avg Average

Definition

Average or mean value of data in a histogram.

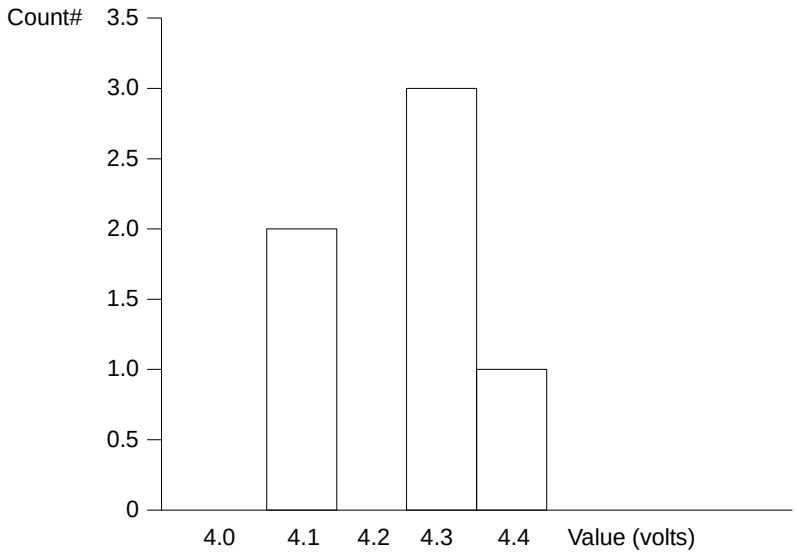
Description

The average is calculated by the formula:

$$\text{avg} = \sum_{i=1}^{n} (\text{bin count})_i \, (\text{bin value})_i \; / \; \sum_{i=1}^{n} (\text{bin count})_i \;,$$

where **n** is the number of bins in the histogram, **bin count** is the count or height of a bin, and **bin value** is the center value of the range of parameter values a bin can represent.

Example:



The average value of this histogram is:

(4.1 * 2 + 4.3 * 3 + 4.4 * 1) / 6 = 4.25.

fwhm Full Width at Half Maximum

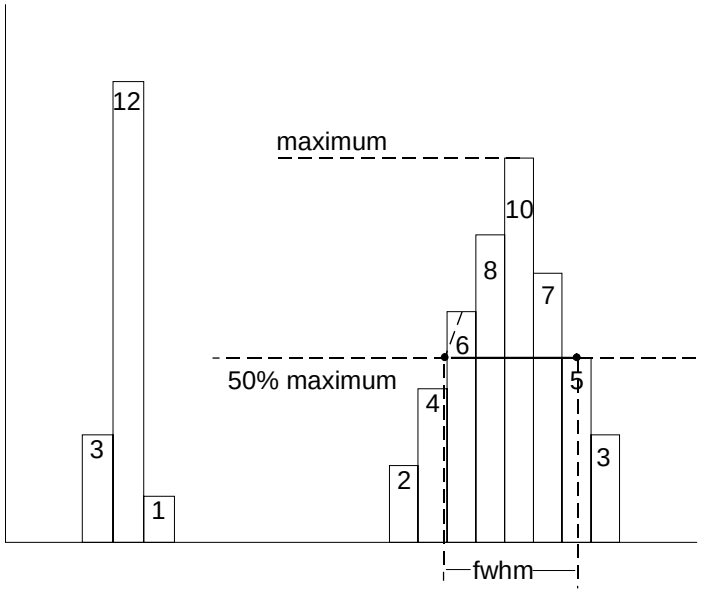
Definition

Determines the width of the largest area peak, measured between bins on either side of the highest bin in the peak that have a population of half the highest's population. If several peaks have an area equal to the maximum population, the leftmost peak is used in the computation.

Description

First, the highest population peak is identified and the height of its highest bin (population) determined. (For a discussion on how peaks are determined, see the **pks** parameter description.) Next, the populations of bins to the right and left are found, until a bin on each side is found to have a population of less than 50% of that of the highest bin's. A line is calculated on each side, from the center point of the first bin below the 50% population to that of the adjacent bin, towards the highest bin. The intersection points of these lines with the 50% height value is then determined. The length of a line connecting the intersection points is the value for **fwhm**.

Example:



fwxx Full Width at xx% Maximum

Definition

Determines the width of the largest area peak, measured between bins on either side of the highest bin in the peak that have a population of xx% of the highest's population. If several peaks have an area equal to the maximum population, the leftmost peak is used in the computation.

Description

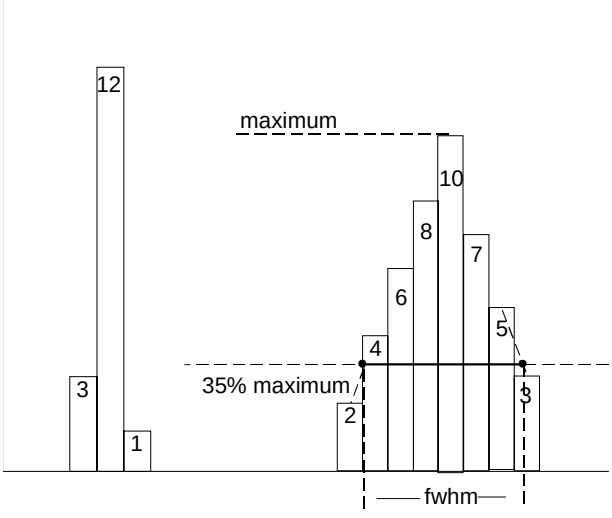
First, the highest population peak is identified and the height of its highest bin (population) determined. (See the **pks** description.) Next, the bin populations to the right and left are found until a bin on each side is found to have a population of less than xx% of that of the highest bin. A line is calculated on each side, from the center point of the first bin below the 50% population to that of the adjacent bin, towards the highest bin. The intersection points of these lines with the xx% height value is then determined. The length of a line connecting the intersection points is the value for **fwxx**.

Parameter Settings

Selection of the **fwxx** parameter in the **CHANGE PARAM** menu group causes the **MORE fwxx SETUP** menu to appear. Pressing the corresponding menu button displays a threshold setting menu that enables the user to set the **xx** value to between 0 and 100% of the peak.

Example

fwxx with threshold set to 35%:



hampl Histogram Amplitude

Definition

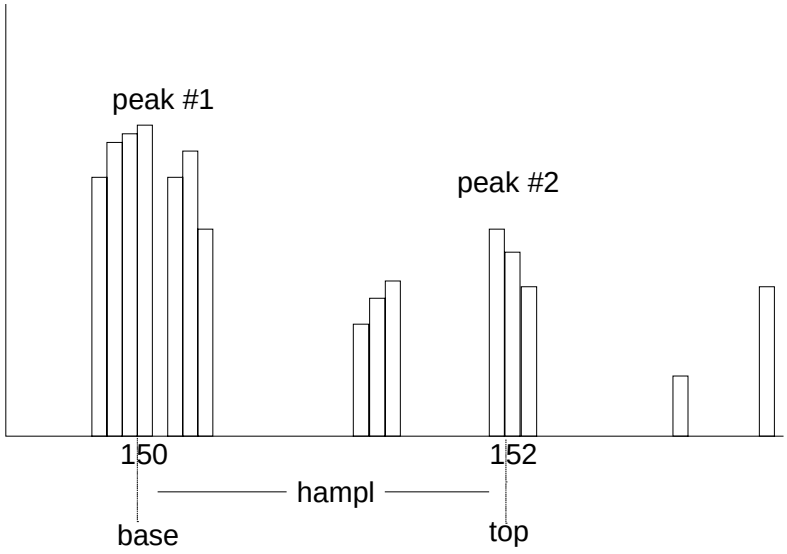
The difference in value of the two most populated peaks in a histogram. This parameter is useful for waveforms with two primary parameter values, such as TTL voltages, where **hampl** would indicate the difference between the binary “1” and “0” voltage values.

Description

The values at the center (line dividing the population of peak in half) of the two highest peaks are determined. (See **pks** parameter description.) The value of the leftmost of the two peaks is the histogram base (See **hbase**), while that of the rightmost is the histogram top (See **htop**). The parameter is then calculated as:

hampl = htop – hbase

Example:



In this histogram, **hampl** is 152 mV – 150 mV = 2 mV.

Hbase Histogram Base

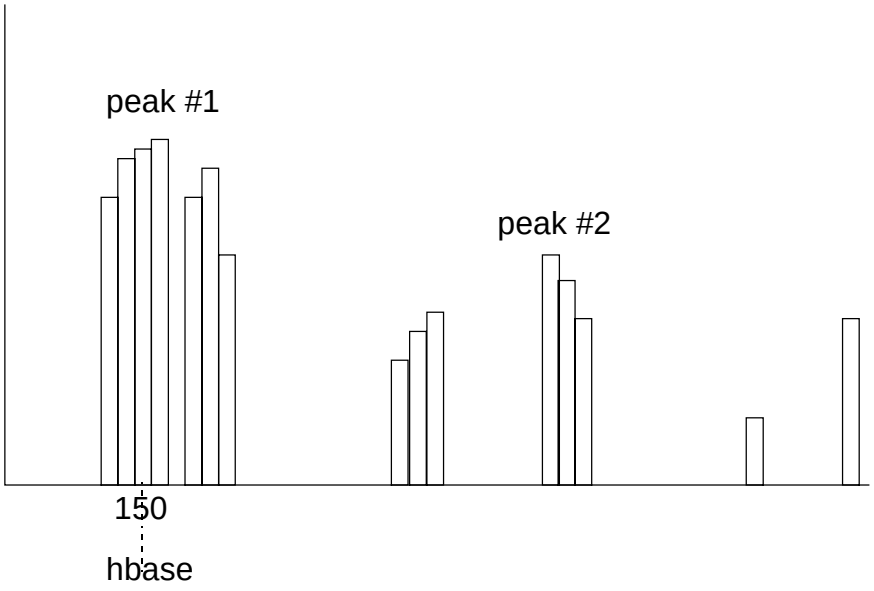
Definition

The value of the leftmost of the two most populated peaks in a histogram. This parameter is primarily useful for waveforms with two primary parameter values such as TTL voltages where **hbase** would indicate the binary “0” voltage value.

Description

The two highest histogram peaks are determined. If several peaks are of equal height, the leftmost peak among these is used (see **pks**). Then the leftmost of the two identified peaks is selected. This peak’s center value (line that divides population of peak in half) is the **hbase**.

Example:



high

High

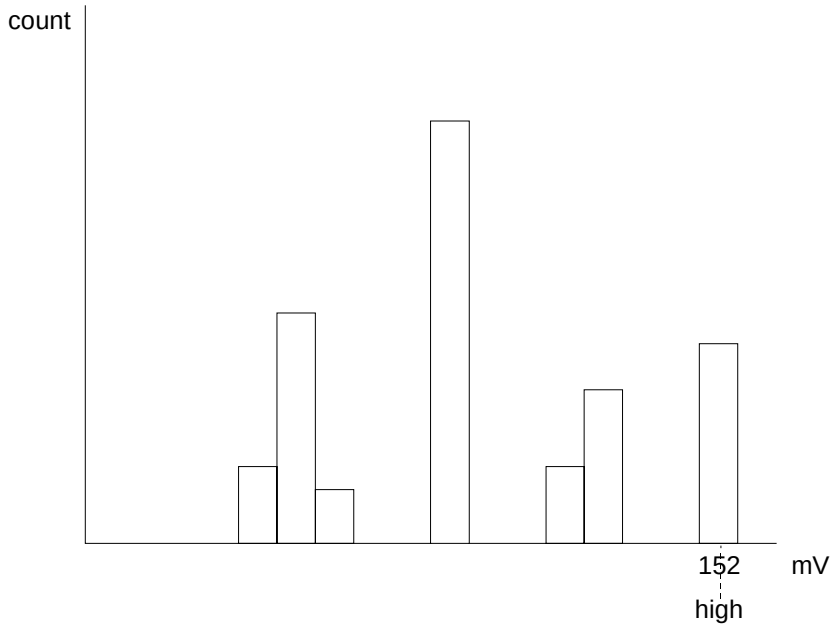
Definition

The value of the rightmost populated bin in a histogram.

Description

The rightmost of all populated histogram bins is determined: **high** is its center value, the highest parameter value shown in the histogram.

Example:



In this histogram **high** is 152 mV.

hmedian Histogram Median

Definition

The value of the **x** axis of a histogram, dividing the histogram population into two equal halves.

Description

The total population of the histogram is determined. Scanning from left to right, the population of each bin is summed until a bin that causes the sum to equal or exceed half the population value is encountered. The proportion of the population of the bin needed for a sum of half the total population is then determined. Using this proportion, the horizontal value of the bin at the same proportion of its range is found, and returned as **hmedian**.

Example:

The total population of a histogram is 100 and the histogram range is divided into 20 bins. The population sum, from left to right, is 48 at the eighth bin. The population of the ninth bin is 8 and its sub-range is from 6.1 to 6.5 V. The ratio of counts needed for half- to total-bin population is:

2 counts needed / 8 counts = .25

The value for **hmedian** is:

6.1 volts + .25 * (6.5 - 6.1) volts = 6.2 volts

hrms Histogram Root Mean Square

Definition

The **rms** value of the values in a histogram.

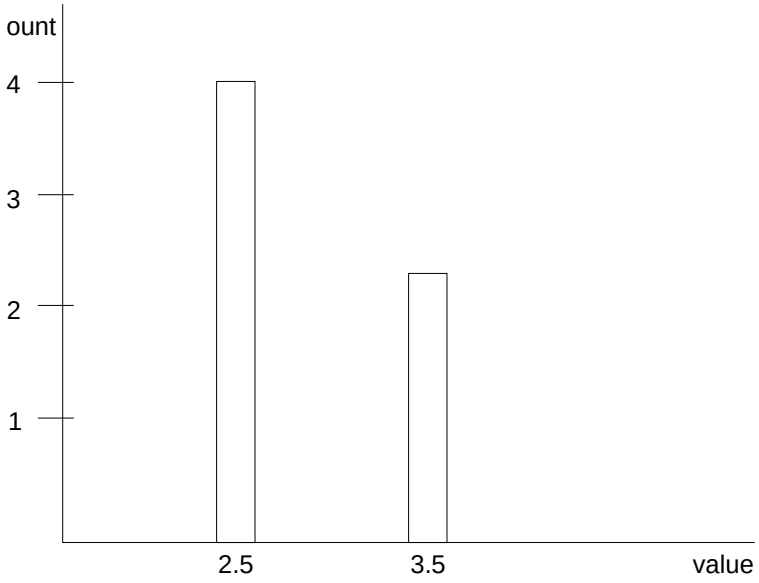
Description

The center value of each populated bin is squared and multiplied by the population (height) of the bin. All results are summed, and the total is divided by the population of all the bins. The square root of the result is returned as **hrms**.

Example:

Using the histogram shown here, the value for **hrms** is:

$$\text{hrms} = \sqrt{(3.5^2 * 2 + 2.5^2 * 4)/6} = 2.87$$



htop Histogram Top

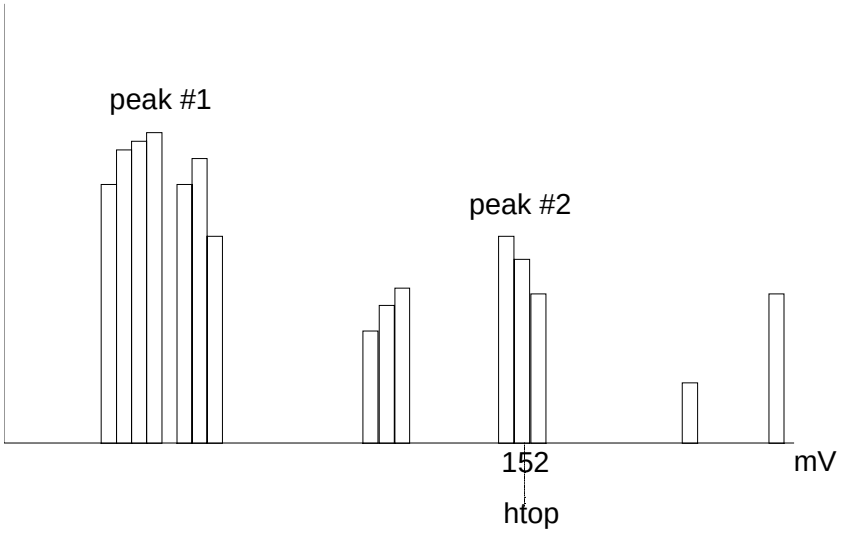
Definition

The value of the rightmost of the two most populated peaks in a histogram. This parameter is useful for waveforms with two primary parameter values, such as TTL voltages, where **htop** would indicate the binary "1" voltage value.

Description

The two highest histogram peaks are determined. The rightmost of the two identified peaks is then selected. The center of that peak is **htop.** (Center is the horizontal point where the population to the left is equal to the area to the right.)

Example:



low Low

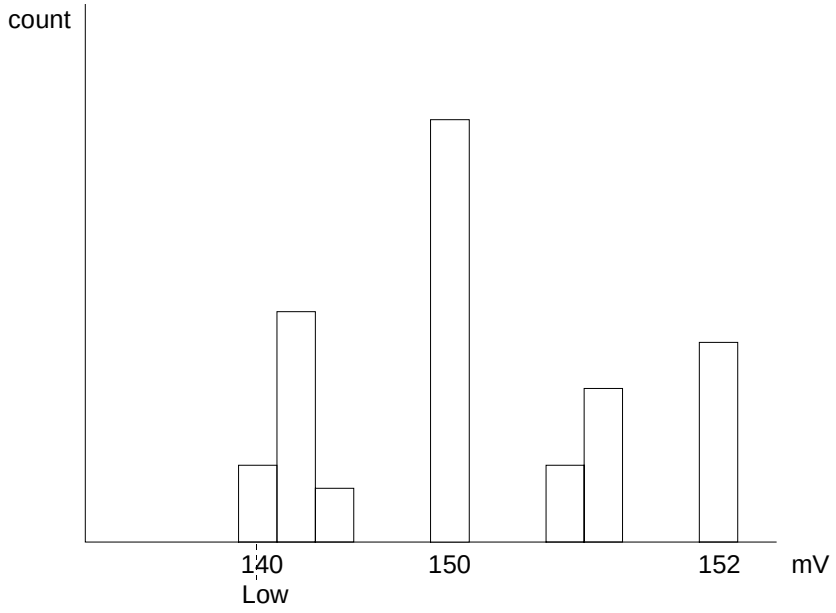
Definition

The value of the leftmost populated bin in a histogram population. It indicates the lowest parameter value in a histogram's population.

Description

The leftmost of all populated histogram bins is determined. The center value of that bin is **low**.

Example:



In this histogram **low** is 140 mV.

maxp Maximum Population

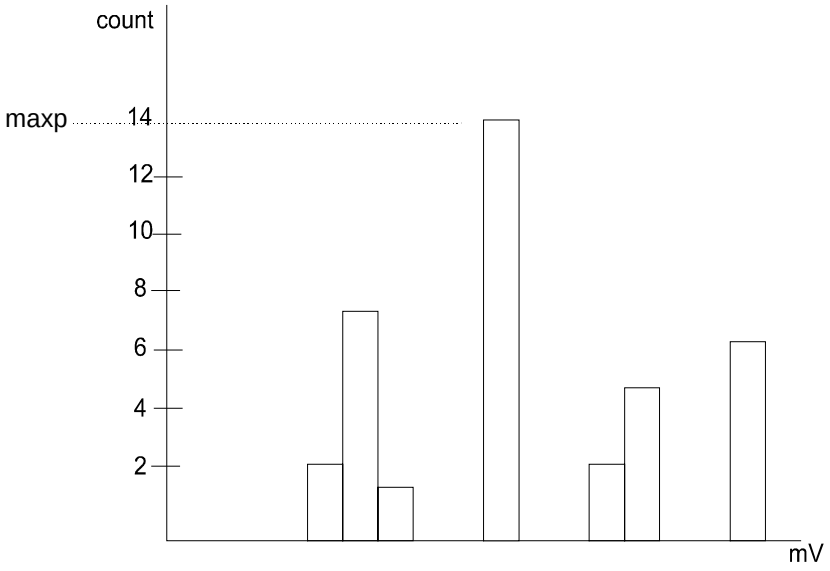
Definition

The count (vertical value) of the highest population bin in a histogram.

Description

Each bin between the parameter cursors is examined for its count. The highest count is returned as **maxp**.

Example:



In this example, **maxp** is 14.

mode Mode

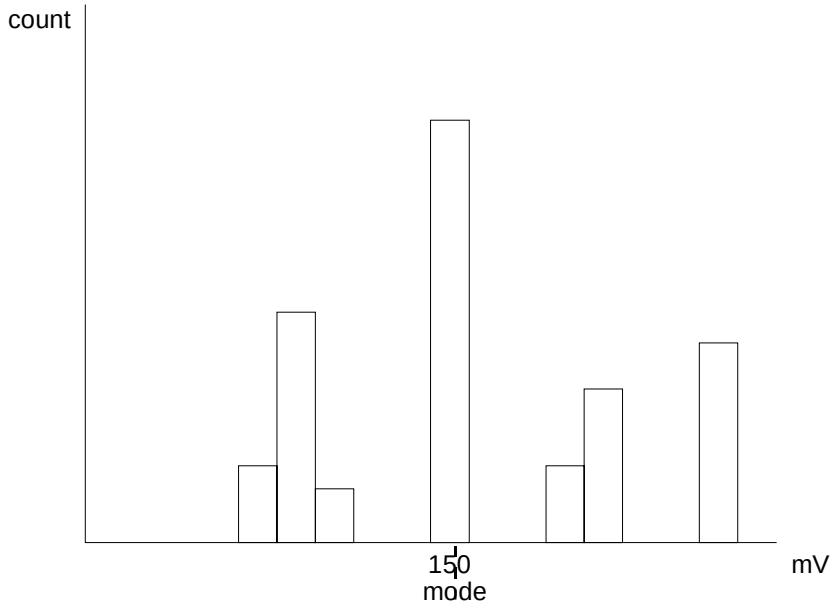
Definition

The value of the highest population bin in a histogram.

Description

Each bin between the parameter cursors is examined for its population count. The leftmost bin with the highest count found is selected. Its center value is returned as **mode**.

Example:



In this example **mode** is 150 mV.

pctl Percentile

Definition

Computes the horizontal data value that separates the data in a histogram, so that the population on the left is a specified percentage, **xx** of the total population. When the threshold is set to 50%, **pctl** is the same as **hmedian**.

Description

The total population of the histogram is determined. Scanning from left to right, the population of each bin is summed until a bin that causes the sum to equal or exceed **xx**% of the population value is encountered. A ratio of the number of counts needed for **xx**% population/total bin population is then determined for the bin. The horizontal value of the bin at that ratio point of its range is found, and returned as **pctl**.

Example:

The total population of a histogram is 100. The histogram range is divided into 20 bins and **xx** is set to 25%. The population sum at the sixth bin from the left is 22. The population of the seventh is 9, and its sub-range is 6.1 to 6.4 V. The ratio of counts needed for 25% population to total bin population is:

3 counts needed / 9 counts = 1/3.

The value for **pctl** is:

6.1 volts + .33 * (6.4 – 6.1) volts = 6.2 volts.

Parameter Settings

Selection of the **pctl** parameter in the **CHANGE PARAM** menu group causes the **MORE pctl SETUP** menu to appear. Pressing the correponding menu button displays a threshold setting menu. With the associated knob, the user can set the percentage value to between 1% and 100% of the total population.

pks Peaks

Definition

The number of peaks in a histogram.

Description

The instrument analyzes histogram data to identify peaks from background noise and histogram binning artifacts such as small gaps.

Peak identification is a three-step process:

1. The mean height of the histogram is calculated for all populated bins. A threshold (T1) is calculated from this mean where:

   T1= mean + 2 sqrt(mean).

2. A second threshold is determined based on all populated bins under T1 in height, where:

   T2 = mean + 2 * sigma,

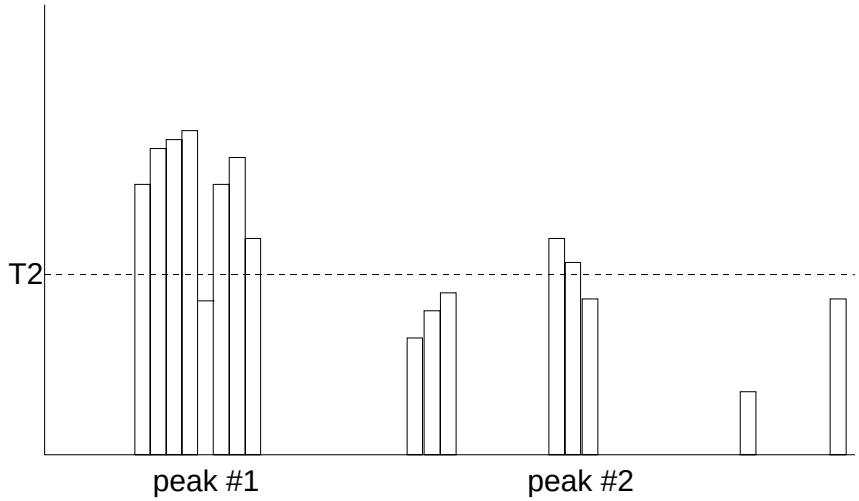
   and where sigma is the standard deviation of all populated bins under T1.

3. Once T2 is defined, the histogram distribution is scanned from left to right. Any bin that crosses above T2 signifies the existence of a peak. Scanning continues to the right until one bin or more crosses below T2. However, if the bin(s) cross below T2 for less than a hundreth of the histogram range, they are ignored, and scanning continues in search of a peak(s) that crosses under T2 for more than a hundredth of the histogram range. Scanning goes on over the remainder of the range to identify additional peaks. Additional peaks within a fiftieth of the range of the populated part of a range from a previous peak are ignored.

Note:	If the number of bins is set too high, a histogram may have many small gaps. This increases sigma and thereby T2, and in extreme cases can prevent determination of a peak, even if one appears visible to the eye.

Example:

Two peaks have been identified below. The one with the highest population is peak #1.



range Range

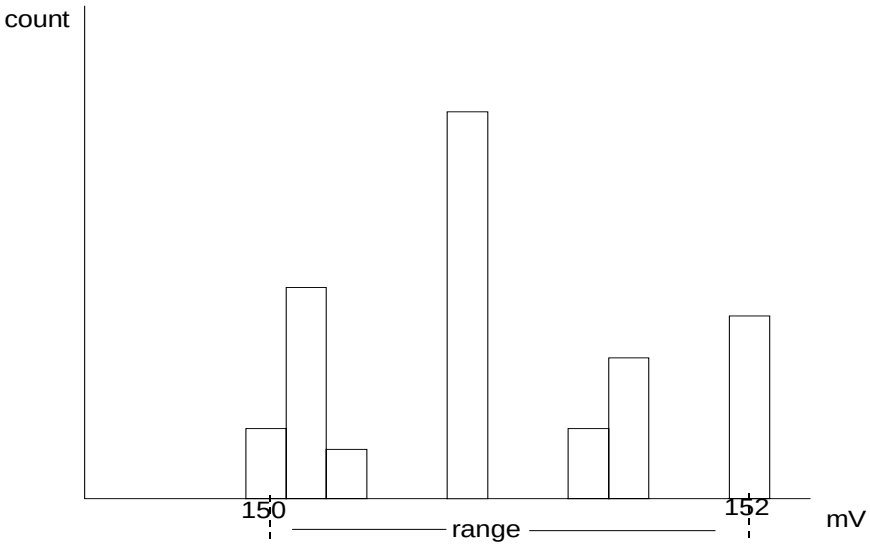
Definition

Computes the difference between the value of the rightmost and that of the leftmost populated bin.

Description

The rightmost and leftmost populated bins are identified. The difference in value between the two is returned as the **range**.

Example:



In this example, **range** is 2 mV.

sigma Sigma

Definition

The standard deviation of the data in a histogram.

Description

sigma is calculated by the formulas:

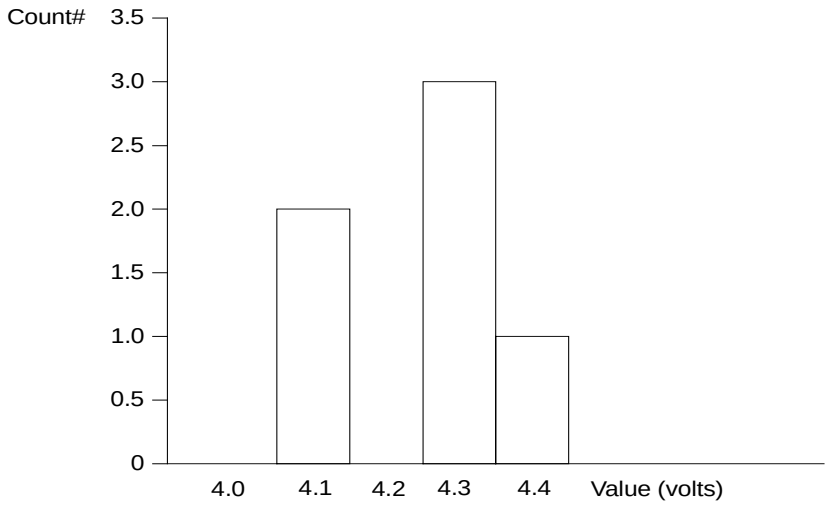
$$\text{mean} = \sum_{i=1}^{n}[\text{bin count}_i * \text{bin value}_i] \Big/ \left(\sum_{i=1}^{n}\text{bin count}_i\right);$$

$$\text{sigma} = \sqrt{\sum_{i=1}^{n}[\text{bin count}_i * (\text{bin value}_i - \text{mean})^2] \Big/ \left(\sum_{i=1}^{n}[\text{bin count}_i] - 1\right)},$$

where **n** is the number of bins in the histogram, bin count is the count or height of a bin and bin value is the center value of the range of parameter values a bin can represent.

Example:

For the histogram:



mean = (2 * 4.1 + 3* 4.3 + 1 * 4.4) / 6 = 4.25

sigma = $\sqrt{(2*(4.1 - 4.25)^2 + 3*(4.3 - 4.25)^2 + 1*(4.4 - 4.25)^2) / (6-1)}$ = .1225

totp Total Population

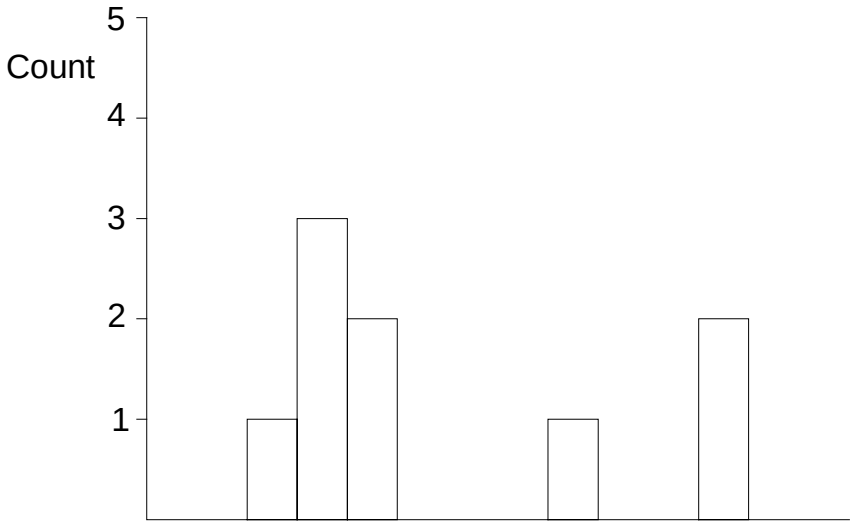
Definition

Calculates the total population of a histogram between the parameter cursors.

Description

The count for all populated bins between the parameter cursors is summed.

Example:



The total population of this histogram is 9.

xapk — X Coordinate of xxth Peak

Definition

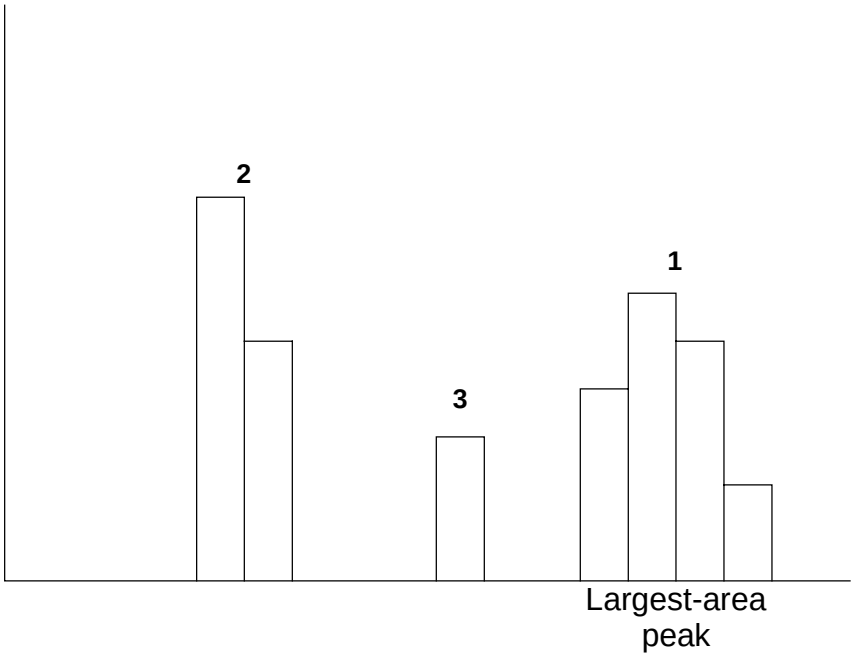
Returns the value of the **xx**th peak that is the largest by area in a histogram.

Description

First the peaks in a histogram are determined and ranked in order of total area. (For a discussion on how peaks are identified, see the description for the **pks** parameter.) The center of the **n**th ranked peak (the point where the area to the left is equal to the area to the right), where **n** is selected by the user, is then returned as **xapk**.

Example:

The rightmost peak is the largest, and thus the first-ranked, in area (1). The leftmost peak, although higher, is ranked second by area (2). The lowest peak is also the smallest in area (3).



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