SC20FAST Magnetic Field Cancelling System

- **Cancels the high frequency (9kHz typ.) magnetic field from robotic wafer transports in 300mm wafer fabs.**
- **Enables electron beam tools to meet full specification in the vicinity of overhead wafer transport robots.**
- **12 x field reduction at 9kHz**
- **>20 x field reduction from 25 Hz- 6 kHz with AC sensor**
- **>50 x field reduction from DC - 1 kHz with added DC sensor**
- **Adapts to field changes within 10 µs**
- **Full 3 axis (X, Y, Z) system**
- **>20 mG (2.0 µT) pk-pk cancelling range**
- **Simple "set and forget" operation**
- **Cancels and monitors the field**
- **Network monitoring option available**
- **Supports multiple sensors for TEMs**

Overview

The SC20FAST is a new version of our established SC20 field cancelling system that has been optimised to cancel the high frequency fields, typically at 9kHz, from robotic wafer transports in 300mm wafer fabs. These fields limit the performance of electron beam tools in the fab and are a barrier to achieving the next semiconductor device CD node.

The principle of operation of the SC20FAST is similar to our other field cancelling systems, as on our website www.spicerconsulting.com

The field cancelling cables are installed in the EBeam Tool enclosure (Figs. 1 & 2) or on a frame (Fig. 8) around un-enclosed tools.

The SC20FAST uses our new, 25Hz - 200kHz bandwidth AC field sensor (Fig. 4). The control unit has faster output amplifiers and retuned filters in the feedback loop. An SC20/DCMR sensor (Fig. 5) can be added if DC field cancelling is also required.

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Product Description

The SC20FAST is a new version of our established SC20 field cancelling system that has been optimised to cancel the high frequency fields, typically at 9kHz, from robotic wafer transports in 300mm wafer fabs. These fields limit the performance of electron beam tools in the fab and are a barrier to achieving the next semiconductor device CD node.

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A typical SC20FAST AC system installation in an EBeam tool is shown in Fig. 1. The control unit is not shown. The field cancelling cables make one turn and are shown in red, green and blue. The 200kHz AC magnetic field sensor (Fig. 4) measures the field, the control unit processes and filters the measurements and drives currents through the cables with the correct amplitude and phase to null the measured field.

The amount by which the field is reduced by this negative feedback control is determined by the loop gain of the system. The loop gain depends on the details of the installation, but is typically >20 from 25Hz to 6kHz and falls to 12-15 at 9kHz.

The front panel loop gain controls enable the loop gain to be increased until the control loop just oscillates (at typically 150kHz) then backed off by 3dB for stable operation. A graph of the measured cancelling factor for the AC system is shown in Fig. 6.

In wafer fabs where there are also bad DC fields, an SC20/DCMR sensor (Fig. 5) can be added to the system. The outputs from the AC and DC sensors are combined with a 25Hz crossover frequency in a small adapter box that plugs into the back of the control unit. When the DC sensor is added, the control unit changes the signal path to provide increased loop gain at low frequencies. The cancelling factor at 9kHz is unchanged.

The system does not cancel the field everywhere inside the EBeam tool. It creates a region around the magnetic field sensor where the 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 metal structure of the EBeam tool is a factor. A bigger cancelled volume can be achieved with 2 loop field cables as in Fig 2.

When the SC20FAST is used with just the AC sensor, DC field changes in the EBeam tool caused by the operation of the tool (e.g. during wafer loading or mode change in the EBeam column) can overload the field cancelling system. It is important that the cancelling system recovers from the overload in time to resume cancelling.

The SC20FAST/AC system recovers within 2 seconds. If the SC20FAST has the added SC20/ DCMR sensor, semi-permanent DC field changes caused by the EBeam tool may require the sensor DC zero to be reset by the EBeam tool.

The SC20FAST system has all the measurement and control functions of the standard SC20. The control unit displays the amplitudes of the X, Y & Z field components and the total vector field on 3.5 digit panel meters. The meters display RMS field values. When an SC20/DCMR sensor is added, they can be switched to display incremental DC field values.

The real time measured fields are available on front panel BNC's as analog voltage levels for oscilloscope or chart recorder display.

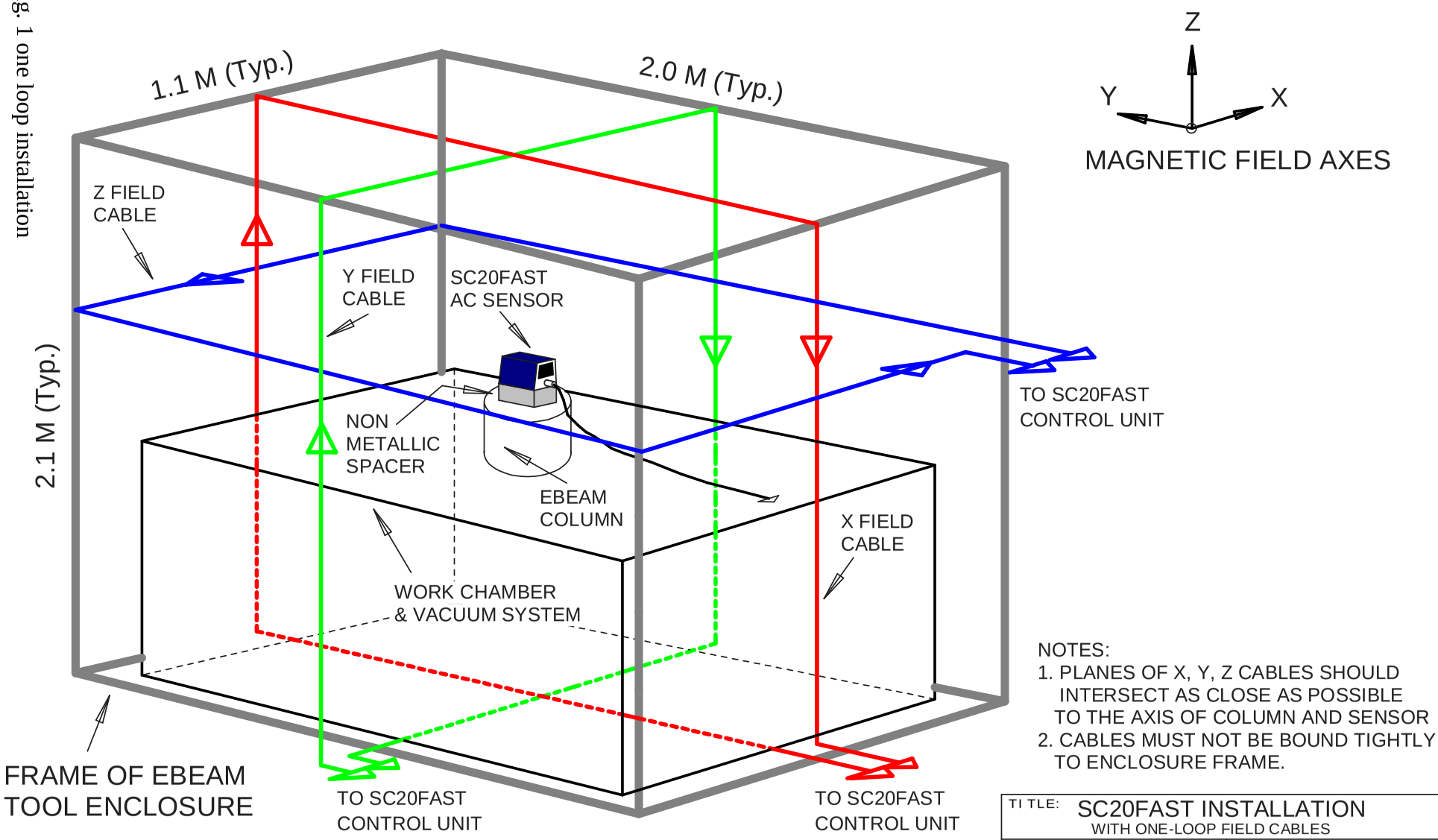
The magnetic field amplitude is continuously monitored in the SC20 and compared with preset "trip levels" to provide "GO/NOGO" indication of the field quality. A large green LED on the control unit and a smaller LED on the sensor indicate that the field is "OK".

The controls used to set up the system are behind the drop down panel (Fig. 7) which is normally bolted shut. The general operation controls are on the front panel. The two grey front panel switches control the display meters and have no effect on cancelling. The five black switches disable cancelling and reset the system but can be locked out by a switch behind the drop down panel.

To enable the performance of the SC20FAST to be accurately specified a reference cable configuration is used, as shown in Fig. 3.

Initially, the SC20FAST will be available with 2 types of field cables, one loop, as in Fig. 1 and two loops, as in Figs. 2 & 3. Later, custom cables tailored for specific EBeam tools will be available.

Fig. 1 one loop installation



NOTES:
1. PLANES OF X, Y, Z CABLES SHOULD INTERSECT AS CLOSE AS POSSIBLE TO THE AXIS OF COLUMN AND SENSOR
2. CABLES MUST NOT BE BOUND TIGHTLY TO ENCLOSURE FRAME.

TITLE: SC20FAST INSTALLATION WITH ONE-LOOP FIELD CABLES	
DRAWING NUMBER:	SCALE: UNITS:
DRAWN BY: DATE: SEPT 7 2006	RELEASE SIGNATURE:
MATERIAL:	***PROPRIETARY INFORMATION***
SPICER CONSULTING	

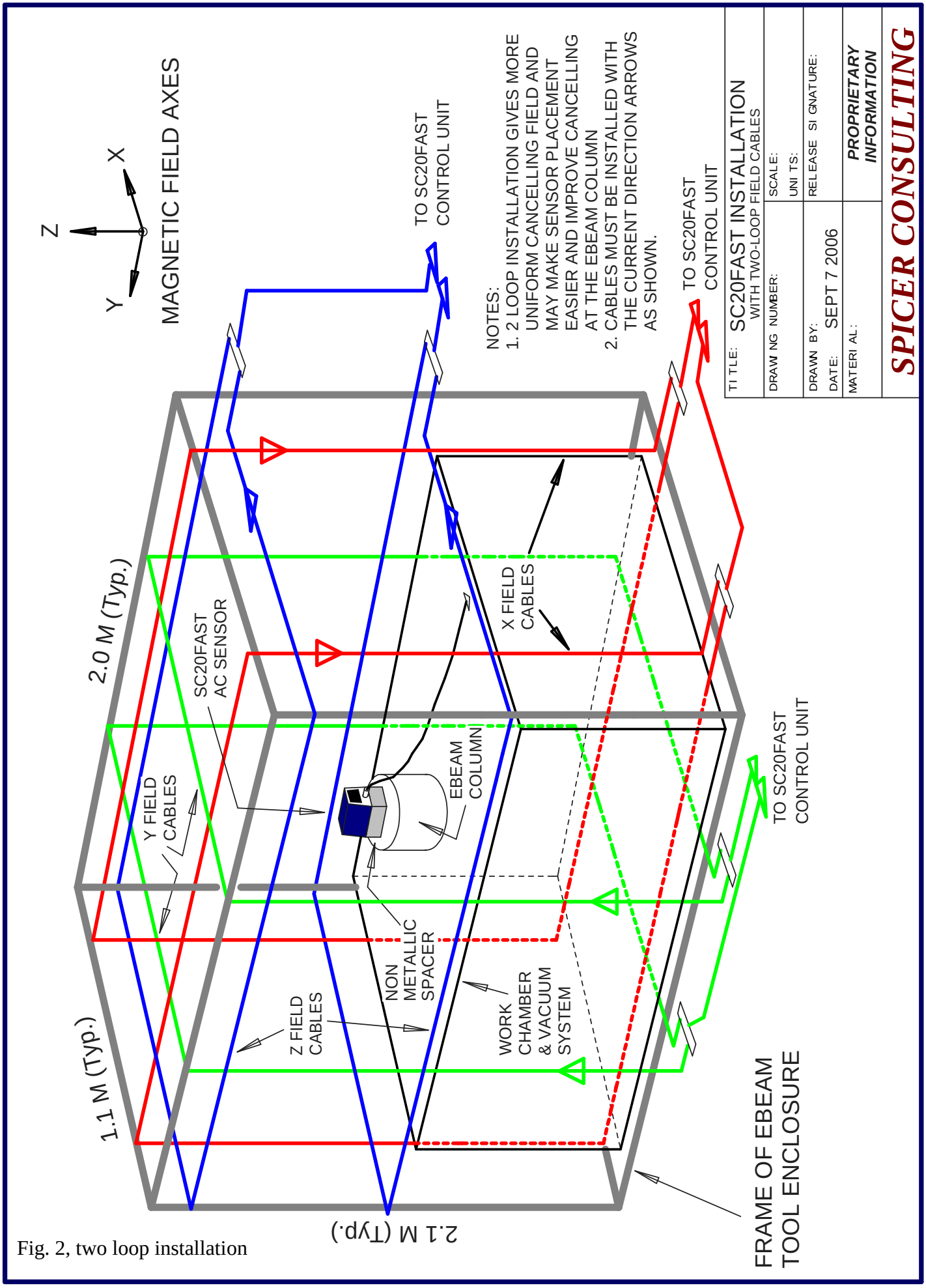
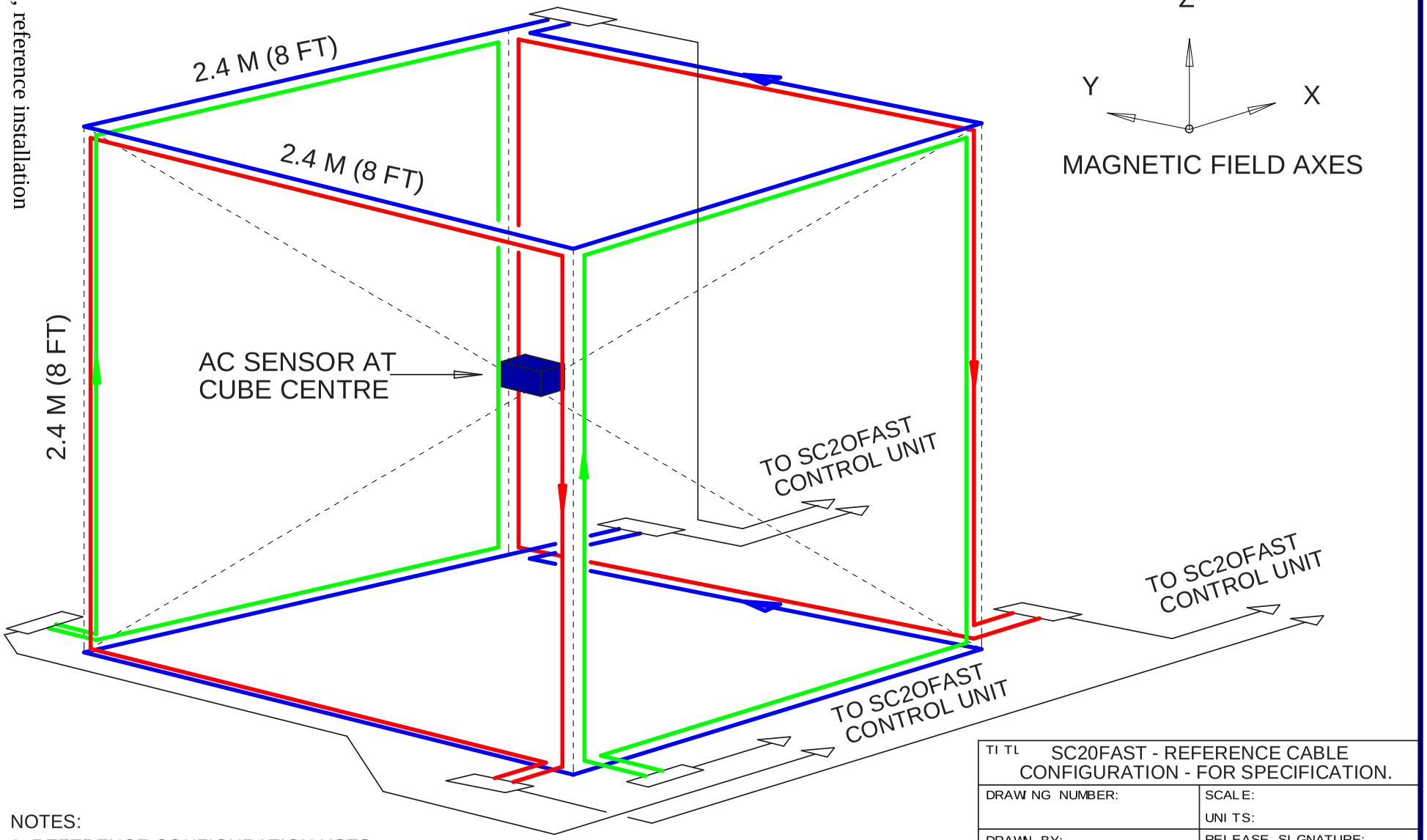


Fig. 2, two loop installation

Fig. 3, reference installation



NOTES:
1. REFERENCE CONFIGURATION USES
   THE 2 - LOOP CABLE SET INSTALLED
   AS ABOVE ON A NON-METALLIC FRAME
2. X CABLE RED, Y CABLE GREEN, Z CABLE BLUE

TITLE: SC20FAST - REFERENCE CABLE CONFIGURATION - FOR SPECIFICATION.	
DRAWING NUMBER:	SCALE: UNITS:
DRAWN BY: DATE: SEPT 8 - 2006	RELEASE SIGNATURE:
MATERIAL:	***PROPRIETARY INFORMATION***
SPICER CONSULTING	

Fig. 4 SC20FAST AC Sensor

Fig. 5 SC20 DCMR Sensor

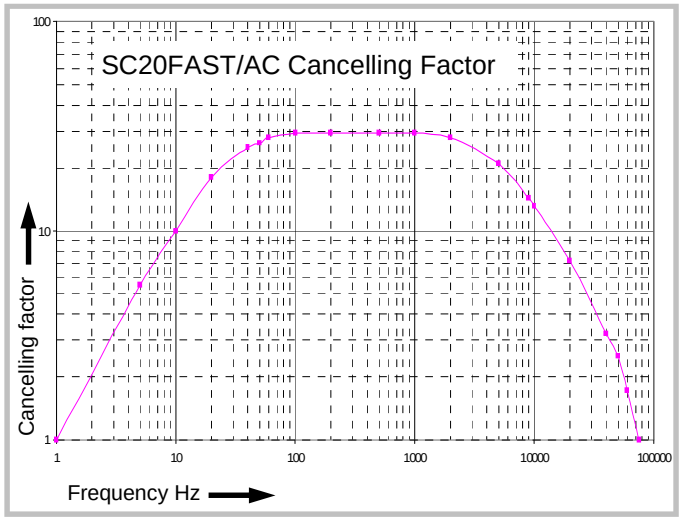


Fig. 6 SC20FAST cancelling factor

Fig. 7 Drop down panel with loopgain and mixer controls

The AC and DC sensors for the SC20FAST are shown in Figs. 4 & 5. Like the standard SC20, the SC20FAST can be used with additional sensors. When two AC sensors are installed, the mixer controls (Fig. 7) become active. The mixer combines the magnetic field outputs from the sensors to create 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 performance of the EBeam tool.

For installation of the SC20FAST system on EBeam tools that do not have an enclosure, a frame for mounting the field cancelling cables is available. The frame is made to order to the dimensions specified by the customer as in Fig. 8, which shows a sample frame with the location of the Y-axis field cancelling cables in green. The frame is manufactured from anodised aluminium and all the frame joints are insulated to prevent the frame creating a "shorted turn" that would attenuate the AC cancelling field. The cancelling cables can be tightly attached to this frame or installed in its longtitudinal grooves.

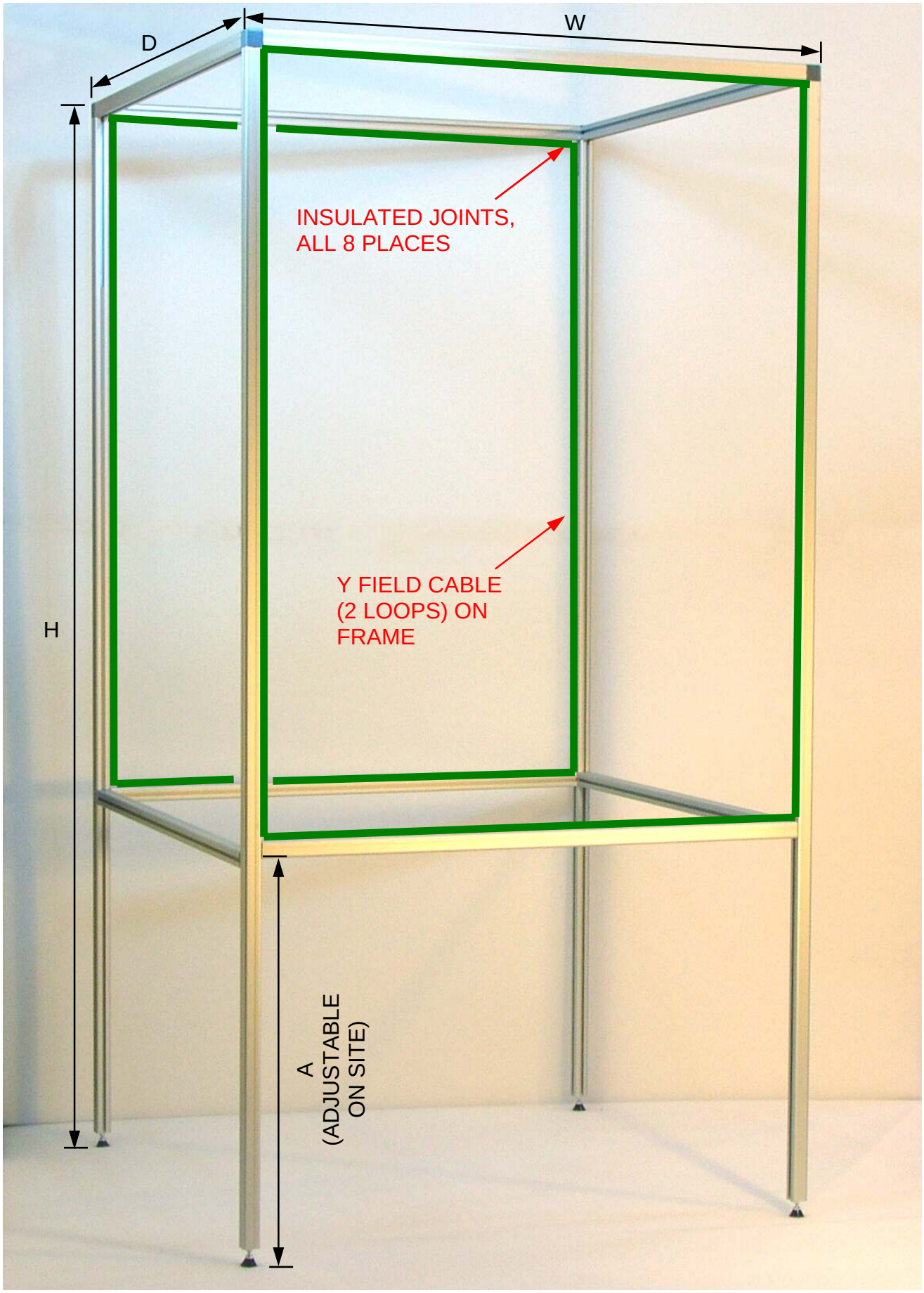


Fig. 8 Cable support Frame.

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.

SC20FAST Specifications

CO-ORDINATE SYSTEM	X, Y, Z rectangular Cartesian
UNITS	Gauss, Tesla (switchable)

FIELD CANCELLING

1. SC20FAST/AC

Components cancelled	X, Y, Z field components
Dynamic range (X & Y &Z)	20 mG (2 µT) pk-pk (installation Fig. 3)
Field cancelling factor	25 X (typical) at 50/60 Hz 12 X (typical) at 9.0 kHz
Bandwidth	1.0 Hz - 60 kHz
Sensor 1/f noise limit (0.05 to 1Hz)	< 50 µG (5 nT) pk-pk
Sensor spot noise (at 50 Hz)	0.1 µG /√Hz (10 pT/√Hz)
DC overload recovery time	< 2 s

2. SC20FAST/DC

Ambient DC field	± 2 G (± 200 µT) max
Dynamic range (X & Y)	± 10 mG (± 1 µT) incremental, (installation Fig. 3)
Field cancelling factor	>50 X , DC - 1kHz 12 X (typical) at 9.0 kHz
Bandwidth	DC - 60kHz
Drift (@23°C ±2°C, 2 hour warm-up)	DC drift/24 hours < 20 µG (2 nT)
ULF noise (0.0001- 0.01 Hz)	5 µG (0.5 nT) pk-pk (typical)
Sensor spot noise (at 50 Hz)	0.1 µG /√Hz (10 pT/√Hz)

FIELD MEASUREMENT

Types	Real time field AC - true RMS amplitude Incremental DC (with DC sensor)
Display	
RMS & DC	3.5 digit LCD panel meters
Sensor dynamic range	24 mG pk-pk
Meter range (reading) NOTE 1	0-19.99 mG (1.999 µT) RMS ± 19.99 mG (1.999 µT) DC
Accuracy NOTE 2	± 1.0 % of reading ± 10µG (1 nT) (DCMR sensor after 2 hour warmup)
X, Y, Z real time field outputs	
Scaling	1.0 V/mG
Range	± 12 Volts
Source resistance	1 kΩ (avoid shorting)
Connectors	3 x BNC
Bandwidth	25 Hz - 200 kHz (AC sensor) DC - 200 kHz (AC + DC sensor)
Trip (AC & DC)	
Range of adjustment	0 - 2.0 mG (200 nT)

POWER	120/240 V 50/60 Hz, 100 VA

Note 1: RMS & DC measurement ranges are limited by sensor dynamic range
Note 2: sensors are calibrated with 50 Hz, 10mG RMS square wave field.

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Engineering Notes:

1. Avoiding "shorted turns"

Most EBeam tools in wafer fabs are inside an enclosure supported by a steel frame (Figs. 1&2). The frame joints are usually welded or bolted together thus creating a closed conducting loop. If the field cancelling cables are attached closely to such a frame (similarly to Fig. 8), the field cancelling system will not work. (The cables in Figs. 1&2 are not attached to the frame for this reason.)

The field cancelling cable and the frame create an "air cored" transformer where the cancelling cable is the primary and the frame is the secondary. The cancelling field passing through the frame area induces a voltage in the frame. This does not matter unless the frame is a continuous loop i.e. a "shorted turn". If it is, then a current will flow in the frame that opposes the cancelling field and prevents the field penetrating the frame area.

The magnitude of the problem depends on the "coefficient of coupling k" between the primary and secondary, which is a strong function of how tightly the cable is attached to the frame.

Fig. 9 shows the results of spice modelling a practical example, as a function of k.

Steel frame:

1.5m x 1.5m from 25 x 25 x 2 mm box section.

Frame resistance = 0.0051Ω

Cable tightly attached to the frame k ≈ 1

Cable spaced 50mm inside frame k ≈ 0.75

Cable spaced 100mm inside frame k ≈ 0.5

Cable spaced 300mm inside frame k ≈ 0.25

Frame not shorted k = 0

Fig. 9 shows that the effect of the frame is to attenuate the cancelling field above 100Hz.

At k = 1 no cancelling is possible at 10kHz.

At k = 0.5 the cancelling effectiveness at 10kHz is halved.

The choices are:

1. Keep the cancelling cables well away from the tool frame.

2. Modify the frame to have insulating joints.

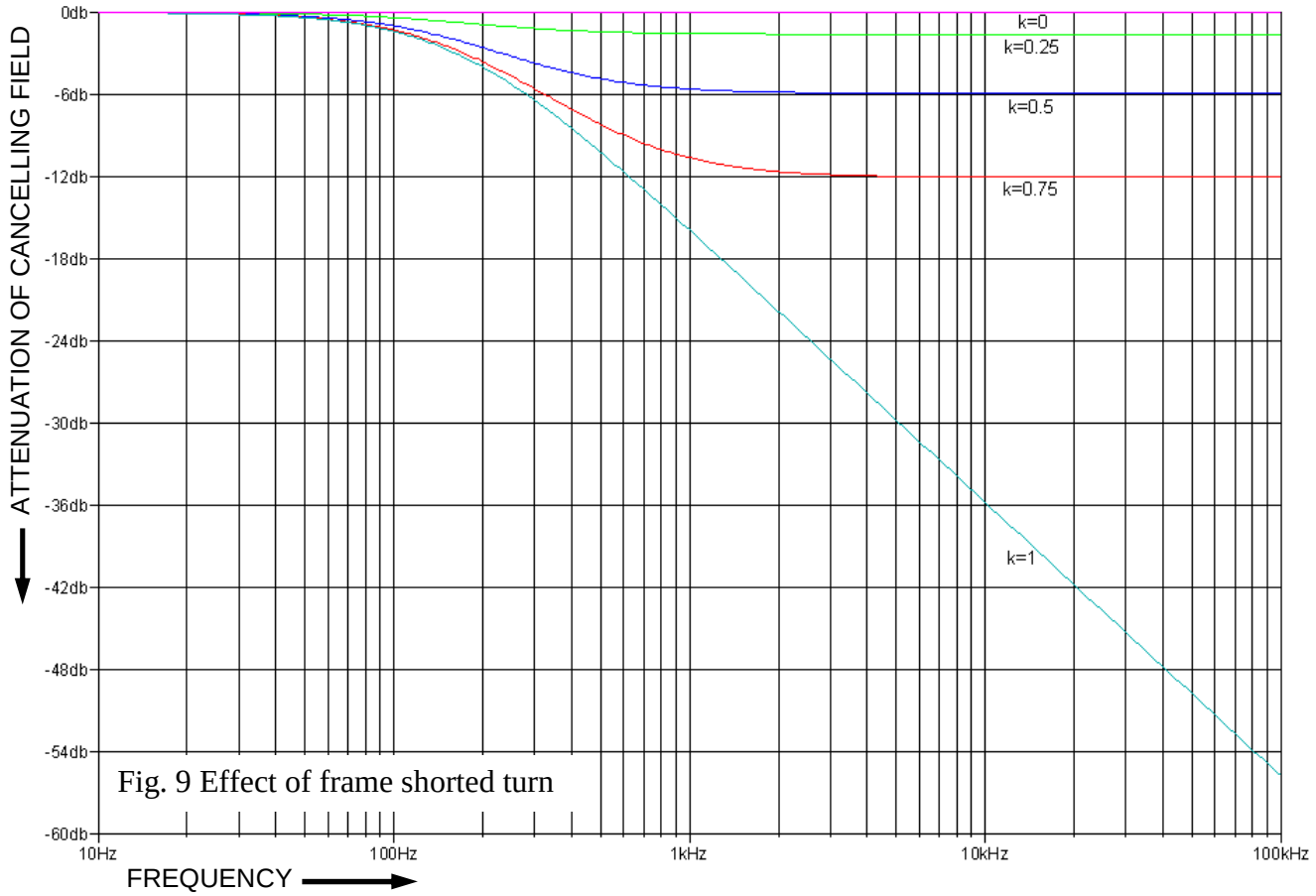

Fig. 9 Effect of frame shorted turn