

CNT-91R/AF

All-in-one Frequency Calibrator/Analyzer & Frequency Reference

pendulum

DATA SHEET

- Frequency calibrator to 3 or 20 GHz
- Integrated Rubidium atomic clock
- A multi-reference Frequency Standard plus a high-resolution Frequency Counter/Analyzer in one box
- 0.1, 1, 5 and 10 MHz ultra-stable frequency reference outputs
- High resolution 50 ps-time; 12 digits/sec-frequency
- Graphic display; numerical statistics, histogram, trend & modulation domain
- 250k meas/sec to internal memory 3.75M stored measurement results
- Zero-dead-time frequency/period measurements
- Continuous Data Streaming over USB/GPIB during, not after, measuring
- Programmable Pulse Output from 0.5 Hz to 50 MHz



The Pendulum **CNT-91R/AF zero-dead-time Frequency Calibrator** features a combination of a multi-output Frequency Reference and a high resolution Frequency Counter/Analyzer, creating a dynamic measurement, analysis, and calibration system. Supply a reference frequency to **any** test instrument, and calibrate **any** frequency source to 3 or 20 GHz. The CNT-91R/AF is a unique all-in-one frequency reference/counter/analyzer/calibrator, with no competing product on the market.

Highest Performance Frequency Calibrator Ever

- The high measurement speed to internal memory of up to 250k measurements/s enables to follow both slow events, like daily aging, and fast events like short-term stability and jitter.
- Zero-dead-time counting provides period/frequency back-to-back measurements and the correct calculation of Allan Deviation.
- High resolution is critical for frequency analysis. The CNT-91R/AF features 50 ps single shot (time) or 12 digits/sec. (frequency) resolution, which allows capturing very small time and frequency changes, displayed to 14 digits.
- Modulation Domain Analysis (MDA). With the TimeView™ SW, the CNT-91R/AF becomes a high-performance MDA, thanks to the high measurement speed (250k meas/sec.) and large memory depth (3.75M). Very fast frequency changes in real time can be captured and analyzed.
- The integrated programmable pulse output offers 0.5 Hz to 50 MHz fast rise time signals as a reference frequency output, external pacing/trigger source, or general purpose pulse source.

Outstanding Ease of Operation

- The graphic presentation of results, histogram, trend line, numerical statistics, modulation domain – provide a clearer understanding of random signal distribution and measurement changes over time – from slow drift over days, to fast jitter, and modulation.
- Both USB and GPIB interfaces are standard. With USB you don't need to invest in a GPIB interface card for your PC. The GPIB operates in either native SCPI or 53131/53132 emulation mode, for plug-and-play replacement in existing test systems. There is also an optional GPIB-to-Ethernet controller, allowing the CNT-91R/AF to be remotely controlled via Ethernet
- Wide frequency range - to 3 or 20 GHz – offers microwave CW frequency measurements and burst measurements
- Menu-oriented settings reduce the risk of mistakes. Valuable signal information, given in multi-parameter displays, removes the need for other instruments like DVM's and Scopes.

The high-performance CNT-91R/AF is the ultimate tool for combining an atomic clock frequency reference and frequency measurement, analysis, and calibration.

CNT-91R/AF Frequency Calibrator/Analyzer

The CNT-91R/AF Frequency Calibrator/Analyzer is an all-inclusive high performance calibrator of frequency sources, that combines high resolution measurements and advanced analysis, with a built-in ultra-stable Rubidium atomic reference clock. Its compact format, and its short warm-up time, makes the CNT-91R/AF an ideal transportable one-box frequency calibrator/analyzer.

CNT-91R/AF delivers ultra stable reference frequencies of 0.1, 1, 5 and 10 MHz, making it suitable as atomic clock reference to any instrument and for any calibration system.

The DUTs (Devices Under Test) can have a frequency range up to 3 GHz or 20 GHz, model dependent.

Besides being a very accurate Frequency Calibrator, to 3 or 20 GHz, the CNT-91R/AF is also an extremely versatile general-purpose high-resolution timer/counter operating to 400 MHz.

A 19" rack-mount adapter is supplied with the instrument as standard.

Excellent Graphical Presentation

One of the great features of the CNT-91R/AF is the graphical display and the menu oriented settings. The non-expert can easily make correct settings without risking costly mistakes.

The multi-parameter display with auxiliary measurement values such as Vmax/Vmin/Vp-p in frequency measurements, and frequency/attenuation/phase, eliminates the need for extra test instruments and provides direct answers to frequently asked questions, like "What is the attenuation and phase shift of this filter?"

Measurement values are presented both numerically and graphically. The graphical presentation of results (histograms, trends etc.) gives a much better understanding of the nature of jitter. It also provides you with a much better view of changes vs time, from slow drift to fast modulation (trend plot). Three statistical views of the same data set can be viewed: Numerical, Histogram and Trend. It is very easy to capture and toggle between views of the same data (see figure 4, 5 & 6).

When adjusting a frequency source to given limits, the graphic display gives fast and accurate visual calibration guidance.



Figure 1: Display showing phase value, frequency, attenuation Va/Vb, and auxiliary parameters.

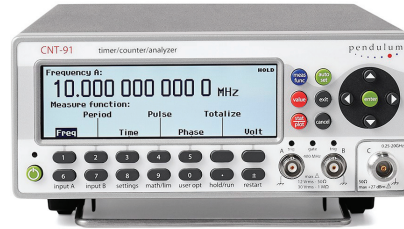


Figure 2: Measure function selection menu, shown with measured results.

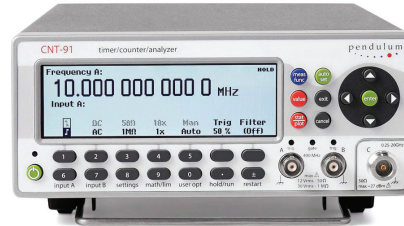


Figure 3: Input parameter setting menu shown with measured result.



Figure 4: Display showing different statistical parameters viewed at the same time.

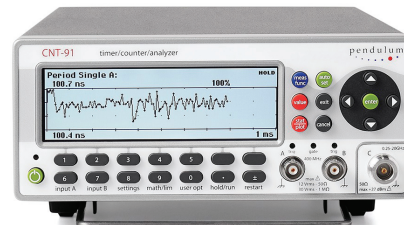


Figure 5: Display showing the trend (signal over time) of sampled data.



Figure 6: The same result as in Figure 5, now displayed as a histogram.

Measuring Functions

All measurements are displayed with a large main parameter value and smaller auxiliary parameter values (with less resolution). Some measurements are only available as auxiliary parameters.

Frequency A, B, C

Mode: Normal, back-to-back

Range:

- Input A, B: 0.002 Hz to 400 MHz
- Input C (option): Up to 3, 8, 15 or 20 GHz

Resolution: 12 digits in 1s measuring time (normal), 11 digits in 1s meas time (back-to-back)

Aux. Parameter (A, B): Vmax, Vmin, Vp-p

Frequency Burst A, B, C (opt. 14/14B)

Frequency and PRF of repetitive burst signals can be measured without external control signal and with selectable start arming delay.

Functions: Frequency in burst (in Hz); PRF (in Hz)

Range: Input A, B, C: See Frequency spec.

Minimum Burst Duration: Down to 40 ns

Minimum Pulses in Burst:

- Input A or B: 3 (6 above 160 MHz)
- Input C: 3 x prescaler factor

PRF Range: 0.5 Hz to 1MHz

Start Delay: 10 ns to 2sec., 10 ns resolution

Aux. Parameter: PRF

Period A, B, C

Mode: Single, average, back-to-back

Range:

- Input A, B: 2.5 ns to 1000 sec. (single, average)
- Input C (option): 10 ns down to 330, 125, 70 or 50 ps

Resolution: 100 ps (single); 12 digits/s (avg)

Aux. Parameter (A, B): Vmax, Vmin, Vp-p

Ratio A/B, B/A, C/A, C/B

Range: (10⁻⁹) to 10¹¹

Input Frequency:

- Input A, B: 0.1 Hz to 400 MHz
- Input C (option): Up to 3, 8, 15 or 20 GHz

Aux Parameters: Freq 1, Freq 2

Time Interval A to B, B to A, A to A, B to B

Range:

- Normal Calculation: 0ns to +10⁶ sec.
- Smart Calculation: -10⁶ sec. to +10⁶ sec.

Resolution: 50 ps (single)

Min. Pulse Width: 1.6 ns

Smart Calculation: Smart Time Interval to determine sign (A before B or A after B)

Positive and Negative Pulse Width A, B

Range: 2.3 ns to 10⁶ sec.

Min. Pulse Width: 2.3 ns

Aux. Parameters: Vmax, Vmin, Vp-p

Rise and Fall Time A, B

Range: 1.5 ns to 10⁶ sec.

Trigger Levels: 10% and 90% of signal Vp-p

Min. Pulse Width: 1.6 ns

Aux. Parameters: Slew rate, Vmax, Vmin

Time Interval Error (TIE) A, B

Normalized period back-to-back measurements, calculated as $TIE(k) = k \cdot TREF - \Sigma T_i$, when T_i = individual period back-to-back and T_{REF} = reference period value

Positive and Negative Duty Factor A, B

Range: 0.000001 to 0.999999

Freq. Range: 0.1 Hz to 300 MHz

Aux. parameters: Period, pulse width

Phase A Relative B, B Relative A

Range: -180° to +360°

Resolution: Single-cycle: 0.001° to 10 kHz, decreasing to 1° >10 MHz. Resolution can be improved via averaging (statistics)

Freq. Range: up to 160 MHz

Aux. Parameters: Freq (A), Va/Vb (in dB)

Totalize A, B

Mode: Tot A, Tot B, Tot A+B, Tot A-B, Tot A/B

Range: 1 to 10¹⁰ counts

Freq range: up to 160 MHz

Start control: Manual, start arming

Stop control: Manual, stop arming, timed

Aux. Parameters: Other Tot functions

Vmax, Vmin, Vp-p A, B

Range: -50 V to +50 V, -5V to +5V

Range is limited by the specification for max input voltage without damage (see input A, B)

Freq. Range: DC, 1Hz to 300 MHz

Mode: Vmax, Vmin, Vp-p

Resolution: 1 mV

Uncertainty (5V range, typical):

- DC, 1Hz to 1kHz: 1% +15 mV
- 1kHz to 20 MHz: 3% +15 mV
- 20 to 100 MHz: 10% +15 mV
- 100 to 300 MHz: 30% +15 mV

Aux parameters: Vmin, Vmax, Vp-p

Time stamping A, B

Raw time stamp data together with pulse counts on inputs A, or B accessible via GPIB or USB only.

Max Sample Speed: See GPIB specifications

Max Frequency: 160 MHz

Timestamp Resolution: 35 ps

Input and Output Specifications

Inputs A and B

Frequency Range:

- DC-Coupled: DC to 400 MHz
- AC-Coupled: 10 Hz to 400 MHz

Impedance: 1M Ω // 20 pF or 50 Ω (VSWR $\leq$ 2:1)

Trigger Slope: Positive or negative

Max. Channel Timing Difference: 500 ps

Sensitivity:

- DC-200 MHz: 15 mVrms
- 200-300 MHz: 25 mVrms
- 300-400 MHz: 35 mVrms

Attenuation: x1, x10

Dynamic Range (x1): 30 mV p-p to 10 V p-p within $\pm$ 5V window

Trigger Level: Read-Out on display

- Resolution: 1mV
- Uncertainty (x1): $\pm$ (15 mV + 1% of trigger level)
- AUTO Trigger Level: Trigger level is automatically set to 50% point of input signal (10% and 90% for Rise/Fall Time)

AUTO Hysteresis:

- Freq. range: 1Hz to 300 MHz
- Time: Min hysteresis window (hysteresis compensation)
- Frequency: One third of input signal amplitude

Analog LP Filter: Nominal 100kHz, RC-type.

Digital LP Filter: 1Hz to 50 MHz cut-off frequency

Max Voltage Without Damage:

- 1M Ω : 350 V (DC + AC pk) to 440 Hz, falling to 12 Vrms at 1MHz.
- 50 Ω : 12 Vrms

Connector: BNC

Input C - 3 GHz (Option 10)

Operating Input Voltage Range opt. 10:

- 100 to 300 MHz: 20 mVrms (-21 dBm) to 12 Vrms
- 0.3 to 2.5 GHz: 10 mVrms (-27 dBm) to 12 Vrms
- 2.5 to 2.7 GHz: 20 mVrms (-21 dBm) to 12 Vrms
- 2.7 to 3.0 GHz: 40 mVrms (-15 dBm) to 12 Vrms

Prescaler Factor: 16

Impedance: 50 Ω nominal, VSWR <2.5:1

Max Voltage without Damage: 12 Vrms, pin-diode protected

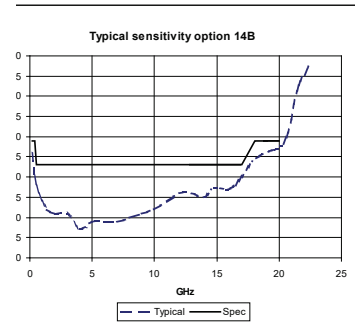
Connector: Type N Female

Input C - 20 GHz (Option 14B)

Freq. Range: 0.25 to 15 GHz (opt. 14) 0.25 to 20 GHz (opt. 14B)

Operating input voltage range:

- 250 to 500 MHz: -21 to +27 dBm
- 0.5 to 15 GHz: -27 to +27 dBm
- 15 to 17 GHz: -27 to +27 dBm
- 17 to 20 GHz: -21 to +27 dBm



Prescaler Factor: 128

Impedance: 50 Ω nominal, VSWR <2.0:1

AM tolerance: > 90% within sensitivity range

Max Voltage Without Damage: +27 dBm

Connector: Type precision N Female

Rear Panel Inputs and Outputs

Reference Input: 1, 5, or 10 MHz; 0.1 to 5Vrms sine; impedance $\geq$ 1k Ω

Reference Outputs:

1x100kHz, 1x1MHz, 1x5MHz and 2x10 MHz 1Vrms sine into 50 Ω (nominal)

Arming Input:

Arming of all measuring functions

- Impedance: Approx. 1k Ω
- Freq. Range: DC to 80 MHz

Auxiliary Functions

Trigger Hold-Off

Time Delay Range: 20 ns to 2sec., 10 ns resolution

External Start and Stop Arming

Modes: Start, Stop, Start and Stop Arming

Input Channels: A, B or E-rear panel

Max Rep. Rate for Arming Signal:

- Channel A,B: 160 MHz
- Channel E: 80 MHz

Start Time Delay Range: 20 ns to 2sec., 10 ns resolution

Statistics

Functions: Maximum, Minimum, Mean, Δ max-Min, Standard Deviation and Allan Deviation

Display: Numeric, histograms or trend plots
Sample Size: 2 to 2×10^9 samples
Limit Qualifier: OFF or Capture values above/below/inside or outside limits
Measurement Pacing:

- Pacing Time Range: 4 μ s to 500 sec.

Mathematics

Functions: $(K \times X + L)/M$ and $(K/X + L)/M$. X is current reading and K, L and M are constants; set via keyboard or as frozen reference value (X_0)

Other Functions

Measuring Time: 20 ns to 1000 sec. for Frequency, Burst, and Period Average. Single cycle for other measuring functions

Timebase Reference: Internal, External or Automatic

Display Hold: Freezes result, until a new measurement is initiated via Restart

Limit Alarm: Graphical indication on front panel and/or SRQ via GPIB

- Limit Values: Lower limit, Upper limit
- Settings: OFF or Alarm if value is above/below/inside or outside limits
- On Alarm: STOP or CONTINUE
- Display: Numeric + Graphic

Stored Instrument Set-ups: 20 instrument setups can be saved/recalled from internal non-volatile memory. 10 can be user protected.

Result Storage: Up to 8 measurements of max 32k samples can be stored in local memory for later downloading.

Display: Backlit LCD Graphics screen for menu control, numerical read-out and status information

- Number of Digits: 14 digits in numerical mode
- Resolution: 320*97 pixels

GPIB Interface

Compatibility: IEEE 488.2-1987, SCPI 1999, 53131A/53132A compatibility mode

Interface Functions: SH1, AH1, T6, L4, SR1, RL1, DC1, DT1, E2

Max. Measurement Rate:

- GPIB: 15k readings/s (block mode)
- 4k readings/s (talker only mode)
- 650 readings/s (individual GET trig'ed)

To Internal Memory: 250k readings/s

Internal Memory Size: Up to 3.75M readings.

USB Interface

USB Version: 2.0 Full speed (11 Mbits/s)

Ethernet Interface (Option 25)

External GPIB to Ethernet controller. Option 25 converts any PC with an Ethernet interface to a GPIB controller. Plugs into the GPIB port on rear panel and allows remote control via Ethernet for many applications, including NI LabView and HP VEE. See separate datasheet.

Calibration

Mode: Closed case, electronic calibration, menu controlled

Cal. Frequencies: 0.1, 1, 5, 10, 1.544 and 2.048 MHz

General Specifications

Environmental Data

Class: MIL-PRF-28800F, Class 3

Operating Temp:

- 0°C to +45°C

Storage Temp: -40°C to +71°C

Humidity: 5%-95% (10°C to 30°C)
5%-75% (30°C to 40°C)
5%-45% (40°C to 50°C)

Altitude: 4,600 meters

Vibration: Random and sinusoidal according to MIL-PRF-28800F, Class 3

Shock: Half-sine 30G per MIL-PRF-28800F; Bench handling

Transit drop test: Heavy-duty transport case and soft carrying case tested according to MIL-PRF-28800F

Reliability: MTBF 30,000 hours (calculated)

Safety: EN 61010-1, pollution degree 2, meas cat I, CSA C22.2 No 1010-1, CE

EMC: EN 61326 (1997); A1 (1998), increased test levels according to EN 50082-2, Group 1, Class B, CE

Power Requirements

- Warm-up (12 minutes):** 100-240 Vac, 50-400 Hz (Nom.), <60 W
- Operating:** 100-240 Vac, 50-400 Hz (Nom.), <50 W

Dimensions and Weight

Width x Height x Depth: 210 x 90 x 395 mm
(8.25 x 3.6 x 15.6 in)

Weight: Net 2.7 kg (5.8 lb),
Shipping app. 3.5 kg (app. 7.5 lb)

Ordering Information

Basic Models

CNT-91R/AF: 3 GHz Frequency Analyzer/Calibrator including Rubidium Time Base and a 400MHz, 50 ps Timer/Counter

CNT-91R/AF/20G: 20 GHz Frequency Analyzer/Calibrator including Rubidium Time Base and a 400MHz, 50 ps Timer/Counter

Included with Instrument: 2 year product warranty*, line cord, user documentation on CD and printed, 19" rack-mount adapter, and Certificate of Calibration

Optional Accessories

- Option 22/90:** Rack-Mount Kit
- Option 25:** External GPIB to Ethernet controller
- Option 27:** Carrying Case - soft
- Option 27H:** Heavy-duty Hard Transport Case
- Option 29/91:** TimeView 3 Modulation Domain Analysis SW for CNT-91R
- Option 90/07:** Calibration Certificate with Protocol; Rubidium oscillator
- Option 90/00:** Calibration Certificate with Protocol; Hold-over frequency aging/week
- Option 95/05:** Extended warranty with 2 extra years
- OM-91R/AF:** Users Manual English (printed)
- PM-90:** Programmers Manual English (printed)
- SM-90:** Service Manual English
- GS-90-EN:** Getting Started English
- GS-90-FR:** Getting Started French
- GS-90-DE:** Getting Started German

*Warranty period can be extended to 3 years by registering the product.

Time Base	
Model	CNT-91R/AF
Time base type:	Rubidium
Uncertainty due to:	
-Aging per 24h	<3x10 ⁻¹⁰ (1)
per month	<5x10 ⁻¹¹ (2)
per year	<3x10 ⁻¹⁰ (3)
-Temperature variations: 0°C to 45°C	<1x10 ⁻¹⁰
20°C to 26°C (typ. values)	<2x10 ⁻¹¹
Short-term stability: $\tau = 1s$	<3x10 ⁻¹¹
(root Allan Variance) $\tau = 10s$	<1x10 ⁻¹¹
Phase noise stability	
at 1kHz offset from carrier	<-140 dBc
Frequency retrace (after 24h OFF time):	
After 24 h ON time	<5x10 ⁻¹¹
After 1 h ON time,	<1x10 ⁻¹⁰
After 12 min. ON time	<5x10 ⁻¹⁰
Typical total uncertainty, for operating temperature 20°C to 26°C, at 2 σ (95%) confidence interval:	
-1 year after calibration	<3x10 ⁻¹⁰ (4)
-2 years after calibration	<5x10 ⁻¹⁰ (4)

¹After 24h of continuous operation ²After 3 months of continuous operation ³After 1 year of operation. Aging during 1st year: <5x10⁻¹⁰; long term < 2 x 10⁻⁹ / 10 years ⁴After 1 year of operation. Uncertainty <6x10⁻¹⁰ the first year of operation