Application Note

# TEST PORT ADAPTER, R&S INTERCHANGEABLE PORT CONNECTOR

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http://www.rohde-schwarz.com/appnote/1MA100

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# Contents

# 1 Overview

An RF Test Port Adapter system is implemented and delivered with some Rohde & Schwarz RF test instruments. These interchangeable port connectors are used on instruments capable of operating at frequencies of 26 GHz and above, and include spectrum analyzers, signals generators and EMC test receivers.

This Application Note identifies the Test Port Adapter types, their parameters, compatibility and usage.

# 2 Introduction

The Rohde & Schwarz RF '*Test Port Adapter*' system is found on some Rohde & Schwarz test instruments that operate at frequencies of 26 GHz and above.

The primary purpose of the RF Test Port Adapter system is to provide a sacrificial interface to a test instrument, thus protecting the instrument RF front panel connector from mechanical damage. After prolonged use, the adapter may simply be exchanged without a need for the instrument to be returned for service.

Co-axial RF connectors for higher frequencies tend to be more fragile and are easily damaged. The Test Port Adapter system offers the additional benefit that an RF port can be temporarily configured with a more rugged connector, if an application does not require the highest frequencies supported by an instrument.

The Test Port Adapter system consists of the RF front-end interface on the test instrument called the '*Test Port Adapter Body*' and a removable '*Test Port Adapter Head*', which connects to the Test Port Adapter Body. The adapter head supports an RF precision coaxial connector, providing the interface to a cable or device under test.

The Rohde & Schwarz RF Test Port Adapter system is also called the '*Interchangeable Port Connector System*'. This document uses the term '*Test Port Adapter*'.

Note that R&S instruments that do not support the Test Port Adapter system will have a panel mounted RF port, providing direct connection to RF cables, etc. Considerable care must be taken to ensure that RF connectors applied to the port are undamaged, clean and mechanically compatible to ensure the longevity of the instrument RF port. Failure to observe these requirements could lead to the instrument RF connector becoming damaged or wearing prematurely. More information on RF connector care may be found in an accompanying application note, "Guidance on Selecting and Handling Coaxial RF Connectors used with Rohde & Schwarz Test Equipment", 1MA99.

# 3 The RF Test Port Adapter System

The Test Port Adapter system comprises two parts:

- *Test Port Adapter Body* – Manufacturer fitted RF instrument port.
- *Test Port Adapter Head* - Provides the RF interconnection between the Test Port Adapter Body and a precision RF coaxial interface.

Figure 3-1 shows an example of the Test Port Adapter Body on a typical R&S microwave instrument. It is easily identified and separated from standard RF connectors due to its mechanical design. It is important to realize that standard commercially available coaxial RF connectors cannot be interfaced directly with the Test Port Adapter Body.


Figure 3-1: Example of the R&S Test Port Adapter Body

Figure 3-2 shows the same instrument fitted with two different interchangeable Test Port Adapter Heads.

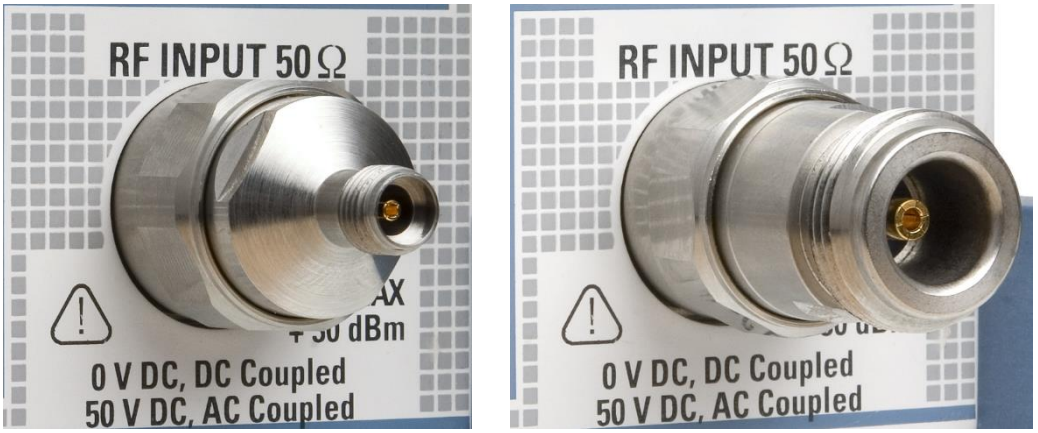


Figure 3-2: Test instrument shown with interchangeable Test Port Adapter Heads.

The Test Port Adapter system offers several advantages, including:

- Damage to the standard RF interface on the Adapter Head (N, precision 3.5 mm, etc.) is easily corrected through simply exchanging the Adapter Head. Therefore, no service costs or lengthy repair waiting times for the whole instrument are incurred.

The Adapter Heads support several standard RF interfaces. This helps to reduce the need for additional in-line RF adapters. This flexibility is particularly useful where mechanical robustness is required, for example, use of a precision 2.4 mm to N-type adapter makes for a mechanically weak interface. Instead, a Test Port Adapter Head supporting a 2.4mm connection can be directly replaced with one supporting an N-type interface, hence making a more robust mechanical connection and removing the need of an RF adapter. See *section 5.1, Supported Test Port Adapter Heads*.

# 4 Test Port Adapter Bodies

The RF port on the instrument supports the Test Port Adapter Body. Two versions exist, each supporting a different frequency range:

- Low frequency range (DC to 26.5 GHz)
- High frequency range (DC to 50 GHz)

These are distinguishable by mechanical differences. These are shown in Figure 4-1 on the opposing interface of the associated Test Port Adapter Heads.

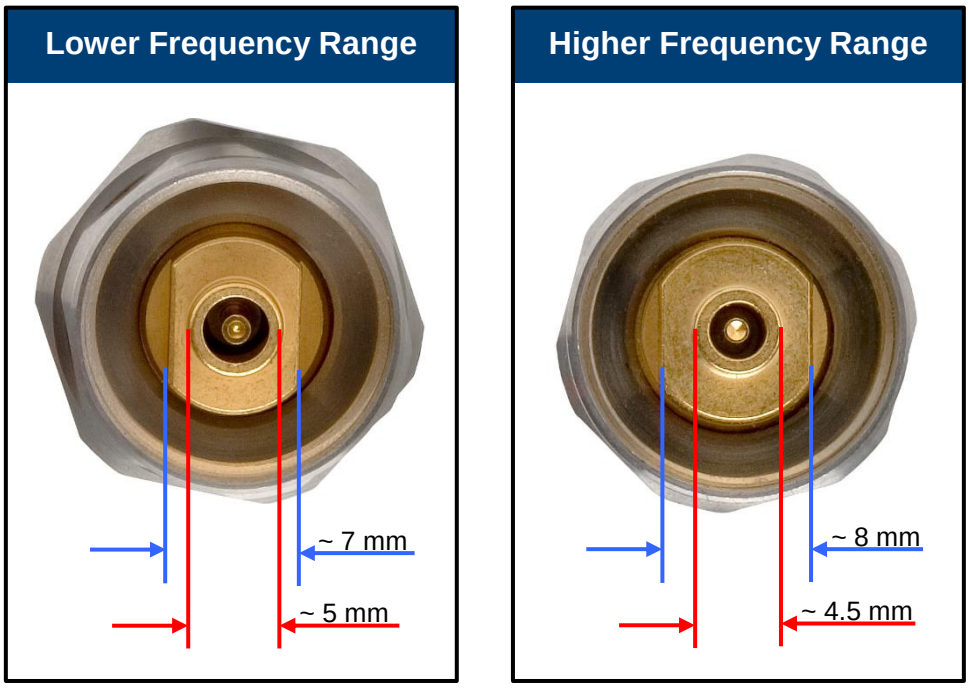


Figure 4-1: Test Port Adapters – Differences in the mechanical interfaces defines the supported frequency range.

Figure 3-1 shows that the Test Port Body supports a slot. Correspondingly, the Test Port Adapter Head has a “key” shown in Figure 4-1 (blue dimensions), that fits into the Test Port Body, but only if both parts support the same frequency range.

# 5 Test Port Adapter Heads

## 5.1 Supported Test Port Adapter Heads

For each of the Test Port Adaptor Bodies, Rohde & Schwarz provides a selection of different Adapter Heads to interface to standard commercially available precision RF coaxial connectors (Table 5-1).

Please consult instrument datasheets for more information about supplied or compatible Test Port Adapter Heads.

| Test Port Adapter Body type | RF connector type | Upper frequency limit | Gender | R&S Part number |
|---|---|---|---|---|
| Low frequency (40 GHz) | Type-N | 18 GHz | Male | 1021.0541.00 |
| | | | Female | 1021.0535.00 |
| | Precision 3.5 mm | 26.5 GHz | Male | 1021.0529.00 |
| | | | Female | 1021.0512.00 |
| High frequency (50 GHz) | Type-N | 18 GHz | Male | 1036.4783.00 |
| | | | Female | 1036.4777.00 |
| | Precision 2.92 mm | 40 GHz | Male | 1036.4802.00 |
| | | | Female | 1036.4790.00 |
| | Precision 2.4 mm | 50 GHz | Female | 1088.1627.02 |

Table 5-1: Test Port Adapter Heads for Rohde & Schwarz microwave instruments

The physical structure of an RF coaxial connector defines the upper frequency limit of operation. This is the primary consideration when choosing an Adapter Head[1]. Most commercial RF connectors are named after, and are referred to by the inside diameter of the outer conductor.

Rohde & Schwarz instruments that do not have the RF Test Port Adapter system will always be fitted with an RF connector type that supports the maximum frequency limit of the instrument, e.g. the R&S®ZNB40 vector network analyzer operates to 40 GHz and therefore is supplied with 2.92 mm connectors. Considerable care must be taken to avoid damaging these instrument mounted RF connectors.

## 5.2 Female Adapter Heads

Figure 5-1 is an example of a Test Port Adapter Head showing the RF connector structures seen at both ends of the Adapter. The left image shows the interface to the Test Port Adapter Body on the instrument. The right image shows the other end of the Adapter, in this example, a female Type-N RF connector.

Figure 5-1: Test Port Adapter - Interface to the Test Adapter Body (left) and at the opposite end, a female Type-N RF connector (right).

[1] *The power handling capability of the Adapter Head is not a concern since the Adapter Head can tolerate power levels above the power handling limitations imposed by the instrument hosting the Adapter Head.*

Figure 5-2 provides a further example of a Test Port Adapter, converting from the Test Port Adapter Body on the instrument to a female 2.92 mm RF connector.

Figure 5-2: Test Port Adapter with female 2.92 mm RF connector.

## 5.3 Male Adapter Heads

Similarly, there are also Test Port Adapter Heads supporting male versions of commercially available RF coaxial connectors. Figure 5-3 shows both ends of a Test Port Adapter Head supporting a male precision 3.5 mm interface. Examples of male Type-N and 2.92 mm RF Test Port Adapter Heads are given in Figure 5-4.

Figure 5-3: Test Port Adapter - Interface to the Test Adapter Body (left) and at the opposite end, a male 3.5 mm RF connector (right).

Figure 5-4: Test Port Adapter Heads with male Type-N (left) and male precision 3.5 mm (right).

## 5.4 Connecting a Test Port Adapter Head to the Body

The process of applying the Test Port Adapter Head to the Body on the instrument is straightforward, but care must be taken to avoid mechanical damage:

1. Check that the Test Port Adapter Head and Body support the same frequency range (See Figure 4-1).
2. Carefully align the two connectors, bringing them together along a common axis (Figure 5-5).

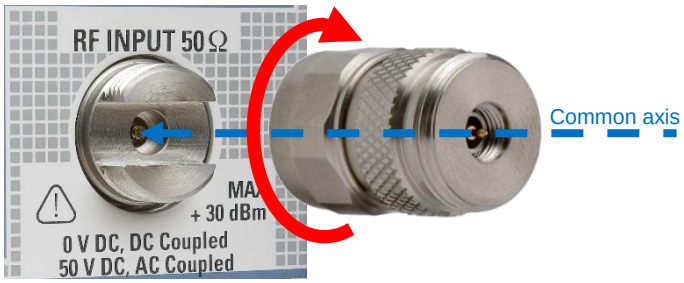


Figure 5-5: Applying a Test Port Adapter Head to the RF Body on a test instrument

3. Align and slot the metal “key” of the Adapter into the “slot” on the Body.
4. The nut on the Adapter and the thread on the Body should now be in close proximity or touching. Using fingers, engage the Adapter nut with the thread of the Body through turning the nut clockwise.
5. Continue to finger tighten the nut and support the Adapter, ensuring that both the Adapter and the Body maintain a common axis about the connector central conductor.

6. If the connector assembly is clean and undamaged, it will be possible to finger tighten the assembly to within about half a turn of the required torque. If any resistance is experienced prior to this point, or if a spanner is required, then it is very likely that one or both of the connectors is damaged and therefore the assembly should be taken apart and inspected immediately.
7. Once firmly coupled, the nut should be torqued to a prescribed limit using a calibrated torque wrench.

## 5.5 Recommended Torque Requirements

To provide accurate, repeatable RF measurements, the Test Port Adapter Head must be correctly torqued on to the instrument Test Port Body using a calibrated torque wrench.
(*R&S torque wrench: Part No: 9016.4989.02*).

| Connector Type | Torque Limit | | Nut opening | |
|---|---|---|---|---|
| | lb-inch | Nm | Inch | mm |
| **Test Port Adapter system** | 17.7 | 2 | 0.709 | 18 |

Table 5-2: Test Port Adapter system torque wrench requirements

# 6 Mechanical compatibility between RF coaxial connector types.

Table 5-1 provides a list of precision coaxial RF connectors supported by the R&S Test Port Adapter system. For information, mechanical compatibility exists between some of the small coaxial RF connector types and is summarized in Table 6-1.

| Mechanical compatibility of RF connectors | | | | | |
|---|---|---|---|---|---|
| **Connector name** | **1.85 mm** | **2.4 mm** | **2.92 mm** | **3.5 mm** | **SMA** |
| **1.85 mm** | ✓ | ✓ | X | X | X |
| **2.4 mm** | ✓ | ✓ | X | X | X |
| **2.92 mm** | X | X | ✓ | ✓ | ✓ |
| **3.5 mm** | X | X | ✓ | ✓ | ✓ |
| **SMA** | X | X | ✓ | ✓ | ✓ |

Table 6-1: Mechanical compatibilities of small threaded RF coaxial connectors

The table shows that there are two clear groups of mechanically compatible RF connectors. The two groups are defined by two mechanical parameters:

- Thread parameters
- Dimensions of the connector center pin

The two groups of RF connectors are summarized as:

- 1.85 mm and 2.4 mm (Ø = 0.25 inch, 36 threads per inch).
- 2.92 mm, 3.5 mm and SMA (M7 x 0.75-6G: Ø = 7mm, pitch = 0.75 mm, 6G tolerance)

Connector types within one group cannot be connected to types in the other group. Figure 6-1 shows that the inner measurement of the center conductor of female 3.5 mm and 2.92 mm connectors are the same (0.92 mm). However, the same parameter on a 2.4 mm female connector is considerably smaller (0.51 mm) and therefore leads to incompatibility.

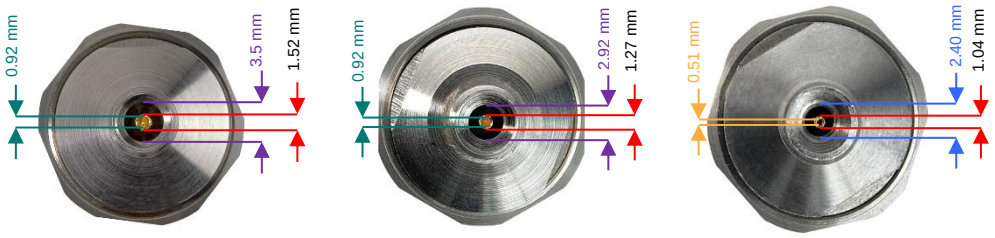


Figure 6-1: Three different female connectors, 3.5 mm (left), 2.92 mm (center) and 2.4 mm (right). Note compatibility of center pins (0.92 mm) on the 2.92 mm and 3.5 mm connectors, and incompatibility with the center pin (0.51 mm) on the 2.4 mm connector.

Caution is advised when interfacing Subminiature Version A (SMA) connectors to 2.92 mm and 3.5 mm precision connectors. Orange ticks in Table 6-1 identify this concern. SMA connectors are easily recognized by the use of a white PTFE[2] dielectric instead of the air dielectric used in precision connector types. The mechanical tolerances applied to SMA connectors are lower than other connector types, leading to considerable mechanical variance. Therefore, a poor quality SMA connector applied to a precision connector can result in permanent damage to one or both connectors.

**Very Important:**

- ► When using any threaded RF connector, use of a calibrated torque wrench is essential to ensure repeatable accurate measurements and to avoid damaging the RF connectors through over tightening. Each type of RF connector has a specified torque setting.
- ► When connecting two mechanically compatible types of connector, the upper frequency limit of the combined RF assembly will be limited by the connector with the lower operating frequency. Additionally, impedance mismatch will occur at the interface of the two connectors. For these reasons, it is always advisable to use one connector type throughout a test system, specified to cover the required frequency range.

Further important information on compatibility, cleaning, correctly connecting and recommended torque requirements of popular commercially available RF connectors is given in the R&S application note: "Guidance on Selecting and Handling Coaxial RF Connectors used with Rohde & Schwarz Test Equipment", 1MA99.

[2] *PTFE - Polytetrafluoroethylene*

# 7 Literature


1. Rohde & Schwarz, Application Note, "Guidance on Selecting and Handling Coaxial RF Connectors used with Rohde & Schwarz Test Equipment", 1MA99.
2. IEEE Standard for Precision Coaxial Connectors (DC to 110 GHz), IEEE Std 287™-2007.
3. Doug Skinner, "Guidance on using Precision Coaxial Connectors in Measurement", Version 3, National Physics Laboratory. 2007.
4. Rohde & Schwarz, Data Sheets of the Measurement Instruments listed in the Appendix

# 8 Appendix

The following three tables provide information about R&S spectrum analyzers, receivers and signal generator instruments that support the Test Port Adapter system. Microwave instruments that do not support the Test Adapter System, are therefore not listed.

| Test Port Adapter Body type | RF connector type | Upper frequency limit | Gender | R&S Part number | R&S Spectrum Analyzers | | |
|---|---|---|---|---|---|---|---|
| | | | | | FSVR30, FSUP26 | FSVR40, FSV40 | FSUP50 |
| Low frequency (40 GHz) | Type N | 18 GHz | Male | 1021.0541.00 | A | x | x |
| | | | Female | 1021.0535.00 | ✓ | x | x |
| | Precision 3.5 mm | 26.5 GHz | Male | 1021.0529.00 | A | x | x |
| | | | Female | 1021.0512.00 | ✓ | x | x |
| High frequency (50 GHz) | Type N | 18 GHz | Male | 1036.4783.00 | x | A | A |
| | | | Female | 1036.4777.00 | x | ✓ | ✓ |
| | Precision 2.92 mm | 40 GHz | Male | 1036.4802.00 | x | A | A |
| | | | Female | 1036.4790.00 | x | ✓ | A |
| | Precision 2.4 mm | 50 GHz | Female | 1088.1627.02(1) | x | A | ✓ |

Table 8-1: R&S Spectrum Analyzers.

✓ Adapter delivered with the instrument

A Accessory available from R&S

x Not compatible

(1) Also referred to as R&S product *FSE-Z5*

Please check the instrument data sheets for specific details of which test port adapter heads are supplied by default.

| Test Port Adapter Body type | RF connector type | Upper frequency limit | Gender | R&S Part number | R&S Measurement Receivers | |
|---|---|---|---|---|---|---|
| | | | | | ESR26, ESU26 | ESU40 |
| Low frequency (40 GHz) | Type N | 18 GHz | Male | 1021.0541.00 | A | x |
| | | | Female | 1021.0535.00 | ✓ | x |
| | Precision 3.5 mm | 26.5 GHz | Male | 1021.0529.00 | A | x |
| | | | Female | 1021.0512.00 | ✓ | x |
| High frequency (50 GHz) | Type N | 18 GHz | Male | 1036.4783.00 | x | A |
| | | | Female | 1036.4777.00 | x | ✓ |
| | Precision 2.92 mm | 40 GHz | Male | 1036.4802.00 | x | A |
| | | | Female | 1036.4790.00 | x | ✓ |
| | Precision 2.4 mm | 50 GHz | Female | 1088.1627.02(1) | x | A |

Table 8-2: R&S Measurement Receivers.

✓ Adapter delivered with the instrument

A Accessory available from R&S

x Not compatible

(1) Also referred to as R&S product *FSE-Z5*

Please check the instrument data sheets for specific details of which test port adapter heads are supplied by default.

| Test Port Adapter Body type | RF connector type | Upper frequency limit | Gender | R&S Part number | R&S Signal Generators | |
|---|---|---|---|---|---|---|
| | | | | | SMB100A: 12 / 20 GHz(4)<br>SMF100A: 22 GHz | SMW200A:12 / 20 / 31.8 / 40 GHz(2,3)<br>SMM100A: 12 / 20 / 31.8<br>SMA100B: 12 / 20 / 31.8 / 40 GHz(3)<br>SMB100A: 31.8 / 40 GHz(3,4)<br>SMF100A: 43.5 GHz(3,5) |
| Low frequency (40 GHz) | Type N | 18 GHz | Male | 1021.0541.00 | A | x |
| | | | Female | 1021.0535.00 | A | x |
| | Precision 3.5 mm | 26.5 GHz | Male | 1021.0529.00 | A | x |
| | | | Female | 1021.0512.00 | ✓ | x |
| High frequency (50 GHz) | Type N | 18 GHz | Male | 1036.4783.00 | x | A |
| | | | Female | 1036.4777.00 | x | A |
| | Precision 2.92 mm | 40 GHz | Male | 1036.4802.00 | x | A |
| | | | Female | 1036.4790.00 | x | ✓ |
| | Precision 2.4 mm | 50 GHz | Female | 1088.1627.02(1) | x | A |

Table 8-3: R&S Signal Generators.

✓ Adapter delivered with the instrument

A Accessory available from R&S

x Not compatible

(1) Also referred to as R&S product *FSE-Z5*

(2) Also applies to SMW200A instruments equipped with 2nd RF path option, SMW-B2020 (20 GHz).

(3) Includes models with limited minimum pulse width and I/Q modulation bandwidth (SMW-B104xN, SMx-B14xN).

(4) Includes models with the option, no step attenuator (SMB-B1xxL).

(5) SMF100A-B144 (43.5 GHz) is also delivered with a precision 2.4 mm female Test Port Adapter.

Please check the instrument data sheets for specific details of which test port adapter heads are supplied by default.

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Data without tolerance limits is not binding | Subject to change

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