# Boonton

Data Sheet

## 4500C
## RF Peak Power Analyzer

# 4500C RF Peak Power Analyzer

The Boonton Model 4500C is the instrument of choice for capturing, displaying, analyzing and characterizing micro-wave and RF power in both the time and statistical domains. It is ideal for design, verification, and troubleshooting of pulsed and noise-like signals used in commercial and military radar, electronic warfare (EW), wireless communications (e.g., LTE, LTE-A, and 5G), and consumer electronics (WLAN), as well as education and research applications.

The 4500C features 100 ps time base resolution, video band-width up to 125 MHz, flexible triggering and greater than 80 dB dynamic range without any range switching to cover the most demanding peak power measurement applications. The 4500C also features continuous statistical analysis of power at acquisition rates up to 100 MegaSamples per second (MS/s), a text display of up to 15 automatic measure-ments per channel, as well as envelope and persistence views to provide fast, in-depth signal analysis. The instrument incorporates convenient I/O, including USB ports for storing data such as instrument setups, trace waveforms and bitmap image files.
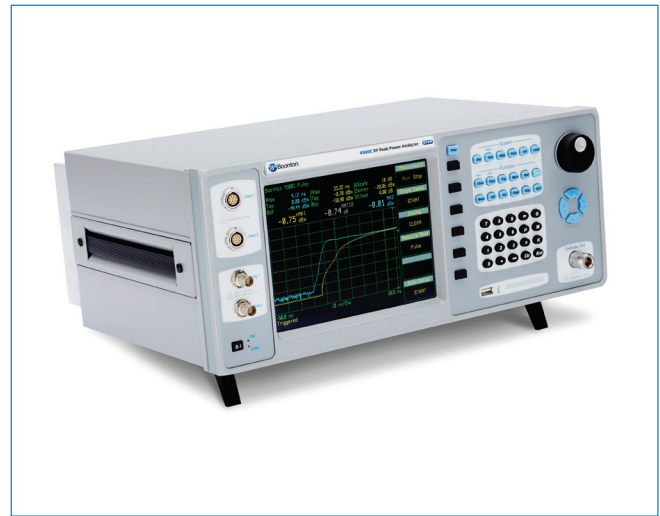
## Key Specifications

| | |
|---|---|
| Frequency range | 30 MHz to 40 GHz |
| Measurement range | -60 dBm to +20 dBm |
| RF channel video bandwidth | 125 MHz |
| RF channel rise-time | < 5 ns |
| Overall accuracy | 0.2 dB |
| Time Resolution | 100 ps |
| Min Pulse Width / Max PRF | 6 ns / 50 MHz |
| Channels | 2 RF and 2 trigger |

## Key Features

- **Real-Time Power Processing™**

- **Ultrafast trace acquisition and refresh rate**

- **One button push for 15 automated power and time measurements**

- **Automatic peak-to-peak, delay-by-time and delay-by-events triggering**

- **Multi-level, multi-function calibrator**

- **Continuous statistical analysis (optional)**
  - Includes gated PDF, CDF, and CCDF

- **Displays up to 4 measurement, 2 memory, and 1 math channel simultaneously**

**High Bandwidth**
Peak power meter with video bandwidth up to 125 MHz and rise time less than 5 ns

**Dual Trigger System**
Internal and external trigger with auto peak-to-peak and B trigger delay by time or events qualifier

**Large Display**
View multiple channels and measurements on the 8.4'' color TFT display

**Wide Dynamic Range**
Peak power sensors are available up to 40 GHz, some with 80 dB dynamic range

**Powerful Automatic Measurements**
One button text key automatically displays up to 15 power and time measurements per channel

**Interactive Control**
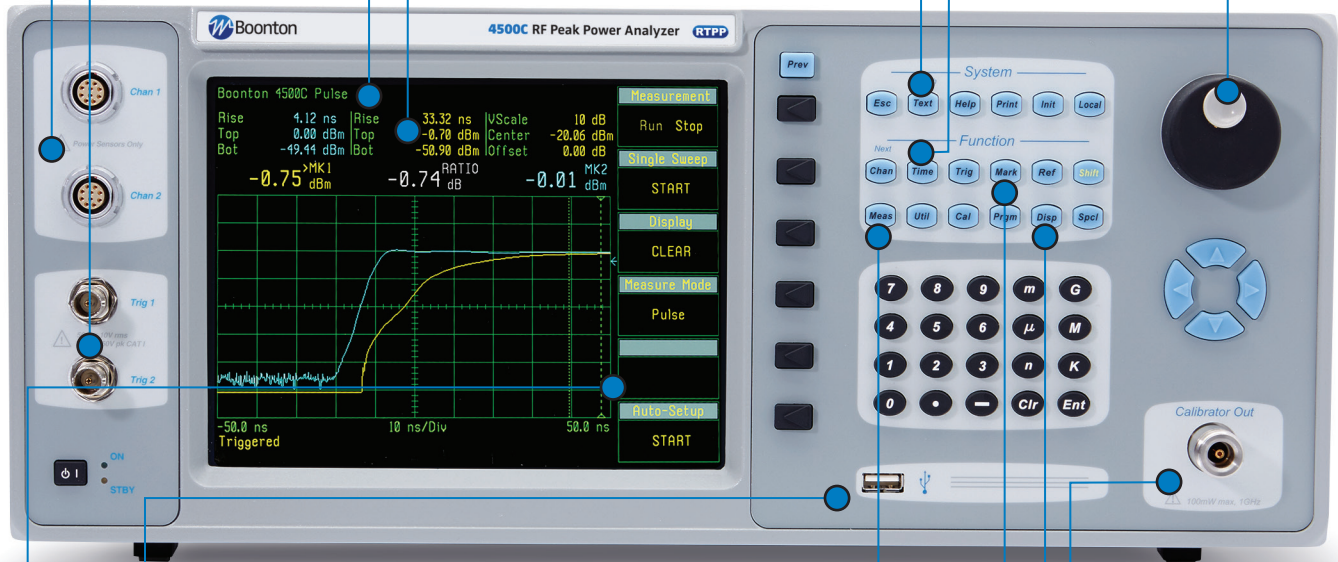Most settings can be selected and updated interactively with instant visual feedback

**Superior Time Capture**
View signals from 5 ns/div to 1 hr/div with 100 ps resolution

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4500C RF Peak Power Analyzer RTPP

Boonton 4500C Pulse

| | | | | | |
|---|---|---|---|---|---|
| Rise | 4.12 ns | Rise | 33.32 ns | VScale | 10 dB |
| Top | 0.00 dBm | Top | -0.70 dBm | Center | -20.06 dBm |
| Bot | -49.44 dBm | Bot | -50.90 dBm | Offset | 0.00 dB |

-0.75 >MK1 dBm    -0.74 RATIO dB    -0.01 MK2 dBm

-50.0 ns    10 ns/Div    50.0 ns
Triggered

Measurement
Run  Stop

Single Sweep
START

Display
CLEAR

Measure Mode
Pulse

Auto-Setup
START

Prev

System
Esc  Text  Help  Print  Init  Local

Next  Function
Chan  Time  Trig  Mark  Ref  Shift

Meas  Util  Cal  Prgm  Disp  Spcl

7 8 9 m G
4 5 6 μ M
1 2 3 n K
0 . – Clr Ent

Calibrator Out
100mW max, 1GHz

ON
STBY

Chan 1
Chan 2
Power Sensors Only
Trig 1
Trig 2

**Convenient I/O**
Windows based connectivity such as USB for data storage directly to a flash drive

**Precise Measurements**
Markers and time gates allow for the analysis of specific portions of a waveform

**Accurate Auto-Calibration Precision**
1 GHz RF step calibrator for superior linearity and absolute level accuracy

**Intuitive User Interface**
Easy to navigate, soft menu driven

**Fast Data Analysis**
Statistical displays of PDF, CDF and CCDF including time-gated analysis (optional)

**Clear Views**
Persistence, envelope and roll mode displays aid visual analysis

**Efficient Design**
Power factor corrected power supply and thermostatically controlled, dual-fan cooling system

**Remote Control**
SCPI compliant command set and legacy support

**Convenient I/O**
VGA and HDMI, external monitor, LAN and USB (optional GPIB)

**Optional Inputs**
Replace front panel inputs, optional trigger output

## Real-Time Power Processing™

Boonton Real-Time Power Processing™ dramatically reduces the total cycle time for acquiring and processing power measurement samples. By combining a dedicated acquisition engine, hardware trigger, integrated sample buffer, and a real-time optimized parallel processing architecture, Real-Time Power Processing™ performs most of the sweep processing steps simultaneously, beginning immediately after the trigger instead of waiting for the end of the acquisition cycle.

The advantages of the Real-Time Power Processing technique are shown in Figure 1a. Key processing steps take place in parallel and keep pace with the signal acquisition. With no added computational overhead to prolong the sweep cycle, the sample buffer cannot overflow. As a result, there is no need to halt acquisition for trace processing. This means gap-free signal acquisition virtually guarantees that intermittent signal phenomena such as transients, dropouts, or interference will be reliably captured and analyzed. These sorts of events are most often missed by conventional power meters due to the acquisition gaps while processing takes place, shown in Figure 1b.
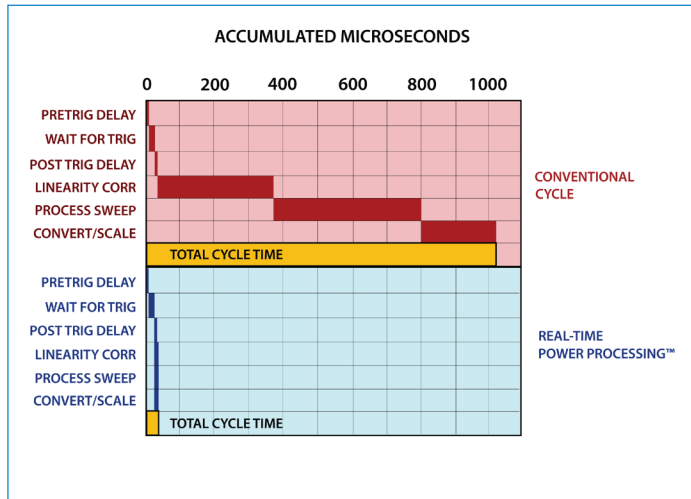


Figure 1a. Comparison between conventional power measurement sample processing and Real-Time Power Processing™.
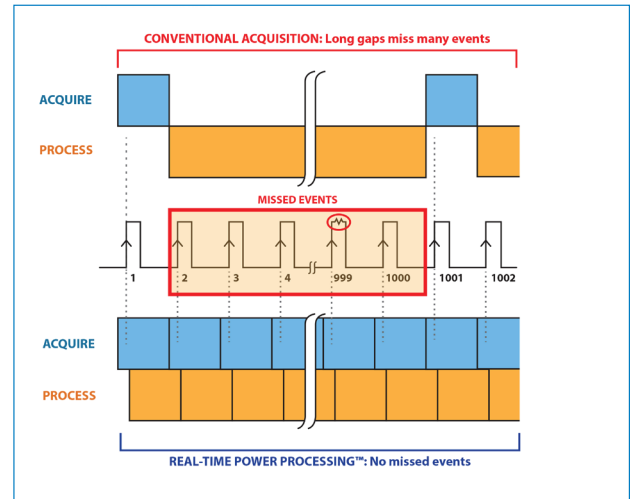


Figure 1b. Conventional power measurement misses key information and events while processing samples.

## Unique Trigger System

The 4500C features a unique trigger system that allows users to qualify the trigger on a specific event or a specific delay time. This allows a user-selected pulse to be captured, even when its timing is variable. The B trigger qualifier with resolution <100 ps eliminates problematic synchronization issues associated with time jitter within pulse bursts – often found in UWB and radar applications. This qualifier may be setup to 999,999 events or up to 1 second.
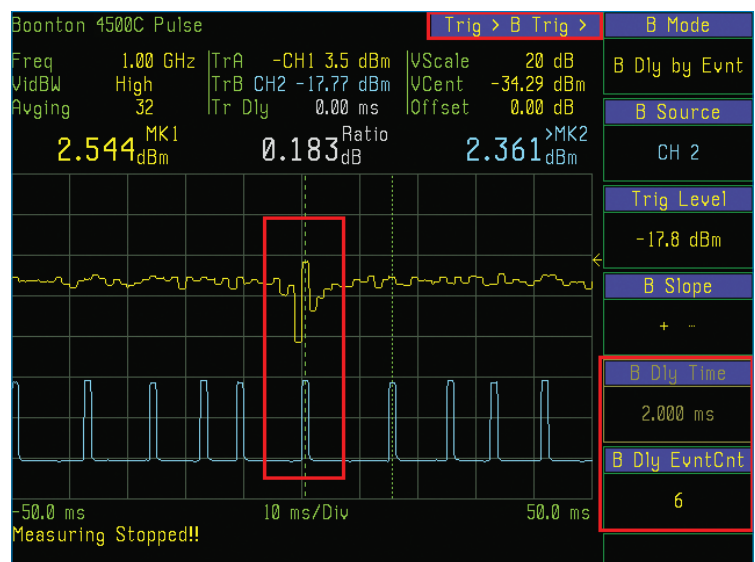


Figure 2. Qualify the trigger on a specific event in a pulse train.

## Superior Time Management

The 4500C features 100 ps time base resolution and with an acquisition rate up to 100 MS/s, can provide 50 points per division with a time base range as low as 5 ns / division. This enables users to see meaningful waveform information (Figure 3a) missed by alternative power analyzers (Figure 3b).

In addition, Boonton's superior time management enables several other advantages. Pulse widths as narrow as 6 ns can be captured and characterized. The 4500C can also allow users to analyze long waveforms, whether a long pulse train or shorter waveforms over more repetitions. With a viewing range up to 10 hours, users can monitor for temporal behavior such as amplifier droop as it heats up.
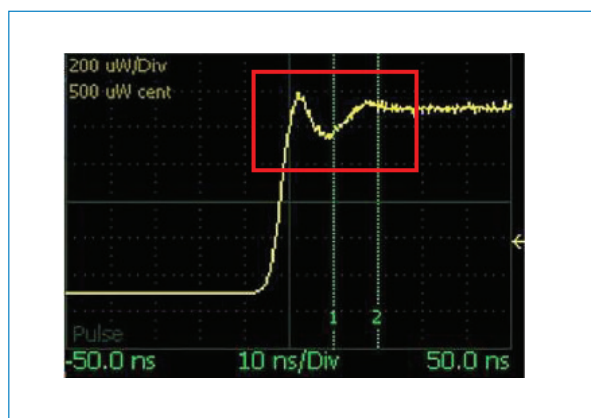


Figure 3a. Waveform analysis with time 10 ns/div time base and 50 samples per division.
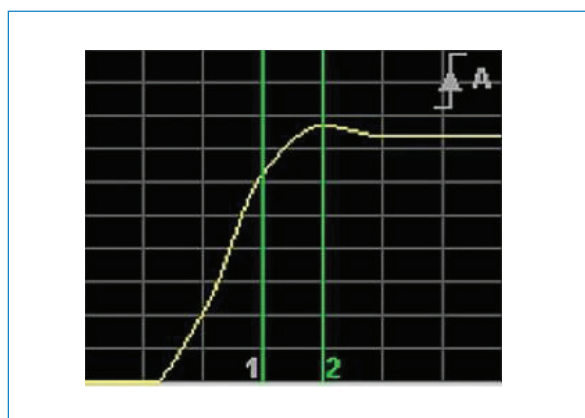


Figure 3b. Waveform analysis with time 10 ns/div time base and 1 sample per division.

## Powerful Statistical Analysis

The 4500C features optional probability density functions (PDF) and cumulative distribution functions (CDF, CCDF) to accurately characterize noise-like RF, such as OFDM and WLAN signals. These statistical functions build and analyze a very large population of power samples continuously or triggered at a 100 MS/s acquisition rate on all channels simultaneously. These functions are fast, accurate and allow the measurement of very infrequent power peaks for a user-defined population size or acquisition interval. Although the programmable acquisition time can be very long or continuous, even short runs can resolve very low probabilities, due to the extremely high sample throughput.
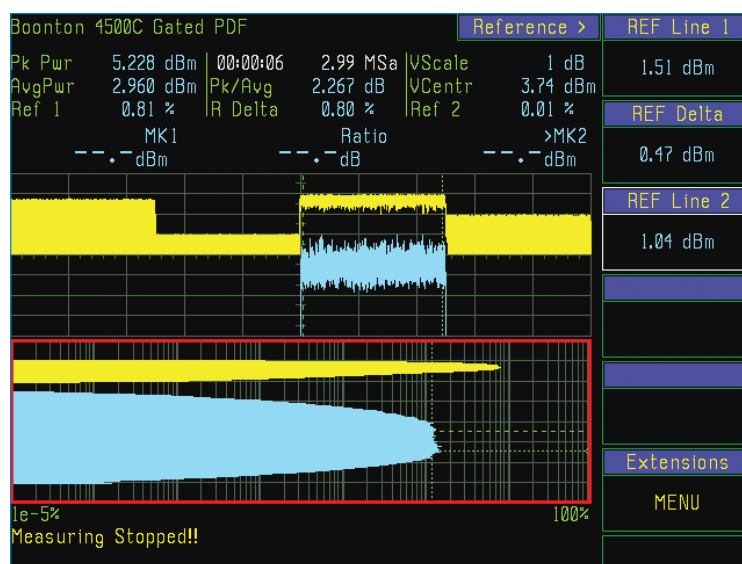


Figure 4. Analyze timeslots with time gated probability density function (PDF).

# Specifications

## Sensor Inputs

| | |
|---|---|
| RF Frequency Range | 30 MHz to 40 GHz |
| Pulse Measurement Range | -50 to +20 dBm |
| Modulated Measurement Range | -60 to +20 dBm |
| Relative Offset Range | ±100.00 dB |
| Logarithmic Vertical Scale | |
|     0.1 to 50 dBm/div | in 1-2-5 sequence |
|     0.1 to 50 dBV/div | in 1-2-5 sequence |
|     0.1 to 50 dBmV/div | in 1-2-5 sequence |
|     0.1 to 50 dBuV/div | in 1-2-5 sequence |
| Linear Vertical Scale | |
|     1 nW/div to 50 MW/div | in 1-2-5 sequence |
|     1 mV/div to 50 kV/div | in 1-2-5 sequence |
| Video Bandwidth | 125 MHz |
| Rise-Time | <5 ns |
| Single-Shot Bandwidth | 35 MHz |
| Pulse Repetition Rate | 50 MHz max |
| Minimum Pulse Width | 6 ns |

## Time Base

| | |
|---|---|
| Time Base Range | 5 ns/div to 1 hr/div |
| Time Base Accuracy | +/- 1.4 ppm peak |
| Time Base Resolution | 100 ps |
| Time Base Display | Sweeping or roll mode |

## Statistical X-Axis (optional)

| | |
|---|---|
| Scale | Linear or logarithmic, 1 to 7 cycles |
| Linear Ranges | 0.1%/div to 10%/div |
| Linear Offset | 0 to 99.9%, 0.1% resolution |
| Log Range | 1e-9% to 100% |

## Calibration Source

| | |
|---|---|
| Operating Modes | CW, internal or external pulse |
| Frequency | 1.024 GHz ± 0.01% |
| Level Range | -50 to +20 dBm |
| Resolution | 0.1 dB |
| Output VSWR | 1.10 maximum |
| Absolute Accuracy | ±0.04 dB (±0.9%) at 0 dBm |
| Accuracy vs Level | add ±0.02 dB per 5 dB increment from 0 dBm |
| Preset Internal Pulse Period | 0.1 or 1 or 10 ms |
| Preset Internal Pulse Duty Cycle | 10% to 90% in 10% increments |
| Variable Pulse On Time | 7 µsec to 65.535 ms in 1 µsec steps |
| Variable Pulse Period | 28 µsec to 131.070 ms in 2 µsec steps Off-time limits - within 7 µsec to 65.535 ms |
| Pulse Polarity | + or – |

| | |
|---|---|
| RF Connector | Precision Type N |
| External Pulse Input | Rear panel BNC, TTL level compatible |

Auto-Calibration

  The calibrator is used to automatically generate linearity calibration data for peak power sensors.

## Measurement System

| | |
|---|---|
| Sensor Inputs | Two peak power sensor measurement channels and two trigger/oscilloscope channels. |

Measurement Technique

  Random interleaved and real-time sampling system that provides pre- and post- trigger data, as well as statistical histogram accumulation.

Maximum Sampling Rate

  100 MS/s on up to four channels simultaneously.

  (Equivalent effective sampling rate of 10 GS/s with Random Interleaved Sampling)

| | |
|---|---|
| Waveform Averaging | 1 to 16,384 samples per data point (time domain measurement) |
| Number of Histogram Bins | 16,384 |
| Size of Sample Bins | 32-bits (4,096 mega-samples) |
| Bin Power Resolution | <0.02 dB |

## Statistical Acquisition (optional)

| | |
|---|---|
| Modes | Continuous or gated by pulse mode time markers |
| Sampling Rate | 100 MS/s on all channels simultaneously |
| Limit Count | Adjustable, 2 to 4096 Mega-samples |
| Limit Time | 3600 seconds (approx. 41 s at full sample rate) |
| Terminal Action | Stop, flush and restart or decimate |

## System Displays

Display Type

  Power versus time (pulse mode), Power versus time (modulated mode), External trigger versus time (pulse mode), Auto-measure text (all modes), Help text (all modes), Reports (sensors, configuration, calibrator, files, stored waveforms, GPIB commands, GPIB buffers)

Statistical Display Type (optional)

  Cumulative Distribution Function (CDF), Complementary Cumulative Distribution Function (CCDF), Split screen, gated CCDF and power versus time (pulse mode,CCDF), Distribution function (histogram), External trigger statistical (statistical mode), Auto-measure text (statistical mode)

## Trigger

| | |
|---|---|
| Trigger Source | |
| Channel 1 (internal), Channel 2 (internal) | |
| External trigger 1, External trigger 2 | |
| Trigger Slope | + or − |
| Trigger Delay Range | pre-trig(-), post-trig(+) |
| Time base setting | Delay range |
| 5 ns to 500 ns/div | -4 ms to +100 ms |
| 1 µs to 10 ms/div | ±4000 divisions |
| 20 ms to 3600 s/div | -40 to +100 s |
| Trigger Delay Resolution | 0.02 divisions |
| Trigger Hold-off Range | 0.0 to 1.0 s |
| Trigger Hold-off Resolution | 10 ns |
| Trigger Mode | Normal, auto, auto peak-to-peak, free run |
| B Trigger Mode | A only, B delay-by-time, B delay-by-events specs |
| B Trigger Source | Chan 1, Chan 2, Ext trig 1, Ext trig 2 |
| B Trigger Slope | + or − |
| B Trigger Events Counter Range | 1 to 999,999 events |
| B Trigger Time Delay Range | 0.0 to 1.0 s |
| B Trigger Time Delay Resolution | 10 ns |
| Internal Trigger Level Range | -40 to +20 dBm (sensor-dependent) |
| External Trigger Level Range | ±5 volts, ±50 volts |
| External Trigger Input | 1M or 50 ohm, DC Coupled |

## Pulse and Modulated Mode Marker Measurements

| | |
|---|---|
| Markers (Vertical Cursors) | Settable in time relative to the trigger position |
| Marker Independently | Power at specified time |

Pair of Markers:

Power at two specified times with ratio or average power between them. The minimum and maximum power between the markers and the ratio or average power between them. The average power, peak power (hold) and peak-to average power ratio between the markers.

| | |
|---|---|
| Ref Lines (Horizontal Cursors) | Settable in power |

Automatic Tracking

Intersection of either marker and the waveform. Either marker and pulse distal, mesial or proximal levels.

## Statistical Mode Marker Measurements (optional)

| | |
|---|---|
| Markers (Vertical Cursors) | Settable in percent (distribution functions) |
| Each Marker Independently | Power at specified percent |

Pair of Markers

Power ratio at two specified percents. Statistical analysis between markers (using triggered statistical mode)

| | |
|---|---|
| Ref Lines (Horizontal Cursors) | Settable in power |

Automatic Tracking

Set to track the intersection of either marker and the distribution function measure percent probability at a defined power level.

## Pulse Mode Automatic Measurements

| | |
|---|---|
| Pulse width | Pulse rise-time |
| Pulse fall-time | Pulse period |
| Pulse repetition frequency | Pulse duty cycle |
| Pulse off-time | Peak power |
| Pulse power | Percent overshoot |
| Average power | Top level power |
| Bottom level power | Edge delay |
| Pulse edge skew between channels | |

## Statistical Mode Automatic Measurements (optional)

| | |
|---|---|
| Peak power | Average power |
| Minimum power | Peak to average ratio |
| Dynamic range | Percent at reference lines |
| Power at markers | |
| (absolute or normalized) | |
| Total time (indicated) | |
| Total number of samples (indicated) | |

## Waveform Storage

Storage Locations

Waveforms & distribution functions can be saved to and recalled from internal storage locations and removable file-based memory devices.

## External Interfaces

| | |
|---|---|
| GPIB (optional) | Programmable interface; complies with SCPI ver. 1990 |
| USB | General purpose I/O interface |
| LAN | Ethernet port |

## Other Characteristics

| | |
|---|---|
| Display | 8.4'' Diagonal TFT color LCD, 800 x 600 pixels, with LED backlight. |
| Storage | Internal SSD ≥60GB Optional removeable drive |
| Acquisition Engine | |
| Real-Time Power Processing™ | |
| Environmental | |
| Operating Temperature | 0 °C to 50 °C |
| Storage Temperature | -20 °C to 70 °C |
| Operating Humidity | 15 to 95% RH, non-condensing |
| Storage Humidity | 0 to 90% RH, non-condensing |
| Operating Altitude | 10,000 ft max (3048 m) |
| Storage Altitude | 50,000 ft max (15,240 m) |
| Regulatory | |
| Construction Manufactured to the intent of MIL-PRF-28800F, Class 3 | |
| Classifications | Class A: Electrical equipment for control, measurement, and laboratory use Group 1: Industrial, scientific, or medical equipment that does not intentionally generate radio frequency energy |

Regulatory (continued)

| | | |
|---|---|---|
| CE Mark | | |
| Low Voltage Directive 2014/35/EU | EN and EIC 61010-1:2010 | |
| EMC Directive 2014/30/EU | EN: 61326-1:2013 | |
| RoHS Directive 2011/65/EU | | |
| Power Requirements | 90 to 260 VAC, 47 to 63 Hz, 90W | |
| Dimensions (HxWxD) | 19'' rack-mountable; | |
| | 7.0'' x 17.5'' x 13.5'' | |
| | (17.8 cm x 44.5 cm x 34.3 cm) | |
| Weight | 18 lbs (8.2 kg) | |
| Warranty | 3 years | |

## Ordering Information

**4500C**     **RF PEAK POWER ANALYZER**

Dual Channel, Front Panel Input

**Options**

| | |
|---|---|
| 4500C-003 | Dual Channel, Rear Panel Inputs |
| 4500C-006 | Dual Trigger Outputs (rear panel only) |
| 4500C-007 | Calibrator, Rear Panel Output |
| 4500C-010 | Statistical Package (includes gated CCDF and PDF) |
| 4500C-015 | Removable SSD (replacing internal SSD) |
| 4500C-016 | GPIB Control (internally installed) |

**Optional Accessories**

| | |
|---|---|
| 4500C-RSSD | Additional removable SSD with Software (requires option 4500C-015) |
| 4500C-ISSD | Spare internal SSD with Software |
| 4500C-TCASE | Transport case for 4500C |
| 4500C-RMEO | Rack Mount Kit (4400 and 4500 Series) Ears Only |
| 4500C-RMEH | Rack Mount Kit (4400 and 4500 Series) Ears and Handles |

**Available Sensors (For a complete list, visit www.boonton.com)**

| | |
|---|---|
| 57006 | Peak Power Sensor: 50 MHz to 6 GHz, < 7 ns risetime |
| 57518 | Peak Power Sensor: 50 MHz to 18 GHz, < 100 ns risetime |
| 57540 | Peak Power Sensor: 50 MHz to 40 GHz, < 100 ns risetime |
| 59318 | Peak Power Sensor: 50 MHz to 18 GHz, < 10 ns risetime |
| 59340 | Peak Power Sensor: 50 MHz to 40 GHz, < 10 ns risetime |