# CNT-91 & CNT-91R

## Timer/Counter/Analyzer & Calibrator

DATA SHEET

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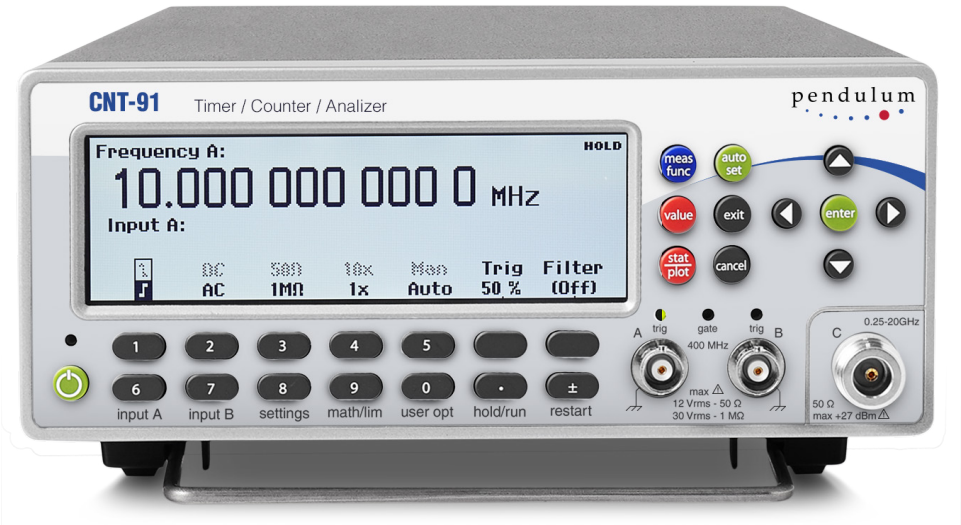
- Continuous Data Streaming over the bus during, not after, measuring
- Zero-dead-time frequency/ period measurements
- Fast GPIB/USB bus speed; 4k meas/sec in talker only mode 15k meas/sec in block mode
- High resolution 50 ps-time; 12 digits/sec-frequency
- Graphic display; numerical statistics, histogram, trend & modulation domain
- 250k meas/sec to internal memory 3.75M stored measurement results
- Programmable Pulse Output from 0.5 Hz to 50 MHz
- Integrated Rubidium atomic clock (model CNT-91R)




The Pendulum CNT-91 zero-dead-time counter features continuous data streaming of measurements over GPIB/USB during, not after, measuring; creating a dynamic measurement/analysis system, a fi rst in the counter industry! The CNT-91 is a unique frequency analyzer, outperforming any universal timer/ counter.

### Highest Performance Ever

- High GPIB/USB bus speed reduces test time in ATE test systems. Individual measurements up to 4k meas/sec in talker only mode. Fast Block measurements with continuous data streaming.
- Zero-dead-time counting provides period/frequency back-to-back measurements and the correct calculation of Allan Deviation.
- High resolution is critical for R&D and production testing. 50 ps single shot (time) or 12 digits/sec. (frequency) resolution allows capturing very small time and frequency changes, displayed to14 digits.
- Modulation Domain Analysis (MDA). With TimeViewTM SW, the CNT-91 becomes a high-performance MDA. Thanks to the high measurement speed (250k meas/sec.) and large memory depth (3.75M) of these, very fast frequency changes in real time can be captured.
- CNT-91's integrated programmable pulse output offers 0.5Hz to 50 MHz fast rise time signals as a reference frequency output,external pacing/trigger source, or general purpose pulse source.

### Outstanding Performance/Price Ratio

The CNT-91 timer/counter/analyzer outperforms every counter on the market, independent of measurement task.

- 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 to fast jitter, and modulation.
- Both USB and GPIB interfaces are standard. With USB you won't need to invest in a GPIB interface card for your PC. The GPIB operates in either SCPI/GPIB or 53131/53132 emulation mode, for plug-and-play replacement in existing ATE systems.
- Wide frequency range - to 20 GHz – offers microwave CW frequency measurements and very short burst measurements down to 40 ns.
- 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-91 is the only tool you need for time & frequency measurement, analysis, and calibration.

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## CNT-91R Frequency Calibrator/Analyzer

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

## Excellent Graphical Presentation

One of the great features of the CNT-91 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 fi lter?"

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 fi gure 4, 5 & 6).

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

## CNT-91/91R vs CNT-90 selection chart

| Feature | CNT-91/91R | CNT-90 |
|---|---|---|
| Graphic display of trend, histogram, modulation domain | yes | yes |
| Frequency resolution | 12 digits/sec | 12 digits/sec |
| Time resolution (single shot) | 50 ps | 100 ps |
| Voltage resolution | 1mV | 2.5mV |
| Measurement speed to internal memory | 250k meas/sec<br>3.75M results | 250k meas/sec<br>750k results |
| Talker only output (GPIB/USB) | 4k meas/sec | no |
| Individually triggered measurements | 650/sec | 500/sec |
| Block transfer speed | 15k meas/sec | 5k meas/sec |
| Freq, period, time, phase, volt, duty c, pulse w, rise time | yes | yes |
| Totalize, TIE | yes | no |
| Programmable pulse output | yes | no |
| Continuous measurements | yes | no |
| Timebase CNT-91 | OCXO (opt) | OCXO (opt) |
| Timebase CNT-91R | OCXO (opt) | OCXO (opt) |

**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.

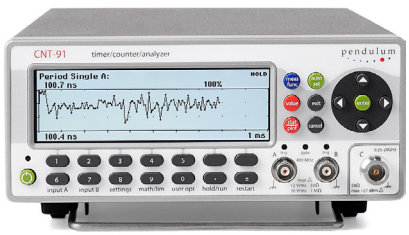



**Figure 5:**
Display showing the trend (signal over time) of sampled data.

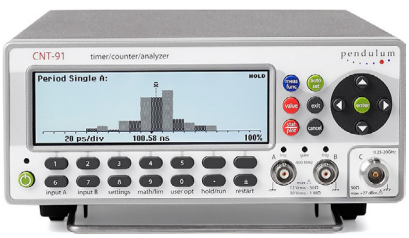



**Figure 6:**
The same result as in Figure 5, now displayed as a histogram.

## 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 $10^{11}$
**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 $+10^6$ sec.
- Smart Calculation: $-10^6$ sec. to $+10^6$ 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 $10^6$ sec.
**Min. Pulse Width:** 2.3 ns
**Aux. Parameters:** Vmax,Vmin, Vp-p

### Rise and Fall Time A, B

**Range:** 1.5 ns to $10^6$ 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 •TREF - ΣTi, 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 $10^{10}$ 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 specifi cation 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, C

Raw time stamp data together with pulse counts on inputs A, B or C, accessible via GPIB or USB only.
**Max Sample Speed:** See GPIB specifications
**Max Frequency:** 160 MHz
**Timestamp Resolution:** 35 ps

## Input and Output Specifi cations

### Inputs A and B

**Frequency Range:**
- DC-Coupled: DC to 400 MHz
- AC-Coupled: 10 Hz to 400 MHz

**Impedance:** 1MΩ // 20 pF or 50 Ω (VSWR ≤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 ±5V window
**Trigger Level:** Read-Out on display
- Resolution: 1mV
- Uncertainty (x1): ±(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:**
- 1MΩ: 350 V (DC + AC pk) to 440 Hz, falling to 12 Vrms at 1MHz.
- 50 Ω: 12 Vrms

**Connector:** BNC

### Input C (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

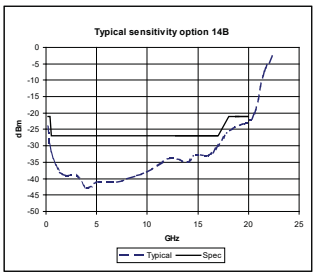
### Input C (Option 13)

**Operating Input Voltage Range:**
- 100 to 200 MHz: 100 mVrms to 7Vrms (typ.)
- 200 to 300 MHz: 40 mVrms to 7Vrms (typ.)
- 300 to 500 MHz: 20 mVrms to 7Vrms
- 0.5 to 3.0 GHz: 10 mVrms to 7Vrms
- 3.0 to 4.5 GHz: 20 mVrms to 7Vrms
- 4.5 to 6.0 GHz: 40 mVrms to 7Vrms
- 6.0 to 8 GHz: 80 mVrms to 7Vrms

**Prescaler Factor:** 256
**Impedance:** 50 Ω nominal, VSWR <2.5:1
**Max Voltage Without Damage:** 7Vrms
**Connector:** Type N Female

### Input C (Option 14 and 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 (Option 14B only)
- 17 to 20 GHz: -21 to +27 dBm (Option 14B only)




**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 ≥1kΩ
**Reference Output:** 10 MHz; >1Vrms sine into 50 Ω
**Arming Input:**
Arming of all measuring functions
- Impedance: Approx. 1kΩ
- Freq. Range: DC to 80 MHz

**Pulse Output:**
- Programmable via front/GPIB/USB.
- Mode: Pulse out, Gate open, Alarm out
- Period: 20 ns – 2sec., in 10 ns increments
- Pulse width: 10 ns – 2sec., in 10 ns increments
- Output: TTL-levels in 50 Ω, rise time 2ns

**Rear Panel Measurement Inputs:**
A, B, C (opt. 11/90)
Impedance: 1MΩ//50 pF or 50 Ω (VSWR ≤ 2:1)
**Connectors:** SMA female for rear input C, BNC for all other inputs/outputs

## 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, Δmax-Min, Standard Deviation and Allan Deviation
**Display:** Numeric, histograms or trend plots
**Sample Size:** 2 to 2 x $10^9$ samples
**Limit Qualifier:** OFF or Capture values above/below/inside or outside limits
**Measurement Pacing:**

- Pacing Time Range: 4µs to 500 sec.

### Mathematics

**Functions:** (K*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)

## Calibration

**Mode:** Closed case, electronic calibration, menu controlled
**Cal. Frequencies:** 0.1, 1, 5, 10, 1.544 and 2.048 MHz

## General Specifi cations

### Environmental Data

**Class:** MIL-PRF-28800F, Class 3
**Installation category:** II
**Operating Temp:**

- 0°C to +50°C (CNT-91)
- 0°C to +45°C (CNT-91R) bench top; 0 °C to +40 °C rack mounted

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

### Power Requirements

**Basic Version:** 100-240 Vac, 50-400 Hz (Nom.), <40 W.
**CNT-91R:**

- **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 Model

**CNT-91:** 400 MHz, 50 ps Timer/Counter including Standard Time Base
**CNT-91R:** 400 MHz, 50 ps Timer/Counter including Rubidium Time Base
**Included with Instrument:** 3 years product warranty, line cord, user documentation on CD, and Certifi cate of Calibration

### Input Frequency Options

- Option 10: 3 GHz Input C
- Option 13: 8 GHz Input C
- Option 14: 15 GHz Input C
- Option 14B: 20 GHz Input C

### Oscillator Options

Option 19/90: Medium Stability Oven Time Base; 0.06 ppm/month
Option 30/90: Very High Stability Oven Time Base; 0.01 ppm/month
Option 40/90: Ultra High Stability Oven Time Base; 0.003 ppm/month

### Optional Accessories

- **Option 11/90:** Rear Panel Inputs (replaces front panel inputs)
- **Option 22/90:** Rack-Mount Kit
- **Option 27:** Carrying Case - soft
- **Option 27H:** Heavy-duty Hard Transport Case
- **Option 29/91:** TimeView 3 Modulation Domain Analysis SW for CNT-91/CNT-91R
- **Option 90/01:** Calibration Certifi cate with Protocol; Standard oscillator
- **Option 90/06:** Calibration Certifi cate with Protocol; Oven oscillator
- **Option 90/07:** (CNT-91R only) Calibration Certificate with Protocol; Rubidium oscillator
- **Option 90/00:** Calibration Certifi cate with Protocol; Hold-over frequency aging/week
- **Option 95/05:** Extended warranty from 3 to 5 years
- **OM-90:** 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

## Time Base Options

| Option model | STD | 19/90 | 30/90 | 40/90 | CNT-91R |
|---|---|---|---|---|---|
| Time base type: | Standard | OCXO | OCXO | OCXO | Rubidium |
| Uncertainty due to:<br>-Aging per 24h<br>per month<br>per year<br>-Temperature variations: 0˚C to 50˚C 20˚C<br>to 26˚C (typ. values) | <br>n/a<br><5x$10^{-7}$<br><5x$10^{-6}$<br><1x$10^{-5}$<br><3x$10^{-6}$ | <br><5x$10^{-9}$[1]<br><6x$10^{-8}$<br><2x$10^{-7}$<br><5x$10^{-8}$<br><2x$10^{-8}$ | <br><5x$10^{-10}$[1]<br><1x$10^{-8}$<br><5x$10^{-8}$<br><5x$10^{-9}$<br><1x$10^{-9}$ | <br><3x$10^{-10}$[1]<br><3x$10^{-9}$<br><1.5x$10^{-8}$<br><2.5x$10^{-9}$<br><4x$10^{-10}$ | <br>n/a<br><5x$10^{-11}$[2]<br><2x$10^{-10}$[3]<br><1x$10^{-10}$<br><1.2x$10^{-11}$ |
| Short-term stability: τ =1s<br>(root Allan Variance) τ =10s | not specified | <1x$10^{-10}$<br><1x$10^{-10}$ | <1x$10^{-11}$<br><1x$10^{-11}$ | <5x$10^{-12}$<br><5x$10^{-12}$ | <1x$10^{-11}$<br><3x$10^{-12}$ |
| Power-on stability:<br>Deviation vs. fi nal value after 24 h on time,<br>after a warm-up time of: | n/a<br>30 min | <1x$10^{-7}$<br>30 min | <1x$10^{-8}$<br>10 min | <5x$10^{-9}$<br>10 min | <5x$10^{-10}$<br>12 min |
| Typical total uncertainty, for operating temperature 20˚C to 26˚C, at 2σ (95%) confi dence interval:<br>-1 year after calibration<br>-2 years after calibration | <br><7x$10^{-6}$<br><1.2x$10^{-5}$ | <br><2.4x$10^{-7}$<br><4.6x$10^{-7}$ | <br><0.6x$10^{-7}$<br><1.2x$10^{-7}$ | <br><1.8x$10^{-8}$<br><3.5x$10^{-8}$ | <br><2.5x$10^{-10}$<br><5x$10^{-10}$[4] |

[1]After 1 month of continuous operation [2]After 3 months of continuous operation [3]After 1st year, aging during 1st year: <5x10-10; long term< 2 x 10-9 / 10 years
[4]After 1 year of operation. Uncertainty <6x10-10 the first year of operation [5]Temperature variation 0˚C to 45˚C for CNT-91R



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Specifications subject to change or improvements without notice.

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