



SC22 Magnetic Field Cancelling System



- **Protects your investment in electron beam technology by stabilising the magnetic field environment**
- **Cancels and monitors the AC field**
- **Low cost, high performance system**
- **Intelligent user interface**
- **Automated set up**
- **Cancels AC fields from 0.5 Hz to 5 kHz**
50 x field improvement at 60Hz
- **Full 3 axis (X, Y, Z) system**
- **Up to 60 mG (6.0 μ T) pk-pk range**
- **Adapts to field changes within 100 μ s**
- **Supports dual sensors for TEMs and high gradient fields**
- **USB monitoring port**

Overview

Today's high performance electron beam tools are very sensitive to changing ambient magnetic fields. The fields move the beam causing loss of resolution and measurement accuracy. The SC22 system reduces the ambient AC field and restores the resolution and accuracy.

The SC22 system comprises a Magnetic Field Control Unit, an AC Magnetic Field Sensor and three multicore cables, which are installed in the room where the field is to be cancelled.

Each power amplifier in the control unit drives a current through its cable to create a field of the opposite sign to the change in ambient field. The magnetic field sensor measures the resulting field and real time negative feedback reduces the ambient field by the loop gain of the system.

The system is dynamic, automatically responding to field changes within 100 μ s. AC Line fields (50/60 Hz) are reduced by 50 x.

The SC22 does not cancel DC field changes from sources such as elevators, trains and traffic. The larger SC20 system is available to cancel both AC and DC fields.

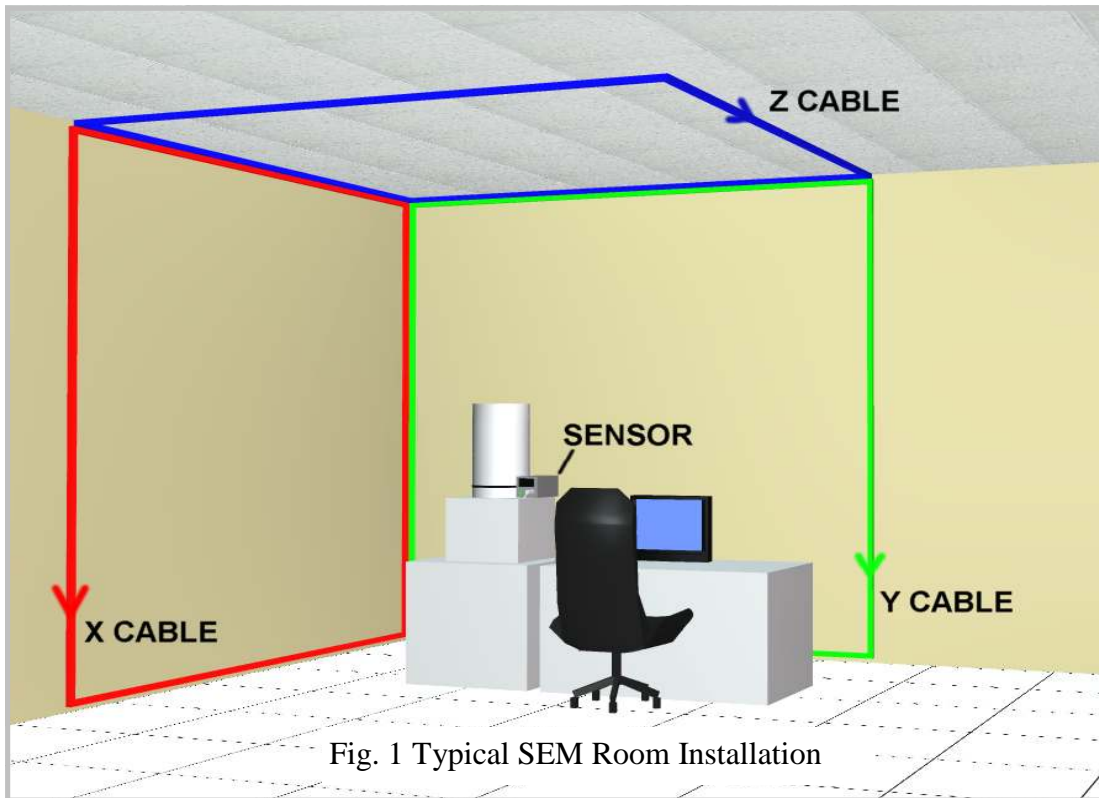


Fig. 1 Typical SEM Room Installation

Product Description

The SC22 is a fourth generation Magnetic Field Cancelling System, designed to improve the performance of electronic instruments that are sensitive to magnetic fields, such as electron microscopes and electron beam metrology tools.

The SC22 is a replacement for the SC12 system, which has an installed base of over 1000 units world wide.

It is important to note that mechanical vibration, acoustic noise and ground loops in the electron beam tool installation can produce imaging defects similar to magnetic fields. The SC22 cannot improve images which are affected by these other interfering sources because they are not magnetic fields.

A typical SC22 system installation on an SEM is shown in Fig. 1. The control unit is not shown. The cables make one turn and are shown in red, green and blue. The actual cables are grey and usually installed in white plastic conduits. Where the room has a false ceiling, the Z cable is usually installed above it. The magnetic field sensor is located close to the bottom of the electron beam column. An optional mount enables it to be strapped to the column if required.

The amount by which the field is reduced is determined by the loop gain of the system, which is automatically set by the SC22 to 50 times. The system does not cancel the earth's DC magnetic field, nor does it cancel the field everywhere in

the room. It creates a region around the magnetic field sensor where the AC field is much reduced. The volume of this region depends mostly on the gradient of the ambient field and the positioning of the field cables.

The SC22 control unit displays the amplitudes of the X, Y & Z field components and the total vector field on its LCD panel. Tesla and Gauss units, RMS & pk-pk can be selected. The measuring system can resolve $1\mu\text{G}$ (100 pT) field changes. The real-time measured fields are available on front panel BNC's as analog voltage levels for oscilloscope display.

The magnetic field amplitude is continuously monitored and compared with preset "trip levels" to provide "GO/NOGO" indication of the field quality. The LCD panel and a small green LED on the sensor indicate that the field is "OK".

The SC22 controls are much simpler than the SC12 and are supervised by the embedded microcomputer. There are just 3 control buttons on the front panel. The "units" button enables choice of the displayed field units. It has no effect on field cancelling. The "setup" button starts a 4 second program that measures and sets the gain and phase of the feedback loop. The "cancel/standby" button turns cancelling on and off.

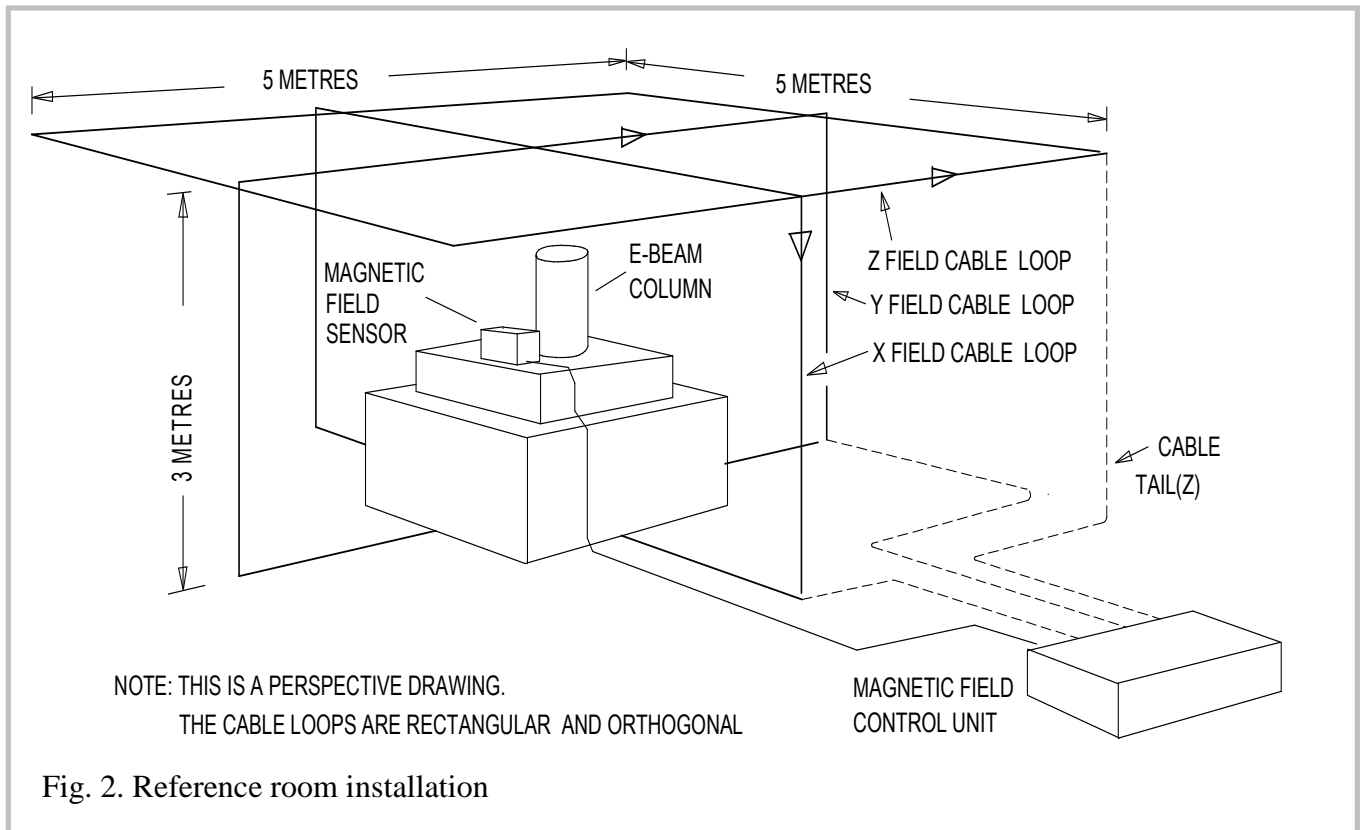


Fig. 2. Reference room installation

Installation options

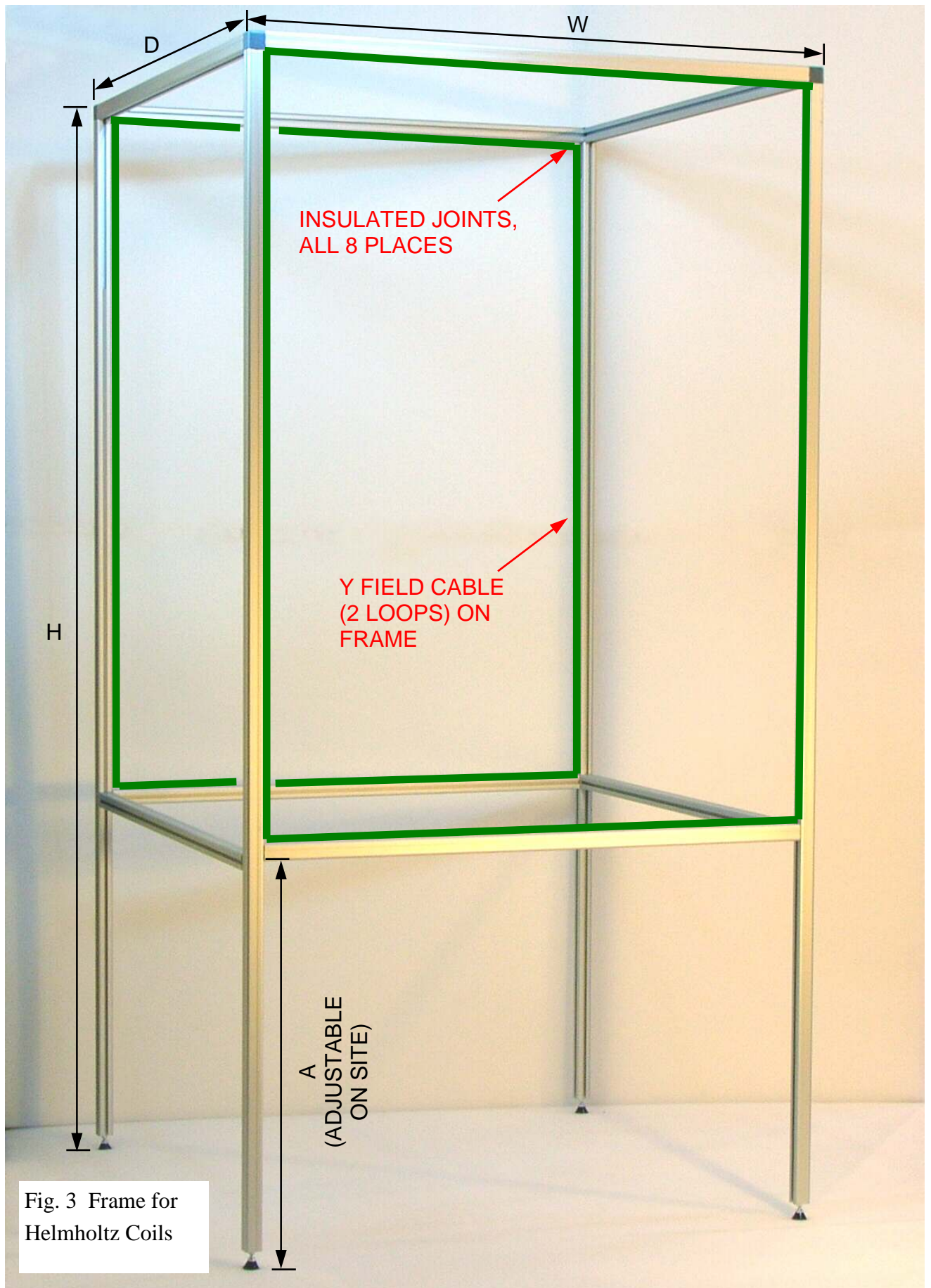
The SC22 field cancelling cables are made with a loop and a tail. The loop creates the field and the tail (which makes no field) connects the loop to the control unit. The loop parts are shown in Fig. 1 in red, green and blue. SC22 room cables have X and Y loops 16 metres long and a Z loop 20 metres long. Longer cables are available to special order.

The Fig. 1 installation is suitable for most SEM applications where the electron beam column is typically 1.5 metres from the room walls. The maximum field which can be cancelled (the dynamic range) depends on the size and position of the cable loops relative to the electron beam column. With 5m x 3m X and Y loops and the column 1.5m from the walls the dynamic range is about 25 mG (2.5 μ T) pk-pk.

To specify the SC22 performance more rigorously, we use a reference room cable installation. This is shown in Fig. 2. The electron beam column is centred in the 3m x 5m X and Y loops (which cross over above and below the column) and the 5m x 5m Z loop. The SC22 specifications on page 6 apply to this reference room installation.

For leading edge TEM installations, double loop room sized helmholtz cables are available. These are recommended for TEM's fitted with Gatan Imaging filters (GIF's). Customers are advised to consult Spicer Consulting support staff for design and installation of these special field cables.

When the room is large or in clean rooms where there are no local walls, a frame around the electron beam tool can be used to mount Helmholtz cables. Fig. 3 shows our current frame design. A frame limits access to the tool so should only be used where room cable installation is not possible. The cancelling performance with a frame may be inferior to a room cable installation.



Frame is made to order. Customer specifies dimensions H, W, D. Frame in photo has H=2060, W=1060, D=1060 mm. Frame is supplied dismantled, for on-site assembly.

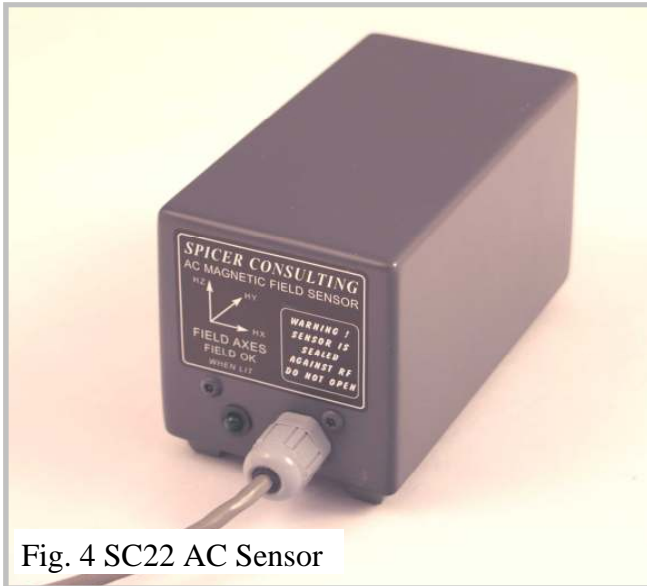


Fig. 4 SC22 AC Sensor

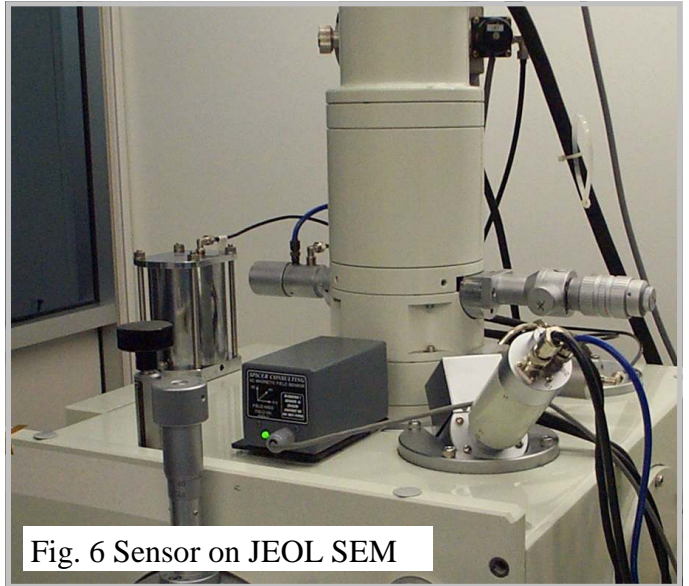


Fig. 6 Sensor on JEOL SEM

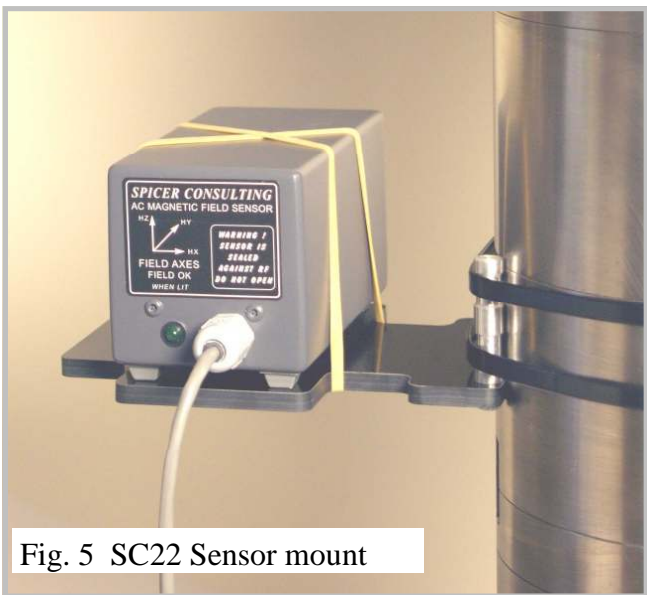


Fig. 5 SC22 Sensor mount

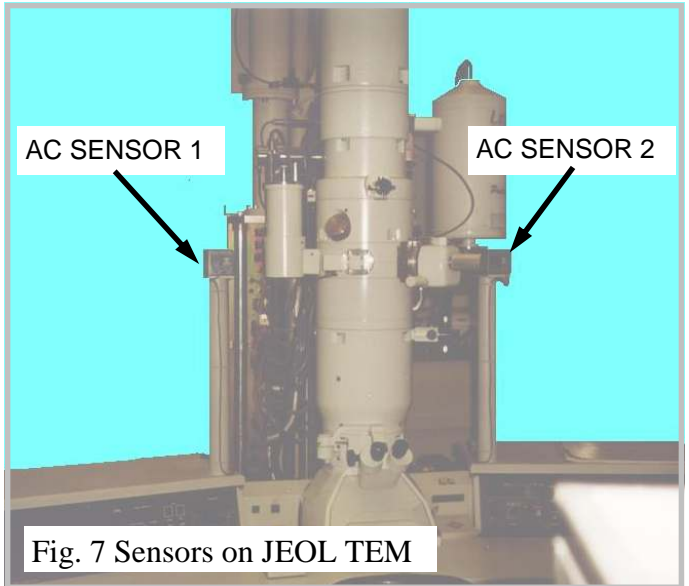


Fig. 7 Sensors on JEOL TEM

Sensor options

The SC22 AC field sensor is shown in Fig. 4 and on the optional sensor mount in Fig. 5. The sensor mount is for attaching the sensor to an electron beam column. Fig. 6 shows a typical installation on an SEM where the sensor is standing on the work chamber at the bottom of the column. This is the most common configuration with one sensor.

For some applications, there are advantages in using two sensors. An example is shown in Fig. 7. When two sensors are used their outputs are combined by a mixer shown in Fig. 8.

The mixer creates a “virtual sensor” which can appear to be located inside the column. The mixer controls enable the apparent position of the sensor to be adjusted separately for the X, Y, and Z axes to tune the cancelling system for optimum improvement in the tool imaging.

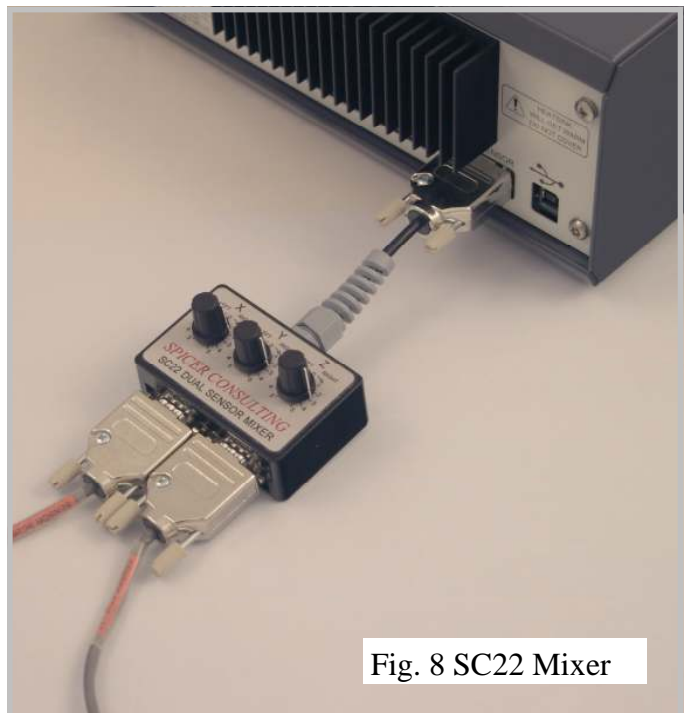


Fig. 8 SC22 Mixer

Specifications

CO-ORDINATE SYSTEM X, Y, Z rectangular Cartesian

UNITS Gauss, Tesla (switchable)

FIELD CANCELLING

Components cancelled	X, Y, Z field components
Dynamic range (X & Y) ^(note:1)	60 mG (6 μ T) pk-pk (installation Fig. 2)
Dynamic range (Z) ^(note:1)	45 mG (4.5 μ T) pk-pk (installation Fig. 2)
Field cancelling factor	50 X at 50/60 Hz
Bandwidth	0.5 Hz - 5000 Hz
System 1/f noise limit below 0.1Hz	< 100 μ G (10 nT) pk-pk
System wideband noise limit	1 μ G (100pT) RMS 5 Hz - 20 kHz

FIELD MEASUREMENT and MONITORING

Display	3.5 inch LCD TFT colour panel
Measurements displayed (updated every 0.4 secs)	X axis field at sensor Y axis field at sensor Z axis field at sensor TOTAL vector field at sensor
Measurement bandwidth	5 Hz -20 kHz
Readout units selectable	mG RMS mG pk-pk μ T RMS μ T pk-pk nT RMS nT pk-pk
Display range (reading)	X, Y, Z pk-pk 0 - 40.000 mG (0 - 4.0000 μ T) (0 - 4000.0 nT) X, Y, Z RMS 0 - 20.000 mG (0 - 2.0000 μ T) (0 - 2000.0 nT) TOTAL pk-pk 0 - 69.282 mG (0 - 6.9282 μ T) (0 - 6928.2 nT) TOTAL RMS 0 - 34.641 mG (0 - 3.4641 μ T) (0 - 3464.1 nT) (note: sensor output clip detector displays if pk-pk exceeds 99% of range)
Accuracy	\pm 1.0 % of reading \pm 1 μ G (100 pT)
Sensor wideband noise limit	1 μ G (100pT) RMS
Field OK indicator	Green field OK indicator appears when X & Y & Z fields are < 250 μ G RMS
Trip indicators X, Y, Z	Trip indicator appears if the field on that axis > 250 μ G RMS and disappears after 60 seconds if the field < 250 μ G RMS

X, Y, Z REAL TIME FIELD OUTPUTS

Scaling	1.0 V/mG (10V/ μ T)
Range	\pm 12 Volts
Source resistance	10 k Ω
Connectors	3 x BNC
Bandwidth	5 Hz - 20 kHz

POWER 120/240 V (+10% -20%) 50/60 Hz , 50 VA

Note 1: Dynamic range is stated when operating at the nominal AC power input of 120 or 240 volts RMS.
de-rate linearly for lower voltages.