

avg

Average

Definition:

Average or mean value of data in a histogram.

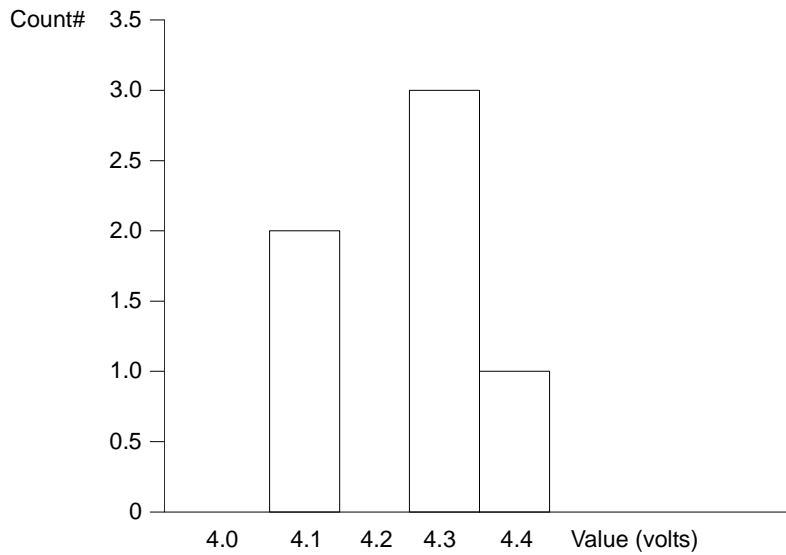
Description:

The average is calculated by the formula: Avg =

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

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

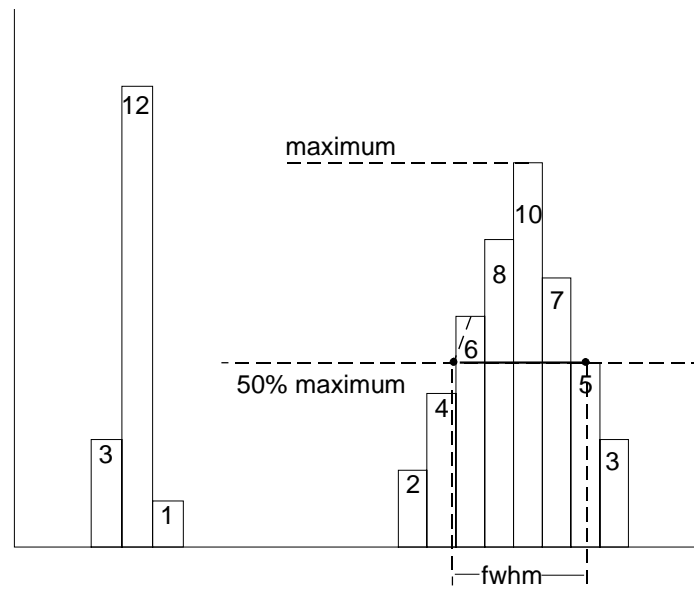
Definition:

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

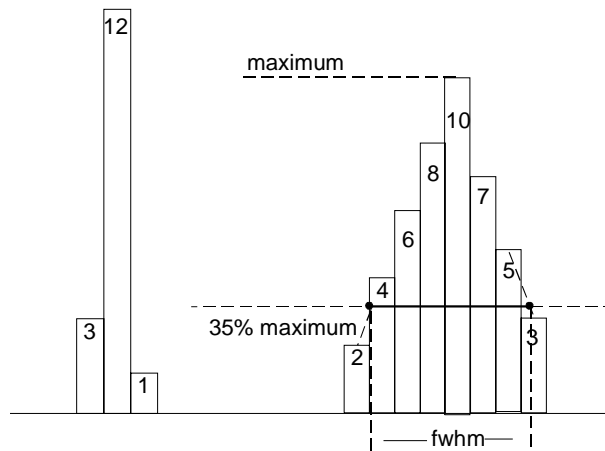
Full Width at xx% Maximum

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 you to set the 'xx' value to between 0 and 100% of the peak.

Example: **fwxx** with threshold set to 35%:



hampl

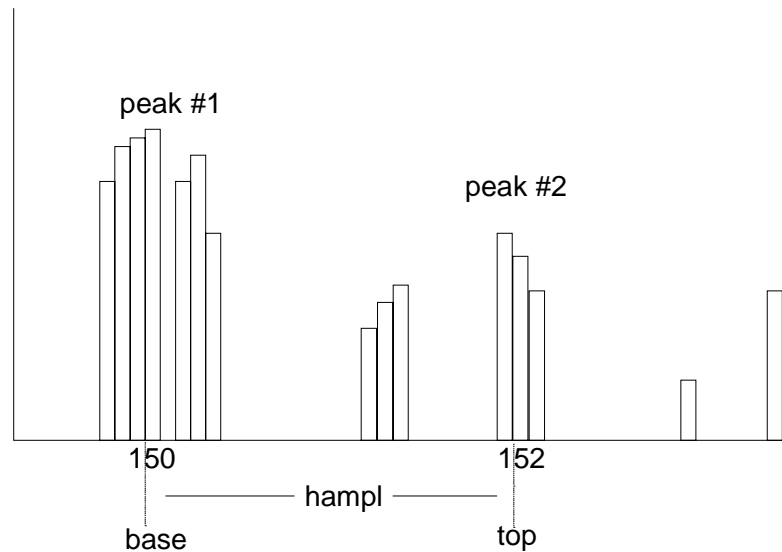
Histogram Amplitude

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:

$$\text{hampl} = \text{htop} - \text{hbase}$$

Example:



In this histogram, **hampl** is $152 \text{ mV} - 150 \text{ mV} = 2 \text{ mV}$.

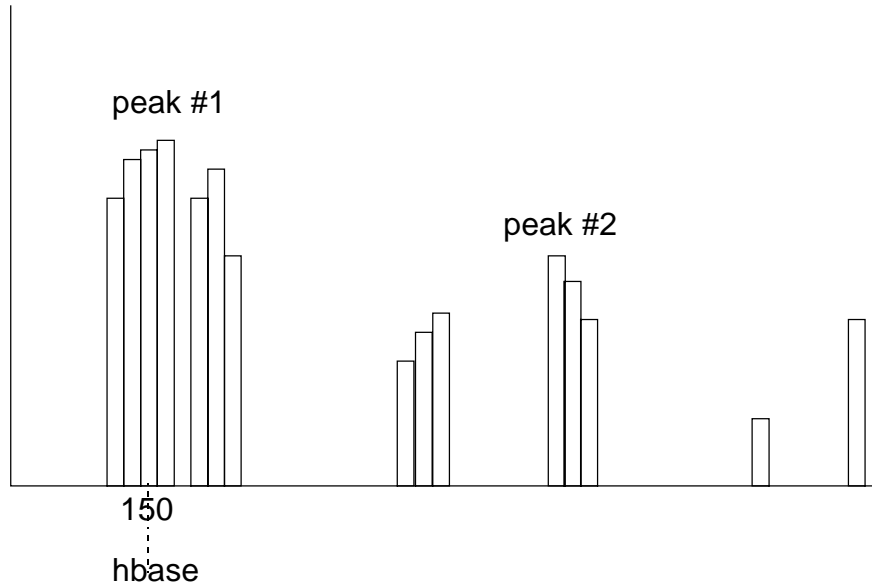
Hbase

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 (the line that divides the population of the peak in half) is the **hbase**.

Example:



HISTOGRAMS

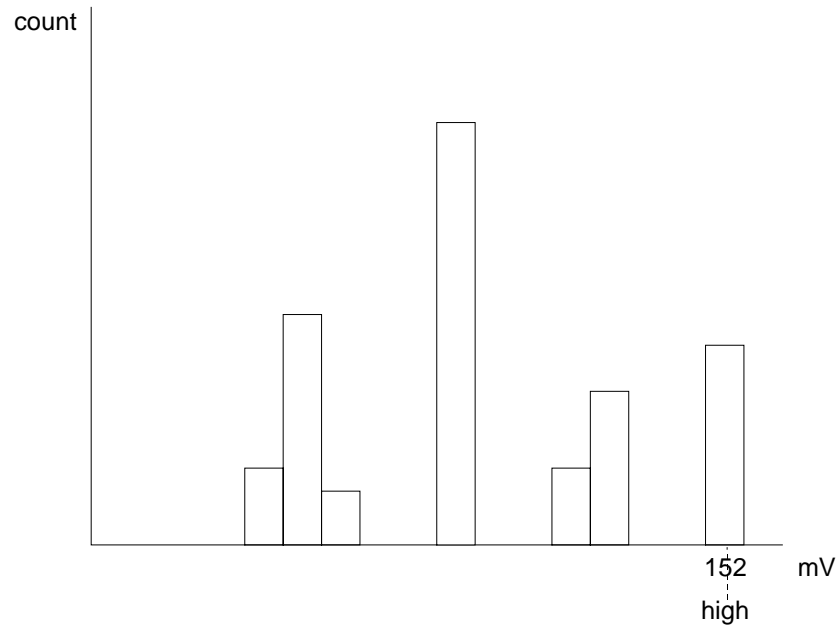
high

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:

$$2 \text{ counts needed} / 8 \text{ counts} = .25$$

The value for **hmedian** is:

$$6.1 \text{ volts} + .25 * (6.5 - 6.1) \text{ volts} = 6.2 \text{ volts}$$

hrms

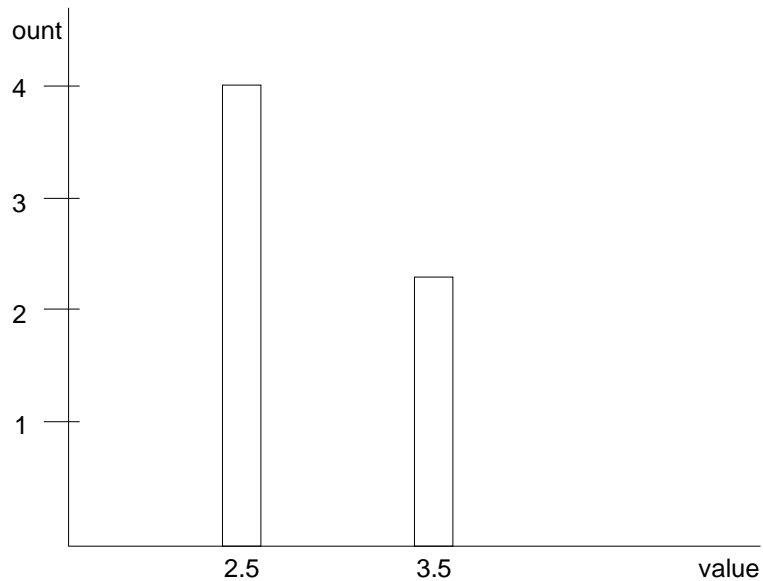
Histogram Root Mean Square

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:

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



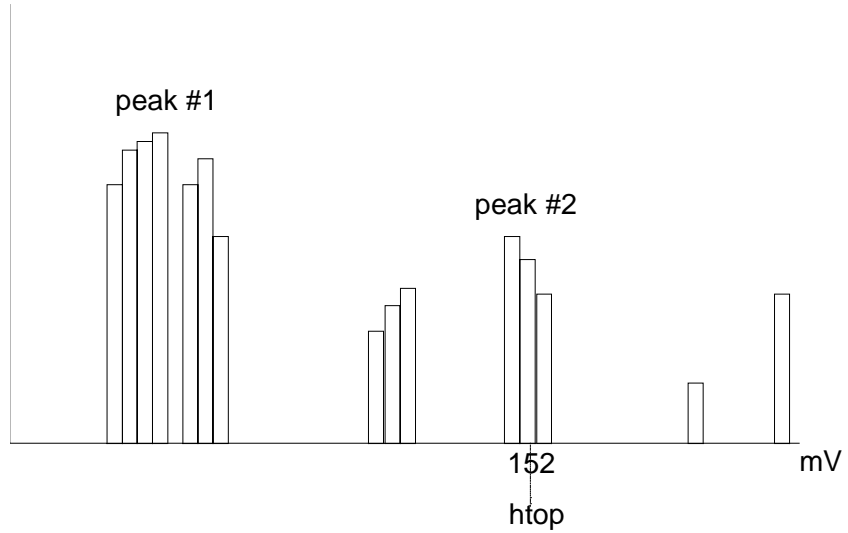
htop

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:



HISTOGRAMS

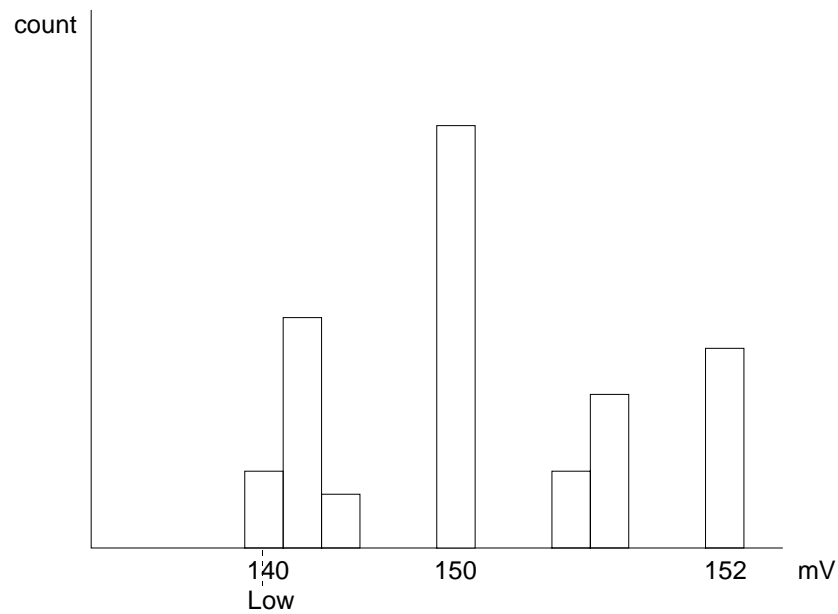
low

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

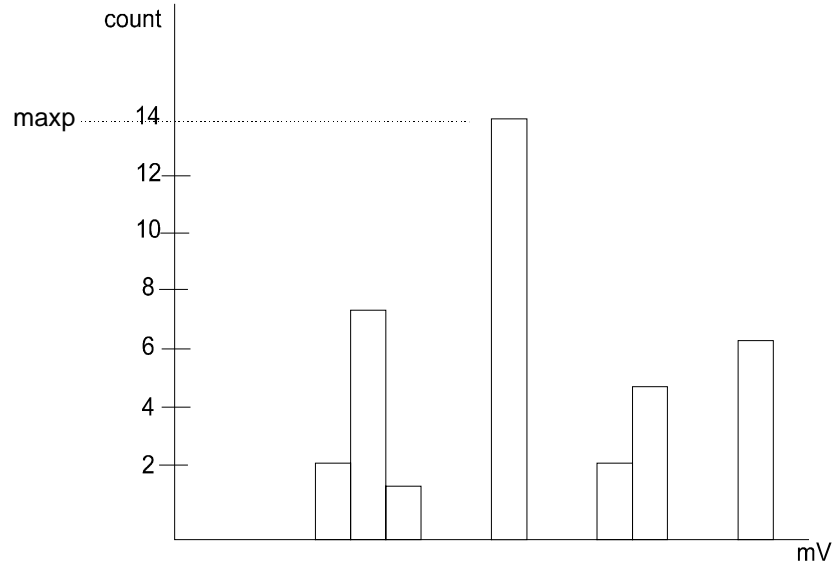
Definition:

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:



Here, **maxp** is 14.

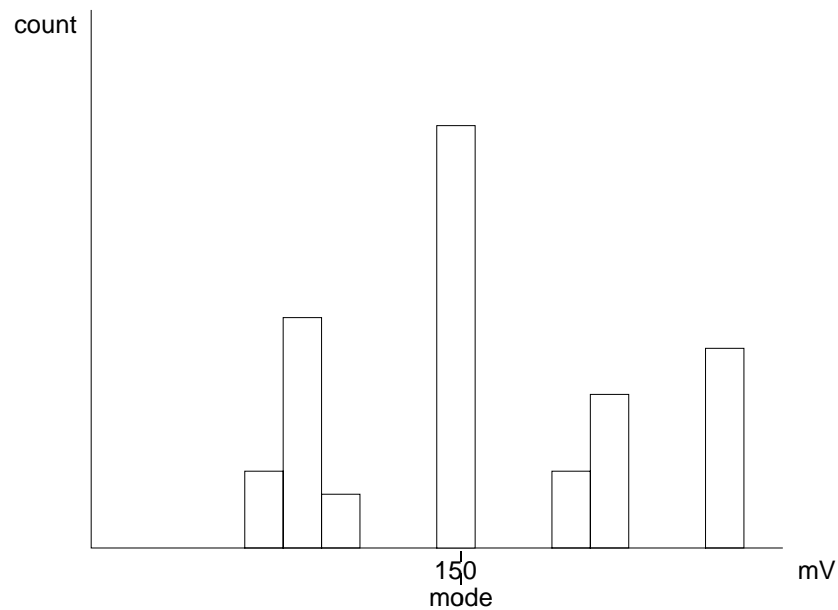
mode

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:



Here, **mode** is 150 mV.

pctl

Percentile

- Definition:** Computes the horizontal data value that separates the data in a histogram such 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:

$$3 \text{ counts needed} / 9 \text{ counts} = 1/3.$$
 The value for **pctl** is:

$$6.1 \text{ volts} + .33 * (6.4 - 6.1) \text{ volts} = 6.2 \text{ volts}.$$
- Parameter Settings:** Selection of the **pctl** parameter in the "CHANGE PARAM" menu group causes the "MORE pctl SETUP" menu to appear. Pressing the corresponding menu button displays a threshold setting menu. With the associated knob you 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 3-step process:

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

$$T1 = \text{mean} + 2 \sqrt{\text{mean}}.$$

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

$$T2 = \text{mean} + 2 * \text{sigma},$$

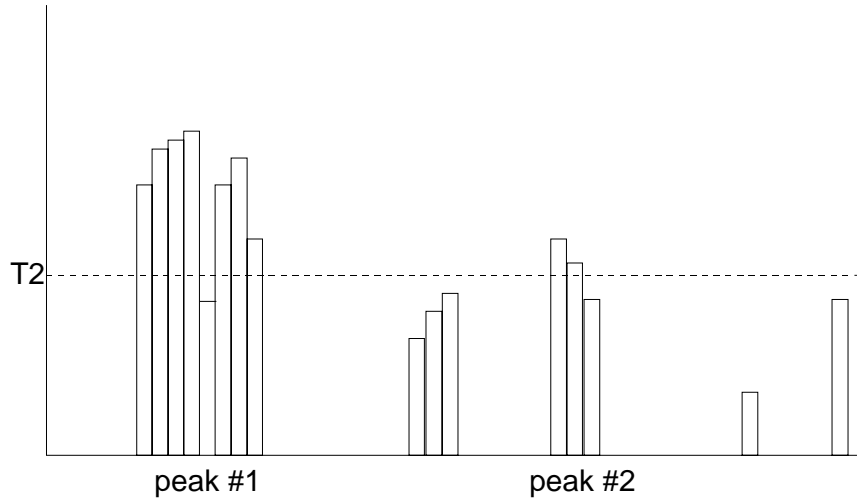
and where sigma is the standard deviation of all populated bins under T1.

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 hundredth 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 bin 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 to be present to the eye.

Example:

Here the two peaks have been identified. The peak with the highest population is peak # 1.



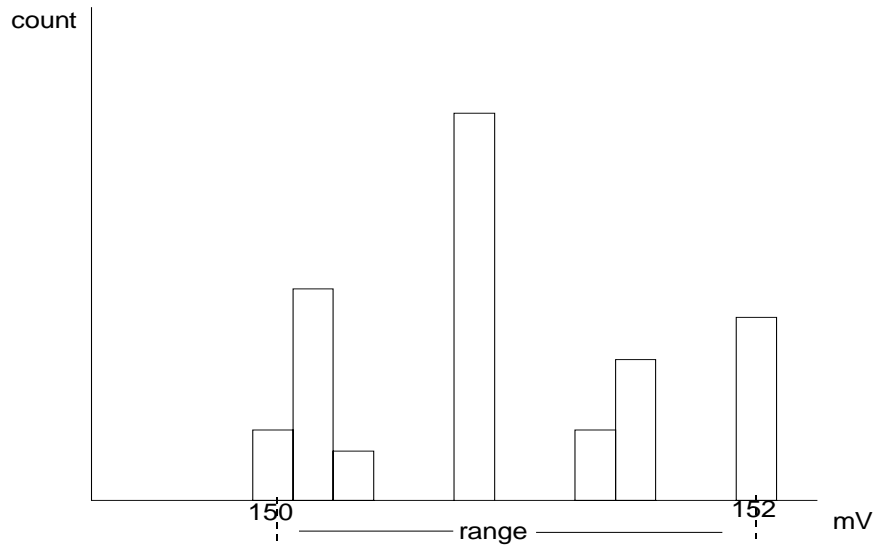
range

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.

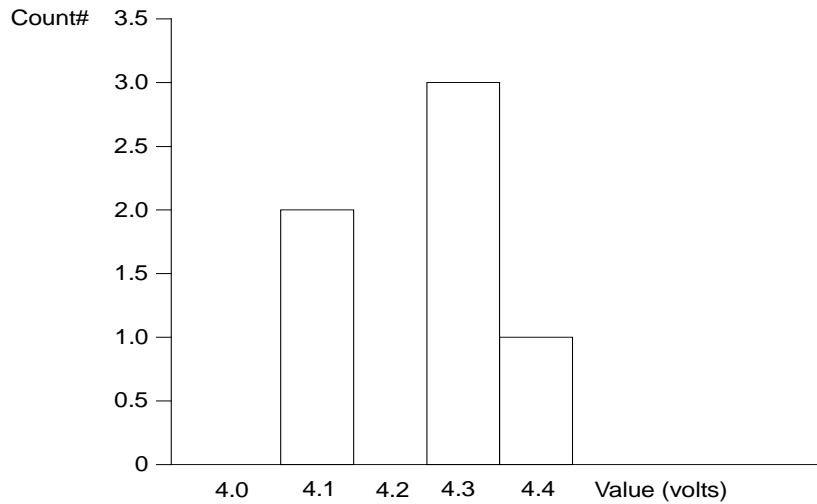
Description: **sigma** is calculated by the formulas:

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

$$\text{sigma} = \sqrt{\frac{\sum_{i=1}^n [\text{bin count}_i * (\text{bin value}_i - \text{mean})^2]}{(\sum_{i=1}^n [\text{bin count}_i] - 1)}};$$

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:



$$\text{mean} = (2 * 4.1 + 3 * 4.3 + 1 * 4.4) / 6 = 4.25$$

$$\text{sigma} = \sqrt{(2 * (4.1 - 4.25)^2 + 3 * (4.3 - 4.25)^2 + 1 * (4.4 - 4.25)^2) / (6 - 1)} = 0.1225$$

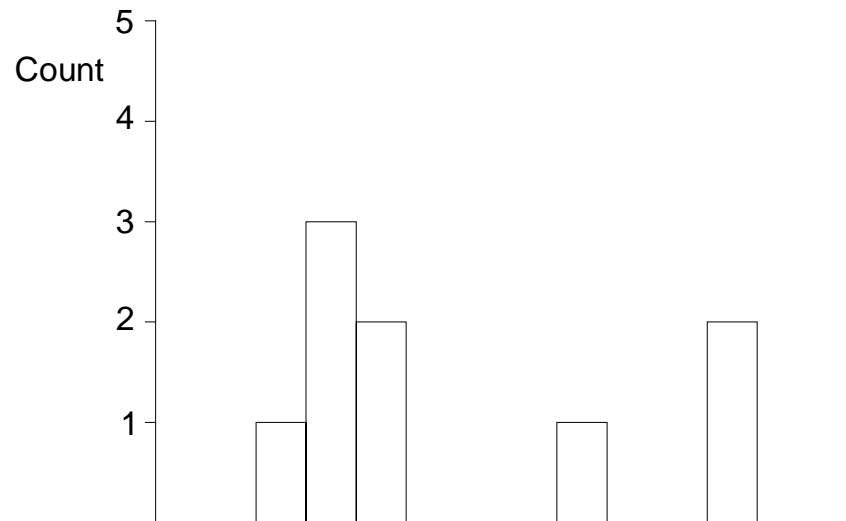
totp

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 xx'th Peak

Definition:

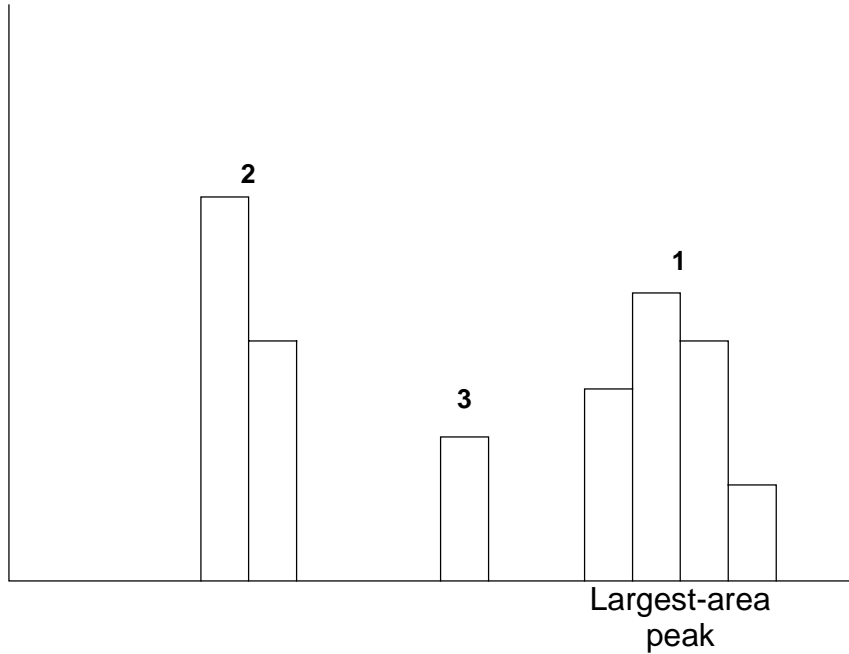
Returns the value of the xx'th peak that is the largest by area in a histogram.

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 you, is then returned as **xapk**.

Example:

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



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