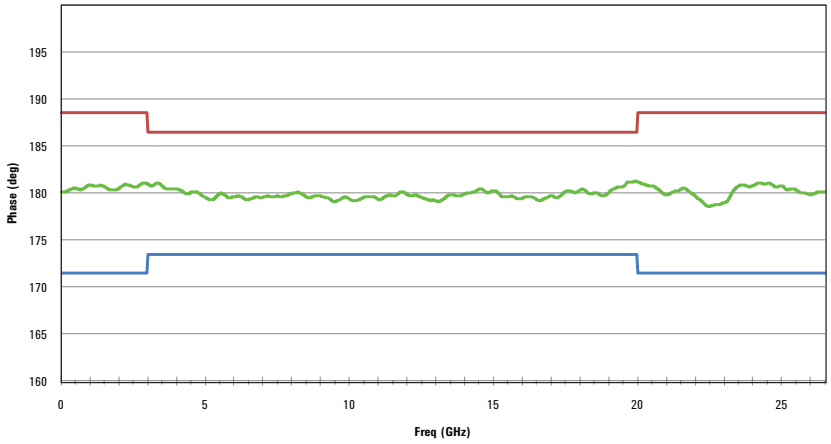


Figure 3. U9391C Comb Generator Phase at 10 MHz PRF

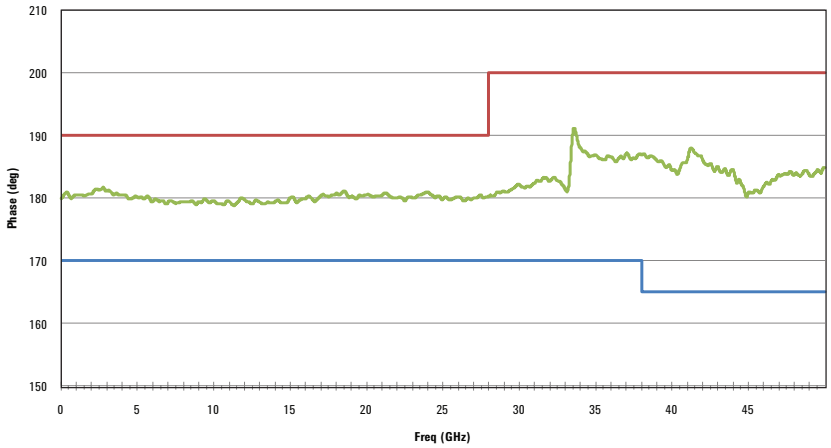


Figure 4. U9391F Comb Generator Phase at 10 MHz PRF

Typical Performance

continued

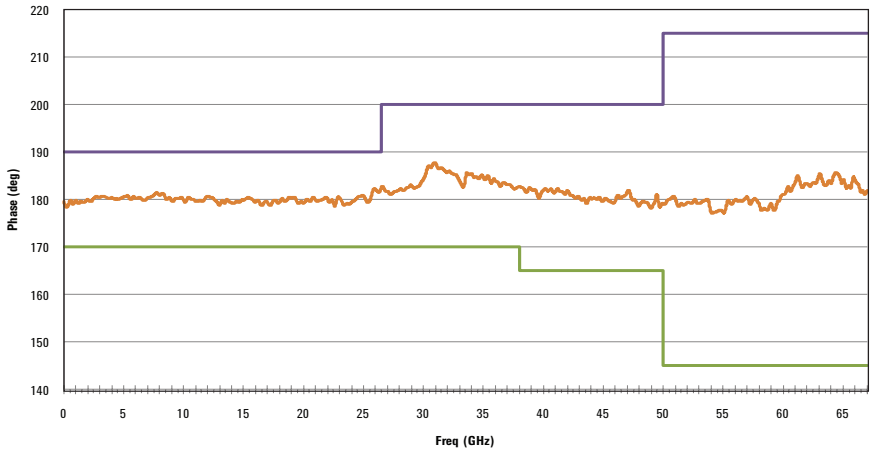


Figure 5. U9391G Comb Generator Phase at 10 MHz PRF

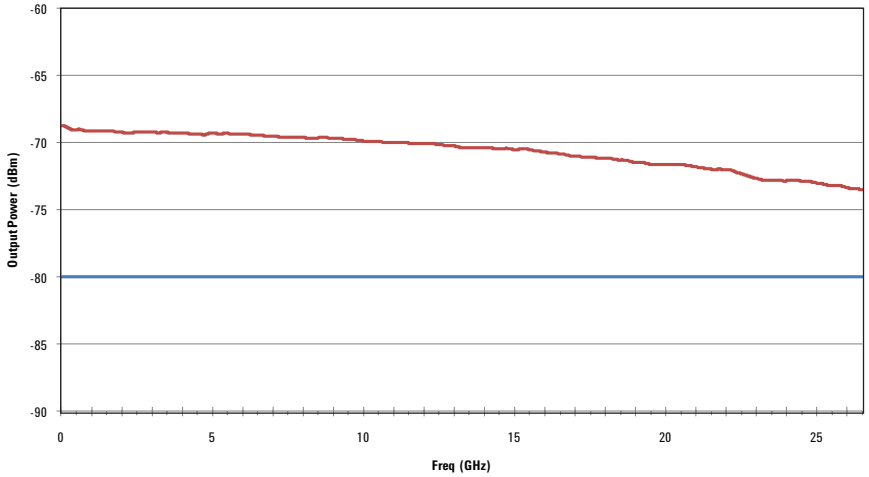


Figure 6. U9391C Comb Generator Output Power at 10 MHz PRF

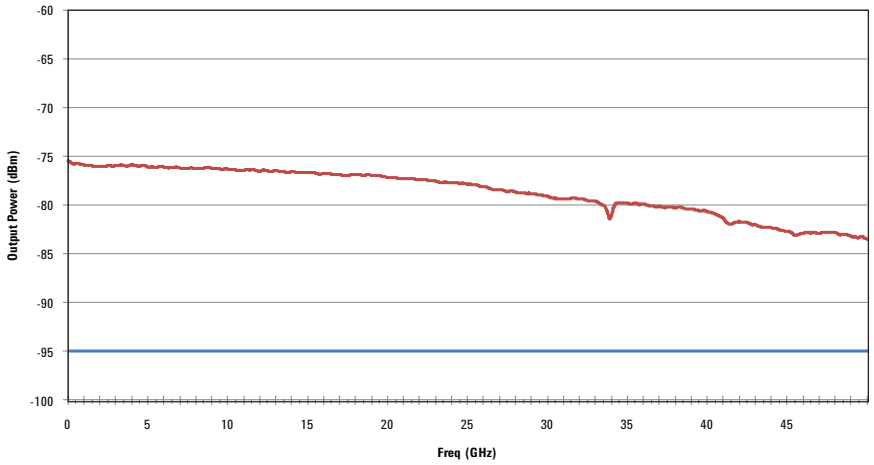


Figure 7. U9391F Comb Generator Output Power at 10 MHz PRF

Typical Performance

continued

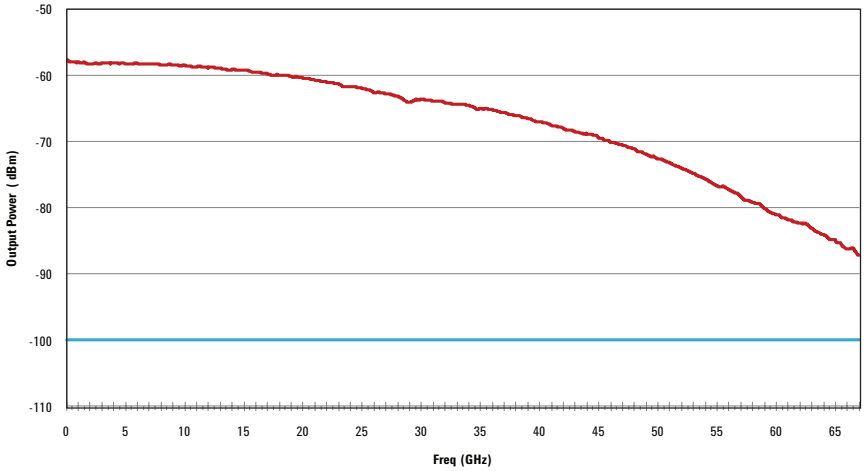


Figure 8. U9391G Comb Generator Output Power at 10 MHz PRF

Ordering Information

Product

U9391C 26.5 GHz Comb Generator

U9391F 50 GHz Comb Generator

U9391G 67 GHz Comb Generator

Connector options

There are two connector options available for the Keysight U9391C/F/G comb generator.

- Option FFF - female (output connector)
- Option FFM - male (output connector)

U9391-60009 squaring circuit is available for U9391C/F/G.

Warranty, calibration and services

Standard warranty is 3 years. Other options available:

- R-51B-001-5Z Warranty Assurance Plan – Return to Keysight – 5 years

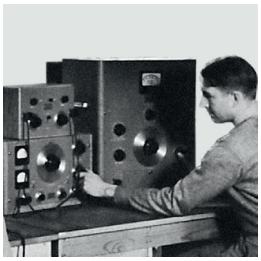
Calibration

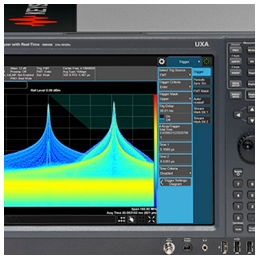
- Option 1A7 Calibration + Uncertainties + Guardbanding (not accredited)
- Option A6J ANSI Z540-1-1994 Calibration

- R-50C-011-3 Calibration Assurance Plan – Return to Keysight – 3 years
- R-50C-011-5 Calibration Assurance Plan – Return to Keysight – 5 years
- R-50C-021-3 ANSI Z540-1-1994 Calibration - 3 years
- R-50C-021-5 ANSI Z540-1-1994 Calibration - 5 years

Evolving Since 1939

Our unique combination of hardware, software, services, and people can help you reach your next breakthrough. We are unlocking the future of technology.
From Hewlett-Packard to Agilent to Keysight.







myKeysight

myKeysight
www.keysight.com/find/mykeysight
A personalized view into the information most relevant to you.

KEYSIGHT SERVICES
Accelerate Technology Adoption.
Lower costs.

Keysight Services
www.keysight.com/find/service
Keysight Services can help from acquisition to renewal across your instrument's lifecycle. Our comprehensive service offerings—one-stop calibration, repair, asset management, technology refresh, consulting, training and more—helps you improve product quality and lower costs.

STANDARD 3YR WARRANTY

Three-Year Warranty
www.keysight.com/find/ThreeYearWarranty
Keysight's committed to superior product quality and lower total cost of ownership. Keysight is the only test and measurement company with three-year warranty standard on all instruments, worldwide. And, we provide a one-year warranty on many accessories, calibration devices, systems and custom products.

CALIBRATION WARRANTY UP TO 10 YEARS ASSURANCE PLANS

Keysight Assurance Plans
www.keysight.com/find/AssurancePlans
Up to ten years of protection and no budgetary surprises to ensure your instruments are operating to specification, so you can rely on accurate measurements.

Keysight Channel Partners
www.keysight.com/find/channelpartners
Get the best of both worlds: Keysight's measurement expertise and product breadth, combined with channel partner convenience.

www.keysight.com/find/mta
www.keysight.com/find/pnax
www.keysight.com/find/signaloptimizer

KEYSIGHT TECHNOLOGIES
Unlocking Measurement Insights

For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at:
www.keysight.com/find/contactus

Americas

Canada	(877) 894 4414
Brazil	55 11 3351 7010
Mexico	001 800 254 2440
United States	(800) 829 4444

Asia Pacific

Australia	1 800 629 485
China	800 810 0189
Hong Kong	800 938 693
India	1 800 11 2626
Japan	0120 (421) 345
Korea	080 769 0800
Malaysia	1 800 888 848
Singapore	1 800 375 8100
Taiwan	0800 047 866
Other AP Countries	(65) 6375 8100

Europe & Middle East

Austria	0800 001122
Belgium	0800 58580
Finland	0800 523252
France	0805 980333
Germany	0800 6270999
Ireland	1800 832700
Israel	1 809 343051
Italy	800 599100
Luxembourg	+32 800 58580
Netherlands	0800 0233200
Russia	8800 5009286
Spain	800 000154
Sweden	0200 882255
Switzerland	0800 805353 Opt. 1 (DE) Opt. 2 (FR) Opt. 3 (IT)
United Kingdom	0800 0260637

For other unlisted countries:
www.keysight.com/find/contactus
(BP-6-20-17)

DEKRA Certified
ISO9001 Quality Management System

www.keysight.com/go/quality
Keysight Technologies, Inc.
DEKRA Certified ISO 9001:2015
Quality Management System

This information is subject to change without notice.
© Keysight Technologies, 2013 - 2017
Published in USA, September 6, 2017
5989-7619EN
www.keysight.com

Artisan Technology Group is an independent supplier of quality pre-owned equipment

Gold-standard solutions

Extend the life of your critical industrial, commercial, and military systems with our superior service and support.

We buy equipment

Planning to upgrade your current equipment? Have surplus equipment taking up shelf space? We'll give it a new home.

Learn more!

Visit us at **artisantg.com** for more info on price quotes, drivers, technical specifications, manuals, and documentation.

Artisan Scientific Corporation dba Artisan Technology Group is not an affiliate, representative, or authorized distributor for any manufacturer listed herein.

We're here to make your life easier. How can we help you today?

(217) 352-9330 | sales@artisantg.com | artisantg.com

ARTISAN® TECHNOLOGY GROUP