NOISE MEASUREMENTS

Lock-in amplifiers can be used to measure noise. Noise measurements are generally used to characterize components and detectors.

The SR830 measures input signal noise AT the reference frequency. Many noise sources have a frequency dependence which the lock-in can measure.

How does a lock-in measure noise?

Remember that the lock-in detects signals close to the reference frequency. How close? Input signals within the detection bandwidth set by the low pass filter time constant and roll-off appear at the output at a frequency $f=f_{sig}-f_{ref}$. Input noise near f_{ref} appears as noise at the output with a bandwidth of DC to the detection bandwidth.

For Gaussian noise, the equivalent noise bandwidth (ENBW) of a low pass filter is the bandwidth of the perfect rectangular filter which passes the same amount of noise as the real filter.

The ENBW is determined by the time constant and slope as shown below. Wait time is the time required to reach 99% of its final value.

T= Time Constant

Slope	ENBW	Wait Time
6 dB/oct	1/(4T)	5T
12 dB/oct	1/(8T)	7T
18 dB/oct	3/(32T)	9T
24 dB/oct	5/(64T)	10T

Noise estimation

The noise is simply the standard deviation (root of the mean of the squared deviations)of the measured X, Y or R .

The above technique, while mathematically sound, can not provide a real time output or an analog output proportional to the measured noise. For these measurements, the SR830 estimates the X or Y noise directly.

To display the noise of X, for example, simply set the CH1 display to X noise. The quantity X noise is computed from the measured values of X using the following algorithm. The moving average of X is computed. This is the mean value of X over some past history. The present mean value of X is subtracted from the present value of X to find the deviation of X from the mean. Finally, the moving average of the absolute value of the deviations is calculated. This calculation is called the mean average deviation or MAD. This is not the same as an RMS calculation. However, if the noise is Gaussian in nature, then the RMS noise and the MAD noise are related by a constant factor.

The SR830 uses the MAD method to estimate the RMS noise of X and Y. The advantage of this technique is its numerical simplicity and speed.

The noise calculations for X and Y occur at 512 Hz. At each sample, the mean and moving average of the absolute value of the deviations is calculated. The averaging time (for the mean and average deviation) depends upon the time constant. The averaging time is selected by the SR830 and ranges from 10 to 80 times the time constant. Shorter averaging times yield a very poor estimate of the noise (the mean varies rapidly and the deviations are not averaged well). Longer averaging times, while yielding better results, take a long time to settle to a steady answer.

To change the settling time, change the time constant. Remember, shorter settling times use smaller time constants (higher noise bandwidths) and yield noisier noise estimates.

X and Y noise are displayed in units of Volts/√Hz. The ENBW of the time constant is already factored into the calculation. Thus, the mean displayed value of the noise should not depend upon the time constant.

The SR830 performs the noise calculations all of the time, whether or not X or Y noise are being displayed. Thus, as soon as X noise is displayed, the value shown is up to date and no settling time is required. If the sensitivity is changed, then the noise estimate will need to settle to the correct value.