

# CNT-104R

Multi-channel Rubidium Frequency  
Calibrator / Analyzer

DATA SHEET

pendulum



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Your Partner:

**dataTec AG**

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>>> [www.datatec.eu](http://www.datatec.eu)

- Combined 400 MHz Multi-channel Frequency Analyzer and 10 MHz Frequency Reference with integrated Rubidium oscillator
- Ultra-stable 10 MHz Frequency Reference, using optional built-in GNSS-control of the Rubidium oscillator
- Excellent one-box, ultra-accurate Frequency Calibrator
- Time calibration is accurate to 10 ns rms to UTC (with GNSS option)
- Test 1-4 DUTs in parallel
- Gap-free frequency measurements; 50ns to 1000s gate time
- Ultra-high resolution: Time: 7 ps; Freq.: 12-13 digits/s
- Graphic touch screen display for settings and display of values, statistics (numeric and distribution graph), trend & modulation domain
- The instrument can be controlled locally via touch screen or mouse, or remotely (from anywhere in the world) - via web interface or VNC
- Intelligent and easy-to-use



The Pendulum CNT-104R is a new concept for super-performance **multi-channel frequency and time-interval calibration** & analysis, in a bench-top unit. It is a one-box Frequency and Time Interval calibrator combining an ultra-stable 10 MHz Rubidium Frequency Reference with a 4-channel advanced Frequency Analyzer. You can calibrate up to 4 oscillators/clocks in parallel simultaneously on 4 input channels.

The optional **GNSS control of the Rubidium clock** eliminates the small ageing drift giving an unprecedented accuracy in a compact one-box solution. On the large graphic screen, you can watch drift over time and frequency distribution, as well as traditional numeric and statistics parameters. CNT-104R has gap-free measurements, <7 ps time resolution, 12-13 digits/s frequency resolution, and variable gate time setting from 50ns to 1000s.

## Highest Performance for R&D and metrology

- The ultra-high resolution of 12 to 13 digits for 1s gate time gives faster and more accurate calibration results. Track and compare 4 parallel signals with 7 ps resolution/timestamp, at a settable rate from 1000s down to 50 ns between samples in each channel.
- Gap-free, zero-dead-time counting provides back-to-back measurements without losing any cycle, even for very long measurements.
- The CNT-104R is also a high-performance Modulation Domain Analyzer (MDA) for the advanced user. Thanks to the high speed of up to 20M meas./s for 4 parallel signals, very fast frequency or phase/time changes can be captured in real time.

## Save money in production test

- The 4-channel design enables 4 parallel frequency measurements. One CNT-104R can replace 4 existing frequency counters in a test system at a lower cost/counter, **plus** provide an ultra-stable reference frequency to the test stand. 5 instruments-in-one-box.
- Choose between Ethernet, or WLAN as a communication interface to a PC/Laptop/Tablet, or to the test system controller.
- High bus speed reduces test time in ATE test systems. Perform fast block measurements up to 170k meas./s. Test time is reduced compared to existing solutions, and time is money.

## Optional GNSS control for ultimate calibration performance

- Using the optional GNSS control, the 10 MHz frequency reference accuracy is 1E-12 averaged over 24h, day after day, forever. The intrinsic ageing of the Rubidium clock is totally eliminated.
- You can use the GNSS control either for continuous disciplining of the Rubidium timebase, or as a one-shot reset of the accumulated ageing drift, e.g. when you work mostly in a GNSS-denied environment.
- Calibrate 1-4 frequency sources in a short time to 11 digits uncertainty
- The GNSS receiver also provides an *internal Phase/Time Reference* with an outstanding accuracy
- Calibrate 1-3 external sync signals, with an uncertainty of 10 ns rms to UTC
- The portable format, short warm-up time, and the GNSS option, makes CNT-104R an excellent "Travelling clock" for field testing of sync clocks outside the normal lab.
- Calibration results can be saved in internal memory, on a USB stick, or on a connected PC

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## Display modes

### Values & Statistics

Numeric display of Measurement values or Statistics parameters. Values mode also display auxiliary parameters.

### Time-line & Distribution

Multi-channel graphs are color-coded. Up to 4 input signal graphs can individually be hidden/displayed,

## Measuring Functions

**Resolution** Measure up to 4 input signals in parallel with down to 7 ps resolution per timestamp (Period single, Time Interval, Pulse width, Rise/Fall time, Duty cycle, TIE), or 12 digits/s (frequency and period average).

### Smart Frequency/Period avg. calculation mode

All measurements are made **gap-free** (back-to-back). Statistics resolution enhancement algorithm (*smart mode*) gives up to one extra result digit depending on input signal and measurement setting.

### Frequency A, B, D, E

**Mode:** *Parallel measurements* on up to 4 inputs.

**Range:** 0.001 Hz to 400 MHz

**Aux. Parameter:** Vmax, Vmin, Vp-p

### Frequency C (option)

**Range:** See input C

**Aux. Parameter:** Period C

### Frequency Ratio (A,B,C,D, or E) / (A,B,C,D, or E)

**Mode:** *Parallel measurements* on 2 or 4 inputs.

**Range:**  $(10^{-9})$  to  $10^{11}$

**Aux Parameters:** Freq 1, Freq 2

### Period A, B, C, D, E average

**Mode:** *Parallel measurements* on up to 4 inputs.

**Range:** See the inverse of Frequency specifications

**Aux. Parameter:**

- Ch. A, B, D, E: Vmax, Vmin, Vp-p
- Ch. C: Frequency C

### TIE A, B, C, D, E (Option 151)

**TIE** = Time Interval Error, calculated as: *Accumulated period - Expected ("ideal") accumulated period*

**Mode:** *Parallel measurements* gap-free on 1 to 4 inputs.

**Freq range:** See Frequency specifications

**Aux. Parameter:** Ref Frequency

### Period A, B, D or E single

**Mode:** *Parallel measurements* on 1 or 2 inputs

**Range:** 2.5 ns to 1000 sec.

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

### Time Interval A, B, D, E (single or continuous)

**Mode:** *Parallel timestamping* of trigger events on up to 4 channels on continuous or single-shot signals.

**Start and stop channel(s):** any of A, B, D, E

**Note:** each input can produce 1 or 2 trigger events with individual trigger level and slope

**Accumulated Time Interval:** add/subtract 1 start channel period to the Time Interval, when required)

**Range:** -1000s to +1000s

**Repetition rate:** up to 300 MHz or single-shot events

**Min. Pulse width:** 1.5 ns

### Positive and Negative Pulse Width A, B, D, E

**Mode:** *Parallel measurements* on 1 or 2 inputs

**Range:** 1.5 ns to 1000 sec.

**Repetition rate:** up to 300 MHz or single-shot events

### Rise/Fall Time A, B, D, E

**Mode 1:** *Parallel measurements* on 1 or 2 inputs of

Rise OR Fall time, or

**Mode 2:** *Single* input measurement of Rise AND Fall time on the same pulse

**Range:** 1.5 ns to 1000 sec.

**Aux. Parameters:** Slew rate, Vmax, Vmin

### Positive and negative Slew Rate A, B, D, E

**Mode:** *Parallel measurements* on 1 or 2 inputs

**Calculation:**  $(80\% \text{ of } V_{p-p}) / (\text{Rise or Fall Time})$

**Aux. Parameters:** Rise/Fall time, Vmax, Vmin

### Positive and Negative Duty Cycle A, B, D, E

**Mode:** *Single* input measurement; rep. rate  $<300$  MHz

**Range:** 0.000001 to 0.999999

**Aux. parameters:** Period, Pulse width

### Phase A Relative B, B Relative A

**Mode:** Intended for phase shift or delay measurements of two signals with identical frequency

**Accumulated Phase:** add/subtracting  $360^\circ$  to the Phase, when required.

**Range:**  $-180^\circ$  to  $+180^\circ$  (Acc. Phase is OFF)

**Resolution:** 0.00003° to 100 kHz, decreasing to  $0.03^\circ > 100$  MHz. (10k sample statistics averaging)

**Freq. Range:** up to 300 MHz

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

### Totalize A, B, D, E

**Inputs:** up to 4 inputs (A, B, D, E)

**Mode:** Tot A, B, D, E; A+B, D+E; A-B, D-E; A/B, D/E

**Range:** 1 to  $10^{10}$  counts

**Freq range:** up to 400 MHz

**Start control:** Manual, start arming

**Stop control:** Manual, stop arming, timed

### Vmax, Vmin, Vp-p A, B, D, E

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

**Freq. Range:** DC, 1Hz to 200 MHz

**Coupling:** Sine (AC or DC), Square (DC only)

**Resolution:** 1 mV (5V range), 10 mV (50V range)

**Uncertainty (5V range):**

- DC, 1Hz to 1kHz:  $<1\% + 15$  mV
- 1kHz to 20 MHz sine:  $3\% + 15$  mV (typ.)
- 20 to 100 MHz sine:  $10\% + 15$  mV (typ.)
- 100 to 200 MHz sine:  $30\% + 15$  mV (typ.)

(For square waves add 10% to Vmax/min & 20% to Vp-p)

(For 50V range, add 2% + 150 mV)

**Aux parameters:** Vmin, Vmax, Vp-p

### Input Specifications

#### Inputs A, B, D, E (BNC connector)

**Frequency Range:**

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

**Impedance:**  $1\text{M}\Omega // 40\text{ pF}$  or  $50\ \Omega$  (VSWR  $\leq 2.1$  typ.)

**Trigger Slope:** Positive or negative

**Channel-channel skew:**  $<30$  ps (after calibration)

**Sensitivity (typical):**

- DC-400 MHz:  $<70$  mVrms (PreAmp=OFF)
- DC-100 MHz: 15 mVrms (PreAmp=ON)
- 100-200 MHz: 25 mVrms (PreAmp=ON)
- 200-350 MHz: 35 mVrms (PreAmp=ON)
- 350-400 MHz: 50 mVrms (PreAmp=ON)

**Hysteresis window:** approx. 20 mV (PreAmp=OFF)

**Attenuation:** x1, x10

**Dynamic Range (x1):**

PreAmp = OFF: 0.2 to 10 Vp-p within  $\pm 5$  V window

PreAmp = ON: 0.01 to 3 V p-p within  $\pm 1.5$  V window

**Trigger Level:** Read-out in menu

- Resolution: 1mV
- Uncertainty (x1):  $\pm(15\text{ mV} + 1\% \text{ of trigger level})$

**Trigger Level modes:** Manual, Relative (to Vp-p), Auto

**Auto Trigger Level** is set to:

- 50% point of input signal's Vp-p, combined with a wide hysteresis between the 40% and 60% points, for frequency, period average, TIE
- 10% and 90% points, for Rise/Fall Time, Slew rate
- 50% point with minimum hysteresis for all other functions
- Min. voltage 200 mVp-p

**Analog LP Filter:** Nominal 10 or 100kHz selectable

**Max Voltage Without Damage:**

- $1\text{M}\Omega$ : 350 V (DC + AC pk) to 440 Hz, falling to 12 Vrms at 1MHz.

- $50\ \Omega$ : 12 Vrms

### Input C (Option 10)

**Operating Input Power Range opt. 10:**

- 100 to 300 MHz: -21 dBm to +35 dBm

- 0.3 to 2.5 GHz: -27 dBm to +35 dBm

- 2.5 to 2.7 GHz: -21 dBm to +35 dBm

- 2.7 to 3.0 GHz: -15 dBm to +35 dBm

**Prescaler Factor:** 16

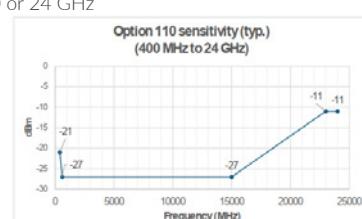
**Impedance:**  $50\ \Omega$  nominal, VSWR  $<2.5:1$  typ.

**Max Power without Damage:** +35 dBm

**Connector:** Type N Female

### Input C (Option 110)

**Freq. Range:** 0.4 to 24 GHz; As standard SW limited by 10 GHz. Upgradable by SW license to 15, 20 or 24 GHz



**Max Operating Input Power Level:** +20 dBm

**Prescaler Factor:** 64

**Impedance:**  $50\ \Omega$  nominal, VSWR  $<2.0:1$  typ.

**AM tolerance:** > 90% within sensitivity range

**Max Power Without Damage:** +27 dBm

**Connector:** 2.92 mm, SMA compatible Female

## Rear Panel Inputs and Outputs

### Reference Frequency Input (BNC)

**Frequency:** 1, 5, or 10 MHz; 0.1 to 5Vrms sine

**Impedance:**  $50\ \Omega$  (nom.)

### Reference Frequency Output (BNC)

**Source:** External input if used, otherwise internal

**Frequency:** External ref freq., or 10 MHz (internal)

**Output impedance:**  $50\ \Omega$

**Amplitude:** 1Vrms sine into  $50\ \Omega$  (nom.)

### External Disciplining Input (SMA)

**Frequency:** 1 pps (from external source)

**Input levels:** TTL levels in  $50\ \Omega$

### Arming Input (BNC)

Arming of all measuring functions

- Impedance: Approx.  $1\text{k}\Omega$
- Freq. Range: DC to 160 MHz
- Trigger level: approx. 1.5V fixed
- Trigger slope: Pos. or neg. selectable

### Programmable Pulse Output (Option 132)

**Pulse mode:** Pulse generator, Gate open, Alarm

**Period range:** 10ns-2s in 2ns steps

**Pos. Pulse width range:** 4ns-2s in 2ns steps

**Rise time:** 2.5 ns (nom.)

**Output impedance:**  $50\ \Omega$  (nom.)

**Output level:** Low <0.4V; High: 4.5-5.25V (open output); 2.0-2.5V (50 ohm load)

### Multi-GNSS antenna input (SMA) - Option 55

**Supported Systems and Frequencies:**

- GPS: L1 C/A, L5
- Galileo: E1 B/C, E5a
- GLONASS: L1OF
- BeiDou: B1I, B1C, B2A
- NavIC: SPS-L5
- QZSS: L1 C/A, L5

System/frequency bands can be individually enabled/disabled

## Supported active antenna parameters:

**Gain:** 17 to 50 dB, <+10 dBm at receiver input  
**DC feed on center pin:** +5V, 100 mA max.

## Auxiliary Functions

### Trigger Hold-Off

**Time Delay Range:** 20 ns to 2 s in 10 ns steps

### External Start and Stop Arming

#### Modes:

- Start Arming
- Stop Arming
- Ext. Gate (combined Start and Stop Arming)

**Arming channels:** A, B, D, E or rear panel ARM

**Arming delay to first trigger ready:** <5 ns (typ.)

**Start/Stop Time Delay Range:** 20 ns to 2 sec.

## Statistics

**Functions:** Maximum, Minimum, Mean,  $\Delta$ max-min, Standard Deviation and Allan Deviation

**Display:** Numeric or frequency distribution graph

**Sample Size:** 2 to  $16 \times 10^6$  samples

## Limit alarm

Graphical indication of limits with Pass/Fail message on front panel.

**Limit Qualifier:** OFF or Capture values above, below, inside or outside limits

## Sample Interval (Gate time)

The Sample Interval sets the measuring time (gate) in Frequency/Period and Totalize modes, and the time between measurements/samples in all other modes

**Range:** OFF or 50 ns to 1000 sec.

## Mathematics

**Functions:** OFF,  $(K^*X-L)/M$ ,  $(K/X-L)/M$ ,  $X/M-1$   
X is current reading, and K (Scale factor), L (Nulling value) and M (Reference value) are constants

## Other Functions

**Timebase Reference:** Internal, External or Auto-selected

**Restart:** Aborts current measurement and starts a new

**Run/Hold:** Switch between RUN (continuous measurements) and HOLD (Freezes result, until a new measurement is initiated via Restart)

## Save and Recall Settings and Measurements

**Instrument Set-ups** can be saved/recalled. Setups saved to internal memory can be user protected.

**Measurement results (RAM)** can be accessed by connected PC, and/or saved in internal non-volatile memory, and moved to USB stick.

## Time Base Oscillator

Mode	Disciplined	Free run
Time base type:	Rubidium	Rubidium
Uncertainty due to:	<ul style="list-style-type: none"> <li>- Aging per 24h</li> <li>per month</li> <li>per year</li> </ul>	<ul style="list-style-type: none"> <li><math>&lt;1 \times 10^{-12}</math> (1)</li> <li><math>&lt;1 \times 10^{-12}</math> (1)</li> <li><math>&lt;1 \times 10^{-12}</math> (1)</li> </ul>
- Temperature variations: 0°C to 50°C	$5 \times 10^{-12}$ (1) typ. value	
20°C to 26°C (typ. value)	$<5 \times 10^{-11}$ (1)	
	$<5 \times 10^{-10}$ (1)	
	$<3 \times 10^{-10}$	
	$<3 \times 10^{-11}$	
Short-term stability: $\tau = 1$ s (Allan Deviation) $\tau = 10$ s $\tau = 24$ h	<ul style="list-style-type: none"> <li><math>&lt;5 \times 10^{-11}</math></li> <li><math>&lt;2 \times 10^{-11}</math></li> <li><math>&lt;1 \times 10^{-12}</math></li> </ul>	<ul style="list-style-type: none"> <li><math>&lt;5 \times 10^{-11}</math></li> <li><math>&lt;2 \times 10^{-11}</math></li> </ul>
Phase noise stability (typ. value) at - 10 Hz / 100 Hz / 1 kHz / 10 kHz offset from carrier:	$<-95$ / -125 / -135 / -140 dBc	$<-95$ / -125 / -135 / -140 dBc
Frequency retrace (after 24h OFF time): - After 1 h ON time - After 7 min. ON time Time to lock:	$<3 \times 10^{-11}$ $<5 \times 10^{-10}$ $<6$ minutes	$<3 \times 10^{-10}$
Free run: Typical total uncertainty at $2\sigma$ (95%) confidence interval, averaged over 24h, for temperature 20°C to 26°C, up to 1 year after last calibration/adjustment		

(1) After 24h of continuous operation

## Max. Measurement Speed and Storage size (RAM):

20 MSa/s (1 to 4 inputs): 16k samples  
12.5 to 3.125 MSa/s (1 to 4 inputs): 32M samples

## Display

**Display:** Graphic screen for menu control, numerical read-out, status information, plus distribution, trend and time-line graphs

**Resolution:** 1280x720 pixels

**Type:** Color Touch 5" TFT LCD display with backlight

**Front panel accessible tools:** Graph smoothing, pan and zoom, cursor read-out

## Remote interfaces

### Remote operation

**Programmable Functions:** All front panel accessible functions

**Max. measurement rate (depending on measurement settings):**

**Block mode:** up to 170k readings/s

**Individual results:** up to 425 readings/s

**To Internal Memory:** up to 20M readings/s

**Data Output format:** ASCII, IEEE double precision floating point, or packed

## USB interface

**USB version:** 2.0

### Front panel connectors:

2x Type A; (Host) 5V (nom.) max. 0.5A. For FW updates, SW licenses, external mouse, result storage, WiFi dongle.

## LAN & WLAN interface

**Speed:** 10/100/1000 Mbps

### Capabilities:

- Web server
- SCPI over HiSLIP protocol, compatibility with VISA

### Supported WiFi USB-dongles:

TP-Link TL-WN321G, TP-LINK Archer T4U v.2, TP-LINK Archer T4U v.3

## General Specifications

### Environmental Data

**Class:** MIL-PRF-28800F, Class 3

### Installation category:

#### Operating Temp:

0°C to +50°C / 5 to 75% RH, bench-top,

0°C to +40°C / 5 to 75% RH, rack-mount

**Storage Temp:** -40°C to +71°C

**Max altitude:** 4600 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:** According to MIL-PRF-28800F

**Safety:** EN 61010-1:2011, pollution degree 2, installation/over voltage category II, measurement category I, CE, indoor use only.

CSA C22.2 No 61010-1-12

**EMC:** EN 61326-1:2013-06, increased test levels according to EN 61000-6-2:2008, Group 1, Class B, CE

## Power Requirements

**Max. Version:** 100 to 240 V<sub>AC</sub>  $\pm 10\%$ , 47 to 63 Hz, <70W

## 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 3 kg (6.6 lb)

## Ordering Information

### Basic model

**CNT-104R:** 4-channel 400 MHz Frequency Analyzer, 7 ps resolution, Rubidium timebase

### Input C Frequency Options

**Option 10:** 3 GHz Input C (HW-Factory installed)

**Option 110:** 10 GHz Input C (HW-Factory installed)

**Option 110/15:** SW upgrade from 10 to 15 GHz

**Option 110/20:** SW upgrade from 15 to 20 GHz

**Option 110/24:** SW upgrade from 20 to 24 GHz

### Other HW options (factory installed)

**Option 55:** GNSS control of Rubidium oscillator

**Option 11A:** Rear panel inputs for inputs A,B,D,E

**Option 11C:** Rear panel inputs for input C

### Options (SW license enabled)<sup>2</sup>

**Option 132:** Enable pulse output 0.5 Hz to 100 MHz

**Option 151:** TIE measurement function

**Option 152:** Add Easy-to-use Frequency Offset measurement function

*2: These options can be installed at any time by the user*

### Included with Instrument:

- 2 year product warranty<sup>3</sup>
- Line cord (dependent on destination country)
- Link to User documentation (PDF)
- Certificate of Calibration
- Important information document

*3: Warranty period is extended to 3 years, at no cost, by registering the product within 1 year from delivery.*

### Optional Accessories

**Option 01/200:** Multi-GNSS L1&L5 antenna, 40 dB gain, N-female connector, incl. mounting kit

**Option 02/A:** Antenna cable adapter SMA to TNC

**Option 02/20T:** Antenna cable, N to TNC, 20m

**Option 02/50T:** Antenna cable , N to TNC, 50m

**Option 22/90:** Rack-Mount Kit- 1 unit

**Option 22/05:** Rack-Mount Kit -2 units

**Option 27:** Carrying Case - soft

**Option 27H:** Heavy-duty Hard Transport Case

**Option 90/07:** Calibration Certificate with

Protocol; Rubidium oscillator

**Option 90/07A:** Accredited ISO 17025 calibration; Rubidium oscillator

**Option 95/05:** Extended warranty 2 extra years

**OM-100:** User's Manual English (printed)<sup>4</sup>

**PM-100:** Programmer's Manual English (printed)<sup>4</sup>

**GS-100-EN:** Getting Started English (printed)<sup>4</sup>

*4: Always available as download from the Pendulum website*