COPPER MOUNTAIN®
TECHNOLOGIES

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PE0312-75 Port Extender

Operating Manual

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Contents

Contents

Introduction

This manual contains designs, functional overview, and operation procedures for the PE0312-75 port extender (hereinafter referred to as the extender) produced by Copper Mountain Technologies, to ensure effective and safe use of its technical capabilities.

Maintenance and operation of the extender should be performed exclusively by qualified engineers possessing fundamental expertise in microwave circuit operation.

Web Sites

Copper Mountain Technologies

Safety Instructions

All general safety precautions related to operation of electrically energized equipment must be observed.

NOTE Connecting a 50-ohm male N-Connector to any of the front panel 75 ohm N connectors will cause permanent damage.

To ensure reliable operation of USB devices manufactured by Copper Mountain Technologies, it is recommended to use a powered USB hub (USB port extender with external power supply).

The extender should be used only by skilled and thoroughly trained personnel with the required skills and knowledge of safety precautions.

The extender complies with INSTALLATION CATEGORY II as well as POLLUTION DEGREE 2 as defined in IEC61010–1.

The extender is a MEASUREMENT CATEGORY I (CAT I) device. Do not use the extender as a CAT II, III, or IV device.

The extender is for INDOOR USE only.

The extender has been tested as both a stand-alone device and in combination with the accessories supplied by Copper Mountain Technologies, in accordance with the requirements of the standards described in the Declaration of Conformity. If the extender is integrated with another system, compliance with related regulations and safety requirements are to be confirmed by the builder of the system.

Never operate the extender in an environment containing flammable gases or fumes.

Operators must not remove the cover or any other part of the housing. The extender must not be repaired by the operator. Component replacement or internal adjustment must be performed by qualified maintenance personnel only.

Never operate the extender if the power cable is damaged. Never connect the test ports to AC power mains.

Electrostatic discharge can damage the extender, whether connected to or disconnected from the device under test (DUT). Static charge can build up on your body and damage sensitive internal components of both the extender and the DUT. To avoid damage from electric discharge, observe the following:

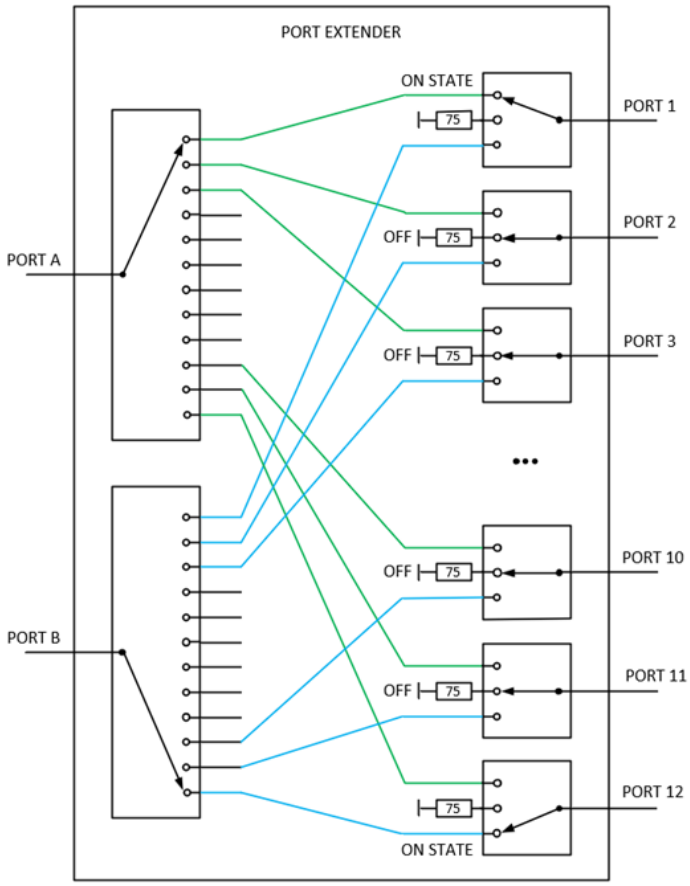
- Use a desktop anti-static mat.
- Always wear a grounding wrist strap connected to the desktop anti-static mat via daisy-chained 1 MΩ resistor.
- Connect the post marked ⏚ on the body of the extender to the common ground of the test station.

WARNING	This sign denotes a hazard. It calls attention to a procedure, practice, or condition that, if not correctly performed or adhered to, could result in injury or death to personnel.
CAUTION	This sign denotes a hazard. It calls attention to a procedure, practice, or condition that, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the instrument.
NOTE	This sign denotes important information. It calls attention to a procedure, practice, or condition that is essential for the user to understand.

Principles of Operation

The extender is designed for RF signal switching and can be used either as a standalone switching device or as part of a measurement system to extend the number of ports of a vector network analyzer in a multiport S-parameters setup.

The device implements a full crossbar switching architecture, allowing any input to be routed to any output. It is based on solid-state semiconductor technology. The inactive output ports (in the OFF states) of the device are connected to internally matched 75 Ohm loads.



Simplified block diagram

The extender is compatible with the SC7540 compact series vector network analyzers. A dedicated mounting kit has been developed to securely attach the devices to each other.

During the development of the extender, particular attention was given to the following characteristics, which enable its integration with a vector network analyzer for the measurement of transmission and reflection coefficients of multiport devices:

- The double insertion losses of the extender should not exceed the raw directivity of the analyzer, so as not to prevent the signal separation group during reflection measurements.
- Isolation between channels is critical for ensuring accuracy and dynamic range when measuring the transmission coefficient.
- The repeatability of magnitude and phase when switching between ports should be high to avoid degrading the reflection and transmission measurement accuracy.
- The extender should withstand millions of switching cycles without degradation of its parameters.
- It is important that inactive ports are automatically terminated with matched loads to prevent reflections.
- The extender should be linear and should not introduce significant harmonics, intermodulation, or other distortions.

The main advantages of the extender are listed below:

High Switching Speed

Port-to-port switching is performed within microseconds, significantly reducing measurement time and increasing the efficiency of test procedures.

Reliability and Long Service Life

The absence of mechanical moving parts ensures wear resistance and allows for a long operational life — up to millions of switching cycles without performance degradation.

Integrated Matched Loads

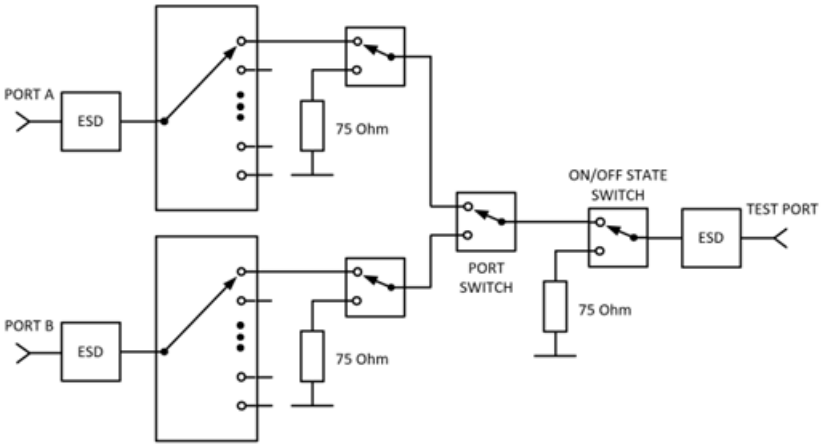
Inactive output ports are automatically connected to internal matched loads, minimizing signal reflections and enhancing measurement accuracy.

Full Crossbar Switching

The extender supports any-to-any port connections, enabling flexible test path configuration and implementation of multiport measurement setups.

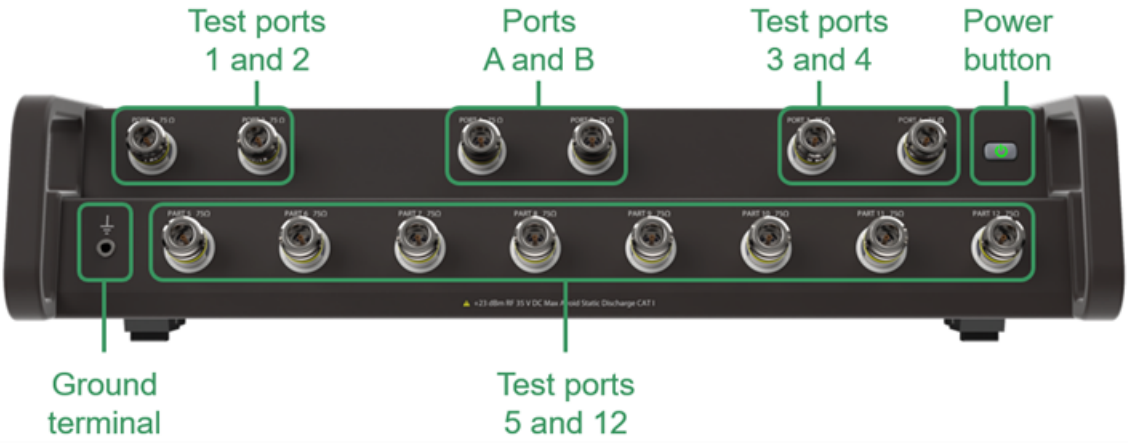
Compact Design and Easy Integration

The device connects to a control computer via a USB interface, simplifying system deployment and eliminating the need for additional interface modules.

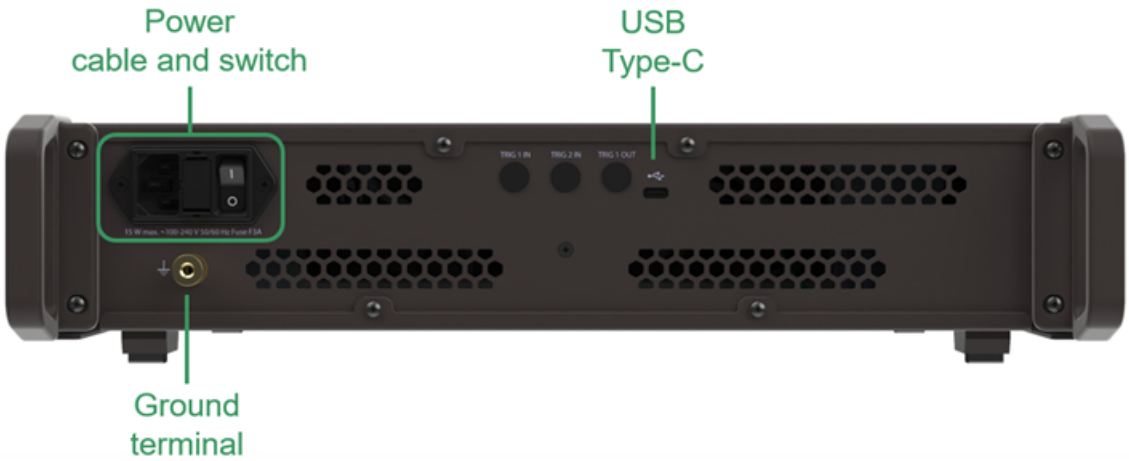


Functional diagram of a single test port

Front and Rear Panel



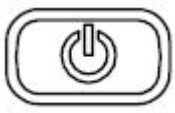
Front Panel



Rear Panel

Parts of the Front Panel

Power Button



Switches the extender ON and OFF. When powered on, the power symbol will be green.

Input Ports

Labeled as Port A and Port B. Ports for connecting a vector network analyzer, or for the connection of other devices when using the extender as a switch matrix.

Test Ports

Test Port 1, Port 2 etc. are intended for DUT connection (12 ports in all).

Each test port has an LED indicator. A test port can be used either as a source of the stimulus signal or as a receiver of the response signal from the DUT. The stimulus signal can only appear on one port at a time.

Connecting the DUT to only one test port on the extender allows the measurement of reflection parameters (e.g. S11 or S22) of the DUT.

Connecting the DUT to all test ports of the extender allows the measurement of the S-parameter matrix of the DUT.

NOTE The LED indicator shows which test port is connected to which input port.

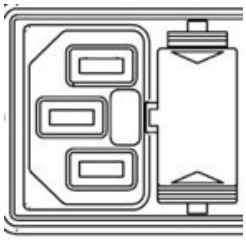
Ground Terminal

Terminal for grounding.

To avoid damage from electric discharge, connect the ground terminal to the body of the extender.

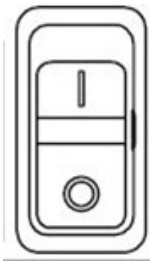
Parts of the Rear Panel

Power Cable Receptacle



The power cable receptacle is intended for 100 to 240 VAC 50/60 Hz power cable connection.

Power Switch

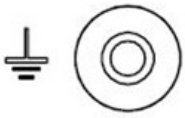


The power switch serves as the disconnecting device (device that cuts off power supply) of the extender. Power supply must be turned off to avoid danger, such as electric shock when the device is unused for prolonged periods of time.

USB 2.0 High Speed Port

The USB port is intended for connection to an external PC.

Ground Terminal

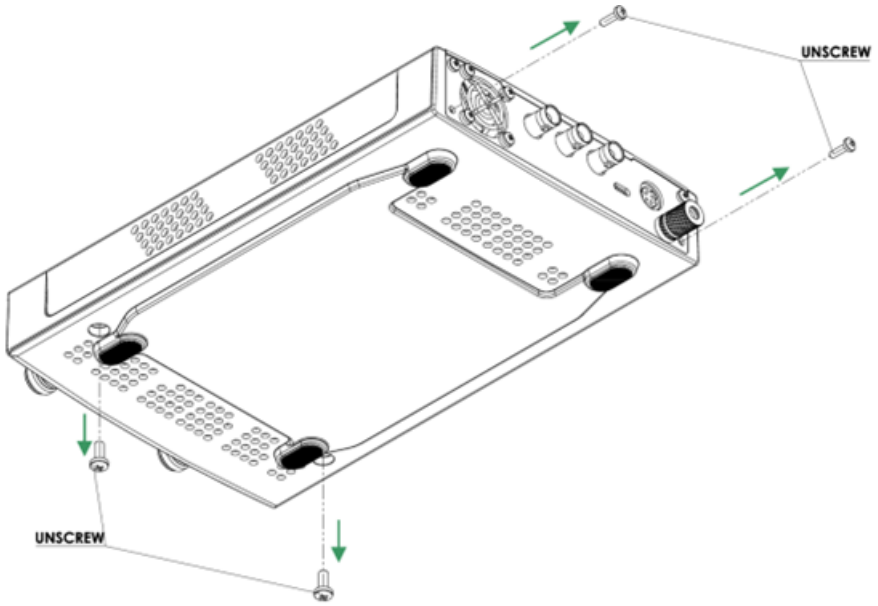


To avoid electric shock, use the terminal for grounding. The ground terminal allows connection directly to the body of the extender to the test station ground to ensure electrical safety.

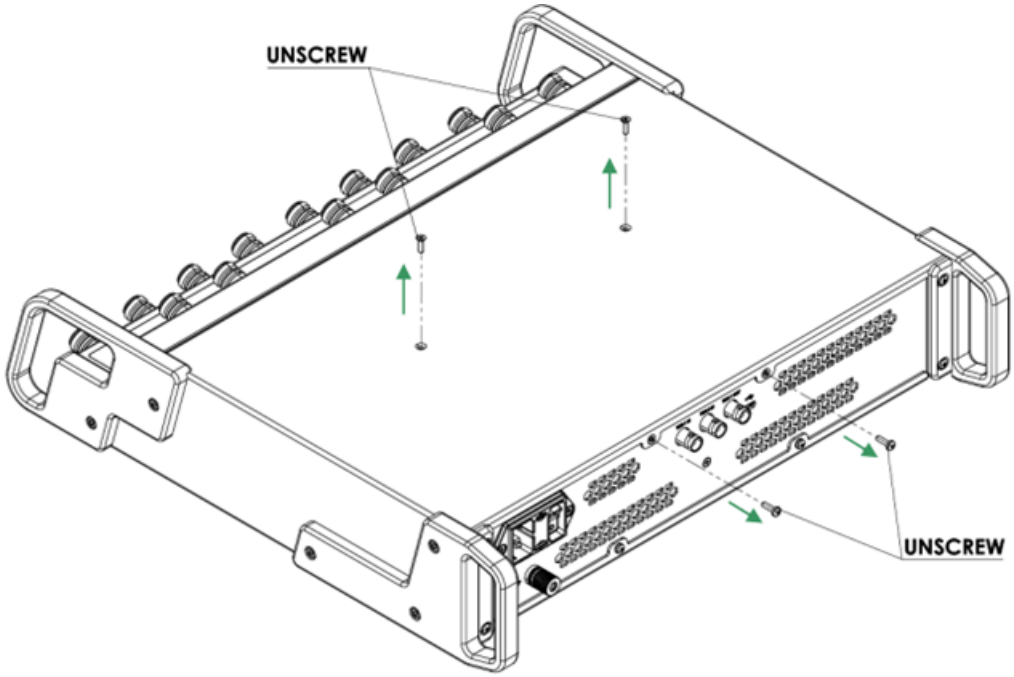
Mounting Instructions

Below is a brief instruction on how to mount the SC7540 analyzer onto the extender.

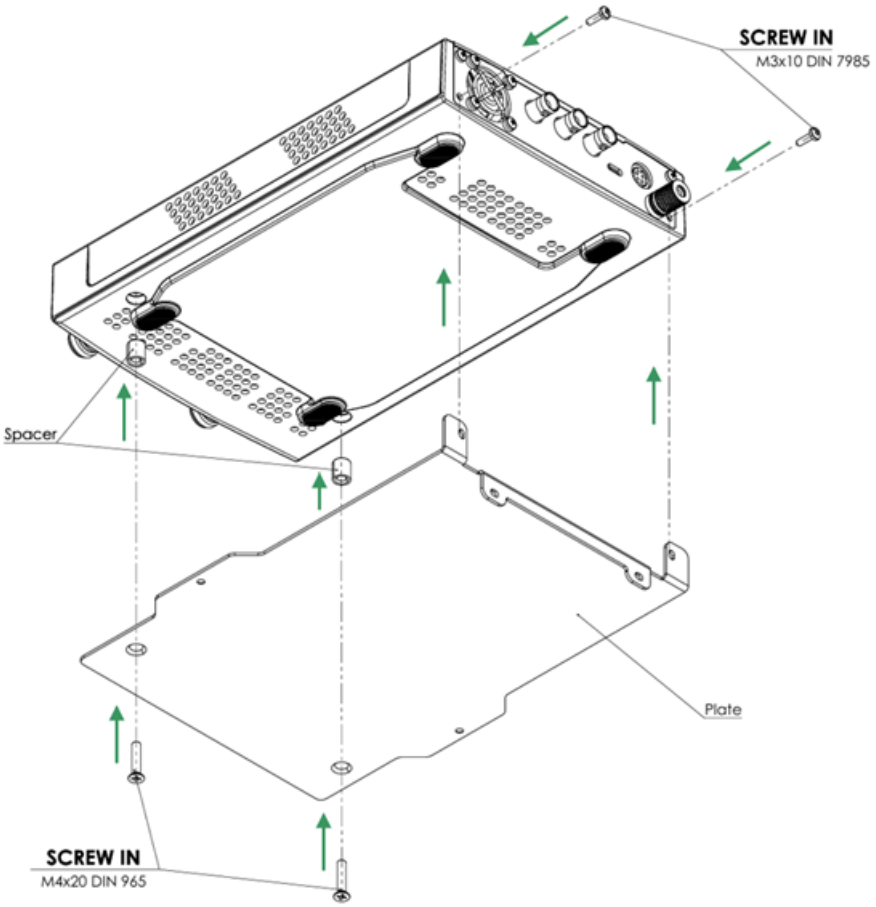
1. Unscrew the two screws at the bottom of the analyzer, as well as the two lower screws on the rear panel.

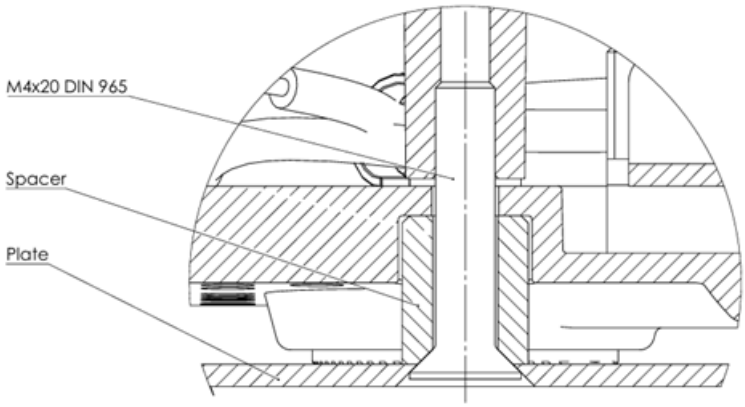


2. Unscrew the two screws at the top and two screws on the rear panel of the extender.

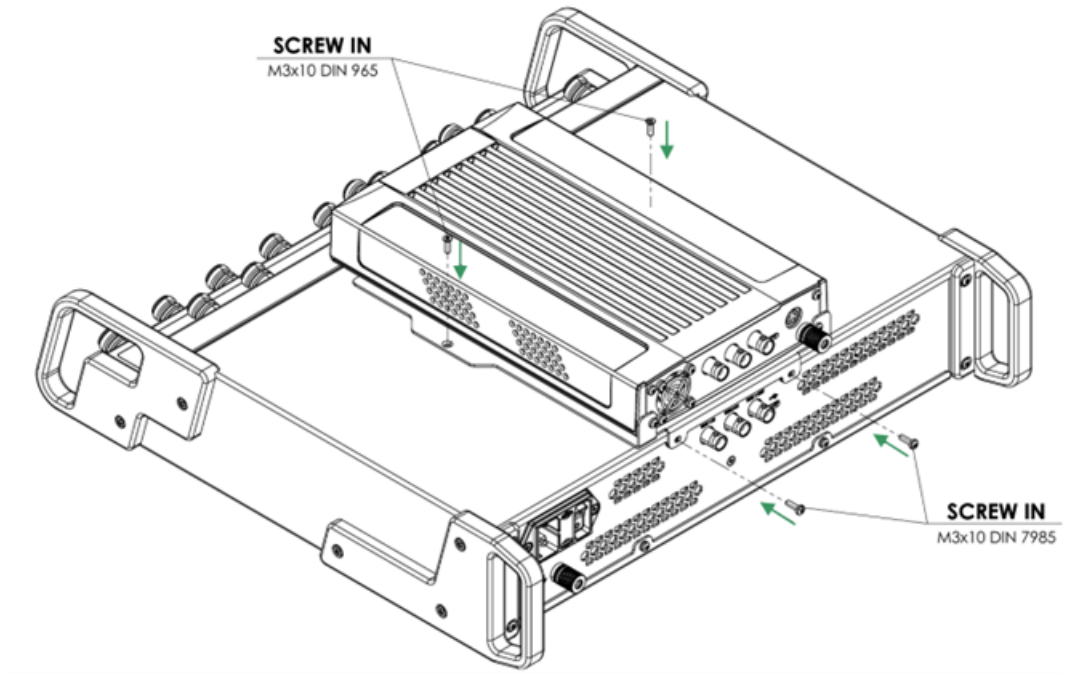


3. Mount the plate to the analyzer as shown in the figure, using spacers, and screws. Tighten the two M4X20 DIN 965 screws included in the mounting rack assembly on the bottom and screw the two M3X10 DIN 7985 screws into the rear panel.





4. Install the analyzer with the plate onto the extender, then tighten the two M3X10 DIN 7985 screws on the rear side of the extender and then the two M3X10 DIN965 screws on the top of the extender.



Preparation for Use

If the instrument and its connected accessories have been exposed to conditions other than the specified operating conditions, they should be kept under operating conditions for at least two hours before being switched on and operated.

Unpack the instrument if it is still in its packaging.

Place the instrument at the workplace. The workbench surface should be large enough to accommodate the instrument, the devices under test, and the required cables.

Install the instrument on a flat workbench surface so that all feet rest firmly on it, ensuring unobstructed access to the connectors and the power switch. Devices connected to the instrument should be placed on the workbench surface or directly above it.

Inspection is permitted only when the instrument is disconnected from the mains power supply and the power cable is unplugged.

Electrostatic discharge (ESD) precautions must be taken in the workplace.

Perform a visual inspection of the instrument.

Visual Inspection

Visual inspection should be carried out to identify visible defects of the extender.

Sequence of the inspection:

- Verify the presence and integrity of the manufacturer's seals, and ensure that there are no signs of the extender enclosure being tampered with.
- Verify that there are no deep scratches or dents on the extender housing, no traces of corrosion on metal parts, no signs of exposure to liquids or aggressive vapors, and markings remain intact.
- Check each port connector of the extender for contamination. If necessary, clean the connectors. For instructions on cleaning connectors, see Cleaning.
- Check each port connector of the extender for mechanical damage (dents or irregularities on the inner and outer conductors).

WARNING If mechanical damage to the connectors is detected, further operation with the extender should be avoided. The extender should be set aside and isolated in order to prevent its use and to avoid damage to the serviceable connectors of other devices.

Powering On/Off

WARNING Before connecting the instrument to the mains, check that the power cable is in good condition. Never operate the extender if the power cable is damaged.

The extender should be powered from an AC mains at a frequency of 50/60 Hz and a voltage from 100 to 253 V.

Powering On

Proceed with the following sequence to power on the extender:

- Turn on the computer.
- Connect the "ground terminal" of the extender to the protective grounding bus.
- Connect the extender to the computer using the USB cable supplied.
- Connect the power cable to the AC mains.
- Switch on the extender by pressing the power button.
- Install the software (where applicable), if it has not been previously installed. Launch the software.
- Allow the extender to warm-up (15 min).
- An example of a measurement session is provided in the Operation of the Extender and Analyzer section.

NOTE To ensure reliable operation of USB devices, it is recommended to use a powered USB hub (USB port extender with external power supply).

Powering Off

- Switch off the extender by pressing the power button.
- If necessary, disassemble the measurement setup.
- If necessary, disconnect the extender, first from the AC mains, then from the computer, and finally from the protective grounding bus.

Example Measurement Session

This section provides a step-by-step guide for setting up a Python environment to communicate with test and measurement instruments using the VISA protocol. It is intended for engineers and developers working with instruments such as port extenders, and vector network analyzers.

Using the PyVISA library, this guide shows how to list available VISA devices, connect to an instrument, send SCPI commands, and read responses. The document also includes examples for communication with:

- A port extender connected via USB and operating through the VISA interface
- An analyzer using TCP/IP interface

Operation of the Extender and Analyzer

Extender with the Analyzer Mounted

This section presents a typical example of the integrated operation of the extender and the analyzer in the sequential measurement of the S-parameters of a pair of two-port devices.

Overview of the measurement sequence:

- Connection to the extender;
- Connection to the analyzer;
- Selection of the required pair of extender ports;
- Recalling the analyzer state file containing its settings and calibration coefficients;
- Measurement of the S-parameters for the first device under test (DUT);
- Repetition of the procedure for the next pair of the extender ports and the second DUT.

Setting Up the Python Environment

Install Python. Download and install Python from:

https://www.python.org/downloads/.

During installation, ensure the checkbox "Add Python to PATH" is selected.

Install NI-VISA Runtime. PyVISA relies on the National Instruments VISA backend. Download and install the NI-VISA runtime from:

https://www.ni.com/en/support/downloads/drivers/download.ni-visa.html

General Example Description

In this example, synchronized measurements are performed using an analyzer, with data acquisition from the first trace of the active channel, and switching of outputs on a port extender via Python.

For simplicity and demonstration purposes, the example uses channel states within the analyzer software (Save/Recall → Recall Channel → {A|B|C|D}).

You should configure the desired measurement parameters in the active channel and perform calibration **when Analyzer ports are routed to Port extender outputs 1A and 2B**.

Then, save this configuration as **State A** (Save/Recall → Save Channel → State A). Repeat the same process and save as **State B**, this time with **Port extender outputs 7A and 8B** active.

The script will:

- Connect to the first available VISA device;
- Connect to the analyzer software at **localhost:5025**. Make sure the socket server is enabled in the analyzer software: *System → Misc Setup → Network Remote Control Settings → Socket Server ON, Socket Port 5025*.

Then, it will:

- Print information about both devices;
- Set the analyzer to triggered mode using SCPI commands;
- Recall **State A**, switch the extender to test ports 1 and 2, trigger a measurement, and read data from the first trace;
- Then repeat the same steps for **State B** with the extender test ports 7 and 8.

The example consists of three files:

- main.py – Contains the core logic for the measurement process and handles interaction with both the analyzer and the VISA device;
- tcp_client.py – Implements communication specifics for a device connected via the TCP/IP protocol;
- visa_client.py – Implements communication specifics for a device connected via USB using the VISA interface.

All files should be placed in a single directory.

How to Run the Script on Windows

The attached archive contains a folder with:

- All three Python files (main.py, tcp_client.py, visa_client.py);
- A requirements.txt file with the necessary dependencies.

To run the script:

1. Extract the archive anywhere on your computer (e.g., to your Desktop).

2. Open Command Prompt:

- Press Win + R, type cmd, and press **Enter**.
- Use the cd command to navigate to the extracted folder.

```
cd %USERPROFILE%\Desktop\port-extender-example
```

3. Create a Virtual Environment

Create a new virtual environment in the current folder:

```
python -m venv venv
```

4. Activate the Virtual Environment

```
venv\Scripts\activate.bat
```

You should see (venv) at the beginning of the command line, indicating the environment is active.

5. Install dependencies from requirements.txt:

```
pip install -r requirements.txt
```

6. Run the script

```
python main.py
```

Ensure all connected devices (VNA, port extender) are powered on and detected.

Make sure the analyzer software is running and the socket server is enabled (port 5025).

Source Code

main.py

```
import sys

from visa_client import list_visa_devices, VISAClient
from tcp_client import TCPClient

# Configure the VNA to trigger via SCPI command.
def configure_vna(vna: TCPClient):
    vna.send("SYSTem:PRESet")
    vna.send("INITiate:CONTinuous ON")
    vna.send("TRIGger:SOURce BUS")

# Perform the measurement and wait for the sweep to complete.
def make_sweep_vna(vna):
    vna.send("TRIGger:SINGle")
    vna.query("*OPC?")

# An example of how data can be retrieved.
def retrieve_trace_data_vna(vna):
    trace1 = vna.query("CALCulate:TRACe1:DATA:FDATa?")
    print("Trace:", trace1)

if __name__ == "__main__":
    print("Searching for VISA devices...")
    visa_devices = list_visa_devices()

    if not visa_devices:
        print("No VISA devices found.")
        sys.exit(1)

    for i, dev in enumerate(visa_devices):
        print(f"{i}: {dev}")

    # Select the first device for demonstration purposes
    # We expect the first detected device to be the port extender.
    # If that's not the case, you can either change the index or
    # replace selected_address with the specific address
    index = 0
```

```
    selected_address = visa_devices[index]
    port_extender = VISAClient(selected_address)

    # Example of connecting to the VNA using the default local
    # address
    try:
        vna = TCPClient("localhost", 5025)
    except Exception as e:
        print(f"Failed to connect to VNA: {e}")

    if not port_extender or not vna:
        sys.exit(1)

    print("Instrument info:", port_extender.query("*IDN?"))
    print("VNA info:", vna.query("*IDN?"))

    configure_vna(vna)

    # Recalls the Analyzer state for the active channel from
    # the memory register. It is assumed that in the restored
    # channel state, all necessary settings (traces,
    # calibrations) for ports 1 and 2 of the port extender are
    # already in place.
    vna.send("MMEMory:LOAD:CHANnel A")

    # Signal from port A is routed to output port 1 of the
    # extender, and from port B to output port 2 of the extender.
    port_extender.send("CTRL:PORT 1, 2")

    make_sweep_vna(vna)
    retrieve_trace_data_vna(vna)

    # Recalls the Analyzer state for the active channel for port
    vna.send("MMEMory:LOAD:CHANnel B")

    port_extender.send("CTRL:PORT 7, 8")

    make_sweep_vna(vna)
    retrieve_trace_data_vna(vna)
```

tcp_client.py

```
import socket

class TCPClient:
    def __init__(self, host: str, port: int):
        self.host = host
        self.port = port
        self.sock = socket.socket(socket.AF_INET,
                                  socket.SOCK_STREAM)
        self.sock.connect((self.host, self.port))

    def send(self, message: str):
        full_message = message + '\n'
        self.sock.sendall(full_message.encode('utf-8'))

    def query(self, message: str) -> str:
        self.send(message)
        data = b""
        while True:
            try:
                chunk = self.sock.recv(1024)
                if not chunk:
                    break
                data += chunk
                if b'\n' in chunk:
                    break
            except socket.timeout:
                break
        return data.decode('utf-8').strip()

    def close(self):
        self.sock.close()
```

visa_client.py

```
import pyvisa

def list_visa_devices():
    rm = pyvisa.ResourceManager()
    devices = rm.list_resources()
    return devices

class VISAClient:
    def __init__(self, address: str):
        self.address = address
        self.instrument = self._connect()

    def send(self, message: str):
        if self.instrument:
            full_message = message + '\n'
            self.instrument.write(full_message)

    def query(self, message: str) -> str:
        self.send(message)
        response = self.instrument.read()
        return response

    def close(self):
        self.instrument.close()

    def _connect(self):
        rm = pyvisa.ResourceManager()
        instrument = rm.open_resource(self.address)
        return instrument
```

SCPI Commands

The set of common commands from the IEEE488.2 standard. These commands start with an asterix ("*").

Command	Description	
*CLS	Status System	Clear status
*ESE		Event status enable
*ESR?		Event status enable register
*IDN?		Identify
*OPC		Operation complete command
*OPC?		Operation complete query
*RST		Restore default settings
*SRE		Service request enable
*STB?		Status byte query

SCPI Overview

The extender implements a set of commands based on the standard SCPI-1999 (Standard Commands for Programmable Instruments). This is a set of instructions for the exchange of text messages.

SCPI was developed by the SCPI Consortium (currently supported by the IVI Foundation). The main details of the SCPI standard are described further on.

Messages

The SCPI is an ASCII text protocol. The commands are sent as character messages. One message can contain one or several commands.

Command Tree

The SCPI commands are organized in a tree structure. Each tree structure forms a functional system. The base of the tree is called the *root*. Each functional system can have subsystems of lower level. The final nodes are called *leaves*. The entire sequence from root to leaf makes up the command.

Long and Short Formats

Each keyword in a command specification has a long format and a short format. The short format of a command is indicated by capital letters. For example, the following command specification can be written as:

SYSTem:ERRor[:NEXT]? or SYST:ERR?

Only one form can be used at a time, as combining forms will be incorrect. For example, the following specification is incorrect:

SYSTem:ERR?

Case Sensitivity

The commands are not case sensitive. Upper case and lower case letters are only used to indicate the long and short formats of a command specification. For example, the following commands are equivalent:

CTRL:PORT?

ctrl:port?

Parameters

The commands can have parameters. The parameters are separated from the command by a space. If a command has several parameters, they are separated by commas (','').

Query Commands

The query commands read out the parameter values from the extender. After a query command has been sent, the response should return via remote control interface. The query commands has a question mark ('?') at the end of the command.

For example:

CTRL:PORT?

Command Reference

The following conventions are used throughout this section.

Syntax	Description
<>	Identifiers enclosed in angular brackets indicate that a particular type of data must be specified.
[]	Parts enclosed in square brackets can be omitted.
{}	Parts enclosed in curly brackets indicate that you must select one of the items in this part. Individual items are separated by a vertical bar "|".
Space	Space separates commands from parameters.
,	Comma separates adjacent parameters.
…	Ellipses indicate that parameters in that part are omitted.

Identifiers

Identifier	Parameter	Description
<numeric>	Number	{<integer>|<real>}
<string>	String parameter	Quoted string

*CLS

Description

Clears the following:

- Error Queue.
- Status Byte Register.
- Standard Event Status Register.

no query

*ESE

*ESE <numeric>

*ESE?

Description

Sets or reads out the value of the Standard Event Status Enable Register.
command/query

Parameter

<numeric> 0 to 255

Query Response

<numeric>

Out of Range

Bitwise AND with number 255

Preset Value

0

*ESR

*ESR?

Description

Reads out the value of the Standard Event Status Register. Executing this command clears the register value.
query only

Query Response

<numeric>

*IDN

*IDN?

Description

Reads out the Extender identification string.

The identification string is in the format: <manufacturer>, <model>, <serial number>, <software version>/<hardware version>.

For example: CMT, SWB-00-SIM, 00000001, 1.0/01

query only

Query Response

String up to 40 characters

*OPC

*OPC

Description

Sets the OPC bit (bit 0) of the Standard Event Status Register at the completion of all pending operations.

NOTE The command is implemented only for compatibility, since there are no asynchronous operations in the switch.

no query

*OPC?

Description

Reads out the "1" at the completion of all pending operations.

NOTE The command is implemented only for compatibility, since there are no asynchronous operations in the switch.

no query

Query Response

1

*RST

*RST

Description

Sets the device to the initial state.
no query

*SRE

*SRE <numeric>

*SRE?

Description

Sets or reads out the value of the Service Request Enable Register.
command/query

Parameter

<numeric> 0 to 255

Query Response

<numeric>

Query Response

<numeric>

Out of Range

Bitwise AND with number 255

Preset Value

0

*STB

*STB?

Description

Reads out the value of the Status Byte Register.
query only

Query Response

<numeric>

SYSTem

SYSTem:ERRor[:NEXT]?

Description

Reads out the error message when executing SCPI commands, from the FIFO (First In First Out) error queue stored in the extender. The read-out error is deleted from the error queue. The *CLS command clears the error queue. The maximum size of the queue is 16 messages.

query only

Query Response

<numeric>, <string>

Where:

<numeric> — error code,

<string> — error message.

If there is no error in the queue, "0, No error" is read out.

CTRL:PORT

CTRL:PORT N1, N2

Description

Switches port N of the extender to one of the available outputs of the Extender.
command

Parameter

N1 -- switch port number from 1 to 12 (to extender port 1).

N2 -- switch port number from 1 to 12 (to extender port 2).

If the port is not switched, then 0 is sent.

Invalid parameter

Error is returned

Query Response

{OK}

Example

CTRL:PORT 4, 5 Switch port 1 of the extender to output 4 of the extender, port 2 of the analyzer to output 5 of the extender.

CTRL:PORT?

CTRL:PORT?

Description

Reads out the switching status of the extender ports.
query

Invalid parameter

Error is returned

Query Response

{N1, N2}

Where N1, N2 are numbers of switched outputs (for the first and second ports of the analyzer, respectively)

N1, N2 are integers between 1 and 12

Example

CTRL:PORT? Get port switching status.

SCPI Error Codes

Name	Description
100	Command error
101	Unmatched quote
102	Unmatched bracket
103	Invalid value in numeric list
104	Data type error
106	Numeric parameter overflow
107	Wrong units in numeric data
108	Parameter not allowed
109	Missing parameter
110	Command header error
114	Header suffix out of range
115	Input buffer is full
130	Suffix error
300	Device-specific error
302	Status reporting system error
400	Query error
403	Query error: no data
404	Query truncated
410	Query Interrupted

Connector Care

This section contains information about the proper use of devices with coaxial connectors to extend their service life and provide accurate measurements. This document contains important requirements for handling and storage, cleaning, gauging, connecting, and disconnecting these devices.

Handling and Storage

Connectors need to be handled carefully. They should be stored in a safe environment. Always install protective plastic end caps on the connectors of the device when they are not in use.

Keep connectors clean (see Cleaning). Avoid touching the connector mating surfaces with your fingers. Use gloves when working with the connectors to avoid contamination from dirt or grease and to improve accuracy of measurement.

CAUTION Do not touch mating plane surfaces. Grease and microscopic dirt particles are difficult to remove from these surfaces.

Inspect connectors before mating using a magnifying glass. Check for scratches on the plating, worn mating surfaces, metal particles in the threads or on the mating surfaces, and bent or misaligned conductor centers.

CAUTION No device should be used if the center connector conductor is bent or broken.

No device should be used if the connector has deformed threads.

Holding the connector in your hand or cleaning the connector with compressed air can significantly change its temperature. Wait for the connector temperature to stabilize before using it for calibration or measurement.

Wear a grounding wrist strap and cover the working table with a grounded, conductive mat. This helps to protect devices from electrostatic discharge (ESD).

Connector lifetime:

- All connectors have a limited lifetime. This means that connectors can become defective due to wear during normal use. For best results, all connectors should be inspected and maintained to maximize their lifetime.

- A visual inspection should be performed each time the connectors are mated. Metal particles from connector threads often find their way onto the mating surface during connection or disconnection.

Cleaning

Cleaning off any contamination on the connector mating plane surfaces and threads can extend the lifetime of the connector and improve the quality of calibration and measurement.

Remove loose particles from threads and mating surfaces of the connectors with low-pressure air or nitrogen. Using a compressor is not recommended (air filtration is required), it is safer to use a can. Compressed air is the safest method for cleaning connectors with air dielectrics. Wear safety glasses when cleaning.

If further cleaning is required, a lint-free cleaning swab can be moistened with isopropyl alcohol and applied lightly. If desired, you may clean the connector with a dry cleaning swab without alcohol first. If contamination is still present, use alcohol. Use minimum amount of alcohol.

Only clean connectors with alcohol when there is no power cord connected, ensuring that the instrument is in a well-ventilated area. Allow all residual alcohol moisture to evaporate, and the fumes to dissipate prior to powering up the instrument.

If the connector is still contaminated, use a very small toothpick with a small amount of alcohol applied. Use a magnifying glass when using a toothpick to clean, and apply extreme care to avoid damaging the connector.

CAUTION

Never use any metal objects or any abrasives to clean the connectors.

Never use high pressure air (>60 psi).

Never allow alcohol into connector support beads. If alcohol unintentionally enters connector support beads, allow the connector to dry for at least 8 hours.

Avoid using too much pressure on the center conductor, as swab fibers can become tangled in the center of the female conductor. When the alcohol evaporates, use compressed air to ensure that the surface is clean.

CAUTION

Never apply lateral force to the center conductor.

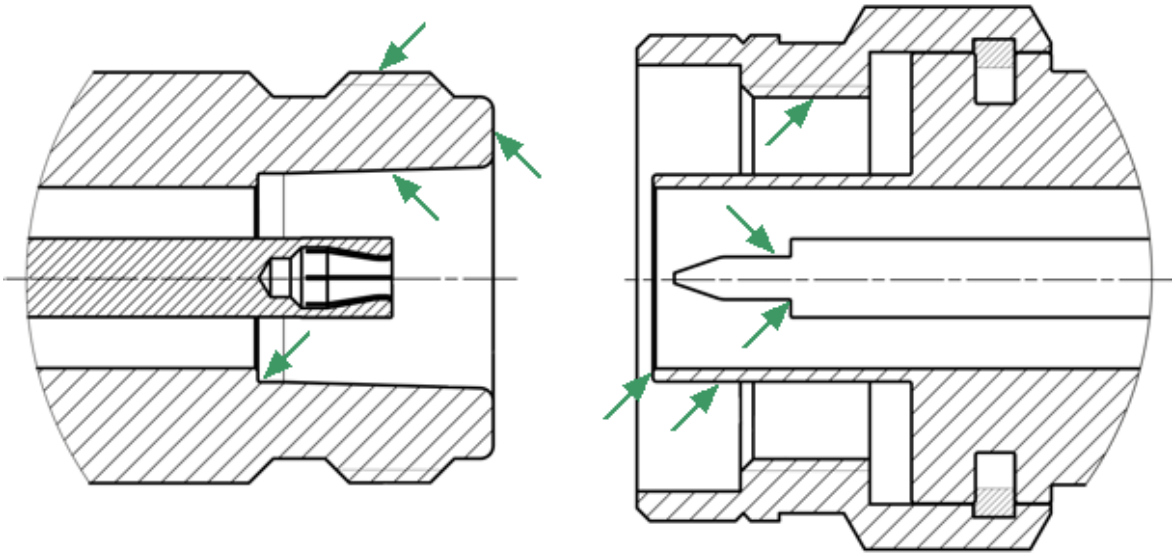
Never wipe the center conductors of the female connectors. They should be cleaned with compressed air.

Connector cleaning should be performed as follows:

1. Wipe the connector surfaces with the swab moistened with alcohol as shown by arrows (See figures below).
2. Use compressed air to clean the other internal connector surfaces.
3. Let the alcohol evaporate.
4. Visually inspect the connectors to make sure that no particles or residue remain.
5. Repeat the cleaning procedure if necessary.
6. If cleaning does not correct any issues, the connector should not be used for measurements.

When cleaning connectors:

- Always use protective eyewear when using compressed air or nitrogen.
- Keep isopropyl alcohol away from heat, sparks, and flame. Use with adequate ventilation. Avoid contact with eyes, skin, and clothing.
- Avoid electrostatic discharge (ESD). Wear a grounding wrist strap (with a 1 MOhm series resistor) when cleaning connectors.



Type-N Connectors (female and male)

Procedure for Cleaning Connectors

Gauging

Gauging connectors not only provides assurance of proper mechanical tolerances, and thus connector performance, but also indicates when there is potential for causing damage to another connector.

Connector gauging should be performed before the instrument is first used, and during regular operation.

The first gauging of connectors obtains the pin depth, which can be used during operation with the module to evaluate its changes.

Gauge the connectors if:

- the device (instrument, calibration standard, cable, adapter, attenuator, or other RF item with coaxial connectors) is being used for the first time.
- visual inspection of the extender suggests that the connector may have defects or damage.
- the connectors of the device used with the extender are damaged, or their pin depth values are out of the range for this type of connector.
- the device is shared with someone else.
- after every 100 connections or as often as experience suggests.

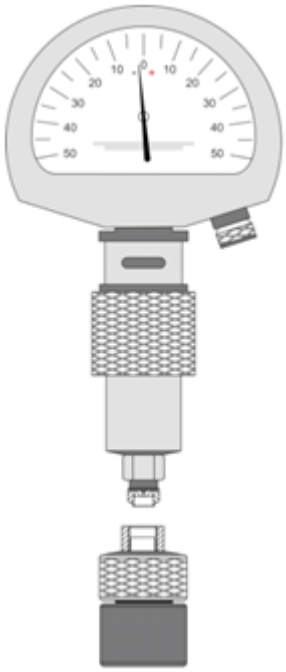
The procedure for connector gauging is as follows (See figure):

1. Select the proper gauge for your connector.
2. Inspect and clean the gauge, the gauge master, and the connectors to be gauged.
3. Zero the connector gauge before use (according to the gauge documentation).
4. Gauge the connector: while holding the gauge by the barrel, carefully connect the connector under test to the gauge. Read the gauge indicator dial value to determine recession or protrusion and compare the readings with the device specifications (See the figure and table below).

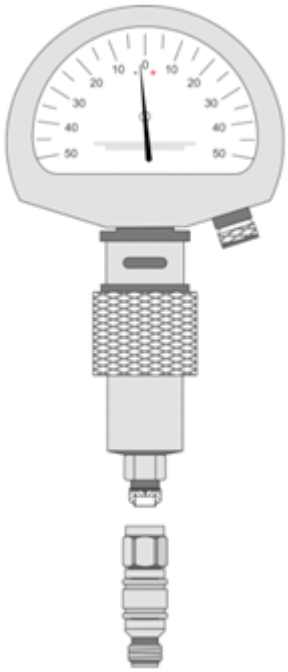
NOTE Use multiple measurements and keep records of readings.

NOTE Never use an out of specification connector.

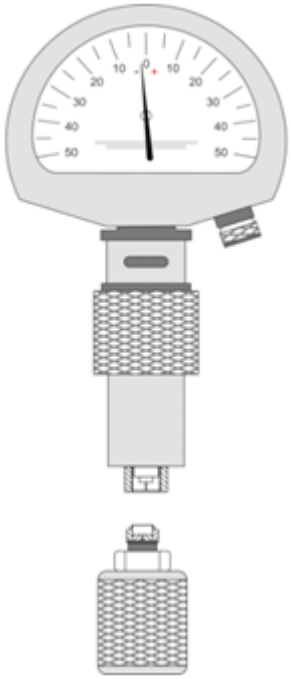
Do not hold connector gauge by the dial.



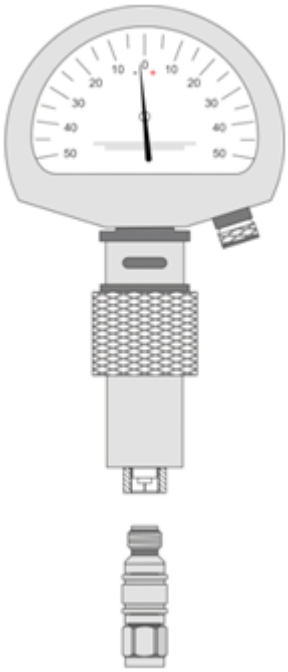
Gauge Master, male



Connectors, male

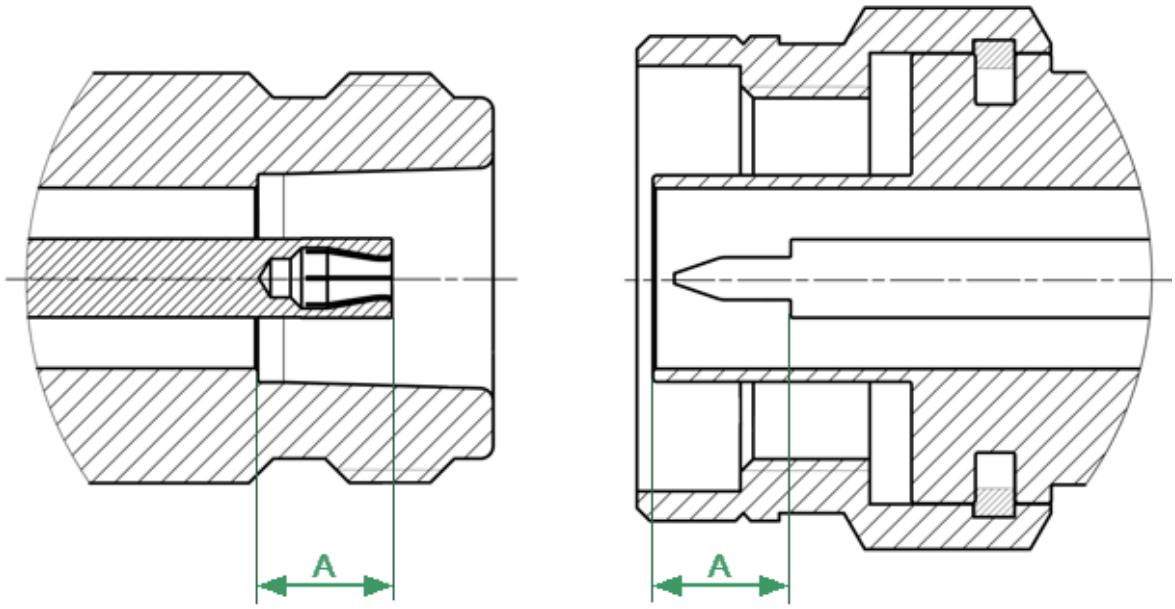


Gauge Master, female



Connectors, female

Example of Gauging Connectors



Type-N Connectors (female and male)

Mechanical Requirements for Measured Connectors

The A pin depth value of connector

Connector type	A pin acceptable depth range
Type-N, female	5.18 to 5.26 mm
Type-N, male	5.26 to 5.36 mm

If the pin depth values of the gauged connectors are out of the acceptable range, the connectors may be eligible to be sent in for repair.

Connecting and Disconnecting

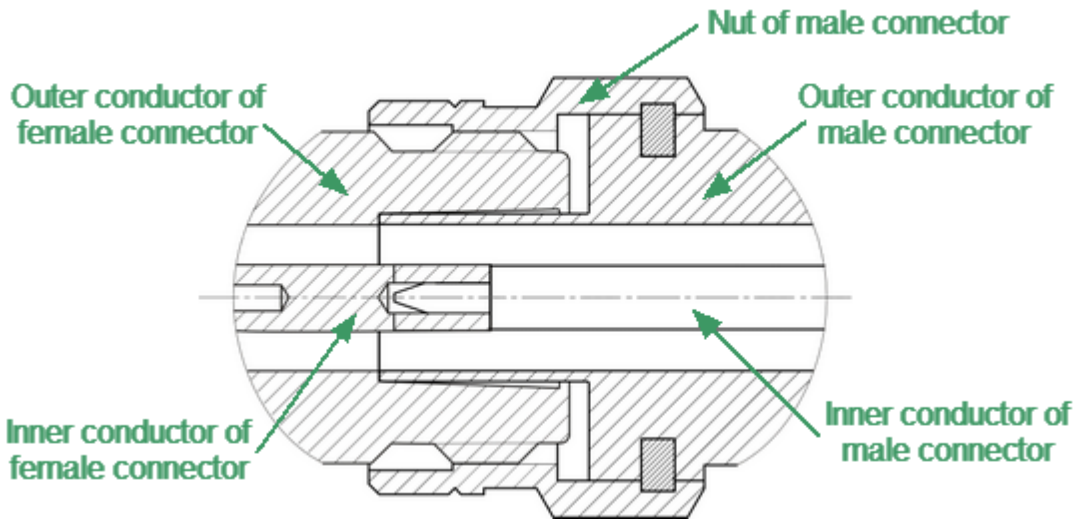
When operating the Extender, it is often necessary to connect various devices to each other: cables to analyzer measurement ports, junctions to cables, calibration tools to junctions or analyzer ports, devices under test to ports, etc.

Connecting

Connect devices with coaxial connectors in the following sequence to ensure maximum repeatability of measurement results, as well as to prevent breakage:

1. Carefully align the connectors of the devices being connected.

2. While holding the device that is being connected, tighten the male connector nut manually. The mating plane surfaces of the center conductors and the outer conductors must make uniform light contact, as shown in figure below.

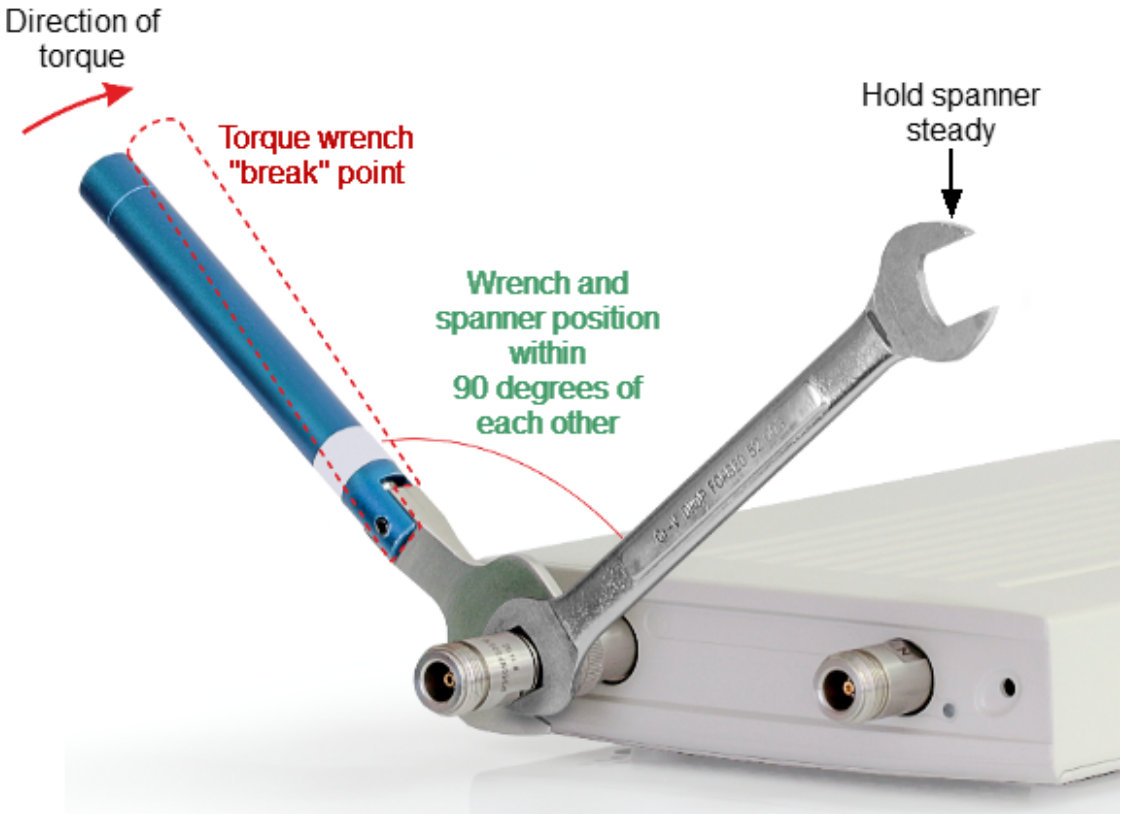


Type-N connectors (female on the left, and male on the right)

Connecting example

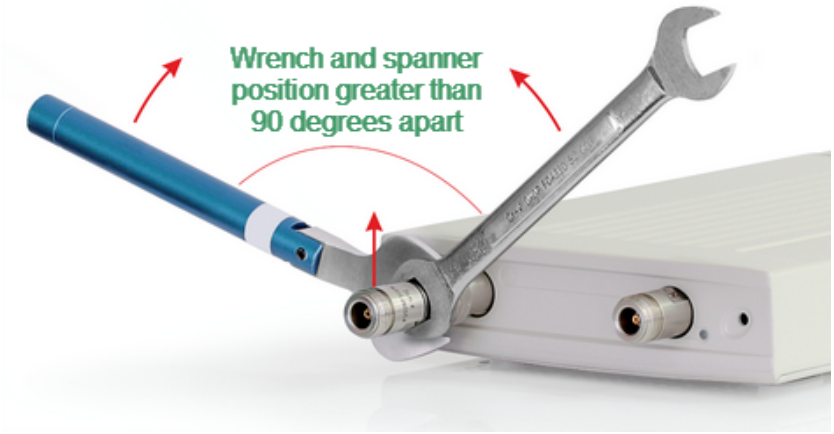
3. Tighten the male connector nut using the appropriate torque wrench while holding the device being connected, or hold the device by using an open-end spanner to keep it from rotating. Position the wrench and spanner within 90 degrees of each other before applying force. Finally, tighten the male connector nut by holding the wrench at the end of the handle. Tighten the connection just to the torque wrench “break” point (See figures below).

Hold the torque wrench by the end of the handle when tightening. The torque value depends on the connector type (See table below).



Correct torque wrench and spanner positions

CAUTION The wrench and spanner should not be positioned more than 90 degrees apart. A larger degree of separation can cause excessive misalignment of the connectors.



Incorrect usage of torque wrench and spanner (too much lift on connection).

Recommended Torque Values

Connector type	Recommended torque values
Type-N	1.1 to 1.7 N·m (12 in. lbs)
NMD 2.4 mm, NMD 3.5 mm, NMD 1.85 mm	0.8 to 1.0 N·m (8 in. lbs)
SMA	0.56 N·m (5 in. lbs)

CAUTION	When making and breaking connections, connector mating surfaces should not rotate. Rotate the nut of the male connector only. Avoid rotating the devices. Use a suitable torque wrench.

CAUTION	Never cross-thread the connection. Never twist the connector body to make the connection. Never mate the connectors of incompatible types.

Disconnecting

Disconnect the connectors in the following order:

1. Using the torque wrench used for tightening, loosen the male connector nut while holding the device, or hold the device with an open-end wrench to prevent it from turning.
2. Turn the male connector nut while holding the device so that the connector center conductor remains in the same straight line position as it was connected. Pull the connectors straight apart.

Maintenance and Storage

The following section describes the proper maintenance and storage procedures for the Extender.

Maintenance Procedures

This section describes the guidelines and procedures of maintenance, which will ensure fault-free operation of the Extender.

The maintenance of the Extender consists of cleaning the instrument, factory calibrations, and regular performance tests.

Instrument Cleaning

This section provides the cleaning instructions required for maintaining proper operation of the Extender.

To remove contamination from parts other than test ports or any connectors of the Extender, wipe them gently with a soft cloth that is dry or wetted with a small amount of water and wrung tightly.

It is essential to always keep the test ports clean, as any dust or stains on them can significantly affect the measurement capabilities of the instrument. To clean the test ports (as well as other connectors of the Extender), use the following procedure:

- Using compressed air, remove or loosen the contamination particles.
- Clean the connectors using a lint-free cleaning cloth wetted with a small amount of ethanol and isopropyl alcohol (when cleaning a female connector, avoid snagging the cloth on the center conductor contact fingers by using short strokes).
- Dry the connector with low-pressure compressed air.

Always completely dry a connector before using it.

Never use water or abrasives for cleaning any connectors on the Extender. Do not allow alcohol contact on the surface of the connector.

When connecting male-female coaxial connectors, always use a calibrated torque wrench.

WARNING	Never perform cleaning of the instrument if the power cable is connected to the power outlet. Never clean the internal components of the instrument.

Storage and Transportation

The extender should be loaded and unloaded with care, avoiding mechanical shock and preventing damage to the packaging.

The extender should be placed in accordance with the package markings during transportation.

The extender should be transported in closed vehicles under the following environmental conditions:

- Temperature range: –50 to +70 °C (–58 to +158 °F)
- Relative humidity up to 95 % at 30 °C (86 °F)
- Atmospheric pressure from 70.0 to 106.7 kPa (537 to 800 mmHg)

The extender may be transported in their original packaging, provided that they are protected against mechanical impact and packaging damage.

Cargo holds, railway cars, containers, and truck beds should be free of residues such as cement, coal, chemicals, or other substances that may cause damage.

When transported by air, the extender should be carried in sealed aircraft compartments.

After transportation under conditions differing from the operating ones, the extender should be kept under normal operating environmental conditions for not less than 2 hours prior to operation.

Before being put into operation, the extender should be stored in their packaging in warehouses at an ambient air temperature from 0 °C to +40 °C (32 °F to 104 °F) and at a relative humidity of no more than 80 % at 35 °C (95 °F).

The unpackaged extender should be stored at an ambient temperature from +10 °C to +35 °C (50 °F to 95 °F) and at a relative humidity not exceeding 80 % at a temperature of 25 °C (77 °F).

Storage premises should be free of dust, acid and alkali vapors, corrosive gases, and other harmful contaminants causing corrosion.

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