

## CrossLoopPatterner User Guide

110.01.1609.UG

Sep 23, 2016



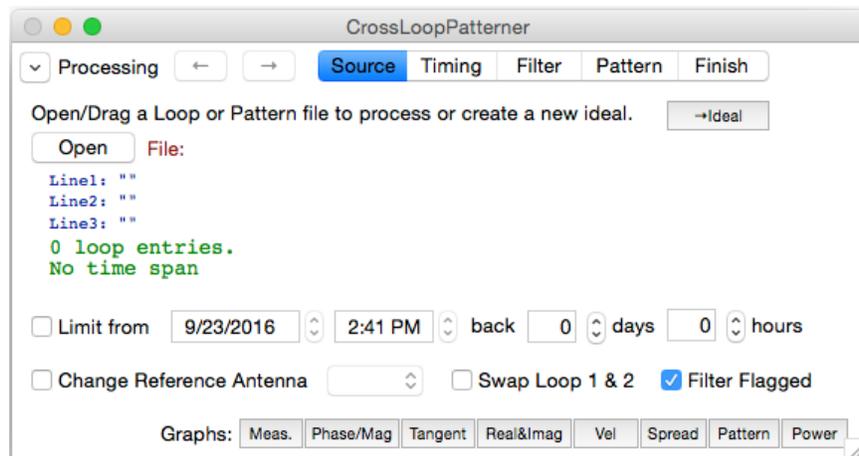
**CrossLoopPatterner** converts antenna pattern measurements (LOOP) files and AIS measurements into SeaSonde antenna patterns which are used to obtain more accurate current bearings.

The general method for creating an antenna pattern is:

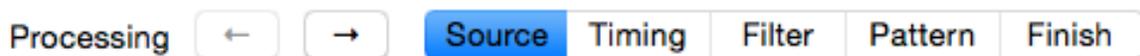
1. Walk or Cruise a Transponder & GPS in front of the antennas on a arc during which the GPS track is recorded and the SeaSonde Radial Site records Time series data.
2. Download the GPS track info into the computer and use utility GPSTracker to convert the GPS lat, lon, time into bearing, time from the SeaSonde Radial Site. The output file is a TRAK\_XXXX\_YYYY\_MM\_DD\_HHMM.trak file.
3. Use SeaSonde Acquisition to import the Time Series data in the diagnostics mode to record the measured transponder peak and the associative bearing from the GPS track. The Output file is an antenna measurement and bearing over time called a LOOP "LOOP\_XXXX\_YYYY\_MM\_DD\_HHMM.loop" file.
4. Use CrossLoopPatterner to filter bad measurement points, adjust for time discrepancies, smooth, interpolate and output the final Pattern file to be used by SeaSonde Radial processing software.

This document first covers the steps needed to create a measured pattern, followed by detail on the graph plots.

When you launch CrossLoopPatterner you'll see the follow window.



CrossLoopPatterner divides the processing tasks into different sections or steps which are indicated by the button bar.



If an AIS LOOP is used, an extra AIS Filter section is available and Timing is not needed.



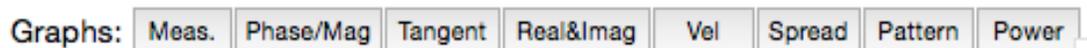
Creating a new pattern always starts with Source step. You can jump to any step by clicking on the button or by using arrow button which jump to the next or previous step.

- Source** Select the source Loop File(s)
- Timing** Adjust timing between Loop and Track files.
- Filter** Filter measurements.
- AISFilter** Filter AIS measurements.
- Pattern** Reduce, Smooth, and/or Interpolate.
- Finish** Save the Pattern File

Clicking the ->**Ideal** button jumps to a Ideal pattern creation mode.



The **Graphs** buttons select which plots to show.



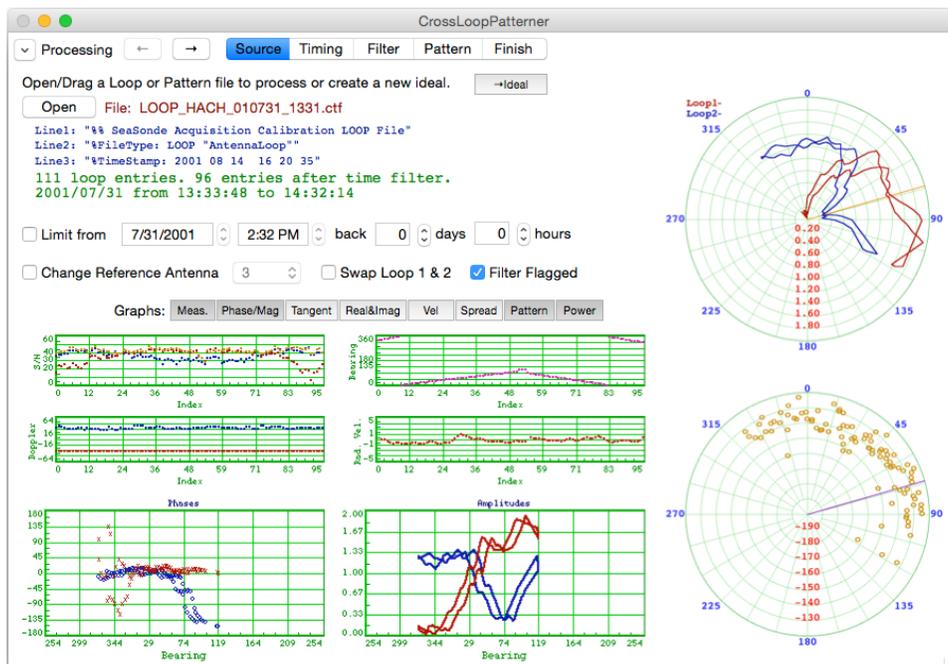
## Source Section

The first section Source is where you enter the LOOP file(s), Pattern file(s), or select 'Ideal' to start with. Select the radio button 'Ideal' if you want to switch to the ideal generator section.

To select a source file, use the Open button or drag a LOOP file to the window, or application's icon. Note, dragging a LOOP file to the application's icon will always take you back to the source section. CrossLoopPatterner will automatically load and identify the source file as a Measurement (LOOP) or Pattern file. If not a valid file, you will see '0 Loop Entries'. CrossLoopPatterner will show the first three lines of the file to help you identify the file. CrossLoopPatterner will then open several plots of the source data.

When you drop multiple files onto CrossLoopPatterner, it will use them all. Use the command key in the open dialog or in the Finder to select more than one file at a time.

The following graphs will open automatically when you drop the source and plot your source loops. Note that AIS loops are so large you might see a spin cursor while it loads them.



The blue text is the first three lines of the file and should indicate that it's a loop file. These are followed by green text which shows the number of loop measurements read and the time span of the measurements.

**Limit from** entries are an optional time filter which is typically only used for AIS Loops

Limit from     back   days   hours

**Change Reference** entries enables a swap the antennas if you think somehow they were assembled incorrectly.

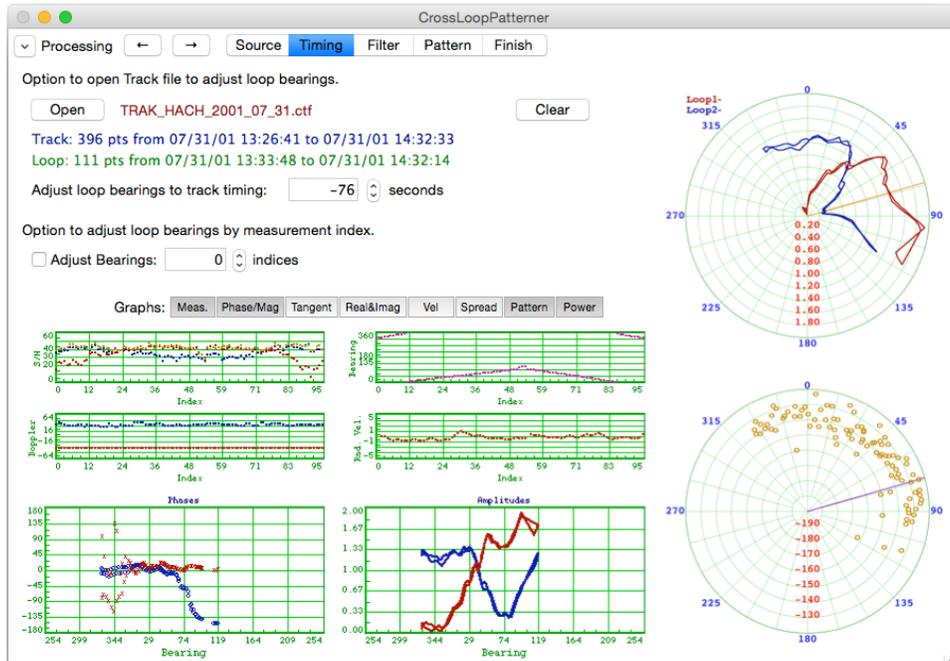
Change Reference Antenna    Swap Loop 1 & 2  Filter Flagged

If swapping, appears to create a valid antenna pattern, it cannot be used because it won't represent the swapped antennas; you'll need to correct the antenna connections on the SeaSonde.

Click on the right arrow button to proceed to the Timing section.

## Timing Section

The timing section is to adjust for possibly timing misalignment between the GPS time and the computer time. If the computer time was correct, then likely no adjustment is necessary. If the run was done with both CW and CCW arcs, then the two runs should line up. If they don't line up then likely the timing needs to be adjusted.



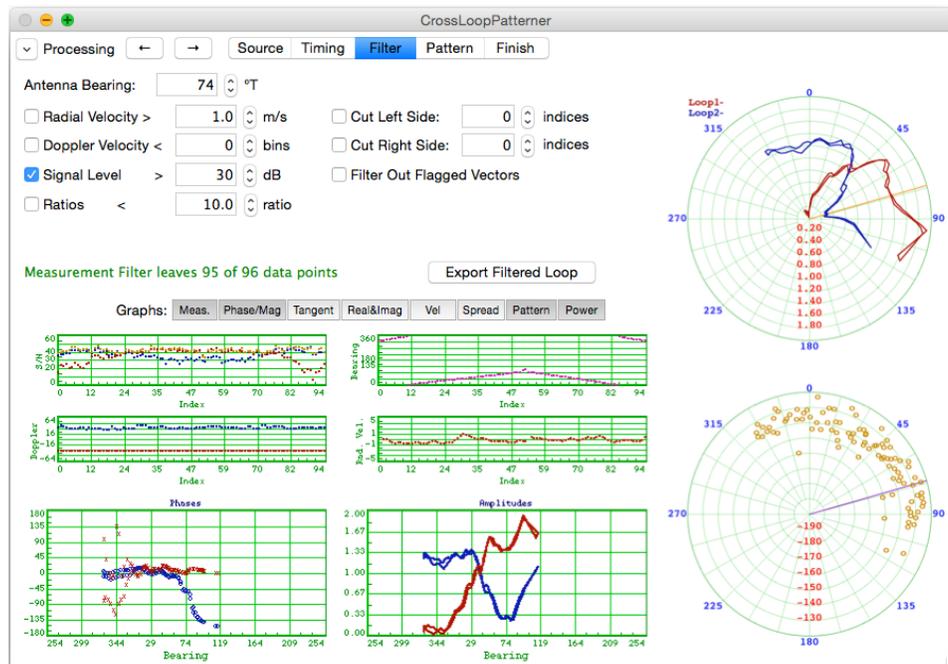
Drag the TRAK file onto the window or use the Open button to select the TRAK file. TRAK files are created with GPSTracker which calculates the bearing relative to the site for the measurement times.

If you know the timing error, enter it into Adjust loop bearings; otherwise, if you have a CW/CCW run then use the up/down arrow next to the Adjust loop bearings entry to change the timing until the two runs have maximum overlap like above example.

If you don't have a TRAK file, you can still adjust the bearings by setting the check box **Adjust Bearings** and adjust the indices entry, until the pattern runs have maximum overlap. This is not as accurate as a TRAK file, but will usually suffice.

## Filter Section

The Filter section is for removing undesired measurement points.



Near each edit field is an up/down spin control allowing you to change the value and see real time graph updates. Filtered out points will disappear from the graphs and the control dialog shows how many points are still valid (above example shows 95 out of 96 points). Each filter is enabled by setting the check box before the filter's name.

**Antenna Bearing** field sets where the main lobe of loop 1 is pointing relative to True North. (Note that all bearings in CrossLoopPatterner are handled as True North). In the Pattern Magnitudes polar graph, the antenna bearing is plotted as an orange line. Note, changing the Antenna Bearing does not rotate the pattern loop data.

**Radial Velocity** filter, if enabled, keeps all points, which have less than the entered velocity. The radial velocity is zero, if the Transponder kept a perfect arc relative to the SeaSonde Radial Site.

**Doppler Velocity** filter keeps all points, which are less than plus/minus entered cells from average doppler velocity cell. The doppler velocity cell is the cell of the transponder peak measured in SeaSonde Acquisition. If the transponder momentarily dropped out, another signal might be accidentally recorded into the loop. You would want to filter these points out. Note that if the transponder velocity exceeds the max / min doppler cells it will wrap to the negative/

positive doppler cell. In this case, CrossLoopPatterner will still calculate the average doppler cell making it a very poor filter.

**Signal Level** filter will keep all points, which have a signal to noise ratio greater than the entered dB. It will remove any point in the vertical (orange in signal to noise graph) is less than this value. It will only remove points in which both loop 1 (red) and loop 2 (blue), which are less than this value. Each loop can be expected to drop in signal to noise near its null region, which happens at a  $\pm 180$  deg. from its main lobe (strongest signal). **Signal Level filter is the most dominate filter for undesirable measurements.**

**Ratio** filter will keep all points where loop1 and loop2 have magnitude ratios less than this entry. **When processing AIS loops and even APM loops, be sure to set this to reasonable value to filter out a lot of undesirable results.**

**Cut Left Side** filter removes the entered number of points from the beginning of the loop file. Typically when start a transponder run the transponder may have been sitting still for while or setting up for the arc and you may not want to include the points. If you look at the Pattern Measurement graphs you can pick out the horizontal index you want to cut.

**Cut Right Side** filter removes the entered number of points from the end of the loop file. If you look at the Pattern Measurement graphs you can pick out the horizontal index you want to cut.

**Filter Loop File Flags** check box, if check marked, will remove any points whose Flag column value is not zero. SeaSondeAcquisition currently always sets this value to zero. It is still possible to hand edit the loop file to flag extra points you may wish to remove.

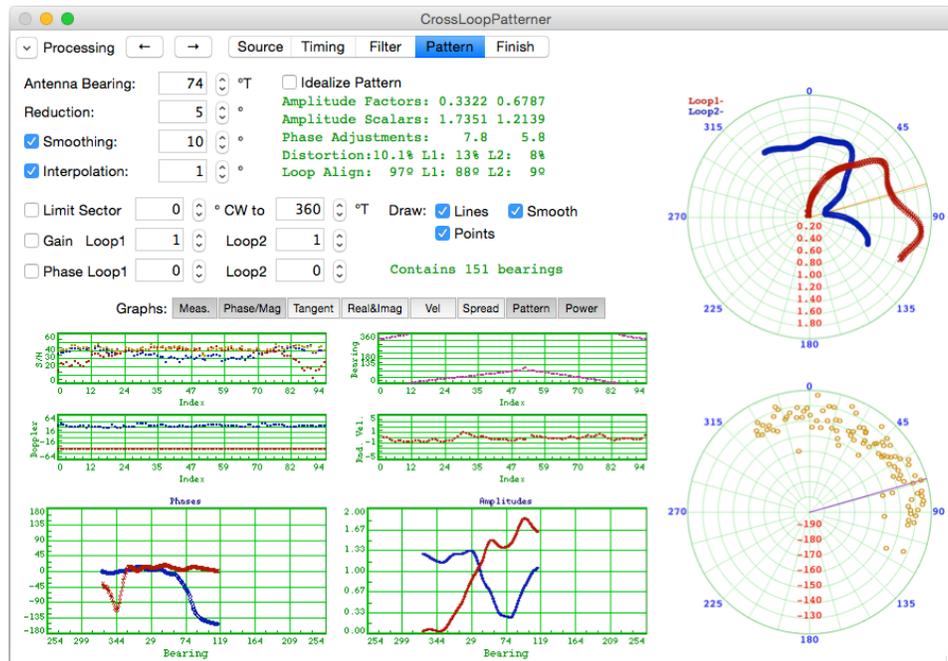
**Export Button** will output a Loop file of the filtered data. The point of this is if you want to further process the Loop file on your own and then import your filtered Loop file back into CrossLoopPatterner.

## **AIS Filter Section**

If the source is an AIS LOOP file, then this section comes after Filter. The AIS Filter is describe later in this document after the graph descriptions. Standard APM loop measurement does not use AIS filtering.

## Pattern Section

The Pattern section is for reducing, smoothing, and interpolation before saving the pattern.



The Antenna Bearing entry allows you to still change the bearing reference here. It is important to have the right antenna bearing at the time of the Transponder measurement. The pattern is stored relative to the antenna bearing.

CrossLoopPatterner applies, in order, first a reduction of 0.01 deg, then Smoothing, then the Reduction entry, then Interpolation, and lastly Idealize Pattern, if enabled.

The green text in the middle of the window are calculation on how the measured pattern varies from ideal.

```
Amplitude Factors: 0.3322 0.6787
Amplitude Scalars: 1.7351 1.2139
Phase Adjustments: 7.8 5.8
Distortion:10.1% L1: 13% L2: 8%
Loop Align: 97° L1: 88° L2: 9°
```

**Amplitude Scalars** are how much the measure pattern loop1 and loop2 magnitudes would need to be divided by to reach unity.

**Amplitude Factors** are one would multiply the cross spectra by to match an ideal pattern. These factors are one over the scalar squared.

**Phase Adjustments** are how much the measured pattern loop1 and loop2 phases are off from ideal.

**Distortion** is  $(1 - \text{correlation of ideal}) * 100$ . which is a measurement of how far off from ideal the pattern is where 0% is ideal and 100% is not very ideal at all. The L1 and L2 are distortion of the individual loops.

**Loop Align** is the bearing where the distortion is at a minimum. This is a possible indication of how the antenna might be rotated.

**Reduction** entry averages and reduces the loop to the entered precision. The Reduction entry causes all bearings within +/- the reduction/2 to be averaged into one point. Without Interpolation enabled this will be the output degree resolution of the pattern. Typically SeaSonde uses 5 degrees. This step is always required so that duplicate points at the same bearing are always averaged down to a single point.

**Smoothing** entry if enabled smoothes (averages) bearings over +/- the smoothing/2. It does not reduce the number of points like Reduction does.

**Interpolation** entry if enabled, it will fill in all points at the entered resolution. It is currently set to only interpolate between bearings at 30 deg or less apart. The interpolation is done using a cubic Bezier curve using the previous bearing and post bearing plus the two points be interpolated across (4 points). This is much the same as the Draw Smooth check box except that it is done on the real and imaginary parts of the pattern separately.

(You should always turn on interpolation at the output resolution of your pattern; otherwise any missing bearings in the pattern will show up as missing radial spokes in the output.)

**Idealize Pattern** entry uses the calculated amplitudes and phases with antenna bearing to create an ideal pattern at the Reduction resolution. This is typically only used as a visualization tool to see how far the actual pattern is from ideal.

**Draw Smooth** check box toggles drawing the graphs with a Bezier curve or straight line.

**Draw Lines** check box toggles drawing lines (straight or curved) between the points on and off for the Pattern Magnitudes polar plot.

**Draw Points** check box toggles drawing markers at the data points for the Pattern Magnitudes polar plot. (X's for Loop 1. O's for Loop 2).

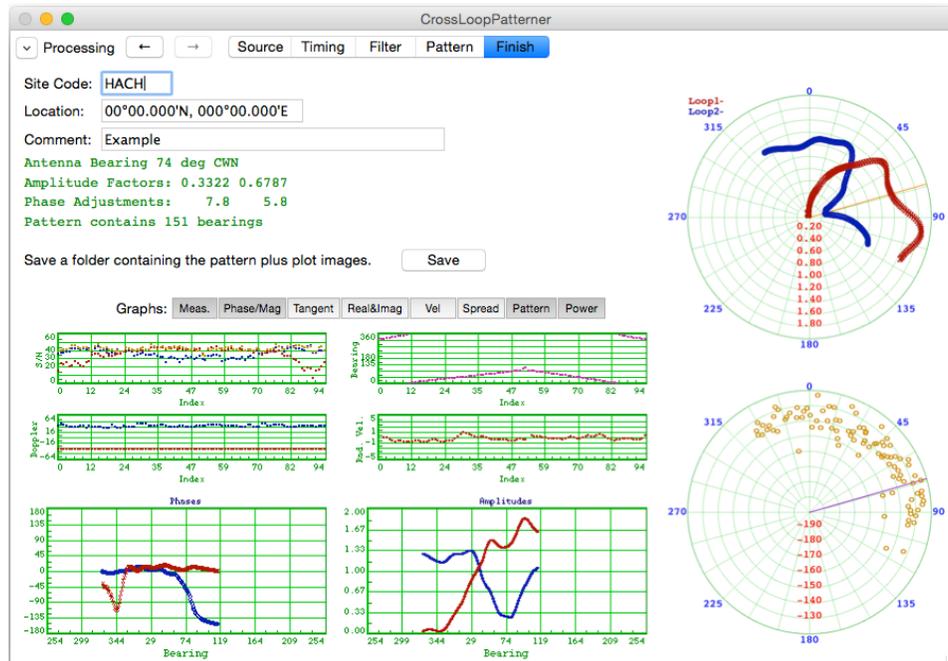
**Limit Sector** entries allows you to cut off a portion of the pattern. You would only do this if you thought that part of the pattern was not good. The kept part of the pattern will be clockwise from the Start Angle to the Stop Angle.

**Gain Loop 1** and **Loop 2** entries allow you to scale the loop magnitudes up or down. There is no reason to do this for normal patterns.

**Phase Loop1** and **Loop 2** entries allow you to adjust the phases. There is no reason to do this for normal patterns.

## Finish Section

The Finish section allows you to enter site info and a user comment before saving the pattern file.



**Site Code** entry is the four-character site name.

**Location** entry is the latitude,longitude of the site. This is typically already set by from Loop file.

Alternately, drop a RadialConfig/Header.txt file onto this window to automatically update the Site Code, Lat and Lon entries.

**Comment** entry is whatever you want as a note about the pattern. It's common to put your Initials here.

**Save** button will create a folder that contains the pattern, png images and source loops and trak files. The folder default name is PATT\_XXXX\_YYYY\_MM\_DD\_HHMM.xlp. The file MeasPattern.txt is the one to copy to RadialConfigs folder for future radial processing. Phases.txt can also be copied to RadialConfigs folder which is used for ideal pattern processing as a backup when measured pattern no longer fits the actual pattern because something changed at the site.

## Graphs

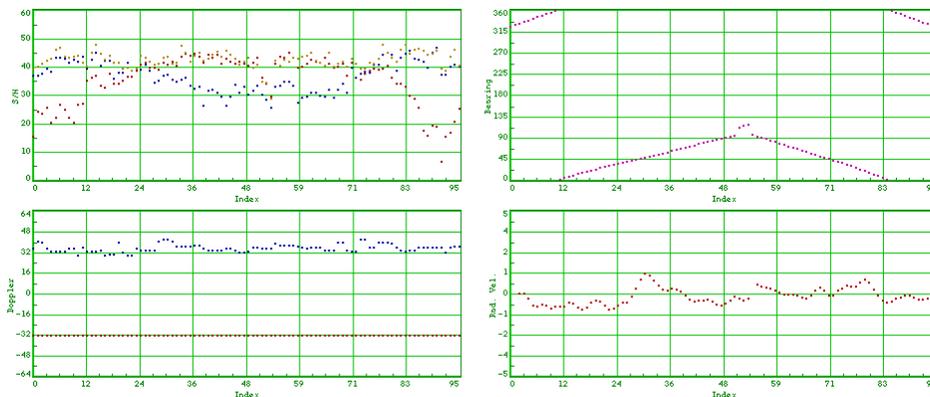
The buttons following “Graphs:” toggle each graph on and off. The button is a dark gray when graph is enabled. CrossLoopPatternner automatically adjusts the size of the graphs to fill the window.



To save any graph image in png format, first select the graph by clicking on it, then use menu File -> Save Image...

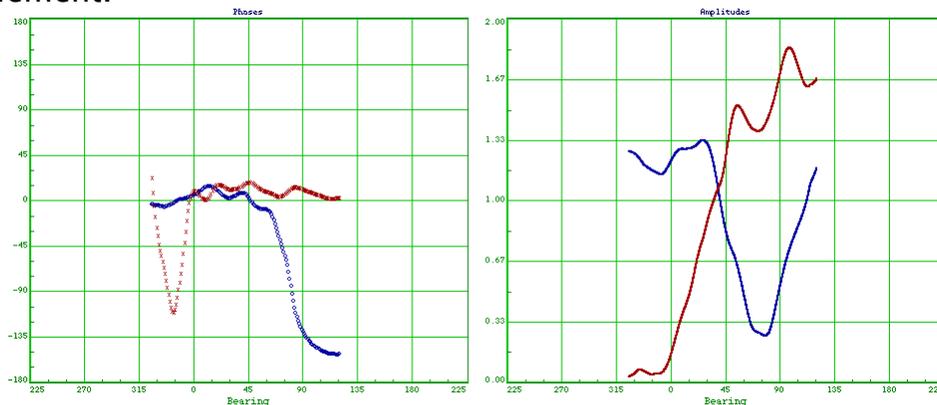
### Meas. Graph

Measurement graph is composed of four different graphs of signal to noise, bearing, signal range and doppler bins, and radial velocity versus measurement index. For Signal to Noise Loop1 is red, Loop2 is blue and Vertical is orange. Loop1 and Loop2 are expected to drop in power in the null of the loop. For range and doppler bins, range is red (different scale of 0 to max range) and doppler bin is blue. This indicate how stable the transponder signal is.



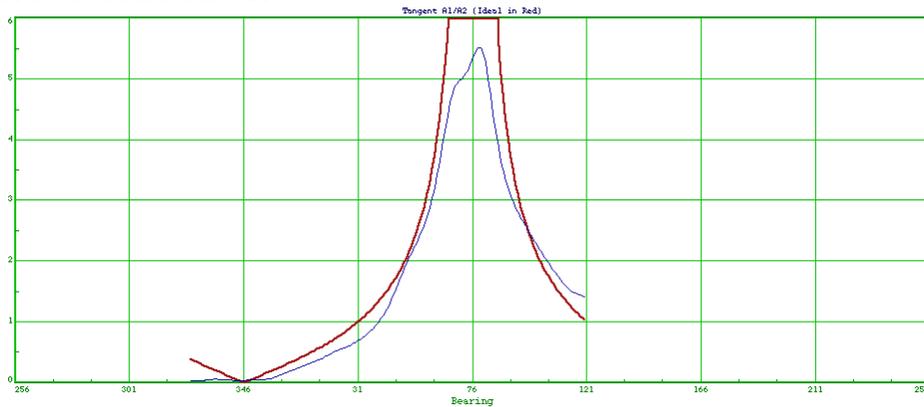
### Phase/Mag Graph

Shows phase and magnitude of loop1(red) and loop2(blue) relative to the vertical element.



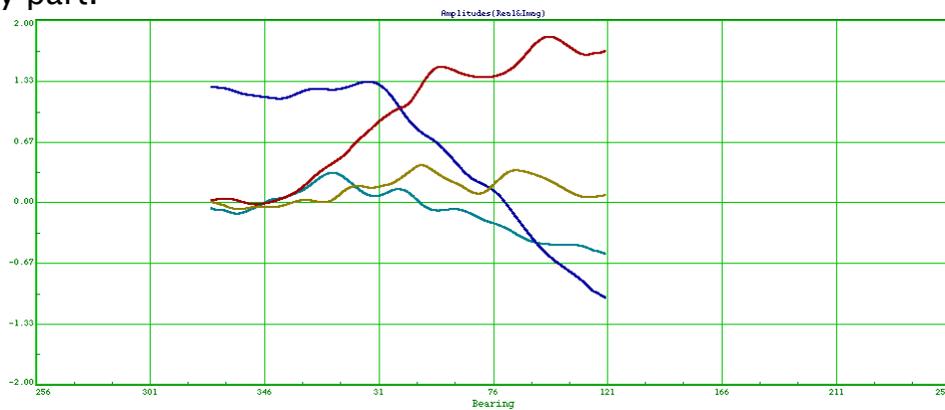
## Tangent Graph

Tangent graph is a plot of  $\text{loop1}/\text{loop2}$ . This is an indication of how balanced the loops are to each other.



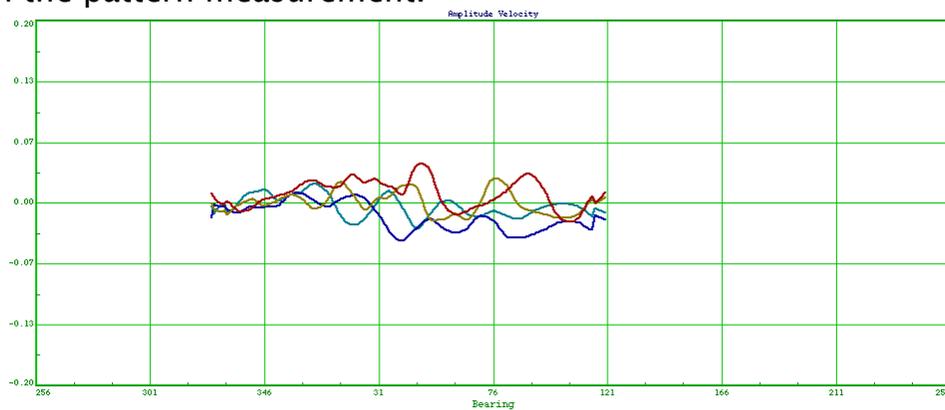
## Real&Imag Graph

Real and Imaginary components of loop1 and loop2 ratios. Red is Loop1 real part. Yellow is Loop1 imaginary part. Blue is Loop2 real part. Teal is Loop2 imaginary part.



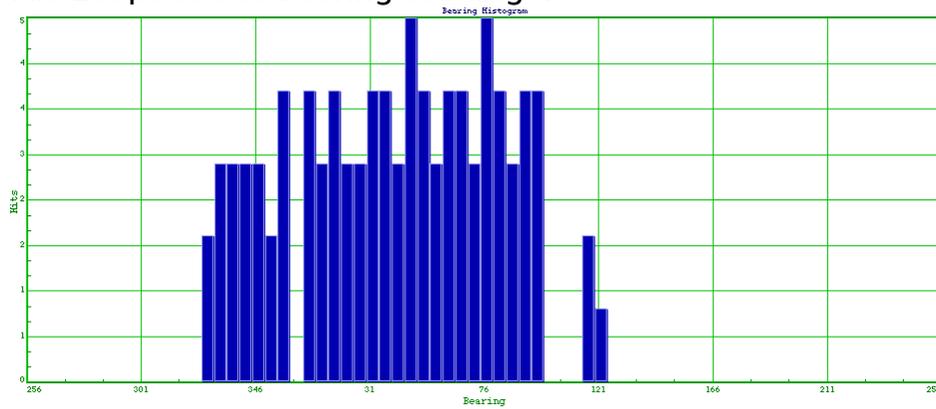
## Vel Graph

Velocity graph is a plot of the rate of change of the real and imaginary parts of Loop1 and Loop2. Spikes or large jumps here indicate an improbably rate of change in the pattern measurement.



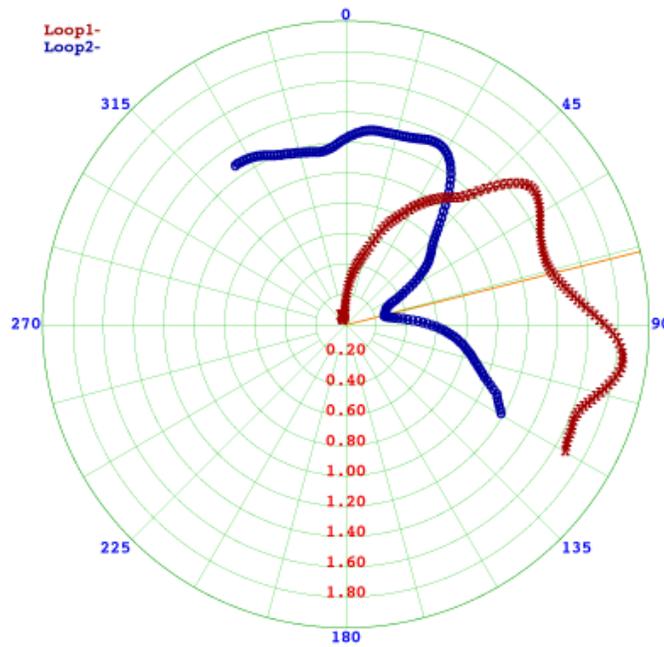
## Spread Graph

Distribution of number of measurements for each 5 degrees. This is most useful for AIS Loops to see bearing coverage.



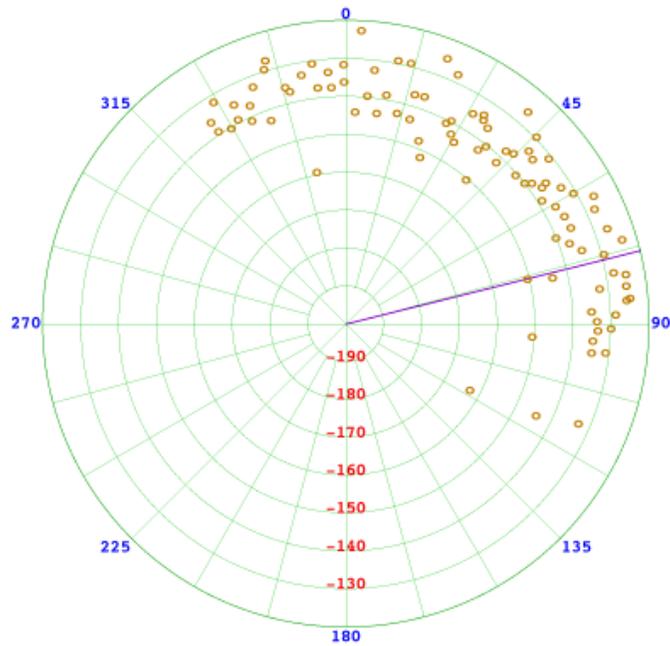
## Pattern Graph

Magnitude plots of Loop1(red) and Loop2(blue) versus bearing. This illustrates how well the pattern matches the ideal cross loop pattern.



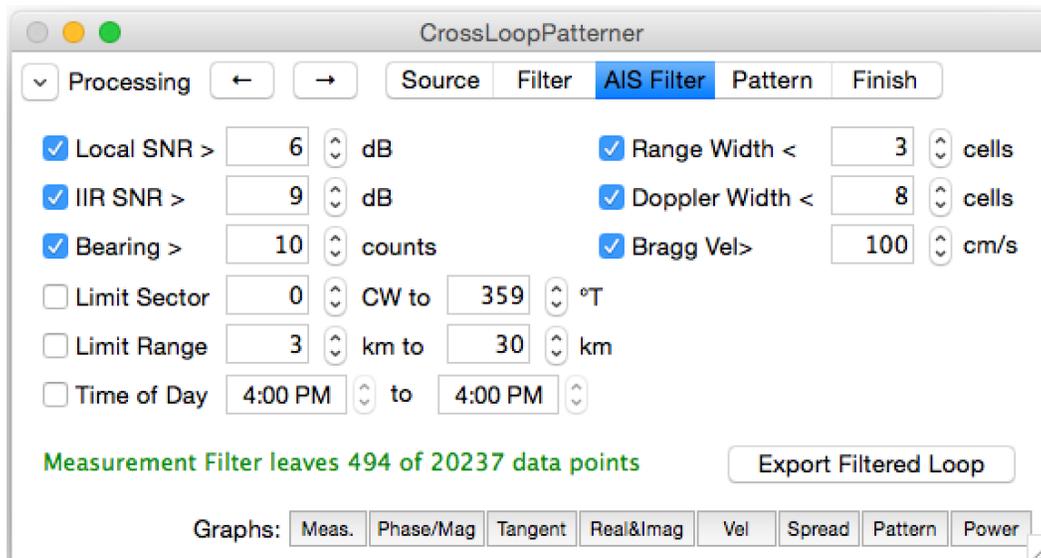
## Power Graph

Plot of vertical antenna power versus bearing. Where this drops, it shows possible coverage issue or something happened to the transponder signal in that sector.



## AIS Filter Section

AIS Loop measurements contain a lot more noisy measurements which need to be filtered out.



**Local SNR** filters low S/N where noise floor was calculated using near by doppler and range.

**IIR SNR** filters low S/N where S/N is calculated based on using a background IIR average of past cross spectra.

**Bearing** filters out bearings where there were less than this entry counts per 5 degree bin.

**Range Width** filters out where the signal power spans more than entered range cells.

**Doppler Width** filters out where the signal power span more than entered doppler bins.

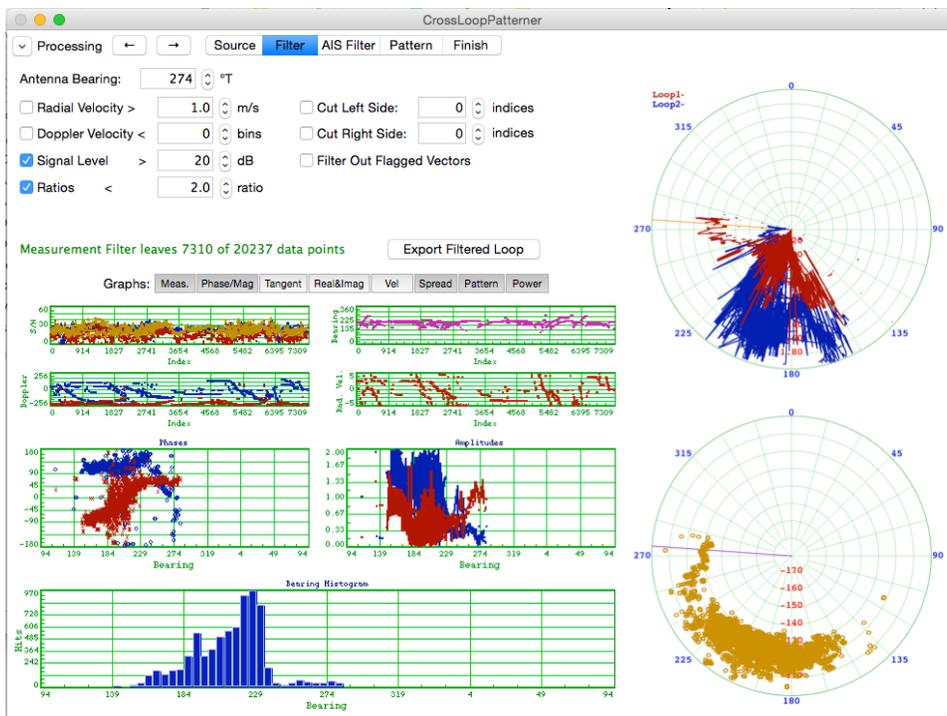
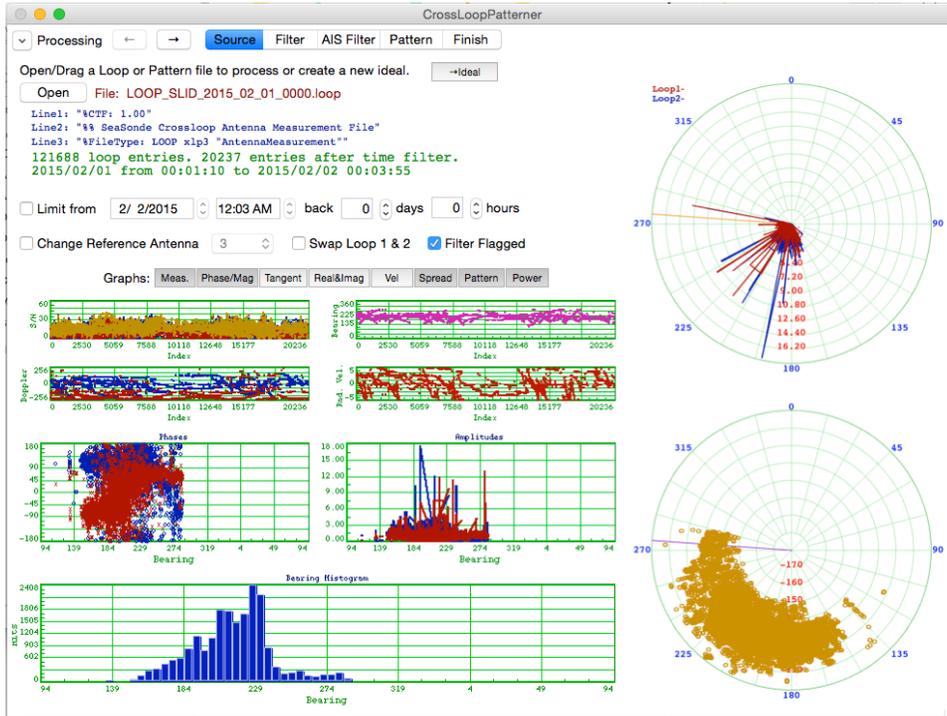
**Bragg Vel** filters out measurements that closer in doppler bins to the Bragg Index than this specified current velocity.

**Limit Sector** entries limit the field of view from the site for starting bearing True going clockwise to stop bearing True.

**Limit Range** entries limit the range of AIS measurements detected from the site in kilometers.

Time of Day entries limit the AIS measurements to specific part of the day. Some SeaSonde have a high diurnal noise variation, so filter out the high times can help.

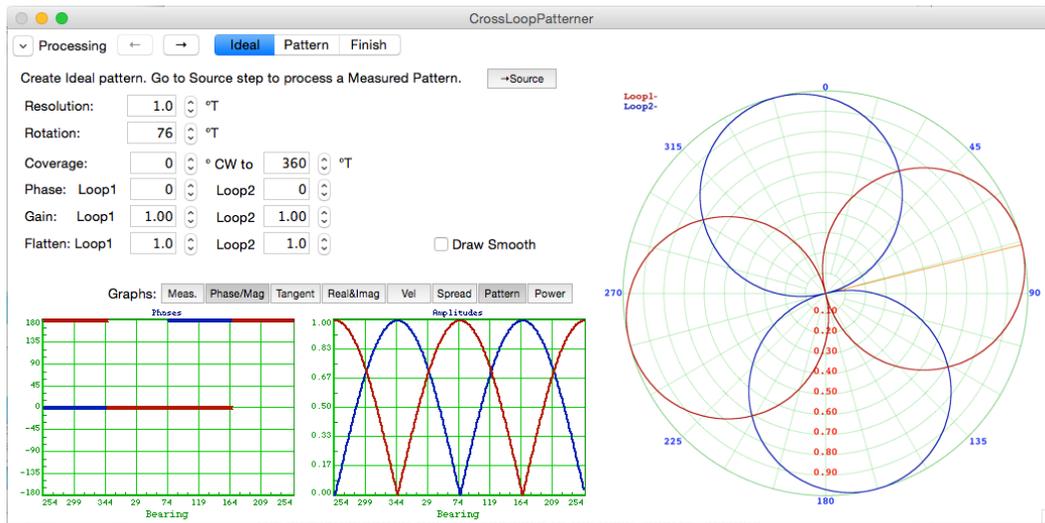
## AIS Loop Example





# Ideal Mode

The Ideal mode allows you to create/explore an ideal antenna pattern.



→**Source** button will take you back to the main "Source" section.

**Resolution** entry sets the bearing degree resolution of the pattern. SeaSonde uses 1 degree.

**Rotation** entry will rotate the pattern. Although typically zero, this entry will not matter as the antenna pattern is always references to the SeaSonde Radial Site's bearing.

Warning: Changing the following from the typical / default will create a non-standard ideal pattern. These are available for experimentation use only.

**Coverage** entries sets the starting bearing angle clockwise to non-inclusive stopping bearing angle of the pattern. Typically, start and stop would be 0,360.

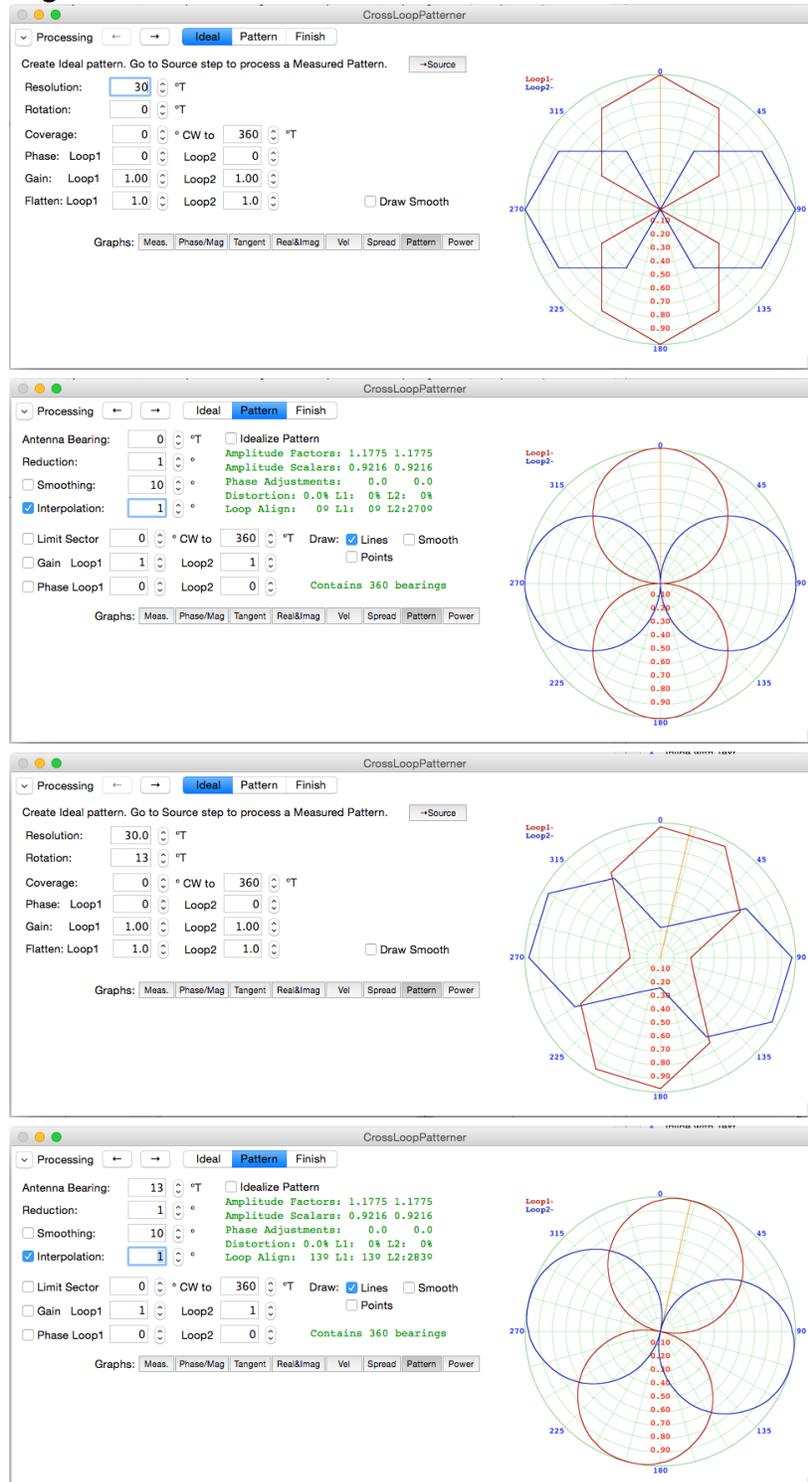
**Phase** entries adjust the Loop1 and Loop2 Phases. (Graphs shows Loop1 as red and Loop2 as blue.)

**Gain** entries are multiplication factor on the magnitude of Loop1 and Loop2. Default value is one for an ideal pattern.

**Flatten** entries apply a power factor on the magnitude of Loop1 and Loop2. Typical value is one. Values >1 apply a  $\text{pow}(\text{mag}, \text{squish})$  causing the circular lobe to narrow. Values <0 apply a  $\text{pow}(\text{mag}, 1/(-\text{squish}))$  cause the circular lobe to widen. This adjustment is for trying out an artificial distortion.

## Interpolation.

Pattern interpolation is done using a cubic spline applied to real and imaginary parts separately. You should typically avoid trying to interpolate across a missing expected null in the cross loop pattern. The following illustrates how well interpolation works by using the ideal pattern with very coarse resolution and interpolating across.



## **Revision History**

First Draft Sep 23, 2016

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