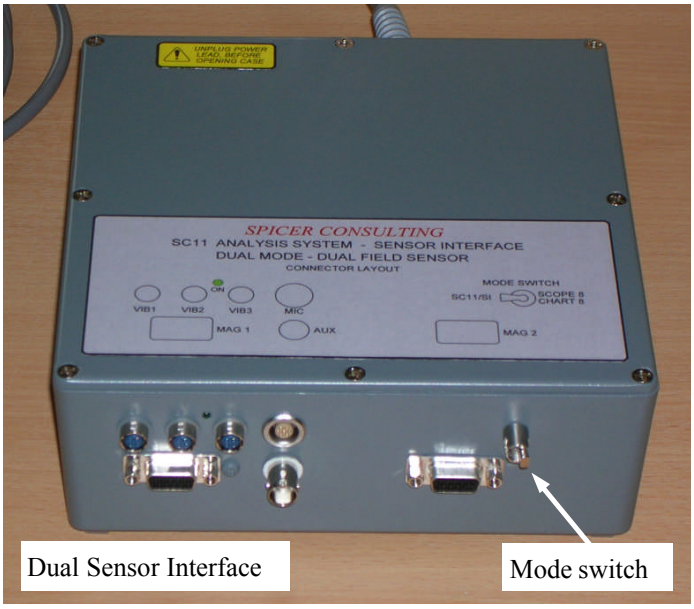
SC11 Analysis System - Sensor Interface/Dual



SC11/SI/Dual System in case

- **Dual mode, sensor interface, SC11 analysis system**
- **All the functions of the SC11/SI System** **(see pages 5 - 10)**
- **Plus 8 channel scope function**
- **And 8 channel chart function**
- **Supports two SC20/DCMR 3 axis wideband magneto resistive sensors**
- **Simultaneous magnetic field measurements at two locations**
- **Laboratory precision measurements of AC & DC magnetic fields and field gradients**
- **Makes the measurements required to certify the field environment for TEMs with aberration correctors and energy analysers**

Overview

The SC11/SI/Dual system is an enhanced version of the Spicer Consulting SC11/SI Analysis System that can measure real time magnetic fields and magnetic field gradients. It uses two SC20/DCMR magneto resistive sensors to measure at two locations simultaneously to determine the real time field gradient in the AC and DC field.

The SC11/SI/Dual is used to survey the magnetic field at proposed site locations for the latest TEMs fitted with aberration correctors and energy analysers, which require very low levels of magnetic field over the entire length of the electron optics column for operation to full specification .

Magnetic field cancelling is usually required to provide acceptably low fields. In order to determine if field cancelling will be effective, it is necessary to know the field levels and the real time field gradient. The field gradient usually sets the cancelling performance limit over the length of the column.

To measure the field and its gradient the sensors are placed along the column location, above and below the goniometer, typically spaced 1-2 m apart.

The measured real time field data is saved to a file for post processing by the SCPLOT program to determine the field gradient.

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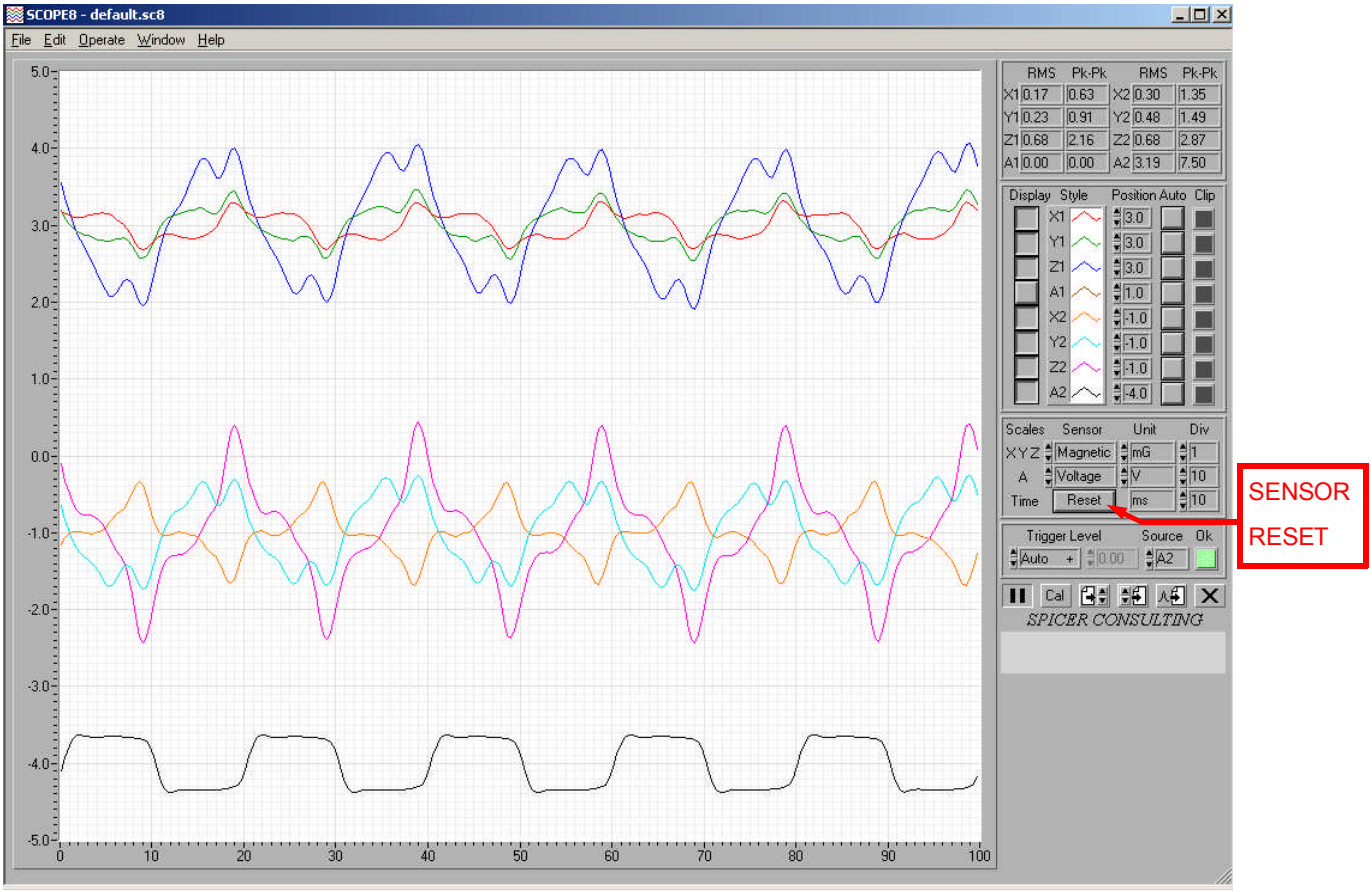
Mode control

The operating mode of the SC11/SI/Dual is controlled by a hardware switch on the front of the interface box. In the SC11/SI switch position it functions as a standard SC11/SI system and the MAG2 sensor input is ignored. In the SCOPE8/CHART8 switch position the four SC11/SI data acquisition channels used for the 3 vibration inputs and the precision microphone are reassigned to the MAG2 sensor and an internal line sync function. With the mode switch in the SC11/SI position it will operate with SC11 software version 4.0 and later as a standard SC11/SI. *Note that the SC11 software cannot tell the position of the mode switch. Very confusing results will be obtained if the mode switch is incorrectly set. The* MAG2 *fields will be interpreted as vibration and the line sync as sound (mains hum).*

With the mode switch in the SCOPE8/CHART8 position the SC11/SI/Dual can run the beta release software programs SCOPE8 and CHART8.

The SCOPE8 Program

A typical screen display when running the SCOPE8 program is shown below.



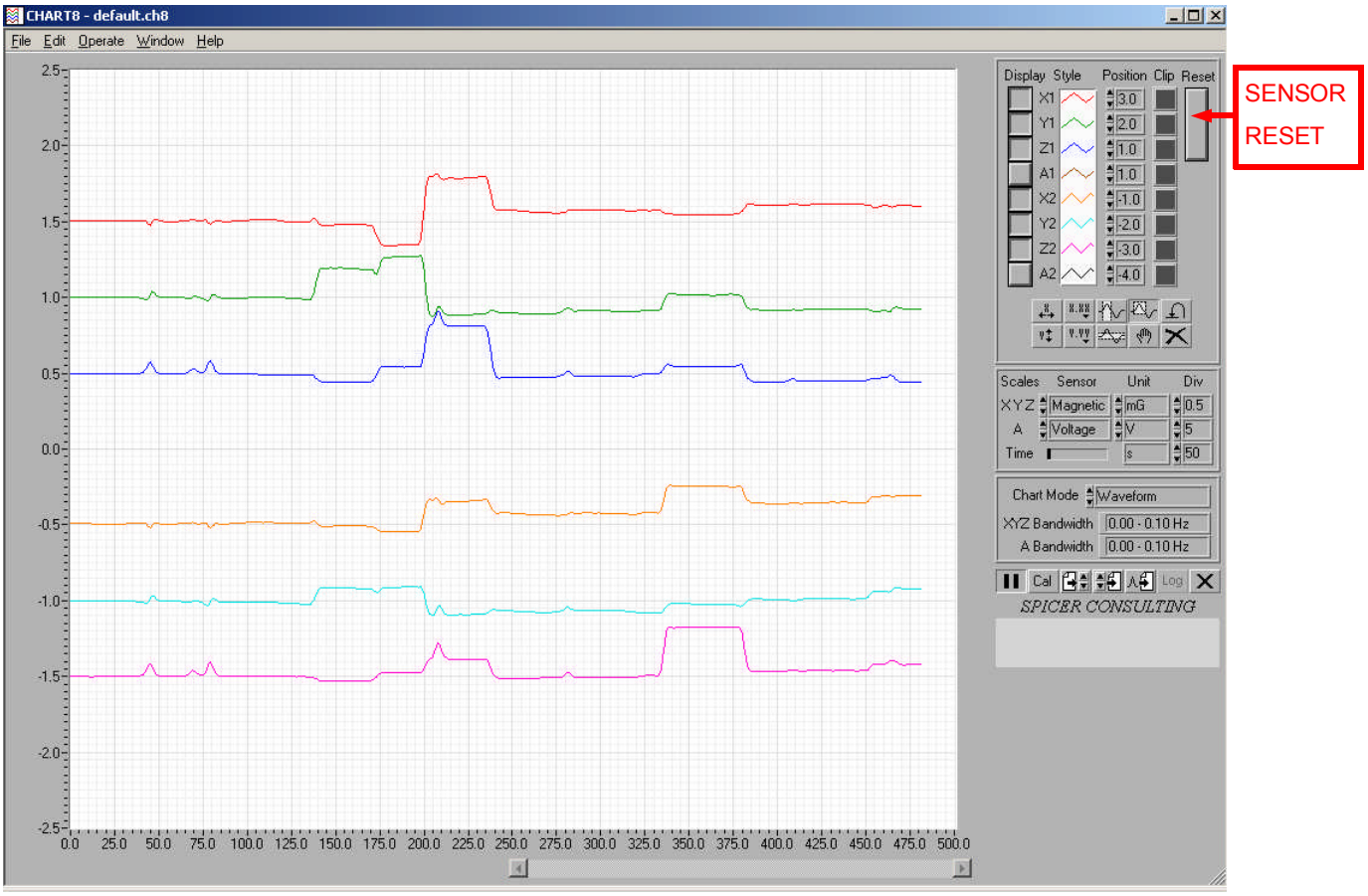
The operation of the on-screen controls is similar to the Scope program in the standard SC11software. In this example the line sync signal has been displayed on screen by clicking on the A2 button. The X, Y, Z AC magnetic fields from the two sensors are displayed above it synchronised to line by selecting channel A2 as the trigger source. Note the SENSOR RESET button that must be clicked after the program starts and every time that the DCMR sensors are moved to reset the measurement zero of the sensors. The results are exported to a text file for post processing by the SCPLOT program to determine the AC field gradients.

The CHART8 Program

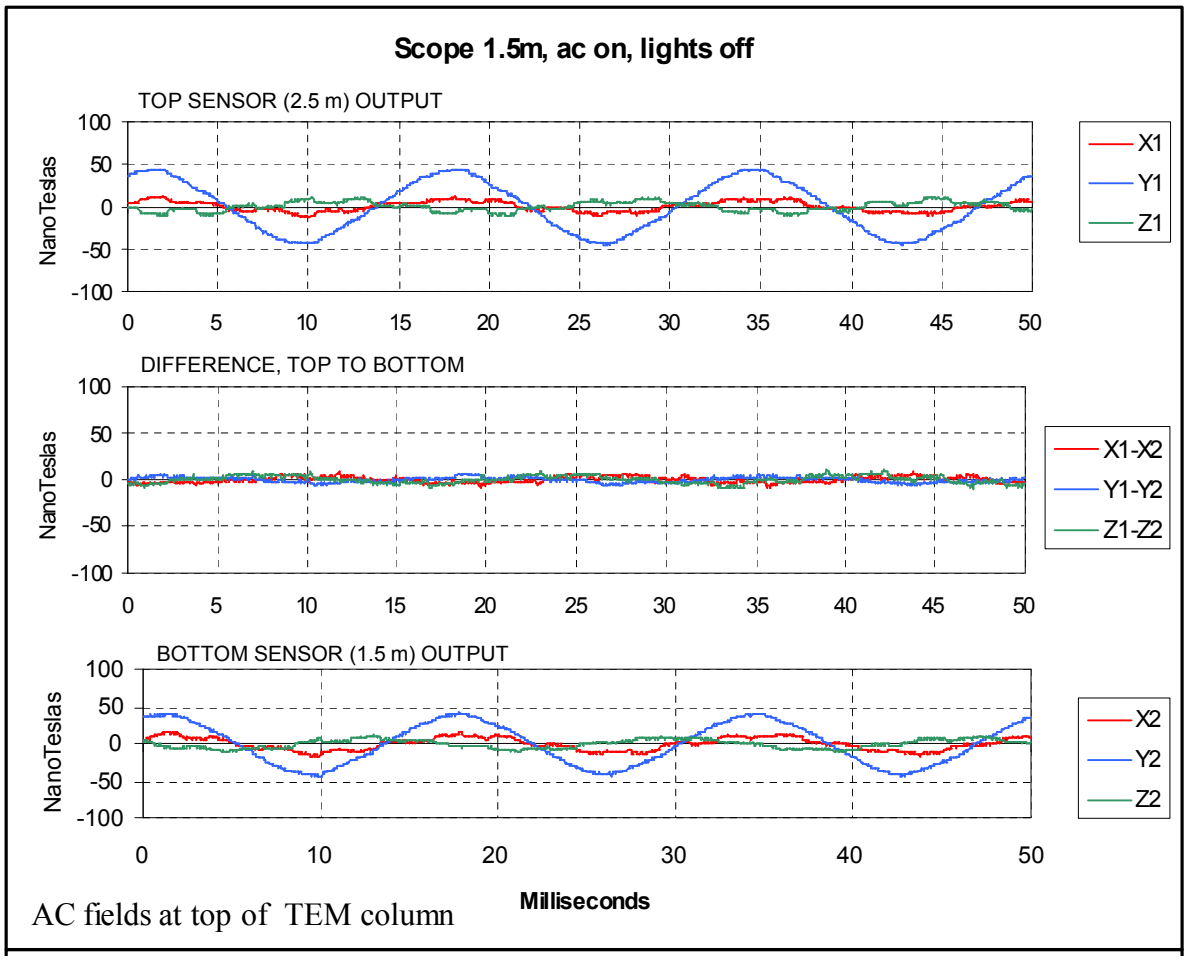
A typical screen display when running the CHART8 program is shown on the next page. In this example, the position controls have been adjusted to separate the X, Y & Z field traces on the screen. Note again the SENSOR RESET button that must be clicked after the program starts and every time that the DCMR sensors are moved to reset the measurement zero of the sensors.

The line sync signal remains connected to the A2 input but is not required to synchronise the CHART8 measurements and is not displayed in this example because it would be filtered to zero by the low bandwidth of the chart recorder.

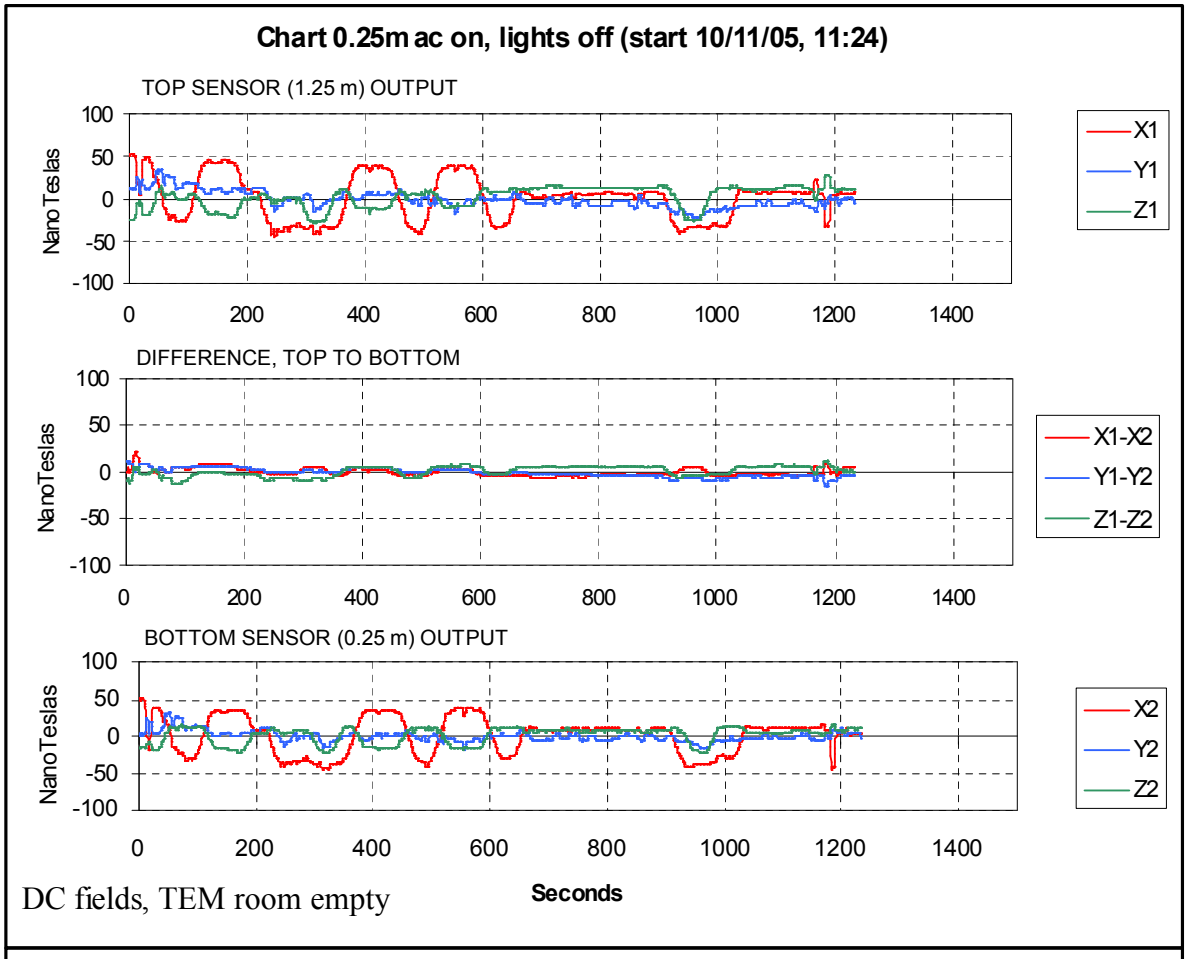
The results are exported to a text file for post processing by the SCPLOT program to determine the DC field gradients.



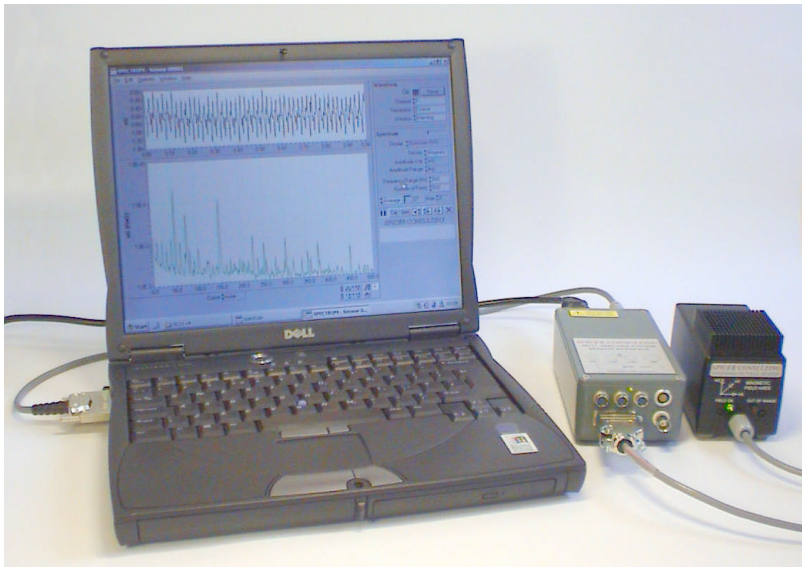
Example of post processed AC field results with low gradient



Example of post processed DC field results with low gradient



SC11 Analysis System - Sensor Interface



SC11 System in case

- **Portable, laptop based, measurement and analysis system**
- **Laboratory precision measurements of environmental magnetic fields, vibrations and sound levels**
- **Universal AC power input 100 - 240 V~ powers and supports**
  - **Wideband DC sensor for 3-axis magnetic fields, DC to 2 kHz**
  - **3 x Wilcoxon 731A accelerometers for 3-axis vibration, 0.1 Hz to 500 Hz**
  - **Brüel & Kjær 4190/2669L precision microphone, 1.5 Hz to 2 kHz**
- **Narrow-band and third octave spectrum analysis with immediate comparison to pre-set specifications**
- **Chart recorder with data logging for long term measurements**
- **Windows 98/Me/NT/2000/XP**

Overview

The performance of the Spicer Consulting SC11 Analysis System is now enhanced using the SC11 Sensor Interface so that it can make all the measurements required for the next generation TEMs.

Based on a laptop computer and operating under Windows 98/Me/NT/2000/XP, the SC11/SI is purpose-designed for precision site surveys. It is a portable tool for measurement and analysis of ambient magnetic fields, vibrations and acoustic levels in one compact system.

The sensor interface powers and supports a three axis wideband DC magnetic field sensor, up to 3 accelerometers and a precision microphone. An auxilliary BNC input allows other sensors to be used if desired.

The software suite consists of three virtual instruments, an oscilloscope, a spectrum analyser and a chart recorder. Results are displayed graphically on the laptop screen. The data can be printed directly or exported for further processing in spreadsheet programs.

The SC11 fits neatly into a carrying case which is supplied. The complete system is accurate, easy to operate with a minimum of training and produces user friendly results.

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SC11 Applications

Surveys
Designed with electron microscope and E-beam vendors and consultants in mind, the SC11 provides all the features needed for site surveys in one simple, easy to use package.

The SC11 is ideal for making accurate surveys of magnetic fields, vibrations and acoustic levels prior to installing an instrument such as a scanning or transmission electron microscope (SEM or TEM). In an environment where there are many pieces of equipment, power cables and air handling units it is difficult to judge in advance whether there could be problems. You can use the SC11 system to survey the magnetic field, vibration and sound levels to make sure that they are within specification at the proposed site. You can load the instrument specifications into the spectrum analyser for quick comparison with your measurements.

Trouble shooting and Analysis
All the sensors are chosen to provide the sensitivity and frequency ranges you need to find sources of interference that affect electron microscopes.

The three SC11 programs provide different troubleshooting clues. A quick look at the waveforms with the oscilloscope can help in finding interference sources by observing changes of amplitude or phase with position. The chart recorder gives the best view of slow or intermittent sources. You can use it to chart floor displacement or slowly varying magnetic fields. You can chart the RMS value for the full frequency range or just for a single known frequency. The datalogging feature lets you chart for an indefinitely long time. You can use the spectrum analyser to reveal the frequency components of the beam movement of an SEM in spot mode by connecting its video output to the AUX input.

Left to right: SC20 wideband DC sensor, SC11 Sensor Interface, B&K 4190 microphone, Wilcoxon 731A accelerometer

SC11 Hardware

Laptop computer
The laptop computer is optionally supplied by Spicer Consulting with all the software pre-installed. Alternatively you may install the software on your own laptop PC. If desired, Spicer Consulting can install the system on your own computer. The minimum requirement for the computer is a 700 MHz Pentium with 128 MB RAM, 100 MB free hard disc, CD-ROM and PCMCIA slot.

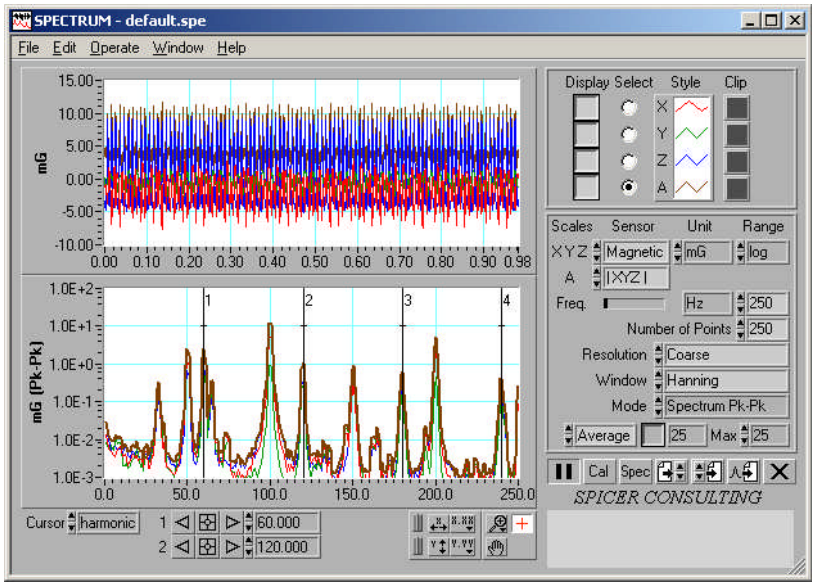
Sensor Interface
The SC11 Sensor Interface has a universal AC power input. It powers and supports an SC20 3-axis magnetic field sensor, up to 3 accelerometers and a precision microphone. It also has an auxiliary voltage input with a range of ±10 V. The interface connects to a National Instruments DAQCard-6024E, a PCMCIA card in the laptop computer.

Magnetic Field Sensor
The SC20 wideband DC sensor can measure both AC and DC magnetic fields in three axes. It enables quick surveys of low frequency fields and 3-axis capture of unrepeatable events such as passing trains or trucks. It is convenient to be able to measure AC fields with the same sensor.

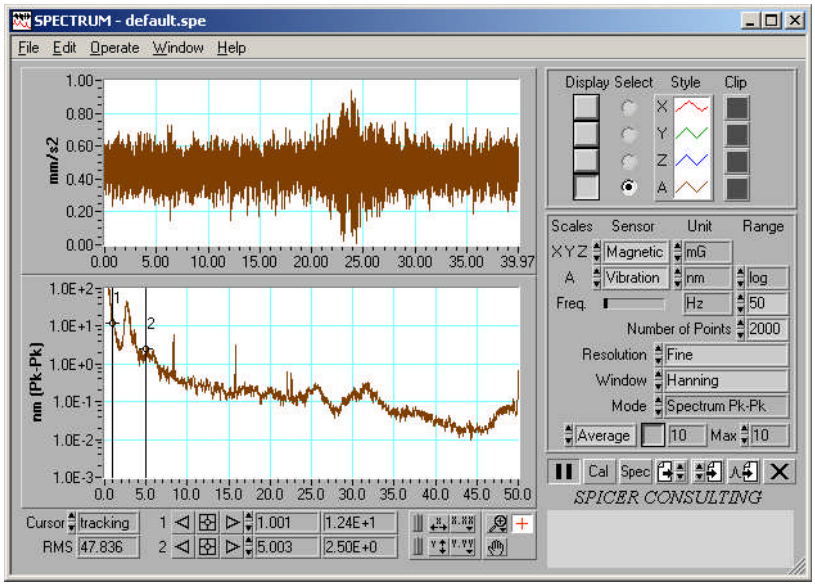
The sensor has a magnetic field measurement range of 40 mG (4 µT) pk-pk with a bandwidth of DC to 5 kHz and is also used in Spicer Consulting field cancelling systems.

Precision Microphone
The Brüel & Kjær 4190 microphone with 2669L preamplifier connects directly to the sensor interface. It measures sound levels from 20dB to 103dB and 1.5 Hz to 2 kHz in this system.

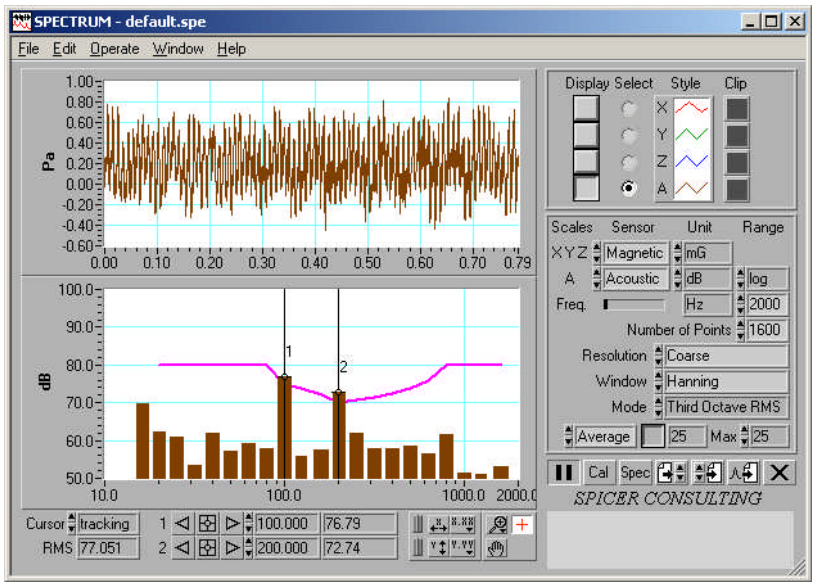
Accelerometer
The accelerometer is a Wilcoxon Research model 731A, with a bandwidth of 0.1 Hz to 500 Hz. It is suitable for the measurement of extremely low level vibrations. Each accelerometer measures vibration along its axis. Up to three can be connected to measure the three orthogonal X, Y and Z axes at once, or one can be rotated to measure them one at a time.



Magnetic field spectrum with harmonic cursors



Displacement vibration spectrum with harmonic cursors



Sound level spectrum with specification and tracking cursors

Sensor Calibration

The calibration of the magnetic field sensor is NAMAS traceable. The accelerometer and microphone are supplied with a calibration certificates traceable to the National Institute of Standards and Technology, USA. Spicer Consulting provides a re-calibration service for the entire system.

SC11 Spectrum Analyser

The spectrum analyser displays the waveforms and spectra of up to 4 channels (3 Magnetic Field or Vibration, and one other). It highlights the selected channel.

This tool has a wide range of units for use with all the sensors. The software integrates the output of the accelerometer to provide measurements of velocity and displacement as well as acceleration.

Tracking cursors are provided to measure features of the spectrum as well as define bands for RMS measurement. Harmonic cursors can be used to recognise harmonics in the spectrum and enable more accurate measurement of the fundamental frequency.

The spectra can be averaged over a period of time to reduce noise, enabling state of the art measurements of floor vibration with the Wilcoxon 731A accelerometer. The displacement vibration spectrum shown here was measured on the concrete floor of our laboratory during the night. This spectrum demonstrates the noise limit specification of the vibration sensor.

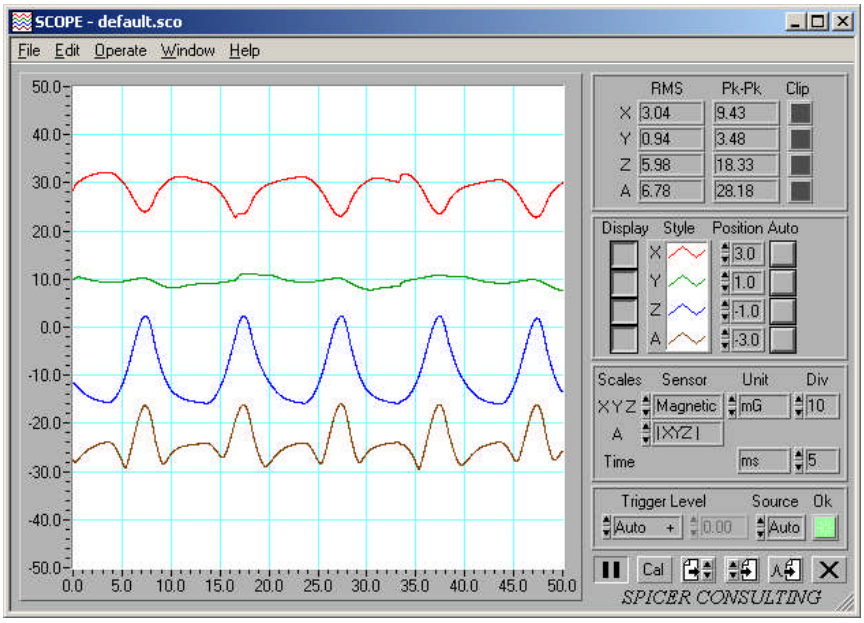
In a similar way to averaging, the peak values over a period of time can be displayed, for example to provide an estimate of the worst case vibrations at a site.

The spectra can also be data-logged to a file at a maximum rate of once every minute, to monitor or trace sources of interference that vary from time to time.

The sound level spectrum shown here is a typical 1/3 octave analysis display. The frequency range from 16 Hz to 2000 Hz is divided into 22 frequency bands, each one third of an octave wide. The total amplitude of the frequency components in each band is computed to provide the histogram display. The figure also shows an electron microscope specification that has been loaded in for comparison with the measurements. In this case, the specification is highlighted in magenta, showing that the specification has been exceeded.

SC11 Oscilloscope

A typical oscilloscope display is shown here. There are common controls for the timebase and vertical gain of the magnetic field axis and independent controls for the vertical gain of the auxiliary channel and vertical position of each channel. The Auto position controls provide AC coupling that varies with the timebase. The oscilloscope screen also displays numerically both RMS and Pk-Pk continuously. The scope has a bandwidth of 5 kHz.



Oscilloscope display showing magnetic field waveforms

SC11 Chart Recorder

The chart recorder simulates plotting on a paper chart which is up to 200 divisions long, of which typically 10 divisions are displayed as it scrolls. Controls for vertical gain, chart speed and bandwidth are provided. Pan and zoom controls enable any section of the plot to be examined.

The chart recorder can be used to monitor slow events. The SC20 wideband DC sensor has very low drift and can measure the magnetic field of lifts and passing trains for extended periods. A typical chart recorder display is shown here.

An integrating filter tailored to the 731A accelerometer allows direct displacement and velocity charts to be made.

A narrow band filter allows the RMS or Pk-Pk value of the signal to be recorded at an adjustable centre frequency.

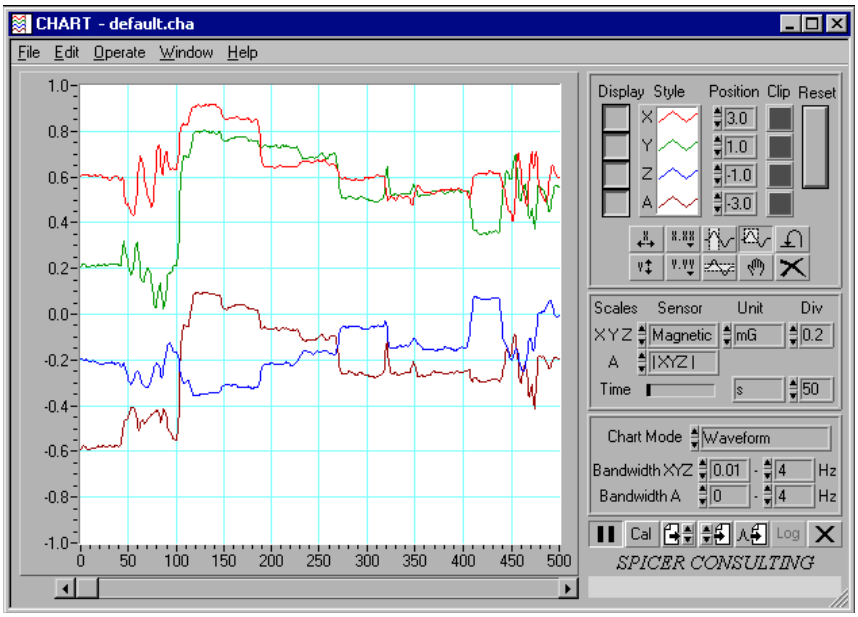
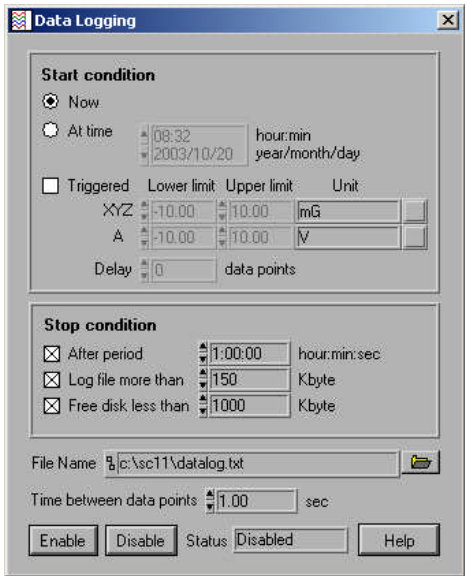


Chart recorder display showing 500 s of magnetic field waveforms made with the SC20/DC Wideband DC sensor



Data logging control panel

You can mark events that occur during measurement of the chart, such the movement of trains. The markers are exported with the results.

The data logging feature of the chart recorder writes each point to a file as the data is acquired, for open-ended long term recording of disturbances that occur occasionally or overnight. The figure here shows the comprehensive start and stop controls for data logging.

Customisation

All the virtual instruments can load and save their control settings to named files so that they can be quickly configured for standard measurements.

User-defined units may be entered for use with other sensors connected to the auxiliary input.

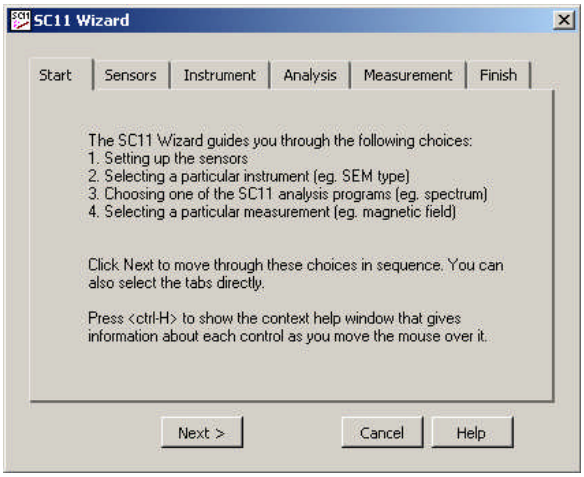
Wizard

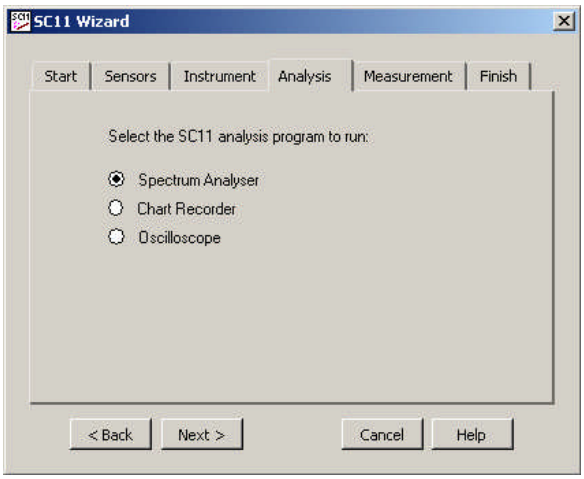
The SC11 Wizard enables pre-defined measurements to be quickly and easily loaded by infrequent users of the system. It guides you through a step-by-step sequence to select the sensors that are to be used, the type of instrument the survey is for, the type of analysis (such as spectrum analyser) and finally the type of measurement (such as x-axis vibration).

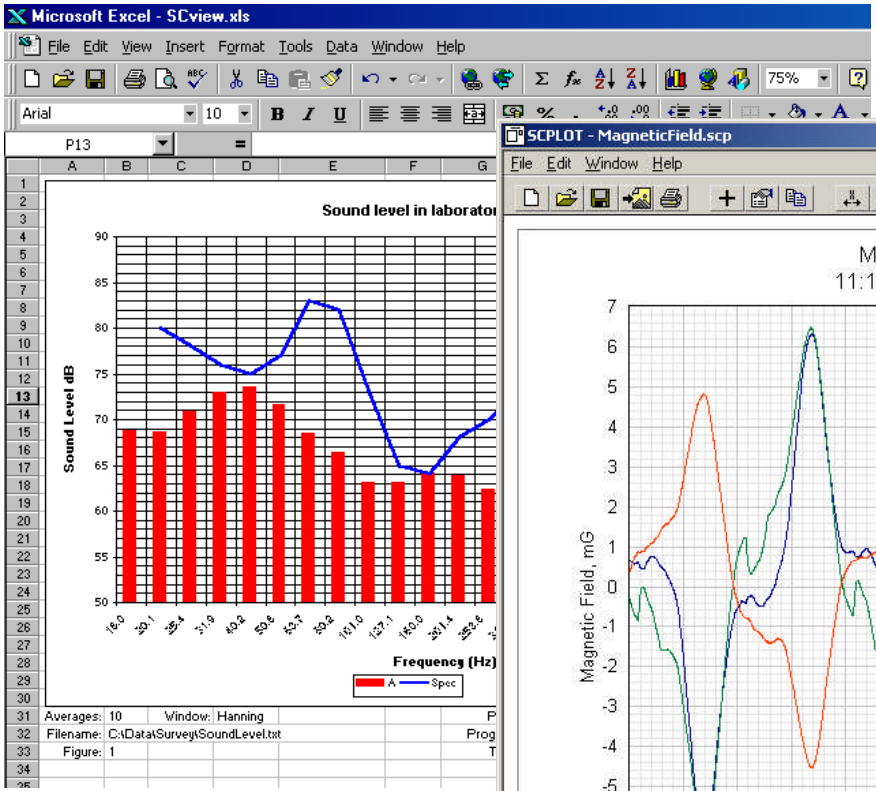
Viewing and Printing Results

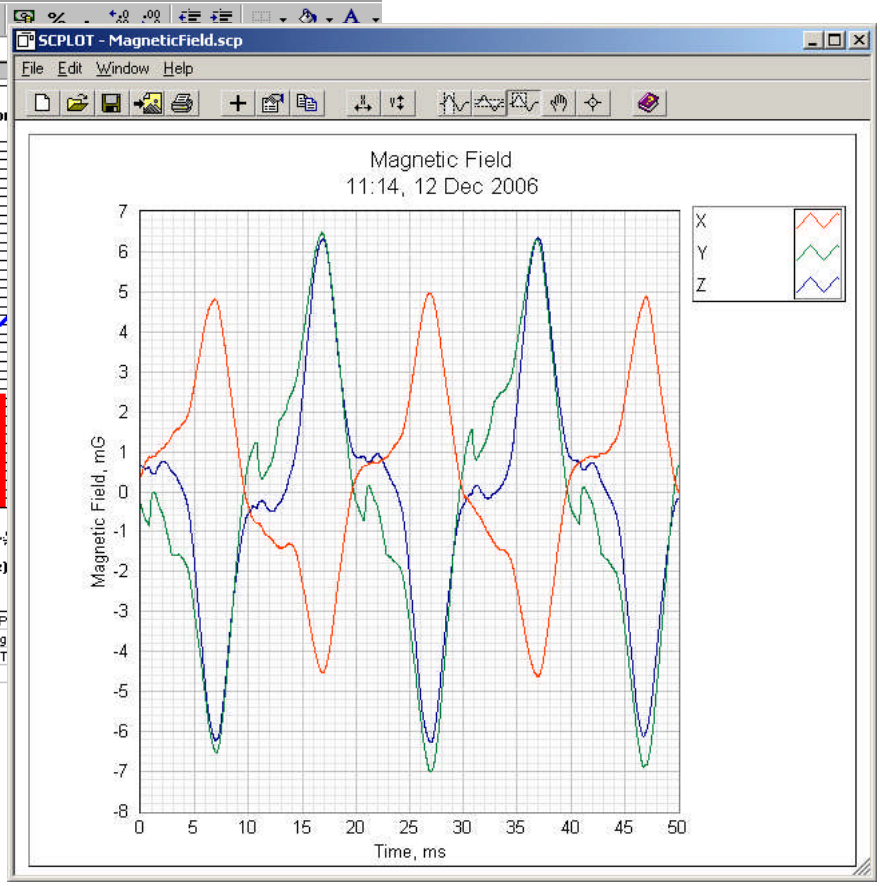
All the programs allow you to export your results into a text file for further processing. New in software verion 4.2 is the SCplot program for results viewing and presentation. Spicer Consulting also provides a free Excel spreadsheet SCview.xls for quickly viewing and printing your results. You can also copy and paste charts from the spreadsheet directly into reports.

All the programs allow you to print the front panel on a printer or to capture an image of it using the Windows Alt-PrintScreen keystroke.









SC11/SI Specification

System

Carrying Case Size	58 x 36 x 19 cm approx. (23 x 14 x 7.5 in approx.)
Weight	11 kg (24 lb) approx. including typical laptop.

Laptop Personal Computer

Processor	700 MHz Pentium min, 1 GHz Pentium rec.
Memory	128 MB min, 256 MB rec.
Free Hard Disc	100 MB min.
CDROM	24X rec.
PCMCIA Slot	Type 2
Operating System	Windows 95/98/Me/NT/2000/XP

Data Acquisition Card

Type	National Instruments DAQCard-6024E
Resolution/Range	Bits 12 Range: Fine: ±0.5V, Coarse: ±10V Resolution: Fine: 0.24 mV, Coarse: 4.8 mV

Core System: SC11/SI (Sensor Interface)

Inputs	
MAG	3-axis magnetic field sensor
VIB1-3	3-axis vibration (3 x Wilcoxon 731A)
MIC	Microphone (B&K 4190/2669L)
AUX	BNC voltage input, DC coupled, ±10 V range 100 kΩ impedance.
Anti-aliasing Filters	5 kHz, 250 Hz (switchable)
Power	100-240V AC, 50-60 Hz, 0.25A max

3-axis Magnetic Field Sensor: SC20/DCMR

Co-ordinate System	X, Y, Z rectangular Cartesian
Bandwidth	DC - 5 kHz
Ambient Field Range	±2 G (±200 uT)
Dynamic Range	40 mG (4 µT) Pk-Pk
Noise Limit	5 µG (0.5 nT) Pk-Pk typ. (0.0001-0.01 Hz) 0.1 µG (10 pT)/√Hz RMS typ. at 50 Hz
Accuracy	±2 %

Vibration Sensor: Wilcoxon 731A Accelerometer

Type	Wilcoxon Research, model 731A
Bandwidth	0.1 - 500 Hz
Dynamic Range	2 m/s^2 (0.2 g's*) Pk-Pk (in this system)
Noise Limit	7 µm/s^2 RMS max. 0.35 µm/s RMS at 1Hz, 0.11 µm/s RMS at 5Hz, 0.07 µm RMS at 1Hz, 0.0035 µm RMS at 5Hz
Accuracy	±5 % (with gain calibration file)

Acoustic Sensor: B&K 4190/2669L Microphone

Type	Brüel & Kjær, Condenser microphone 4190, Pre-amplifier 2669L
Bandwidth	1.5 Hz - 20 kHz
Dynamic Range	103 dB (in this system)
Noise Limit	20 dB (in this system)
Accuracy	±1 dB 3 Hz - 20 kHz

Programs (General)

Clipping	Audio/visual indication
Pause control	Freeze/resume instrument operation
Calibration panel	Add/select sensors, set ranges, calibrate offsets, microphone self check, add/edit user defined units, set export file options
Setup file	Open/save instrument controls
Export	Export results for spreadsheet
Print window	Print current screen display
Help	Context help on controls, online help file
Year 2000	All SC11 programs are year 2000 compliant

Oscilloscope

Channels	4 (X, Y, Z, A) each with style and position controls
Divisions	10 X 10
Amplitude units	
Magnetic Field	mG, nT, µT, mA/m, A/m
Vibration	mg's *, mm/s^2
Acoustic	mPa, Pa
Voltage	mV, V, user defined units
Resultant |XYZ|	Magnetic Field, Vibration, Voltage units
Timebase	0.5, 1, 2, 5, 10, 20, 50, 100, 200 ms/div
Bandwidth	5 kHz (0.5 ms/div - 5 ms/div) 250 Hz (10 ms/div - 0.2 s/div)
Digital Meter	RMS, Peak to Peak (all channels)
Trigger	Auto/Manual level, +/- edge, Auto/Manual source, Single Shot

Spectrum Analyser

Channels	4 (X, Y, Z and A)
Displays	Waveform (autoscaling), Spectrum
Amplitude units	
Magnetic field	mG, nT, uT, mA/m, A/m
Vibration	µg's*, mg's*, µm/s^2, mm/s^2, µm/s, mm/s, nm, µm
Acoustic	mPa, Pa, dB, dBA, dBC
Voltage	mV, V, user defined units
Resultant |XYZ|	Magnetic Field, Vibration, Voltage units
Amplitude ranges	0.5, 0.7, 1, 1.5, 2.5, 3.5, 5, 7, 10, 15, 25, 35, 50, 70, 100, 150, 250, log full scale.
Frequency ranges	20, 25, 30, 40, 50, 60, 80, 100, 125, 150, 200, 250, 300, 400, 500, 600, 800, 1000, 1250, 1500, 2000 Hz full scale.
Number of points	200, 250, 400, 500, 800, 1000, 1600, 2000, 3200, 4000
Accuracy	Frequency: ±0.01% ±0.02 div
Waveform windows	None, Hanning, Flat top
Spectrum modes	RMS, 0-Pk, Pk-Pk, PSD, Third Octave
Combine spectra	Average/Peak, Max no. spectra
Cursor modes	Total RMS between 2 tracking cursors, 10 harmonic cursors
Pan & Zoom Palette	Pan, zoom and format spectrum display
Capture indicator	Indicates progress of data acquisition
Specification files	Create, edit, add & remove. Compare with measurements.
Data logging	Start: Now, At time, Triggered by flat level, Triggered by spec Stop: Period, File size, Disk space Min. time step: 1 minute

Chart Recorder

Channels	4 (X, Y, Z, A) each with style and position controls
Divisions	10 X 10
Amplitude units	
Magnetic Field	mG, nT, µT, mA/m, A/m
Vibration	mg's *, mm/s^2, µm/s, mm/s, µm
Acoustic	mPa, Pa, dB
Voltage	mV, V, user defined units
Resultant |XYZ|	Magnetic Field, Vibration, Voltage units
Timebase	0.5, 1, 2.5, 5, 10, 25, 50 s/div (50 points/div)
Chart length	200 div. max. (1.6 min - 2:45 hr:min)
Max Bandwidth	(Bandwidth may be reduced by controls)
Magnetic field	DC - 5 kHz
Vibration	0.1 Hz - 500 Hz
Acoustic (SLM)	32 Hz - 5 kHz
Acoustic (B&K mic)	1.5 Hz - 5 kHz
Voltage	DC - 5 kHz
Bandwidth controls	XYZ/A upper/lower - all modes except narrow band
Narrow band filter	Centre frequency, f_0 range: 1 Hz - 1250 Hz Accuracy: ±1% within pass band, (f_0 ± 3%) Attenuation: 60 dB min. in stop band, (f_0 ± 20%)
Chart modes	Waveform, RMS, Peak to Peak, Narrow band RMS, Narrow band Pk-Pk.
Markers	Time, text string
Update modes	Strip chart, scope chart, sweep chart
Chart palette	Pan, zoom, format, reset and clear chart
Data logging	Start: Now, At time, Triggered Stop: Period, File size, Disk space Time step: Whole no. of points (0.01 s at 0.5 s/div)

* g's are the unit of acceleration due to gravity