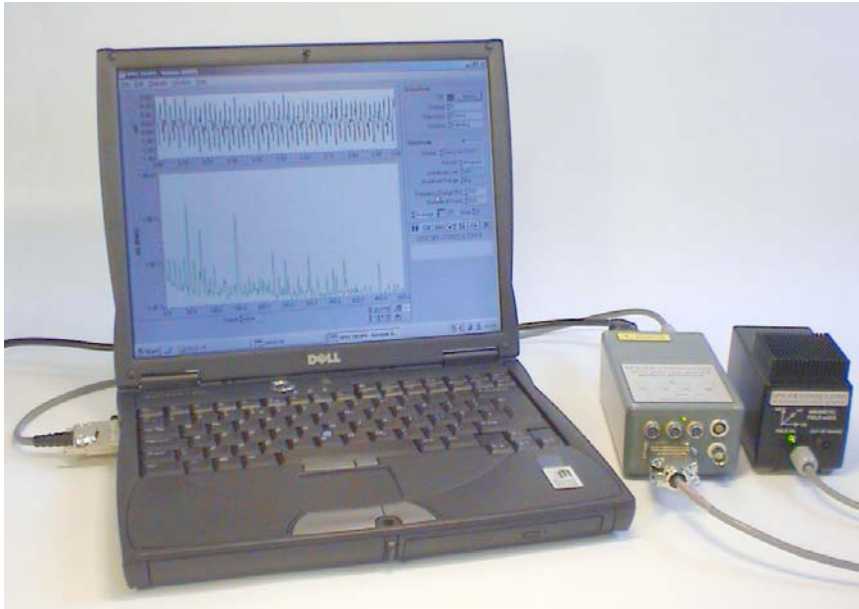




## SC11 Analysis System - Sensor Interface



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.

## 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 266 MHz Pentium with 64 MB RAM, 100 MB free hard disc, CD-ROM, 3½in floppy disc drive 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  $\pm 10$  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.

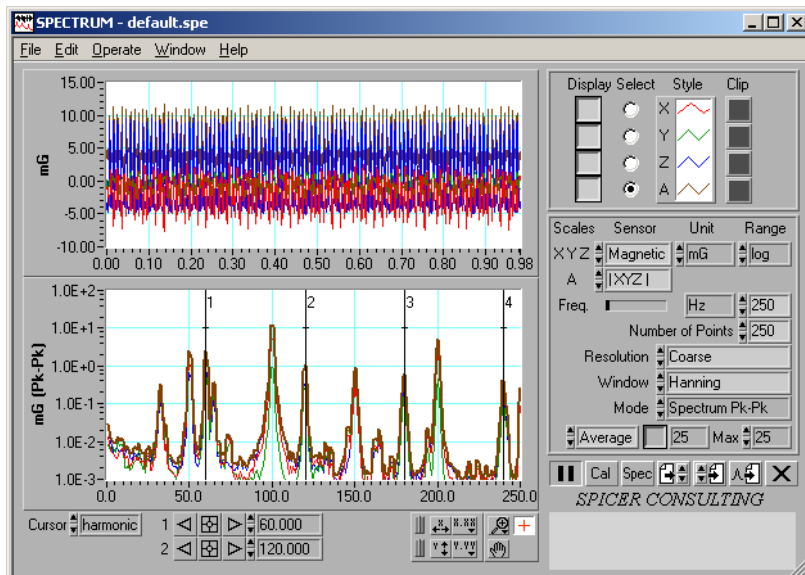
The sensor has a magnetic field measurement range of 40 mG ( $4 \mu\text{T}$ ) pk-pk with a bandwidth of DC to 5 kHz and is also used in Spicer Consulting field cancelling systems.

### Precision Microphone

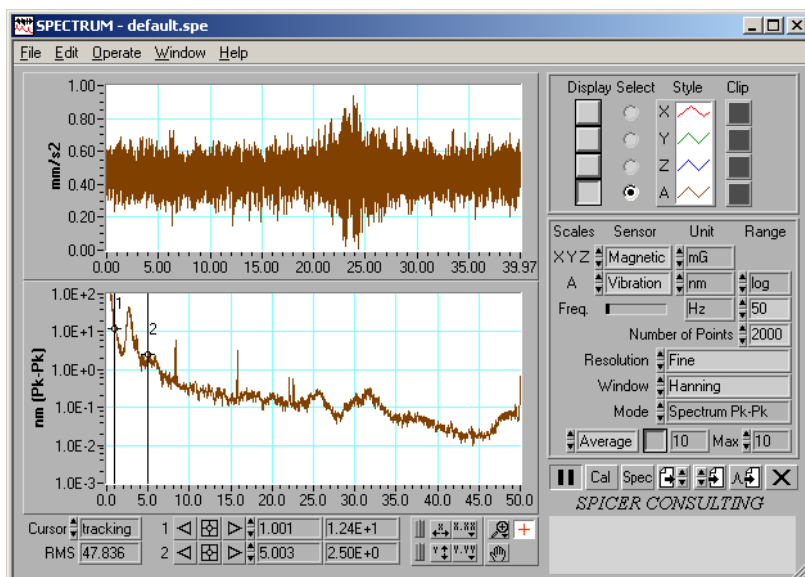
The Brüel & Kjær 4190 microphone with 2669L preamplifier connects directly to the sensor interface. It measures sound levels from 20dB to 103dB and 1.5 Hz to 2 kHz in this system.

### Accelerometer

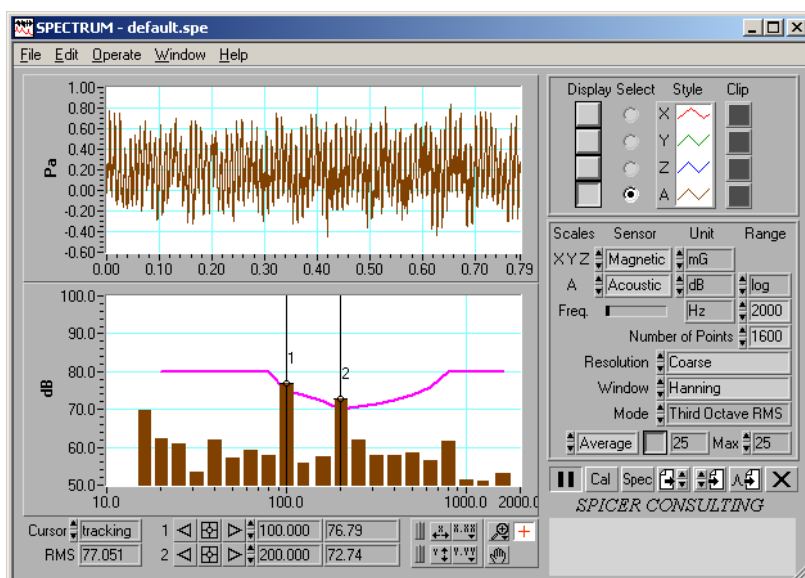
The accelerometer is a Wilcoxon Research model 731A, with a bandwidth of 0.1 Hz to 500 Hz in this system. It is suitable for the measurement of extremely low level vibrations. Each accelerometer measures vibration along its axis. Up to three can be connected to measure the three orthogonal X, Y and Z 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

## 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 2 minutes, 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.

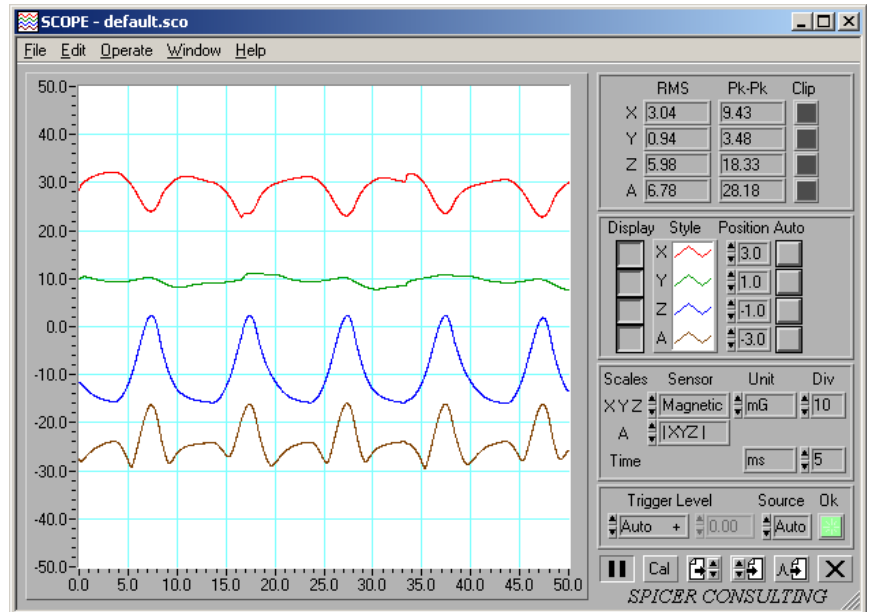
## SC11 Chart Recorder

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 and chart speed 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.



Oscilloscope display showing magnetic field waveforms

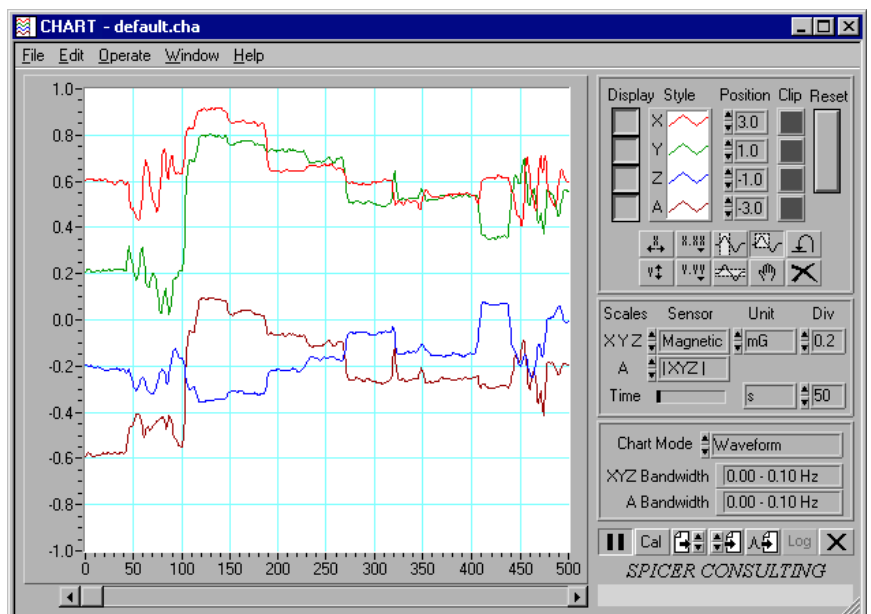


Chart recorder display showing 500 s of magnetic field waveforms made with the SC20/DC Wideband DC sensor

The screenshot shows the 'Data Logging' control panel. It has two main sections: 'Start condition' and 'Stop condition'. The 'Start condition' section has a 'Now' button and an 'At time' section with a date/time picker (08:32, 2003/10/20). There are also 'Triggered' checkboxes for XYZ and A channels, with 'Lower limit' and 'Upper limit' fields (both -10.00 and 10.00) and a 'Unit' dropdown (mG and V). A 'Delay' field is set to 0 data points. The 'Stop condition' section has three checkboxes: 'After period' (1:00:00), 'Log file more than' (150 Kbyte), and 'Free disk less than' (1000 Kbyte). The 'File Name' field is set to 'c:\sc11\data\log.txt'. The 'Time between data points' field is set to 1.00 sec. At the bottom, there are 'Enable', 'Disable', 'Status' (Disabled), and 'Help' buttons.

Data logging control panel



## 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.

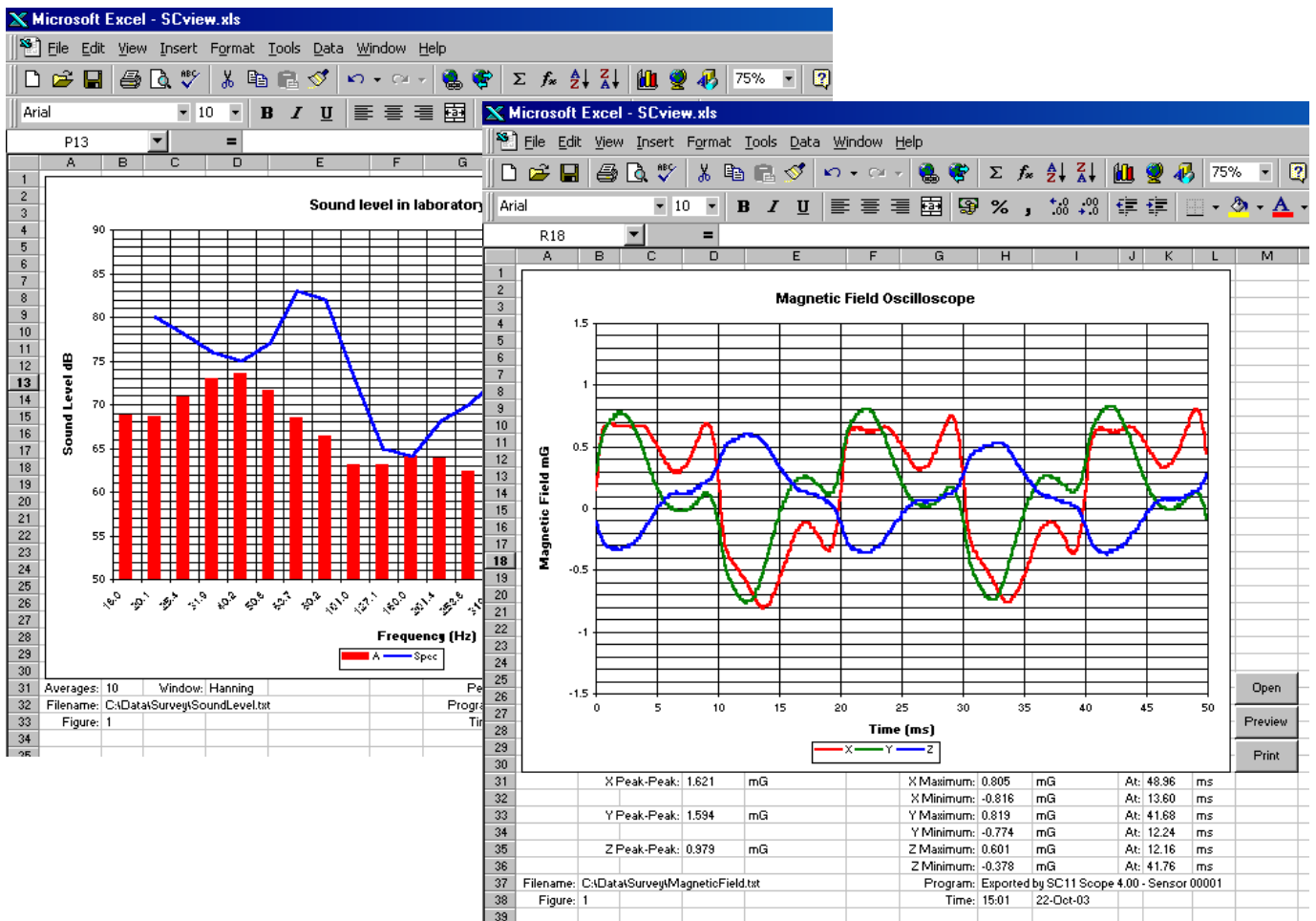
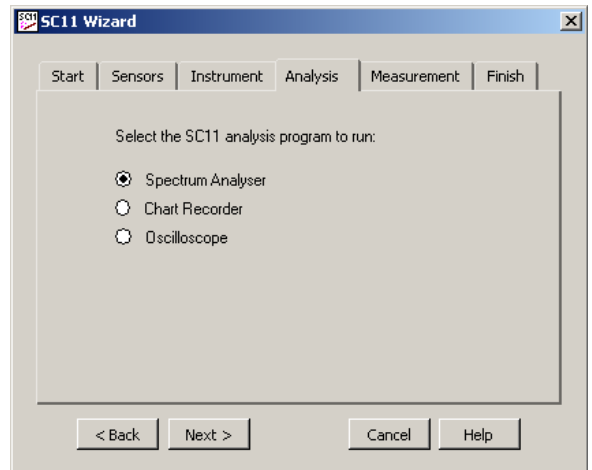
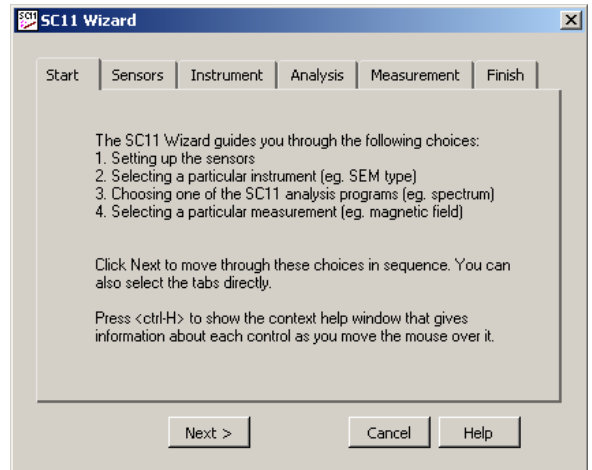
## Wizard

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 that can be read into a spreadsheet for further processing. Spicer Consulting provides a free Excel spreadsheet 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	266 MHz Pentium min, 1 GHz Pentium rec.
Memory	64 MB min, 128 MB rec.
Free Hard Disc	100 MB min.
CDROM	24X rec.
Floppy Drive	3.5 in. 1.44 MB
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: $\pm 0.5V$ , Coarse: $\pm 10V$ Resolution: Fine: 0.24 mV, Coarse: 4.8 mV
Anti-aliasing Filters	5 kHz, 250 Hz (switchable)

## Core System: SC11 Sensor Interface

Inputs	MAG: 3-axis magnetic field sensor VIB1-3: 3-axis vibration (3 x 731A) MIC: microphone (B&K 4190/2669L) AUX: BNC DC coupled $\pm 10V$ input 100 k $\Omega$ 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/DC

Co-ordinate System	X, Y, Z rectangular Cartesian
Dynamic Range	40 mG (4 $\mu T$ ) Pk-Pk
Ambient Field Range	$\pm 2G$ ( $\pm 200 \mu T$ )
Bandwidth	DC - 5 kHz
Noise Limit	30 $\mu G$ (3 nT) Pk-Pk typ. (0.0001-0.01 Hz) 1 $\mu G$ (100 pT)/ $\sqrt{Hz}$ RMS typ. at 50 Hz
Accuracy	$\pm 5\%$ (after >1hour warm up). ( $\pm 15\%$ cold)

## Vibration Sensor: Wilcoxon 731A Accelerometer

Type	Wilcoxon Research, model 731A
Dynamic Range	2 m/s <sup>2</sup> (0.2 g's*) Pk-Pk
Bandwidth	0.1 - 500 Hz, 0.1 - 250 Hz (switchable)
Noise Limit	7 $\mu m/s^2$ RMS max. 0.35 $\mu m/s$ RMS at 1Hz, 0.11 $\mu m/s$ RMS at 5Hz, 0.07 $\mu m$ RMS at 1Hz, 0.0035 $\mu m$ RMS at 5Hz
Accuracy	$\pm 5\%$ (with gain calibration file)

## Acoustic Sensor: B&K 4190/2669L Microphone

Type	Brüel & Kjær, Condenser microphone 4190, Pre-amplifier 2669L
Dynamic Range	20 dB to 103 dB (in this system)
Bandwidth	1.5 Hz - 20 kHz
Accuracy	$\pm 1dB$ 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 decimal symbol
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	
Ranges	Division Size	Unit
Magnetic Field	0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50	mG
	10, 20, 50	nT
	0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50	μT
	10, 20, 50	mA/m
Vibration	0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50	A/m
	0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50	mg's *
	0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50	mm/s <sup>2</sup>
	20, 50	mPa
Acoustic	0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50	Pa
	20, 50	mV
Voltage	0.1, 0.2, 0.5, 1, 2, 5, 10	V
	Resultant [XYZ] Magnetic Field, Vibration, Voltage units	
User defined	0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50	
Timebase	0.5, 1, 2, 5, 10, 20, 50, 100, 200	ms
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	

## Spectrum Analyser

Channels	1 (X, Y, Z, A,  XYZ  selectable)
Displays	Waveform (autoscaling), Spectrum
Amplitude units	
Magnetic field	mG, nT, $\mu T$ , mA/m, A/m
Vibration (731A)	$\mu g's^*$ , mg's*, mm/s <sup>2</sup> , $\mu m/s$ , mm/s, nm, $\mu m$
Acoustic (SLM)	mPa, Pa, dB
Voltage	mV, V
Amplitude ranges	0.5, 1, 2.5, 5, 10, 25, 50, 100, 250, log fs.
Frequency ranges	20, 25, 30, 40, 50, 60, 80, 100, 125, 150, 200, 250, 300, 400, 500, 600, 800, 1000, 1250, 1500, 2000 Hz fs.
Number of points	200, 250, 400, 500, 800, 1000, 1600, 2000
Accuracy	Amplitude: $\pm 5\%$ (not including sensor accuracy or noise) Frequency: $\pm 0.01\%$ $\pm 0.02$ div
Pan & Zoom Palette	Pan, zoom and format spectrum display
Waveform windows	None, Hanning, Flat top
Spectrum modes	RMS, 0-Pk, Pk-Pk, Third Octave
Combine spectra	Average/Peak, Max no. spectra
Cursor modes	Total RMS between 2 tracking cursors, 10 harmonic cursors
Specification files	Create, edit, add & remove. Compare with measurements.
Capture indicator	Indicates progress of data acquisition

## Chart Recorder

Channels	4 (X, Y, Z, A) each with style and position controls		
Divisions	10 X 10		
Ranges	as Oscilloscope, except		
	Division Size		Unit
Vibration	10, 20, 50		μm/s
	0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50		mm/s
	0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50		μm
Timebase	0.5, 1, 2, 5, 10, 20, 50		s
	50 points/div		
Chart length	200 div. max. (1.6 minutes - 2.7 hours)		
Bandwidth	250 Hz (Bandwidth is reduced in some modes)		
Chart palette	Pan, zoom, format, reset and clear chart		
Chart modes	Waveform, RMS, Peak to Peak,		
	Waveform ext. LF, Narrow band RMS, Narrow band Pk-Pk.		
Bandwidth display	XYZ/A upper/lower for all modes except narrow band		
Narrow band filter	Centre frequency, $f_0$ range: 1 Hz - 250 Hz		
	Accuracy: $\pm 1\%$ within pass band, $f_0 \pm 3\%$		
	Attenuation: 60 dB min. in stop band, $f_0 \pm 20\%$		
Data logging	Start: Now, At time, Triggered		
	Stop: Period, File size, Disk space		
	Time step: Whole number of points (0.01 s at 0.5 s/div)		

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