



FTR-210R

GNSS-disciplined Rubidium Frequency & Time Reference

U S E R M A N U A L

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Chapter 1

General information

Revision 1.5

12NC 4031.602.21001

About this Manual

This manual contains directions for use that apply to the FTR-210R GNSS disciplined Frequency and Time References.

Warranty

The Warranty Statement is part of the folder *Important Information* that is included with the shipment.

Declaration of Conformity

The complete text with formal statements concerning product identification, manufacturer and standards used for certification type testing is available on request.

Chapter 2

Preparation for Use

2.1 Preface

2.1.1 Introduction

Congratulations on your choice of Measurement Instrument - FTR-210R GNSS disciplined Frequency and Time Reference.

The FTR-210R GNSS disciplined Frequency & Time Reference is a multi-output Frequency Standard, with close-to-Cesium stability, thanks to the GNSS control. There are 7 standard outputs (5x 10MHz, 1x 5MHz and 1x 1-pps) that can be expanded with up to 4 extra outputs, plus a programmable 100 MHz pulse output option. An optional input for frequency measurements to 400 MHz turns the FTR-210R into a one-box ultra-high performance frequency calibrator with up to 13 digits resolution in a second. The optional integrated independent frequency calibrator guarantees true traceability to GPS-time scale and NIST. Traceable calibration reports are easily generated.

The FTR-210R offers for example the following benefits:

- GNSS controlled Rubidium atomic clock
- Primary standard traceability option via built-in calibrator and generation of calibration reports
- Optional Frequency measurement input to 400 MHz with ultra-high resolution (up to 13 digits/s)
- Graphical intuitive User Interface, with large 5" color touch-screen control
- Web server functionality ensures Control and Monitor from anywhere in the world via Ethernet.
- Up to 9x 10 MHz outputs
- 1x 5 MHz and 5x 10 MHz ultra-stable frequency reference outputs as standard
- Optional outputs include: 4x10 MHz, 4x1-pps, or 0.1, 1, 5, 10 MHz
- Optional programmable pulse output 0.5 to 100 MHz
- Integrated 1Gbit Ethernet interface with SCPI commands support

2.1.2 Design Innovations

Frequency and/or Time standard

When used as a **GNSS disciplined Frequency standard**, the short-term stability is very high, and ageing is virtually zero. When used as a stand-alone Frequency standard, in **manual holdover mode**, the stability is ultra-high. Ageing is less than $5E-11$ /month. When used as a **GNSS disciplined Time standard**, the 1-pps time reference output, differs less than 10 ns rms from the GNSS receiver. When GNSS disciplining is removed, the hold-over drift is very low; typical $1 \mu\text{s}/24\text{h}$.

Disciplined Mode The frequency deviation between the local oscillator and the received GPS-signal is used to continuously adjust the oscillator. The resulting 1 h and 24 h mean freq. and phase offsets are displayed continuously on the front panel (if traceability option is installed).

Hold-Over Mode The internal timebase oscillator is not adjusted. This mode is normally automatically entered when there is no usable received GNSS-signal. This mode can also be activated via the Manual Hold-over setting. If there is a valid received GNSS signal, the actual frequency offset and phase offset are calculated and displayed (if traceability option is installed).

Modular, multi-output configuration

The basic configuration contains 5x 10MHz, 1x 5MHz, and 1x 1-pps outputs, to support other instruments, testers, or test objects. If that is not sufficient, 4 additional outputs can be fitted on the rear panel. These outputs are either

- 4x 10 MHz
- 4x 1-pps
- 0.1, 1, 5, and 10 MHz

Additionally you can enable an optional programmable pulse output, 0.5 Hz to 100 MHz, via a SW license, at any time.

Measurement input for one-box frequency calibration

The ultra-stable frequency reference, combined with the optional DC to 400 MHz measurement input, converts the FTR-210R Frequency Reference to a complete one-box frequency calibrator, at any time via a SW license.

Measurement functions include Frequency and Period Average. TIE (Time Interval Error) and Frequency Offset are optional functions (SW enabled).

The performance of the measurement input is state-of-the art. You have 14 ps time resolution (7 ps optional) and up to 12 - 13 digits of frequency resolution for 1s gate time. Measurements are gap-free, meaning all individual cycles are counted without any gap.

You can follow short-term and long-term stability of the device under test on the 5" color display, both numerically and graphically. The measurement rate can be set from 1 MSa/s (20M Sa/s optional) up to one sample every 1000 s.

You can store up to 32M measurement samples in each session, and store up to 1G measurements in a non-volatile memory.

The FTR-210R can produce traceable calibration protocols in csv format of both the internal timebase reference (optional), and the device under test, at any time.

Unique Traceable Frequency Standard for the calibration lab

Off-air frequency standards have existed for decades. But they all have had the same internal architecture (Fig. 2.1). The unit is, in effect, a "black box", with an antenna input and a frequency output. The local oscillator's control process (disciplining) is hidden from the user. Typically, users have used another frequency reference, a timer/counter and a PC for logging the deviation between the "black box" and the external frequency reference.

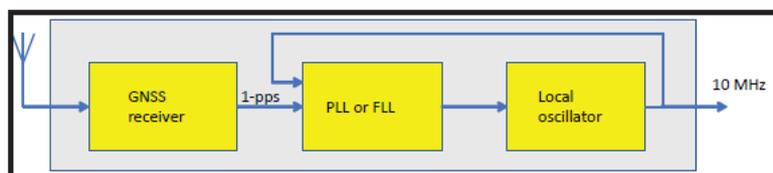


Fig. 2.1: A typical "black box" GPS-receiver (antenna in - reference out). Internal oscillator off set and adjustments are invisible to the user.

The concept of traceability requires an unbroken chain of comparisons to international standards, on a continuing basis, where all comparisons produce documented results with stated uncertainty. The option 220 in FTR-210R is a documenting frequency comparator/calibrator that is **independent from the disciplining process**. The received GNSS signal is continuously and gap-free measured against the local oscillator. Phase and frequency deviations are stored internally and can at anytime be transferred to any PC, via the Ethernet interface, to almost anywhere in the world.

A traceability record for print-out can be obtained. The unbroken calibration history chain – day by day – is maintained in the non-volatile memory for several years, with the current mean offsets being displayed continuously on the front panel color display.

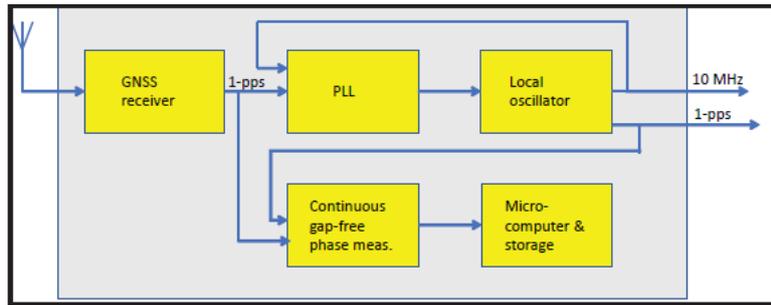


Fig. 2.2: FTR-210R has built-in continuous comparison between the GNSS receiver and the internal oscillator. The frequency off set is displayed and stored and a traceable calibration protocol can be produced at any time.

Such unique traceability to primary standards means that the FTR-210R never needs to be sent away for traceable re-calibration. Thanks to this design, the very high stability built-in rubidium oscillator is continuously calibrated to the primary time and frequency standards.

Powerful and easy-to-use calibration tools

The optional measurement input converts FTR-210R to a-box Frequency Calibrator. Using the MATH function or dedicated Frequency Offset measurement function (Option 152F, SW enabled), the Frequency of the device under test can be displayed either as absolute frequency, e.g. “10.000 000 01 MHz”, or as deviation from nominal frequency, e.g. “10 mHz”, or as relative deviation e.g. “1E-9”.

Setting limits for calibration tolerance, with clear pass/fail indicators, further eases the manual or semi-automatic calibration.

Full flexibility for local or remote control

The FTR-210R is operated manually on the bench via the 5” graphical touch-screen display. You can also connect a mouse, wired or wireless, to one of the front panel USB ports for easier operation.

The FTR-210R comes as standard with a Gbit Ethernet interface for remote control and data transfer. Using a Wi-Fi dongle in the front panel USB port, enables you to connect FTR-210R to your local wireless network.

You can access and control the instrument from your lab bench, or from anywhere in the world, using the integrated web server interface function.

2.2 Safety

2.2.1 Introduction

Please take a few minutes to read through this part of the introductory chapter carefully before plugging the line connector into the wall outlet.

This instrument has been designed and tested for Measurement Category I, Pollution Degree 2, in accordance with EN 61010-1:2011, and CSA C22.2 No 61010-1-12 (including approval). It has been supplied in a safe condition. Study this manual thoroughly to acquire adequate knowledge of the instrument, especially the section on Safety Precautions hereafter and the section *Installation*.

2.2.2 Safety Precautions

All equipment that can be connected to line power is a potential danger to life. Handling restrictions imposed on such equipment should be observed.

To ensure the correct and safe operation of the instrument, it is essential that you follow generally accepted safety procedures in addition to the safety precautions specified in this manual.

The instrument is designed to be used by trained personnel only.

2.2.3 Serviceable parts

There are no parts or components inside the instrument that are serviceable by user.

Removing the cover for repair, maintenance, and adjustment of the instrument must be done by qualified personnel who are aware of the hazards involved.

The warranty commitments are rendered void if unauthorized access to the interior of the instrument has taken place during the given warranty period.

To prevent electrical shock or damage to the device, do not insert foreign objects into any openings or ports except as explicitly instructed in this User Manual for the intended replacement of parts or the installation of approved accessories.

2.2.4 Caution and Warning Statements

Caution

Shows where incorrect procedures can cause damage to, or destruction of equipment or other property.

Warning

Shows a potential danger that requires correct procedures or practices to prevent personal injury.

2.2.5 Symbols

Several symbols are depicted on various parts of the instrument.



Shows where the protective ground terminal is connected inside the instrument. Never remove or loosen this screw.

Grounding faults in the line voltage supply will make any instrument connected to it dangerous. Before connecting any unit to the power line, you must make sure that the protective ground functions correctly. Only then can a unit be connected to the power line and only by using a three-wire line cord. No other method of grounding is permitted. Extension cords must always have a protective ground conductor.

Caution

If a unit is moved from a cold to a warm environment, condensation may cause a shock hazard. Ensure, therefore, that the grounding requirements are strictly met.

Warning

Never interrupt the grounding cord. Any interruption of the protective ground connection inside or outside the instrument or disconnection of the protective ground terminal is likely to make the instrument dangerous.



This symbol is used for identifying the chassis terminal. It is always connected to the instrument chassis.



Caution, risk of danger. User manual must be consulted when any action is made with any connector/terminal which this symbol refers to, in order to find out the nature of the potential hazards and any actions which have to be taken to avoid them.

Personal safety is ensured when the input signal level is below $30 V_{\text{rms}}$ (when accidentally touching the input signal lead)

Damage level for the input decreases from $350 V_p$ to $12V_{\text{rms}}$ when you switch the input impedance from $1 M\Omega$ to 50Ω .

Measurement BNC cables length shall be kept below 3m.

Circuits of external devices connected to BNC sockets, USB sockets and Ethernet sockets should be separated from the power supply network (and from other sources of dangerous voltage) at the level of reinforced insulation. This separation should not be confused with the permissible voltage of the external signal, including the voltage of $350 V_p$ referred to in the manual. If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

Fuse

The secondary supply voltages are electronically protected against overload or short circuit. The primary line voltage side is protected by a fuse located on the power supply unit. The fuse rating covers the full voltage range. Consequently, there is no need for the user to replace the fuse under any operating conditions, nor is it accessible from the outside.

Caution

If this fuse is blown, it is likely that the power supply is badly damaged. Do not replace the fuse. Send the instrument to the local Service Center.

Removing the cover for repair, maintenance and adjustment must be done by qualified and trained personnel only, who are fully aware of the hazards involved.

Detachable mains supply cords

Detachable mains supply cords must be 3-wire IEC 60320 cords having connector type C13 on the side connectable to the instrument, rated for at least 10A, 250 VAC. Don't use damaged or inappropriate cables.

Environmental requirements

The instrument is designed for indoor use only. The instrument must not be placed in potentially explosive atmospheres.

Operating temperature and relative humidity: 0°C to $+50^{\circ}\text{C}$ at 5% to 75% relative humidity (when using in bench-top installation), 0°C to $+40^{\circ}\text{C}$ at 5% to 75% relative humidity (when using in rack-mount installation)

Maximum operation altitude 4600 m. Storage temperature: -40°C to $+71^{\circ}\text{C}$.

See *Specifications* for more information about environmental data.

2.2.6 Position, Orientation, Cooling and Connection of the Instrument

The instrument can be operated only in horizontal position, with all text labels on front panel oriented parallel to the floor.

In case of bench-top use the instrument's feet (optionally unfolded) should be standing on a horizontal surface. In case of rack-mounted use, the mounting holes for the feet are supposed to be under the cabinet, all located in a plane, parallel to the floor.

Make sure that the air flow through the ventilation slots at the side panels is not obstructed. Leave 5 centimeters (2 inches) of space around the instrument.

Avoid positioning the instrument in a way that makes it difficult to disconnect it from the AC mains.

Never block access to power cords or power switches. Do not rely solely on unplugging the power cord as a mean of emergency disconnection. Always ensure a readily accessible external power disconnection method is available.

When laying out the mains cable be careful that you avoid tripping hazards and prevent damage to the electric main.

Rack-mounting

When rack-mounting this instrument, it's crucial to ensure easy access to power disconnection in case of emergencies, malfunctions, or maintenance needs. Failure to do so can lead to extended, potential equipment damage, or even safety hazards.

Power Strip Placement. Utilize a rack-mounted power strip with readily accessible power outlets. Position the power strip so its power switch and individual outlet switches are easily reachable, even when the rack is fully populated. Consider using a power strip with remote management capabilities.

Emergency Disconnect. Consider installing a dedicated Emergency Power Off (EPO) switch within easy reach of the rack. This switch should disconnect power to the entire rack or specific sections in an emergency. Clearly mark the location of the main power breaker or disconnect for the rack in the facility's electrical panel. Ensure personnel are aware of its location.

2.2.7 Disposal of Hazardous Materials

This instrument uses a 3 V cell lithium battery to power real time clock. It is installed in a dedicated holder and can be replaced by qualified personnel aware of potential hazards involved.

Warning

Disposal of lithium cells requires special attention. Do not expose them to heat or to excessive pressure, which may cause the cell explode. Make sure they are recycled according to the local regulations.

You should dispose of your worn-out instrument, after a long and happily life, at an authorized recycling station or return it to Pendulum Instruments.



2.2.8 Potentially poisonous or injurious substances

This instrument uses a 3 V cell lithium battery which is hermetically sealed and does not have any hazard potential except if damaged or dismantled. Never try to disassemble or damage the battery! Do not allow battery contact with water or other liquids. Never swallow. Keep beyond the reach of infants. In case of mistreatment or damage the substances contained inside the battery may be released, which can lead to distortion, leakage (unintended escape of liquid from a battery), overheating, explosion, or fire and cause human injury or equipment trouble. The battery contains Lithium / Manganese Dioxide, with Li component less than 0.3 g.

2.2.9 If in Doubt about Safety

Whenever you suspect that it is unsafe to use the instrument, you must make it inoperative by doing the following:

- Disconnect the line cord
- Clearly mark the instrument to prevent its further operation
- Inform your Pendulum Instruments representative.

Do not overlook the safety instructions!



For example, the instrument is likely to be unsafe if it is visibly damaged.

2.3 Unpacking

Check that the shipment is complete and that no damage has occurred during transportation. If the contents are incomplete or damaged, file a claim with the carrier immediately. Also notify your local Pendulum Instruments sales or service organization in case repair or replacement may be required.

2.3.1 Check List

The shipment should contain the following:

- Power supply Line cord
- Printed version of Important Information
- Options you ordered should be installed. See Identification below.

Note: To ensure always up-to-date user documentation, the user manual (this document) and SCPI guide are not included on any media in the shipment. Instead, the user documentation can be read on-line or downloaded as PDF from manuals.pendulum-instruments.com

2.3.2 Identification

The type plate on the rear panel shows type number and serial number. Installed options are listed under the menu About, where you can also find information on firmware version and calibration date.

FTR-210R family configuration guide

Product code (12NC): **9446 102 10XYZ**

The instrument is configured using factory installed HW options, and customer installable options via SW license keys. **The 12NC code only describes the HW configuration.** SW enabled options and built-in measurement apps are coded separately, and not shown in the HW configuration 12NC code

X = Output option

X=0: No output option

X=1: Option 211: 4x10 MHz

X=2: Option 212: Multi-frequency output; 0.1, 1, 5, 10 MHz

X=3: Option 213: 4x 1-pps

Y = Oscillator

Y=7: Rubidium

Z = Input and Power options

Z=1: No measurement input

Z=2: Measurement input (Opt. 230)

Examples

9446 102 10071 FTR-210R; GNSS disciplined Rubidium Frequency and Time Reference, no optional rear panel outputs

9446 102 10072 FTR-210R; GNSS disciplined Rubidium Frequency and Time Reference, measurement input

9446 102 10171 FTR-210R; GNSS disciplined Rubidium Frequency and Time Reference, 4 extra 10 MHz outputs

9446 102 10271 FTR-210R; GNSS disciplined Rubidium Frequency and Time Reference, 4 extra multi-frequency outputs

9446 102 10371 FTR-210R; GNSS disciplined Rubidium Frequency and Time Reference, 4 extra 1-pps outputs

9446 102 10372 FTR-210R; GNSS disciplined Rubidium Frequency and Time Reference, 4 extra 1-pps outputs, measurement input

Software options

Product code for ordered SW licenses (12NC): 9446 101 XXXYY

XXX/YY = Main option / Version NOTE: the first "X" cannot be a 0

220 = Enable Traceability to UTC(GPS) SW

121F = Activate 7ps resolution SW

122F = Activate High-Speed option (20 MSa/s) SW

132F = Enable 0.5 Hz to 100 MHz Pulse output SW

151F = Unlock TIE & Timestamp meas. SW

152F = Frequency Calibration app (Frequency offset) SW

Examples of separately ordered software options

9446 101 22000 Add traceability option

9446 101 12100 Upgrade from 14 ps to 7 ps resolution

9446 101 12200 High-speed option (upgrade from 1MSa/s to 20 MSa/s)

9446 101 13200 Enable 0.5 Hz to 100 MHz Pulse output

9446 101 15100 Unlock TIE measurements

Hardware Accessories

Product code for ordered accessories (12NC): 9446 108 XXYYY

XX/YYY = Main option / Version

Examples of separately ordered hardware options

9446 108 01200 Multi-GNSS antenna, N-connector, option 01/200

9446 108 02020.T Option 02/20T Antenna Cable, 20 m, N to TNC

9446 108 02050.T Option 02/50T Antenna Cable, 50 m, N to TNC

9446 108 02130.T Option 02/130T Antenna Cable, 130 m, N to TNC

2.4 Installation

2.4.1 Safety precautions

Please carefully study *Safety* chapter before installation of the instrument.

2.4.2 Supply Voltage

The instrument may be connected to any AC supply with a voltage rating 100-240 V_{AC} 50-60 Hz (Nom.). The instrument automatically adjusts itself to the input line voltage.

2.4.3 Fold-Down Support

For bench-top use, a fold-down support is available for use underneath the instrument.

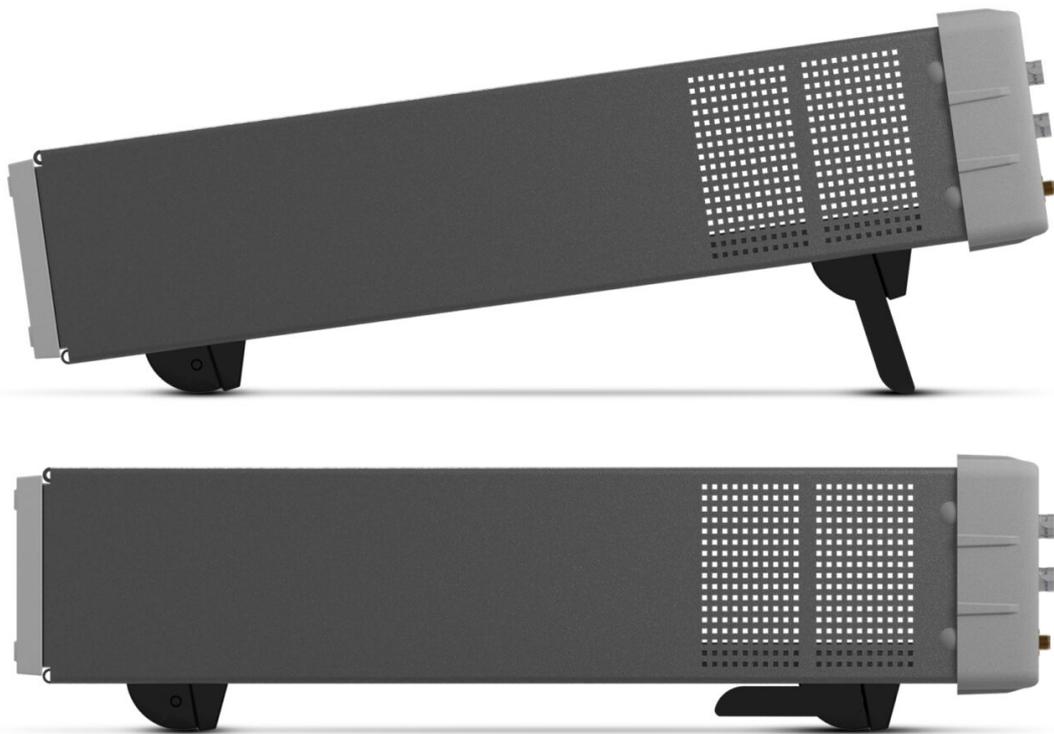


Fig. 2.3: Fold-down support for comfortable bench-top use.

2.4.4 Rackmount Adapter - one unit



Fig. 2.4: Dimensions for rackmounting hardware.

If you have ordered a 19-inch rack-mount kit for your instrument, Option 22/90 for one instrument, it has to be assembled after delivery of the instrument. The rackmount kit consists of the following:

- 2 brackets, (short, left; long, right)
- 4 screws, M5 x 8
- 4 screws, M6 x 8

Warning

Do not perform any internal service or adjustment of this instrument unless you are qualified to do so.



Fig. 2.5: Fitting the rack mount brackets on the instrument.

2.4.5 Assembling the Rackmount Kit (Option 22/90)

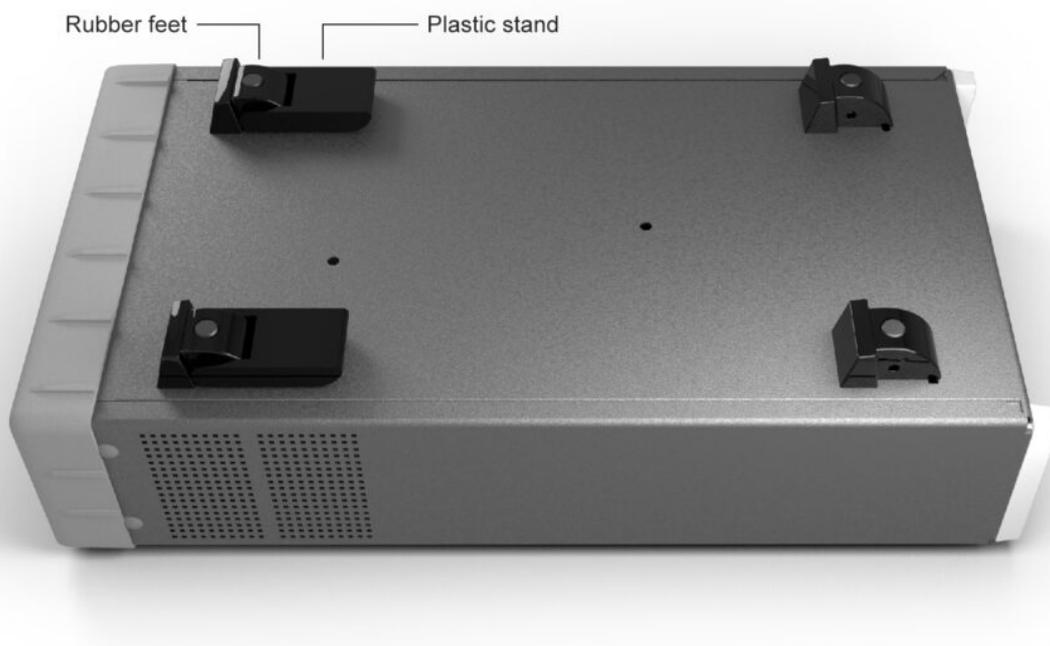


Fig. 2.6: Assembling the Rackmount Kit (Option 22/90)

- Turn the device upside down
- Remove the rubber feet in the plastic stand
- Loosen the screws underneath the rubber feet
- Remove the plastic stands
- Remove the four decorative plugs that cover the screw holes on the right and left side of the front panel.
- The long bracket in Option 22/90 has an opening so that cables for Input signals can be routed inside the rack.

- Mount the rackmount kit with the included screws

2.4.6 Reversing the Rackmount Kit

The instrument may also be mounted to the right in the rack. To do so, swap the position of the two brackets.

2.4.7 Rackmount Adapter - two units

This rackmount adapter can hold any two standard Pendulum ½ x 19" units.



Fig. 2.7: Rackmount Adapter - two units

If you have ordered the Option 22/05 rack-mount kit for two instruments, it has to be also assembled after delivery of the instrument. The rackmount kit consists of the following:

- 4 Brackets, rear
- 1 Hinge Spring Latch
- 2 Ear, rack
- 1 Assembly instruction, SXS Rack kit
- 2 Screws M4x8
- 8 Screws M5x10
- 1 Spacer M4x16

2.4.8 Assembling the Rackmount Kit (Option 22/05)

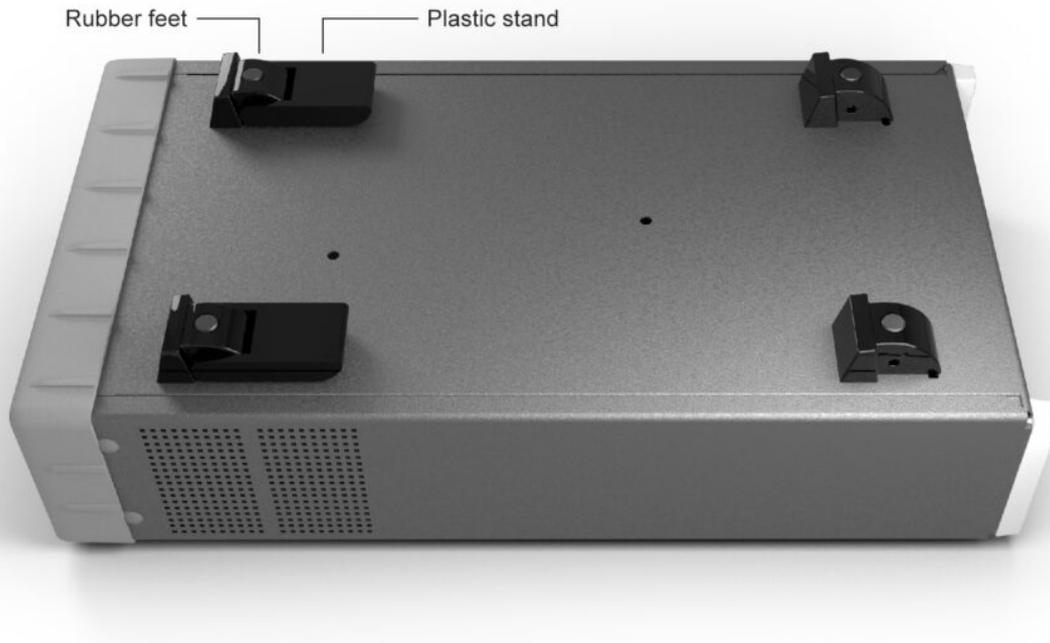


Fig. 2.8: Assembling the Rackmount Kit (Option 22/05)

- Turn the devices upside down
- Remove the rubber feet in the plastic stand
- Loosen the screws underneath the rubber feet
- Remove the plastic stands
- Remove the four decorative plugs that cover the screw holes on the right and left side of the front panel.

Use the following steps to complete the side by side rack mount installation for your products. If necessary, refer to the item numbers in the following diagram for additional detail.

- Determine where you would like each unit positioned (i.e., on the right or left side)
- If plugs exist on the mounting holes on the front left and right side of product cover, remove and discard them
- Using screwdriver, screw the rack ear (Item #2) into place using the supplied 10mm screws (Item #5)
- Pinch the hinge pins together to separate the right and left hinge halves (Items #3 and 4)
- Attach hinge halves to the unit with hinge facing towards the front (as displayed in diagram)
- Using a screwdriver, remove the existing rear brackets on the back of each unit
- Using existing machine screws removed in previous steps, attach the rear brackets supplied with the mounting kit (Item #1)
- Pinch the hinge pins together into the stored position. Align the hinge halves together between the two units, and swing together side by side. The hinge pins should snap into place securing the front of the two units together
- Take the supplied Hex Spacer (Item #7) and place between middle rear brackets, and secure using the supplied 8mm screws (Item #6)
- Assembly is now ready for installation into standard 19" rack



Fig. 2.9: Rackmount Adapter - two units

Chapter 3

Getting Familiar with the Instrument

3.1 Stand-by button



Stand-by button is located in the left side of the front panel and is intended for switching stand-by mode of the instrument.

In stand-by mode, the instrument is not completely disconnected from the AC mains, but remains in a state of low power consumption. The instrument's internal oscillator and GNSS module remain powered and continue to operate. Oscillator disciplining settings are maintained in stand-by mode. Stand-by mode is indicated by an illuminated LED above the stand-by button on the front panel of the instrument.

3.2 Front Panel Inputs and Outputs



Fig. 3.1: Front panel

Front panel has 4 standard outputs:

- Output 1 - 10 MHz Out Sine Reference Outputs (BNC)
- Output 2 - 10 MHz Out Sine Reference Outputs (BNC)
- Output 3 - 5 MHz Out Sine Reference Output (BNC)
- Output 4 - 1 PPS Out Time Reference Output (BNC)

It also has optional measurement input, for signals up to 400 MHz (BNC, Option 230).

3.3 Rear Panel Inputs and Outputs

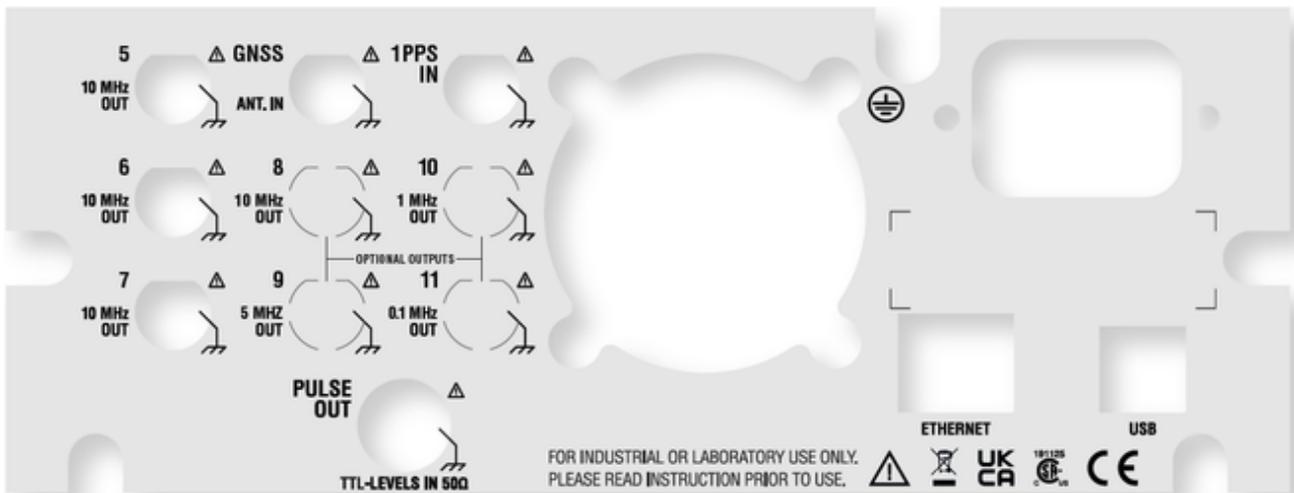


Fig. 3.2: Rear panel

Rear panel has 3 standard 10 MHz Sine Reference Outputs (3x BNC), marked by numbers from 5 to 7.

Depending on ordered configuration, Instrument could have 4 optional outputs (4x BNC), marked by numbers from 8 to 11.

- Option 210: 4x 10 MHz (sine). See front panel 10 MHz output specs
- Option 211: 0.1, 1, 5, 10 MHz (sine). See front panel 10 MHz output stability specs
- Option 213: 4x 1-pps (pulse). See front panel 10 MHz and 1-pps output specs

There is also Optional Pulse Output (BNC, Option 132)

Rear panel has the following inputs:

- Multi-GNSS antenna input (TNC)
- 1PPS External Disciplining Input (BNC)

3.4 Connection of accessories and other equipment to the instrument

The FTR-210R comes as standard with a Gbit Ethernet interface for remote control and data transfer. Use standard Ethernet 8P8C connectors and Cat 6 (recommended) or Cat 5 Ethernet cables. The instrument can be connected to Ethernet router (switch) or directly to a PC or another equipment supporting Ethernet interface.

For BNC connectors located on front and back panels use male type BNC connectors with 50 Ohm characteristic impedance. Use coaxial cables with 50 Ohm characteristic impedance coaxial cables.

GNSS antenna input located at the rear panel of the instrument is TNC connector. Use antenna cable with male type of TNC connector. Use GNSS antennas supporting L1 and L5 bands. The instrument outputs 5V supply voltage on antenna connector for powering active antennas.

On the left side of the front panel, two USB type A connectors are located. Those connectors can be used for connection of Wi-Fi adapters, mouse, keyboard, or removable flash drives. Supported list of Wi-Fi adapters see in the [Specifications](#) section. Removable flash drives must be formatted in FAT32 or exFAT file system.

USB type B connector on the rear panel is intended for service needs.

3.5 Home Screen

Note

Measurement Control and Status are only available for the instruments with purchased Measurement Option (Option 230).

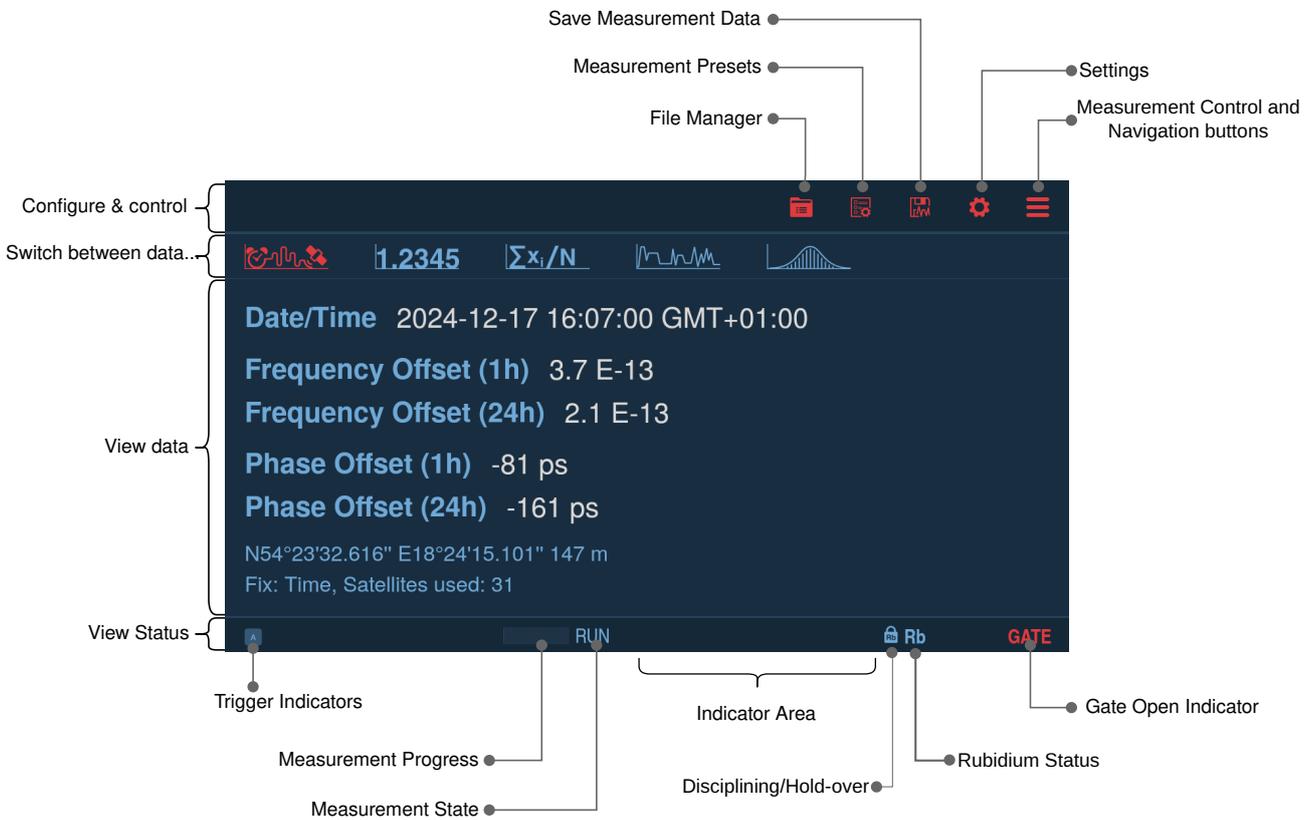


Fig. 3.3: Home screen

3.6 Settings

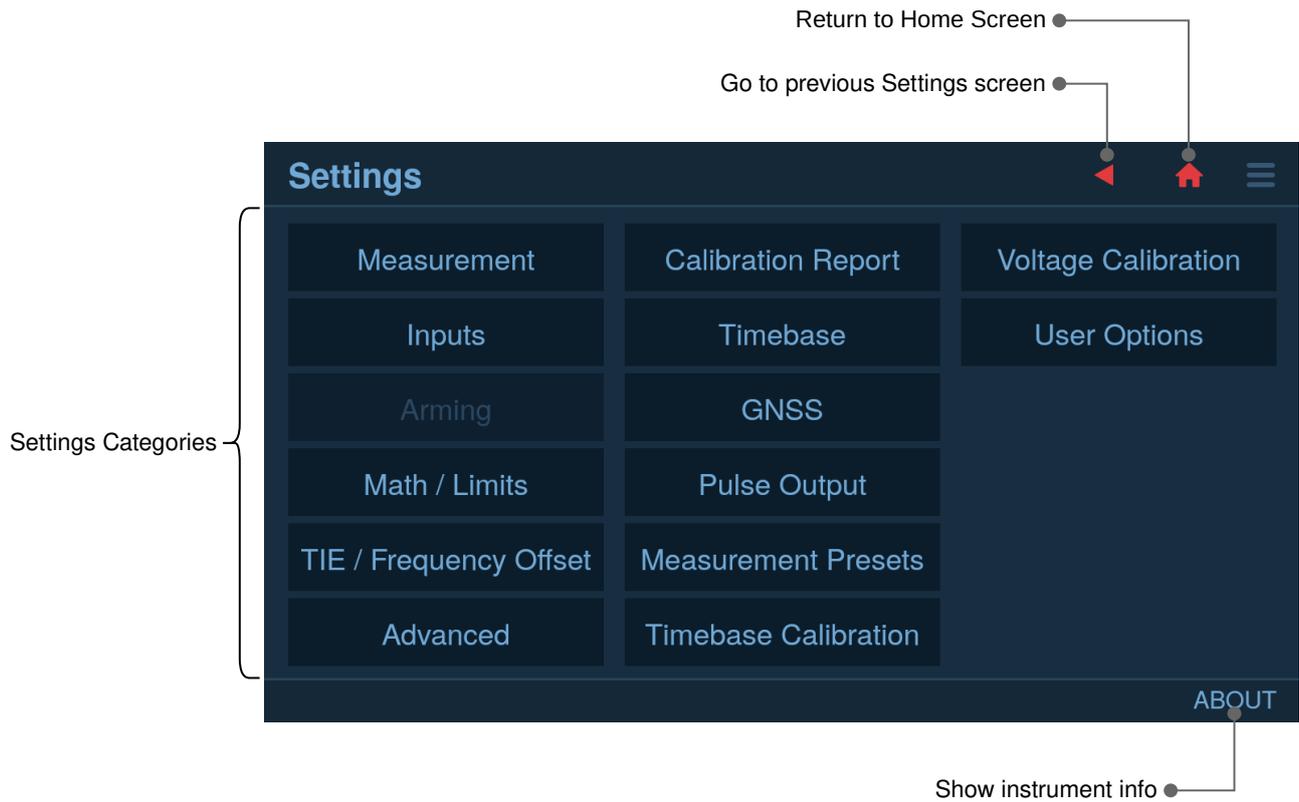


Fig. 3.4: Settings screen

3.6.1 Disciplining settings

By default FTR-210R will be disciplined from GNSS. This behavior can be reconfigured via Settings → Timebase → Oscillator Disciplining and Disciplining Source.

FTR-210R can be put to Manual Holdover by setting Oscillator Disciplining to Manual Hold-Over.

Disciplining source can be set to External PPS IN by setting Disciplining Source to External 1PPS.

1 PPS Output signal phase can also be shifted in the range of -0.5 to +0.5 s with 1 ns step via 1PPS OUT Offset parameter.

Note

1 PPS Output Offset parameter is persistent configuration that is not reset by recalling defaults.

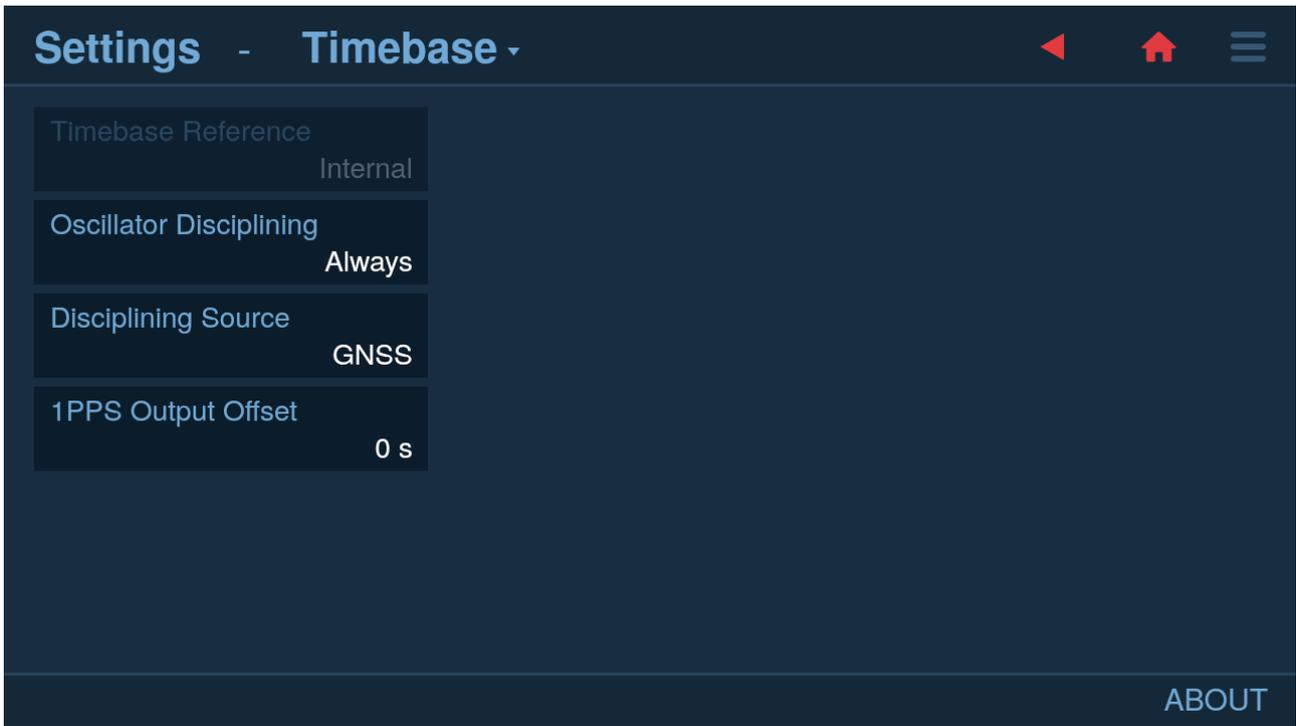


Fig. 3.5: Disciplining Settings

3.6.2 GNSS Settings & Status

GNSS Settings & Status are available via Settings → GNSS

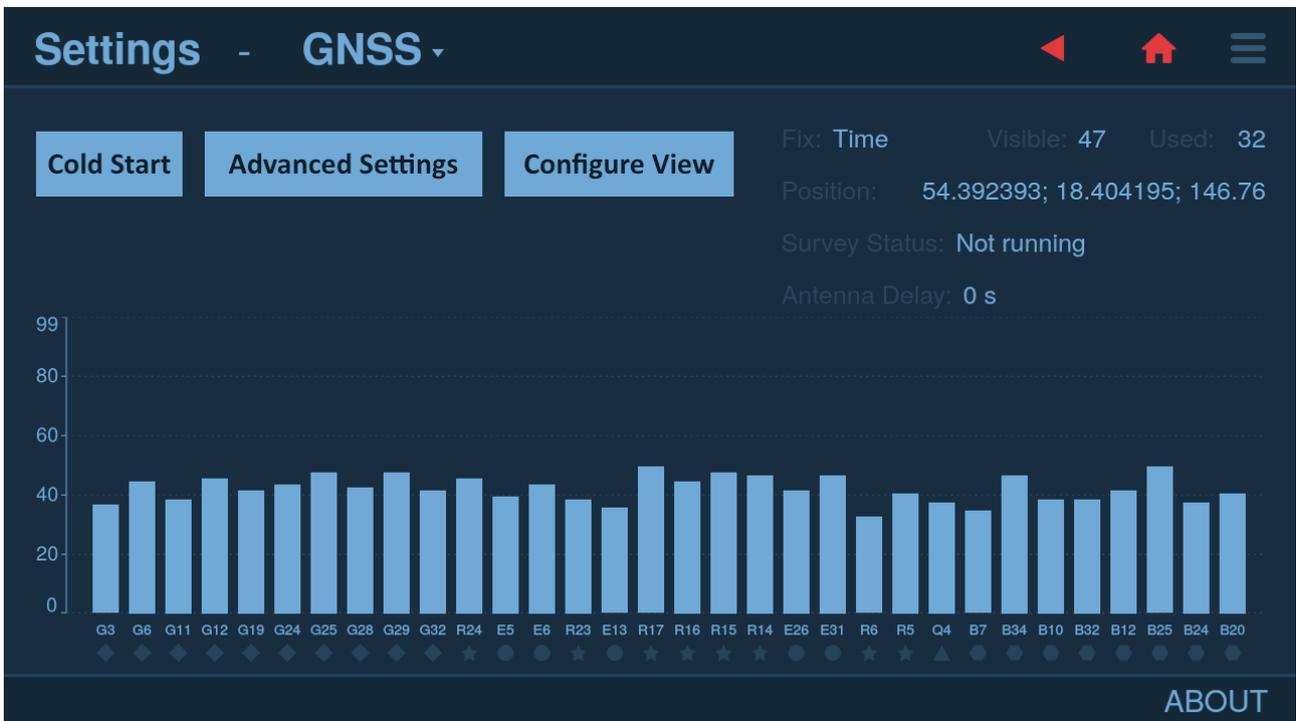


Fig. 3.6: GNSS Settings & Status

Note

It is necessary to do Cold Start of the receiver when you move the instrument to a new location. Please also do a Cold Start when you first turn the instrument on after receiving it.

Note

Self-survey is never run automatically after it has completed at least once. On power up the instrument will use fixed position which is the result of the last successful self-survey. To force self-survey (e.g. after moving the instrument/antenna to new location) please use Cold Start button under Settings → GNSS. Changing self-survey parameters (Settings → GNSS → Advanced) will also force self-survey to be restarted.

3.6.3 Measurement Settings

Note

Measurement Settings are only available for the instruments with purchased Measurement Option.

Please refer to CNT-100 series Frequency Analyzer User Manual for detailed information regarding measurement settings.

See *Measurements* for info how to set up particular measurements in FTR-210R GNSS disciplined Frequency and Time Reference.

3.7 Traceability (Option)

FTR-210R GNSS disciplined Frequency & Time Reference traceability data is continuously saved to internal database.

The user can export calibration report and accompanying raw data for configurable time period via Settings → Calibration report

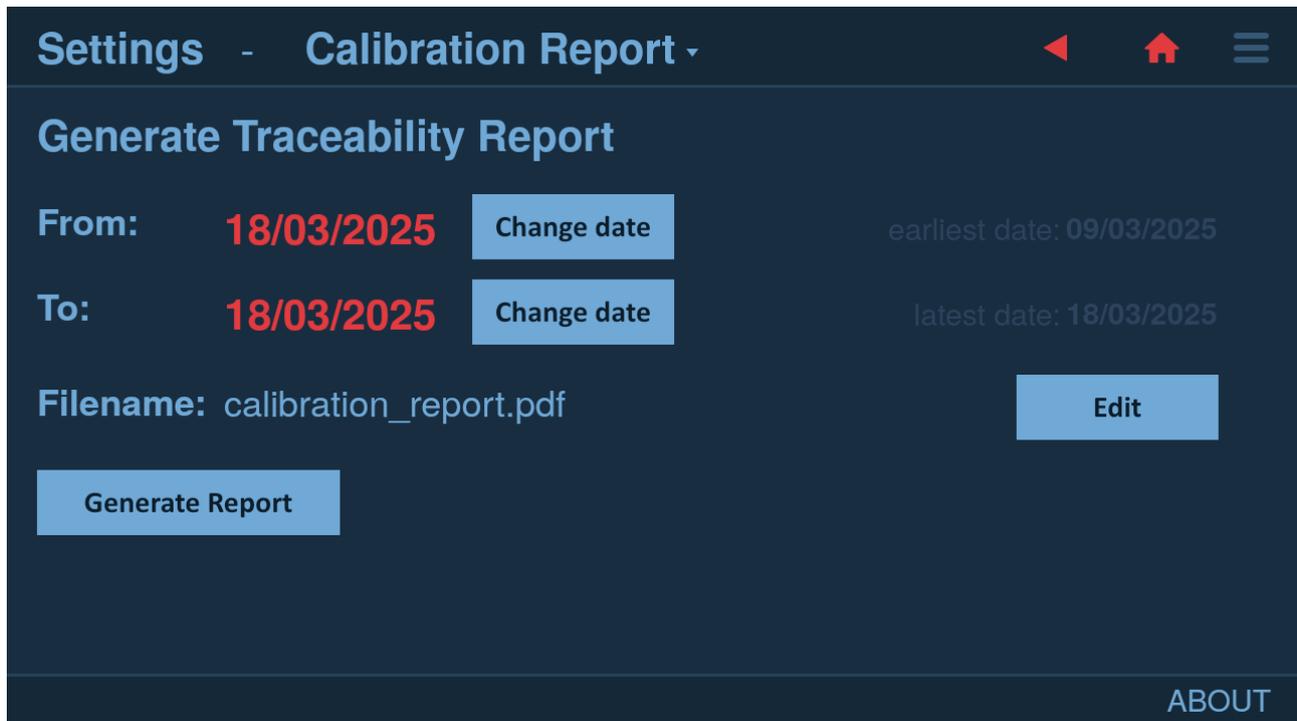


Fig. 3.7: Calibration Report export user interface

Upon pressing Generate Report button 2 files are saved to the instrument's internal memory:

- Calibration Report in PDF format with traceable calibration figures, uncertainties and calibration procedure description,
- Raw data in CSV format.

Raw data CSV file contains records of:

- UTC time,
- Whole part of internal timestamp (in 700 MHz clock ticks),
- Flags
 - Bit 0: Hold-Over
 - Bit 1: Manual Hold-Over
 - Bit 2: UTC time not valid
 - Bit 3: No GNSS fix
 - Bit 4: No GNSS Time fix (self-survey has not been completed)
 - Bit 5: The instrument has been restarted
- Fractional part of internal timestamp (in 1/65536 parts of 700 MHz clock ticks)
- Estimated 1 PPS phase error

The report files can be downloaded at any time in one of 2 ways:

- Downloading via File Download section of the instrument web interface
- Copying to USB stick via Settings → User Options → File Manager

CSV file can be opened in e.g. Excel to further post-process and/or visualize the data.

Note

Phase offset values obtained during periods when 1 PPS and UTC time from GNSS are not reliable (no fix) are not saved and not taken into account for the mean offsets calculations.

3.8 Measurement Data Display

Note

Measurement Data Display is only available for the instruments with purchased Measurement Option.

View large numeric data along with auxiliary data (e.g. voltage):

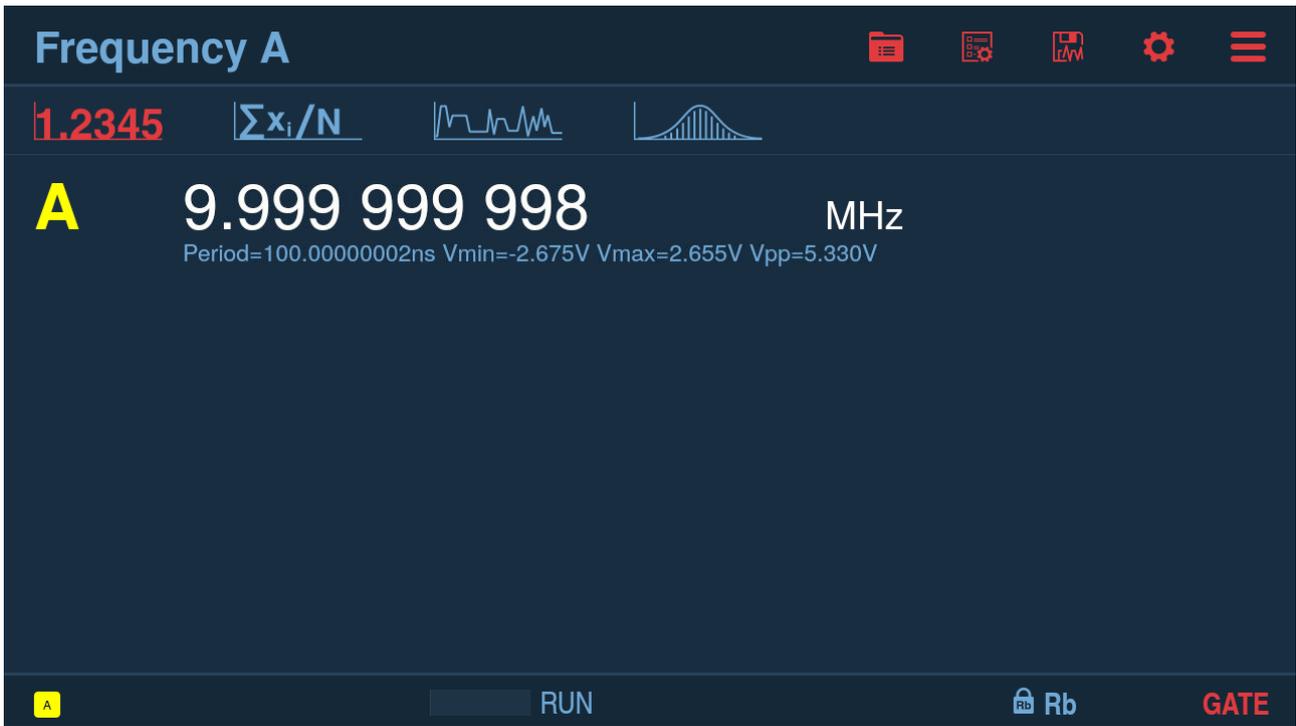


Fig. 3.8: Numeric screen

View detailed statistics for all measurement channels (click numbers for particular channel to zoom):



Fig. 3.9: Statistics screen

View graph and distribution along with detailed statistics (click numbers for particular channel to zoom):



Fig. 3.10: Graphs screen



Fig. 3.11: Distribution graph screen

Chapter 4

Measurements

Note

Requires Option 230 (Measurement input)

4.1 Frequency/Period Average measurements

In this measurement mode each sample is a Frequency/Period value averaged over sample interval (which acts as gate).

This is back-to-back measurement with no dead-time between the samples.

Minimal sample interval is 50 ns or 1 us (depending on particular model and licenses installed). Up to 32 million samples total can be measured in a single measurement session. Resolution is 12 digits per 1 s of gate time (Sample Interval).

If the signal period is greater or equal to the set Sample Interval – each signal period can be captured. When measuring Frequency/Period Average on input A and Trigger Mode is set to Auto or Relative, wide hysteresis (see details below) is used to improve noise tolerance. In this mode 2 comparators with different trigger levels are used for each input. First trigger level (e.g. Trigger Level A) defines the upper limit of wide hysteresis band and the second one (e.g. Trigger Level A2) defines the lower limit. Trigger Mode Auto sets trigger levels to 60% and 40% of signal's voltage range and Relative allows modifying them to fine tune the hysteresis band.

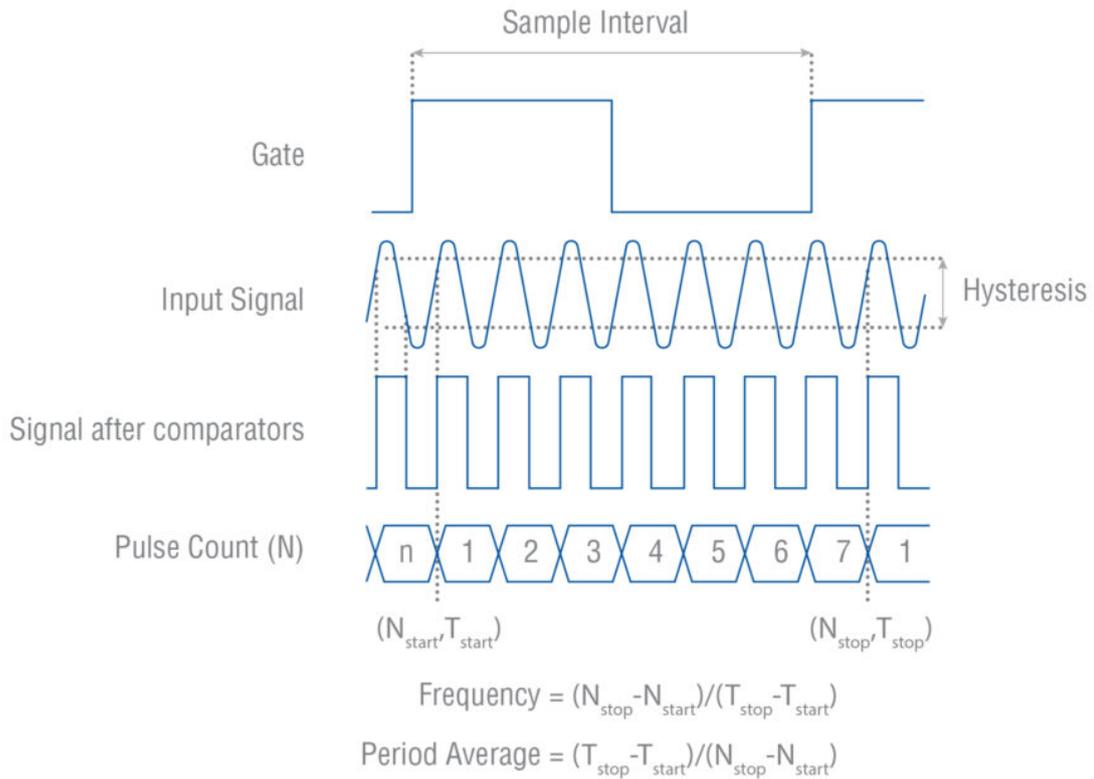


Fig. 4.1: Frequency/Period Average measurement with Wide Hysteresis

Without wide hysteresis, the signal needs to cross the approx. 20 mV in case of 1x Attenuation (200 mV in case of 10x) input hysteresis band before triggering occurs. This hysteresis prevents the input from self-oscillating and reduces its sensitivity to noise. If signal noise is comparable or higher than hysteresis band – it can result in false extra triggering producing erroneous counts. These could ruin the measurement.

Fig. 4.2 shows how spurious signals can cause the input signal to cross the trigger or hysteresis window more than once per input cycle and give erroneous counts. Fig. 4.3 shows that a wide enough hysteresis prevents false counts.

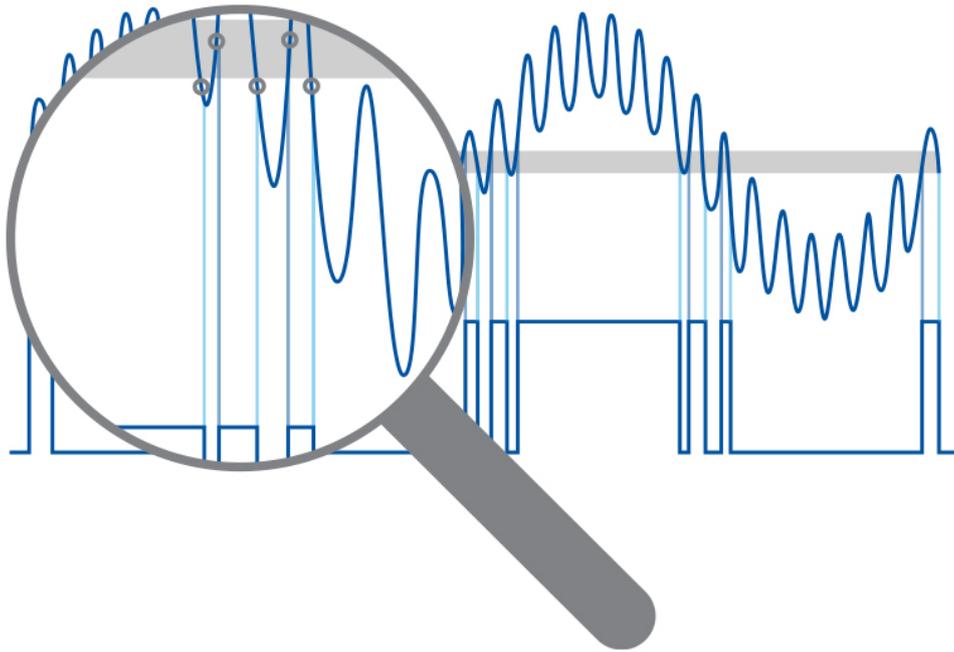


Fig. 4.2: Too narrow hysteresis gives erroneous triggering on noisy signals.

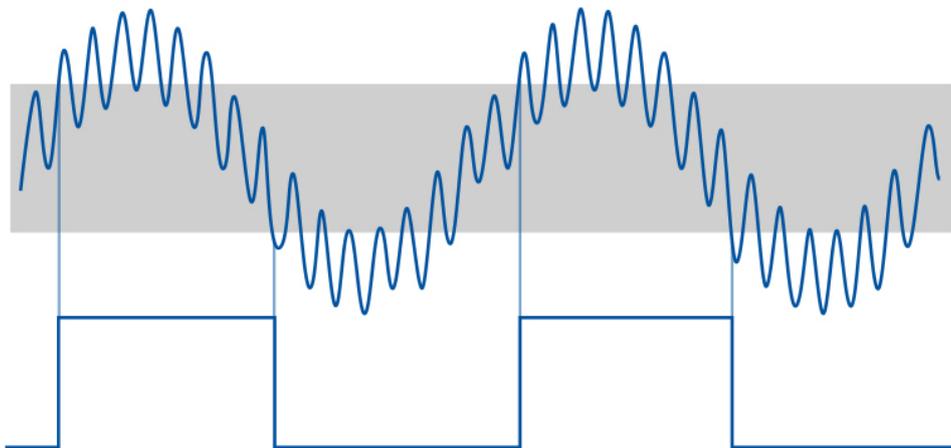


Fig. 4.3: Wide trigger hysteresis gives correct triggering.

4.2 Frequency Offset measurements (Calibrator Use-case)

Note

License is needed to unlock Frequency Offset option (Option 152F).

The optional measurement input converts FTR-210R to a 1-box Frequency Calibrator. Using the Frequency Offset function, the Frequency of the device under test can be displayed as relative deviation with automatic tolerance limits control.

When using Frequency Offset function the user can use Settings → Measurement → Frequency Tolerance to specify the required DUT tolerance limits and Sample Interval will be set automatically based on the tolerance value.



Fig. 4.4: Setting calibration tolerance for Frequency Offset function (Frequency Tolerance setting)

The Limits function is automatically activated with limits set to calibration tolerance. In combination with clear pass/fail indicators this further eases the manual or semi-automatic calibration.



Fig. 4.5: Example of calibration measurement trend graph

4.3 Time Interval Error (TIE)

Note

License is needed to unlock TIE option (Option 151F).

TIE measurement uses continuous back-to-back time-stamping to observe slow phase shifts (wander) in nominally stable signals during extended periods of time. The measurement itself is performed the same way as Frequency/Period Average but different processing is applied.

TIE is only applicable to clock signals, not data signals. Monitoring distributed PLL clocks in synchronous data transmission systems is a typical application.

The nominal frequency of the signal under test can be either manually or automatically set. Auto detects the frequency from the first samples, and rounds to number of digits set by the user (5 by default). TIE is measured as the period deviation of the input signal from the “ideal” reference period, and the accumulated deviation, up or down, is calculated for each Sample Interval, and displayed.

Minimal sample interval is 50 ns or 1 us (depending on particular model and licenses installed). Up to 32 million samples total can be measured in a single measurement session.



Fig. 4.6: Example of TIE measurement trend graph

Chapter 5

Performance Check

5.1 General Information

Before turning on the instrument, ensure that it has been installed in accordance with the Installation Instructions outlined in the Chapter *Installation* of this Manual.

This performance procedure is intended for incoming inspection to determine the acceptability of newly purchased instruments.

Note

The procedure does not check every facet of the instrument. It is concerned primarily with those parts of the instrument which are essential for determining the function of the instrument.

Note

This GNSS-controlled Frequency Reference is continuously calibrated via the GNSS-signal as long as there is a sufficient contact with the GNSS-satellites. It is not necessary to remove the cover of the instrument to perform frequency calibration. If Traceability option (Option 230) is installed the instrument does not need to be sent away for frequency calibration.

Recommended Test Equipment

- DSO with 50 Ohm input
- CNT-104/102 Multi-Channel Frequency Analyzer

5.2 Preparations

Power up your instrument at least 30 minutes before checking to let it reach normal operating temperature. Failure to do so may result in certain test steps not meeting equipment specifications.

Connect the antenna including cable to the antenna input (rear)

5.3 Power-On Test

Connect the power cord. At power-on the frequency standard performs an automatic Internal Self-Tests

Internal self-tests are run on every instrument power up. In case of a failure information message box appears described the type of the error.

Note

Power up your instrument at least 30 minutes before continuing. This will allow the instrument to reach normal operating temperature and go into GNSS-locked mode.

5.4 Touch Panel Test

- Press Settings icon on top right. Open User Options → Recall Defaults. Confirmation dialog will appear.
- Press Yes.
- Press BACK icon on top right. Main Settings screen will appear.
- Press ABOUT in bottom right corner. About box will appear.
- Press OK.
- Press HOME icon on top right. Main screen will appear.

5.5 Frequency Offset Calculation Test (only for Option 220)

After 24h the calculated frequency offset value may be far from the specification. After 48h the frequency offset value should be near the specification $1 * 10^{-12}$. If not, check if it has had continuous satellite contact and that the ambient temperature has been stable (within ± 3 degrees). Redo the test.

5.6 Front and Rear Panel Outputs

5.6.1 10 MHz

Connect a DSO with 50 Ohm inputs to all “10 MHz Out” BNC-connectors, one at a time. Verify that the output signal is sinusoidal and that the voltage is at least 900 mVrms. Connect a CNT-104/102 Multi-Channel Frequency Analyzer and verify that the frequency is $10 \text{ MHz} \pm 0.01 \text{ Hz}$.

5.6.2 5 MHz

Connect a DSO with 50 Ohm inputs to the “5 MHz Out” BNC-connector. Verify that the output signal is sinusoidal and that the voltage is at least 900 mVrms. Connect a CNT-104/102 Multi-Channel Frequency Analyzer and verify that the frequency is $5 \text{ MHz} \pm 0.005 \text{ Hz}$.

5.6.3 1 PPS

Connect a DSO with 50 Ohm inputs to the “1 pps Out” BNC-connector. Verify that the voltage is a square wave and that the low level is $<0.9\text{V}$ and the high level $>1.8\text{V}$. Connect a CNT-104/102 Multi-Channel Frequency Analyzer and verify that the frequency is $1\text{Hz} \pm 1 \mu\text{Hz}$.

5.6.4 Optional Ref. Frequency outputs (4x BNC)

- Option 210: 4x 10 MHz (sine)
See front panel 10 MHz output specs
- Option 211: 0.1, 1, 5, 10 MHz (sine)
Connect a DSO with 50 Ohm inputs to all BNC-connectors, one at a time. Verify that the four sine wave output signals are sinusoidal and that the voltage is at least 1Vrms.
Connect a CNT-104/102 Multi-Channel Frequency Analyzer and verify that the frequency is $10 \text{ MHz} \pm 0.01 \text{ Hz}$, $5 \text{ MHz} \pm 0.005 \text{ Hz}$, $1 \text{ MHz} \pm \text{Hz}$ and $0.1 \text{ MHz} \pm 0.0001 \text{ Hz}$ respectively.
- Option 213: 4x 1-pps (pulse)
See front panel 10 MHz and 1-pps output specs.

5.6.5 Pulse Output (Option 132F)

Connect a DSO with 50 Ohm inputs to the "Pulse Out" BNC-connector. Verify that the voltage is a square wave and that the low level is <0.9 V and the high level >1.8 V. Connect a CNT-104/102 Multi-Channel Frequency Analyzer and verify that the frequency is $1 \text{ Hz} \pm 1 \text{ } \mu\text{Hz}$ (factory default setting is 1 Hz).

5.6.6 Measuring Input Functions (Option 230)

For performance check of measuring functions, please refer to Chapter 8. Performance Check of CNT-100 series Frequency Analyzer User Manual.

Chapter 6

Preventive Maintenance

6.1 Calibration

Calibration and adjustment in the traditional sense are not necessary as long as the instrument is operating in disciplined mode. Then the internal rubidium timebase is continuously monitored and forced to follow the cesium clocks of the navigational satellites. These clocks are traceable to, for instance, NIST and USNO. Thus the normal aging characteristics of the internal timebase will be concealed. However, if the device is operating in hold-over mode for long periods, the aging characteristics are no longer concealed. Then you may need to reset the timebase from time to time by letting the device operate in disciplined mode for at least 48 hours.

6.1.1 Calibration intervals

Normally it is quite adequate to check the frequency deviation between one of the reference outputs and a corresponding, independent, cesium-controlled reference source once a year. Shorter intervals may be necessary if the main operating mode is hold-over, and the allowed deviation is less than the specified annual aging. See the timebase specifications to collect the data for these calculations.

6.1.2 Traceability option (Option 220)

With the traceability option there is NO NEED to ever send the instrument away for a traceable calibration. The instrument is continuously calibrating the internal Rubidium to UTC and can print traceable calibration reports at any desired time.

6.2 Maintenance of internal components

There are no parts or components inside the instrument that are serviceable by user. Power supply inside the instrument is not serviceable.

6.3 Handling of the removable battery

This instrument uses a 3 V cell lithium battery of type CR1220 to power real time clock. The instrument controls the state of the battery and notifies if the battery needs replacement with a message box on its screen, at start up. The battery is installed in a dedicated holder inside the instrument and can be replaced by qualified personnel.

Using an incorrect battery type can lead to malfunction or damage to the instrument. Do not allow the battery terminals to come into contact with conductive materials. Never attempt to disassemble or modify the battery. Never try to re-charge the battery. Before replacing the battery, ensure that the measurement instrument is powered off to prevent any electrical hazards. When inserting new battery ensure that the positive and negative terminals are aligned correctly.

See *Disposal of Hazardous Materials* for information about disposal of the battery.

6.4 Cleaning the instrument

When cleaning the instrument, wipe it with a silicone cloth or soft cloth to remove dust or dirt. When it is hard to remove the dirt, wipe it with a cloth wet with water and dry the instrument completely after cleaning.

Caution

Never use any organic solvent such as benzene, acetone, etc.

Chapter 7

Specifications

Up-to-date specifications for FTR-210R GNSS disciplined Frequency and Time Reference are available on the Pendulum Instruments web site: <https://pendulum-instruments.com/datasheets/FTR-210R-Datasheet.pdf>

Chapter 8

Sales and Service Contacts

For additional product information, customer support and service, please contact Pendulum Instruments at the following addresses:

Pendulum Instruments

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POLAND Lotnicza 37, 80-297 Banino, Poland **Phone:** +48 (58) 681 89 01

CHINA Room 1208, 12F, Building 2, Fuhai Center Daliushu, Haidian District, Beijing 100081 **Phone:** +86 13501221550

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