



# COMPASS – Strong Motion

Interactive Weak and Strong Motion Data Processing Software

Rev 2008.11.19 Document Rev C

2011.02.22

This COMPASS manual provides a detailed overview of using the Strong Motion processing menu of the COMPASS software. It covers the following broad operational topics: Loading RAW REF TEK Acceleration records, providing parameters, Stage 1 Base Line, Stage 2-4 setting parameters and Final steps display and print.



**Refraction Technology**  
**1600 Tenth Street**  
**Suite A**  
**Plano, Texas 75074**  
**Tel: 214-440-1265**  
**Fax: 972-578-0045**  
[www.reftek.com](http://www.reftek.com)

## COMPASS – Strong Motion

---

### Revision History:

Revision	Date	Reason for change	Pages
C	2008.12.30	New Version 2008Nov19	All
B	2008.07.08	Updated for COMPASS	All
A	2007.05.05	Update for REF TEK SM	All
0.1	2007.02.23	Initial Draft	All

**Copyright© 2009 Refraction Technology, Inc.**

**All rights are reserved. No part of this manual may be reproduced, copied or transmitted in any form outside the approved recipient's organization without written permission from Refraction Technology Inc.**

**Printed in USA.**

## Notation Conventions

The following notation conventions are used throughout REF TEK documentation:

Notation	Description
ASCII	Indicates the entry conforms to the American Standard Code for Information Interchange definition of character (text) information.
Binary	Indicates the entry is a raw, numeric value.
Hex	Indicates hexadecimal notation. This is used with both ASCII characters (0 – 9, A – F) and numeric values.
BCD	Indicates the entry is a numeric value where each four bits represents a decimal digit.
FPn	Indicates the entry is the ASCII representation of a floating-point number with n places following the decimal point.
<n>	Indicates a single 8-bit byte. When the contents are numeric, it indicates a hexadecimal numeric value; i.e. <84> represents hexadecimal 84 (132 decimal). When the contents are capital letters, it represents a named ASCII control character; i.e. <SP> represents a space character, <CR> represents a carriage return character and <LF> represents a line feed character.
MSB	Most Significant Byte of a multi-byte value.
MSbit	Most Significant Bit of a binary number.
LSB	Least Significant Byte of a multi-byte value.
LSbit	Least Significant Bit (bit 0) of a binary number.
YYYY	Year as a 4-digit number
DDD	Day of year
HH	Hour of day in 24-hour format
MM	Minutes of hour
SS	Seconds of minute
TTT	Thousandths of a second (milliseconds)
IIII	Unit ID number

n, nS	nano, nanoSecond; $10^{-9} = 0.000000001$
u, uS	micro, microSecond; $10^{-6} = 0.000001$
m, mS	milli, milliSecond; $10^{-3} = 0.001$
K, KHz	Kilo, KiloHertz; $10^3 = 1,000$
M, MHz	Mega, MegaHertz; $10^6 = 1,000,000$
G, GHz	Giga, GigaHertz; $10^9 = 1,000,000,000$
Kb, KB	Kilobit, KiloByte; $2^{10} = 1,024$
Mb, MB	Megabit, MegaByte; $2^{20} = 1,048,576$
Gb, GB	Gigabit, GigaByte; $2^{30} = 1,073,741,824$

**Related Manuals:**

<b>130-SMA System Documents</b>	<b>Number</b>	<b>PDF file</b>
130-SMA Startup (Command Line)	Doc-SMA-Ops	130SMA_startup.pdf
Data Utilities Users Guide	Doc-Datautils	130_utilities.pdf
<b>130-SMA Command Interface</b>	<b>Number</b>	<b>PDF file</b>
130 Cmd Line - Theory of Operations	Doc-CmdL-Theory	130_CLtheory.pdf
130 Cmd Line - Release Notes	Doc-CmdL-Release	130_CLRN.pdf
130 Cmd Line - Reference	Doc-CmdL-Ref	130_CLcmd.pdf
130 Cmd Line - Recording Format	Doc-CmdL-Record	130_CLrecord.pdf
130-SM GUI Users Guide	Doc-130-SMGui	RT130SM.pdf
<b>Optional Manuals</b>	<b>Number</b>	<b>PDF file</b>
SNDP Installation and Users Guide	Doc-SNDP-Users	SNDPUser.pdf
SNDP Reference Guide	Doc-SNDP-Reference	SNDPRef.pdf
RTCC Command / Control Users Guide	Doc-RTCC	RTCC.pdf
RT_Display Users Guide	Doc-RTDisplay	RTDisplay.pdf
RT_View Users Guide	Doc-RTView	RTView.pdf
RTPMonitor Installation and Users Guide	Doc-RTPMonitor	RTPM.pdf
RTPD Installation and Users Guide	Doc-RTPD	RTPD.pdf
RTP Protocol	Doc-RTProtocol	Rtprotocol.pdf
<b>Accelerometers</b>		
131A-02/3 3G Triaxial Accelerometer	Doc-131A-03/2	131A023.pdf
131A-02/2 3G Triaxial Accelerometer	Doc-131A-02/2	131A022.pdf
131A-01/3 4G Triaxial Accelerometer	Doc-131B-01/3	131B013.pdf
131B-01/1 4G Unixial Accelerometer	Doc-131B-01/1	131B011.pdf

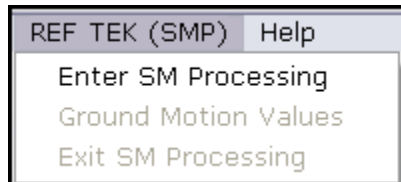
---

**Software Version:**

Current software and documentation is available on our web site. Some early units may require hardware modifications to use the latest software. Contact REF TEK if you have any queries on the compatibility of your unit(s) and the current software release.

**About this manual:**

This COMPASS Technical Reference manual provides a detailed overview of using the Strong Motion Processing menu of the COMPASS software. It covers the following broad operational topics:



- Loading RAW REF TEK Acceleration records.
- Provide Strong Motion Processing parameters with Spectral plot options.
- Stage 1 - Base Line and Side Effect Processing.
  - Uncorrected Acceleration
  - Remove Side Effects
- Stages 2 – 4 Corrected Acceleration, Velocity and Displacement.
  - Compute Response Spectra
- Final Stage – Display and Print.
- Preview Ground Motion Values.

## **REF TEK      Support and update notifications**

**As a valued user of REF TEK equipment we would like to provide the best support possible by keeping you up to date with our product updates.**

**If you would like to be notified of any REF TEK product updates please spend a couple of minutes to register with the REF TEK customer support team.**

**To register, enter your company information through the [Register](http://support.reftek.com) link on our website at <http://support.reftek.com> .**

**Our support team will send you a unique Username and Password allowing secured access to all product documentation and software sold to your company.**

**Once we register your contact we will only send necessary notifications via email. The same notifications will be shown on our website <http://support.reftek.com> notifications page**

**Thanks,**

**Your REF TEK support team**

## Contents

<b>9 Strong Motion Processing .....</b>	<b>1</b>
9.1 REFTEK (SMP) Menu.....	1
9.1.1 Comments .....	2
9.1.2 Process records obtained on REF TEK Accelerometers.....	3
9.1.3 Provide Strong Motion Processing parameters: .....	5
9.2 Stage 1 - Base Line and Side Effect method .....	7
9.2.1 Compute Stage 1 – Uncorrected Acceleration .....	7
9.3 Setting parameters for Stages 2 - 4 .....	8
9.3.1 Compute Stage 2 – Corrected Acc, Vel, Displacement.....	8
9.3.2 Compute – Response Spectra .....	8
9.3.3 Final Steps.....	9
9.4 Ground Motion Values .....	11
9.4.1 Parameters are computed for each component: .....	12
9.5 Exiting Reftek (SMP) .....	12

---

**This Page Left Intentionally Blank**



**List of Figures:**

Figure 9-1 Traces not selected Error .....	2
Figure 9-2New Trace .....	3
Figure 9-3 Select RAW File .....	3
Figure 9-4 Select Channels .....	3
Figure 9-5 Zoom In .....	4
Figure 9-6 Strong Motion Processing.....	4
Figure 9-7 SM Processing .....	5
Figure 9-8 Base Line Correction Method .....	7
Figure 9-9 Side Effect .....	7
Figure 9-10 Stage 2 and 3.....	8
Figure 9-11 Stage 4.....	8
Figure 9-12 Response Spectra .....	8
Figure 9-13 Strong Motion Display.....	9
Figure 9-14 Ground Motion Values.....	11
Figure 9-15 Exit SMP .....	12





## 9 Strong Motion Processing

### 9.1 REFTEK (SMP) Menu

This figure represents the primary stages of Strong Motion Processing (SMP) of Raw REF TEK Data Files.

A screenshot of the "Strong Motion Processing" dialog box. The dialog has a title bar with standard window controls. On the left, a "Preview" section shows a "Time Series Plot" with a list of data types: "Uncorrected Acceleration", "Corrected Acceleration", "Velocity", "Displacement", "Arias Intensity", "Cumulative Abs. Vel.", and "Jma-Filter". Below this is a "Spectral Plot" section with two dropdown menus: "PSD Uncorrected Acceleration" and "Pseudo Spectral Vel.". At the bottom left, there are checkboxes for "LogX" and "LogY", both of which are checked. The main area of the dialog is divided into several sections. "Stage 1:" includes a "Base Line Correction Method" dropdown set to "Linear" and "Side Effect" radio buttons for "None", "ZeroCross" (which is selected), and "5%Taper". "Stage 2:" has a checkbox for "Instrument Correction" which is unchecked. "Stage 3:" has a checkbox for "High Cut Filter (Hz)" which is unchecked, with a text box next to it containing the value "45". "Stage 4:" has a checked checkbox for "High Pass Filter (Hz)" with a text box next to it containing the value "0.1". Below these stages is a "Response Spectra:" section with a "Damping Values:" group containing checkboxes for 0%, 0.5%, 1%, 2% (checked), 3%, 5%, 7%, 10% (checked), 15%, and 20% (checked). To the right of these is a "Period Range (sec):" section with two text boxes containing "0.02" and "50". On the far right, there are four buttons: "DISPLAY", "PRINT", "Default Settings", and "Cancel".

### 9.1.1 Comments

- Raw REF TEK files should contain acceleration records recorded by 131 Accelerometer.
- Raw REF TEK files should have at least the following information in the EH packet:
  - TrueBit Weights
  - Volts per Unit
  - LookUp units; !!! M/S<sup>2</sup> or G !!!
- If the this information is not available in the EH packet - > create an appropriate rt\*\*\*\*.rtu ini file.

**If the correct traces are not selected (Response file must match) this error can result. Correct then reselect the traces with the File=>New Trace command.**



**Figure 9-1 Traces not selected Error**

## 9.1.2 Process records obtained on REF TEK Accelerometers

### 9.1.2.1 \*Basic stages:\*

1. Load RAW REF TEK acceleration Records to the programs memory using the **New Trace** command.

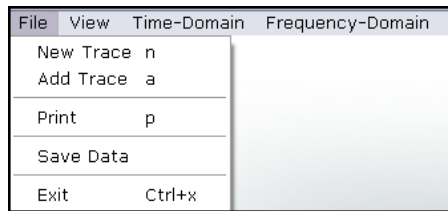


Figure 9-2New Trace

2. Select the file to open.

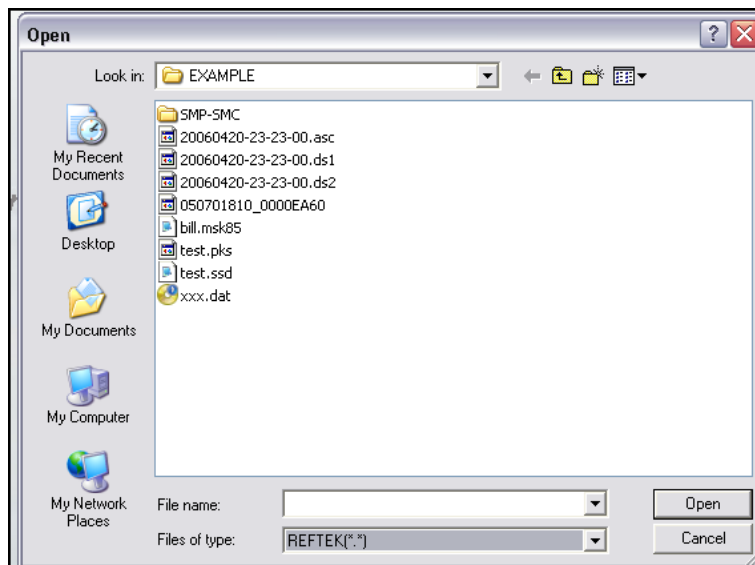


Figure 9-3 Select RAW File

3. Select all channels corresponding to Raw acceleration.

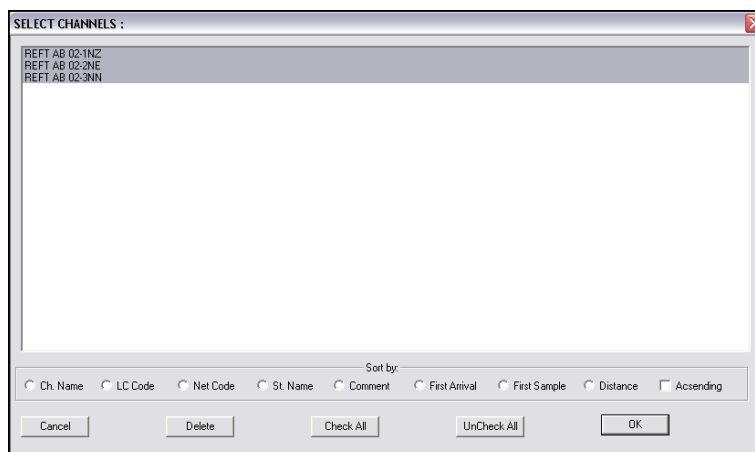


Figure 9-4 Select Channels

4. On the display use the **Zoom In** command to select the part of the record with the strong motion signal.

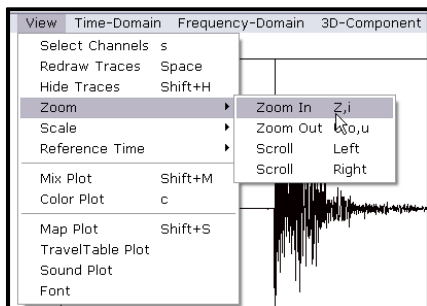
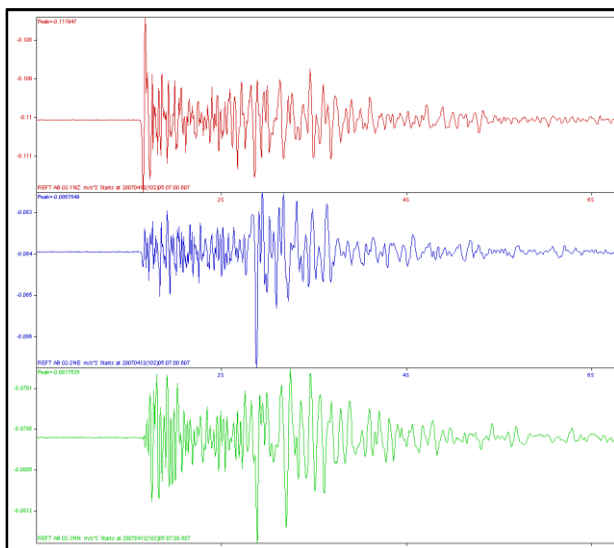


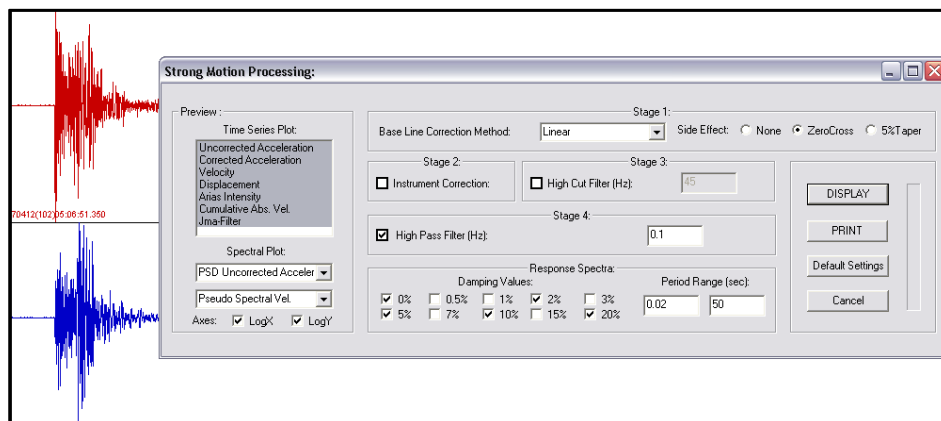
Figure 9-5 Zoom In



5. Select the **Enter SM Processing** command from **Reftek (SMP)** pull-down menu.



Figure 9-6 Strong Motion Processing



### 9.1.3 Provide Strong Motion Processing parameters:

1. Highlight one of the **Time Series** of interest for default preview.

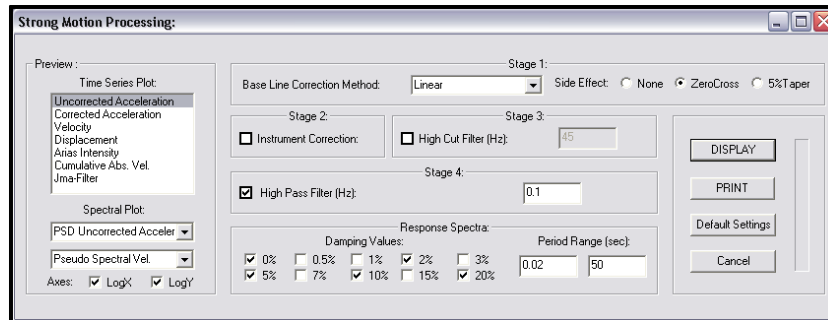
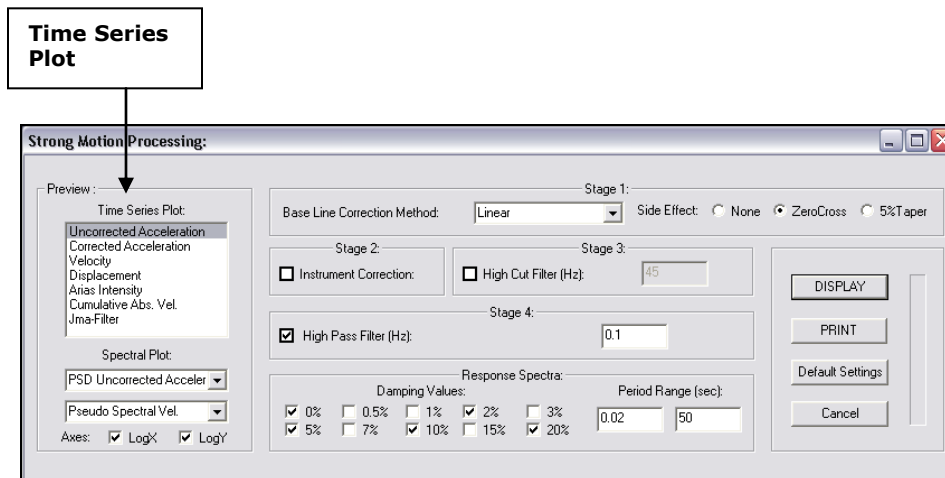
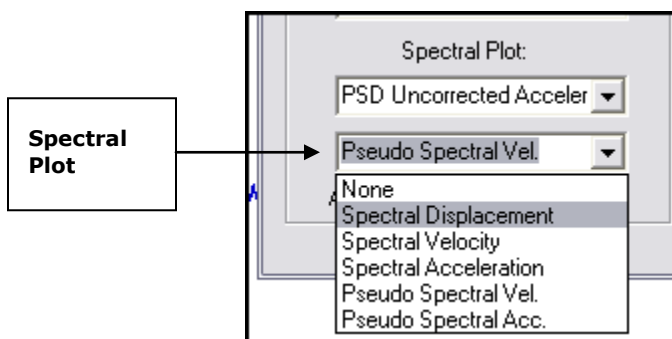


Figure 9-7 SM Processing

2. Highlight a second **Time Series** of interest for default preview.



3. Select two kinds of **Spectral** plots for default preview.



The spectral plot can be any combination of:

- Spectral Amplitude of RAW Acceleration FFT  
-OR-
- Power Spectral Density of RAW Acceleration PSD  
-AND-
- Spectral Displacement  
-OR-
- Spectral Velocity  
-OR-
- Spectral Acceleration  
-OR-
- Pseudo Spectral Velocity  
-OR-
- Pseudo Spectral Acceleration

**Note: For the Response Spectra Plot define the number of Damping Values by checking ON corresponding check box and Edit the range of periods for Response Spectra computation.**

4. Select the type of Spectral **Axes** for Spectral Plot.

Preview :

Time Series Plot:

- Uncorrected Acceleration
- Corrected Acceleration
- Velocity
- Displacement
- Arias Intensity
- Cumulative Abs. Vel.
- Jma-Filter

Spectral Plot:

PSD Uncorrected Acceleration

Spectral Displacement

Axes: ☒ LogX ☒ LogY



## 9.2 Stage 1 - Base Line and Side Effect method

### 9.2.1 Compute Stage 1 – Uncorrected Acceleration

1. Select **Base Line Correction Method** (None, Mean, Linear, Quadratic, Cubic) from the pull-down menu to remove permanent DC offset from the signal.

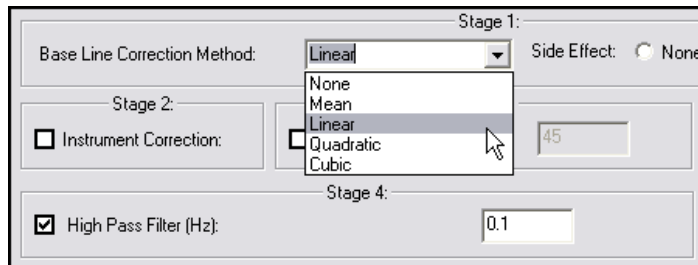


Figure 9-8 Base Line Correction Method

2. To remove side effect during math calculation choose the appropriate method. Select **Side Effect** Method (None, ZeroCross, 5%Taper) to decrease side effect in Math calculations.

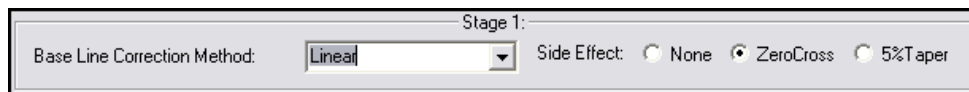


Figure 9-9 Side Effect

## 9.3 Setting parameters for Stages 2 - 4

### 9.3.1 Compute Stage 2 – Corrected Acc, Vel, Displacement..

1. Set Instrument Correction **On** - if the Transfer Function of the Strong Motion is available and defined in poles and zeros inside rtDAS.rtu file.

**Note: This is NOT needed for 131 sensors. Since the REF TEK 131 accelerometer has very flat response for most frequencies of interest the user can easily keep it Off**

2. To remove High Frequency noise from the signal select the High Filtering Corner if necessary (since the REFTEK 130 has already the set of FIR filters during – this can be adequately controlled by stream sample rate – so by default the **High Cut Filter** is in the **Off** position.)
3. Select a Long Period Filtering corner frequency to filter out long periods – to decrease the noise effect that appears during single and double integration.

Stage 2: ☐ Instrument Correction:

Stage 3: ☐ High Cut Filter (Hz): 45

Figure 9-10 Stage 2 and 3

4. Select the **High Pass Filter** Frequency to decrease Low noise effect during single and double integration.

Stage 4: ☒ High Pass Filter (Hz): 0.1

Figure 9-11 Stage 4

### 9.3.2 Compute – Response Spectra

5. To compute the **Response Spectra** ( $S_a$ ,  $S_v$ ,  $S_d$ , Pseudo- $S_a$ , Pseudo- $S_v$ ) for different percentages of damping and within a selected Period Range, check the corresponding damping boxes.

Response Spectra:

Damping Values: ☒ 0% ☐ 0.5% ☐ 1% ☒ 2% ☐ 3% ☒ 5% ☐ 7% ☒ 10% ☐ 15% ☒ 20%

Period Range (sec): 0.02 50

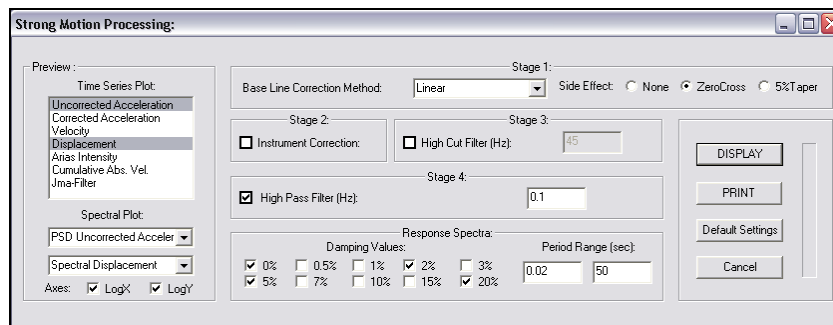
Figure 9-12 Response Spectra

### 9.3.3 Final Steps

1. Clicking "Default Settings" will set all parameters to the program defaults.
2. Click DISPLAY to perform calculation.

**Note:** Depending on time series length and the number of selected dumpings this operation can take up to a few minutes

**Note:** Selecting PRINT will act the same way as Display but the plot for all channels will be forwarded to the Default Printer if installed in the System.



3. The Strong Motion Display will then contain the time series and spectral plots corresponding to the First acceleration channel.
4. To navigate to the next channel or previous channel plot use the **Page Up** or **Page Down** keys.

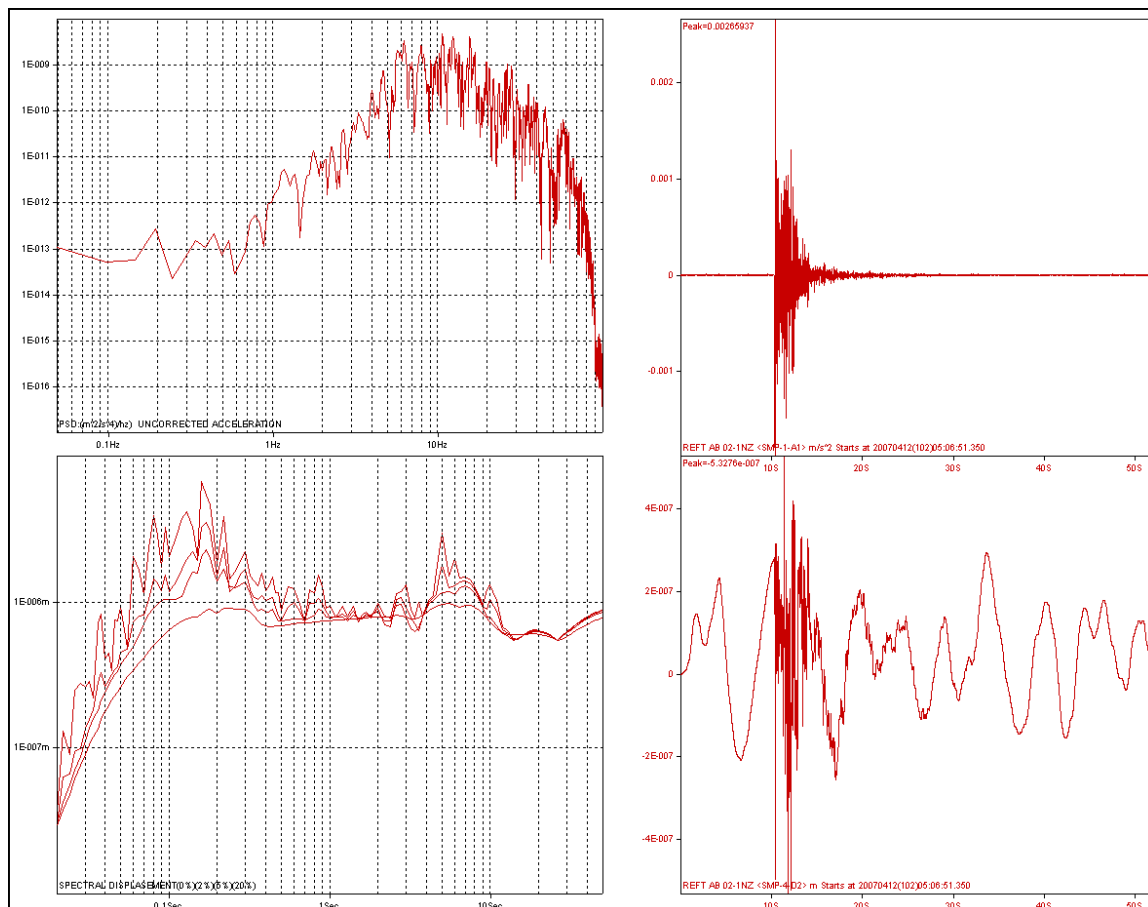
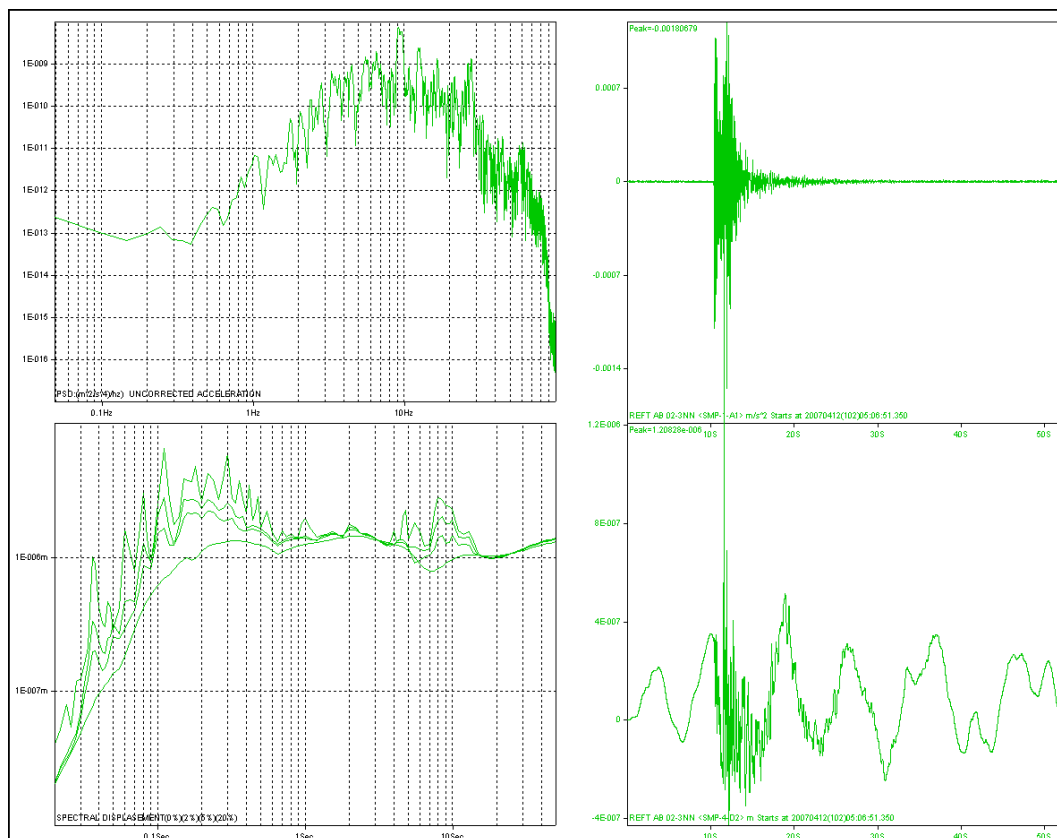
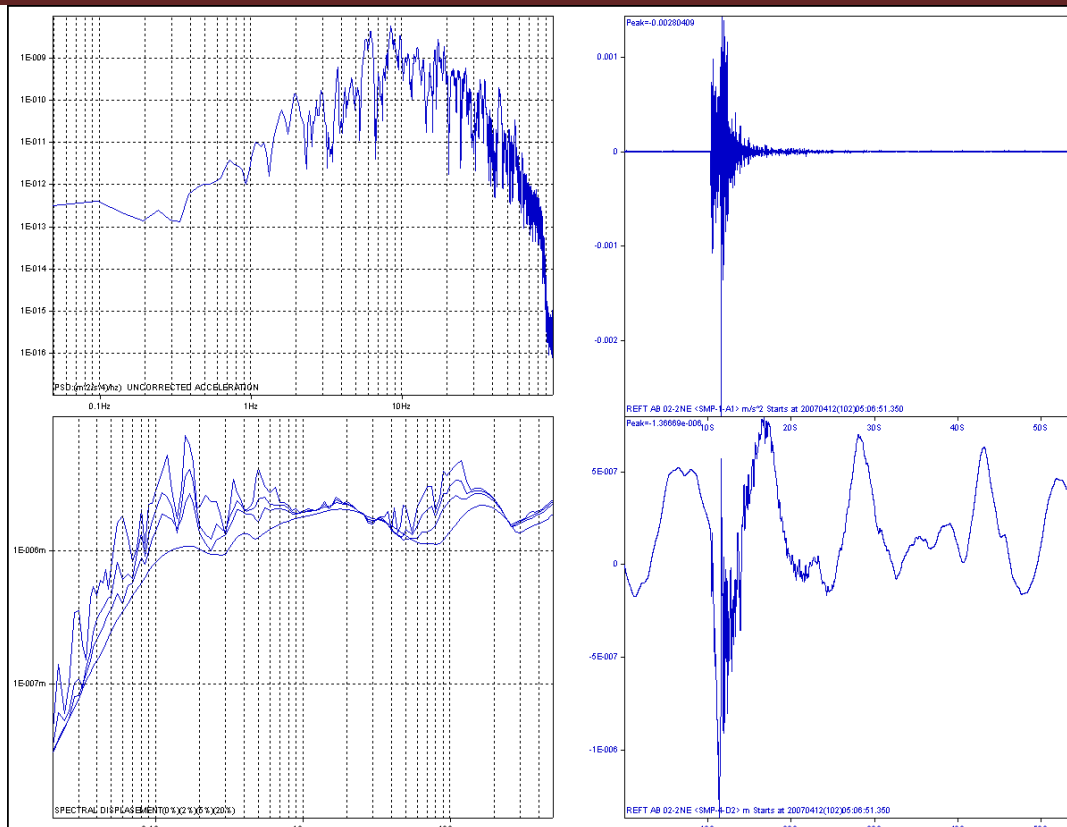


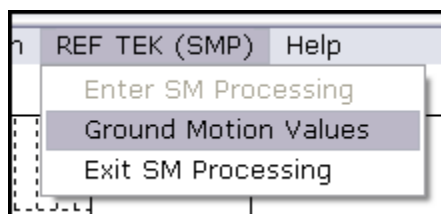
Figure 9-13 Strong Motion Display



## 9.4 Ground Motion Values

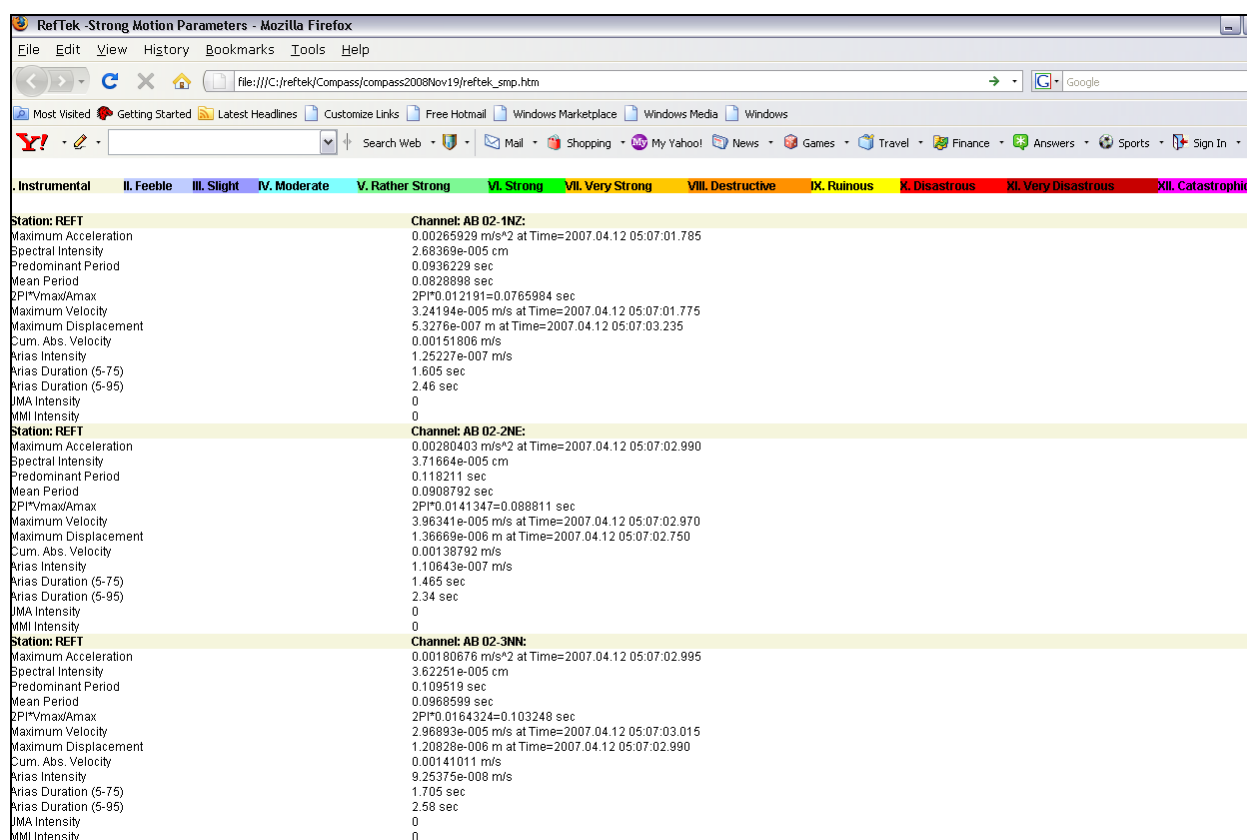
To preview ground motion values obtained during the Ref Tek Motion session:

1. Select the **Ground Motion Value** menu on the **Reftek (SMP)** pull-down menu.



- 2.** This will appear in a Internet Explorer window.

The color of each channel corresponds to the computed MMI Instrument Intensity.



### Figure 9-14 Ground Motion Values

### 9.4.1 Parameters are computed for each component:

- Maximum Acceleration - Peak ground Acceleration.
- Spectrum Intensity - For 5% damping. It is defined as the integral of the pseudo-Spectral velocity curve within 0.1-2.5 seconds.
- Predominant period – Period corresponding to the peak value of FFT acceleration spectrum.
- Mean period - Period corresponding to the average of the weighted values of acceleration spectrum.
- $2\pi V_{max}/A_{max}$  – Period calculated from the (Peak Ground velocity to Peak Ground Acceleration ratio).
- Maximum Velocity – Peak ground velocity.
- Maximum Displacement – Peak ground displacement.
- Cumulative Absolute Velocity.
- Arias Intensity
- Arias Duration of strong motion within ( 5-75%) of Arias charging curve.
- Arias Duration of strong motion within ( 5-95%) of Arias charging curve.
- JMA Intensity - Instantaneous Instrumental Seismic Intensity =  $\log(A*V)+0.94$ .
- MMI Intensity - equal to  $JMA*11/7+0.5$ .

### 9.5 Exiting Reftek (SMP)

1. To exit **Reftek (SMP)** and clear program memory select **Exit SM Processing**.



Figure 9-15 Exit SMP



**Refraction Technology**  
**1600 Tenth Street**  
**Suite A**  
**Plano, Texas 75074**  
**Tel: 214-440-1265**  
**Fax: 972-578-0045**  
[www.reftek.com](http://www.reftek.com)