BOONTON

Peak Power Meters

4400A RF Peak Power Meter

The Boonton Model 4400A is the instrument of choice for viewing and analyzing RF power in the time domain. Whether you are analyzing radar, pulse bursts, GSM or TDMA wireless signals, broadcast TV and radio transmitters, or any RF signal in which the power-versus-time relationship must be accurately measured and recorded, the Model 4400A is the instrument for you.

- **>60-dB dynamic range**
- **Frequency range: 30 MHz to 40 GHz**
- **1-GHz NIST Traceable Calibrator**
- **Color VGA display**
- **1-Msa/sec. Sampling rate**
- **14 automatic measurements**
- **Parallel printer port**
- **PC-compatible 1.44-MB floppy**

Fast display updates and GPIB measurements save you time and gather data faster than ever before. The PC-compatible 1.44-MB floppy drive can store data such as front panel setups and trace waveforms, and you can print or plot the display to disk for later printing or to import into your documents.

Flexible triggering, greater than 60-dB dynamic range (sensor dependent) without any range switching, channel math on active and reference (saved) traces, and Boonton's wide selection of Peak Power Sensors round out the Model 4400A's industry-leading capabilities.

4500A RF Peak Power Meter/Analyzer

For analyzing RF signals with digital modulation, multiple carriers or today's complex coding techniques, the Boonton Model 4500A yields the answers that designers and manufacturers of state-of-the-art wireless communications systems demand. Hard-to-measure HDTV and spread-spectrum signals like CDMA and WCDMA are now easy to view and analyze, thanks to the innovative capabilities of the Model 4500A.

Along with all the time-domain measurements of Boonton's Model 4400A, the Model 4500A adds a host of statistical measurements that are made on a continuously sampled RF signal. Adding the second input channel to these capabilities allows you to monitor two sources, such as input and output power, simultaneously. Powerful math functions can be used to analyze the differences between channels, making difficult measurements like output stage compression and intermodulation distortion easy to identify and to correct.

- **>60-dB dynamic range**
- **Frequency range: 30 MHz to 40 GHz**
- **Dual-channel CDF/PDF**
- **1-GHz NIST Traceable Calibrator**
- **Synchronous/asynchronous measurements**
- **Color VGA display**
- **PC-compatible 1.44-MB floppy**

THE MODEL 4400A IS THE LEADER IN PULSE MEASUREMENTS

The Model 4400A provides power-versus-time waveform analysis of repetitive RF signals. Applications include AM, radar, TDMA, and GSM, as well as RF amplifier linearity testing. The time base extends to 10 nanoseconds per division with internal and external triggering. The logarithmic power display permits the entire dynamic range of more than 60 dB to be seen at the same time.

Convenient scale and centering controls allow vertical expansion of any portion of the display. A linear display scale is also provided covering power levels from nanowatts to megawatts. Two adjustable markers can read the power at any point across the waveform. In addition, the markers can be used to define a region on the waveform in which maximum power (peak hold), minimum power, long-term average power, and peak-to-average ration are measured.

This function is especially useful for characterizing the power level over a portion of the top of a pulse, such as top-level power. Two adjustable reference lines can be used with the markers to identify and measure particular power levels.

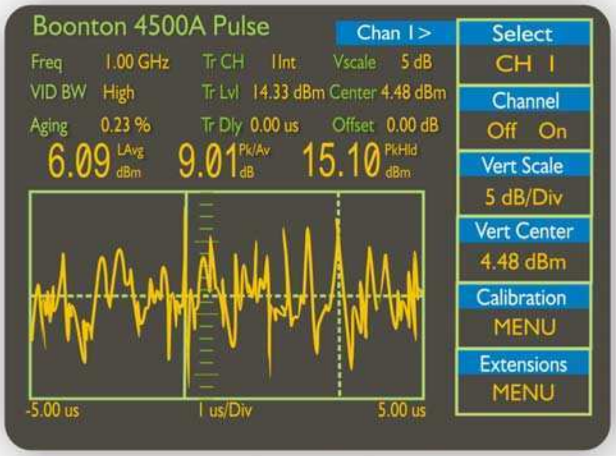
The reference lines also have the ability to automatically track the following:

- Markers
- Top/Bottom Power
- Distal/Mesial Power
- Distal/Proximal Power

An Automeasure function measures and calculates 14 common parameters of a pulse waveform and makes them available at all times in a both a summary text table and individually as a user-defined display parameter. The 14 Automeasure functions are:

• Peak Power	• Pulse Power
• Average Power	• Overshoot
• Risetime	• Falltime
• Top Amplitude	• Bottom Amplitude
• Pulse Width	• Pulse Period
• Duty Cycle	• Offtime
• Delay	• Pulse

An Autosetup function is provided to assist the user in obtaining a useful time-domain display of the input signal by just pressing a key. Appropriate vertical scaling, time base, and trigger settings are determined



Time-domain waveform of 8 carriers spaced 700 kHz apart from 1.8 GHz to 1.8049 GHz and phase aligned for highest peak power.

automatically. The Model 4400A is made even more powerful by the addition of a second measurement channel. Comparisons between signals are facilitated by a Math channel that displays the sum or difference of the inputs. The full-color display provides unambiguous data, with each trace clearly identified. Two Reference channels are used to save waveforms for comparison purposes. The Reference channels can be displayed with their own unique colors, just as the input channels, and compared using the Math channel. For archival purposes, the Reference waveforms can be saved on a floppy disk using the built-in 3.5-inch, 1.44-Mbyte floppy drive.

The problem of diode non-linearity for levels above –30 dBm, which occurs in all conventional power meters, is eliminated in the Model 4400A. Each individual sample is converted to power before averaging. Since the sampling rate is one megasample per second, the system completes the analog-to-digital conversion, interpolates the level in a calibration table, and stores the result in less than one microsecond.

To create the calibration tables, a 1-GHz step calibrator, traceable to NIST, is built-in to the Model 4400A. This precision source provides calibrated power levels from +20 dBm (100 milliwatts) to –40 dBm (100 nanowatts) in steps as small as 0.1 dB. An Autocalibration function makes the process completely automatic. At all other times, the calibrator is available as a test source with both CW and pulsed output.

MODEL 4500A ADDS STATISTICAL MEASUREMENTS CAPABILITY

Many modern communications systems use modulation methods that result in pseudorandom or noise-like signals. Examples of this are CDMA, WCDMA, multi-carrier, HDTV, and DAB. The traditional methods of RF power measurement are not adequate for these systems. A CW power meter can measure the average power of these signals provided care is taken not to overload the sensor or operate above the linear power region for diode sensors. Since the peak power can be 16 dB higher than the average power and these peaks are often compressed by amplifiers and other components of the communication system, some method is needed to measure the peak power as well as the average power. The Pulse Measurement mode described above can measure peak power over relatively short time intervals as required for time-based systems. However, CDMA, in particular, requires the measurement of infrequent power peaks over long time periods. It is also necessary to know how often various power levels occur as a percentage of the total run time.

This is achieved by calculating a cumulative distribution function (CDF) from a large number of power measurements. The Model 4500A can accumulate 500,000 power readings per second from one channel and internally create a histogram containing 4,096 discrete power levels of better than 0.02-dB resolution. Each power level bin is a 31-bit counter that records the number of occurrences of the corresponding power level. This process can be performed for two channels simultaneously at a rate of 250,000 power readings per second.

The histogram data is displayed as a cumulative distribution function (CDF) or a complementary cumulative distribution function (CCDF) for each channel. CCDF is also referred to as 1-CDF. A statistical measurement begins by clearing the histogram array to zero and resetting the elapsed time and sample counters. The measurement can be allowed to continue until one of the count bins fills to the maximum allowable number of counts: 2,100,000,000. At the maximum sampling rate, the running time exceeds one hour. The advantage of this method is that even a single occurrence of the highest power level during the running time will be recorded and appear on the distribution function display.

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SOPHISTICATED SIGNAL PROCESSING FOR FAST, AUTOMATIC MEASUREMENTS

Both the Models 4400A and 4500A have a dedicated floating point digital signal processor that performs shaping, filtering, calibration, offset compensation, and conversion of the test signal. Random repetitive sampling and selectable averaging provide accurate, stable measurements of all user-programmed waveform parameters. Digital signal processing permits pre-trigger information. Logarithmic detection provides the best dynamic range of 60 dB (-40 to +20 dBm) for peak power measurments.

Measurements are fast…two marker values and their delta are available 80 times per second over the bus, and all 14 automatic measurements are available 20 times per second.

SETUP & WAVEFORM STORAGE

Up to 10 complete panel setups can be stored and recalled from internal memory for applications in which the same instrument setups are used repetitively. For permanent hard-copy documentation, complete display data can be transmitted to a plotter or printer via an RS-232 serial, IEEE-488 port, or LPT port, supporting LaserJet, ThinkJet, and HPGL formats.

COLOR DISPLAY

The display is a VGA-compatible seven-inch diagonal color CRT with a resolution of 640 x 480 pixels. Waveforms are displayed at 501 x 281 resolution.

PEAK POWER SENSORS TO MATCH YOUR APPLICATION

Boonton Electronics offers a wide selection of sensors that are optimized for different characteristics such as frequency, risetime, and dynamic range.

All sensors feature a balanced diode configuration for high sensitivity and eve-order harmonic suppression. Low VSWR minimizes mismatch errors. Calibration factors traceable to NIST standards are stored in EEPROM, and an internal temperature sensor tracks temperature change. Calibration factor information and other sensor data are automatically downloaded to the instrument when the sensor is connected.

PRECISION 1-GHz CALIBRATION FOR PERFORMANCE VERIFICATION

A spectrally pure, 1-GHz NIST traceable calibrator guarantees measurement reliability. The user-selectable automatic routine calibrates the sensor and instrument over the full dynamic range of the instrument. An output of –40 to +20 dBm (CW or pulsed) makes this a versatile source.

DISK DRIVE

The display is a VGA-compatible seven-inch diagonal color CRT with a resolution of 640 x 480 pixels. Waveforms are displayed at 501 x 281 resolution.

MODEL 4400A & 4500A PERFORMANCE SPECIFICATIONS

Sensor Inputs

Frequency Range	30 MHz to 40 GHz, selectable[1]
Pulse Measurement Rage	-40 to +20 dB[1]
CW Measurement Range	-50 to +20 dB[1]
Risetime (10 – 90%)	See sensor specifications
Single-Shot Bandwidth	100 kHz (based on 10 samples per pulse)
Pulse Repetition Rate	25 MHz
Minimum Pulse Width	30 ns

Vertical Scale

Relative Offset Range	
Log	+99.99 dB
Linear	0 to 99 divisions
Vertical Scale	
Log	0.1-20 dB/div in 1-2-5 sequence[2]
Linear	1 nW -50 MW in 1-2-5 sequence[2]

Time Base Pulse Mode

Time Base Range	10 ns to 1 s/div
Time Base Accuracy	0.01%
Time Base Resolution	200 ps
Statistical Mode (Model 4500A only)	
X-Axis	0.1, 0.2, 0.5, 1, 2, 5, 10% per division
Percent Offset Range	0 – 99% (x-axis dependent)
Percent Resolution	0.002%

Trigger Pulse Mode Only

Trigger Source	Channel 1 internal or external; or Channel 2 internal or external[5]
Trigger Slope	+ or –

Pre-Trigger Delay:

Time Base Setting	Delay Range
10 ns to 50 µs	-500 µs
100 µs to 1 sec	-10 div

Post-Trigger Delay:

Time Base Setting	Delay Range
10 ns to 1 µs	10,000 div
2 µs to 50 µs	2 ms
100 µs to 1 sec	200 div

Trigger Delay Resolution	0.02 divisions
Trigger Holdoff Range	65 ms
Trigger Holdoff Resolution	62.5 ns
Trigger View	
Vertical Scale	0.1V to 1V in 1-2-5 sequence
Relative Offset	+3 volts
Internal Trigger Range	-27 to +20 dBm[1]
External Trigger Range	+3 volts
External Trigger Input	50 ohms, dc coupled

Statistical Processing (Model 4500A only) CDF, 1-CDF, PDF Modes

Sampling Rate	500,000 samples per second
Number of Sampling Bins	4,096
Size of Sample Bins	32 bits
Bin Power Resolution	<0.02 dB[1]
Percent Resolution	CDF, 1-CDF in log or linear scales and plots normalized to average power PDF log or linear scales and plots normalized to average power
Automatic Measurements	Peak max. power, average power, peak to average ratio, minimum power, total samples, sampling time, confidence band of measurements, dynamic range, and tolerance

Calibration Source

Operating Modes	CW, internal or external pulse
Frequency	1.024 GHz + 0.1%
Level Range	-40.0 to +20.0 dBm
Resolution	0.1 dB
Output SWR (Refl. Coeff.)	1.20, (0.091)[3]
Accuracy (NIST traceable)[4] (-30 to +20 dBm)	
Absolute	+0.065 (1.5%) at 0 dB and 25°C, +0.001 dB per °C
Linearity	+0.03 dB per 5 dB
Internal Pulse Period	100 µs, 1 ms or 10 ms
Internal Pulse Duty Cycle	10% to 90% in 10% increments
Internal/External Pulse Polarity	+ or –
Connector	Type N

Power Measurement Accuracy

Measurement Uncertainty	Total measurement uncertainty (worst case) is the sum of the calibrator uncertainty, source mismatch error, sensor calibration factor uncertainty, sensor temperature coefficient, sensor shaping, noise and drift.
Mismatch Uncertainty	+2 x sensor reflection coefficient x source reflection coefficient x 100%

CUMULATIVE DISTRIBUTION FUNCTION (CDF)

The Model 4500A CDF is a plot of power on the vertical axis versus probability on the horizontal axis. The logarithmic power capability allows the entire dynamic range to be viewed at one time or a small region to be expanded up to 0.1 dB/division for detailed analysis. Likewise, the probability scale can be expanded up to 0.1%/division. Both scales can be offset over their full range to bring any portion of the magnified CDF into view. For every possible power level (p) within the total dynamic range, the CDF shows the probability in percent that the measured power is less than or equal to p. The maximum power level during the entire run will appear at 100% probability.

The adjustable markers allow the power to be read at any probability value along the curve, interpolating to a resolution of 0.01%. Adjustable reference lines allow the probability to be read for any power level to a resolution of 0.01 dBm. Summary results are continually updated and appear at the top of the display, as follows:

- Peak Power
- Average Power
- Peak-to-Average Ratio
- Total Elapsed Time
- Total Number of Samples
- Tolerance
- Reference Line Value

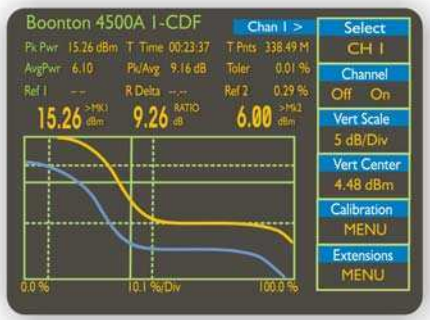
Alternatively, a TEXT display may be selected to display the above in addition to the following:

- Minimum Power
- Dynamic Range
- Confidence
- Marker Position and Value
- Reference Line Position and Value

When the second channel is installed, the CDFs for the two channels can be compared using the Math channel. CDFs can also be saved into REF1 and REF2 and to the floppy disk. The confidence level of the CDF is determined by the number of samples taken. For many purposes, useful results are obtained in just a few seconds of run time. For events with a low probability of occurrence, the run time must be increased to ensure capture.

COMPLEMENTARY CUMULATIVE DISTRIBUTION FUNCTION

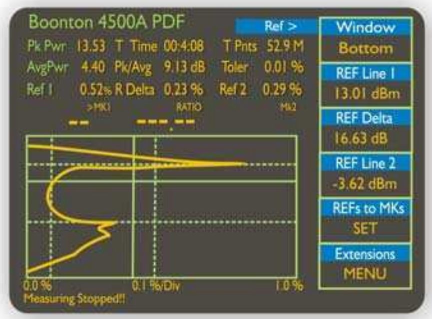
The same histogram data can be used to display the complement of the CDF or CCDF, which is also called the 1-CDF because of the manner in which it is calculated. For every possible power level (p) within the totally dynamic range, the CCDF shows the probability in percent that the measured power is greater than p. This definition flips the CDF curve from left to right placing the maximum power value on the zero percentage axis. This form is often more convenient to use, but contains the same information as the CDF.



CCDF of 8 carriers spaced 700 kHz apart from 1.8 GHz to 1.8049 GHz and phase aligned for highest peak power.

PROBABILITY DENSITY FUNCTION (PDF)

The cumulative distribution function can be further processed to obtain an approximate probability density function or PDF. The PDF shows the relative occurrence of the various power levels. The probability that the power lies between any two values on the power axis is equal to the integral of the PDF between the two values. When the difference between the two values is equal to zero, the integral of the PDF is also zero. This means that it is not possible to determine the probability of occurrence of a particular power level. Strictly speaking, a discrete array such as the histogram of power values described above does not have a density function. However, it is useful for qualitative analysis to create an approximate PDF from the first-order derivative of the CDF. The process of differentiation exaggerates any errors in the CDF values. For this reason, measurements should always be made from the CDF or CCDF. The PDF is useful for visualizing QAM and other signals that have a finite number of discrete levels. For random noise signals, A Gaussian amplitude distribution will appear as a Rayleigh distribution in the linear power domain.



PDF of 8 carriers spaced 700 kHz apart from 1.8 GHz to 1.88049 GHz and phase aligned for highest peak power.

The TEXT display of measurements for the PDF is the same as for the CDF and CCDF. Adjustable markers and reference lines are also provided; there are no marker measurements in the PDF mode.

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SUPPLEMENTAL INFORMATION

Measurement Characteristics

Measurement Techniques

Stat Mode (4500A only): Continuous sampling 0.5 M Samples per second

Power Mode: Random repetitive sampling system that provides pre- and post-trigger data

Maximum Sample Rate	1MHz
Memory Depth	4 K/Channel
Vertical Resolution	0.025%, 12-bit A/D converter
Waveform Averaging	1 to 10,000 samples per data point
Waveform Storage	Two reference waveforms in internal non-volatile memory
Trigger Channel Bandwidth:	> 30 MHz typical

Sensor Characteristics

Power Detection Technique:	Dual diode with selectable detector bandwidth
Log Amplifier:	The logarithmic amplifier in the sensor enables the instrument to measure and analyze changes in power exceeding 60 dB in a single display range.
Internal Data	Sensor calibration factors, frequency range, power range, sensor type, serial number and other sensor dependent information are stored in EEPROM within the peak power sensor.
Sensor Cable	The sensor cable is detachable from both the sensor and instrument. The standard cable length is 5 feet. Other cable lengths are 10 feet, 20 feet, 25 feet and 50 feet.

Rear Panel Connections

External Calibrator Pulse Input	Provides a means of applying an external TTL level signal to control the pulse rate and duty cycle of the calibrator output (50 ohm input impedance)
IEEE-488 Interface	Complies with IEEE-488-1978. Implements AH1, SH1, T6, LE0, SR1, RL1, PP0, DC1, C0, and E1
RS-232 Interface 1	Serial Printer/Plotter interface
RS-232 Interface 2	Diagnostic interface
Parallel Port	Parallel Pinter/Plotter interface
Optional Connectors[5]	Rear Panel Channel 1 and 2, Trigger 1 and 2, calibrator output

Physical and Environmental

General	Manufactured to the intent of MIL-T-28800E, Type III, Class 5, Style E
Disk Drive	3.5-inch, 1.44-MB (DOS compatible)
Display	VGA-compatible, seven-inch diagonal color CRT with 640 x 480-pixel resolution. Waveform display area resolution is 501 x 281.
Operating Temperature	0 to 50^{O}C
Storage Temperature	-40 to 75^{O}C
Humidity	95% $\pm$ 5% maximum (non-condensing)
Altitude	Operating: 10,000 feet (3,000 meters)
Power Requirements	90 to 260 VAC, 47 to 440 Hz, 200 VA maximum
Dimensions	17.25 inches (43.8 cm) wide, 7 inches (17.8 cm) high, 22 inches (55.9 cm) deep
Weight	38 pounds (17.2 kg) with second channel installed
Hard Copy Output	The screen can be output to a printer or plotter on the RS-232m parallel, IEEE-488 devices, or to a file on disk.
HPGL Plotters	HP7475, HP7470, ATT 435
Printers	ThinkJet, LaserJet II

Sensors

See Appendix D or the Boonton Electronics Sensor Data Manual for detailed specifications of Boonton Peak Power Sensors.

CE Mark

Boonton Electronics Corporation declares conformity of the Model 4400A RF Peak Power Meter and the Model 4500A RF Peak Power Meter/Analyzer to the following European Community Council (ECC) regulations:

Directives: 89/336/EEC/93/68/EEC and 73/23/EEC/93/68/EEC
Standards: EN55011, EN50082-1, EN61010-1

Notes

[1]Sensor dependent
[2]Sensitives are decreased by a factor of two in the split-screen mode.
[3]CW mode
[4]CW mode, 0 to 40^{O}C
[5]Available with optional second channel

ADDITIONAL PRODUCTS AND SERVICES AVAILABLE* FROM BOONTON ELECTRONICS CORPORATION

Model 4530 series RF Peak Power Meter 10 kHz to 40 GHz
Model 4230A series RF Power Meter 10 kHz to 40 GHz
Model 9230 series RF Voltmeter 200µ to 300 V, 10 Hz to 2.5 GHz
Model 5230 series Universal RF Power Meter/Voltmeter 200 µV to 300 V, 10 Hz to 100 GHz
Model 4300 RF Power Meter, multi-channel 10 kHz to 40 GHz
Model 92EA RF Millivoltmeter 200µV to 300 V, 10 Hz to 1.2 GHz
Model 7200 Capacitance Meter 0 to 2,000 pF, 1 MHz, Analog display
Model 72B Capacitance Meter 1 pF to 3,000 pF, 1 MHz, Analog display
Model 8201 Modulation Analyzer 100 kHz to 2.5 GHz
Model 8701 VXI Modulation Analyzer 100 kHz to 2.5 GHz
Model 1121 Audio Analyzer 10 Hz to 140 kHz

Service and Support You Can Count On

Boonton Electronics backs all of its products with a full range of test, repair, upgrade and calibration services assuring that all your instrumentation remains accurate, reliable and conforms to original factory specifications.

Services include:

- Certified Repairs (NIST Traceable)
- Repair Warranty (Six Months, Materials and Labor)
- Automatic Instrument/Software Upgrades*
- 10-day Turnaround
- Priority Service
- Flexible Service, Repair, and Calibration Contracts

Contact our Customer Service Department at (973) 386-9696 for details and pricing information.

** Available on most models.*