

Bandpass Filter

Bandpass Filter applies a frequency filter(s) to each input trace.

Theory

The filter algorithm operates in the frequency domain. You can specify one or more sets of bandpass filter frequencies, and a set of notch filter parameters. Filters are four-frequency Ormsby or Butterworth, and can be zero phase or minimum phase.

This process allows you to perform three types of bandpass filtering:

- **Single bandpass filter** applies a single filter to all traces at all times. This filter is input via the keyboard. Only the four corner frequencies need be specified for the Ormsby filter or only one group of (freq-slope-freq-slope) for the Butterworth filter.
- **Time variant filter** allows you to specify a time-varying filter, which is then applied to all traces. This filter is input via the keyboard. The first filter is applied from the beginning of the trace to the end of the first window, then with decreasing linear taper to the beginning of the second window. The second filter is applied with increasing linear taper from the end of the first window to the beginning of the second window, and so on. The last filter is then held constant through the last window to the end of the record. Filter windows may overlap.

Avoid using filter windows which abut one-another since this provides no opportunity for interpolation between windows and may create artifacts.

- **Time and spatially variant filter** applies a series of time varying filters that vary along the seismic line.

Usage

You can specify the percent of the input trace to pad with zeroes for FFT considerations.

A notch filter can be applied in addition to the bandpass filter. You can control the center frequency and width of the notch. The notch filter can also be centered at the maximum spectral amplitude within a specified frequency range by using the automatic notch frequency search option.

Each filter is specified by a set of four integers separated by dashes. The numbers sequentially represent the 0% and 100% points of the low-cut ramp, and the 100% and 0% points of the high-cut ramp in Hz for the Ormsby filter, and -3dB low frequency - low slope - -3dB high frequency -high slope for the Butterworth filter. The ramps for the Ormsby filter are formed by cosine tapers (Hanning windows) in the frequency domain. The Butterworth ramps are formed by:

$$\frac{1}{\sqrt{1 + \left(\frac{F}{FMID}\right)^{2P}}}$$

where FMID is the center frequency of the pass band and P is computed for the lower and upper slopes to get the correct dB/octave rolloff.

References

- Oppenheim A. V., and Schaffer, R. W., 1975, Digital signal processing, 211-218: Prentice-Hall.
- Robinson E. A., and Treitel, S., 1964. Principles of digital filtering: Geophysics, 29, 395-404.
- Yilmaz. O., 1987, Seismic data processing: Society of Exploration Geophysicists, 20-26.

Parameters

TYPE of filter

Select the type of filter to apply to input data from the following choices:

- **Single Filter** applies a single bandpass filter, specified as four corner frequency values.
- **Time and Space-Variant Filter** applies time and space variant filters in space variant time windows.

Type of filter specification

Select the type of filter from:

- **Ormsby bandpass** specifies filters using four frequencies.
- **Butterworth bandpass** specifies filters using (F1-db/Octave1) - (F2-db/Octave 2).

PHASE of filter

Select the phase of your bandpass filter(s) from: **Zero phase** or **Minimum phase**.

Percent additive noise factor

This appears if **Minimum phase** to **Phase of filter**. Enter the percentage of the maximum frequency to add to the spectrum prior to conversion to minimum phase.

Domain for filter application

This appears if **Single Filter** to **Type of filter**. Select either **Frequency** or **Time domain** filter application.

Tapered filter length in ms

This appears if **Time domain** to **Domain of filter application**. Enter a Hanning tapered length in ms. Accepted values are between **20-1000** ms. The resulting time domain filter will not have the same rejection as those applied in the frequency domain unless the filter length is quite long, such as 300-600 ms. However, a modest 160 ms filter is often accurate enough for most prestack applications and may be considerably faster on some machines.

Beyond performance issues, a truncated time domain filter can be desirable due to its limited temporal effects. For example, large amplitude events or noise bursts can only affect the trace a half filter length above and below the offensive sample.

Percent zero padding for FFTs

This appears if **Frequency** to **Domain of filter application**. Enter the percentage of the input trace length to pad with zeroes to avoid wrap-around effects of circular FFTs.

Apply a notch filter?

Select **Yes** to apply a notch filter to all input traces. A notch filter may be applied at virtually any frequency.

Notch filter frequency

This appears if **Yes** to **Apply a notch filter**. Enter the center frequency of the notch filter to apply in Hz.

Example: 60.0

Width of notch filter

This appears if **Yes** to **Apply a notch filter**. Enter the width of the notch filter to be applied, in Hz. A notch filter at 60 Hz with a width of 2 Hz will provide a 59 - 61 Hz notch, with exponential edge tapers. A wider filter will produce more attenuation at the central frequency than a narrower filter.

Automatic notch frequency search?

This appears if **Yes** to **Apply a notch filter**. Select **Yes** to center the notch at the maximum spectral amplitude.

Maximum notch frequency variation

This appears if **Yes** to **Automatic notch frequency search**. Enter the maximum notch frequency variation. This is the frequency range on either side of the spectral maximum where the notch is centered. A value of 3.0 based on a 50 Hz notch will center the notch on the maximum spectral magnitude found between 47 and 53 Hz.

Ormsby filter frequency values

This appears if **Single Filter** to **Type of filter** and **Ormsby bandpass** to **Type of filter specification**. Enter a set of four Ormsby corner frequencies separated by dashes. The values may be integers or real numbers. They represent sequentially the 0% and 100% points of the low-cut ramp, and the 100% and 0% points of the high-cut ramp, in Hz. These ramps are formed by Hanning (cosine) tapers in the frequency domain.

For example, the entry

0-0-40-60

creates a 20 Hz wide high-cut ramp. For high-cut filters the first two frequencies are set to zero. And similarly, for low-cut filters the third and fourth frequencies are set to Nyquist.

The entry

```
5-10-Nyq- Nyq
```

creates a 5 Hz wide low-cut ramp.

Butterworth filter freq-slope values

This appears if **Single Filter** to **Type of filter** and **Butterworth bandpass** to **Type of filter specification**. Enter a set of freq - slope - freq - slope values separated by dashes, where frequency values represent the -3dB points of the amplitude spectrum. For example, the entry

```
10-18-40-36 /
```

creates a 10 to 40 Hz pass-band filter with an 18 dB/octave low roll-off and a 36 dB/octave high roll-off. The 10 and 40 Hz value correspond to the -3 dB points of the filter.

Space-variant filter parameters

This appears if **Time and Space-Variant** to **Type of filter**. Enter each time gate value. The editor window contains both the generic format for value entry, and an example. If you are using a time gate parameter file, then the primary and secondary location keys must be the same as the data sort order when the parameter file was created. If no header word values are specified, either a 1: or a 1:1: is automatically inserted for header word values.

Ormsby bandpass

For a single time-invariant filter, only a single filter should be entered. For example, the entry

```
6-10-40-60/
```

creates a 10 to 40 Hz pass-band filter with a 4 Hz wide low-cut ramp and a 20 Hz wide high-cut ramp.

Multiple frequency bandpass filter specifications are separated by commas. For example, the entry

```
5-10-40-60,8-12-80-120/
```

creates two Ormsby filters, the first with a 10 to 40 Hz pass-band with a 5 Hz wide low-cut ramp and a 20 Hz wide high-cut ramp. The second filter will be a 12 to 80 Hz pass-band with a 4 Hz wide low-cut ramp and a 40 Hz wide high-cut ramp.

Butterworth bandpass

The entry

10-18-40-36,12-24-80-72/

creates two Butterworth frequency bandpass filters, the first with a 10 to 40 Hz pass-band with a 18 db/octave low-cut roll-off and a 36 db/octave high-cut roll-off. The second filter will be a 12 to 80 Hz pass-band with a 24 db/octave low roll-off and a 72 db/octave high roll-off.

Note: The number of filters and time gates must match exactly. You should be warned that this is a much slower process than a simple bandpass filter.

Get time gates from the DATABASE?

This appears if **Time and Space-Variant** to **Type of filter**. Select **Yes** if you interactively created a parameter file containing spatially varying time gates. Enter **No** to enter a single time-invariant bandpass filter, or a spatially varying bandpass filter from the keyboard.

Note: Avoid using time gates which abut one another since this provides no margin for interpolation between windows.

SELECT time gate parameter file

This appears if **Yes** to **Get time gates from the Database**. Select a filter time gate parameter file.

SELECT Primary time gate header word

This appears if **No** to **Get time gates from database**. Select a header word to use as the primary key for specifying time gate values. Time gates can be specified without a primary header word selection.

SELECT Secondary time gate header word

This appears if **No** to **Get time gates from database**. Select another header word to use as the secondary header word

key for specifying time gate values. A secondary header word selection is not required.

SPECIFY filter time gate parameters

This appears if **No** to **Get time gates from database**. Enter values for the primary header word, the secondary header word, and the time gate(s) for a time-variant filter, each value separated from the previous one by a colon. The editor window contains both the generic format for value entry, and examples. For example:

Primary header word:	Secondary header word:	Time gate/
Source(1):	Aoffset(1):	Time gate(1)/
1:	0:	700-2000/

Source(1):	Aoffset(2):	Time gate(2)/
1:	5280:	1200-2200/

You can define multiple time gates per primary:secondary header word location by separating them with commas. You may define additional time gate location changes by specifying more Source or CDP values farther along your dataset, with corresponding secondary values and time gates.

Examples:

1:10560:1500-2400/

1:0:700-2000,2500-4000/

20:0.0:800-2100/20:2640:1200-2400/20:5280:1500-2500/

Design windows are interpolated between locations and extrapolated as constant outside specified location ranges. If no primary location key is specified, then one set of windows is used for the entire dataset, and only time ranges are entered.

A wildcard character * is supported for entire trace time window specification. For example:

CDP:Time gate/

101:0-4000/ is the same as 101:*/

where 4000 ms is equal to the trace length

Reapply trace mute after filter?

Select **Yes** to reapply a trace mute to your data after filtering. Select **No** to leave the data as output. You will probably want to reapply mutes after filtering stacked data.