

Keysight Technologies

USB Preamplifiers

U7227A 10 MHz to 4 GHz

U7227C 100 MHz to 26.5 GHz

U7227F 2 to 50 GHz

Technical Overview



Key Features and Benefits

- Automatic gain correction value with temperature compensation and transfer of calibration data (noise figure and S-parameters) through USB plug and play features for improved noise figure measurements with Keysight N9000/10/20/30A X-Series analyzers
- Excellent noise figure and optimized gain with the X-Series signal analyzers; improves measurement accuracy and minimizes uncertainty
- Provides ultra-broadband operating frequency from 10 MHz up to 50 GHz for various applications
- Rugged and portable design for benchtop measurements or remote front-end applications

Benchtop/Remote Front End Use

In many RF systems, noise figure is known as a key parameter for characterizing a receiver and its ability to detect weak incoming signals combined with self-generated noise. The presence of these signals are typically low level, so adding a reliable preamplifier will greatly increase the sensitivity of your measurement system.

The Keysight Technologies, Inc. U7227A/C/F USB preamplifiers are designed to bring reliable gain and low noise figure to measurement systems to improve overall system performance and reduce systematic errors. Powered on a USB platform, compact and portable, the USB preamplifiers eliminates the need for an external power supply and is ideal for either benchtop measurements or on remote front end applications.

When connected to the Keysight X-Series signal analyzers, the USB preamplifiers can automatically configure the signal analyzer to detect the specific preamplifier connected. The preamplifier will then download the embedded calibration data such as gain, noise figure and S-parameters. The calibration data provides accurate correction data and more repeatable results for each measurement made.

The combined solution of the Keysight U7227A/C/F USB preamplifiers and the X-Series signal analyzers delivers the most efficient test setup, highest accuracy and lowest measurement uncertainty for noise figure measurement applications up to 50 GHz.

Improve Noise Figure Measurements

Adding a preamplifier to a noise figure measurement system can significantly reduce the overall system noise figure. The total system noise is dominated by the noise figure of the preamplifier.

$$F_{new} = F_{pa} + \frac{F_{sys} - 1}{G_{pa}}$$

Where F and G are noise figure and preamplifier gain, both in linear terms.

$$NF_{sys} = 10 \log (F_{sys}) \text{ in dB}$$

For systems with a single preamplifier, where the gain of the preamplifier is greater than or equal to the spectrum analyzer noise figure, the system noise figure is approximately equal to the noise figure of the preamplifier.

Increase Sensitivity and Speed

Measurement system sensitivity for measuring low-level signals can be improved by adding a preamplifier. Alternatively, boosting the sensitivity of your signal or spectrum analyzer with the U7227A/C/F USB preamplifiers can provide a means for achieving a faster measurement speed. Spurious tests often require narrow resolution bandwidths to reduce the noise floor of the analyzer, thus allowing for low-level signal detection. An analyzer with low noise figure allows you to use a wider resolution bandwidth, yet achieve the same sensitivity. Sweep times can improve one hundred times for each decade increase in bandwidth. The U7227A/C/F USB preamplifiers have gain and noise figure characteristics that optimize dynamic range and sensitivity.

Low Noise Amplifier Measurements

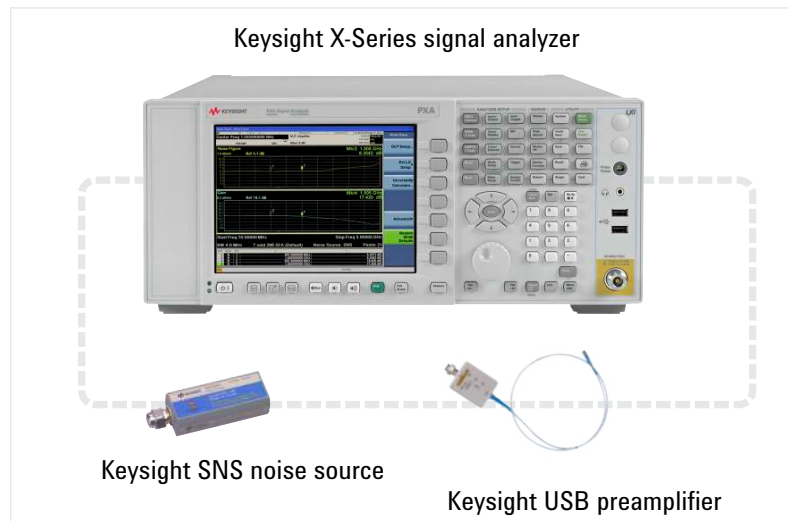


Figure 1. USB Preamplifier calibration setup

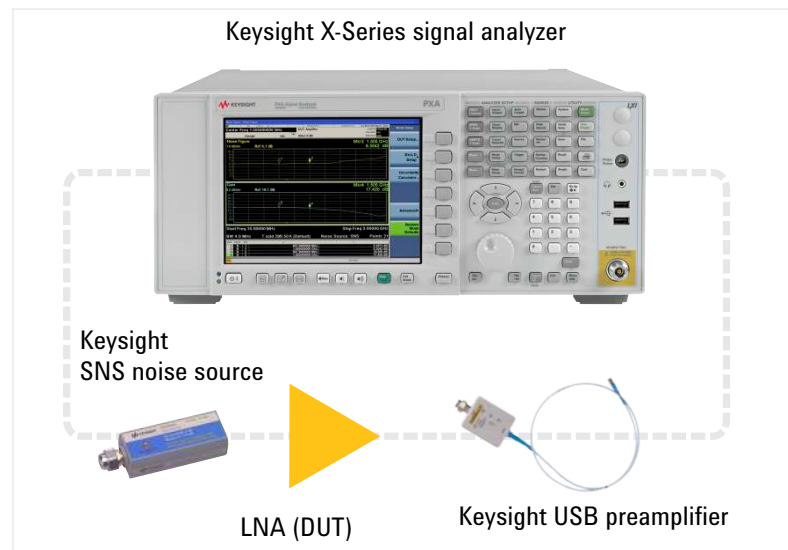


Figure 2. LNA noise figure measurement setup

Figure 2 above shows the typical setup with a Keysight X-Series signal analyzer for noise figure measurements on a low noise amplifier (LNA) device using the Y-factor measurement technique. The method begins with the calibration setup shown in figure 1; connecting the USB preamplifier and noise source to the X-Series signal analyzer, setting a start and stop frequency, then calibrate the system through the noise figure measurement application on the signal analyzer. The next step is to insert the LNA and observe the gain and noise figure for the measurement as shown in figure 2. The built-in uncertainty calculator for the signal analyzer will perform the calculation work for you by importing uncertainties from the specification guide, calibration data from the SNS (noise source), and the gain, noise figure, and match terms of the USB preamplifiers. The uncertainty calculator will also import the LNA noise figure and gain terms from the previous measurement.

Mixer Measurements

For noise figure measurements on frequency-converting devices such as mixers, a more complicated setup is required.

Figure 4 shows a setup using a low pass filter (LPF) before the mixer (DUT) to remove any LO feed through. First the measurement system will require calibration (figure 3) which includes calibrating the LPF to include it in the measurement system. When the mixer local oscillator (LO) and IF input is connected to the signal analyzer, calibration is being carried out. When the calibration process is complete, the DUT will be inserted between the low pass filter and the SNS source with the LO input being connected to a source. Noise figure measurements can now be carried out for the DUT.

Built-in uncertainty calculators do not work for frequency converting devices. For this application, you will need the RF (input) and IF (output) VSWR from the data sheet of the mixers to estimate the uncertainty of the system being measured.

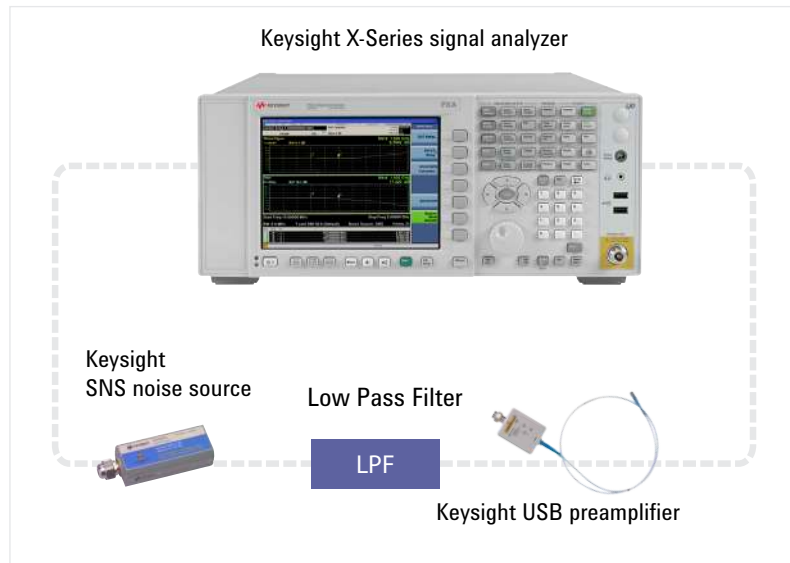


Figure 3. USB preamplifier calibration setup

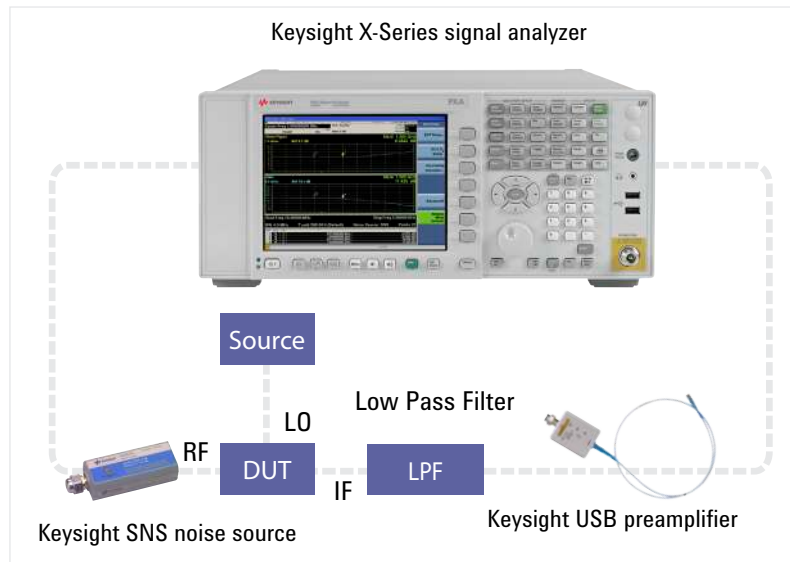


Figure 4. Mixer noise figure measurement setup

Specifications*

Specifications refer to the performance standards or limits against which the U7227A/C/F USB preamplifiers are tested.

Typical characteristics are included for additional information only and they are not specifications. Those are denoted as “typical”, “nominal” or “approximate” and are printed in italic.

Specifications subject to change

Specification	U7227A	U7227C	U7227F
Frequency	10 MHz to 4 GHz	100 MHz to 26.5 GHz	2 to 50 GHz
Gain (dB)	10 to 100 MHz: > 16 100 MHz to 4 GHz: > 0.5F + 17	100 MHz to 26.5 GHz: > 16.1 + 0.26F	2 to 50 GHz: > 16.5 + 0.23F
Input return loss (Input SWR)	10 to 100 MHz: > 5 dB (3.57) 100 MHz to 2 GHz: > 13.5 dB (1.54) 2 to 3 GHz: > 11.5 dB (1.73) 3 to 4 GHz: > 10 dB (1.93)	100 MHz to 4 GHz: > 15 dB (1.43) 4 to 26.5 GHz: > 8 dB (2.32)	2 GHz to 40 GHz: > 8 dB (2.32) 40 to 44 GHz: > 6 dB (3.00) 44 to 50 GHz: > 5 dB (3.57)
Output return loss (Output SWR)	10 MHz to 4 GHz: > 18 dB (1.29)	100 MHz to 4 GHz: > 18 dB (1.29) 4 to 26.5 GHz: > 11 dB (1.78)	2 GHz to 4 GHz: > 18 dB (1.29) 4 to 40 GHz: > 11 dB (1.78) 40 to 50 GHz: > 8 dB (2.32)
Noise figure	10 to 100 MHz: < 5.5 dB 10 MHz to 4 GHz: < 5 dB	100 MHz to 4 GHz: < 6 dB 4 to 6 GHz: < 5 dB 6 to 18 GHz: < 4 dB 18 to 26.5 GHz: < 5 dB	2 to 4 GHz: < 10 dB 4 to 40 GHz: < 8 dB 40 to 44 GHz: < 9 dB 44 to 50 GHz: < 10 dB
Plug and play USB connection	Yes	Yes	Yes
Optimized gain slope for better spectrum analysis	Yes	Yes	Yes
Automatic gain compensation	Yes	Yes	Yes
Automatic temperature compensation	Yes	Yes	Yes

* Specifications are tested and measured with an operating temperature of 23 °C.

* “F” signifies frequency in GHz

Supplemental Characteristics	U7227A	U7227C	U7227F
Data storage	EEPROM	EEPROM	EEPROM
Bias voltage and current	USB 5 Vdc at 360 mA	USB 5 Vdc at 400 mA	USB 5 Vdc at 460 mA
Survival input power	+ 17 dBm	+ 17 dBm	+ 10 dBm
Power dissipation (typical)	1.8 W	2 W	2.3 W
Temperature coefficient (typical)	-0.009 dB/C	-0.03 dB/C	-0.18 dB/C
Pin depth	0 to -0.05 mm (0 to -0.002 in)		
RF connector	3.5 mm (m)	3.5 mm (m)	2.4 mm (m)

Amplitude accuracy (typical)

		Total Measurement Uncertainty, 95th dB	Interpolation Error, 2σ
0	0.01 to 3.6 GHz	0.036	0.0326
1	3.5 to 8.4 GHz	0.085	0.0267
2	8.3 to 13.6 GHz	0.091	0.0188
3	13.5 to 17.1 GHz	0.096	0.0354
4	17.0 to 26.5 GHz	0.106	0.1138
5	26.4 to 34.5 GHz	0.153	0.1082
6	34.4 to 50 GHz	0.238	0.3438

Input VSWR (typical)

Model	Frequency Range	95th Percentile VSWR
U7227A	0.01 to 4 GHz	1.811
U7227C	0.1 to 26.5 GHz	2.073
U7227F	2 to 50 GHz	2.265

Note: The 95th percentile VSWR shown is actually the 95th percentile of a Rayleigh distribution that would give similar mismatch uncertainty to that from an observed example preamplifier. The actual 95th percentile distribution is smaller than this, but it only modestly matches a Rayleigh distribution. Still, Keysight recommends using the methods outlined in Application Note 1449-3 and companion Average Power Sensor Measurement Uncertainty Calculator to compute mismatch uncertainty. Use this 95th percentile VSWR information and the Rayleigh model (Case C or E in the application note) with that process.

Typical performance

U7227A 10 MHz to 4 GHz USB Preamplifier

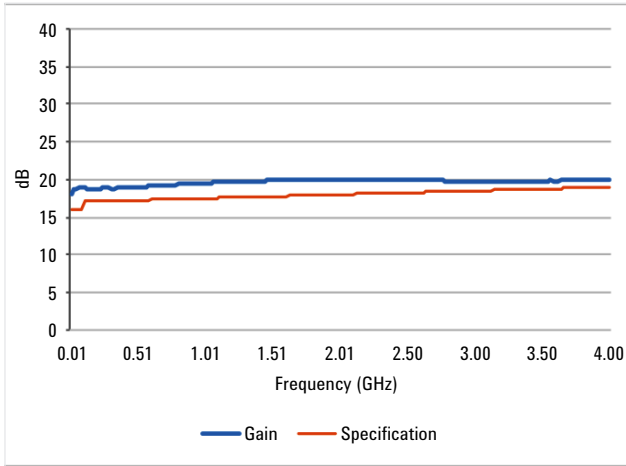


Figure 5. U7227A Gain versus frequency (typical)

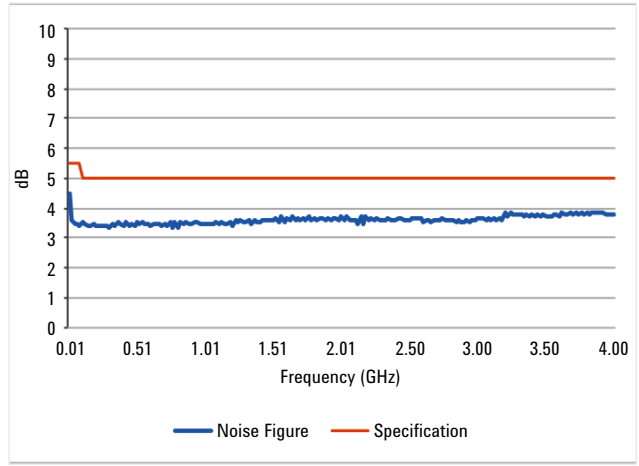


Figure 6. U7227A Noise figure versus frequency (typical)

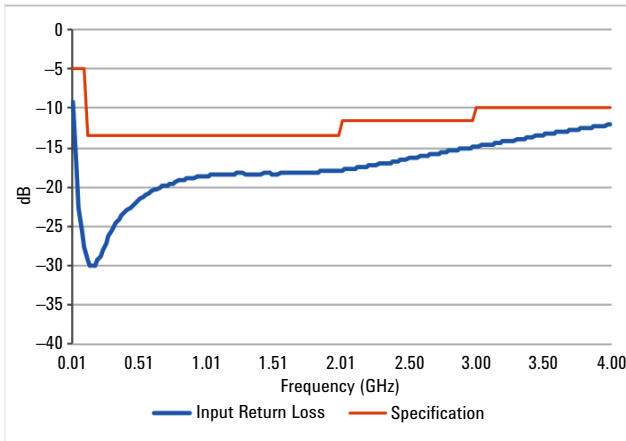


Figure 7. U7227A return loss versus frequency (typical)

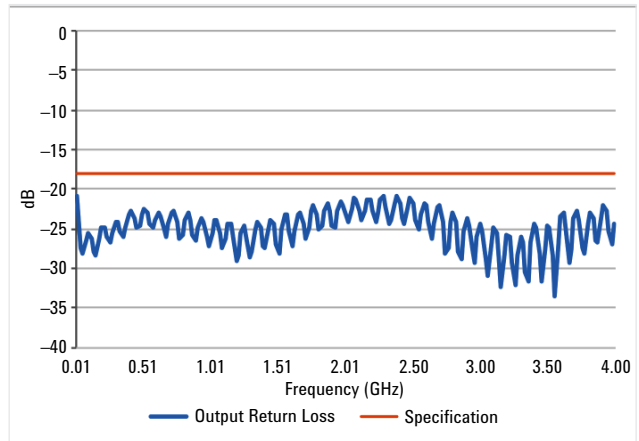


Figure 8. U7227A Output return loss versus frequency (typical)

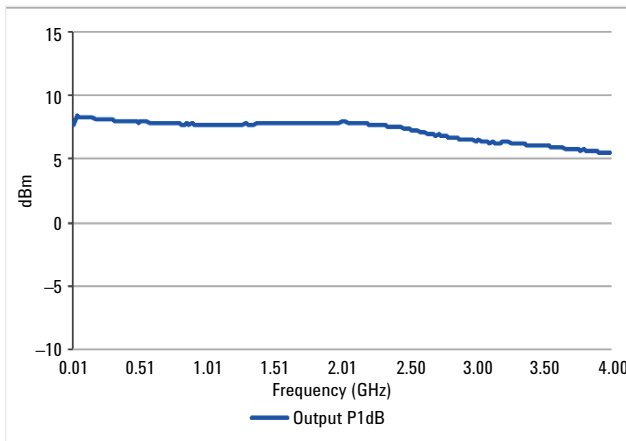


Figure 9. U7227A Output P1dB versus frequency (typical)

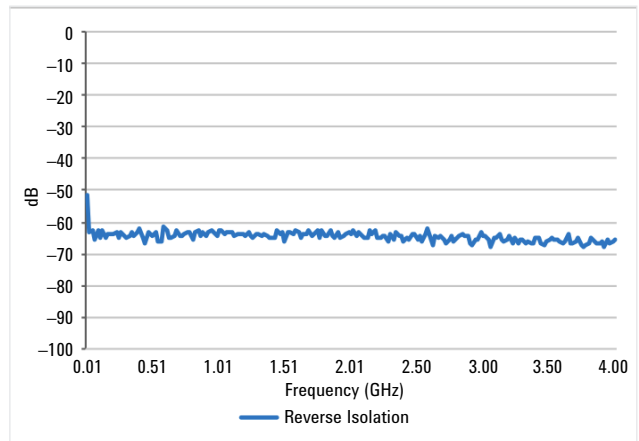


Figure 10. U7227A Reverse isolation versus frequency (typical)

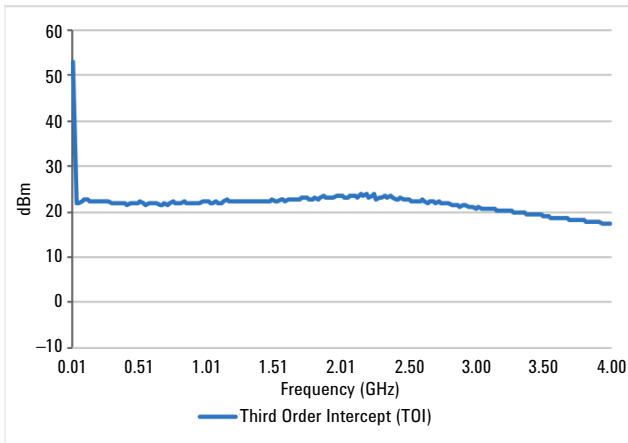


Figure 11. U7227A Third order intercept (TOI) versus frequency (typical)

Typical performance

U7227C 100 MHz to 26.5 GHz USB Preamplifier

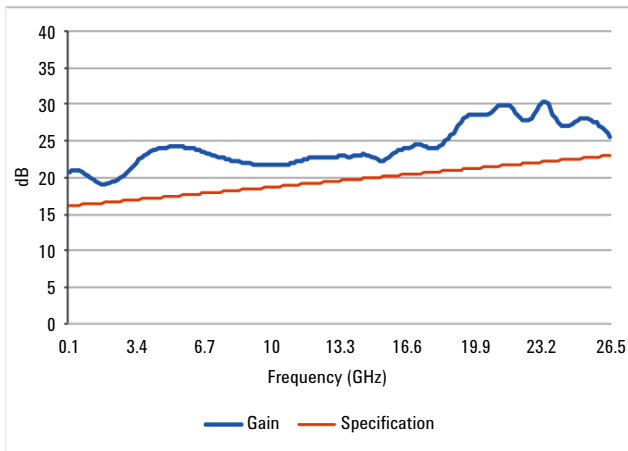


Figure 12. U7227C Gain versus frequency (typical)

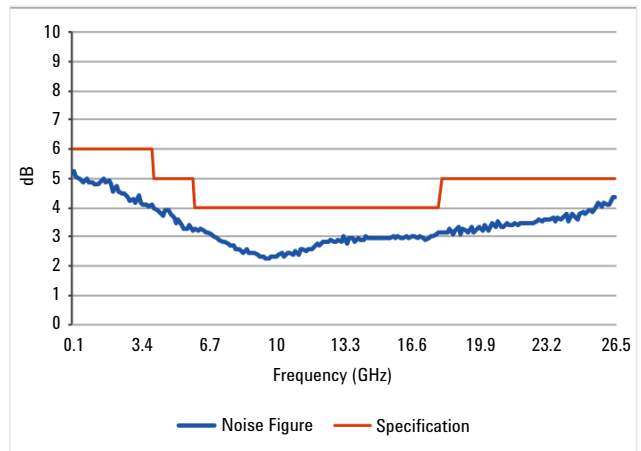


Figure 13. U7227C Noise figure versus frequency (typical)

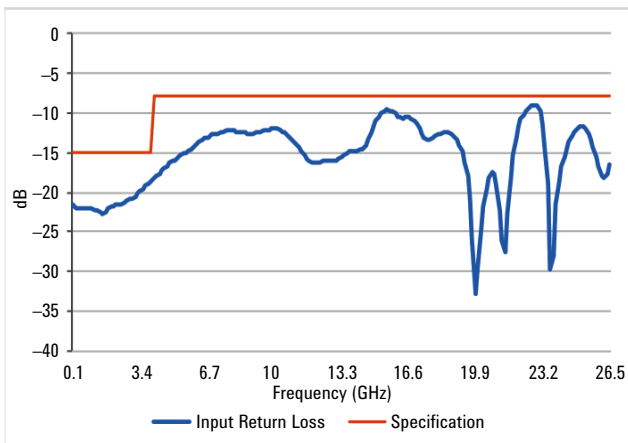


Figure 14. U7227C Input return loss versus frequency (typical)

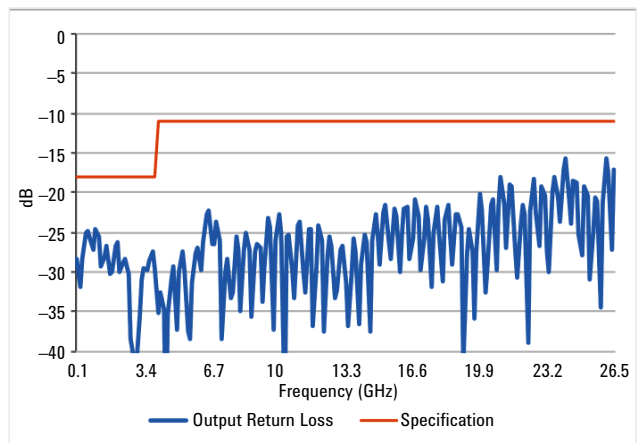


Figure 15. U7227C Output return loss versus frequency (typical)

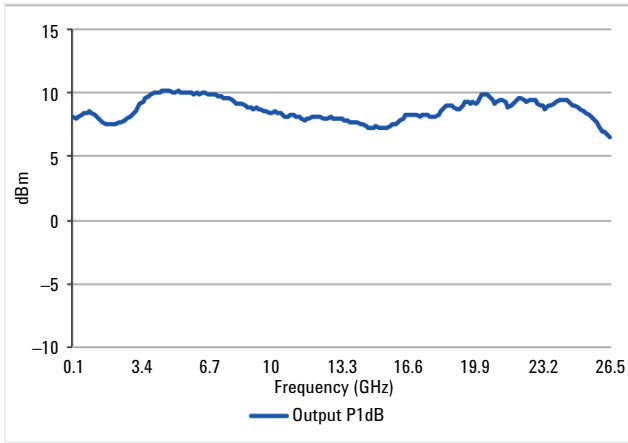


Figure 16. U7227C Output P1dB versus frequency (typical)

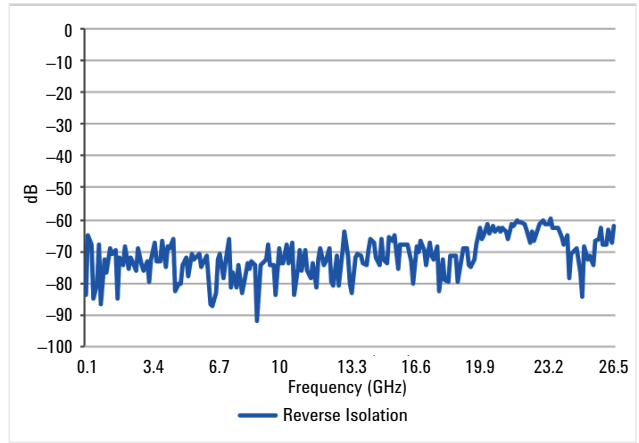


Figure 17. U7227C Reverse isolation versus frequency (typical)

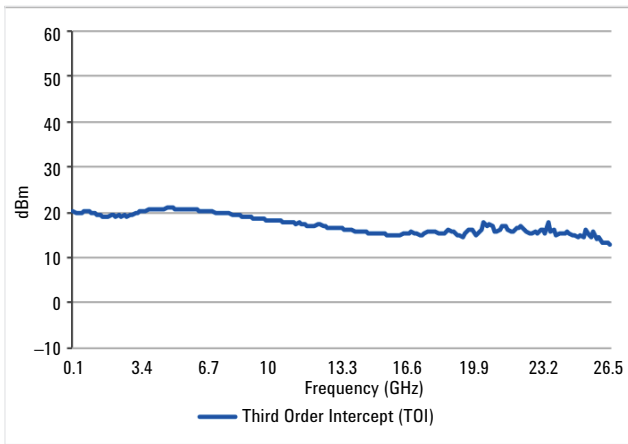


Figure 18. U7227C Third order intercept (TOI) versus frequency (typical)

Typical performance U7227F 2 to 50 GHz USB Preamplifier

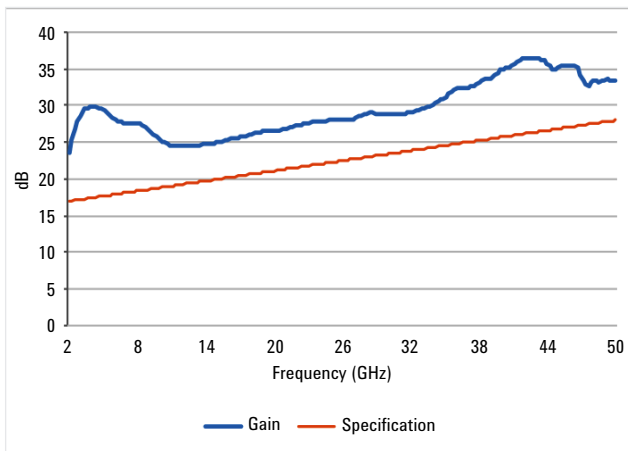


Figure 19. U7227F Gain versus frequency (typical)

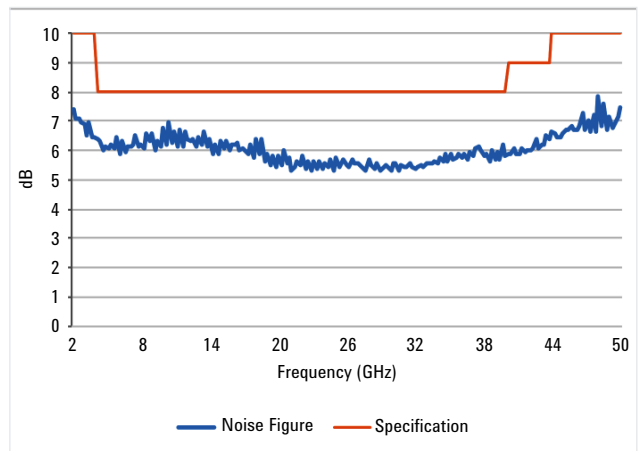


Figure 20. U7227F Noise figure versus frequency (typical)

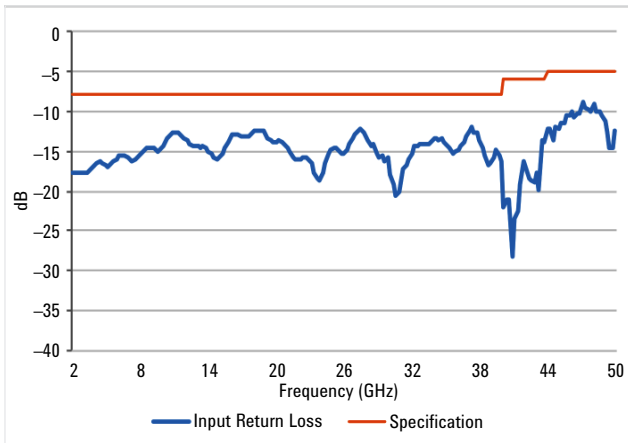


Figure 21. U7227F Input return loss versus frequency (typical)

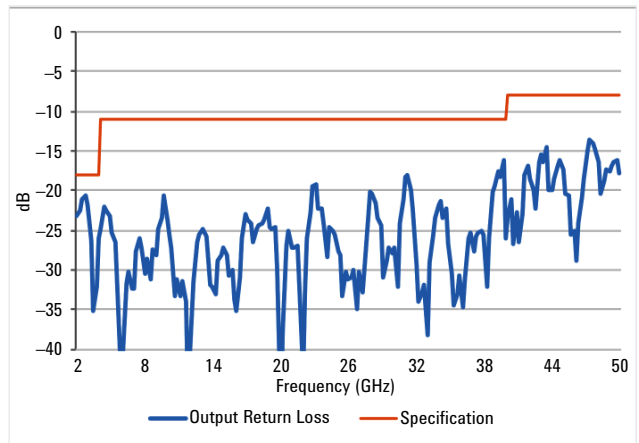


Figure 22. U7227F output return loss versus frequency (typical)

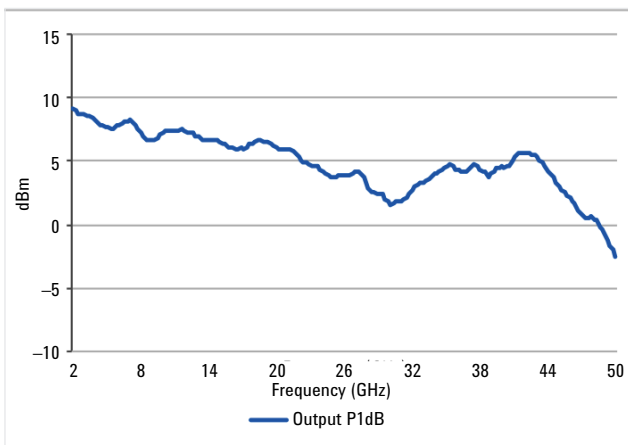


Figure 23. U7227F output P1dB versus frequency (typical)

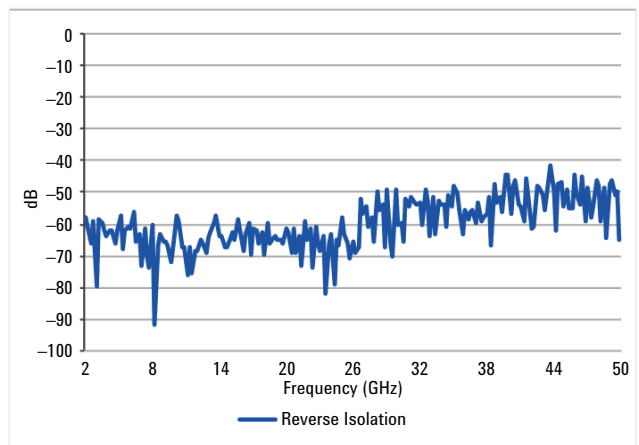


Figure 24. U7227F Reverse isolation versus frequency (typical)

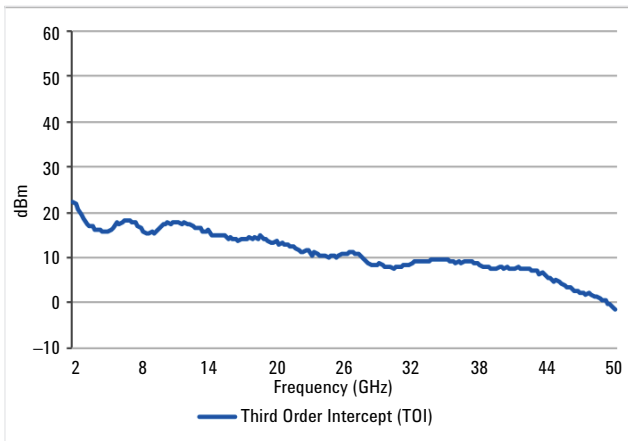


Figure 25. U7227F third order intercept (TOI) versus frequency (typical)

Environmental Specifications

Keysight U7227A/C/F USB preamplifiers fully comply with Keysight Technologies' product operating environmental specifications. The following are the summarized environmental specifications for these products.

Temperature range	
Operating	0 to 55 °C
Storage	-40 to 70 °C
Relative humidity	
Operating	50 % to 95 % RH at 40 °C
Storage	90 % RH at 65 °C
Shock	
End-use handling shock	1.6 m/s
Transportation shock	50 g, 8 m/s
Vibration	
Operating	Random: 5 to 500 Hz, 0.21 g rms
Survival	Random: 5 to 500 Hz, 2.09 g rms
	Swept sine: 5 to 500 Hz, 0.5 g rms
ESD immunity	
Direct discharge	6 kV per IEC 61000-4-2
Air discharge	15 kV per IEC 61000-4-2

Mechanical Dimension

Mechanical dimensions do not include RF cables and connectors

Model	Weight	Pin depth	Height	Width	Length
U7227A	0.38 kg (0.84 lbs)	0 to – 0.05 mm (0 to – 0.002 in)	35.50 mm (1.40 in)	60.00 mm (2.36 in)	75.00 mm (2.95 in)
U7227C					
U7227F					

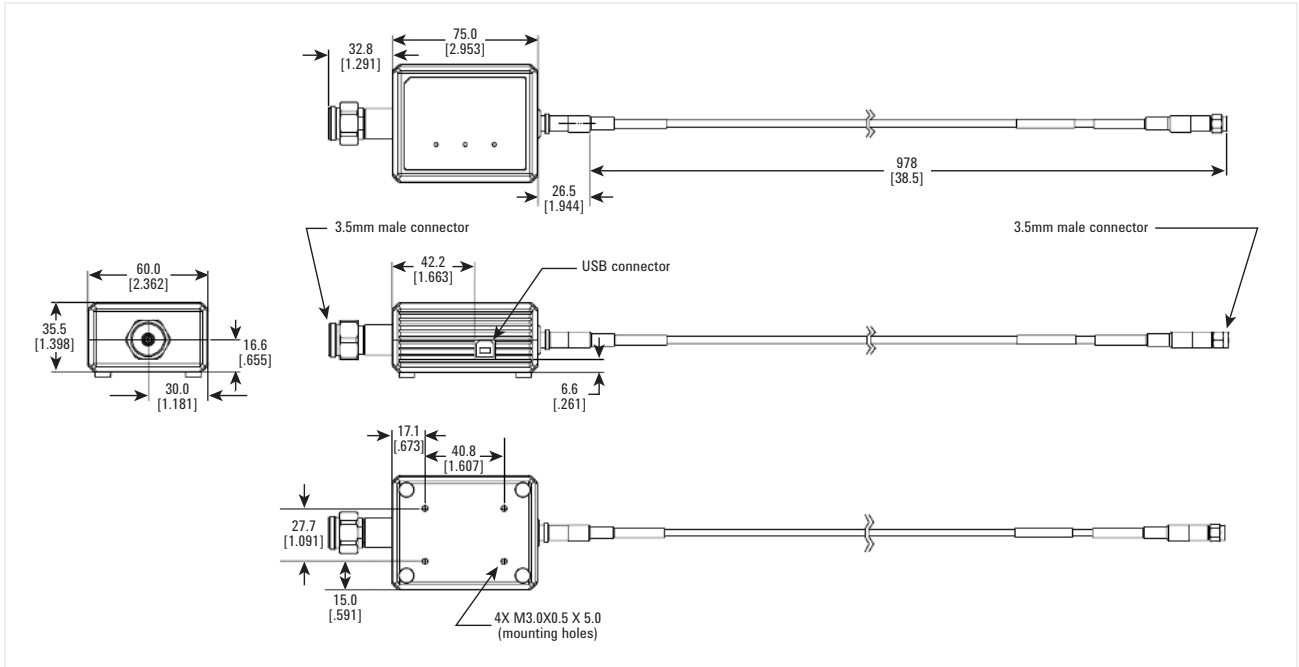


Figure 26. Mechanical dimensions for U7227A and U7227C USB preamplifiers

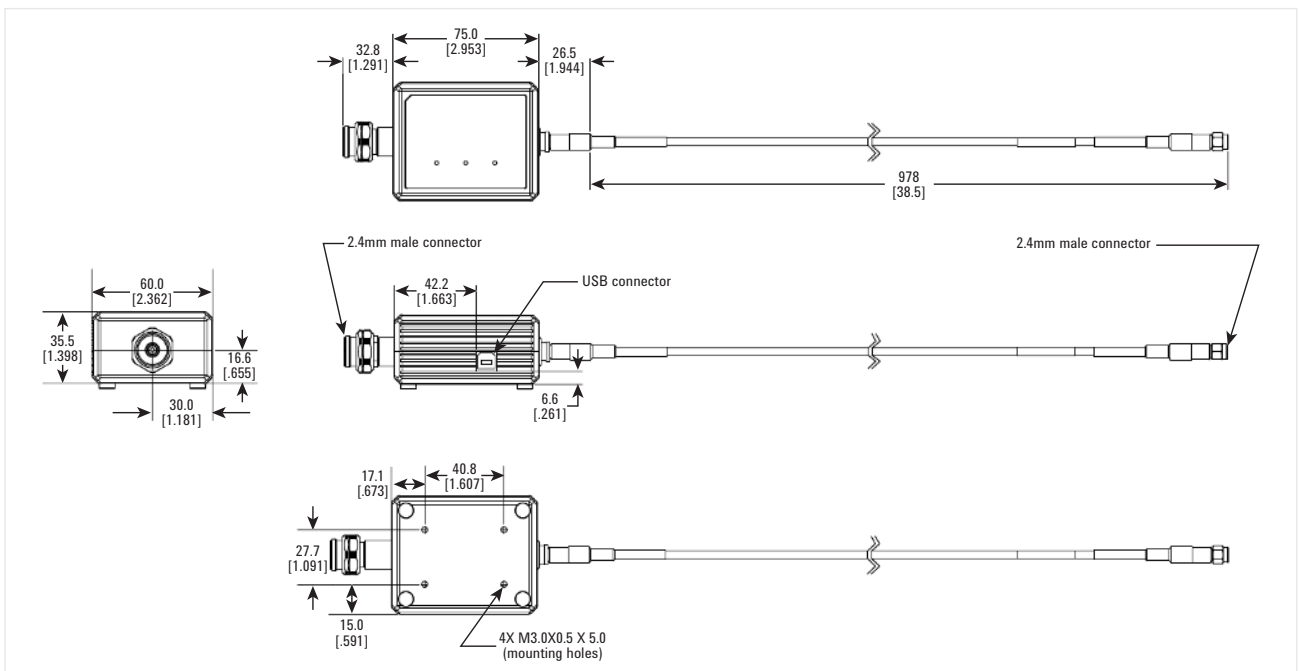


Figure 27. Mechanical dimensions for U7227F USB preamplifier

Ordering Information

U7227A 10 MHz to 4 GHz USB Preamplifier¹
U7227C 100 MHz to 26.5 GHz USB Preamplifier¹
U7227F 2 to 50 GHz USB Preamplifier²

¹ The product ships with one 3.5 (f) to Type-N (m) adapter.

² The product ships with one 2.4 (f) to 2.4 (f) adapter.

Recommended Signal Analyzers

N9000A CXA Series Signal Analyzers, 9 kHz to 26.5 GHz
www.keysight.com/find/cxa

N9010A EXA X-Series Signal Analyzers, 10 Hz to 44 GHz
www.keysight.com/find/exa

N9020A MXA X-Series Signal Analyzers, 10 Hz to 26.5 GHz
www.keysight.com/find/mxa

N9030A PXA X-Series Signal Analyzers, 3 Hz to 50 GHz
www.keysight.com/find/pxa

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www.keysight.com/find/ThreeYearWarranty

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www.keysight.com/find/AssurancePlans

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