LOOK

A digital signal analysis and processing program for PCs

Introduction

LOOK is a program for signal analysis and graphical display. It also performs some signal processing functions and can save the results to a disk file. Input is from data files stored on disk or signals generated within the program.

Requirements

LOOK runs on PCs with Windows 95 and higher. It is not compatible with MAC or SUN computers

Windows Vista: LOOK should be run in compatibility mode for Windows 98/ME

1. Right click on LOOK32.EXE in File Manager or Explorer
2. Select "Properties"
3. Select "Compatibility" tab
4. Check the box that says, "Run this program in compatibility mode for:"
5. Select "Windows 98 / Windows ME" from the drop-down list
6. Click "OK"

Version history

- Version 12/05.0 posted December, 2005.
- Version 08/08.0 posted August, 2008. The only change from ver. 12/05.0 is the ability to read .WAV files which have extra information included in the header (name of song, copyright notice, etc.). The extra information is not preserved if you write a .WAV file with LOOK.

Installation

LOOK does not need to be installed. Just put LOOK.EXE in whatever folder you wish and create a shortcut on the desktop.

License

Capability

LOOK can read time or frequency domain input signals from disk:

- Real time domain data
- Complex time domain data
- Real frequency domain data
- Complex frequency domain data

Or, LOOK can read two independent real or complex signals of any type.

Or, LOOK can generate real or complex signals from an arbitrary equation.

LOOK is intended for use with uniformly sampled data. That is, the sampling interval of the x axis (time, frequency or whatever) must be uniform throughout the data file. Non-uniformly sampled data is NOT supported except for the X-Y plot case.

The program can perform various signal processing operations:

- Fourier transforms and inverse Fourier transforms
- Windowing -- Cosine, Cosine-squared, Rectangular, Kaiser or notch.
- Linear transforms -- add a constant, multiply by a constant, multiply by a complex exponential or multiply by a sinusoid
- Filtering -- Chebyshev, Butterworth, Transitional, Bessel filter or arbitrary Laplace transform, H(s). It will generate the filter functions and apply them to the input signal.
- Change sampling rate -- upsample and downsample
- Differentiation and integration
- Autocorrelation
- Convolution
- Crosscorrelation

It can also graph, list or save to file various parameters of the input signal(s):

- Real component
- Imaginary component
- Amplitude (absolute value)
- Power
- Phase
- Instantaneous frequency (FM demodulation)
- Group delay of filters
- Deviation from linear phase
- X-Y (Lissajous) graphs
- Product of real and imaginary parts
- Sum and difference of real and imaginary parts
- Linear regression lines

It also computes:

- Sliding window averages
- Probability distributions
- Cumulative distributions
- Various statistics such as rms, mean, min, max, etc.

All internal calculations are done with double precision complex arithmetic, which has a precision of about 16 significant figures (decimal).

Quick Start

1) Generate a signal (<ENTER> means press the enter key)
   a. Type **AS EQ <ENTER>** (To enter commands and data, You can 1) type, 2) recall previous inputs with up/down arrow keys, or 3) paste from the clipboard with <Ctrl>v.)
   b. Type **4096, 0, 1/500/512 <ENTER>** (Most numerical inputs can be typed either as a number or an equation like 1/500/512.)
   c. Type **3*sin(twopi*500*x) + sin(twopi*1500*x) <ENTER>** (**pi, hafpi** and **twopi** are predefined; **x** is predefined as the x-axis value, time in seconds in this case.)
2) Show the graph of the signal
   a. Type **WA RE <ENTER>** (Graph the real component of the waveform)
   b. Type **<ENTER>** (XMIN, XMAX, YMIN and YMAX set the scales for the graph. There are usually two predefined values you can select with a single keystroke. / gives a saved value and <ENTER> autoscales the graph.)
   c. Press **<ESC>** (Return to the menu)
   d. Press **/** (Repeat the last command)
   e. Type **xmin, xmin+2/500, -3, 3 <ENTER>** (Look at just 2 cycles of the signal; upper or lower case doesn't matter)
   f. Press **<ESC>** (Return to the menu)
   g. Type **SP AM <ENTER>** (Computes the Fourier transform of the waveform and graphs its amplitude.)
   h. Type **–5000 5000 0 0 <ENTER>** (Inputs can be separated by commas or spaces)
   i. Press **<ESC>** (Return to the menu)
   j. Type **dB <ENTER>** (Plots the amplitude of the spectrum in decibels. Most commands are "sticky" – you don't need to retype the SP AM)
   k. Type **/** (Use saved values of XMIN, XMAX, YMIN, YMAX)
   l. Press **<ESC>** (Return to the menu)
   m. Type **EN <ENTER>** (Exit the program)

Commands

All commands can be abbreviated to the letters shown in upper case. Most commands are “sticky” – they remain in effect until changed.

File and System options

ALlocate	Allocates memory for the maximum number of data points allowed in a signal. The default is 32,768. Do this before attempting to read or create a signal. Limited only by the real plus virtual memory available in the computer. (Each sample point uses 52 bytes of memory.) Some operations, especially Fourier transforms, will run slowly when virtual memory is needed to store the data.
SEt range	Read in only a selected portion of subsequent input files. The program asks for the maximum and minimum sample point numbers to be read and the interval between reads. (The sample points in the file are numbered 1, 2, 3, ...).
RTime	Read in a new time domain waveform. The program will ask for the file names of the real and imaginary components. Either may be omitted and that component will be set to zero. Look can read files in several formats. See the **Data Formats** section near the end of this document. ***** Brings up a dialog box to select a file. **=CONSTANT** sets all data points to A constant. A sub-menu will ask for the necessary data. Time domain data is normally ordered from 0 to (N-1)*Δt, where N is the number of sample points, and Δt is the sampling interval.
RFrequency	Read in a new frequency domain waveform. See comments for RTime above. Frequency domain data is normally ordered from (-N/2)*Δf to (N/2-1)*Δf, where N is the number of sample points, and Δf is the sampling interval.
RAsignal	Read in a new signal **A**. See comments for RTime above. An A signal occupies the same memory space as the time domain waveform and may be used interchangeably. However, LOOK interprets it differently. The time domain and frequency domain signals are always a Fourier transform pair, with the appropriate values of Δt, Δf, time span and frequency span computed automatically. The A and B signals are completely independent and may be interpreted any way the user wishes.
RBsignal	Read in a new signal **B**. A B signal occupies the same memory space as the frequency domain waveform and may be used interchangeably. See comments for RTime and RAsignal above.

SYstem	Allows running a system or DOS command or other program without terminating LOOK.
ENd	Terminates LOOK, erases all temporary files.

Function

After the input file(s) are read, each command consists of an OPERATION, or a FUNCTION, PARAMETER, and as many OPTIONS as apply.

WAveform	Causes all subsequent OPERATIONS, PARAMETERS and OPTIONS to apply to the time domain signal. If frequency domain data was originally entered, it is transformed to time domain using an FFT. If a frequency domain signal is to be transformed to the time domain, the number of sample points must be a power of two or first be extended to the next highest power of two with the **CH**ange #pts operation.
SPectrum	Causes all subsequent OPERATIONS, PARAMETERS and OPTIONS to apply to the frequency domain signal. If a time domain data was originally entered, it is transformed to frequency domain using an FFT. If a time domain signal is to be transformed to the frequency domain, the number of sample points must be a power of two or first be extended to the next highest power of two with the **CH**ange #pts operation.
ASignal	Causes all subsequent OPERATIONS, PARAMETERS and OPTIONS to apply to signal A. There are no automatic transforms.
BSignal	Causes all subsequent OPERATIONS, PARAMETERS and OPTIONS to apply to signal B. There are no automatic transforms.

Operation

Operations permanently alter the copy of the input signal stored in the program, but do not alter the version stored on disk. To see the effect of the operation alone, generate a constant signal (see RT, RF above) of 1 + 0i and apply the operation to that signal.

WIndow	Apply a window function to the signal. A sub-menu gives an option of window types: Cosine, Cosine-squared, rectangular, Kaiser, or rectangular notch.
LT linear transform	Apply one of several arithmetic operations to the signal. A sub-menu gives an option to add a constant, multiply by a constant, multiply by a complex exponential or multiply by a sinusoid.

FF filter function	Apply Chebyshev, Butterworth, Transitional or Bessel filter to the signal. (See A. I. Zverev, *Handbook of Filter Synthesis*, John Wiley & Sons, 1967.) The filter can be either lowpass or bandpass. Or, enter an equation specifying an arbitrary transfer function in Laplace transform notation: H(s), s = jω = j2πf. This operation is intended for use with the **SP**ectrum function only. Use with the **WA**veform function will result in a time domain window having the shape of the (complex) frequency domain response of the specified filter.
CS change sample rate	Either upsample by a power of 2 (2, 4, 8, 16, ...) or downsample by an integer ratio (2, 3, 4, ...). **Upsampling** is useful for interpolation of sampled data signals and the algorithm is very accurate (≈1 part in 10^{12}) if the Nyquist sampling rate criterion is strictly true in the input signal. The number of sample points in the input signal must be a power of 2 because the FFT is used in the upsampling algorithm. **Downsampling** merely keeps every Nth sample and discards the intermediate ones.
CHange #pts, Xmin, dX A|B	Change the number of sample points or change the x value range or sampling interval. This does not resample the data or alter its values. If the number of points is reduced, the signal is permanently truncated. If the number of points is increased, the signal is extended with zeroes. This is useful for "padding" a signal to a power of two sample points so it can be Fourier transformed.
DX time/freq deriv.	For waveform, compute derivative of the signal with respect to time. For spectrum, compute the derivative of the signal with respect to frequency.
IX time/freq integral	For waveform, compute integral of the signal with respect to time. For spectrum, compute the integral of the signal with respect to frequency.
AC auto-correlation A|B	Compute the auto-correlation of signals A or B. Operates on the currently selected function (signal A or signal B)
SWap A&B	Swap the A and B signals
A=B	Overwrite signal A with signal B
B=A	Overwrite signal B with signal A
ADd A&B	Add signals A and B. The result is put in the currently selected function (signal A or signal B)
MUltiply A&B	Multiply signals A and B. The result is put in the currently selected function (signal A or signal B)
CV convolution of A&B	Compute the convolution of signals A and B. The result is put in the currently selected function (signal A or signal B)
XC cross-correlation A&B	Compute the cross-correlation of signals A and B. The result is put in the currently selected function (signal A or signal B)
DEfine	Define a symbolic constant for later use. Other previously defined symbolic constants can be used in the equation. Since the program displays the result, this can also be used as a stand-alone complex calculator. Ex: `X22 = cos(twopi*3) + 7.4`

SHow constants	Display of list of symbolic constants that have been defined. These can be used in any input field in LOOK.
EQuation	Generate an A or B signal from an arbitrary equation. Constants previously set by DEfine can be used in the equation. X is predefined as the x value (time or frequency) for each sample point.
CReate	Creates a Fourier transform pair that can be used as time and frequency domain data. If signal A is selected, it becomes the inverse FFT of signal B. If signal B is selected, it becomes the Fourier transform of signal A.

Parameters

Parameters control what is graphed, listed or written to file. They do not affect the stored time or frequency domain data or signals A or B.

REal	The real component (I component) of the signal, Re(z).
IMaginary	The imaginary component (Q component) of the signal, Im(z)
AMplitude	The amplitude, $(Re(z)^2 + Im(z)^2)^{0.5}$
POwer	The power, $Re(z)^2 + Im(z)^2$
DPhase	4 quadrant phase, ϕ = ARCTAN(Im(z)/ Re(z)), in **degrees**
RPhase	4 quadrant phase, ϕ = ARCTAN(Im(z)/ Re(z)), in **radians**
INstfreq	$(1/2\pi)*(d\phi/dt)$, in Hz. This is the output of an ideal FM discriminator detecting an RF signal represented by time domain I and Q components.
GRoup delay	$-d\phi/df$, of a frequency domain signal. This is the group delay, in seconds, of a filter whose transfer function is represented by the real and imaginary frequency domain components.
DDev lin phase (degrees)	Compute the deviation in **degrees** from linear phase. The actual phase is compared to a linear regression line computed over a specified range of times or frequencies.
RDev lin phase (radians)	Compute the deviation in **radians** from linear phase. The actual phase is compared to a linear regression line computed over a specified range of times or frequencies.
XYplot X=real, Y=imag	Graphs the imaginary part vertically versus the real part horizontally. NOT the Y versus X values of a single data file. This is also known as a Lissajous graph. Most options (**AV**erage, **DI**stribution, etc.) are disabled when **XY**plot is selected.
PRoduct	Re(z) × Im(z)
SUm real ± imag	A×Re(z) + B×Im(z), A and B arbitrary constants.
RX linear regress (x,re)	Linear regression line of Re(z) vs. x (time or frequency)
RR linear regress (re, im)	Linear regression line of Im(z) vs. Re(z)

Option(s)

Options are applied to the parameter. Once selected, most options remain in effect until turned off by entering the option name preceded by "NO". E.g., **PL** to plot and **NOPL** to turn off plot option.

AVerage	The data is averaged over a time interval (for **SP** function) or over a frequency interval (for **WA** function). The program will ask for the interval. This option can be used with the **WA** function for smoothing or for a sliding window type low pass filter. It can be used with the **SP** function for smoothing also. It can be used with the **SP** function and **PO** parameter to show the power in a certain bandwidth, as does a spectrum analyzer.
DIstribution	Compute probability distribution of the data. The program will ask for the number of probability "buckets" to use.
CUmulative	Compute cumulative data. In the time domain, the sum over all sample points of Y(t)*dt. In the frequency domain, the sum over all sample points of Y(f)*df. The program asks the limits, X1 & X2, (in time or frequency) for the summation. If X2>X1 the summation is from smaller to larger values of time or frequency. If X2<X1 the summation is from larger to smaller values of time or frequency. When using the **CU**mulative option, the autoscale function of **PL**ot sets Ymax to the total area under the curve regardless of the X1 & X2 specified.
DB	Convert data to dBV when used with **AM**plitude parameter. Convert data to dbW (1 ohm) when used with **PO**wer parameter. Valid only for the **AM**plitude and **PO**wer parameters.
STatistics	Displays various statistics: rms voltage, power, total energy and equivalent noise bandwidth of the SIGNAL. Also computes mean, mean square, rms, standard deviation, variance, minimum & maximum of the PARAMETER selected (including options) and other data.
SS save statistics	Saves the output of the **ST**atistics option in a disk file, LOOK.STA, in the same folder as LOOK.EXE
FIle	Save the parameter with options data in a disk file instead of graphing it. The file can be saved in several formats. See the **Data Formats** section near the end of this document. Selecting **FI**le turns off **PL**ot and **LI**st.
LIst	Show a list of computed values on the screen instead of graphing the data. The range of x values (time or frequency) can be selected. Selecting **LI**st turns off **PL**ot and **FI**le. The <PageUp>, <PageDown>, <Home> and <End> keys can be used for moving through the list.
PLot	This is the default option. The parameter selected, with options, is plotted on the screen. After looking at the graph, the <Esc> key returns to the menu; the ← → ↑ ↓ keys scroll the screen 1/2 page. Selecting **PL**ot turns off **LI**st and **FI**le.

OVerlay	Overlay current graph on previous graph using the same scale. Used for plotting multiple curves in the same graph. This option affects only the plotted data, not the data saved with the **FI**le option or shown with **LI**st. The **OV**erlay option does not remain on after used; it must be explicitly typed for each overlay. Otherwise the graphics screen is cleared before plotting.
SCale	Either the X or Y plotted data can be scaled by a multiplicative factor, an additive factor, or both. This option affects only the plotted data, not the data saved with the **FI**le option or shown with **LI**st.
MOdulo	Time or frequency axis of graph repeats periodically, as with an oscilloscope. Used for showing eye patterns, etc. This option affects only the plotted data, not the data saved with the **FI**le option or shown with **LI**st. The range of the X axis is the (Xmin, Xmax) you specify for the graph. X values outside this range are "mapped" onto the graph using modulo arithmetic.
WRap	Periodically extends the record length of graphs to 3 times normal. Allows, for example, a periodic waveform which is calculated in the range -.5E-6 sec to .5E-6 sec to be graphed over the range of 0 to 1.E-6 sec, or over any range in the region -1.5E-6 sec to 1.5E-6 sec. Also allows showing a pulse in its entirety when it would otherwise be wrapped around the ends of the graph. This option affects only the plotted data, not the data saved with the **FI**le option or shown with **LI**st.
EXport	Save the x and y data, as graphed, to a file.
MEtafile	Save the graph in Windows metafile format (vector graphics).
BItmap file	Save the graph in Windows bitmap format (raster graphics).
LAbel	Allows changing the default title at the top of the graph.
LO line options	Sets color, width and style for curve on the graph.
MArkers	Sets options for data point markers.
SMoothing	Sets options for curve smoothing.
PG polar graph	Draws graph in polar coordinates instead of rectangular.
AXis options	Sets linear or logarithmic scale. Controls axes and axis labels.
GO grid options	Controls grids.
ZEro line axis	Set zero point lines.
COlor options	Sets color of axes and labels.
FOrmat	Allows changing the default number of divisions on the X and Y axes of the graph and allows logarithmic or semi-logarithmic graphs. Also allows changing line width, adding data point markers, interpolation for smoothing, and other features.
AR aspect ratio	Sets aspect ratio of the graph.
HIgh resolution	To speed up graphing, LOOK normally finds the minimum and maximum points in 512 segments of the data and plots only these. Selecting High resolution plots all points.

Operators And Functions

All can have real or complex arguments, except as noted. These can be used with the **DE**fine and **EQ**uation operations, or in any numeric input field.

Addition	+	3 + 7 = 10
Subtraction	-	12 – 7 = 5
Multiplication	*	3*5 = 15; (3, 4)*(2, -5) = (26,-7) = 26 – 7i
Division	/	9/2 = 4.5
Exponentiation	^ or **	2^3 = 2**3 = 8
Square root	SQRT	SQRT(16) = 16^.5 = 4
Complex number	(a,b)	(2.3e12, -5000) = 2.3×10^{12} –5000i = 2.3×10^{12} –j5000
Convert to complex	CMPLX	CMPLX(12, sin(pi*x)) = 12 + sin(pi*x)i
Common logarithm	LOG10	Base 10 logarithm
Natural logarithm	LOG or LN	Base e logarithm
Exponential	EXP	EXP(2) = e^2 = 7.38905…
Real part	REAL	REAL(4, -7) = 4
Imaginary part	IMAG	IMAG(4, -7) = -7
Sine	SIN	Argument in radians
Cosine	COS	Argument in radians
Tangent	TAN	Argument in radians
Cotangent	COTAN	Argument in radians
Arcsine	ASIN	Result in radians
Arccosine	ACOS	Result in radians
Arctangent	ATAN	Result in radians
4 quadrant arctangent	ATAN2	Result in radians. ATAN2(z) = arctan(Re(z)/Im(z))
Hyperbolic sine	SINH	
Hyperbolic cosine	COSH	
Hyperbolic tangent	TANH	
Absolute value	ABS	
Complex conjugate	CONJG	
Round to nearest integer	NINT	Imaginary part of argument is ignored
Truncate to integer	INT	Imaginary part of argument is ignored
Modulo function	MOD	MOD(z) = Re(z) – INT(Re(z)/Im(z)) = remainder of Re(z)/Im(z)
Sign function	SIGN	SIGN(z) = | Re(z) | if Im(z) ≥ 0 and -| Re(z) | if Im(z) < 0
Positive difference	DIM	DIM(z) = Re(z) – Im(z) if Re(z) > Im(z) and 0 otherwise
Sinc function	SINC	SINC(z) = sin(πRe(z)) / (πRe(z))

Normal distribution	NORM	NORM(z) = normal curve evaluated at x, where Re(z) = standard deviation (s), Im(z) = x - μ, and μ = mean
Cumulative normal distribution	CNORM	CNORM(z) = cumulative normal curve evaluated at x, where Re(z) = standard deviation (s), Im(z) = x - μ, and μ = mean
Rayleigh distribution	RAY	RAY(z) = Rayleigh curve evaluated at x, where Re(z) = RMS value and Im(z) = x
Uniformly distributed random variate	RAND	RAND(z) returns a random number from the uniform distribution in the range Re(z) to Im(z), Re(z) < Im(z)
Gaussian distributed random variate	GAUSS	GAUSS(z) returns a random number from the Gaussian (normal) distribution where Re(z) = mean (μ) and Im(z) = standard deviation (s)

Command Line Options

Format: **LOOK [real file][imag file][RL][RL filename.RL][NOPAUSE]**

Real file	Preloads name of first file to read with RT, RF,, RA or RB. You can also drag files to the program icon.
Imag file	Preloads name of second file to read with RT, RF,, RA or RB. You can also drag files to the program icon.
RL	Repeats last run of LOOK. Commands are stored in LOOK32.RL in same folder as LOOK.EXE
RL filename.RL	Runs LOOK using a set of commands in a file with extension .RL that you have created or saved.
NOPAUSE	Runs LOOK without waiting for the escape key to exit graphs.

Notes On Order Of Operations

LOOK always performs operations in the same order, regardless of the order in which they are entered. The order is:

1. FUNCTION. Transform to time or frequency domain, if required.
2. PARAMETER or OPERATION. Perform the OPERATION or compute the PARAMETER
3. AVerage. Perform averaging, if specified
4. DIstribution. Compute probability distribution, if specified
5. CUmulative. Compute cumulative values, if specified
6. DB decibels. Convert to decibels, if specified
7. STatistics. Compute the statistics of the result, if specified.
8. PLot and its options (OVerlay, Modulo, WRap, SCale, LAbel, FOrmat), or FIle, or LIst

Therefore, the command SP PO DB ST CU DI PL does the following:

1) Compute spectrum of input signal (SP)
2) Compute power vs. frequency of spectrum (PO)

3) Compute probability distribution of power (DI)
4) Compute cumulative power distribution (CU)
5) Convert to decibels (DB)
6) Compute statistics of cumulative power distribution in decibels (ST)
7) Graph cumulative power distribution in decibels (PL)

Data Formats

LOOK can read and write data files in several formats. LOOK automatically determines which type of file it is reading. When writing a file with the **FI**le option, you can specify which type of file to write.

- **2C.** ASCII, two column. The file has two columns of numbers in ASCII format and a row (one record) for each sample point. This format can be used to import data from and export data to other programs such as spreadsheets. **INPUT:** The 2 numbers in each row are interpreted as the X and Y values, respectively, and may be separated by a space(s) and/or comma. They may be integers (e.g., 123, -64), floating point (e.g., 1.234, -567.0), or exponential notation (e.g., -1.4567E+02, .12345E-05). The first two X values are used to determine the first X value and the sampling interval; all subsequent X values are ignored. **OUTPUT:** The numbers are written in exponential format with 16 significant figures, separated by a comma.
- **1C.** ASCII, one column. As above, only one number in each row. This format can also be used to import data from and export data to other programs such as spreadsheets. **INPUT:** The number in each row is interpreted as a Y values. X values are set to 0,1,2,3, ... **OUTPUT:** The numbers are written in exponential format with 16 significant figures.
- **R8.** A format native to LOOK. The file has a 24 byte header: an 8 byte identifier, 'REAL 8', and 2 unformatted 8 byte reals representing the first value and sampling interval of the X scale. This is followed by the Y data in unformatted 8 byte reals (double precision).
- **R4.** A format native to LOOK. The file has a 24 byte header: an 8 byte identifier, 'REAL 4', and 2 unformatted 8 byte reals representing the first value and sampling interval of the X scale. This is followed by the Y data in unformatted 4 byte reals (single precision).
- **I2.** A format native to LOOK. The file has a 24 byte header: an 8 byte identifier, 'NTGR 2', and 2 unformatted 8 byte reals representing the first value and sampling interval of the X scale. This is followed by the Y data in unformatted 2 byte integers. The data must be in the range of (-32768, +32767) or errors will result.
- **WAV.** Microsoft WAV format. If the filename has an extension of **.WAV**, the imaginary filename is ignored and the file is read as a Windows WAV file. If the file is mono, the imaginary component will be set to zero. If the file is stereo, the left and right channels will be read into the real and imaginary components, respectively. The data must be in the range of (-32768, +32767) or errors will result.

Troubleshooting

Problem: LOOK will not show my graph.
Solution: Try specifying Xmin, Xmax, Ymin, Ymax instead of autoscaling. Autoscaling will not work when the range of the Y data or X data is zero.

Problem: My group delay or Instantaneous frequency data turns to "garbage" at the edges of the graph.
Solution: This is characteristic of the algorithms used when the magnitude of the data varies over 50+ db (typical for filters) or has discontinuities at the end points (typical for FM demodulation). Ignore the "garbage" regions or manipulate the signal so these conditions don't occur.

Problem: LOOK "crashes" during a calculation. There may be an error message indicating overflow or underflow or divide by zero.
Solution: LOOK handles most divide by zero exceptions without crashing. Very large (>1E100) or very small numbers (<1E-100) may result in underflows or overflows. Try using values nearer to one. Corrupted input data may result in "not a number" or "indefinite" errors. Check signal data -- convert to ASCII for inspection.

Problem: I get a message "NPTS must be a power of 2".
Solution: LOOK uses a fast Fourier transform routine algorithm that works only when the number of sample points is a power of 2 (2, 4, 8, 16, 32, 64, 128, 256, ...). Use the **CH**ange #pts to extend the number of sample points to the next highest power of two.

The FFT is used for many internal calculations including:

- **WA**veform
- **SP**ectrum
- **DX** time/freq deriv.
- **IX** time/freq integral
- **IN**stfreq (WA only)
- **GR**oup delay (SP only)
- **AC** auto-correlation A|B
- **CV** convolution of A&B
- **XC** cross-correlation A&B

Problem: I get "garbage" at the edges of my graph, or the computation looks correct except for an unexpected scaling factor, or the waveform is wrong or the spectrum is wrong.
Solution:

- This is a potential problem with any of the calculations that use a Fourier transform. Beware of: aliasing, picket fence effect, leakage, etc. that may affect the accuracy of sampled data which is Fourier transformed. Be sure the data is sampled at least at the

Nyquist rate (twice the highest frequency component). Use a windowing function to minimize leakage due to discontinuities at the ends of the sample. Periodic data should be sampled such that exactly a whole number of periods are contained in the length of the signal. Consult a digital signal processing textbook for other tips on avoiding errors in Fourier transforms.

- Scale factors. LOOK is normalized such that Parseval's relation is true;

$$\sum |x(t)|^2 \Delta t = \sum |X(f)|^2 \Delta f$$

In other words, total energy in the time domain equals total energy in the frequency domain. This is the usual convention for Fourier transforms.

- Waveform or spectrum wrong. See the notes on time/frequency scales for imported data under the **TR**ead and **FR**ead commands. LOOK will accept data with arbitrary time/frequency scales but the results of a Fourier transform may not be correct.
- LOOK automatically reorders the data as required for the FFT. All data read into LOOK should have time and frequency samples going in uniform steps from lowest to highest value. Data which has been rearranged for direct use with an FFT algorithm will give incorrect results.

Problem: Some operations, like Fourier transforms, are very slow or never finish.
Solution: LOOK can accommodate signals with millions of sample points. However, parts of those long signals must be stored in virtual memory, that is, on the computer’s hard disk. (Each sample point uses 52 bytes of memory.) The Fast Fourier Transform (FFT) algorithm requires random rather than sequential access to the signal data. That results in continual *paging*, that is, swapping blocks of data back and forth between memory and the hard disk. The result is very slow calculations, regardless of CPU speed. The only solutions are to use shorter signals or a computer with more physical memory.